

**DEVELOPING A MARKUP LANGUAGE FOR
ENCODING GRAPHIC CONTENT IN PLAN
DOCUMENTS**

BY

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DISSERTATION

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ABSTRACT

While deliberating and making decisions, participants in urban development processes need easy access to the pertinent content scattered among different plans. A Planning Markup Language (PML) has been proposed to represent the underlying structure of plans in an XML-compliant way. However, PML currently covers only textual information and lacks specifications about graphic information used in plans. To fill in this gap, this dissertation develops a PML extension, termed PMLGraphics, with the capacity of marking up graphic content of plans in a “plan usable” way. The development of the PMLGraphics can significantly impact how plans are made and used in planning practice.

The PMLGraphics is built on theoretical research on ontology of graphic representations in plan documents and relationships between different entities of plan content (i.e. text, single graphic and graphic group). The ontology of graphic representations includes typical graphic types in plans, representation methods used by graphics, and classification of intended plan information conveyed by graphics. The proposed PMLGraphics has three components: document metadata that summarizes general information of plan documents, document structure that outlines hierarchical structure of topics in plans, and document content that defines sets of elements to mark up plan content in text, single graphic, and graphic group, as well as relationships between these three content entities.

To test the feasibility of the PMLGraphics, three plans are encoded and a prototype for using the PMLGraphics is designed and implemented. Three hypothetical use cases, which simulate scenarios in practical planning processes, are created to test the PMLGraphics capabilities. The use cases demonstrate the feasibility and applicability of the PMLGraphics in accessing graphic content scattered in different plans made by different agents. The significance of the PMLGraphics for planning participants is that, as use cases demonstrate, graphic plan content accessed through PMLGraphics would have been harder to find, if found at all, using hardcopy sources or using electronic files without graphic markup.

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1. Introduction

Plans were ideally regarded as all-controlling, comprehensive solutions or all-controlling disruptions of individual decision making, in the form of a particular urban development or a hierarchy of coordinated plans (Hopkins, 2001). However, Hopkins (2001) argues that the way of plans being used in real urban development situations is far from the ideal centralized conception. In fact it normally involves many different plans and regulations made by different agencies, such as government agencies, voluntary groups, and private firms, at different times. The plans and regulations could be formal, such as adopted public plans, or informal, such as summaries of public hearings or workshops. They could be rather general, such as comprehensive plans that are long term policy statements, or quite specific, such as site plans for what to develop in subdivisions. They could be nationwide, such as for states, or local, such as for small communities. When discussing, deliberating, and making decisions in daily activities, plan participants need to easily access the pertinent content of plans and regulations, which is scattered among disparate locations and available in a variety of formats with different presentation styles, to shape issues and create solutions.

It is not easy to access the plan content pertinent to a decision situation, either in past years or at present. In past years, people had to count on their own and planning officials' expertise to collect all of the related plan documents, and further locate the related content. Walker (1950) argued that "a city plan is of little or no value unless there is a full-time planning official to keep it constantly before the officials who must carry it out" (p. 210). The expertise of the planning participant and planning official, however, could be limited in either field or spatial scope. Some plan content from completely different resources, which can significantly affect the decision situation, may be missed or overlooked. The difficult situation of accessing pertinent plan content does not change much, even when more and more plans are in electronic form and available online since the mid-1990s (Budthimedhee, Li, & Pallathucheril, 2002). Search based on mere keyword matching either retrieves too much irrelevant content that can cause information overload or too rarely locates plan content pertinent to a particular decision situation.

Interestingly, a new Internet-age technology, Extensible Markup Language (XML), paves the way for a solution to easily access plan contents from heterogeneous sources. “A markup language is a set of words and symbols for describing the identity of pieces of a document” (Flynn, 2007). As the emerging standard for the representation of structured documents on the Internet, XML reflects the structure and semantics of documents to facilitate better searching and navigation, “liberating information from the tyranny of proprietary file formats” (Williamson, 2001, p. 39).

To provide a solution for the challenge of accessing diversified resources in the context of urban planning, Hopkins, Kaza, and Pallathucheril (2005) proposed a new domain specific XML variant called Planning Markup Language (PML). The PML lays out the framework and specifications to represent the underlying structure of plans and regulations in a standard, XML-compliant way. As part of the framework, a planning data model (PDM) was designed and represented visually in UML (Unified Modeling Language). The PML tags, the building bricks of XML syntax, can be converted from PDM in a straightforward manner. As an example, an urban growth boundary policy can be encoded in PML as follows:

```
<policy name="Urban Growth Boundary">
  <if>
    <ifClause>
      <state Attribute = "area is designated as urban growth
        boundary"> </state>
      <action Action = "development is proposed outside UGB">
        </action>
    </ifClause>
    <thenClause>
      <action Action = "deny permit" actor = "city & county
        governments"> </action>
    </thenClause>
  </if>
</policy>
```

This way, the diversified plan information can easily be accessed by human and intelligent software agents, especially over a network (Hopkins, Kaza, & Pallathucheril, 2003, 2005a, 2005b).

However, PML currently only covers textual information used in plan documents and lacks specifications about graphical information such as maps, diagrams, and photographs. These forms of graphical information are widely used in plan documents due to their uniquely rich presentation ability (Dykes, 2000; Laurini, 2001; Batty, Chapman, & Evans, 2001; Jepson, Liggett, & Friedman, 2001). Shiffer has long argued that planning ideas have to be represented by multiple media to be communicated effectively (Shiffer, 1995a, 1995b, 1995c, 1998, 1999, and 2001). It is vital, therefore, to extend current PML to encode the graphic content of plan documents.

Thus, this research explores how the current PML framework can be extended to mark up graphic content of plan documents. The PML extension proposed in this research is named as “PMLGraphics”. The research starts with the following fundamental questions:

- What are the different graphic types used in plan documents? How do they convey plan ideas? What are the different plan ideas normally presented by graphics?
- What extensions to the existing PML framework enable encoding graphic content, as well as structure of a plan document?
- Do these extensions indeed make a plan document more useable and accessible, especially its graphic content?

The course of research includes two milestones. The first milestone is to develop the PMLGraphics to enable encoding of graphic content. The second milestone is to test the feasibility and effectiveness of the PMLGraphics via a proof-of-concept prototype application.

The primary focus of this research is to use plans. The proposed PMLGraphics is designed to facilitate encoding of graphic content in a “plan usable” way. Thus, the encoded graphic content can be easily accessed and used whenever the planning participants need it to deliberate about planning ideas or make decisions. To get started in researching these questions, this investigation focuses on formal plans and regulations (e.g. adopted public plans) regarding three most crucial planning themes: land use, transportation, and environmental preservation. The scope of this

research leaves out informal plan documents such as community charrettes or planning commission meeting minutes.

In this research, “Graphic content” or “graphic information” refers to the graphics used to elucidate or illustrate plan information in plan documents. Logos or other graphics for decoration are excluded.

In addition, two terms, “Planning” and “Plan”, frequently appear in this dissertation but with different connotations. “Planning” is defined as a variety of mechanisms (e.g. citizen participation, development strategies, actions, and proposed outcomes) to intentionally intervene in the urban development process. “Planning information” or “planning idea”, therefore, refers to data or thoughts being used to plan and achieve a better future. On the contrary, “Plan” refers to a specific plan document used in the field of urban planning. Consequently, “plan content” means the information delivered by a plan document. “Plan content” could include “planning information” as well as other information such as background of the area or the introduction of the particular plan document.

Once the PMLGraphics is developed and widely accepted, how plans are made and used in practice can be significantly impacted in three ways.

First, the PMLGraphics can serve as the underlying communication and database storage standard and pave the way to develop web-based applications to share and query information contained in diverse sources of plan documents. As a result, it could allow participants in the planning process to access easily and deeply the pertinent content of different plans created at different locations and at different times. Easily accessing plan content could further facilitate implementing the types of planning and community decision making advocated in the contemporary planning literature (Healey, 1997; Innes, 1998; Forester, 1999).

Second, the PMLGraphics can provide well-shared representations essential to plan-making processes. Making plans involves multiple actions and decisions and thus requires means with

which ideas can be created, communicated, tested, and then used. The plan making process requires means for representing “plans-in-the-making” (Hopkins, 2005b).

Third, in the long run, the PMLGraphics can promote public engagement in planning practice by improving two of three prerequisite conditions of effective public participation suggested by scholars in the field (Habermas, 1979; Williams & Matheny, 1995). First, the extended PML can enable the public to easily and equally access appropriate content of many different plans and regulations, especially those on the Internet, made by different agencies at different times. Second, it can help the public comprehend complex plan information, because the extended PML makes it possible for people to access the plan information presented by a variety of media (e.g. text, tables, images, and maps). Different people may find information easier to comprehend when a particular medium, or more than one medium, is used. In addition, integration of multiple media could make the complex information more easily understood.

The research is pursued in five major steps. First, numerous plan documents have been surveyed in order to explore the ontology of graphic representations (such as typical graphic types, representation methods used by graphics, and typical plan ideas presented by graphics) and relationship among different types of presentation media, including text, single graphic, and graphic group. Second, the PMLGraphics is developed around the exploration in the first step, and seamlessly integrates with existing PML framework. The PMLGraphics is expressed by both Unified Modeling Language (UML) diagrams and eXtensible Markup Language (XML) schemas. Third, three documents in *Land Resource Management Plan (LRMP)* are completely encoded in the extended PML with the intention of testing its feasibility. In addition, *2005 Comprehensive Plan* for City of Urbana and *2040 Regional Framework Plan* for Northeastern Illinois are partially encoded to serve for three use cases in the final step. Fourth, a prototype software application for using the extended PML is developed to demonstrate feasibility of encoding and applicability of the PMLGraphics in planning processes. It is not to develop a beta version of a PML system that could be used to observe users’ behaviors. The prototype is developed by using the latest web and XML technologies, including JSP/Servlet, Apache web server, Tomcat application server, Struts 2.0 workflow framework, JAXP (Java XML Processing) as well as XQuery engine. Finally, as proof of concept, three planning use cases are

tested against this prototype application. The experience with these use cases confirms the feasibility of the proposed PMLGraphics as a contribution to more effective planning.

2. Background

This research builds on previous work from four different fields: 1) Planning Data Model (PDM) and Planning Markup Language (PML); 2) graphics and graphic design; 3) graphic indexing; and 4) the Unified Modeling Language (UML) and the Extensible Markup Language (XML). Each of the fields is elaborated one by one in the following sections, along with discussions of its impacts on this research.

In the first section, fundamentals of PDM and PML as well as their limitations that need to be addressed in this research are presented. The difference is highlighted between what PMLGraphics strive to accomplish and what is delivered by the plan documents in digital forms in E-government websites. In the second section, presentational nature of a graphic is highlighted and some works on graphic design are presented. The knowledge in the domain of graphics and graphic design, even though very generic, can be implanted into planning domain and directly used by this research. A variety of popular graphic types used in planning and urban design are introduced as well. In the third section, the previous achievements of graphic indexing in the domains of library science, art and architecture are introduced. These previous works provide valuable references to this research; however, more specific works to index graphics in plan documents are needed. In the fourth section, UML and XML, which are used in this research to present the PMLGraphics, are briefly introduced.

2.1 PDM and PML

A plan in the field of urban planning was defined as “an adopted statement of policy, in the form of text, maps, and graphics, used to guide public and private actions that affect the future” (American Planning Association, 2006, p. 3). “Plans are used when making decisions concerning the future of an area or of a specific topic under consideration” (American Planning Association, 2006, p. 3), for instance, housing needs, transportation needs, open space preservation areas, strategies for a specific area and so on.

While deliberating and making decisions about urban development, planning participants require access to numerous plans and regulations of many different organizations. While making plans, they require representations with which ideas can be created, communicated, and used (Hopkins, Kaza, & Pallathucheril, 2005b). To address the needs in planning practice, from 2003, scholars from the University of Illinois at Urbana Champaign have developed a shared Planning Data Model (PDM) -- a common reference schema for urban development planning – which should cover phenomena of urban development and phenomena of plans and regulations (Hopkins, Kaza, & Pallathucheril, 2003, 2005a, 2005b).

The PDM was presented in two levels of detail by diagrams with associated definitions and examples. In the first level, as shown in Figure 2.1, icons are used to describe “relationships among entities representing the world, entities representing changes in that world, and entities representing plans” (Hopkins, Kaza, & Pallathucheril, 2005b, p. 6).

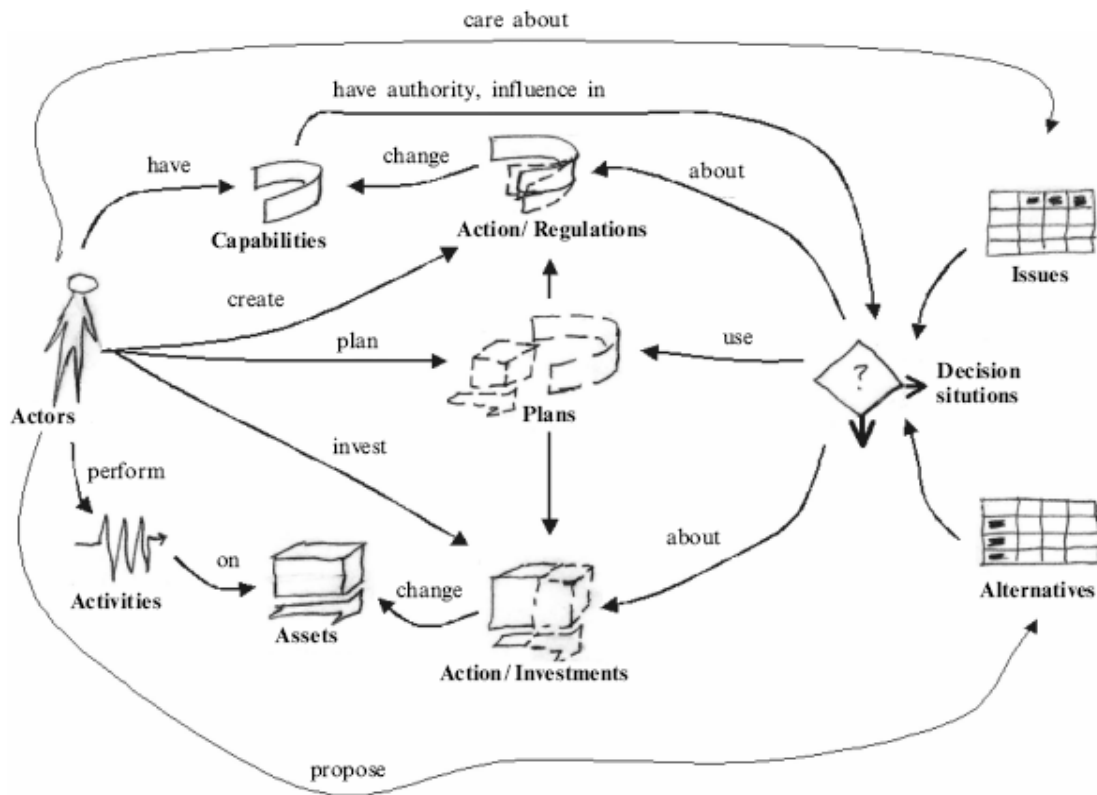


Figure 2.1 Elements of Planning Data Model (PDM)
Source: Hopkins, Kaza, & Pallathucheril, 2005b

In the second level, several major entities – **actor**, **asset**, **action**, **decision situation**, and **plan** – are further elaborated in Unified Modeling Language (UML) diagrams. The entity **plan** is presented in Figure 2.2 because the proposed PMLGraphics is built on it. **Plan** is composed of **agendas**, **designs**, **strategies**, **visions**, and **policies**. “Each of these defines a particular kind of relationship among actions and among actions and consequences in a plan.” (Hopkins, Kaza, & Pallathucheril, 2005b, p. 12) Agenda is lists of actions; design is interdependence among actions with respect to consequences, strategy is decision-tree contingencies among actions and consequences; vision is expected consequences; and policy is if - then condition for actions. **Plan** also incorporates **indicators**, including **issues**, **goals**, and **criteria**, which serve to assess consequences.

The PDM is intended to support three related tasks: using plans, making plans, and analyzing urban development ideas. For purposes of demonstration, three use cases, “using plans in planning commission meetings, revising a comprehensive plan, and analyzing urban development ideas” (Hopkins, Kaza, & Pallathucheril, 2005b, p. 13), are built to show how the PDM supports the use cases.

Planning Markup Language (PML), an eXtensible Markup Language (XML) implementation of the PDM, is proposed accordingly (Hopkins, Kaza, & Pallathucheril, 2003, 2005a, 2005b). The PML is proposed to serve as a well-shared communication channel among different visualization and modeling servers and diverse data sources in planning practice. An initial version of XML schemas of some entities in **Plan**, **agenda**, **design**, **strategy**, and **policy**, is under development, but has not been completed (Hopkins, Kaza, & Pallathucheril, 2003, 2005a).

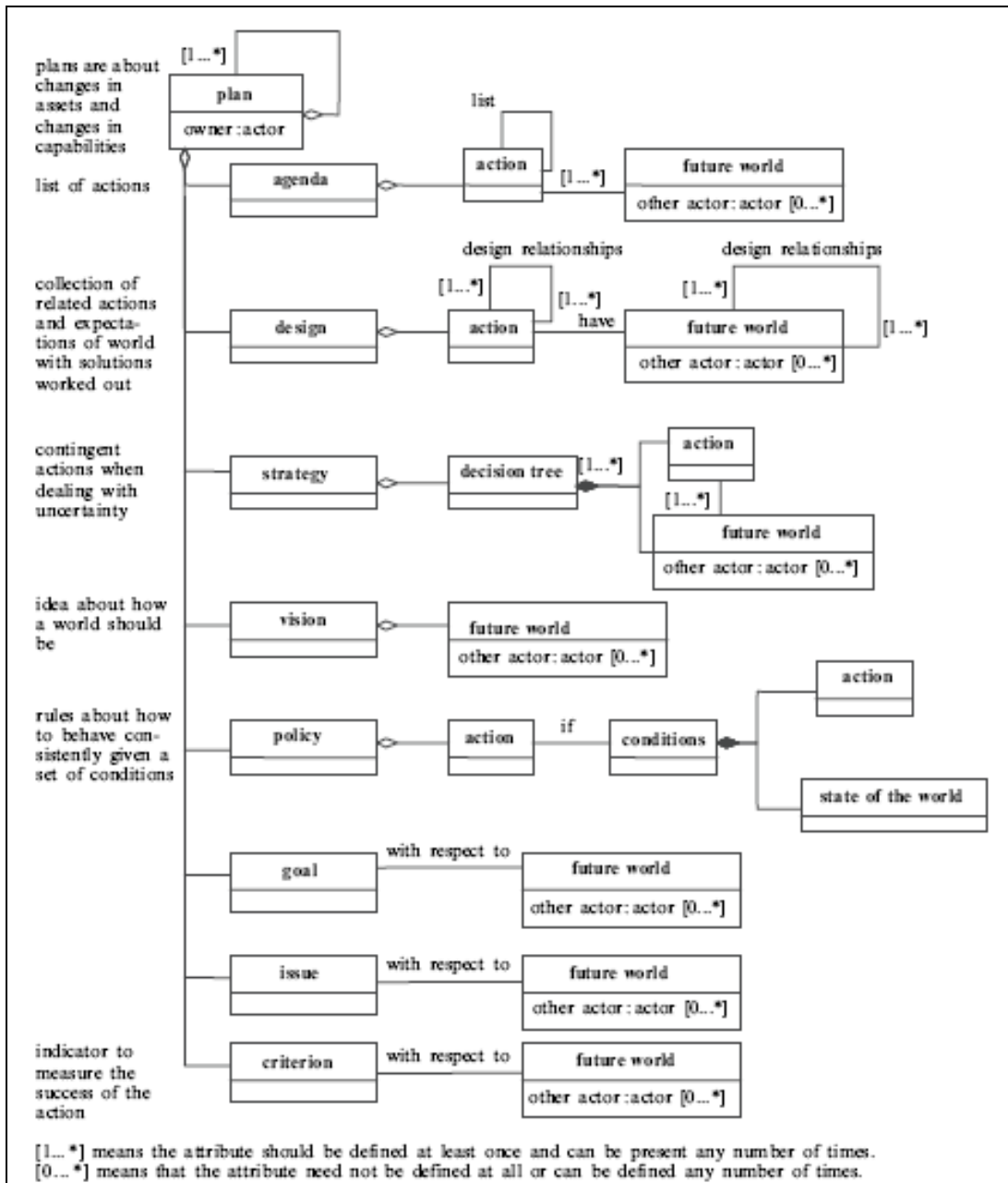


Figure 2.2 Elaboration of Entity Plan
 Source: Hopkins, Kaza, & Pallathucheril, 2005b

Later, Kaza further enriched the PDM and PML in two perspectives. First, he developed a data model for regulations and guidelines for urban development, in which a regulation is construed as an “if then because” statement that could be presented by entities of the world (e.g. **actor**, **action**, **activity**, and **asset**) and relationship between the entities of the world (e.g. asset-asset relationship, asset-activity relationship, and activity-activity relationship) (Kaza, 2004). An XML

implementation of the data model was proposed accordingly. For demonstration, the regulations pertinent to several use cases were described in pseudo code of the proposed data model. Then, Kaza proposed a framework to heuristically discover substitutability and interdependence relationships between actions within and among plans, and use already discovered semantic relationships to discover more relationships thereby enriching decision making processes (Kaza & Hopkins, 2007; Kaza, 2008). Simple databases based on real situations were used to demonstrate that these relationships can be encoded and queried in reasoning with plans.

As pioneering works for purpose to build a widely-shared data model for urban development, plans and regulations, those works are significant and invaluable. However, the current version of PDM and PML focuses merely on textual information. They lack specifications about graphical information that is popularly used in plan documents, owing to their exclusively rich presentation ability (Dykes, 2000; Laurini, 2001; Batty, Chapman, & Evans, 2001; Jepson, Ligget, & Friedman, 2001). To fill in the gap, my research is proposed to extend the PML to incorporate various graphic representations in plan documents. The PML extension is termed “PMLGraphics” for purpose of identification.

For marking up plan contents, regardless of textual or graphical forms, current version of PDM and PML (specifically the data model in Figure 2.2) provides a general framework. However, they have three constraints as follows. First, the data model needs to be further elaborated and tested by encoding instances of plan documents to assess its feasibility for plan contents, which may require lots of time and effort. Second, the entities of **Plan** (e.g. **agenda**, **design**, **strategy**, and so on) are not sufficient to cover some content of plan documents, for instance, background for introducing current situation, relationship among multiple plans. Third, they have little thought in presenting document structure of plan documents and semantic relationships between content objects, which is important for users to grasp general structure and comprehend plan contents. Due to the first constraint, the entities defined in **Plan** are used as content holders in the proposed PMLGraphics; however, their internal structures are not employed. Additional elements are introduced in the PMLGraphics to mitigate the second and third constraints.

Previous works of PDM and PML are prone to challenge as to their feasibility because they have not been tested in a real working prototype. To address this concern, a functional prototype tool for using the PMLGraphics, which includes dozens of functionalities, is proposed and implemented in this research. The database is composed of several encoded practical plan documents. Using the prototype in use cases explicitly presents how the PMLGraphics could facilitate different stakeholders to access, navigate, and comprehend graphic content in plan documents pertinent to their interests, as well as the associated textual information, in planning practice. The experience of employing prototype in use cases also provides answers to some unsolved questions identified by Kaza (2004). For instance, “how can this data model help us retrieve information?”, and “how are queries set up and how are they different from a standard query of a database?” (Kaza, 2004, p. 57).

What the proposed PMLGraphics strive to accomplish is quite different from the plan documents in digital forms in E-government websites. Since the middle of 1990s, E-government (also called online government) as an important trend has been changing the way government works. More and more national or local government information and services are being delivered via the Internet or other digital means to citizens or businesses or other governmental agencies to provide and improve government services, transactions and interactions with citizens, businesses, and other arms of government (Silcock, 2001; Sinrod, 2004; Palvia & Sharma, 2007). A variety of plan documents in electronic forms, such as PDF format, are available online. The PMLGraphics tags are superior to them in two aspects. The first aspect is that the PMLGraphics provides a universal platform to centralize planning information across different web sites and different sources. The encoding process of the PMLGraphics decomposes digital plans into smaller building blocks and funnels them into a XML-based data warehouse. By doing so, the information contained by these digital plans become both searchable and centralized. Comparatively, digital plans in city websites are isolated information. There doesn't exist a systemic approach to integrate different digital plans. The second aspect is that PMLGraphics supports a “structured” search rather than literal keyword matching text search. The “structured” search is made possible by introducing a whole system of semantic elements which annotate the graphics. This approach greatly enhances the relevance of search results in the context of graphics search. Moreover, the textual information in graphics in digital forms, which is typically

displayed as the pixel format, is out of reach for keyword matching. The surrounding text of a graphic, even if matched by the keywords, could be irrelevant to the graphic or unrelated plan information.

The PMLGraphics is a pioneer effort of image search in the domain of urban planning. However, in other domains some extensive works have been done. “Bing Visual Search” recently launched by Microsoft and “Wolfram|Alpha” launched by Wolfram Alpha LLC are two of the most recent ones. Bing Visual Search allows users to formulate and refine their search queries for structured results through data-grouping image galleries that resembles large online catalogue (Visual Search -- Bing; Schroeder, 2009). It is a general-purpose search engine used to search images in entertainment, famous people, online media, reference, shopping, sports, and travel.

Wolfram|Alpha, as world's first computational knowledge engine, can handle free-form natural language input, draw on multiple terabytes of curated data and synthesize it into entirely new combinations and presentations (About Wolfram|Alpha; Wolfram| Alpha officially launched, 2009). It so far “emphasizes domains where computation has traditionally had a more significant role” (About Wolfram|Alpha). Even though those works are not specific for urban planning domain, some concepts being used could be borrowed in the future development of the PML.

Another XML implementation that is a close precedent to the PML is the Geography Markup Language (GML). The GML is the XML grammar defined by the Open Geospatial Consortium (OGC) to express geographical features (Geography Markup Language (GML); OpenGIS Geography Markup Language (GML) encoding standard; Lake). The GML serves as a modeling language for geographic systems as well as an open interchange format for geographic transactions on the Internet. Schema specifications for GML version 3.2.1 are given at <http://www.opengeospatial.org/standards/gml#overview>. The GML provides a rich set of objects for describing geography, including feature, geometry, coordinate reference system, topology, time, dynamic feature, coverage, unit of measure, directions, observation, and map presentation styling rules. The GML schema specifying geographic objects and aspects associated with PML entities could be imported into the PML. There is no reason to reconstruct those parts that are useful for PML. The experiences and methodologies for developing the GML are also valuable resources that could be used in the development of the PML.

2.2 Graphics and Graphic Design

Graphics are all around our daily life, appearing in newspapers, magazines, books, advertisements, television, online materials and so on. Graphics represent information in a different way from sentences. Larkin and Simon (1987) argue that images arrange and index pieces of information in a two-dimensional land, including the topological and geometric relations among the components; whereas, sentences express information in a linear, sequence, and purely one-dimensional way. From information computational perspective, they made a strong argument that a diagram is (sometimes) worth ten thousand words. They elaborate the following three reasons “why a diagram can be superior to a verbal description for solving problems”:

- Diagrams can group together all information that is used together, thus avoiding large amounts of search for the elements needed to make a problem-solving inference.
- Diagrams typically use location to group information about a single element, avoiding the need to match symbolic labels.
- Diagrams automatically support a large number of perceptual inferences, which are extremely easy for humans. (Larkin & Simon, 1987, p. 98)

Later, the advantages of diagrammatic representations for reasoning were further elaborated and extended by Koedinger (1992). Tufte (1983, 1990, and 1997) demonstrates the similar argument – one picture would worth ten thousand words -- from perspective of graphic design. Numerous graphics that contain large amounts of complex information are presented.

Graphics are used as the vehicle of communication for data, concepts and emotions sent from authors of graphics to viewers, with the intention of affecting a viewer’s internal perceptions, including beliefs, opinions and attitudes (Pratt, 1998). Regarding how the viewer’s behavior is affected by communication, Pratt (1998) states that graphics are designed to perform in four different ways -- to motivate (for instance, graphics in advertisements, political, and religious); to articulate, describe, or explain, which is perhaps the most popular usage of graphics; to educate (for instance, graphics in recipes and home improvement articles); to felicitate or provide an experience that is intrinsically valued (for instance, graphics in comic and novels).

Most graphics in plan documents, I believe, belong to the first three categories. Typical examples are diagrams that compare projected situations of congestion delay when metropolitan plan is adopted or not adopted to motivate public to use the plan; flow charts describing how to implement a plan for education; mobility map illustrating the existing and planned road networks for city of Urbana to articulate plan ideas.

Regarding how to convey convincing evidence and effective narratives by graphics, Tufte (1997) made a thorough discussion in the book *Visual Explanations: Images and Quantities, Evidence, and Narrative*. His discussion includes two parts -- examining logic of depicting quantitative evidence for convincing demonstration and considering design strategies for the arrangement of images as narrative.

In the first part, Tufte (1997) argued that “visual representations of evidence should be governed by principles of reasoning about quantitative evidence” (p. 53). He presented two well-known cases of visual arguments, in which two life-and-death decisions (one successful, and one unsuccessful) have been made from the quality of methods used in displaying and assessing the quantitative evidence. In the successful case, the map of cholera deaths in London’s 1854 epidemic helped John Snow discover that cause of the epidemic was the Broad Street pump, and thus removing the pump brought the epidemic to an end. In contrast, in the unsuccessful case, the thirteen charts that obscured relationship between O-ring damage and cold weather misled NASA officials to make a terribly wrong decision to launch the space shuttle Challenger at a very cold day. The decision directly caused the disaster that the Challenger exploded and seven astronauts died because two rubber O-rings leaked.

In the second part, Tufte analyzed design strategies that make for the most effective narratives. Small multiples design, which was first introduced in his book *Envisioning Information* (Tufte, 1990), is further discussed here. Small multiples design makes use of series of postage-stamp size pictures that are clustered together and ordered by time or a quantitative variable in order to visually enforce “comparisons of changes, of the differences among objects, of the scope of alternatives” (Tufte, 1990, p. 67). Small multiples design is also a good solution for presenting

space and time, because “multiple images reveal repetition and change, pattern and surprise”, “directly depict comparisons”, “enhance the dimensionality of the flatlands of paper and computer screen”, “create visual lists of objects and activities, nouns and verbs, helping viewers to analyze, compare, differentiate, decide”, “represent and narrate sequences of motion”, and “amplify, intensify, and reinforce the meaning of images” (Tufte, 1997, p. 105).

Tufte’s argument of representation mechanism and small multiples design, even though very general, is still suitable for planning domain. Since planning process is interpreted as a process of rational argumentation (Goldstein, 1984; Rittel & Webber, 1973; Daly, 1978), plan content is narrated as either rational arguments or elaborations of plan ideas including issues, actions, strategies, and so on. Inspired by Tufte’s argument of representation mechanism, representation methods of graphics conveying plan information are summarized as “demonstrate” and “elaborate” in this research. Inspired by Tufte’s good and poor examples, those graphics providing rich illustrations or strong demonstrations of plan information are labeled as “high” importance, and those graphics providing poor illustrations or weak demonstrations are labeled as “low” importance. Small multiples design discussed by Tufte is also popular in plan documents to normally enforce comparisons or contrasts or reveal patterns.

Tufte presented and analyzed superb collections of statistics graphs ranging from essential forms including bar chart, histogram, box plot, and scatter plot to new derived graphical forms (Tufte, 1983, 2001). Moving beyond the study of statistical graphs, he further presented a wide range of graphical forms (including maps, diagrams, tables, photographs, timetables, computer interfaces) in a broad range of disciplines (including mathematics, physics, mechanics, biology, geometry, geography, urban planning, astronomy, dance and music) as well as discussed strategies used in presentation (Tufte, 1990). Even though Tufte’s works are not specific for planning, they provide valuable references to analyze statistics graphs and other types of graphics in plan documents, and how graphics communicate plan information.

The book *Planning and Urban Design Standards* written by American Planning Association (APA) (2006) elaborates various maps and aerial photographs, commonly used in planning and urban design. The various maps include topographic maps that “provides a representation of the

Earth's surface through contour lines" (American Planning Association, 2006, p. 530), property maps in modern cadastres that "depict land description, value, ownership, and socioeconomic data" (American Planning Association, 2006, p. 535), demographic maps that depict "socioeconomic data, which includes population, median income, and employment" (American Planning Association, 2006, p. 535), satellite image, and images in Geographic Information Systems (GIS). Applications and contents of the various maps, as well as data sources, are also introduced. The intention of presenting the various maps is not to provide an exhaustive list, but rather a sampling of some of the popular maps use.

As the most comprehensive reference book on urban planning, design, and development available today, *Planning and Urban Design Standards* "contains more than 800 illustrations of familiar images, established concepts, and new approaches" (American Planning Association, 2006, p. Xi). Site plans, elevations, charts, process diagrams, maps, photographs, and three dimensional visualizations are among the various types of images included. The book provides a broad array of essential information in planning and urban design. Most importantly, it includes a wide range of references that helps me summarize graphic types commonly used in plans, identify important elements of graphics that need to be marked up, and explore plan information various graphics intended to communicate.

2.3 Graphic Indexing

Due to the rapid growth of the World Wide Web, there is a tremendous amount of graphics or images online. There were 180 million images on the publicly indexed Web, and there was a total of 3Tb (terabytes) of image data in 1999 (Lawrence & Giles, 1999), and one million or more digital images are being produced every day (Jain, 1993). Users in a variety of disciplines, including information scientists, librarians, journalists, designers, teachers, and artists, share the need to find desired graphics. Users' interests vary considerably.

Accordingly, within the last decade, librarians, curators, and archivists have focused energy and thought on how to catalog and index graphics with text-based ontologies and schemes. These cataloging and indexing schemes were often developed internally and customized to reflect

unique features of a collection or specific needs of customers (for example, see Busch, 1994; and Lunin, 1994).

Text-based indexing has many advantages, such as the flexibility of representing an object generally and specifically with a spectrum of complexity (Lancaster, 1998; Lunin, 1987). However, text-based indexing also faces many challenges. One major problem is there could be various inconsistencies between a user's textual queries and annotations or descriptions of graphics. To mitigate the problem, a handful of strategies could be employed: showing textual descriptions of similar graphics as the hints to improve user's query terms, and obtaining relevance feedback from users regarding the retrieved graphics. (Zhang, Chai, & Jin, 2005; Belkin, Cool, Koememann, Ng, & Park, 1996).

To improve consistency in cataloging and effectiveness of information retrieval, several critical works have been done including the Getty's Art and Architecture Thesaurus (AAT) and the Library of Congress Thesaurus of Graphic Materials (TGM). The AAT is a structured vocabulary, which consists of around 34,000 concepts and 131,000 terms, for the description of art, art history, architecture, and material culture (Art and Architecture Thesaurus Online). The AAT contains generic terms, such as "cathedral", but no specific proper name, such as "Chartres Cathedral". The primary users of the AAT include museums, art libraries, archives, catalogers, and researchers in art and art history. Developed by the Library's Prints and Photographs Division in the 1980s, the TGM is one of the major thesauri used for indexing visual materials by subject and genre/format (Alexander & Meehleib, 2002). It includes more than 7,000 subject terms to index topic shown or reflected in pictures (Thesaurus for Graphic Materials I: Subject Term (TGMI)), and 650 genre/format terms to index types of photographs, prints, design drawings, ephemera and other categories (Thesaurus for Graphic Materials II: Genre and Physical Characteristic Terms (TGMII)). The TGM has become an essential tool for numerous libraries, archives, and historical societies that catalog graphics, in the United States and abroad.

However, controlled vocabularies or classification schemes could not entirely solve assignment of terms for describing graphics. Scholars have acknowledged that analyzing the meaning of graphics is a complex and challenging process (see, for example, Hilderley, R. et al., 1995;

Enser, 1993; Enser & Cawkell, 1994; Shatford, 1986, 1994). Based on Panofsky's "levels of meaning" approach (1972), Shatford (1986) proposes a theoretical basis for identifying and classifying subjects a picture may have. Subject of a picture could be described in two levels -- what is actually depicted in the image and what the image is about. Shatford (1994) extended the discussion by identifying importance of accessing groupings of graphics as well as discussing considerations related to creating the groupings.

The previous research in graphic indexing in domains of library science, art and architecture provides valuable references for indexing graphical representations in plan documents. However, more specific and broader taxonomy and terminology that describe graphics in plans are needed. They should cover various graphic types in plans and include useful descriptions to facilitate different stakeholders to access the graphics they need whenever they discuss, make decisions, or make plans.

2.4 UML and XML

The Unified Modeling Language (UML), created by the Object Management Group (OMG), is a standard language for specifying, visualizing, constructing, and documenting the artifacts of software systems, as well as for business modeling and other non-software systems (Object Management Group, n.d.a; Fowler, 2003; Miles & Hamilton, 2006). It uses mostly graphical notations to express the design of software projects. The latest version UML 2.0 defines thirteen types of diagrams. The Class Diagram, one of the thirteen types, describes the structure of a system by showing the system's classes, their attributes, and the relationships between the classes. It is used in this dissertation to provide readable representations of the proposed PMLGraphics. Specifications of the Class Diagram could be found at OMG Unified Modeling Language Specification (Object Management Group, n.d.b).

The Extensible Markup Language (XML) is a general-purpose specification for creating custom markup languages (Williamson, 2001). It can provide not only syntax for document markup but also declaring the structures of documents (Laurent, 1998). XML makes it possible to define the

content of a document separately from its formatting, making it easy to reuse that content in other applications or for other presentation environments. Most importantly, XML provides a basic syntax that can be used to share information between different kinds of computers, different applications, and different organizations without needing to pass through many layers of conversion (Laurent, 1998; Extensible Markup Language (XML); XML from the inside out).

Due to those features of XML, the proposed PMLGraphics is presented as an implementation of XML 1.0 for marking up graphics in plan documents. Specifically, XML schema 1.1 is used to present the PMLGraphics, and XML Query Language (XQuery) 1.0 along with the programming language Java is used to implement the prototype. Specifications of XML 1.0 can be found at URL: <http://www.w3.org/TR/REC-xml/>; specifications of XML schema 1.1 can be found at URL: <http://www.w3.org/XML/Schema>; and specifications of XQuery 1.0 can be found at URL: <http://www.w3.org/XML/Query/>.

2.5 Conclusion

In this chapter, the previous works that this research builds on have been reviewed. The literature review includes four sections. In the first section, I have presented a conceptual work of PDM and PML as well as highlighted the research gap to be filled in this research. Then, I have illustrated what PMLGraphics can achieve beyond plans in digital forms (e.g. city websites with PDFs of plans), and introduced some of the most recent works on image search in other domains. In the second section, I have demonstrated the superior capacity of a graphic in presenting information as well as how graphics in a wide range of disciplines convey convincing evidences and effective narratives. It is followed by the various graphic types commonly used in planning and urban design. In the third section, I have examined the previous research in graphic indexing being used in areas ranging from library science to art and architecture. In the fourth section, a brief introduction of UML and XML is given to provide some technical background of this work.

The next chapter presents the methodology used to conduct the research. The following two chapters illustrate ontology of graphic representations in plan documents and relationships

among content entities. Together, they form the theoretical foundation of the PMLGraphics proposed in this research.

3. Methodology

As shown in Figure 3.1, this dissertation is carried out in five steps. Each of them is explained in details below.

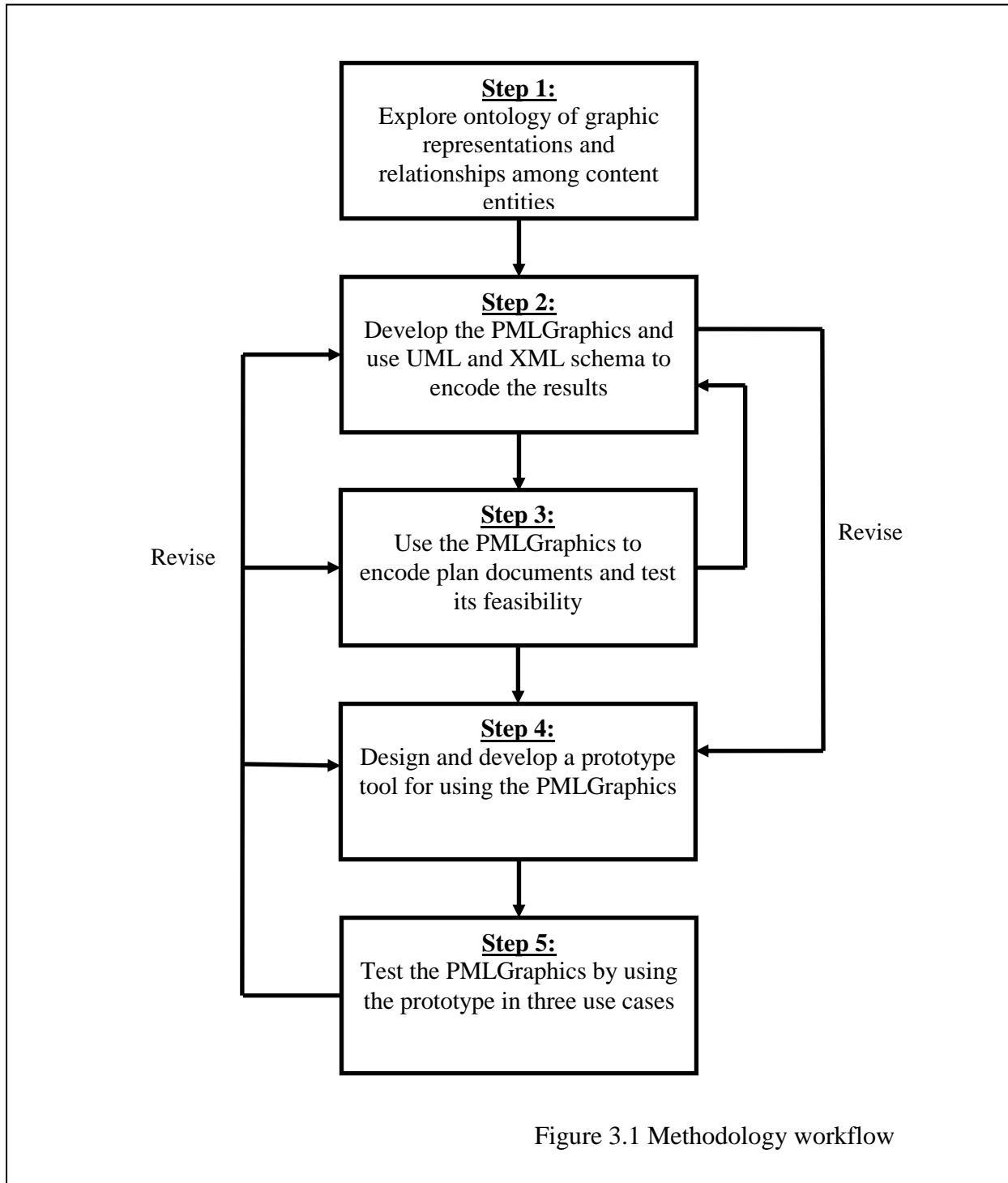


Figure 3.1 Methodology workflow

Step 1: Explore ontology of graphic representations and relationships among content entities

The first step builds a theoretical foundation of the research. Around two hundred and fifty graphic representations in plan documents are studied mainly to explore the following issues:

- significance of context in understanding and encoding graphics,
- typical graphic types in plan documents,
- representation methods used by graphics,
- plan information presented by graphics,
- importance of a graphic for the plan information it is intended to convey,
- graphic group as a unified mechanism for communication,
- associations among group members in a graphic group, and
- relationships among various presentation media, text, single graphic, and graphic group, especially relationship between two single graphics and relationship between single graphic and text.

The many graphic representations are mainly from four plans, which are:

- *2005 Comprehensive Plan* for City of Urbana, Illinois
- *2040 Regional Framework Plan* for Northeastern Illinois made by Northeastern Illinois Planning Commission (NIPC),
- *The Metropolis Plan: Choices for the Chicago Region* made by Chicago Metropolis 2020, and
- *Land Resource Management Plan (LRMP)* of Will County, Illinois, including three documents, *Policy Gateway*, *Forms and Concepts Handbook*, and *Open Space Element*.

Step 2: Develop the PMLGraphics, and use Unified Modeling Language (UML) and eXtensible Markup Language (XML) schema to encode the results

In the second step, the PMLGraphics is developed based on the conceptual study in the first step. The PMLGraphics is composed of three parts, document metadata, document structure, and

document content. Document metadata records general information of a plan document, such as plan name, functionalities, geographical scope being affected, and authors. Document structure outlines hierarchical structure of topics of a plan document as represented, for example, by a table of contents. Document content marks up three types of content entities: text, single graphic and graphic group, as well as relationships among different content entities. The document content is the most important part, because it enables us to encode graphic content in “plan usable” ways.

The PMLGraphics is in the format of an eXtensible Markup Language (XML) schema (see Appendix B). However, the Unified Modeling Language (UML) is used to present it because this visual modeling language makes the data model easily understandable and readable. To illustrate the data model, one or two examples are shown after each piece of the data model is presented.

Step 3: Use the PMLGraphics to encode plan documents and test its feasibility

In the third step, the PMLGraphics is used to encode three of the four plan documents mentioned before. Specifically, the plan *LRMP* that includes three documents is fully encoded in order to test feasibility and applicability of the PMLGraphics; the other two plans, *2005 Comprehensive Plan* and *2040 Regional Framework Plan*, are partially encoded for needs of the three use cases in the final step. Around one hundred and fifty graphic representations are marked up. The encoding results are stored in XML format, and will be used as a toy database in the final step.

The encoding process is a process of testing feasibility of the PMLGraphics. It tests 1) whether the data model is general and flexible enough to mark up different kinds of graphic content in a plan document, and 2) whether the data model is complete enough to mark up important plan information conveyed by graphics. Whenever any difficulty is encountered, possible reasons are identified and the data model is revised accordingly. The iteration of testing and revising the data model could repeat several times until the PMLGraphics successfully marks up all of graphic content to be encoded.

This is, so far, the first effort of encoding plan content with the PMLGraphics. It not only is a necessity of advancing the data model, but also provides first-hand valuable experiences and references for encoding more plan content in the future.

Step 4: Design and develop a prototype tool for using the PMLGraphics

The prototype tool is designed in accordance with two considerations. First, functions of the tool should demonstrate how the PMLGraphics facilitates planning participants easily accessing graphic contents in planning processes. Second, the tool should meet the needs of the three use cases in the final step.

The prototype tool mainly includes two features, “Navigation Tool” and “Query Tool for Graphics”.

In the “Navigation Tool”, content entities (including text entities, single graphic entities, and graphic group entities) are under topics that are organized in a hierarchical structure by following the original structure of a plan document. Thus, if a certain topic interests users, they can browse contents of the topic by accessing details of content entities.

In the “Query Tool for Graphics”, graphic representations can be queried by free-style inputs, pre-defined selections, or a combination of these. Single graphics and graphic groups in a retrieval list are shown as small-size icons and labeled by some important indicators (such as plan information conveyed by graphics or graphic groups, aspect of plan information) to assist users in choosing pertinent graphic content before they open up full-size figure. Single graphics in the retrieval list are automatically ranked in accordance with specific rules. In addition, single graphics and graphic groups in the retrieval list can also be manually sorted by some indicators, such as categorized plan information conveyed by graphics. Via relationships among content entities, users can navigate from one content entity to another one. Besides, users can still navigate through plan content in same way as they do in the “Navigation Tool” after they view details of a single graphic or graphic group that is fed back from a query.

The initial version of the prototype tool uses the method of paper prototyping (Snyder, 2003), in which a collection of rough, hand-drawn sketches labeled with annotations are created to represent design. The draft is essentially for illustrating the following issues:

- Interface of each page,
- implicit logics inside each page (e.g. querying rules, automatically sorting rules of single graphics in a retrieval list),
- details that should be handled in each page (e.g. formatting)
- Workflow among pages,

The prototype tool adopts a three-tier architectural design, which is a preferred structure for complex web-based systems. The application is developed by latest web and XML technologies, including JSP/Servlet, Apache web server, Tomcat application server, Struts 2.0 workflow framework, Java XML Processing (JAXP) as well as XQuery engine.

It is worth mentioning that purpose of the prototype is to demonstrate procedural attributes of system, feasibility of encoding, possibility of finding unexpected results, and most importantly, test the feasibility and applicability of the proposed PMLGraphics in planning processes. It is not to develop a mature commercial product or a beta version of a PML system that could be used to observe users' behaviors. Thus, I focus on developing essential functions significant for demonstration of concept, rather than on polishing the interface and handling various exceptions.

The prototype tool is coupled with the proposed PMLGraphics. Thus, whenever the data model is revised in the second step, the prototype tool has to be modified correspondingly.

This is but the first effort for developing an application tool using the PMLGraphics. Undoubtedly, the implementation process will provide valuable technical experiences and suggestions for developing a more mature PML application tool in the future.

Step 5: Test the proposed PMLGraphics by using the prototype in three use cases

In this step, three hypothetical use cases, which simulate practical scenarios in planning processes, are built for demonstration. These hypothetical cases are placed in real places only for purposes of demonstrating the database and interface prototype. The use cases are not based on any real development proposals. The three use cases are introduced below.

Case one: site selection for an office

An engineering company intends to extend their services and open a branch office in Illinois. It works with consultants to locate a candidate list of sites where an engineering company office fits into future land use development pattern.

Case two: updating plan document

City of Plainfield, Illinois has been experiencing rapid growth from 2005 to 2009. The growth not only brings lots of opportunity in economic development, but also endangers farms and permanent open space. To respond to the change, planning staff in Plainfield needs to update local plan documents regarding land use and environmental preservation, which should be in compliance with context of a broader area.

Case three: developing a commercial center

To meet for demand of rapid growth in City of Aurora, a large-scale commercial center for the City is proposed, and the site for building the center is located. In the project, urban designers need to find references regarding site plans of commercial centers, and architects need to find references regarding architectural designs of commercial buildings.

Through database and the prototype, the use cases show that the PMLGraphics can assist different stakeholders to easily access and conceive of pertinent plan information, especially graphic content, which is scattered in different plan documents made by different agents. Easily accessing plan information is fundamental and significant to shape the focus of attention, to support discussion, and to make decisions. The experience of the use cases demonstrates the feasibility and practicability of the PMLGraphics in accessing graphic content, as well as

demonstrates in which possible ways the PML extension could help planning participants to locate and navigate graphic representations of plans.

Besides testing feasibility of the PMLGraphics, utilizing the prototype in the use cases is also a process of testing the accuracy of encoding in the third step, as well as design and implementation of the prototype in the fourth step. Whenever any of them -- the data model, encoding results, or the prototype-- is modified, the latest version needs to be tested again. The iteration of modification and testing could happen several times. This approach of using prototype to test viability of a proposal is drawn from multiple disciplines ranging from Geography Markup Language (GML) to software development on which this research is founded (for example, see Open Geospatial Consortium, Inc.; Charette, 1989; Crinnion, 1991; Wiegers, 2003).

4. Ontology of Graphic Representations in Plan Documents

Besides text, graphic representations are the most important presentation device in plan documents due to their unique approach and amazing capacity for communicating plan information. To study how to mark up graphics in plan usable ways, some fundamental questions emerged: What exactly are graphic representations in plan documents, especially in formal plans for land use, transportation, and environmental preservation? What plan information do they communicate? How do they communicate this information?

The content of this chapter is developed around these fundamental questions. The chapter includes seven sections. The first section highlights that context of a graphic plays a very important role in understanding the graphic. The second section presents eight graphic types that are general enough to cover the variety of graphics in plan documents, as well as a special graphic type, “index graphic”. The third section categorizes the plan information conveyed by graphics into five groups, and introduces the significant graphic types for each group of plan information. The fourth section presents three representation methods that are universally used by graphic representations in communicating plan information. The fifth section introduces an indicator “effectiveness”, which signifies how well a graphic elaborates or demonstrates a piece of plan information. The sixth section states that sometimes two or more graphics are closely associated together as a graphic group in order to communicate plan information as a whole. Each component of a graphic group is called a group member. The associations among group members are categorized into two types in the seventh section.

The ontology of graphic representations in plan documents, proposed in this chapter, is illustrated by examples. The examples and figures are mainly from two hundred and fifty graphic representations from four plans.

- *2005 Comprehensive Plan* for City of Urbana, Illinois,
- *2040 Regional Framework Plan* for Northeastern Illinois made by Northeastern Illinois Planning Commission (NIPC),

- *The Metropolis Plan: Choices for the Chicago Region* made by Chicago Metropolis 2020, and
- *Land Resource Management Plan (LRMP)* of Will County, Illinois, including three documents, *Policy Gateway*, *Forms and Concepts Handbook*, and *Open Space Element*.

The content in this chapter builds a theoretical foundation on which to develop a data model in order to mark up graphics in plan documents. It thus paves the way to develop the PMLGraphics that has capacity to encode graphic content in plan documents in addition to textual content addressed in the previously developed PML.

4.1 Context of graphic

The term context is defined as “the parts of a discourse that surround a word or passage and help to explain its meaning” (Dictionary and Thesaurus – Merriam-Webster Online). A passage should not be quoted out of context (Engel, 1994). Context for a graphic in a plan document refers to the parts of a written statement that precede or follow the certain graphic. Context also has significant impacts on the intended information a graphic conveys or the effect of the graphic communicating the intended info.

Understanding the significance of context for a graphic is especially crucial for encoding the graphic. To identify information of the graphic, including the intended plan information a graphic conveys, the precise definition of elements in the graphic, the background of the intended information, merely studying the graphic is far from enough; the graphic must be explored within the context of the original plan document. Removing a graphic from its surrounding matter may lead to distort its intended meaning or obscure comprehending the intended plan information.

The following passage demonstrates impacts of context on comprehending a graphic from two perspectives.

First, context could provide valuable hints for viewers to identify the intended information a graphic conveys, especially when the graphic carries a large volume of data. Sometimes, the data could be thought about in many different ways at many different levels of analysis, if it is used without any context.

The map in Figure 4.1 and the context show such an example. The map reports the percentage of Latinos by municipality and Chicago community area, 2000. The data in the map could be thought about in different ways at different levels of analysis, if the map is out of its context. To take a few instances, look at the

- high concentrations of Latinos exist in the whole area
- concentration of Latinos in the Chicago downtown is higher than in the suburbs
- concentration of Latinos in the south suburban is lower than in other areas
- certain cities with highest concentrations of Latino
- rate of minority population in some specific cities

However, the textual statement instantly preceding the map, which is shown below, provides important clues to precisely identify the intended plan information it conveys. The context of the map indicates that the intended plan information conveyed by the map is high concentrations of Latinos in the whole area, the first argument mentioned above, instead of focusing on smaller regions or comparisons among different regions.

NIPC forecasts indicate that our region's changing population will affect the demand for housing and transportation in the future. Centers, therefore, should be planned to welcome diversity and plan for the changing demands. The population in centers should be diverse in terms of race, ethnicity, and age.

By 2030, NIPC estimates that the Latino population will almost double to 33 percent of the region's total population; the African American population will decrease to 18 percent; and the remaining population demographics will decrease to 49 percent of the total. Between today and the year 2030, almost all of the

increase in the region's population will be Latino. (2040 Regional Framework Plan made by NIPC, Chapter 3, p. 32)

▼ Figure 8: Percentage of Latino Population as of 2000¹²

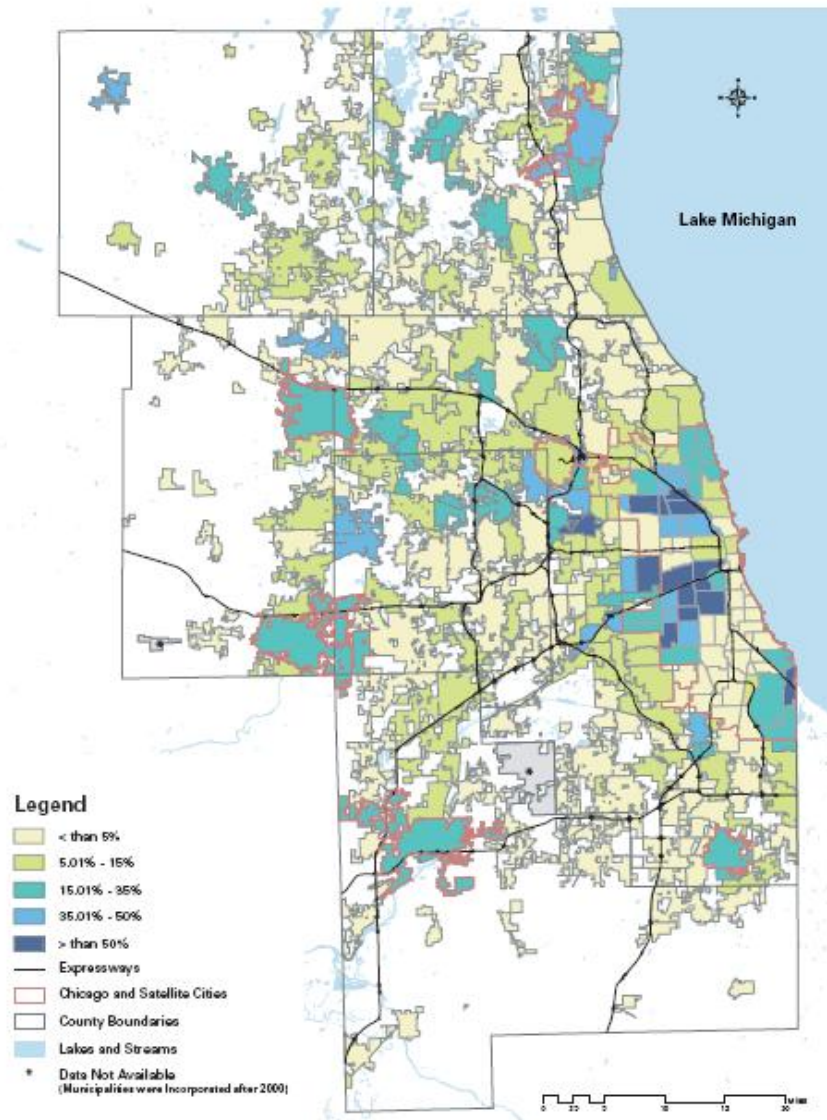
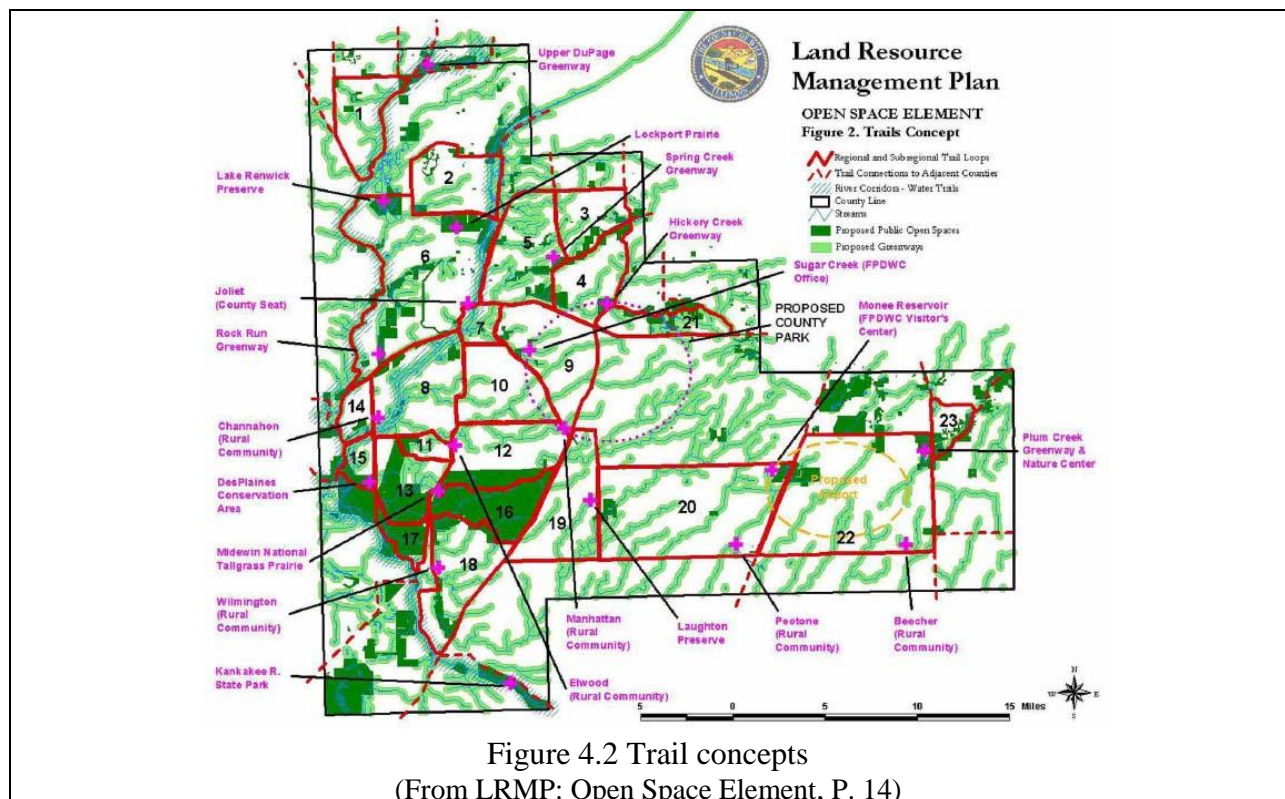


Figure 4.1 Percentage of Latino population as of 2000
(From 2040 Regional Framework Plan, chapter 3, p. 33)

Second, context of a graphic could provide additional explanatory statement for the intended plan information conveyed by the graphic, or the elements included in the graphic. Thus, the intended information and the graphics could be further explored in full details.

The map in Figure 4.2 and the context show such an example. The map presents the trails concept proposed by Will County. The textual statement (*LRMP: Open Space Concept*, p. 9 - 11), which precedes and follows the figure number referring to the map, provides explanation of the trails concept in more details. For instance, the context of the map

- points out two primary issues being addressed in the trails concept “(1) the need for more east-west trail linkages, and (2) the desire for loop trails”;
- identifies three major spines of the trails concept: “the north-south spines include the I&M Heritage Trail and the proposed Wauponsee Glacial Trail; the east-west trail spine is proposed along Peotone-Beecher Road”;
- elucidates positions of each of the twenty-three trail loops presented in the map, for instance, “Naperville Loop (1) – Follows the DuPage River from the DuPage River Park south to Plainfield, then follows the E.J.E. Railroad corridor north to Naperville”;
- and clarifies uses of the trail loops, “The proposed loops should be considered for all appropriate uses such as walking, bicycling, equestrian, and cross-country skiing while taking into consideration issues like terrain, proximity to a large population, habitat preservation, noise, etc.”



4.2 Taxonomy of Graphic Representation

Plan documents include many different types of graphic representations. In the first section, graphics are generally categorized into eight types based on their external characteristics. In the second section, a special kind of graphic “index graphic”, along with its distinguished features, is introduced and defined. Whether a graphic conforms to the definition of “index graphic” also classifies graphics into “index graphic” and “non-index graphic”.

4.2.1 Graphic Types

There are many different graphic representations in different domains (Tufte, 1983, 1990, and 1997). Graphic representations could also be categorized in many different ways for different purposes. For instance, the Getty's Art and Architecture Thesaurus (AAT) categorized graphic document genres into six types: cartographic materials (including maps), charts, diagrams, graphs, prints, and tables (Art and Architecture Thesaurus Online). In contrast, the Library of Congress Thesaurus of Graphic Materials (TGM), which did not specify classifications of graphics, however, defined the same graphic genres in different ways (Thesaurus for Graphic Materials I: Subject Terms (TGM I)). For instance, TGM defined that diagrams include charts and graphs; whereas, AAT defined that diagrams are parallel to charts and graphs. TGM defined that maps include fire insurance maps, plats, and topographic map; whereas, AAT defined that maps are classified by form, function, production method, subject, location, and so on, and maps by forms includes fifteen types of maps, such as cartograms, dot maps, outline maps and topographic maps.

This section focuses on graphics in plan documents. According to their external characteristics, graphic representations are categorized into six major types, two of which are divided into two sub-types (see Figure 4.3). Each of the eight graphic types is defined and illustrated with examples in the following passage. These examples are intended to define and clarify the meaning for each graphic type, which might have some subtle differences from common use of these terms or from other graphic typologies.

The classification of graphics provides a standardized set of vocabulary to describe genres of graphics in plan documents. The classification is essential and significant to promote search efficiency and accuracy. Specifically,

- Most importantly, the classification reduces ambiguity inherent in normal human languages where the same concept can be given different names, and thus facilitates users to search graphics based on predetermined graphic types.
- Using graphic type as indicator, along with other information, such as the intended plan information, plan users can speculate what might be included in a graphic. So they can identify the most pertinent graphics in a long list.
- Users could manually sort a list of graphics retrieved from a query according to their types, when they are interested in some specific graphic types.

In addition, the classification is very important for the research. Specially,

- The classification of graphics sets foundation to later identify “significant” graphic types for each group of intended plan information, which are presented in the Chapter 4.3; and
- The classification helps me to understand various graphic types, so that the proposed PMLGraphics presented in the Chapter 6 is flexible enough to mark up different types of graphics.

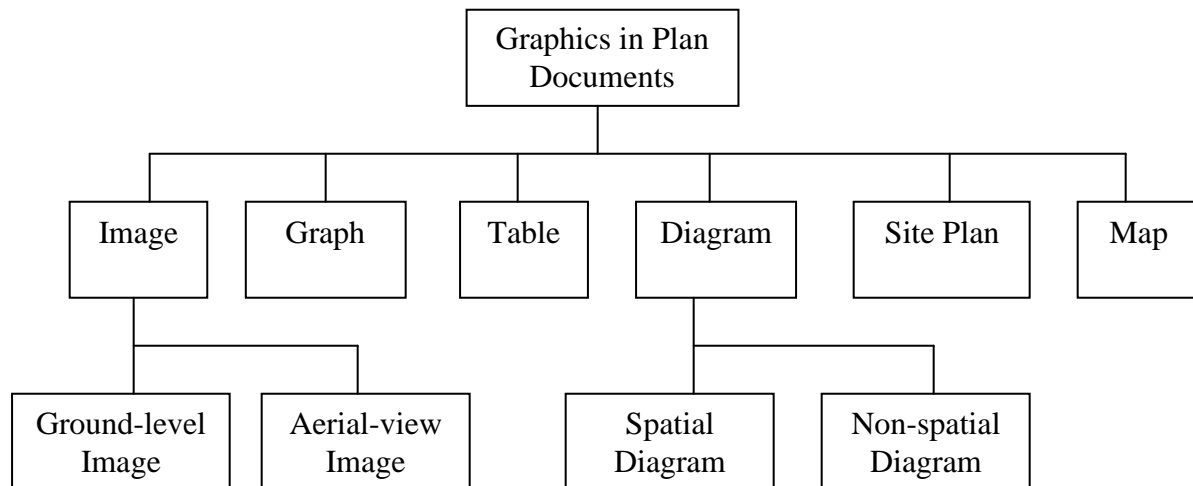


Figure 4.3 Classification of graphic representations in plan documents

Image: Ground-level Image vs. Aerial-view Image

The term image could have multiple meanings in representation: 1) “a likeness or imitation of a person or thing” (e.g. statue) 2) “a picture of an object formed by a device (as a mirror or lens)” 3) “a visual representation of something” 4) “a mental picture or conception: impression, idea, concept” 5) a vivid representation or description (Dictionary and Thesaurus – Merriam-Webster Online). An image as used here refers to a two-dimensional artifact that reproduces the likeness of some subject, usually a physical object or a person. It could be a photograph captured by camera, a picture or a drawing drawn manually, or a digital image rendered by computer. A map, table, graph, or diagram is not included.

Images can be classified into two types with respect to the height of the viewpoint, ground-level image and aerial-view image. A ground-level image shows a view of objects from an observer standing on the ground, or a sketch of objects from a viewpoint that is above the ground. On the other hand, an aerial-view image shows a view of object from above, as though the observer is in an airplane, a bird’s eye perspective. Ground-level image focuses on vertical elements of space because the angle of view is low enough; whereas aerial-view image focuses primarily on horizontal elements and relationships.

Ground-level images as used here include screen snapshots of computer monitor. Aerial-view images as used here include oblique views, drawn from an imagined perspective, as well as aerial photographs and digital orthophoto quadrangles defined by American Planning Association (APA) (2006, p. 529). “Aerial photographs are important tools for planners, designers, developers, and others who need detailed and timely site data” due to its various uses, including providing information on vegetation types, soil conditions, and other features, guiding the creations of sketch maps, serving as tools to study environmental and developmental changes over time, and facilitating the identification of critical and sensitive resources, such as wetlands (American Planning Association, 2006, p. 529).

Figure 4.4 and 4.5 are typical aerial-view images. Figure 4.4 presents Symerton, which is a typical hamlet in Will County, and one of the few hamlets that is incorporated. Figure 4.5 shows

how major centers, corridors, and green areas fit into the regional context of the Chicago area. Figure 4.6 and 4.7 are typical ground-level images. Figure 4.6 is a photograph presenting what urban-style multi-family residential area looks like. Figure 4.7 is a drawing showing the features of campus mixed-use area.



Figure 4.4: A typical “aerial-view image”
(From LRMP: Forms & Concepts Handbook, p. 13)



Figure 4.5: A typical “aerial-view image”
(From 2040 Regional Framework Plan, chapter 2, p.12)



Figure 4.6: A typical “ground-level image”
 (From 2005 Comprehensive Plan for City of
 Urbana, p. 60)



Figure 4.7: A typical “ground-level image”
 (From 2005 Comprehensive Plan for City of
 Urbana, p. 63)

Graph

Graphs are defined by AAT as “representations of any sort of data by means of dots, lines, or bars; usually to illustrate relationships” (Art and Architecture Thesaurus online). Anscombe (1973) and Tufte (1983, 2001) have comprehensively introduced different types of statistical graphs (e.g. pie chart, bar chart, line graph, scatter plot, stem and leaf plot), and how they communicate quantitative information. The following are typical graphs in plan documents. Figure 4.8 shows a bar chart that illustrates the different results in two situations. Figure 4.9 shows a pie chart that illustrates housing mix in Northeastern Illinois in 2000. Figure 4.10 shows a line graph that illustrates age distribution in Northeastern Illinois in 1990, 2000 and 2030.

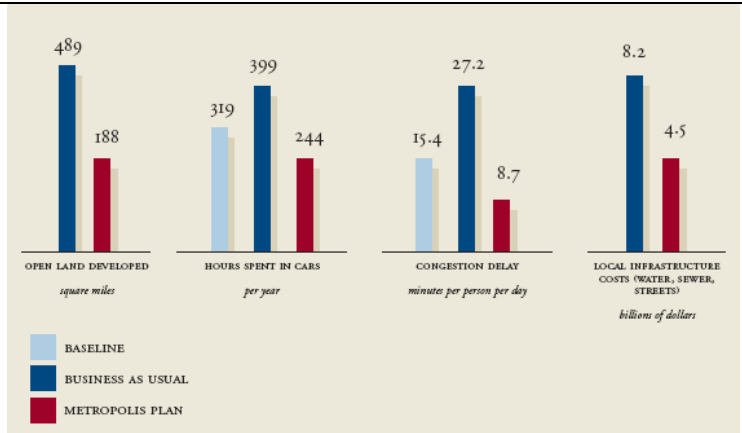


Figure 4.8: A typical bar chart, illustrating the different results caused by metropolis plan and business as usual
 (From The Metropolis Plan: Choices for the Chicago Region, p. 24)

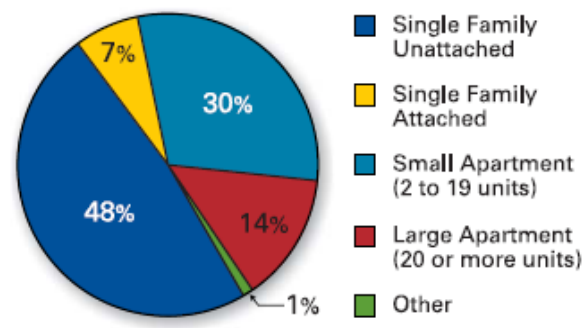


Figure 4.9: A typical bar chart, illustrating housing mix in the northeastern Illinois in 2000
 (From 2040 Regional Framework Plan, chapter 2, p.15)

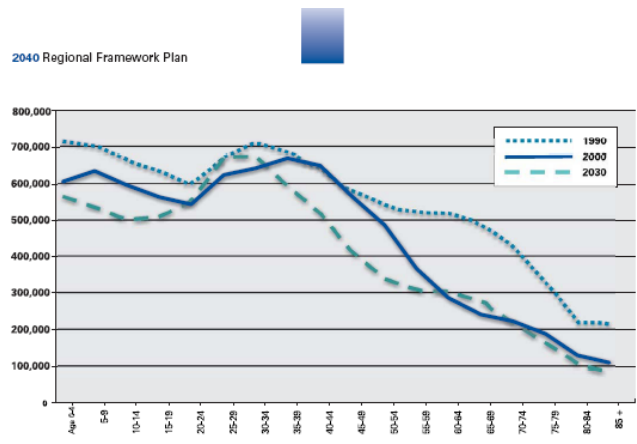


Figure 4.10: A typical line graph, illustrating age distribution in Northeastern Illinois in 1990, 2000 and 2030
 (From 2040 Regional Framework Plan, chapter 7, p. 168)

Table

Tables are defined by AAT as “condensed, orderly arrangements of data, especially those in which the data are arranged in columns and rows” (Art and Architecture Thesaurus online). Rows and columns of a table may be grouped, segmented, or arranged in many different ways, and it can even be nested recursively (Fink, 2005; McNabb, 2002; Morgan et al., 2004).

A “table” could be a simple table or multi-dimensional table (Fink, 2005; McNabb, 2002; Morgan et al., 2004). In the simple table, data is viewed by one dimension, whereas, in the multi-dimensional table, data could be viewed by more than one dimension. Figure 4.11 is a typical simple table. The instance data is organized in one dimension, implementation strategies (including seven items: implementation strategy, type of strategy, related goals / objectives, related maps, timing, responsible city agencies, and other responsible entities). On the contrary, Figure 4.12 is a multi-dimensional table, in which data is arranged in three dimensions: county name (including Cook, DuPage, Kane, Lake, McHenry, and Will), variable of concern (including Jobs, Workers, and Net Jobs), and industry title (including total, agriculture, construction, manufacturing, etc). A multi-dimensional table could be considered as a hypercube, where each dimension (e.g. county name, concerned factor, or industry title) becomes an axis of the hypercube.

A table shares some common attributes with textual information representations. Here, the focus is on the table’s capability of representing relationships between different pieces of textual information, as manifested by multi-dimensional tables. Visualizing the relationships is extremely easy for humans; however, it is difficult, sometimes not feasible, to use textual information to describe it. Thus, table is regarded as a graphic representation and it is treated as a square of information, the essence of which is captured and the internal details of which are purposely ignored.

Implementation Strategy	Type of Strategy	Related Goals / Objectives	Related Maps	Timing	Responsible City Agencies	Other Responsible Entities
Develop a common forum for neighborhood associations to discuss and consider issues facing their neighborhoods. Determine methods for neighborhood associations to have effective input in the decision-making process.	Coordination	I.0; I.1		Ongoing	Community Development	Neighborhood Associations
Develop educational tools and information to allow neighborhood associations to understand and manage common neighborhood issues.	Coordination	I.0; I.1		Short Term	Community Development	Neighborhood Associations
Amend the Urbana Zoning Map where existing zoning is determined to significantly contradict the goals, objectives, and future land use maps of the Comprehensive Plan.	Special Study Council Action	I.0; I.5 4.0; 4.1, 4.3 17.0; 17.1 25.0; 25.1 28.0; 28.1	All Future Land Use Maps	Near Term	Planning Division	
Develop a neighborhood action plan for the "Historic East Urbana" neighborhood. The plan should address issues of zoning inconsistencies, infrastructure improvements and strategies for housing stock improvement.	Special Study Council Action	I.0; I.1, I.2, I.3, I.5 2.0; 2.1, 2.4 12.0; 12.1	IO	Near Term	Community Development; Public Works	"Historic East Urbana" Neighborhood Association (HEUNA)

Figure 4.11: A typical simple table
(From 2005 Comprehensive Plan for City of Urbana, p. 87)

Industry Title	Cook			DuPage			Kane		
	Jobs	Workers	Net Jobs	Jobs	Workers	Net Jobs	Jobs	Workers	Net Jobs
Total	2,947,845	2,421,287	526,558	635,357	476,172	159,185	212,899	196,184	16,715
Agriculture	12,261	2,356	9,905	4,204	800	3,404	2,971	1,196	1,775
Construction	99,212	119,355	(20,143)	34,896	25,308	9,588	10,484	14,549	(4,065)
Manufacturing	395,793	342,422	53,371	81,965	71,402	10,563	41,148	40,752	396
TCU*	220,652	162,465	58,187	41,761	26,374	15,387	6,506	9,661	(3,155)
Trade	585,381	337,050	248,331	166,830	80,708	86,122	41,186	31,905	9,281
FIRE**	232,353	219,831	12,522	39,983	46,314	(6,331)	9,700	13,411	(3,711)
Services	1,242,935	1,144,197	98,738	243,442	214,242	29,200	89,381	79,556	9,825
Government	159,259	93,611	65,648	22,277	11,024	11,253	11,521	5,154	6,367
Industry Title	Lake			McHenry			Will		
	Jobs	Workers	Net Jobs	Jobs	Workers	Net Jobs	Jobs	Workers	Net Jobs
Total	336,893	310,396	26,497	100,985	135,269	(34,284)	157,797	246,431	(88,634)
Agriculture	6,755	930	5,825	2,995	1,289	1,706	4,657	966	3,691
Construction	16,855	19,081	(2,226)	8,449	11,826	(3,377)	13,722	20,209	(6,487)
Manufacturing	57,749	61,291	(3,542)	22,772	28,996	(6,224)	20,252	38,068	(17,816)
TCU	10,684	11,020	(326)	3,201	6,907	(3,706)	10,209	18,441	(8,232)
Trade	83,041	50,982	32,059	21,958	22,295	(337)	35,606	39,950	(4,344)
FIRE	19,651	28,496	(8,845)	2,601	10,756	(8,155)	4,657	19,727	(15,070)
Services	129,946	129,619	(3,673)	33,956	50,039	(16,083)	59,249	100,633	(41,384)
Government	16,204	8,977	7,227	5,054	3,161	1,893	9,446	8,437	1,009

Figure 4.12: A typical multi-dimensional table
(From 2040 Regional Framework Plan, chapter 7, p. 153)

Diagram: Non-spatial Diagram vs. Spatial Diagram

A diagram refers to a simplified and structured graphic design of concepts, ideas, and relationships. The purpose of a diagram is to explain rather than represent pictorially.

Diagrams are subdivided into non-spatial or spatial, depending on whether a diagram depicts geographical information or not. Non-spatial Diagrams as used here include block diagrams, which use “labeled blocks connected by straight lines to represent the relationship of parts or phases”, and Venn diagrams, which are “pictorial representations using circles and squares so positioned as to represent an operation in set theory”, defined in AAT (Art and Architecture Thesaurus online). Figure 4.13, a relational diagram, and Figure 4.14, a flow chart, are two typical examples of non-spatial diagrams. Figure 4.15 is a typical spatial diagram. It compares three scenarios of future development in geographical space – incorporated sensible growth, unincorporated sensible growth, and unplanned sprawl, in order to illustrate the benefits of incorporated sensible growth. Spatial diagrams are different with site plans and maps, two separate graphic types that are introduced below. Spatial diagrams focus on explaining spatial concepts, ideas or relationships but at a higher abstract level; whereas, site plans or maps are intended for visual representation of an area.

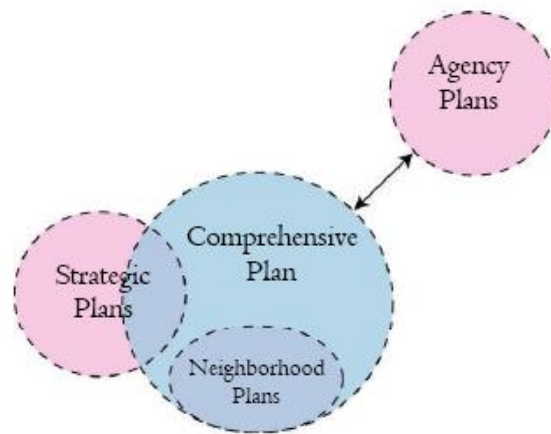
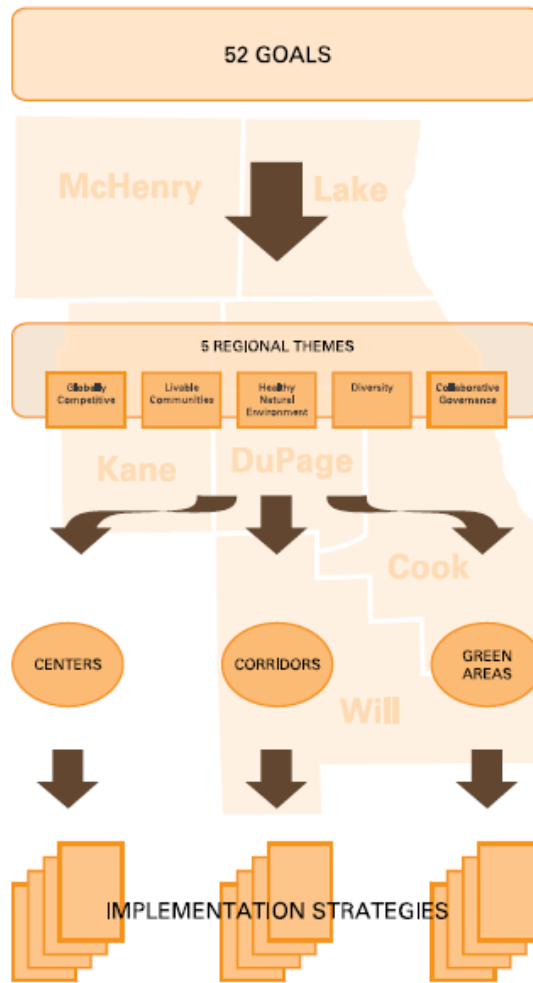


Figure 4.13: A typical non-spatial diagram
(From 2005 Comprehensive Plan for City of Urbana, p. 6)



▲
Figure 2: How Goals Led to Strategies

Figure 4.14: A typical non-spatial diagram
 (From 2040 Regional Framework Plan, chapter 2, p.13)

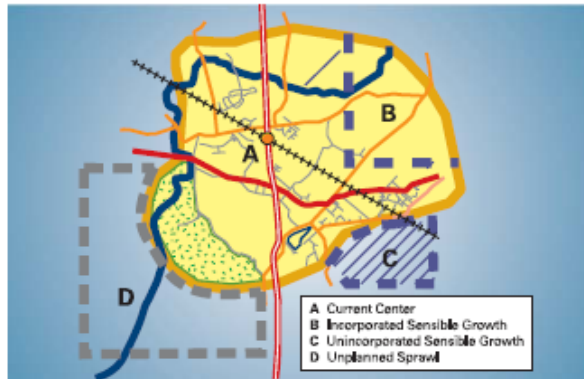


Figure 11: Sensible Growth vs. Sprawl
 Without planning that guides compact growth to sectors B or C, sprawl stretches beyond the incorporated Center to sector D. Illustration by Randi Robin Design

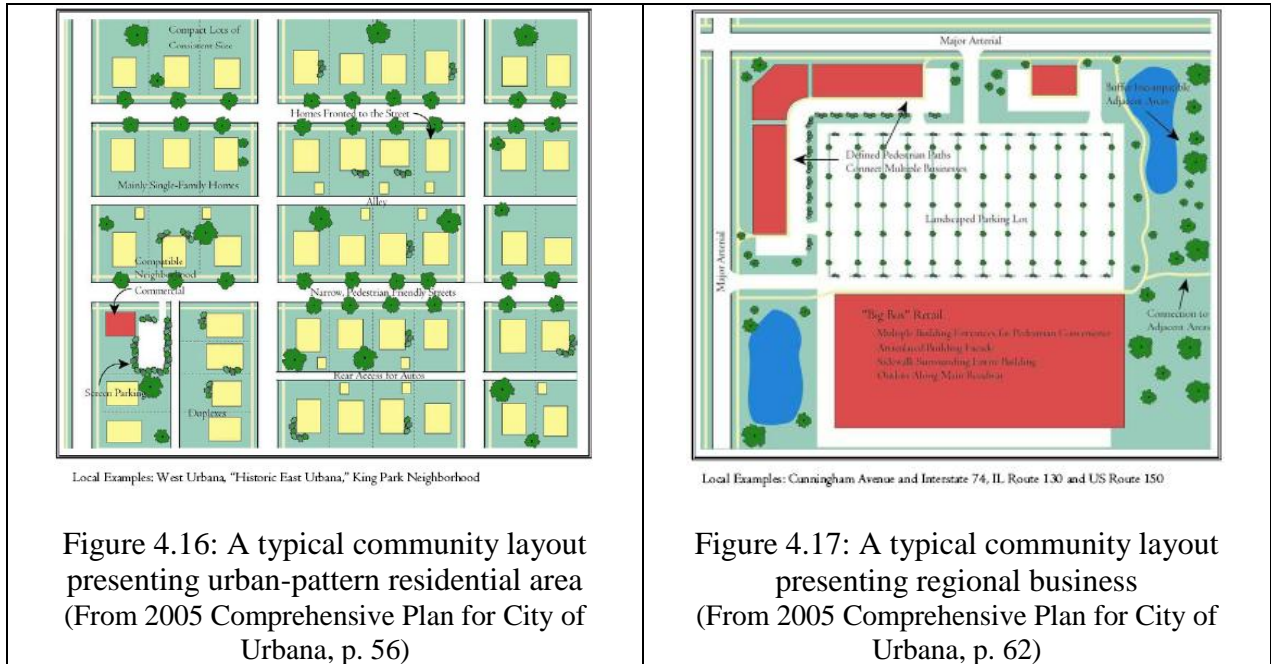
Figure 4.15: A typical spatial diagram
 (From 2040 Regional Framework Plan, chapter 3, p. 43)

Site Plan

Site plans are defined by AAT as follows. “Drawings or works in another medium laying out the precise arrangement of a structure on a plot of land. It may also refer to plans for gardens, groups of buildings, or developments, where the layout of buildings, roadways, utilities, landscape elements, topography, water features, and vegetation may be depicted.” (Art and Architecture Thesaurus online) Site plans include block plans, which are “small-scale, simplified plans of a building or building site, with features or structures indicated by simple outlines or shapes”, grading plans, which are “plans that show the ground surface of a building site or other site, generally including grade elevations and contours”, and landscaping plans, which are “site plans containing landscaping information, such as site grading, and location and description of plantings, sprinklers, or lighting devices” (Art and Architecture Thesaurus online).

The difference of site plans and maps lies in the fact that site plans focus on rather small regions, such as neighborhoods or communities, whereas, maps focus on larger areas, such as cities. Site plans are frequently used in plan documents to portray the characteristics of certain types of land use development. The 2005 comprehensive plan of Urbana uses ten community layouts to

describe ten types of land use patterns, such as urban-pattern residential area (see Figure 4.16), and regional business (see Figure 4.17).



Map

Maps are defined by AAT as “graphic or photogrammetric representations of the Earth's surface or a part of it, including physical features and political boundaries, where each point corresponds to a geographical or celestial position according to a definite scale or projection” (Art and Architecture Thesaurus online). Maps are also symbolized depictions of space that highlight relations between components (e.g. objects, regions, themes) of that space (Buisseret, 1992; O'Connor & Robertson, 2002; Cosgrove, 1999). In planning domain, “maps are a representation of a place at a particular point in time to convey particular ideas or pieces of information” (American Planning Association, 2006, p. 527). Maps are typically depicted on a flat medium, such as on paper, a wall, or a computer screen. Typical elements in a map include title, map legend or key used to identify map features, north arrow, scale, and labels, either by kind of item, name, or attribute (American Planning Association, 2006). As we have discussed before, a map differs from a spatial diagram as the former focuses on visual representation of an area in use of

a direct geographical projection and the latter concentrates on explaining abstract spatial relationships imposed on a geographical representation.

APA (2006) stated that “maps are a fundamental source of information for planning and design activities” (p. 527). In my view, map perhaps is the most important graphic type in plan documents. This is due to the following two reasons. First, map in nature works very well at presenting geographical information that is essential and indispensable in plans. Hopkins (2001) stated, “Plans address spatial phenomena” (p. 41). Second, it is perceived that map is the most frequently used graphic types in plan documents.

Maps in plan documents could be varied in many aspects, such as appearance and accuracy.

From the perspective of appearance, a map could be very simple or rather complex. A simple map consists of basic visual elements such as points, lines, polygons, and easy-to-read legends, just like an ordinary map in our daily life. The typical examples are shown in Figure 4.18, which illustrates existing land use of City of Urbana, and Figure 4.19, which illustrates locations of centers in the Northeastern Illinois. On the other hand, a map could be rather complex and planning oriented. It may consist of unusual visual elements (e.g. irregular legends, and planning specific labels), in addition to the basic ones in a simple map. The typical example is Figure 4.20, which illustrates future land use in the area of the High Cross Road Corridor in Urbana, Illinois. This figure includes lots of annotations that highlight related issues and policies for certain types of land use development, arrows for pre-determined locations of roadway extension, and triangles for directions and approximate locations of roadway extension. Figure 4.21, which illustrates existing and planned road network for the City of Urbana, is another example of complex map.

Most of the maps, such as Figure 4.18, 4.19, 4.20, and 4.21, are geometrically accurate representation of a space. However, a few maps are approximate representation of a world, for instance, sketch maps drawn on paper or computer interface. Figure 4.22, originally used in community planning meeting in Phoenix, Arizona, is a typical sketch map.

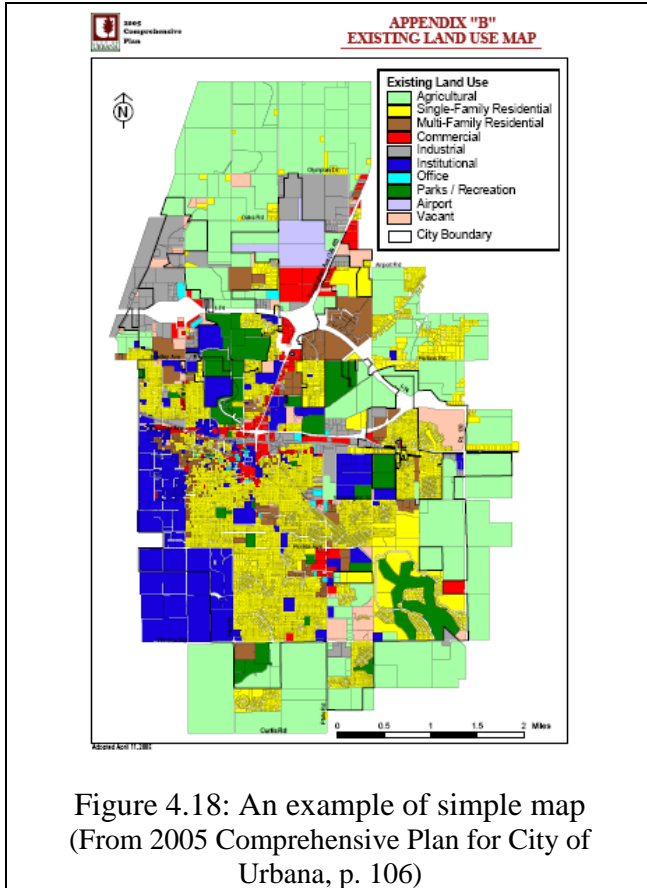


Figure 4.18: An example of simple map (From 2005 Comprehensive Plan for City of Urbana, p. 106)

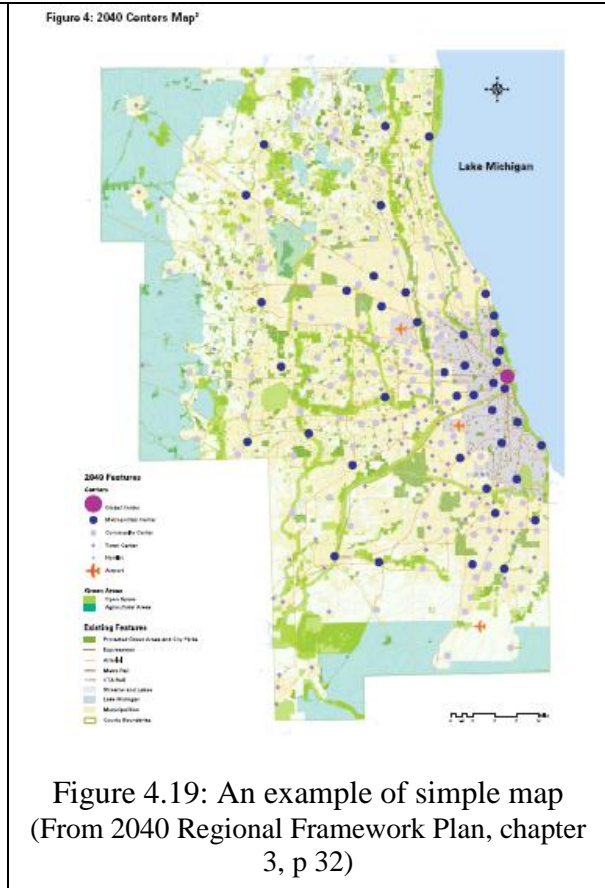
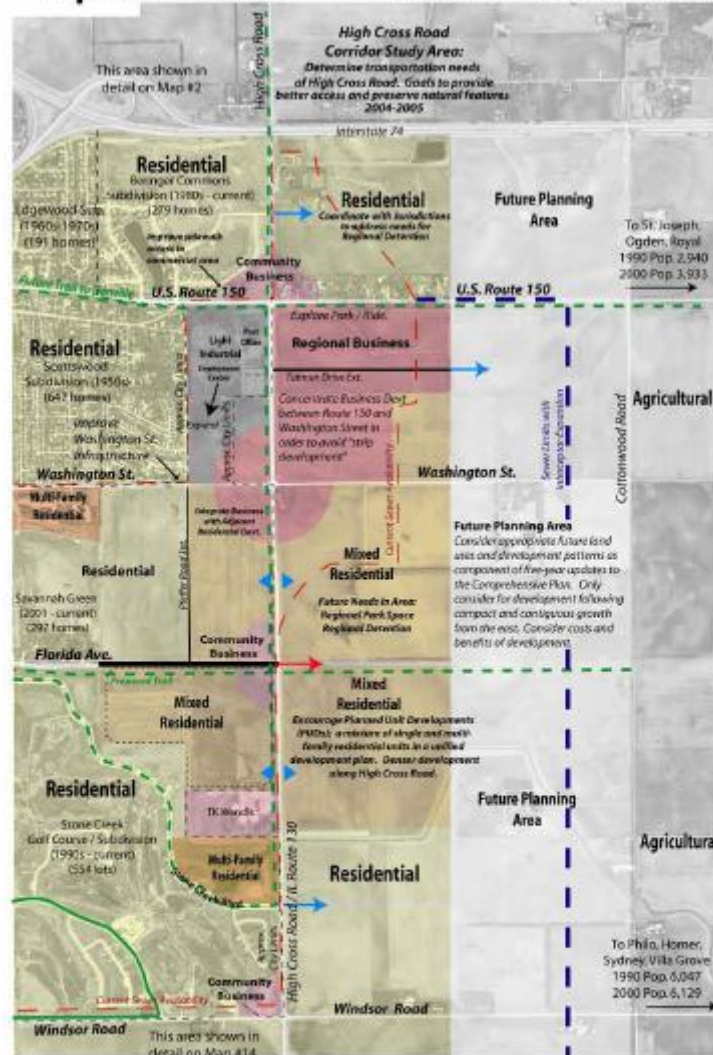


Figure 4.19: An example of simple map (From 2040 Regional Framework Plan, chapter 3, p 32)

Map #7 High Cross Road Corridor



ADOPTED

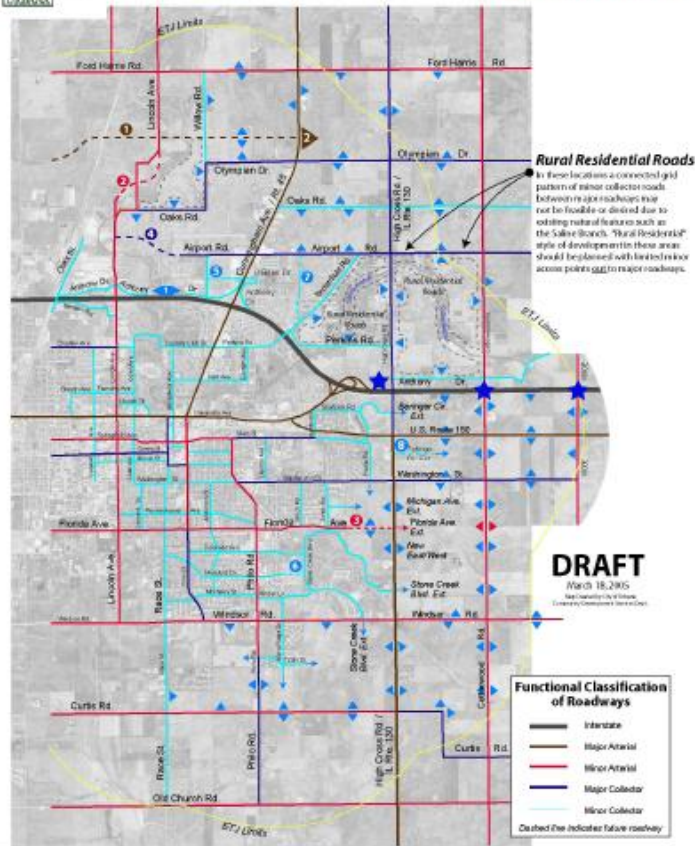
April 11, 2005
 Urban Planning and Development
 Community Development and Services Dept.

Access Management on High Cross Road

- Direction and approximate location:**
 The exact location of markings and/or right-of-way dedication depends on a variety of factors.
- Pre-determined location for retention:**
 The location of markings and/or right-of-way dedications known through further study is required to determine the final design.

Note: See Appendix "D" Liability Map.

Figure 4.20: A example of complex map, which shows the future land use in the area of the High Cross Road Corridor in Urbana, Illinois (From 2005 Comprehensive Plan for City of Urbana, p. 77)



Planned Roadway Extensions
Connections have been determined and planned for accordingly.

- 1 Olympian Drive relocation and extension west from U.S. Route 45
- 2 Lincoln Avenue aligned north between Oaks Road and Olympian Drive
- 3 Florida Avenue extended east to High Cross Road
- 4 Airport Road extended to Lincoln Avenue
- 5 Olympian Drive extended to Willow Road
- 6 Wards Drive extended to Stone Creek Boulevard
- 7 Mary's South Collector between Brownfield Road and Airport Road
- 8 Taitan Drive extended east from High Cross Road

Potential Projects
Projects identified as needing additional study to determine design, location, and function.

- Arbitrary Drive connection between Lincoln Avenue and Willow Road
 - Olympian Drive termination at U.S. Route 45 in conjunction to High Cross Road
 - Interstate 24 interchange alternatives when needed as I-55 to grow east, High Cross Road, Cottonwood Road, 1800E.
- Consideration of interchange alternatives to include:
- * Rural Residential Development Area
 - * Ecological Areas
 - * Horizontal and vertical alignment of intersecting roads
 - * Desired land use patterns

Extending the Grid System

Extending a consistent system of collector and arterial roadways is critical to ensure adequate facilities are constructed in tandem with development. The map indicates general locations where the system shall be extended. The map identifies two different types of grid extension symbols:

- **Alternative and opposite locations.** The road location to be extended and right-of-way dedication shall be determined, depending on project funding but not limited to proposed development plans, natural resources, and safety needs.
- **Pre-determined location for a road.** The desired location of road extension right-of-way dedication known through further study is required to determine the final design.

Figure 4.21: A example of complex map, illustrates the existing and planned road network for the City of Urbana (From 2005 Comprehensive Plan for City of Urbana, p. 108)

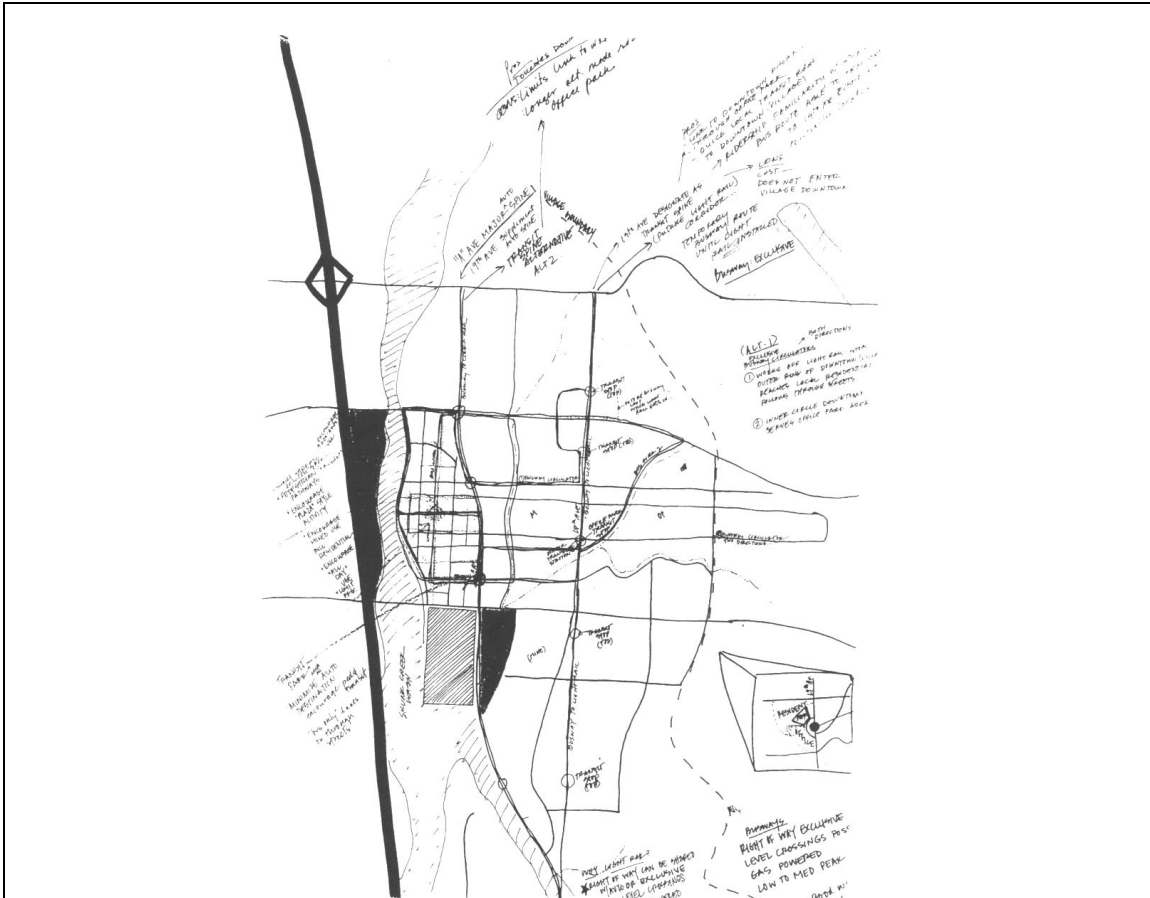


Figure 10-5
 Sketch map from community planning meeting in Phoenix, Arizona

Figure 4.22: A typical sketch map, used in community planning meeting in Phoenix, Arizona
 (From Hopkins, 2001, p. 245)

4.2.2 Index Graphic

In plan documents, there are some special graphics that include or arrange a set of plan concepts, which are defined and explained in details elsewhere. In other words, this kind of graphic, which is similar to a table of contents of a book, arranges a gathering of index terms that direct readers to different plan content located elsewhere in the same document. This type of graphics is coined as “index graphic”. An index graphic generally has three features that distinguish it from a non-index graphic:

- An index graphic provides an easy-to-read framework to organize and relate the crucial plan concepts together;
- The explanation content that explains index terms of an index graphic requires more space than can be incorporated into a single graphic or a single page; and
- The index terms are important plan concepts or issues that require thorough elaboration and detailed illustration.

Accordingly, the PMLGraphics proposed in Chapter six is designed to be able to mark up an index graphic in a way that facilitates plan users to easily navigate the detailed explanations of index terms whenever they navigate the index graphic.

Figure 4.23 and 4.24 are examples of index graphic. Figure 4.23 presents a flow from goals to five regional themes, to three development elements, and finally to implementation strategies. The illustrations of the five regional themes, three development elements, and implementation strategies are scattered somewhere else in the document, and occupy around 160 pages. Specifically, the five regional themes, including livable communities, diversity, natural environment, global competitiveness, and collaborative governance, are illustrated from pages 13 to 18, chapter two. The three development elements, including centers, corridors, and green areas are illustrated by the whole chapter three, from pages 21 to 82. The implementation strategies are illustrated by the whole chapter, from pages 142 to 238. Obviously, Figure 4.23 provides an easy-to-read framework that organizes the different plan content in different chapters together.

The table in Figure 4.24 illustrates the application of the individual Development Use Concepts in each of the defined Development Forms. The index terms include eight development forms (e.g. rural, hamlet, town, urban community, and suburban community) and eleven development concepts (e.g. agricultural, conservation design, conventional residential suburban, and traditional residential), which are also the most essential plan concepts in the plan document. They direct the reader—the plan user—to the corresponding plan content located after the graphic. For instance, rural development form directs user to the plan content from pages 10 to 12, and agricultural development concept refers to the plan content from pages 34 to 35. The content for illustrating the index terms is fifty pages in length, from pages 10 to 60.



Figure 4.23 A typical index graphic
 (Full-size diagram refers to Figure 4.14)
 (From 2040 Regional Framework Plan, chapter 2, p.13)

		Development Forms							
Development Use Concepts		RURAL Pg. 10-12	HAMLET Pg. 13-14	TOWN Pg. 15-16	URBAN COMMUNITY Pg. 19-22	SUBURBAN COMMUNITY Pg. 23-26	INTERSTATE ACCESS LOCATION Pg. 27-28	FORMER JOAAP Pg. 29-30	SSA Pg. 31-33
	AGRICULTURAL Pages 34-35	•	•						•
	CONSERVATION DESIGN Pages 36-39	•		•					
	CONVENTIONAL RESIDENTIAL SUBURBAN Pages 40-42			•		•			
	TRADITIONAL RESIDENTIAL Pages 43-45		•	•	•	•			
	MULTI-FAMILY COMPLEX Pages 46-47			•	•	•	•		•
	EMPLOYMENT CAMPUS Pages 48-50			•	•	•	•	•	•
	REGIONAL COMMERCIAL Pages 51-53				•		•		
	MID-SCALE COMMERCIAL Page 54			•	•	•			•
	NEIGHBORHOOD COMMERCIAL Pages 55-56	•	•	•	•	•			•
	FREESTANDING INDUSTRY & OFFICE Pages 57-58		•	•	•	•		•	
	PROJECTS OF REGIONAL IMPACT Pages 59-60			•	•	•	•	•	•

This Table illustrates the application of the individual Development Use Concepts in each of the defined Development Forms. Each Form and Use Concept is accompanied by an abbreviated version of this table specific to each.

Figure 4.24: A typical index graphic
 (From LRMP: Forms and Concepts Handbook, p. 27)

4.3 Plan Information Conveyed by Graphics

In a plan document, each graphic representation has its purpose. It intended to present a piece of plan information. The plan information could focus on many different topics, such as current situation, proposed future situation, and implementation strategies. It could also be related to many different aspects, such as land use, transportation development, and infrastructure development.

To search for intended plan information of graphics, plan users could conduct a free-styled keywords search by inputting any terms. However, different people, including plan users and encoders, could use many different ways to describe a concept. Thus, guess work is not- avoided and searching efficiency can not be predicted. To alleviate the problem, a controlled vocabulary is needed for describing intended plan information conveyed by graphics. Using a controlled vocabulary of plan information can definitely promote search accuracy and efficiency. The biggest advantage of using controlled vocabulary is that once a user finds the correct term to describe the plan information, most of the graphics needed are retrieved, saving the time of having to search under all of the other synonyms for that term. Besides, using the vocabulary of plan information as an indicator, plan users can easily guess content of a graphic, and thus identify the most relevant graphics in a list. Or, they can manually sort the retrieval items according to their intended plan information.

Thus, according to their content, the intended plan information conveyed by graphics is categorized into five groups:

- Planning Process,
- Current Situation, Issue and Trend,
- Goals and Desired Future,
- Implementation, and
- Others.

The classification of plan information is not exclusive. That is to say, the plan information conveyed by a graphic could simultaneously belong to more than one group. For instance, plan information could be in “Goals and Desired Future” and “Implementation” at the same time. Such instances are presented when the “Implementation” is illustrated.

“Planning process” presents the information about how a plan is created or the procedure of making a plan. “Current situation, issue and trend” presents the information regarding background of a region, or development issues and trends to be addressed. “Goals and Desired Future” presents the goals or the desired future of an area. “Implementation” presents how to achieve the proposed goals and future in practice. The latter two types of plan information are normally the information plan users need most. Because they are used to “guide public and private actions that affect the future”, and “provide decision makers with the information they need to make informed decisions affecting the long-range social, economic, and physical growth of a community”, both of which are main purposes of a plan (American Planning Association, 2006, p. 3).

Thus, the two underlined types of information, “Goals and Desired Future” and “Implementation”, are explored further. They normally include information in the following six aspects:

- Land Use

The land-use information shows the general distribution, location, and characteristics of land uses and urban form, for instance, zoning and different development patterns (e.g. agricultural, residential, commercial, industry and office).

- Transportation

The transportation information commonly addresses traffic circulation, transit, bicycle routes, ports, airports, railways, recreation routes, pedestrian movement, and parking.

- Infrastructure

The infrastructure information refers to the basic facilities, services and installations needed for the functioning of a community or society, such as sewers, wireless network, public facilities (e.g. airports, schools, post offices, and hospital). The roadways and open space are not included, since they are categorized into “transportation” and “environmental preservation” respectively.

- Environmental preservation

The environmental preservation information refers to parks, open space preservation, habitat, and wildlife preservation.

- Cultural Preservation

The cultural preservation refers to the act of maintaining physical artifacts and intangible attributes of a group or society that are inherited from past generations, maintained in the present and bestowed for the benefits of future generations. Physical or tangible cultural heritage includes buildings and historic places, monuments, artifacts, etc. Intangible cultural preservation includes “social values and traditions, customs and practices, aesthetic and spiritual beliefs, artistic expression, language and other aspects of human activity” (Czepczyński, 2008, p. 54).

- Others

It refers to the information that can not be categorized into the five aspects above.

The category of the six aspects is not exclusive. That is to say, sometimes a piece of plan information could be related to two or more aspects at the same time. Examples are shown in the illustrations of “goals and desired future” and “implementation”.

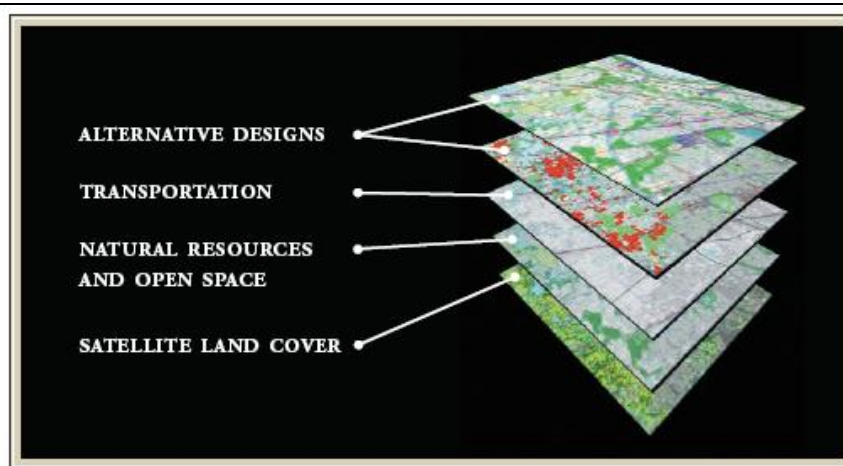
In the following passage, each of the five types of information, “planning process”, “current situation, issue and trend”, “goals and desired future”, “implementation”, and “others”, is elaborated with concrete examples. The examples in “goals and desired future” and “implementation” are also identified with aspects.

The examples of each group are deliberately chosen to include graphics in a variety of types in order to reveal how different types of graphics present each type of information. At the end of the section, graphic types important for each type of information are summarized.

Planning Process

“Planning process” refers to the information related to the procedure of making the plan, for instance, stakeholder or public involvement process, and analysis or visualization tools used to produce plans, or the information about how the planning process is initiated and carried out,.

Below are three typical examples of graphics presenting planning process (see Figure 4.25, Figure 4.26 and Figure 4.27), which involves two graphic types, non-spatial diagram and ground-level image. In Figure 4.25, a non-geographical diagram presents the process of creating two scenarios, “Business As Usual” and “The Metropolis Plan”, which are created by overlaying multiple layers of data. In Figure 4.26, the non-spatial diagram, which is also a flow chart, shows planning process of how regional goals blend into themes and implementation strategies. “Flow charts are often used to illustrate the sequence” [of how the planning is initiated and carried out] (American Planning Association, 2006, p. 16). In Figure 4.27, a ground-level image presents participants’ collaboration in the planning process by using a set of decision-support tools such as facilitated discussion, networked computers, and keypad polling.



The scenarios were created using multiple layers of data.

Figure 4.25: The non-spatial diagram presents the process for creating two scenarios, “Business As Usual” and “The Metropolis Plan”, which were created by overlaying multiple layers of data.

(From Metropolitan Plan: Choices for the Chicago Region, p. 7)

▼ Figure 1: How Regional Goals Blend into Themes and Implementation Strategies

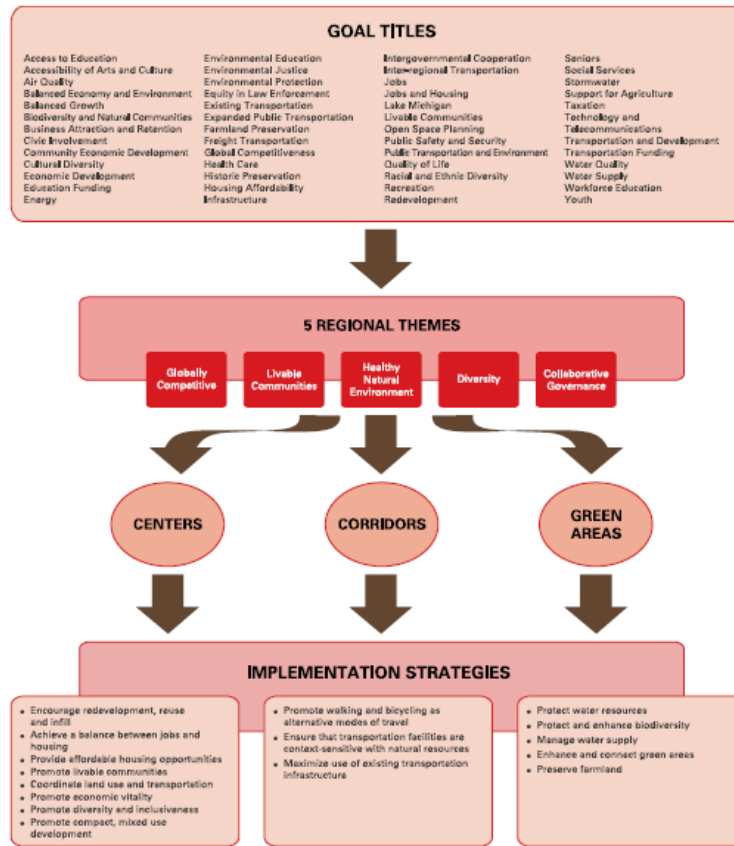


Figure 4.26 The non-spatial diagram, which is also a flow chart, shows planning process of how regional goals blend into themes and implementation strategies. (From 2040 Regional Framework Plan, chapter 4, p. 97)



▲ Participants in the Common Ground process collaborated using a set of decision-support tools such as facilitated discussion, networked computers, and keypad polling.

Figure 4.27 The ground-level image illustrates participants' collaboration in the planning process by using a set of decision-support tools. (From 2040 Regional Framework Plan, chapter 4, p. 92)

Current Situation, Issue and Trend

“Current situation, issue and trend” refers to a description of existing conditions and characteristics of an area, analysis of internal and external trends and forces to be addressed in a plan, or a statement of the major opportunities, problems, advantages, and disadvantages for growth and decline.

Below are six typical examples of graphics presenting current situation, issue, and trend (see Figure 4.28, 4.29, 4.30, 4.31, 4.32 and 4.33), which involve five graphic types – map, spatial diagram, graph, table, and ground-level image.

In Figure 4.28, a map identifies the current land use in City of Urbana. In Figure 4.29, a map presents the crucial development trends and issues in City of Urbana. In Figure 4.30, a spatial diagram illustrates a development issue, “trip chaining” phenomenon and its effects on traffic -- multi-destination local trips tend to occur around or during rush hour, contributing to traffic congestion. In Figure 4.31, a graph shows the increase in population over the past 60 years, and identifies the trend of population growth that had been slowing down in Urbana especially from 1990 to 2000. In Figure 4.32, a table reports the number of employees hired by Urbana’s major employers and reflects the current situation of economic development in City of Urbana. In Figure 4.33, a ground-level image illustrates that a system of well connected pedestrian and bicycle pathways is maintained in City of Urbana.

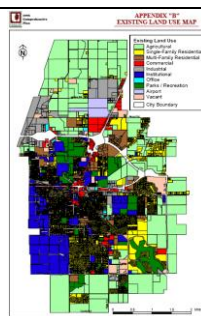


Figure 4.28: The map identifies the current land use in City of Urbana.

(Full-size map refer to [Figure 4.18](#))

(From 2005 Comprehensive Plan for City of Urbana, p. 106)

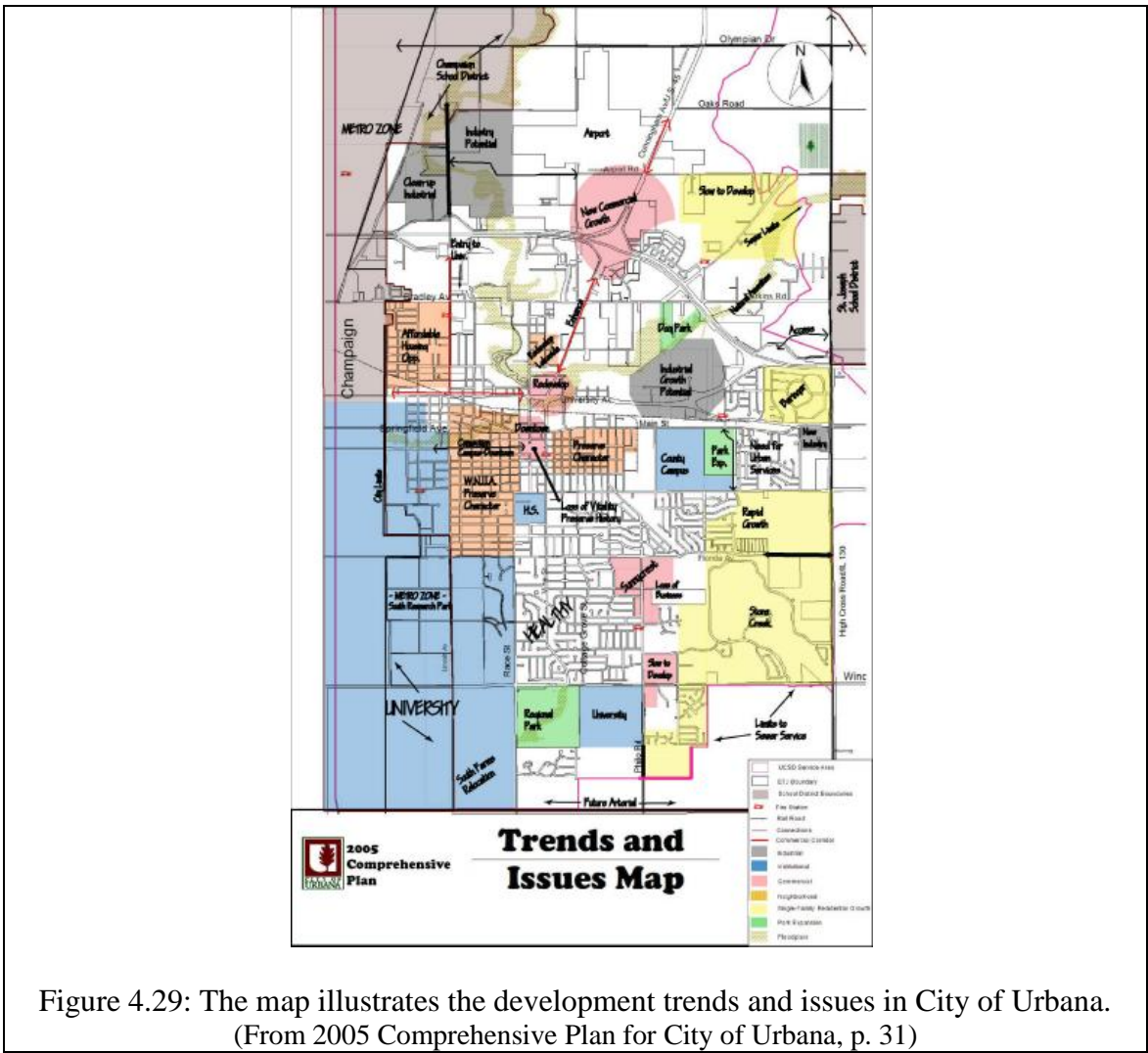


Figure 4.29: The map illustrates the development trends and issues in City of Urbana. (From 2005 Comprehensive Plan for City of Urbana, p. 31)



Figure 13: The 'Trip Chaining' Phenomenon
Multi-destination local trips tend to occur around or during rush hour, contributing to traffic congestion.
Illustration by Randi Robin Design

Figure 4.30: The spatial-diagram illustrates the “trip chaining” phenomenon and its effects on traffic.
 (From 2040 Regional Framework Plan, Chapter 3, p. 44)

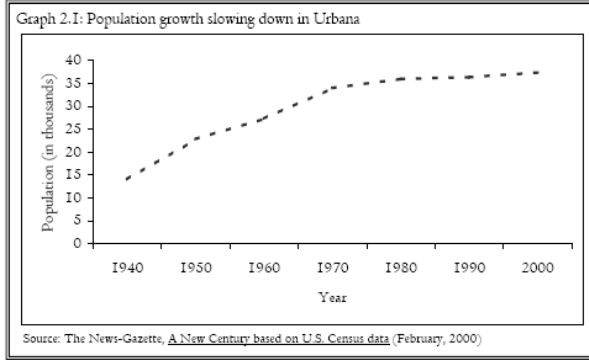


Figure 4.31: The statistical graph shows the increase in population over the past 60 years, and identifies the trend of population growth slowing down in Urbana especially from 1990 to 2000.
 (From 2005 Comprehensive Plan for City of Urbana, p. 13)

Table 2.3: Urbana's Major Employers

	Employees
University of Illinois	20,571
Carle Clinic	2,918
Carle Foundation	2,100
Provena Covenant	1,200
Urbana School District	887
Solo Cup	700
SuperValu Food Distributors	625
Flex-N-Gate	425
Busey Bank	425

Source: City of Urbana website, 9/15/2004

Figure 4.32: The table reports the number of employees hired by Urbana’s major employers and reflects the current situation of economic development in City of Urbana.
 (From 2005 Comprehensive Plan for City of Urbana, p. 16)



Figure 4.33: The ground-level image illustrates that a system of well connected pedestrian and bicycle pathways is maintained in the City of Urbana.
 (From 2005 Comprehensive Plan for City of Urbana, p. 18)

Goals and Desired Future

“Goals and desired future” refers to a formal description of what the area wants to become, including broad goals, objectives that are used for measuring broad goals, and a narrative of the future status of the area. The information could work as, however is not limited to, a vision that is “an image of what could be” (Hopkins, 2001, p. 38). “Visions work by changing beliefs about how the world works (beliefs about the relationships between actions and outcomes), beliefs about intersubjective norms (peer group attitudes about good behaviors), or beliefs about the likelihood of success (raising aspirations or motivating effort)” (Hopkins, 2001, p. 38). The “goals and desired future” include information of the six aspects, which have been introduced before – “land use”, “transportation”, “infrastructure”, “environmental preservation”, “heritage preservation”, and “others”.

Below are the four typical examples of graphics presenting goals and desired future (refer to Figure 4.34, 4.35, 4.36, and 4.37), which involves four graphic types – map, aerial-view image, spatial-diagram, and graph.

In Figure 4.34, a map provides a vision of northeastern Illinois, in which the proposed centers, corridors and green areas in different levels integrate together to set the frame for the future. The desired future conveyed by the map is in three aspects: “land use”, “transportation”, and “environmental preservation”. In Figure 4.35, an aerial-view image provides a vision of northeastern Illinois in 2040 by showing how major centers, corridors, and green areas generally fit into the regional context. The desired future conveyed by the image is related to “land use”, “transportation”, and “environmental preservation”. In Figure 4.36, a spatial-diagram contrasts the anticipated futures in three different strategies, which are “incorporated sensible growth”, “unincorporated sensible growth”, and “unplanned sprawl”, in order to highlight the benefits if the “incorporated sensible growth” is applied. In Figure 4.37, a graph compares the proposed outcomes by 2030 under two different scenarios, which are “Business As Usual” and “The Metropolis Plan”, in order to highlight the benefits if the Metropolis plan is applied. “Business As Usual” reflects what has happened in our region over the last 10 years, and “The Metropolis

Plan” reflects the principles and preferences that planners elicited from residents. The information is related to three aspects: “environmental preservation”, “transportation”, and “infrastructure”.

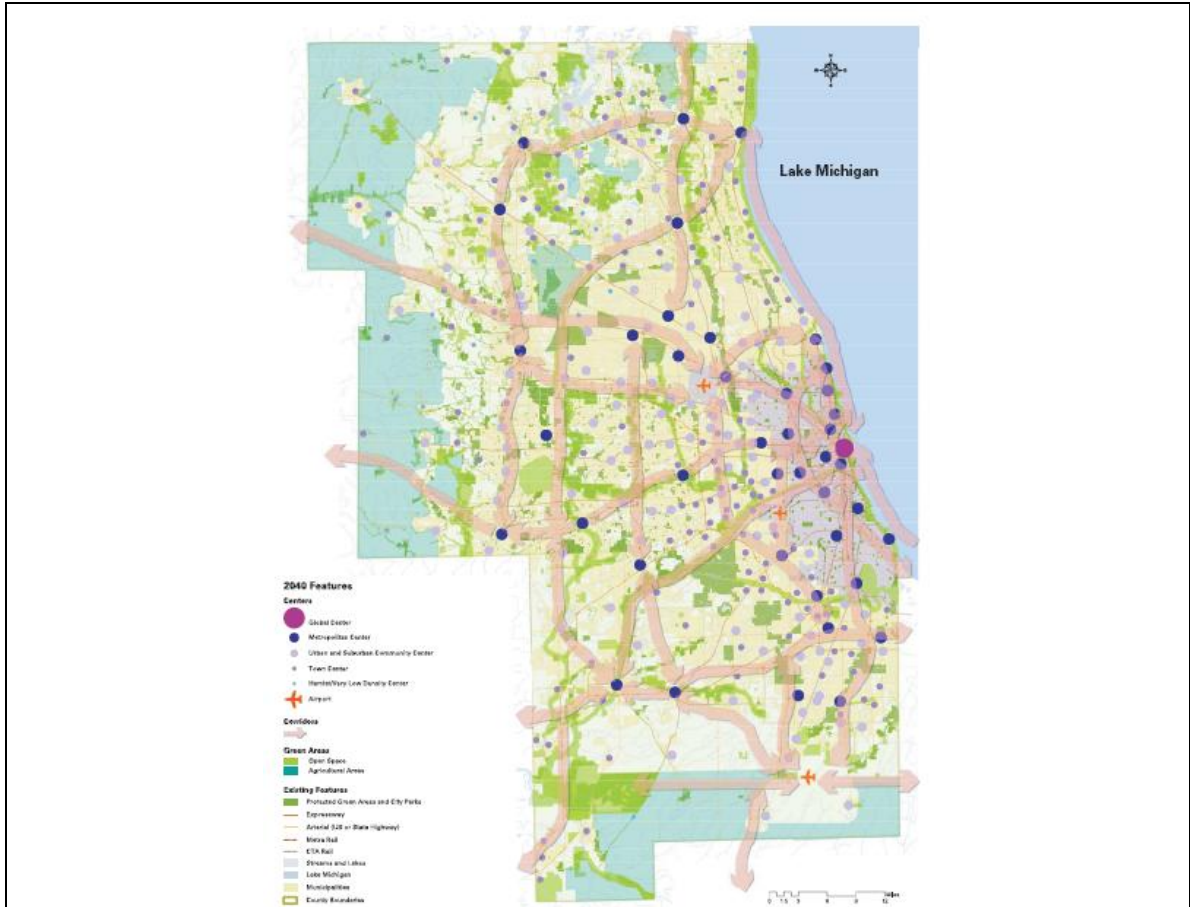


Figure 4.34: The map, titled as “2040 regional framework map”, provides a vision of northeastern Illinois. The desired future is related to “land use”, “transportation”, and “environmental preservation”.

(From 2040 Regional Framework Plan, Chapter 3, p. 23)

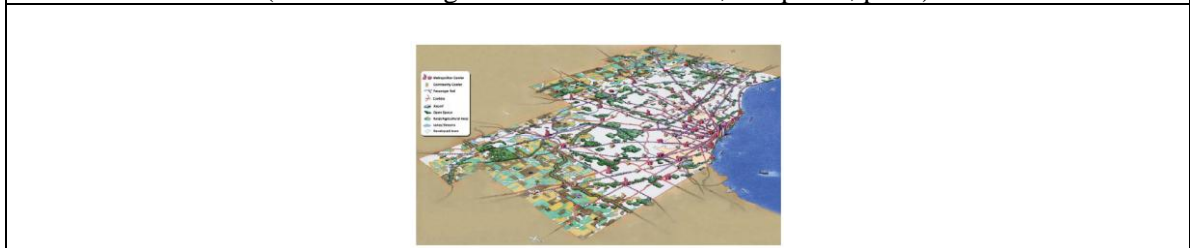


Figure 1: Regional Vision for 2040
The illustration shows how major centers, corridors, and green areas generally fit into the regional context.

Figure 4.35: The aerial-view image provides a vision of northeastern Illinois in 2040. The desired future is related to “land use”, “transportation”, and “environmental preservation”.

(Full-size image refers to [Figure 4.5](#))

(From 2040 Regional Framework Plan, Chapter 2, p. 12)

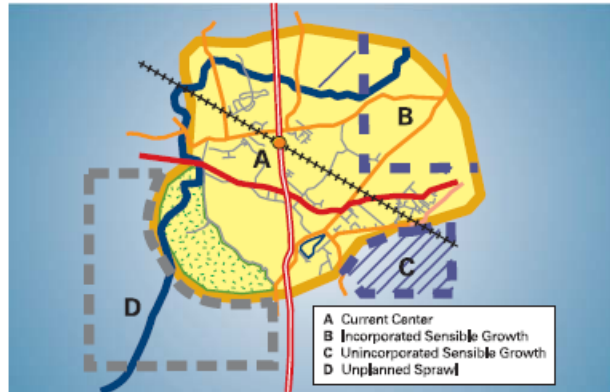


Figure 11: Sensible Growth vs. Sprawl

Without planning that guides compact growth to sectors B or C, sprawl stretches beyond the incorporated Center to sector D. Illustration by Randi Robin Design

Figure 4.36: The spatial-diagram contrasts the anticipated futures in three different strategies -- incorporated sensible growth, unincorporated sensible growth, and unplanned sprawl, in order to highlight the benefits if the incorporated sensible growth is applied. (From 2040 Regional Framework Plan, Chapter 3, p. 43)

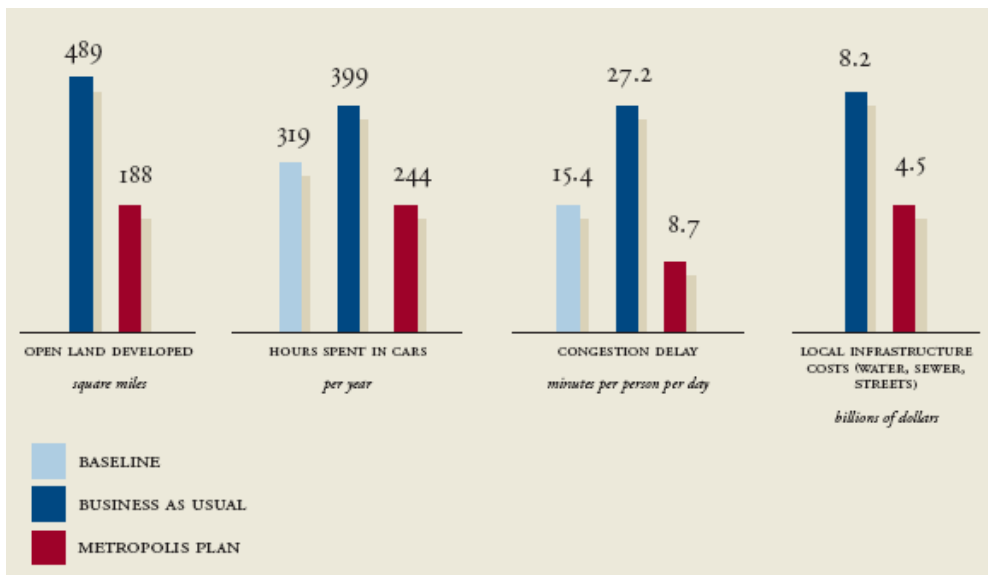


Figure 4.37. The graph compares the proposed outcomes by 2030 under two different scenarios, which are “Business As Usual” and “The Metropolis Plan”, in order to highlight the benefits if the Metropolis plan is applied. The information is related to three aspects, “environmental preservation”, “transportation”, and “infrastructure”. (From The Metropolis Plan: Choices for the Chicago Region, p. 24)

Implementation

“Implementation” refers to the information describing the implementation process to realize the goals and visions proposed in a plan. The implementation information could be presented in many different forms, including regulations and investments to achieve goals, as well as four ways in which a plan works: “agenda” that identifies a list of actions to do, “strategy” that is “contingent actions” or “a contingent path through a decision tree”, “policy” that is “an if-then rule for actions”, and “design” that is “a fully worked out outcome” from relationships among actors, actions, assets, and activities (Hopkins, 2001, p. 38-39). Implementation includes information of the six aspects that have been introduced before – “land use”, “transportation”, “infrastructure”, “environmental preservation”, “heritage preservation”, and “others”.

The following are the seven typical examples of graphics presenting implementation (refer to Figure 4.38, 4.39, 4.40, 4.41, 4.42, 4.43 and 4.44), which involves five graphic types – map, non-spatial diagram, ground-level image, site plan, and table.

In Figure 4.38, a map works as an agenda by listing three types of proposed roadway projects -- planned roadway extensions, potential projects, and extending the grid system. The information presented by the map is related to “transportation” development. In Figure 4.39, a map serves as a policy guideline of land resources management in Northeastern Illinois by identifying various development forms that should be developed in different areas. The info presented by the map is related to “land use”. In Figure 4.40, a non-spatial diagram serves as a policy guide to assist various staff and commissioners throughout the county as they review development proposals to improve the overall quality of growth in the fulfillment of the goals. The information is related to “land use”. In Figure 4.41, a group of small-size ground-level images portray different scenarios for the same corner in different land uses, in order to illustrate a design of how to help communities build more walkable neighborhoods and business districts in the Metropolis Plan. The information is related to “land use”. In Figure 4.42, a non-spatial diagram illustrates a model for implementation: the argument is that initiatives beginning at the local or regional level come together in investments. It is related to “land use”. In Figure 4.43, a site plan illustrates essential features of a rural-residential area, and works as a policy or design to develop the rural

residential area. The information is related to “land use” development. In Figure 4.44, a table illustrates the application of the individual development use concepts in each of the defined development forms, so that it provides a policy to control land use development in the region. The information, again, is related to “land use” development.

One thing worth mentioning is that the classification of plan information is not exclusive. Sometimes the plan information conveyed by a graphic could simultaneously be associated with more than one classification (except for “others”). For instance, the map in Figure 4.38 could be also viewed as a vision of the future roadway network, in addition to an agenda of transportation development. The map in Figure 4.39 could be also viewed as a vision of the region. That is to say, plan information conveyed by the maps in Figure 4.38 and Figure 4.39 could be also categorized into “goals and desired future” and “implementation” correspondingly.



Figure 4.38: The map works as an agenda by listing three types of proposed roadway projects. It also provides a vision of the future roadway network. The implementation is related to “transportation” development.

(Full-size map refers to [Figure 4.21](#))

(From 2005 Comprehensive Plan for City of Urbana, p. 108)

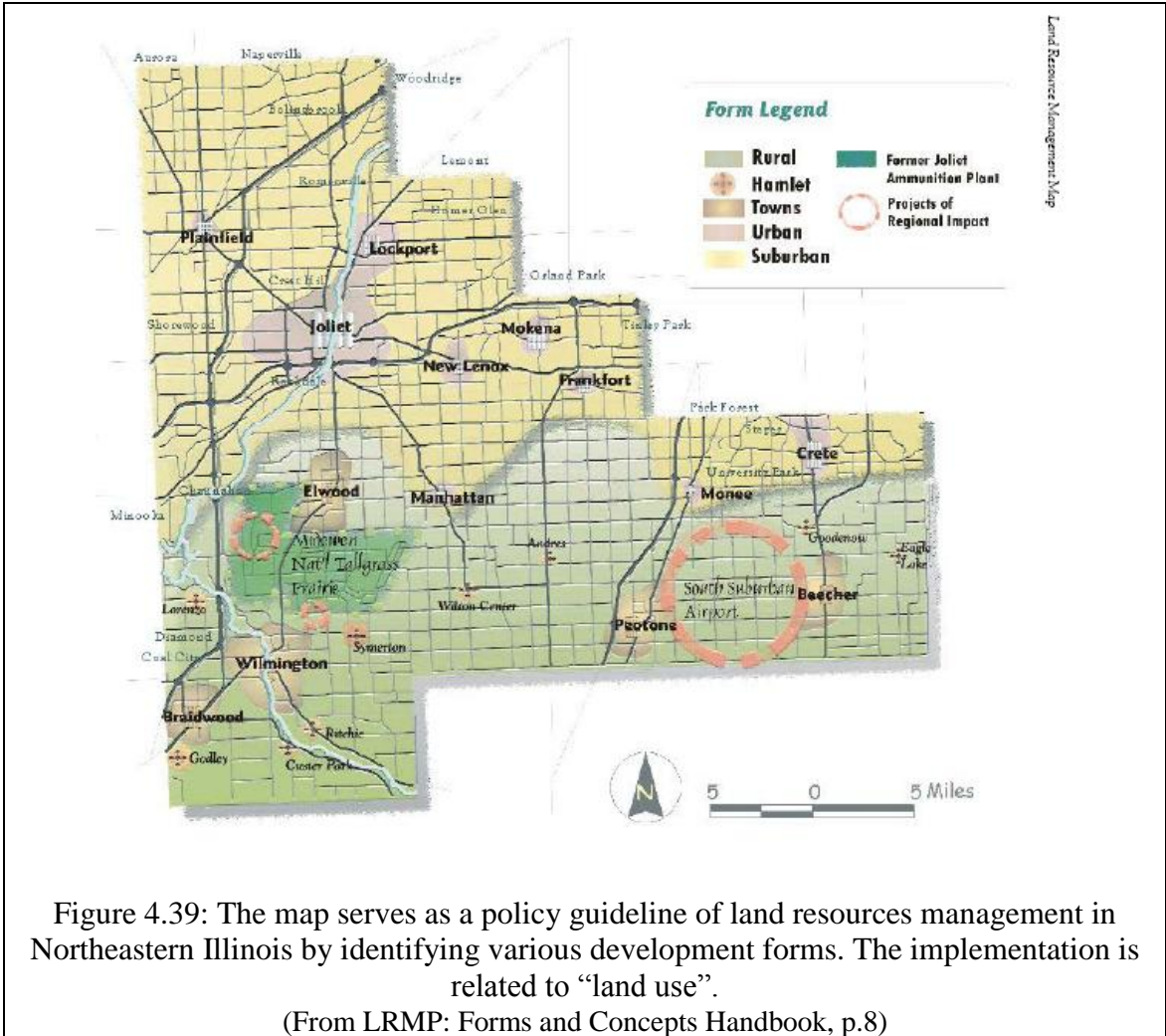


Figure 4.39: The map serves as a policy guideline of land resources management in Northeastern Illinois by identifying various development forms. The implementation is related to “land use”.

(From LRMP: Forms and Concepts Handbook, p.8)

Figure 1: Process Flow Chart

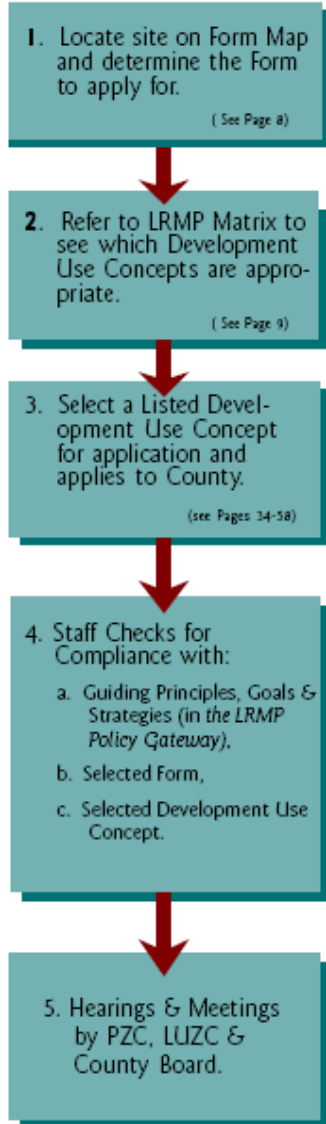


Figure 4.40: The non-spatial diagram serves as a policy guide to assist staff in the county to review development proposals. The implementation information is related to “land use”. (From LRMP: Forms and Concepts Handbook, p.7)



Same corner, different land use. THE METROPOLIS PLAN would help communities build more walkable neighborhoods and business districts.

Figure 4.41. The graphic, consisting of a series of small-size ground-level images, portrays the different scenarios of the same corner in different land uses, in order to illustrate a design of how to help communities build more walk-able neighborhoods and business districts in the Metropolis Plan. The implementation information is related to “land use”. (From The Metropolis Plan: Choices for the Chicago Region, p. 34)

▼ Figure 2: A Model for Implementation

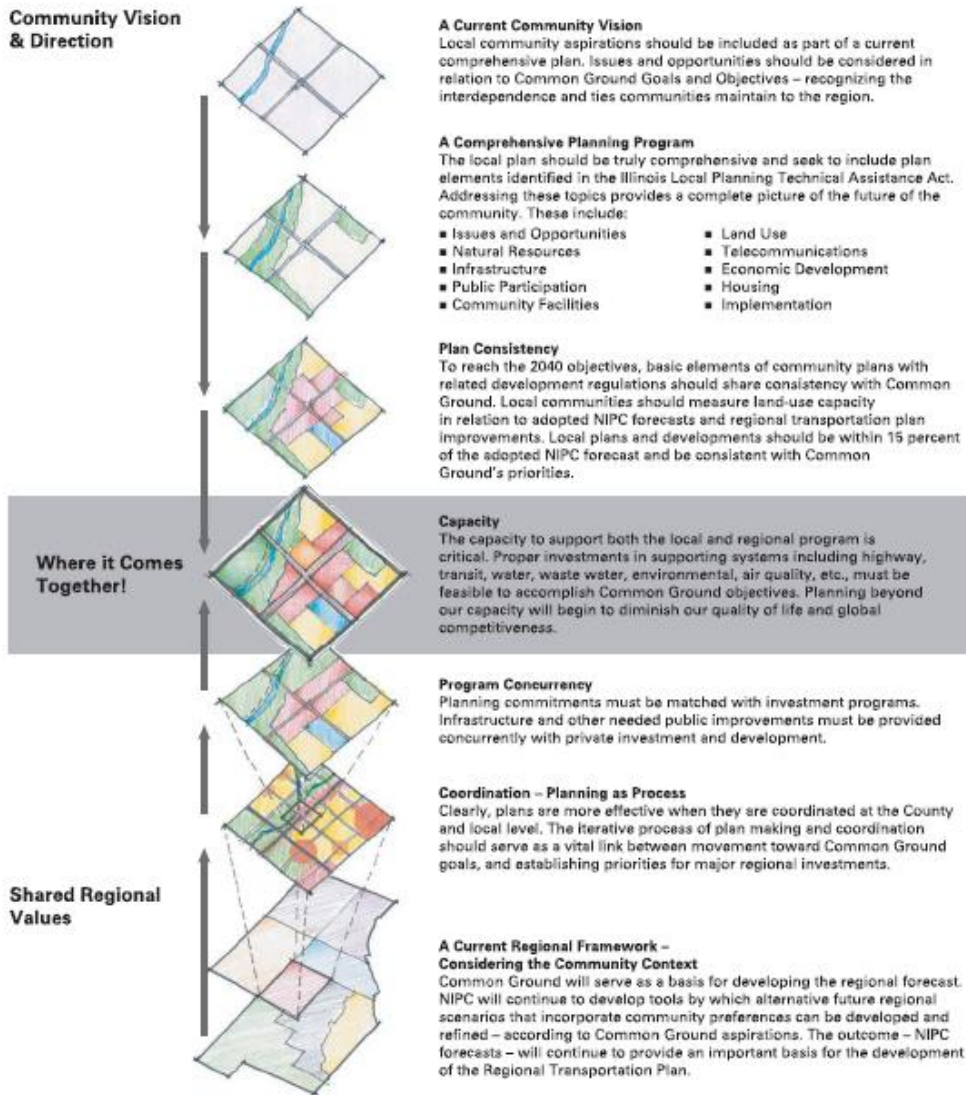


Figure 4.42: The non-spatial diagram illustrates a model for implementation: the argument is that initiatives beginning at the local or regional level come together in investments. The implementation is related to “land use”.
(From 2040 Regional Framework Plan, Chapter 6, p. 130)

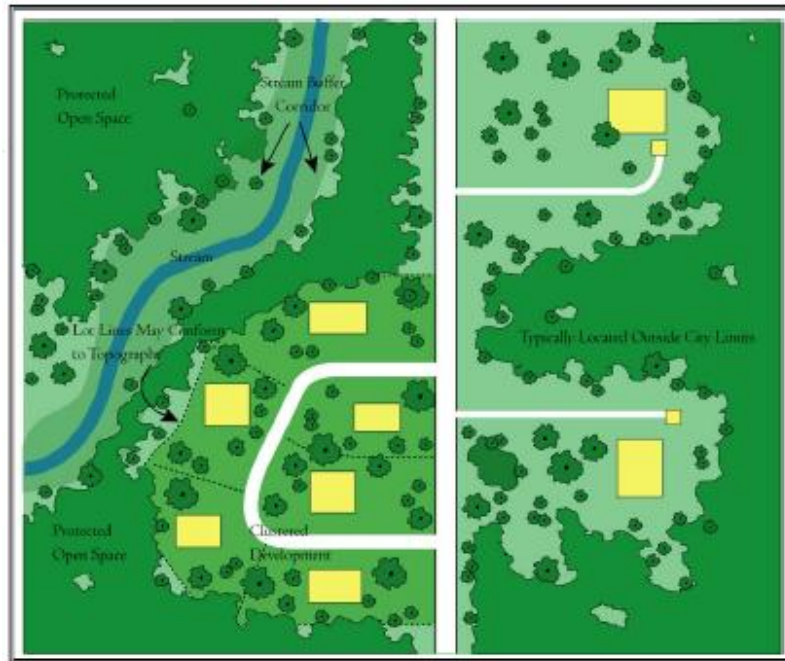


Figure 4.43: The site plan illustrates the essential features of a rural-residential area, and works as a policy or design to develop the rural residential area. The information is related to “land use” development.
 (From 2005 Comprehensive Plan for City of Urbana, p. 61)

Development Use Concept	Development Forms									
	Small	Medium	Large	Very Large	Very Large	Very Large	Very Large	Very Large	Very Large	Very Large
Residential Single-Family										
Residential Medium-Density										
Residential High-Density										
Residential Very High-Density										
Commercial										
Industrial										
Office										
Public										
Other										

Figure 4.44: The table illustrates the application of the individual development use concepts in each of the defined development forms, so that it provides a policy to control land use development in the region. The information is related to “land use” development.

(Full-size table refers to [Figure 4.24](#))
 (From LRMP: Forms and Concepts Handbook, p. 9)

Others

“Others” refer to the plan information that can not fit into the first four groups illustrated above. Below are the two examples of graphics presenting other information (see Figure 4.45 and Figure 4.46), which involves two graphic types, non-spatial diagram and map. The non-spatial diagram in Figure 4.45 is about the relationship among multiple plans. The map in Figure 4.46 presents the geographical scope of the *2040 Regional Framework Plan*.

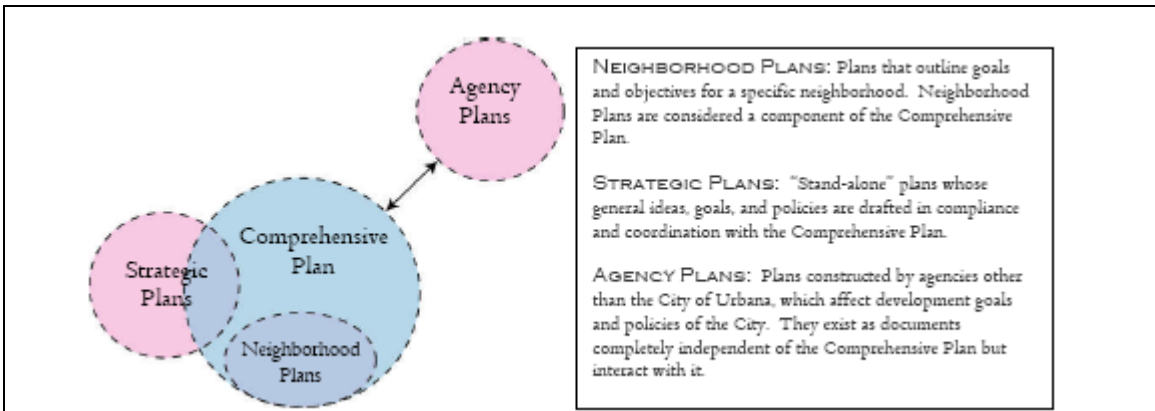


Figure 4.45: The non-spatial diagram illustrates the relationship between comprehensive plan and other three types of plans including strategic plans, neighborhood plans, and agency plans.
 (From 2005 Comprehensive Plan for City of Urbana, p. 6)

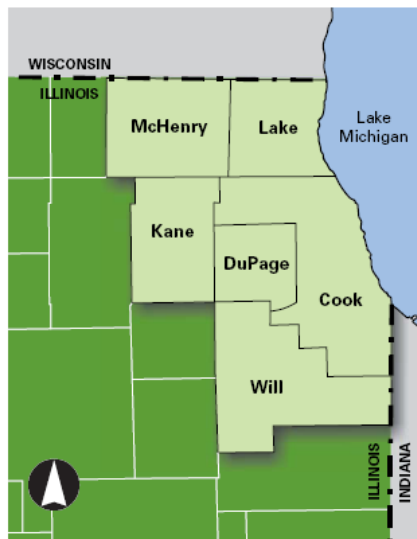


Figure 1: Counties of Northeastern Illinois
 The 2040 Regional Framework Plan addresses six counties in northeastern Illinois: Cook, DuPage, Kane, Lake, McHenry and Will.

Figure 4.46: The map addresses the geographical scope of the 2040 Regional Framework Plan, which includes six counties in northeastern Illinois.
 (From 2040 Regional Framework Plan, chapter 1, p. 2)

Graphic Types Significant for Each Group of Information

Based on the studies of more than two hundred graphics in plan documents, it is perceived that for each group of plan information conveyed by graphics, some types of graphics are more important than others in general. These “significant” graphic types have the following features:

- First, the “significant” graphic types should be one of the most frequently used graphic types for the group of plan information, which have been implied by the illustrations that have been presented for each group of information.
- Second, the “significant” graphic types are more likely to elaborate critical concepts that are indispensable components of a plan document, and general plan information (e.g. issues, views, and implementations) of a whole area.

Table 4.1 summarizes the “significant” graphic types for each group of plan information. For each graphic type, at least one example could be referred to. Those examples are from the illustrations that have been presented for each group of information. The current version of the “significant” graphic types is still in the very beginning stage. It definitely will evolve as more plan documents and more graphic presentations are studied.

The research of “significant” graphic types is the first effort to correlate graphic types with types of plan information. The correlation could be used to automatically rank graphics retrieved from a query according to their relevance. That is to say, for each type of plan information, the graphics in the “significant” types are ranked first. For instance, among the graphics presenting planning process information, the non-spatial diagrams are ranked first. The ranking of retrieval items is very important to promote search efficiency, especially when the number of retrieved items is large. It can save time of plan users having to browse every retrieval item and facilitate their locating the pertinent graphics in a short time. The automatic ranking according to the correlation of graphic types and information types is implemented in the demo prototype, which is presented in Chapter 7.

Groups of plan information	Significant Graphic Types	Examples
Planning process	<u>Non-spatial Diagram</u>	Figure 4.25, 4.26
Current situation, issue and trend	<u>Map</u>	Figure 4.28, 4.29
Goals and desired future	<u>Map</u> <u>Aerial-level Image</u>	Figure 4.34 Figure 4.35
Implementation	<u>Map</u> <u>Non-spatial Diagram</u> <u>Site Plan</u>	Figure 4.38, 4.39 Figure 4.40, 4.42 Figure 4.43
Others	<u>Map</u> <u>Non-spatial Diagram</u>	Figure 4.45 Figure 4.46

Table 4.1 “Significant” graphic types for each group of plan information

4.4 Representation Method

In the book *Visual Explanations: Images and Quantities, Evidence, and Narrative*, Tufte argues that graphic displays could be used to elaborate an idea or narrate a story, as well as make a convincing argument for making important decisions, even life-and-death decisions (Tufte, 1997).

Graphics in plan documents communicate plan content in similar ways. They are frequently used to provide visual explanations of a variety of plan information. Occasionally, graphics also provide quantitative visual evidences to make convincing claims or arguments. In this research, the first representation method is termed “elaborate”, and the second one is termed “demonstrate”. The “elaborate” method is more frequently used by graphics than the “demonstrate” method. Among the instances of “elaborate”, most of the time, a graphic display is devoted to visually illustrate a whole piece of plan information. In other words, the scope of what a graphic visually presents is identical to the scope of the plan information the graphic intends to convey. Accordingly, this representation method is termed as “fully elaborate” in this research. However, occasionally what a graphic visually illustrates is only a part of the plan information rather than the whole. That is, the scope of what the graphic visually presents is

smaller than the scope of the plan information. This representation method is termed “partially elaborate” in this research.

The classification of representation methods that graphics could use to present intended plan information is summarized in Figure 4.47. The classification can promote search efficiency and accuracy. Using the representation method as an indicator, along with the intended plan information and the graphic type, plan users can make a relatively good guess of what might be included in the graphic. Thus, they can quickly identify the most pertinent graphics among a long retrieval list. Besides, plan users can manually sort retrieval items by their representation methods, whenever certain representation methods are of interest. Theoretically, plan users could also search graphics based on their representation methods.

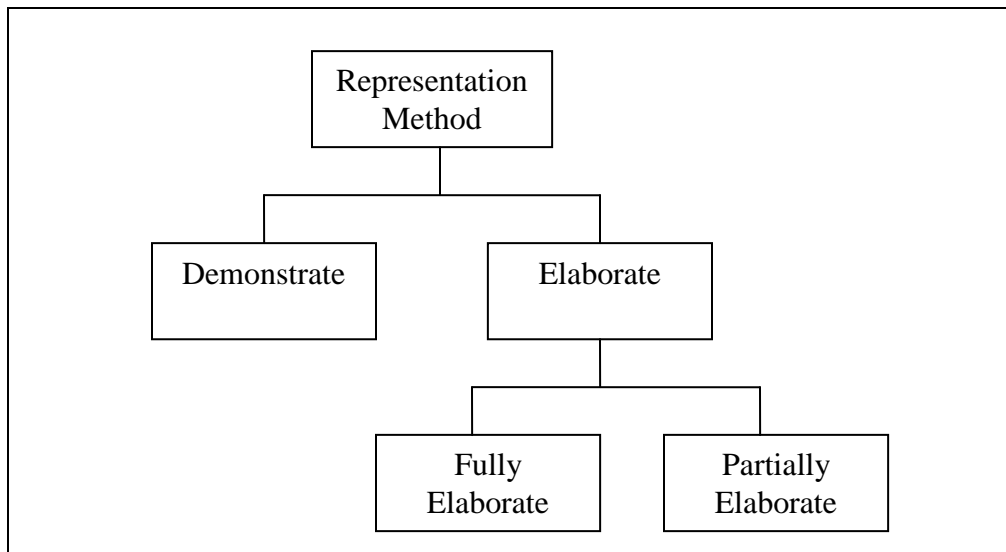


Figure 4.47 Classification of representation methods

Each of the representation methods, “demonstrate”, “fully elaborate”, and “partially elaborate”, is illustrated below with concrete examples.

Figure 4.48 shows a typical example of the “demonstrate” method. A map in Figure 4.48 compares the extent of regional congestion between two situations: without the 2040 Plan’s policies (illustrated in blue), and when the 2040 Plan’s policies are applied (illustrated in red). The purpose is to support the argument that future traffic volumes in outlying areas would be less

under the 2040 Plan than if current trends continue. That is to say, that the 2040 Plan’s policies would control congestion within the urbanized areas instead of sprawling it into the outlying suburban areas.

Figure 4.49 and Figure 4.50 show two typical examples of the “fully elaborate” method. In Figure 4.49, what the map visually illustrates is the planned road network for City of Urbana in the context of the existing road network. The map content is identical to the intended plan information it conveys. In Figure 4.50, the spatial diagram visually presents the layout of Northeast Urbana that is a rural residential area, in order to illustrate the typical features of rural residential area. The graphic content is devoted to illustrate the whole piece of plan information. The “fully elaborate” method is used most frequently by graphics in plan documents to communicate plan information. All of the examples presented in Chapter 4.3, “Plan information Conveyed by Graphics”, use the “fully elaborate” method.

Figure 4.51 is a typical instance of the “partially elaborate” method. In Figure 4.51, the intended plan information conveyed by the ground-level image is stated under the image. “Already in use by other cities, Bus Rapid Transit (BRT) is a hybrid of bus and light transit that can run in a dedicated right of way and/or roadway lanes. Such service may be able to fulfill 2040 goals for transit to connect centers, rail stations and popular attractions in a flexible and cost-effective way.” (2040 Regional Framework Plan, Chapter 3, p. 59) The ground-level image does not elaborate the whole information. Instead, it only visually illustrates the first sentence of the information by showing a picture of BRT being used.

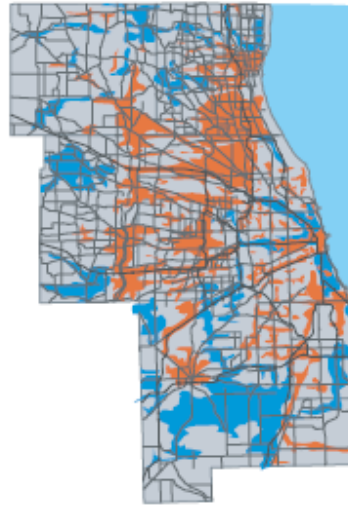


Figure 23: Common Ground (Red) Minus Forecast Traffic Volumes (Blue)

Future traffic volumes in outlying areas would be less under the 2040 Plan than if current trends continue.

Figure 4.48: A typical example of the “demonstrate” method. The map supports the argument that future traffic volumes in outlying areas would be less under the 2040 Plan than if current trends continue.

(From 2040 Regional Framework Plan, Chapter 3, p. 82)



Figure 4.49 A typical example of the “fully elaborate” method. What the map visually illustrates is the planned road network for City of Urbana in the context of the existing road network. The map content is identical to the plan content it conveys.

(Full size image refers to [Figure 4.21](#))
(From 2005 Comprehensive Plan for City of Urbana, p. 108)



Figure 4.50 A typical example of the “fully elaborate” method. The spatial diagram visually presents the layout of Northeast Urbana, in order to illustrate typical features of the rural residential area. The graphic content is devoted to illustrate the whole information.

(Full size image refers to [Figure 4.43](#))
(From 2005 Comprehensive Plan for City of Urbana, p. 61)



Already in use by other cities, Bus Rapid Transit (BRT) is a hybrid of bus and light transit that can run in a dedicated right of way and/or roadway lanes. Such service may be able to fulfill 2040 goals for transit to connect centers, rail stations and popular attractions in a flexible and cost-effective way.

Figure 4.51: A typical example of the “partially elaborate” method. The ground-level image visually elaborates what the Bus Rapid Transit (BRT) is, which is one part of the plan information it intends to convey.

(From 2040 Regional Framework Plan, Chapter 3, p. 59)

4.5 Effectiveness

As illustrated before, each graphic representation in plan documents aims to either elaborate or demonstrate a piece of plan information. However, how well a graphic elaborates or demonstrates the information could be quite different. Some graphics provide rich illustrations or strong demonstrations of plan information; in contrast, some graphics provide poor illustrations or weak demonstrations (Tufte, 1983, 1990, and 1997).

In this research, how well a graphic elaborates or demonstrates the intended plan information is termed “effectiveness”. The value of effectiveness is either “high” or “low”.

For a graphic using “Fully Elaborate” or “Partially Elaborate” method, high effectiveness means that a graphic provides a rich visual illustration of the intended plan information. For instance, it communicates detailed information in an easily-readable way or facilitates viewers comprehension of the information. On the contrary, low effectiveness means that a graphic

provides a poor illustration of the intended plan information, that is to say, it does not provide much valuable information to illustrate the plan information or help users to comprehend the information. For a graphic using “Demonstrate” method, high effectiveness means that the graphic strongly supports the argument it is supposed to convey. On the contrary, low effectiveness means that the graphic is not strong enough to support the argument. The effectiveness can also indicate whether a graphic is worthy to be carefully viewed or not.

The definition of effectiveness can facilitate graphical retrieval. Using the effectiveness as an important indicator, plan users can focus on those graphics with high effectiveness and leave out the graphics with low effectiveness. The effectiveness could also be used to automatically or manually sort retrieval items, which pops up the graphics with high effectiveness on the top.

The John Snow’s map of cholera death presented by Tufte (1999, p. 30) could be viewed as a good example of graphic using “Demonstrate” method in high effectiveness. The Figure 4.48 that is presented to illustrate “Demonstrate” method is another typical example of high effectiveness. The charts of the launch of space shuttle Challenger presented by Tufte (1990, p. 46 – 49) could be regarded as a typical example of low effectiveness of “Demonstrate” method.

For the graphics using “Fully Elaborate” method, Figure 4.49 and Figure 4.50, which were presented previously in this chapter, are two typical examples with high effectiveness. In Figure 4.49, the mobility map provides a visual illustration of the proposed transportation development in City of Urbana, and presents detailed plan content in an easily readable way. In Figure 4.50, the spatial diagram presents the layout of Northeast Urbana to visually illustrate typical features of the rural residential area. In contrast, Figure 4.52 is an example of graphics using “Fully Elaborate” method with low effectiveness. The ground-level image shows a scene of dozens of middle-age people concentrating on a lecture or something, with the intention of illustrating public input workshop that occurred during the process of preparing the *Land Resource Management Plan (LRMP)*. However, the image contains little valuable information that can illustrate the public input workshop or help viewers to understand the intended plan information.

For the graphics using “Partially Elaborate” method, Figure 4.51, which was presented previously in this chapter, is a typical example with high effectiveness. The ground-level image visually illustrates the statement of Bus Rapid Transit, “Bus Rapid Transit (BRT) is a hybrid of bus and light transit that can run in a dedicated right of way and/or roadway lanes” (2040 Regional Framework Plan, Chapter 3, p. 59), which is a part of the intended plan information. Figure 4.53 is a typical example of graphics using “Partially Elaborate” method in low effectiveness. Figure 4.53 presents a scene of a classroom filled with students concentrating on a lecture, in order to symbolize the term “well-educated population”. The term is one of the keywords of the plan information: “According to a 2003 report released by the Workforce Boards of Metropolitan Chicago, northeastern Illinois is well-educated compared to the rest of the country” (2040 Regional Framework Plan, chapter 7, p. 174). The graphic does not add much valuable information either to elaborate the term or to help readers to comprehend it. Even though the photo could contain some information unintentionally, such as, students appear to be all white and mostly women. Associating the photo with its context, it is clear that is not the information the photo is intended to convey.



Public input workshop.

Figure 4.52 The photo is a typical example of graphics using “Fully Elaborate” method with low effectiveness that.

(From LRMP: Policy Gateway, p. 1)



▲
According to a 2003 report released by the Workforce Boards of Metropolitan Chicago, northeastern Illinois is well-educated compared to the rest of the country.

Figure 4.53: The photo is a typical graphic with low effectiveness that uses “Partially Elaborate” method to present plan content.

(From 2040 Regional Framework Plan, chapter 7, p. 174)

One thing that needs to be clarified is that a graphic labeled as low effectiveness just implies that the graphic is not necessary for the plan information it attempts to convey. It does not imply that the plan info the graphic is intended to convey should be overlooked. For instance, in the example presented by Figure 4.53, the photo is not valuable; however, the plan information – “According to a 2003 report released by the Workforce Boards of Metropolitan Chicago, northeastern Illinois is well-educated compared to the rest of the country” (2040 Regional Framework Plan, chapter 7, p. 174) – should not be ignored.

4.6 Single Graphic vs. Graphic Group

As illustrated before, each graphic representation in plan documents aims to communicate a piece of plan information. What is more, some graphics closely associate with other graphics semantically to communicate plan information as a whole. The collection of two or more graphics being united together is termed a “graphic group” in this research. Each component of a graphic group is termed a “graphic group member”, abbreviated as “group member” or “member”. In plan documents, members of a group are usually placed together as much as possible. Even though associated together as a group, each member still has its distinct identity

information, including title, description, comments, and intended plan information, which are different from the attributes of the group and should be marked up individually. In contrast to “graphic group”, a graphic that is not included in any graphic group is termed a “single graphic”. A single graphic presents plan information by itself.

Figure 4.54 shows a typical graphic group, which illustrates growth of a typical urban community by contrasting existing pattern and potential development of an urban community. Obviously, the graphic group includes two members, which respectively illustrate the existing condition and the proposed development of an urban community. Each member has its own title, annotations, as well as intended plan information.

Usually, it is quite easy to distinguish a single graphic from a graphic group because a graphic group is usually composed of several members placed together. In contrast, a single graphic is usually a whole piece that can not be divided. However, occasionally a single graphic could be a combination of small size images that are clustered together, which looks similar to a graphic group apparently. Figure 4.55 is a typical example of the special kind of single graphic. It is composed of five small size photos to illustrate the typical features of “urban-style” multi-family development pattern. Comparing Figure 4.55 with Figure 4.54, we can notice there is a big difference between them. Each component in the special single graphic has no distinct identity information or individual characteristics that make it a separate entity; whereas, in the graphic group at least one component (also called group member) has individual features that should be indexed.

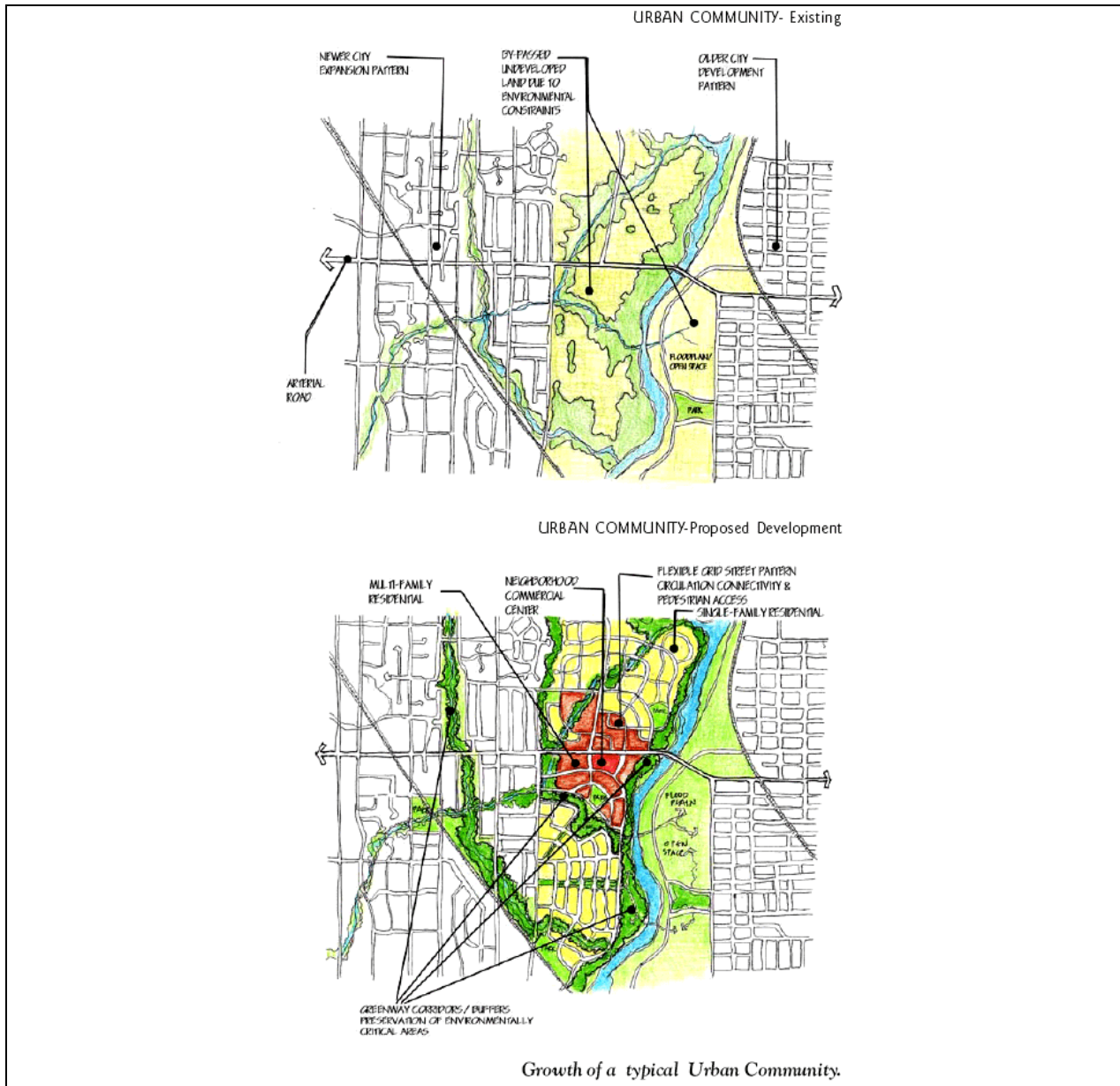
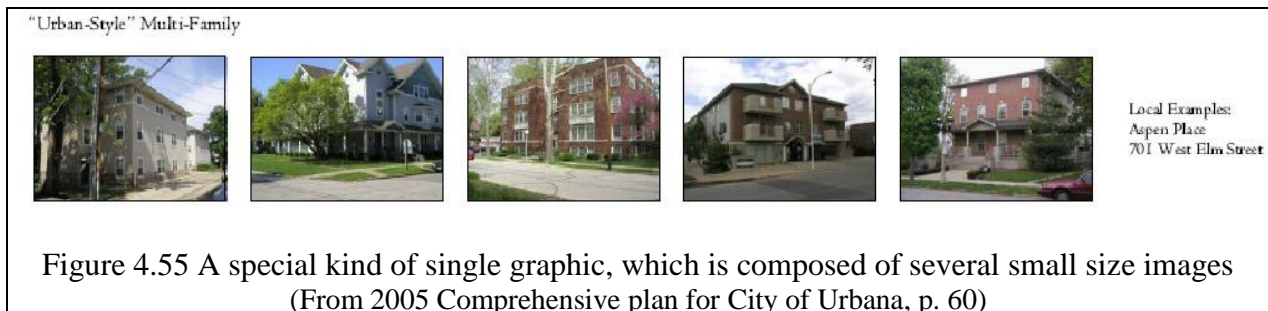


Figure 4.54 A typical graphic group, which illustrates growth of a typical urban community by contrasting existing pattern and potential development of an urban community.
 (From LRMP: Forms and Concepts Handbook, p.19)



4.7 Association among Group Members

In a graphic group, the group members are associated with each other, in order to communicate plan information as a whole. The association among group members could be varied. Thus far, it is generally categorized into two types – “multiples-design relationship”, and “coordinative relationship”. Each of them is defined and illustrated in detail below.

Multiples-design Relationship

“Multiples-design Relationship” used in this research originates from the concept of “small multiples design” defined by Tufte (1990, and 1997). The “small multiples design” makes use of small size pictures that are clustered together and indexed by a quantitative variable, to visually enforce comparisons of changes, of the differences among objects, or of the scope of alternatives. In a similar way, the group members associated with “Multiples-design Relationship” are normally positioned together within the eye span, if possible, to visually reveal repetition and change, pattern and surprise. In addition, the group members associated with this relationship are in same graphic type. The relationship is popularly used in plan documents to correlate group members.

To illustrate the “Multiples-design Relationship”, three typical examples and a special example are introduced.

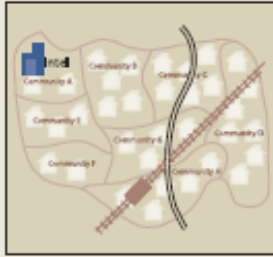
In Figure 4.54 mentioned above, two graphic members, which respectively present the existing situation and the proposed development of urban community, are displayed together to illustrate potential expansion of a typical urban community. In Figure 4.56, four graphic members as a group tell a story of “Adam Smith’s Invisible Hand Drops the Ball” in order to illustrate how regional thinking serves all communities. In particular, three small images on the left are positioned together to narrate a sequence of development scenarios, if every community concerns its own profits separately, and a resulting dilemma of no one winning in long run. The larger image on the right presents a comparison with the previous images, in order to propose a

better solution -- promoting regional cooperation, which can make the same development much more efficient. Similarly, in Figure 4.57, four graphic members associated together as a group tell a story of highway bypass, in order to illustrate how regional thinking serves all communities. Specially, the first three images narrate that even more traffic congestion will be produced, if new highway bypass is the only way to solve the traffic jam between residential communities and work locations. The last image, presenting a comparison to the second image, promotes a better solution – “building affordable housing closer to where people work and shop” than the seemingly simple solution (The Metropolis Plan: Choices for the Chicago Region, p. 22).

Figure 4.58 shows a special example. The graphic on the top, which is composed of five small photos in small multiples design, illustrates the features of “‘Urban-Style’ Multi-Family” land use development. The small photos show local examples in Aspen Place, 701 West Elm Street. The graphic on the top, which has been introduced in the last section, should be regarded as a single graphic, instead of a graphic group, since each small image does not have its own identity to be presented separately. Similarly, the graphic at the bottom including five small photos presents the features of “‘Garden-Style’ Multi-Family” land use development. The small photos show local examples in Amber Pointe and in Town and Country Apartments. The graphic at the bottom should be also regarded as a single graphic due to the same reason. The graphic on the top and the graphic at the bottom are associated together by “Multiples-design Relationship” as a graphic group, which compares the two land use developments, and illustrates the similarities and differences between them.

Case Study: Adam Smith's Invisible Hand Drops the Ball

How regional thinking serves all communities



Development: Intel declares its intention to build a high-tech plant that will provide desirable jobs for workers throughout the region. Because of the state's "winner take all" tax system, communities A through G compete to attract the plant rather than cooperating to determine a location that makes the most sense for the whole region.

Result: Community A captures the tax revenue from the new plant. Yet all communities in the area must bear both the costs of new traffic congestion and the costs of providing additional public services related to the Intel development.



Meanwhile: No community has an incentive to create affordable housing for the new Intel workers because this would incur large education costs, most of which must be funded locally. Thus, many Intel workers must live in distant community X and drive to the Intel plant. The result is more traffic for everyone.



Long-term: Even community A is not a winner. Months later, the same communities compete for a new office park. Community D is the winner, creating a whole new set of traffic challenges for which the region has not planned. Again, there is no incentive for any community to create workforce housing.

A better solution: If there were a mechanism in place to promote regional cooperation, the same development could be done far more efficiently. The result would be:

- Less local traffic.
- Development that is built around existing public transit.
- More housing near jobs, shopping, and services so that residents are not forced to drive long distances.



Figure 4.56: Four graphic members being associated with "multiples-design relationship" (From *The Metropolis Plan: Choices for the Chicago Region*, p.15)

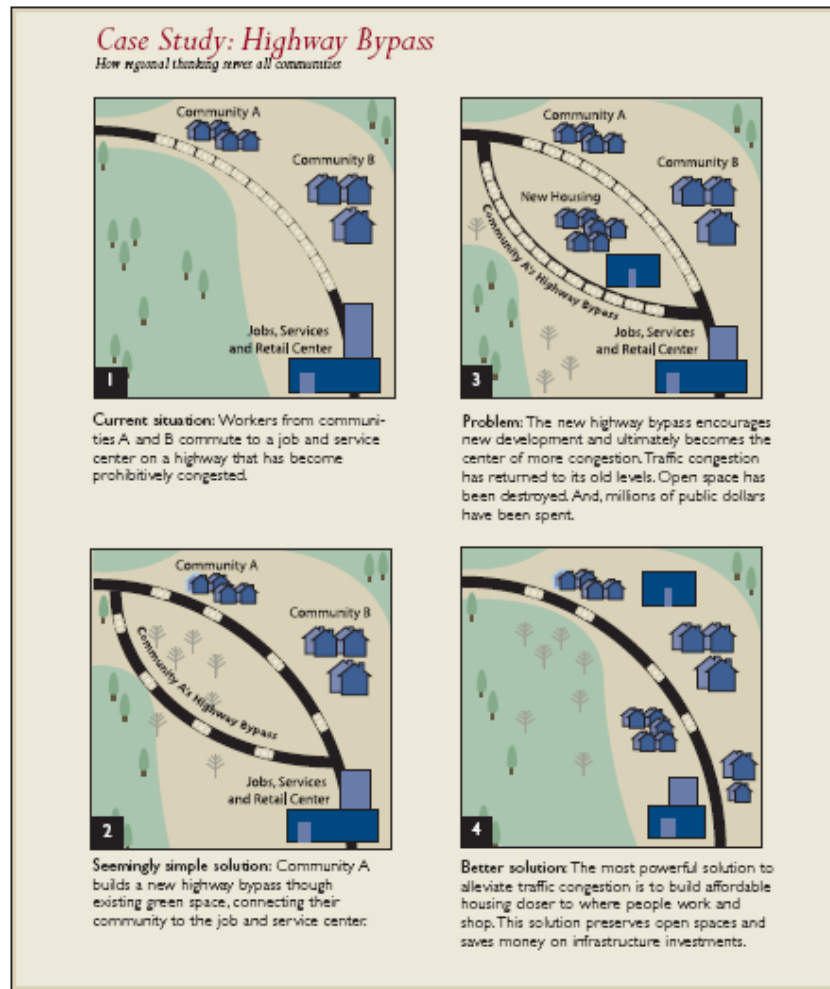


Figure 4.57 Four graphic members being associated with “Multiples-design Relationship”
 (From The Metropolis Plan: Choices for the Chicago Region, p. 22)



Figure 4.58. The graphic on the top and the graphic at the bottom are associated together by “Multiples-design Relationship” as a graphic group, which compares the “Urban-Style” Multi-Family” with “Garden-Style” Multi-Family” land use development.
 (From 2005 Comprehensive plan for City of Urbana, p. 60)

Coordinative Relationship

“Coordinative Relationship” refers to the relationship among two or more group members cooperating with each other in semantic relationships to communicate one plan idea.

Group members in “Coordinative Relationship” and members in “Multiples-design Relationship” differ in the following ways:

- Graphic members in “Coordinative Relationship” do not have to look similar. On the contrary, members in “Multiples-design Relationship” always do.
- Graphic members in “Coordinative Relationship” could be in different graphic types. However, members in “Multiples-design Relationship” should be in same type.
- Graphic members in “Coordinative Relationship” are often more independent than the ones in “Multiples-design Relationship”.

To illustrate the “Coordinative Relationship”, two examples are introduced below.

Figure 4.59 presents a typical example of a graphic group with members being associated by “Coordinative Relationship”. The graphic group is composed of three group members. The first group member titled “Sensible Growth vs. Sprawl” compares the potential expansions of current center in two situations: sensible growth (or compact growth pattern) and uncontrolled sprawl, in order to highlight the benefits of the sensible growth pattern and the problems of uncontrolled sprawl. The second group member titled “Housing Choices” illustrates that “compact centers should feature housing choices near mass-transit hubs; if housing instead is concentrated at the outer edges of incorporated areas, traffic congestion will increase in arterials and expressways” (2040 Regional Framework Plan, chapter 3, p. 43). The third group member titled “The ‘Trip Chaining’ Phenomenon” illustrates the “trip chaining” phenomenon: multi-destination (e.g. school, shopping, soccer field, library, and home) local trips tend to occur around or during rush hour, contributing to traffic congestion. And it is known that developing land around transit stations will be a good way to promote sensible growth, and locating the multiple destinations in the same area or near the train station will be a wise strategy to reduce the need for additional trips. The three members associated together as a graphic group communicate the statement –

Transit-oriented development (TOD) and transit-oriented redevelopment (TOR), which are the design and development of land around transit stations in ways that encourage people to use mass transit, could help to save time and reduce traffic congestion and pollution.

Figure 4.60 shows another example. The first graphic member, which is composed of three small size pictures on the left, depicts the visual features of “urban pattern” residential area. The second graphic member, on the right and in the graphic type of “community layout”, presents a typical layout of “urban pattern” residential area. Two of them as a group illustrate the features of this type of development. The same presentation strategy, one member including multiple photographs associated with the other member in the “community layout”, is repeatedly used more than ten times to illustrate a variety of land use developments (e.g. “suburban pattern” residential area, “urban pattern” mixed-residential, rural residential, regional business) in the same plan document (2005 Comprehensive plan for City of Urbana, p.56-58, p. 59, p. 61-65, p. 68-69).

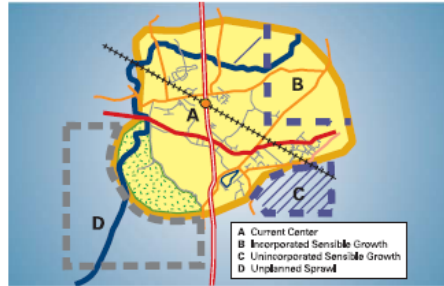


Figure 11: Sensible Growth vs. Sprawl
 Without planning that guides compact growth to sectors B or C, sprawl stretches beyond the incorporated Center to sector D. Illustration by Randi Robin Design

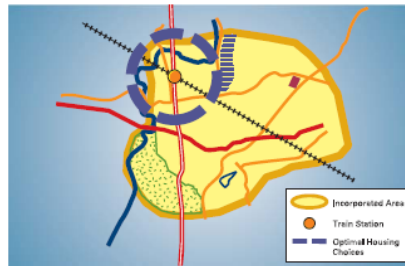


Figure 12: Housing Choices
 Compact centers should feature housing choices near mass-transit hubs. If housing instead is concentrated at the outer edges of incorporated areas, traffic congestion will increase in arterials and expressways. Illustration by Randi Robin Design

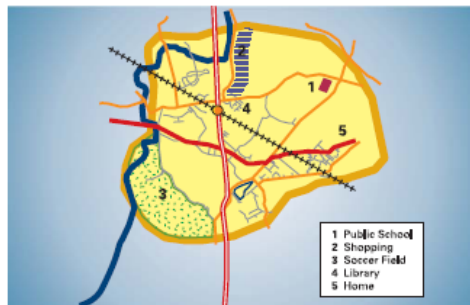
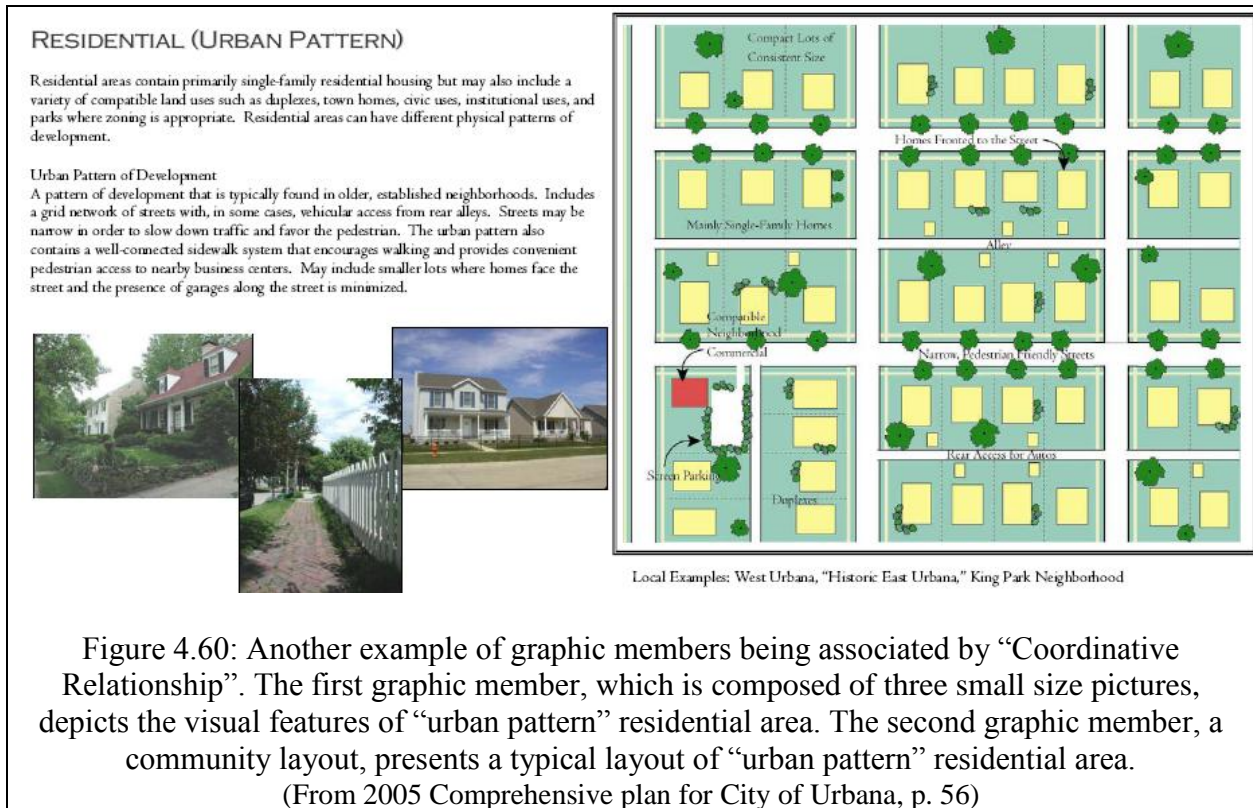


Figure 13: The 'Trip Chaining' Phenomenon
 Multi-destination local trips tend to occur around or during rush hour, contributing to traffic congestion. Illustration by Randi Robin Design

Figure 4.59: The three group members in “Coordination Relationship” collectively communicate a statement -- Transit-oriented development (TOD) and transit-oriented redevelopment (TOR), which are the design and development of land around transit stations in ways that encourage people to use mass transit, could help to save time, reduce traffic congestion and pollution.

(From 2040 Regional Framework Plan, Chapter 3, p. 43)



4.8 Conclusion

In this chapter, the ontology of graphic representations in plan documents is illustrated with respect to several issues. First, the importance of context for understanding a graphic is addressed. Then, the classification of graphics in plan documents is illustrated, which is followed by the category of plan information conveyed by graphics and the significant graphic types for each type of plan information. Next, the classification of the representation methods used by graphics to convey plan information is illustrated. Followed by the indicator effectiveness that identifies how well a graphic elaborates or demonstrates a piece of plan information. Finally, the fact that two or more graphics could be closely associated together as a group is introduced, and the associations among group members are illustrated.

The next chapter gives detailed descriptions of relationships between content entities (i.e. text entity, single graphic entity, and graphic group entity). This chapter and the next chapter build up a solid theoretical foundation for developing the PMLGraphics in chapter six.

5. Relationship between Content Entities

Content entities refer to the objects, which encode plan content of a plan document, in the proposed PMLGraphics. Generally, there are three types of content entities: text entity, single graphic entity, and graphic group entity. Obviously, the text entity presents textual content; the single graphic and graphic group entity present graphical content. The previous chapter illustrated characteristics of graphic representations, including single graphic and graphic group, in plan documents.

However, content entities themselves are not enough. What are also important for plan users to navigate and comprehend plan contents are semantic relationships of plan information presented by two content entities and spatial relationships (e.g. adjacency, containment) between single graphics within a plan document. These relationships are abbreviated as “relationship between content entities” in this research.

The planning process has been interpreted as a process of rational argumentation (Rittel & Webber, 1973; Daly, 1978). A plan document, being a report or summary of argumentation in planning process, is not short of semantic relationships. Substitutability and interdependence relationships between actions within and among plans have been identified, and these semantic relationships can be used to discover more relationships, thereby enriching decision making process (Kaza, 2007, 2008). As urban planning concerns the ordering and design of settlements from the smallest towns to the world's largest cities, a plan document is very likely to include spatial relationships between two graphic entities. For instance, City A presented in map #1 includes Area X presented in map #2, and the Area X presented in map #2 is adjacent to Area Y presented in map #3.

The relationships between content entities include four types of relationships:

- relationship between two single graphic entities,
- relationship between a single graphic entity and a text entity,
- relationship between a graphic group entity and a text entity, and

- relationship between two text entities.

Each of these is defined and exemplified one by one below. The first two relationships, relationship between two single graphic entities and relationship between a single graphic entity and a text entity, are further categorized and illustrated extensively because they are frequently utilized in plan documents and are tightly associated with the research topic, graphic representations. Relationship between a graphic group entity and a text entity is not further classified due to merely a few instances being perceived up to now.

The relationship between content entities facilitates plan users to navigate from one content entity to another one related to the former one. Doing so can help users either better understand plan content or extend navigation based on their information needs. This chapter lays groundwork for developing a data model incorporating a capacity for processing semantic logic and spatial relationships in plan content. This groundwork is necessary to develop the PMLGraphics that enables marking up plan content, especially graphical content, as well as the underlying relationships among plan content.

5.1 Relationships between Single Graphic Entities

Relationships between single graphic entities are summarized in Figure 5.1. The relationships include semantic relationship, including “semantic referral relationship”, as well as spatial relationship, including “adjacency relationship”, “zoom in relationship”, and “whole-part relationship”. Geographic Information Systems (GIS) have analyzed spatial relationships between mapped geographic features describing real world, such as polygon adjacencies, polygon overlap, polygon containment and points within a polygon (ESRI; Ramsey). The spatial relationships in GIS are used to support spatial analysis that could derive solutions to complex problems in various industries, including agriculture production, exploration geology, meteorology, forestry, health care, mining, real estate, city government, and many others. The relationships in this research, however, focus on identifying semantic relationships and spatial relationships between two single graphics, which are employed as the theoretical basis for a navigation link from one graphic to another in the prototype presented in Chapter Seven.

The relationships can be classified as “non-directional relationship” and “directional relationship”, according to whether a relationship is for both directions (i.e. between graphic A and graphic B) or for one direction (e.g. from graphic A to graphic B). If graphic A has a “non-directional relationship” with B, then it is true that the graphic B has the same relationship with A. In contrast, if A has a “directional relationship” with B, it may not be true in a reverse order. Thus, in the directional relationship it is necessary to make clear which one is “from” graphic and which one is “to” graphic. Obviously, a relationship can not be categorized into the “non-directional relationship” and “directional relationship” at the same time.

In the following passage, “adjacency relationship”, “zoom in relationship”, “whole-part relationship”, and “semantic referral relationship” are defined and illustrated with examples one by one.

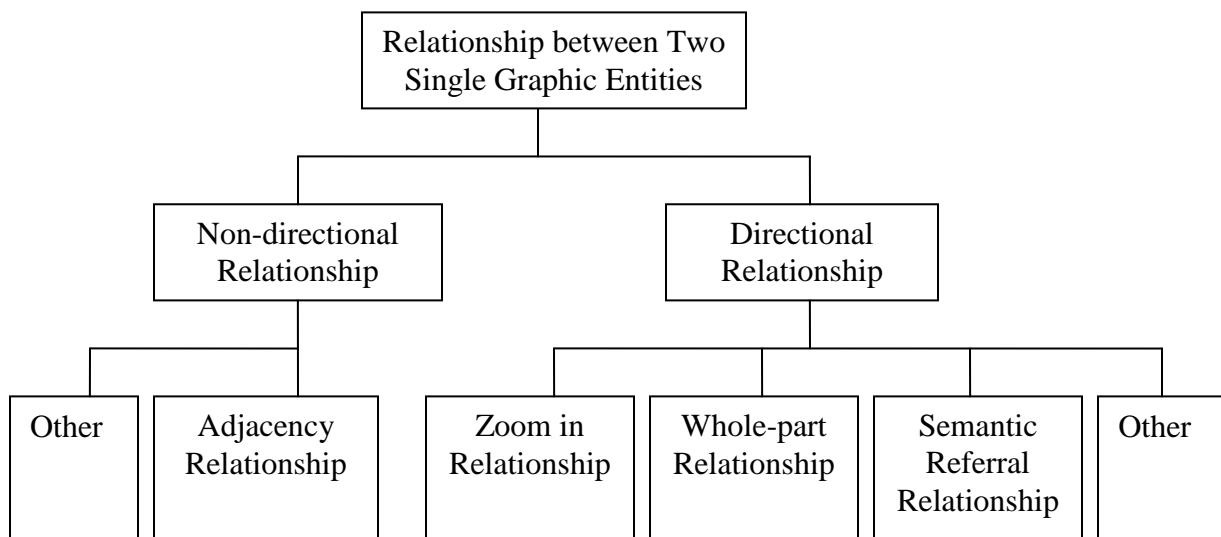


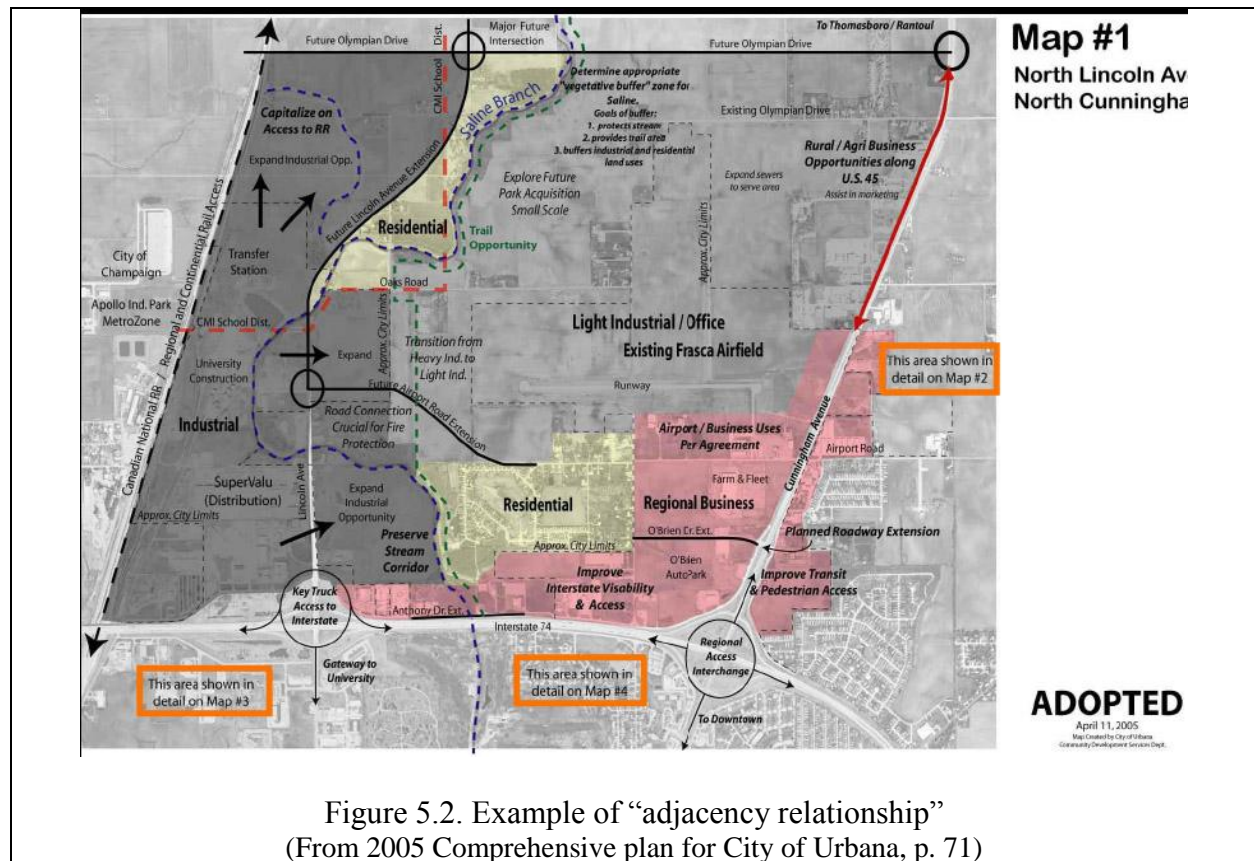
Figure 5.1 Relationships between two single graphic entities

Adjacency Relationship

“Adjacency relationship” refers to spatial relationship between two maps that present two areas adjacent to each other in geography. From the definition, it is obvious that the relationship is a “non-directional relationship” and only valid for maps.

One typical example is shown in Figure 5.2. On the map #1 in Figure 5.2, the annotations highlighted by orange rectangles (that is, “this area shown in detail on map #2”, “this area shown in detail on map #3”, and “this area shown in detail on map #4”) declare the “adjacency relationship” between the map #1 and the map #2, between the map #1 and the map #3, and between the map #1 and the map #4.

The adjacency relationship is frequently presented in “2005 Comprehensive Plan” for City of Urbana. Besides the example shown above, the relationship is also presented in other thirteen maps, from map #2 in page 72 to map #14 in page 84.



Zoom in Relationship

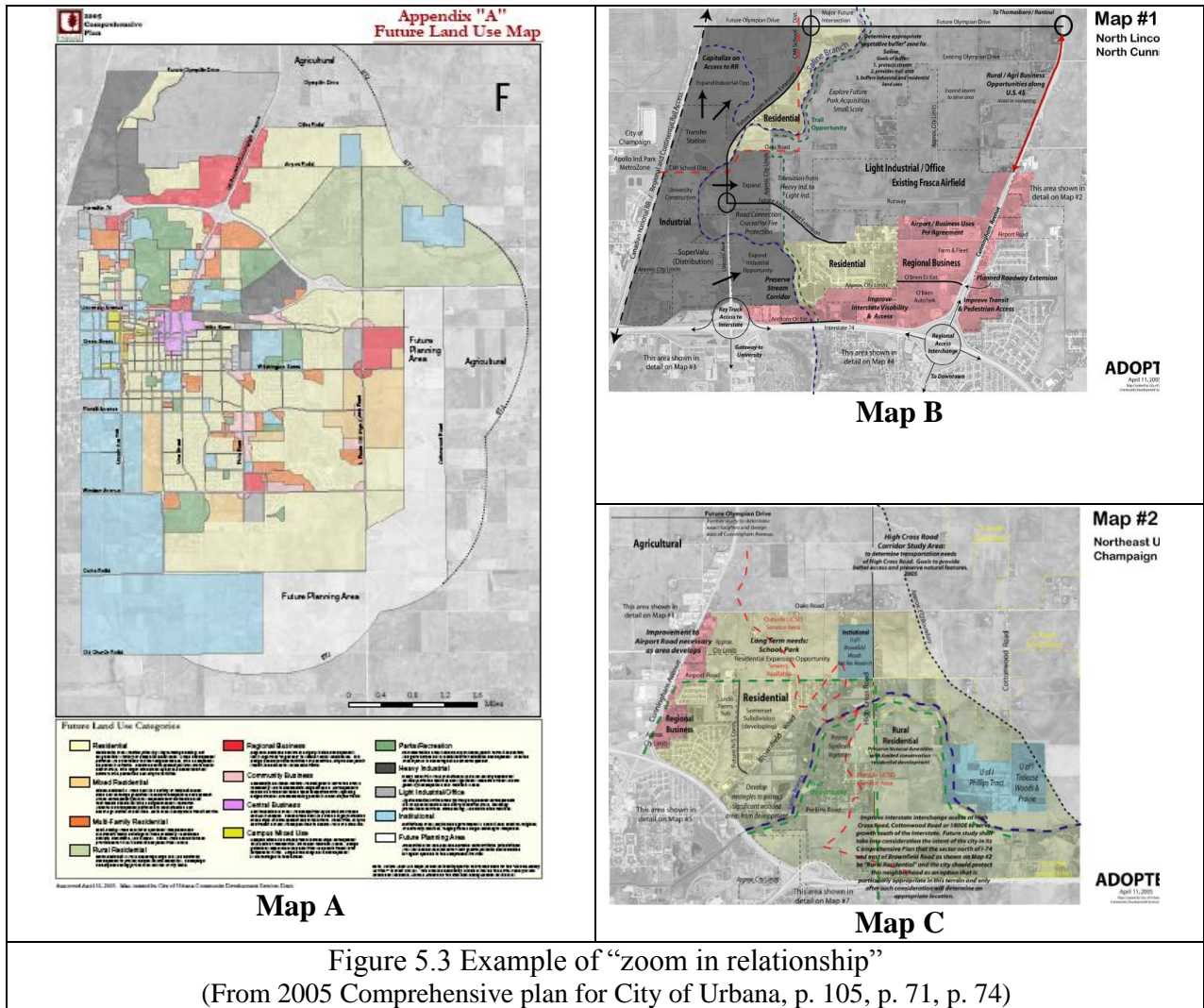
“Zoom in relationship” refers to the relationship between map A and map B only if the two maps have the following features:

- The area presented by the map A includes the area presented by the map B (that is, containment relationship); and
- The two maps could present information in different levels of detail. Normally, the map A that covers a broad area focuses on the overall pattern or trend, and the map B that covers a small region focuses on more detailed information.

In other words, the map B is like a close up zoom of the map A, as shown in Google maps. Obviously, the relationship is a “directional relationship”. It is only valid for maps.

One typical example is shown in Figure 5.3. The left map (Map A) presents the overall future land use of City of Urbana, Illinois. It is “a compilation of the 14 individual area maps in Chapter VII” (2005 Comprehensive plan for City of Urbana, p. 104). The right maps (Map B and C), two of the 14 individual area maps, illustrate detailed designs and actions of the future land use development in specific areas of the City of Urbana. Obviously, the Map A has “zoom in relationship” with the Map B and the Map C.

In semantic logic, the relationship is transitive. That is to say, if Map X has “zoom in relationship” with Map Y and the Map Y has the same relationship with Map Z, then it is true that the Map X has “zoom in relationship” with the Map Z.



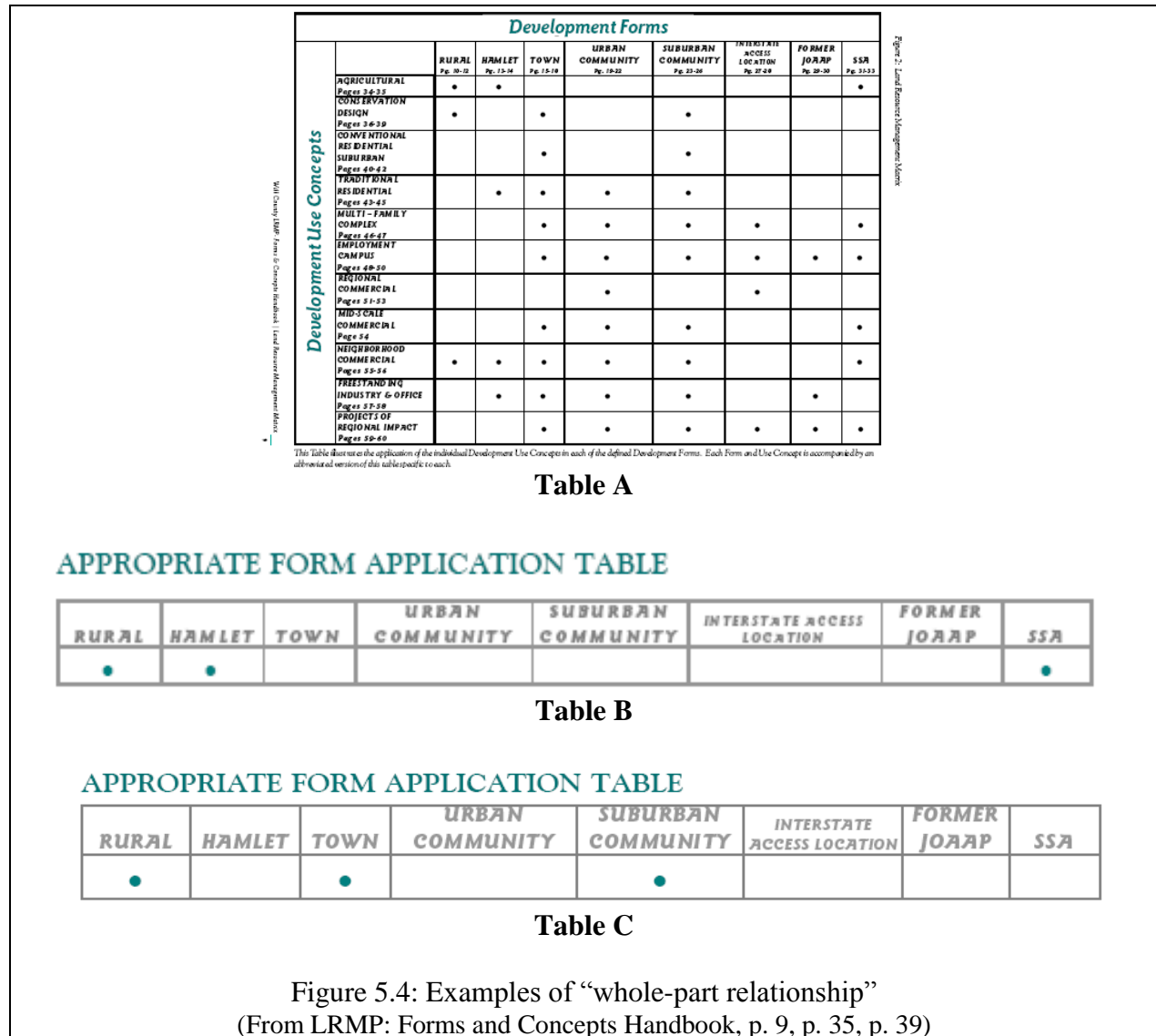
Whole-part Relationship

“Whole-part relationship” refers to the spatial relationship between graphic A and graphic B, if the graphic B is a portion or section of the graphic A. Obviously, the relationship is a “directional relationship”. The relationship is applicable to any type of graphics; however, the two graphics must be in same type.

An example is shown in Figure 5.4. The first table (Table A) illustrates the association between eleven development use concepts (that is, general land uses) and eight development forms that are coupled with locations of properties. The second table (Table B) presents development forms appropriate for agricultural land use, which is one of the development use concepts presented in

the Table A. The third table (Table C) presents development forms appropriate for conservation design land use, which is also one of the development use concepts. Obviously, the Table B is the first row of the Table A, and the Table C is the second row of the Table A. Thus, the Table A has “whole-part relationship” with the Table B and the Table C. The relationship is frequently present in the plan document *Land Resource Management Plan: Forms and Concepts*.

In semantic logic, this relationship is transitive. That is to say, if Graphic X has “whole-part relationship” with Graphic Y and the Graphic Y has “whole-part relationship” with Graphic Z, then it is true that the Graphic X has “whole-part relationship” with the Graphic Z.



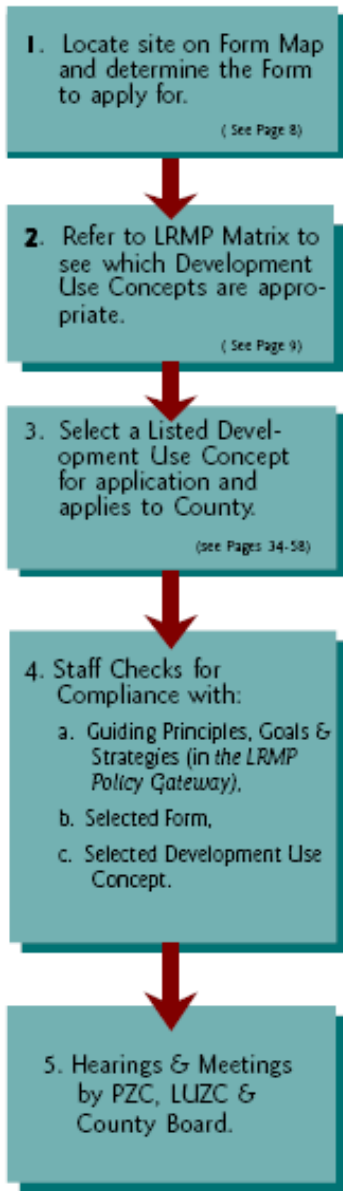
Semantic Referral Relationship

“Semantic referral relationship” refers to the semantic relationship from graphic A to graphic B, only if the graphic A refers to the graphic B in semantic logic. The relationship is a “directional relationship”. The “semantic referral relationship” is valid among different types of graphics.

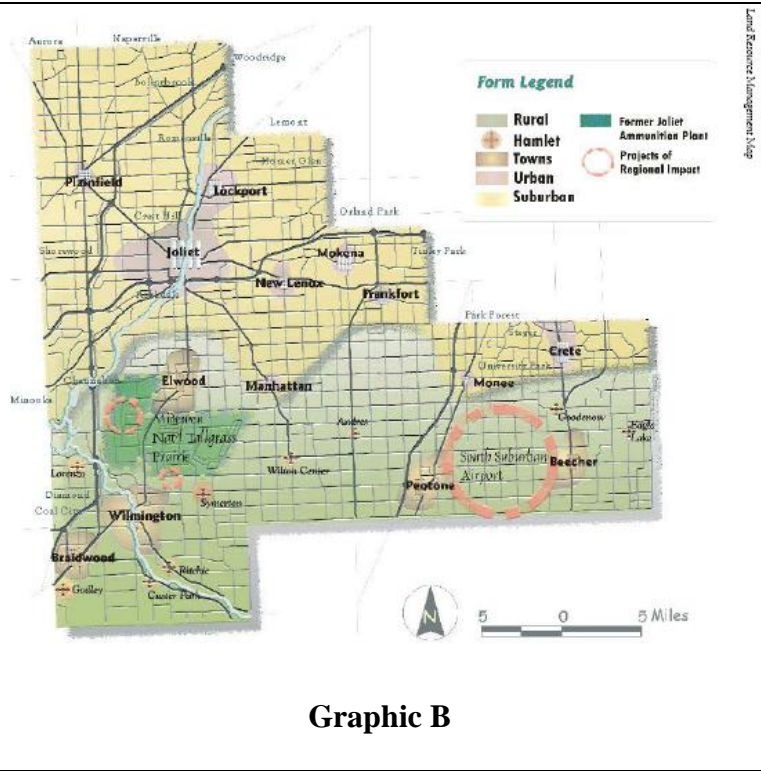
Figure 5.5 presents a typical example. The left graphic (Graphic A), a non-spatial diagram, presents a procedure that should be followed by Will County when reviewing the development proposal submitted by a petitioner. Graphic B, a development form map, is referred to by the first step of the review procedure, “Locate site on Form Map and determine the Form to apply for (see Page 8)”. Graphic C, a matrix of development forms and use concepts, is referred to by the second step, “Refer to LRMP Matrix to see which Development Use Concepts are appropriate (see Page 9)”. Obviously, the Graphic A has “semantic referral relationship” with the Graphic B, and the Graphic C. In addition, the Graphic C, which “illustrates the application of the individual Development Use Concepts in each of the defined Development Forms” (cited for statement under the Graphic C), also refers to graphic B that presents the development forms in Will County. This is to say, the Graphic C has “semantic referral relationship” with the Graphic B as well.

Normally, the graphic that is referred to in the semantic referral relationship is indicated by its name (e.g. Form Map, LRMP Matrix mentioned in the Graphic A, Development Forms mentioned in the Graphic C), its location (e.g. Page 8, Page 9 mentioned in the Graphic A) or figure number (e.g. Figure 50).

Figure 1: Process Flow Chart



Graphic A



Graphic B

		Development Forms							
		RURAL Pg. 30-32	HAMLET Pg. 13-14	TOWN Pg. 15-18	URBAN COMMUNITY Pg. 19-22	SUBURBAN COMMUNITY Pg. 23-26	INDUSTRIAL ACCESS LOCATION Pg. 27-28	FORMER JOLIAF Pg. 29-30	SSA Pg. 33-35
Development Use Concepts	AGRICULTURAL Pages 3-23	*	*						*
	CONSERVATION DESIGN Pages 3-29	*		*		*			
	CONVENTIONAL RESIDENTIAL SUBURBAN Pages 40-42			*		*			
	TRADITIONAL RESIDENTIAL Pages 43-45		*	*	*	*			*
	MULTI-FAMILY COMPLEX Pages 46-47			*	*	*	*		*
	EMPLOYMENT CAMPUS Pages 48-50			*	*	*	*	*	*
	REGIONAL COMMERCIAL Pages 51-53			*	*	*	*		*
	MID-SIZE COMMERCIAL Pages 54			*	*	*	*		*
	NEIGHBORHOOD COMMERCIAL Pages 55-56	*	*	*	*	*	*		*
	TRANSIT-ORIENTED INDUSTRY & OFFICE Pages 57-59		*	*	*	*	*	*	*
	PROJECTS OF REGIONAL IMPACT Pages 60-61			*	*	*	*	*	*

This Table illustrates the application of the individual Development Use Concepts in each of the defined Development Forms. Each Form and Use Concept is accompanied by an abbreviated version of this table specific to each.

Graphic C

Figure 5.5 Examples of “semantic referral relationship”.
(From LRMP: Forms and Concepts Handbook, p. 7, p. 8, p. 9)

5.2 Relationship between Single Graphic and Text Entity

Relationships between a single graphic entity and a text entity are summarized in Figure 5.6. All of the relationships are semantic relationships. The relationships are also classified into “non-directional relationship” and “directional relationship”, according to whether the relationship is for both directions. Obviously, the classification is exclusive. That is, a relationship can not be categorized into “non-directional relationship” and “directional relationship” at the same time.

In the following passage, “semantic complementarity relationship”, “exemplar illustration relationship”, “keyword defining relationship”, and “semantic extendedness relationship” are defined and illustrated with examples one by one.

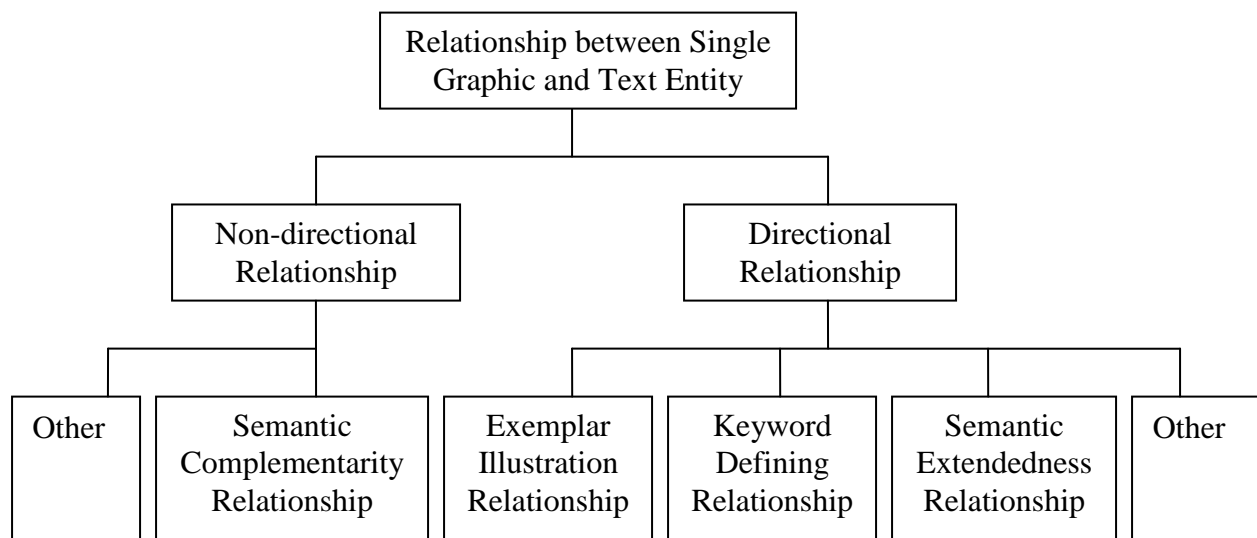


Figure 5.6 Relationships between single graphic and text entity

Semantic Complementarity Relationship

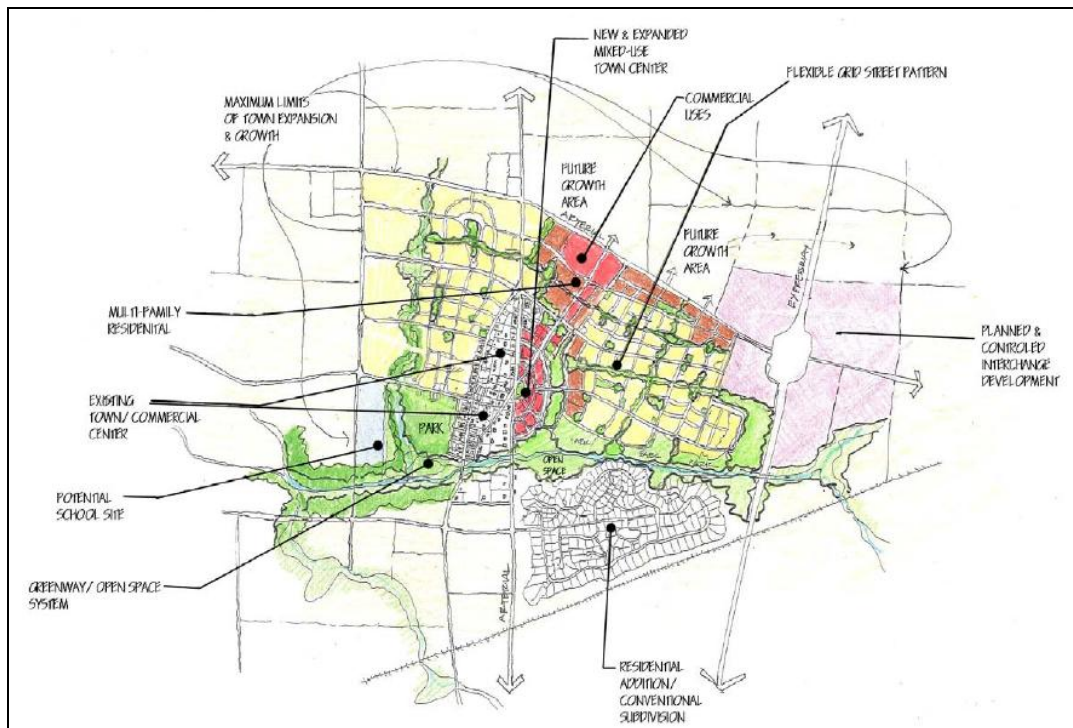
“Semantic complementarity relationship” refers to the semantic relationship between a single graphic entity and a text entity, when each of them communicates the same topic and two of them together are more comprehensive than either one of them alone. In other words, navigating the two entities together could help plan users to easily understand the intended plan information.

The relationship is a “non-directional relationship”. In the relationship, the text entity could not be substituted for the single graphic, and vice versa.

Figure 5.7 presents a typical example. The diagram on the top visually illustrates a typical town, including the features: “multi-family residential”, “commercial uses”, “potential school site”, “greenway/open space system”, “existing town/commercial center”, and “new and expanded mixed-use town center” (p.15, annotations on the diagram, Land Resource Management Plan: Forms and Concepts Handbook). The text at the bottom also describes typical characteristics of a town. The corresponding words, in parallel with the features in the diagram, are highlighted by underlines below.

Towns typically have a variety of land uses including single and multi-family residential, businesses, services, industrial, institutional and civic uses. Towns generally provide at least some municipal services, such as police, fire, sewer, water, drainage, and parks. They also usually have a historic core or “downtown” business district. They are incorporated and have locally elected legislative bodies, which means that they are not within the County’s zoning and subdivision jurisdiction. With each Town having independent planning boards or commissions, countywide planning coordination is a challenge. (From Land Resource Management Plan: Forms and Concepts Handbook, p. 15)

Either the single graphic or the text presents the typical patterns of town development, and meanwhile each provides complementary explanation for the other one in the semantic relationship. Specifically, the graphic visually illustrates parts of textual contents, and the text provides context to help readers comprehend the intended plan idea presented by the graphic.



Semantic Complementarity

Towns typically have a variety of land uses including single and multi-family residential, businesses, services, industrial, institutional and civic uses. Towns generally provide at least some municipal services, such as police, fire, sewer, water, drainage, and parks. They also usually have a historic core or “downtown” business district. They are incorporated and have locally elected legislative bodies, which means that they are not within the County’s zoning and subdivision jurisdiction. With each Town having independent planning boards or commissions, countywide planning coordination is a challenge.

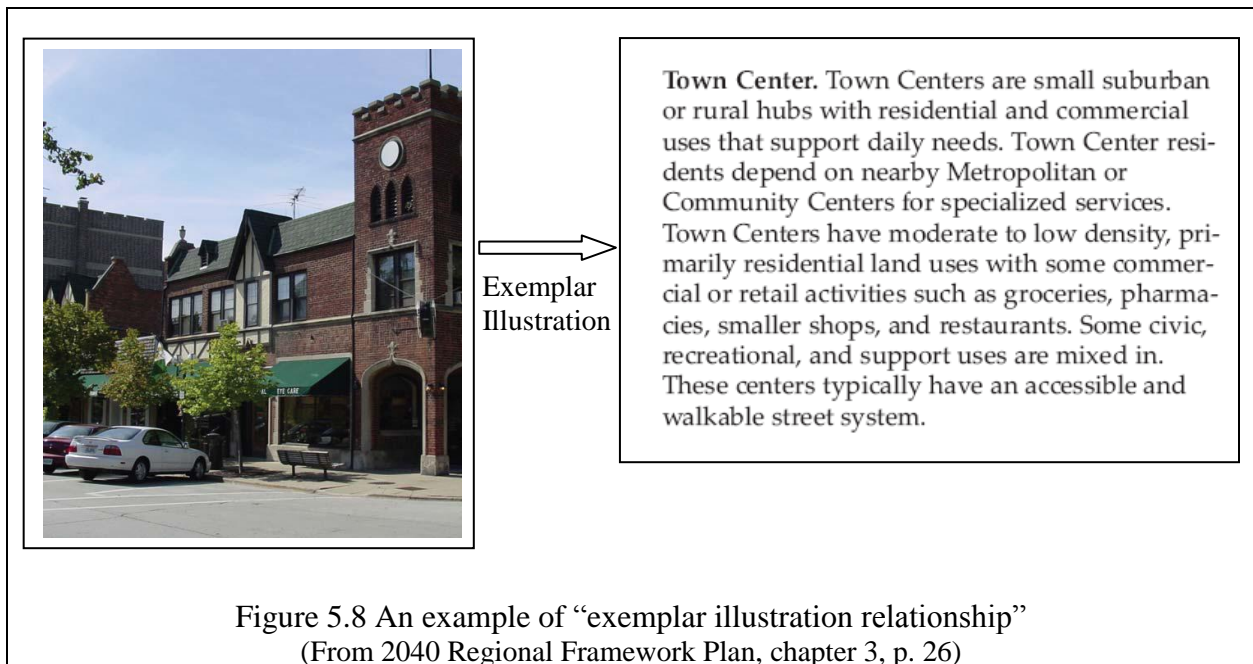
Figure 5.7 A typical example of “semantic complementarity relationship”. Either the single graphic or the text presents the typical patterns of town development, and meanwhile either of them provides complementary explanation for the other one in semantic.

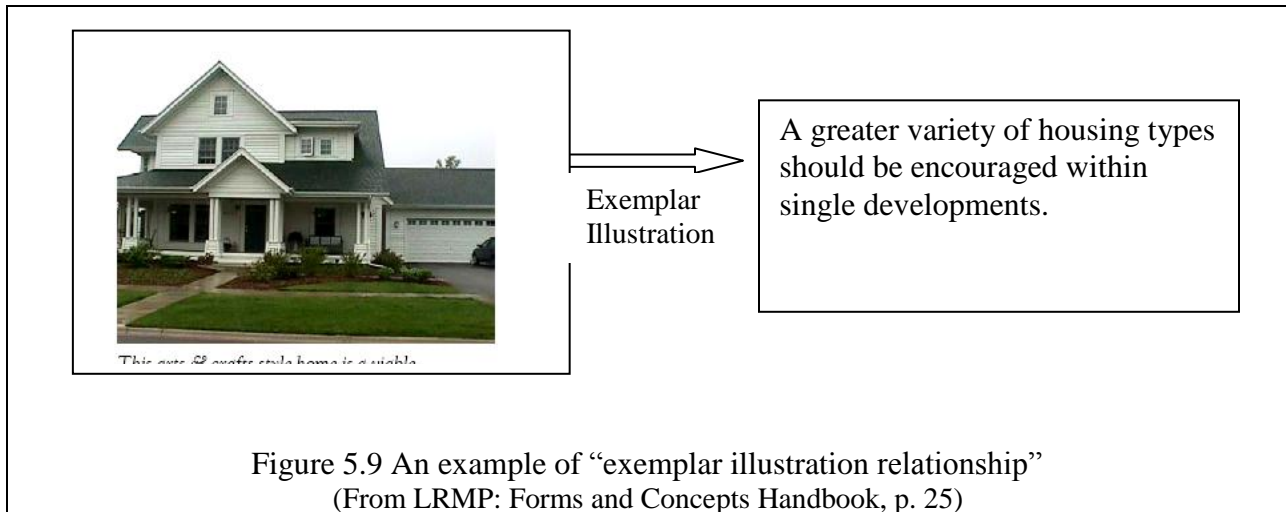
(From LRMP: Forms and Concepts Handbook, p. 15)

Exemplar Illustration Relationship

“Exemplar illustration relationship” refers to the semantic relationship between a single graphic entity and a text entity if the graphic illustrates the textual statement by presenting a typical example or from one specific perspective. The relationship is a “directional relationship”.

Figure 5.8 and Figure 5.9 show two typical examples. In Figure 5.8, the left graphic portrays Flossmoor, which includes restaurants and shops in its downtown area, as a Town Center. By visually illustrating an instance of Town Center, the graphic provides an exemplar illustration to the text on the right, which states the essential features of a Town Center. In Figure 5.9, the left graphic portrays “arts and crafts style home”, which is a viable alternative to traditional suburban architecture. By showing an example of alternative architectural style in residential development, the graphic presents an exemplar illustration to the right textual statement, “a greater variety of housing types should be encouraged within single developments” (From LRMP: Forms and Concepts Handbook, p. 25).



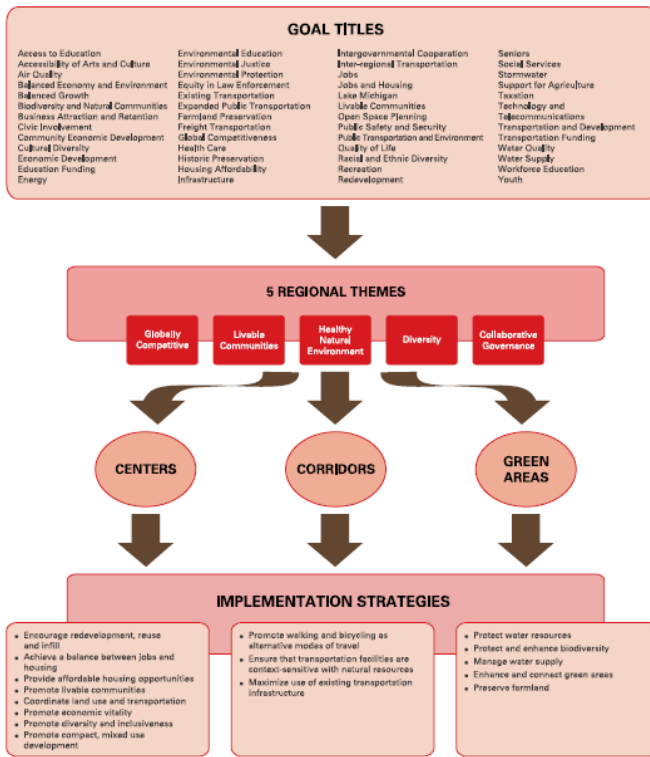


Keyword Defining Relationship

“Keyword defining relationship” refers to the semantic relationship between a single graphic entity and a text entity, if the graphic illustrates one or more keywords or partial content of the text. In the relationship, the keywords or the partial content being illustrated by the graphic should be identified. The relationship is a “directional relationship”.

Figure 5.10 and Figure 5.11 present two typical examples. In Figure 5.10, the left graphic presents how fifty-two regional goals blend into five themes, and further into three sets of implementation strategies for developing centers, corridors, and green areas. It has “keyword defining relationship” to the text on the right by illustrating three keywords – “52 regional goals”, “five core themes”, and “the themes were crafted to provide a condensed summary of the 52 goals”. In Figure 5.11, the graphic on the left portrays the layout of Braidwood, a town in southwestern Will County. It has “keyword defining relationship” to the text on the right by illustrating the keyword “Braidwood”.

▼ Figure 1: How Regional Goals Blend into Themes and Implementation Strategies



Keyword Defining

After this public review process, the Commission voted in March 2003 to endorse the 52 regional goals and the set of five core themes. The themes were crafted to provide a condensed summary of the 52 goals that could be easily communicated to new audiences.

Figure 5.10 The graphic, which illustrates three underlined keywords, has “keyword defining relationship” to the text.

(From 2040 Regional Framework Plan, chapter 4, p. 96-97)



Braidwood: A Town in southwestern Will County.

Keyword Defining

The Town Form of development includes larger communities such as Braidwood, Wilmington, Elwood, Peotone, and Beecher (compared to Hamlets) that are generally found in the southern half of Will County. Unlike their counterparts in the northern half of the County – the Urban Community Form – Towns are more geographically independent. They are typically surrounded by Agricultural or Rural Areas, rather than adjoining municipalities or Suburban Areas.

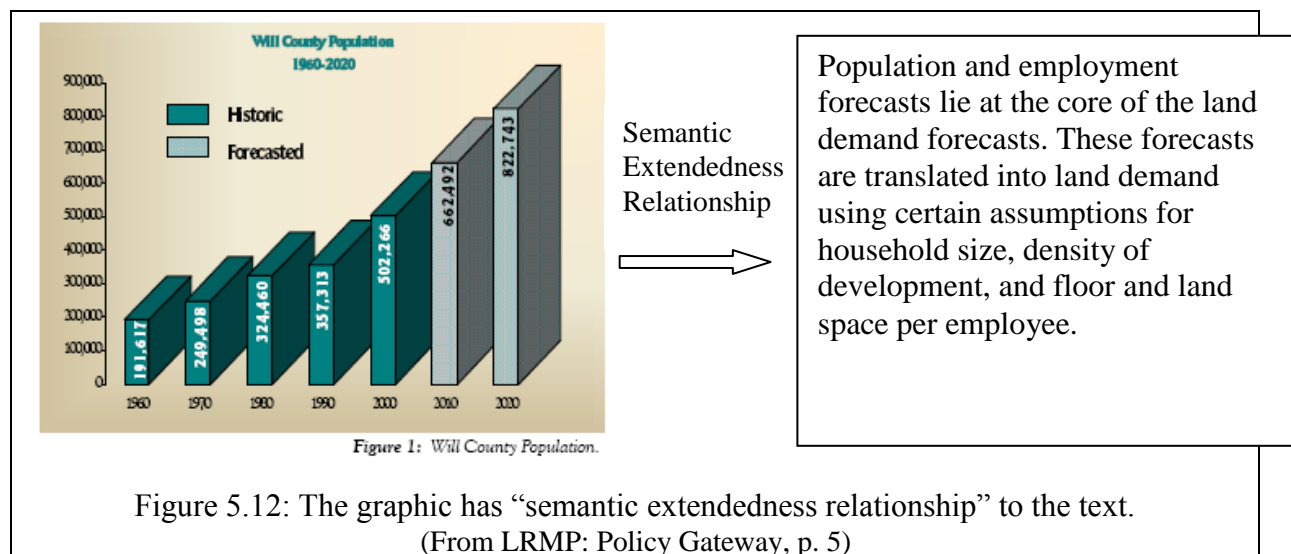
Figure 5.11 The graphic, which illustrates keyword “Braidwood”, has “keyword defining relationship” to the text.

(From LRMP: Forms and Concepts Handbook, p. 17)

Semantic Extendedness Relationship

“Semantic Extendedness Relationship” refers to the semantic relationship from a single graphic entity to a text entity when the graphic initiates an idea and the text as a follow-up presents other information semantically related to the idea, for instance, impacts of the idea. The relationship is a “directional relationship”.

Figure 5.12 and Figure 5.13 present two typical examples. In Figure 5.12, the graphic shows the historic data of population growth in Will County from 1960 to 2000 and the anticipated data from 2000 to 2020. The text further extends the statement of the population growth presented by the graphic to the next level, namely, the rationale of the population growth, which is used to predict the land demand. Therefore, the graphic has “semantic extendedness relationship” with the text. In Figure 5.13, the table presents the comparison of twenty years land demand and capacity for development within Will County. It shows that “even under the most aggressive growth forecasts (assuming the South Suburban Airport is built), there is substantially more capacity for growth than there is demand” (Land Resource Management Plan: Policy Gateway, p. 7). The text on the right further describes what this situation means for the County in two perspectives. In other words, the text presents the significant effects of the situation presented in the table. Thus, the graphic has “semantic extendedness relationship” to the text.



	Demand Existing Airports Acres	South Suburban Airport Acres	Capacity Acres
Residential			
Total	91,796	112,001	263,141
Non-Residential			
Total	3,272	6,054	31,074
TOTAL	95,068	118,055	294,215

Figure 4: Comparison of twenty year land demand and capacity for development within Will County.

Semantic
Extended-
ness
Relationship

What does this mean for the County? On the one hand, having capacity far in excess of demand can be a concern in that it may foster a more “sprawled”, less efficient land use pattern. It can also lead to unproductive competition between communities for economic development where there is an excess of planned industrial areas. On the other hand, if managed properly, there is an opportunity for the County to “have its cake and eat it too”: There is ample land to support a generation worth of growth, while at the same time preserving open space, farms, and environmentally sensitive land.

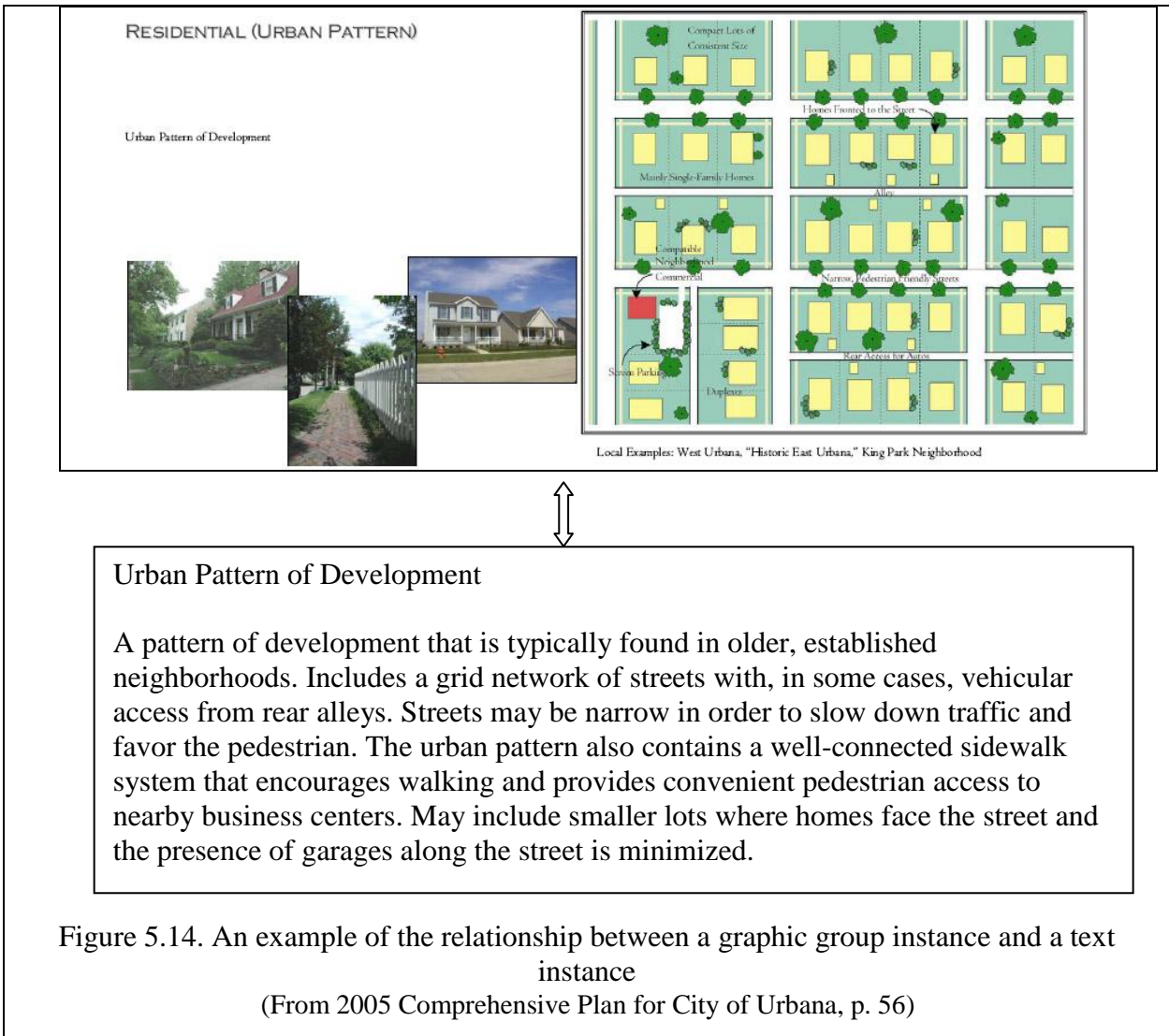
Figure 5.13: The table has “semantic extendedness relationship” to the text.
(From LRMP: Policy Gateway, p. 7)

5.3 Relationship between Graphic Group Entity and Text Entity

For the sake of completeness in the context of encoding plan documents, semantic relationship between a graphic group entity and a text entity is introduced in this chapter. This relationship is defined with a coarse-grained way in response to the few examples that are known so far.

Figure 5.14 shows an example. The graphic group visually presents what the “urban pattern” residential area looks like. The lower part is the content of a text entity, which also describes the typical features of the “urban pattern” residential area. The graphic group entity and the text

entity have semantic relationship, since both of them present a same topic and both together can communicate the topic better than either one alone.



5.4 Relationship between Text Entities

To accommodate the natural association from one textual segment to another in the plan documents, semantic relationship between two text entities is introduced in this chapter. This relationship is loosely defined without detailed classification because it is not closely related to the main focus of the research, graphic representation.

The following is an example of this relationship. The first text entity describes the future land use of Will County, which includes “Development Forms” and “Development Use Concepts”. The second text entity illustrates the “Development Forms”. And the third text entity illustrates the “Development Use Concepts”. In semantic logic, the second and third text entity elaborates parts of content included in the first text instance. In other words, the first text entity has semantic relationship with the second text entity and the third one.

Text entity #1

In keeping with the Guiding Principles and the Goals and Strategies that serve as the driving force of the Will County Land Resource Management Plan (LRMP), the following is the future land use element of the Plan. This land use element focuses on land use at a regional level. It emphasizes the form of development, and addresses the way in which various land uses should and should not occur in different areas. The future land use element includes “Development Forms” and “Development Use Concepts”. (Land Resource Management Plan: Forms and Concepts Handbook, p. 4)

Text entity #2

Development Forms refer to the general character of large areas of the County. As contrasted with specific land uses, the identification of Forms is a way to identify distinguishable development patterns, or “Forms” at a countywide level, and to use these Forms as a way to manage the County’s land resources. Development Forms include

- Rural Area
- Hamlet
- Town
- Urban Community
- Suburban Community
- Interstate Access Location
- Former Joliet Army Ammunition Plant Area (JOAAP)

- South Suburban Airport (SSA)

A description of each of these Form Areas is illustrated on a map. A series of “keystones” are then presented for each area. These keystones are statements of desired characteristics of each Form, and are intended to serve as a guide to the County and its various communities in assessing development proposals, and in particular helping to ensure that new growth occurs as part of a countywide vision. (Land Resource Management Plan: Forms and Concepts Handbook, p. 4-5)

Text entity #3

Following the Development Forms, a series of “Development Use Concepts” are then introduced. Development Use Concepts include

- Agricultural
- Conservation Design
- Conventional Residential Suburban
- Traditional Residential
- Multi-family Complex
- Employment Campus
- Regional Commercial
- Mid-scale Commercial
- Neighborhood Commercial
- Free Standing Industry and Office
- Projects of Regional Impact

These Development Use Concepts focus on more specific land use categories. While not going to the level of traditional site-specific land uses (i.e. single family, multi-family, office, retail, etc.) the Use Concepts are intended to provide additional guidance to the County and its communities in assessing specific development proposals. It is recognized that individual communities in the County will continue to develop and enforce land use regulations that fit their

particular needs, and this plan makes no effort to interfere with those efforts. The Use Concepts are intended to offer guidance that can help bridge the gap between “Forms” on a countywide scale, and specific land use regulations on a local community scale.

As a transition from the Development Forms to the Use Concepts, a matrix introduces each concept type and identifies which one is encouraged for which Form. (Land Resource Management Plan: Forms and Concepts Handbook, p. 4-5)

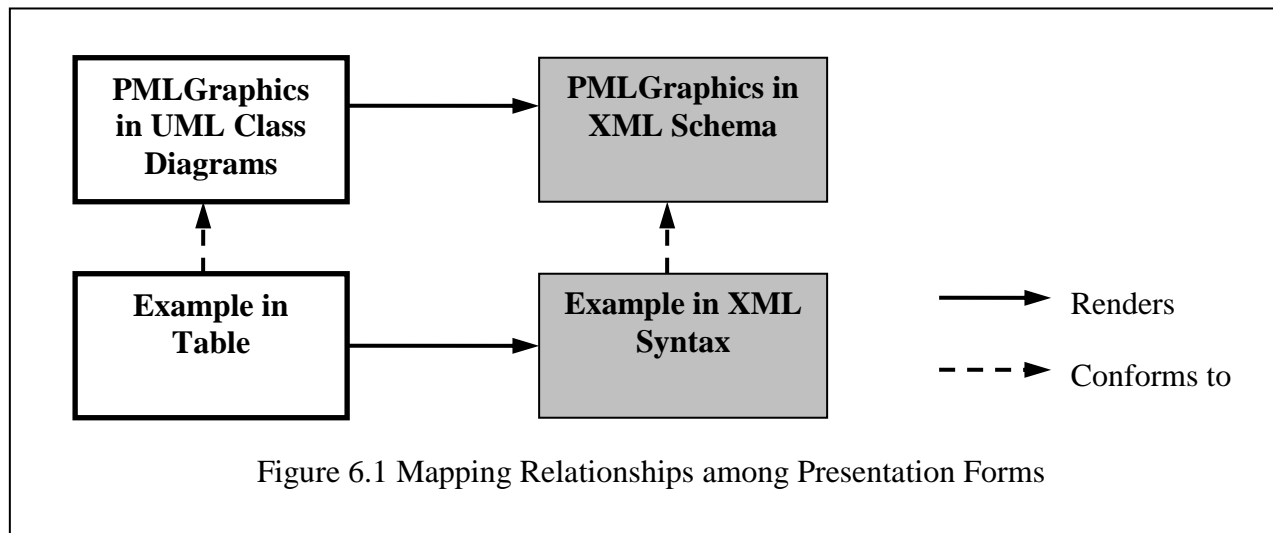
5.5 Conclusion

In this chapter, I have illustrated the four types of relationships between content entities. Extensive categorization is undertaken for first two relationships, namely, the relationship between two single graphic entities and the relationship between a single graphic entity and a text entity. The remaining two relationships, the relationship between a graphic group entity and a text entity and the relationship between two text entities, are briefly introduced without detailed classification.

This chapter thoroughly builds conceptual foundation for developing data model of relationships in the PMLGraphics. The next chapter presents the proposed PMLGraphics in the form of Unified Modeling Language (UML) diagrams, which provide easily readable representation for the PMLGraphics in XML schema shown in Appendix B.

6. PMLGraphics

In this chapter, the proposed PMLGraphics is presented piece by piece in the Unified Modeling Language (UML) class diagrams. The UML diagrams provide intuitive and easily understandable presentation forms for the PMLGraphics in XML schema. After presenting and defining a small piece of the PMLGraphics, one or two examples conforming to it are shown for further illustration. The examples are presented in the form of a table, which renders the corresponding XML syntax in an easily readable way. How the four different presentation forms, UML diagrams, XML schema, XML codes, and tables, map to each other exactly is illustrated in Appendix A.



The examples are from the four plans introduced before. They are

- *2005 Comprehensive Plan* for City of Urbana,
- *2040 Regional Framework Plan* made by Northeastern Illinois Planning Commission (NIPC),
- *The Metropolis Plan: Choices for the Chicago Region* made by Chicago Metropolis 2020, and
- *Land Resource Management Plan (LRMP)* including three documents, *Policy Gateway*, *Forms and Concepts Handbook*, and *Open Space Element*.

When defining and describing the PML extension, names of classes are in bold, and the corresponding label names that are the human-readable labels assigned to the classes are surrounded by quotation marks when presented for the first time. Data members of a class are underlined.

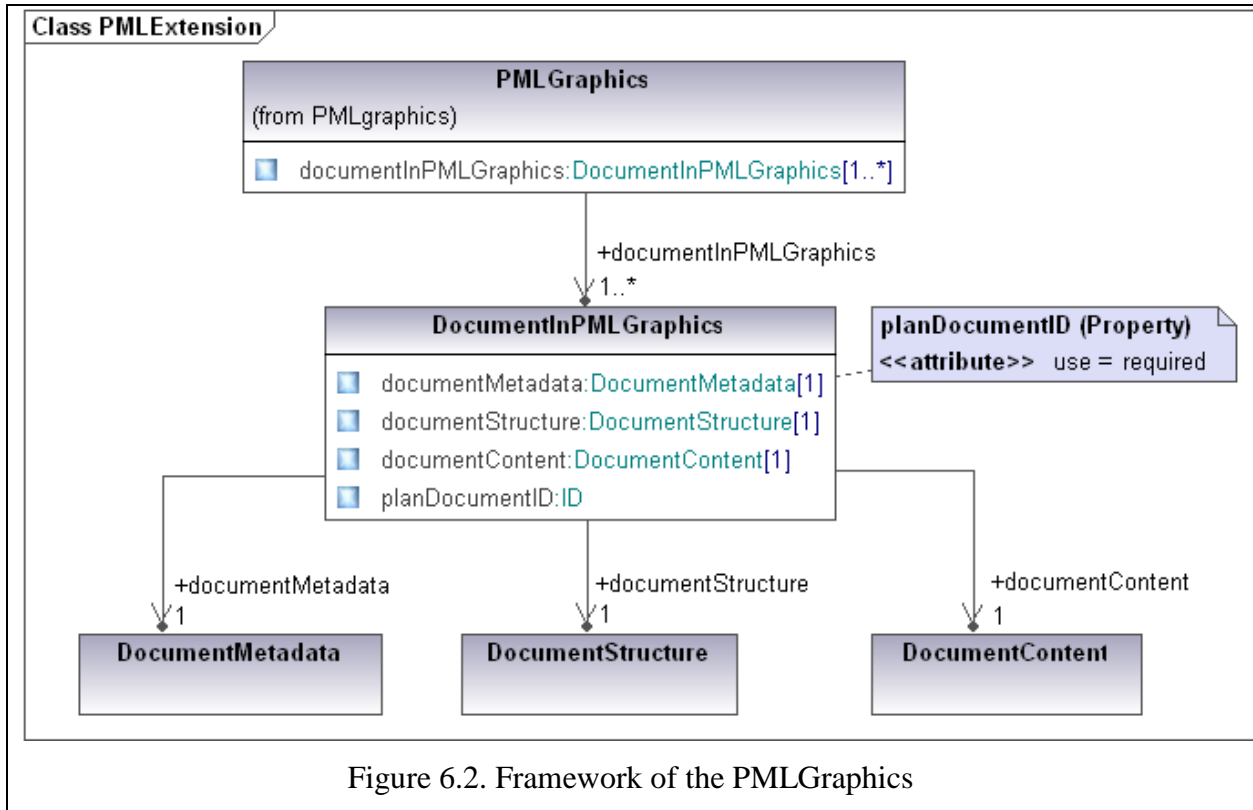


Figure 6.2. Framework of the PMLGraphics

As shown in Figure 6.2, “PMLGraphics” (modeled as **PMLGraphics**) could include one or more “encoded plan document” (modeled as **DocumentInPMLGraphics**). Each encoded plan document has a unique ID for identification, and is composed of three parts:

- “document metadata” (modeled as **DocumentMetadata**), which describes general information of a plan document (e.g. plan name, functions, geographical scope being affected, and authors),
- “document structure” (modeled as **DocumentStructure**), which presents the hierarchical structure of topics in a plan document,
- “document content” (modeled as **DocumentContent**), which includes three types of content entities (text entities, single graphic entities, and graphic group entities) for

presenting detailed plan information in a plan document and relationships among the different types of content entities.

Each of them -- document metadata, document structure, and document content – is defined and illustrated with examples in the following sections. In addition, the rationale of developing each of them is also introduced.

Among them, the document content is more significant and contains more information than the other two parts, since it is directly related to the central theme of the research -- how to encode graphic content of plan documents. Markup language in the document content builds on the theoretical study in Chapters Four and Five. Specifically, Chapter Four significantly contributes to developing a subset of the mark up language for single graphic and graphic group, and the Chapter Five exhaustively builds foundation for developing the markup language for relationships among different types of content entities.

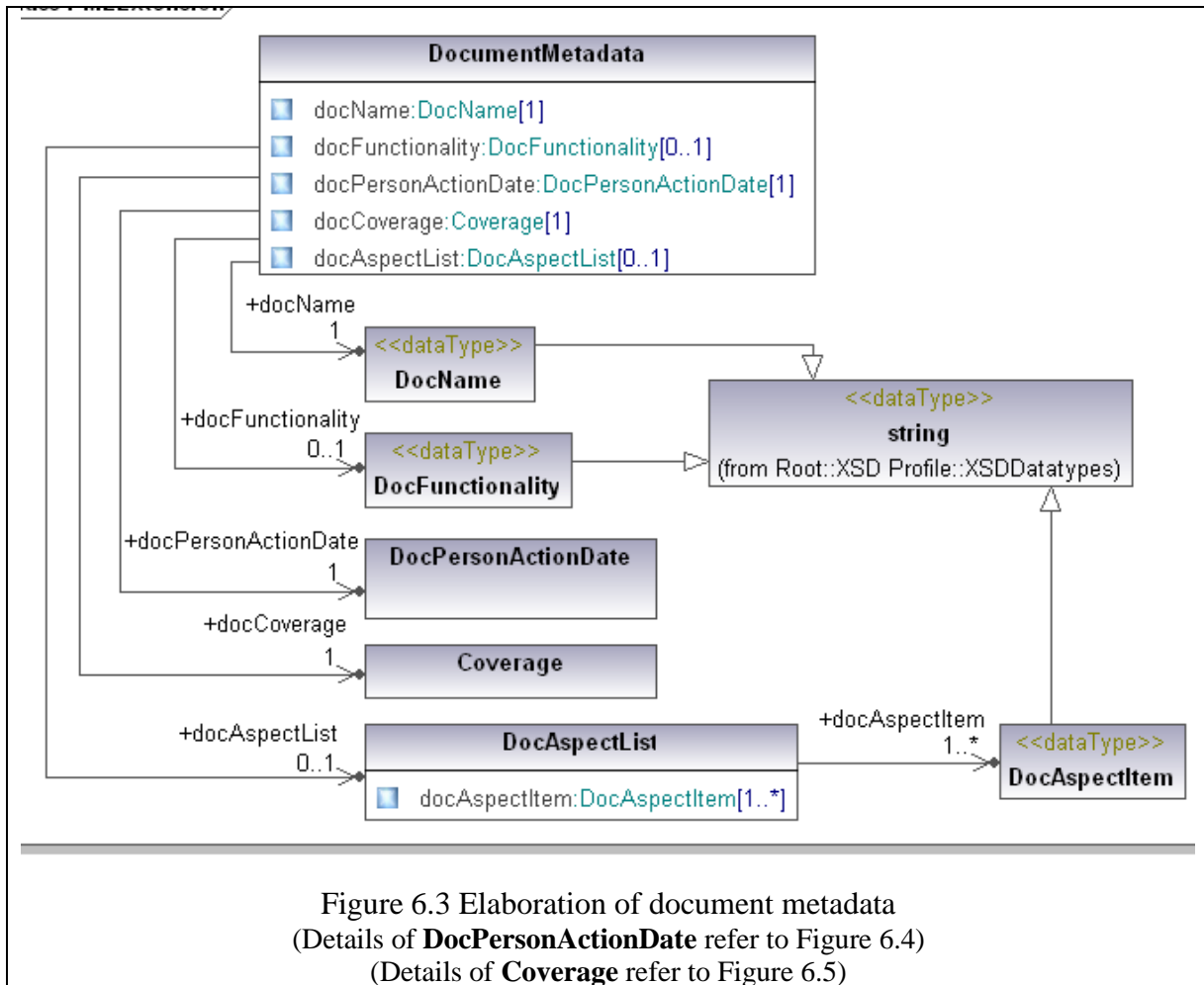
6.1 Document Metadata

“Document metadata” (modeled as **DocumentMetadata**) describes general information of a plan document. Being an outline, it serves to familiarize plan users with essential issues (e.g. name, function, authors, scope, and aspects) of a plan document at a first glance. It can help users to choose pertinent documents from a number of documents in a short time. Refreshing the general information can also help users to comprehend detailed content of a document.

Document metadata (see Figure 6.3) includes five types of information of a plan document:

- “document name” (modeled as **DocName**),
- “document functionality” (modeled as **DocFunctionality**),
- “document-person-action-date” (modeled as **DocPersonactionDate**) presenting actors doing what actions at when,
- “geographical coverage” (modeled as **Coverage**), and
- “document aspect list” (modeled as **DocAspectList**) presenting what kinds of aspects the document is about.

Each of them is defined and illustrated one by one below.



Document name (see Figure 6.3) records the name of a plan document. It is required for document metadata, since every plan document should have a name, and the name is significant for identification. A document name is a string.

Document functionality (see Figure 6.3) contains a statement of main purposes or desires of a plan document. It is optional but highly recommended for document metadata. It is not unusual that functionality of a plan document is not obvious at a first glance. Document functionality is in the form of string.

Document aspect list (see figure 6.3) presents a list of issues a plan document mainly concerns. It is optional but highly recommended for document metadata. It includes one or more “aspect” (modeled as **DocAspectItem**). It is in the form of a string. Five values -- “land use”, “transportation”, “infrastructure”, “environmental preservation”, and “cultural preservation” -- are recommended, however, not required. The five entries have already been illustrated in Section 4.3, “Plan Information Conveyed by a Graphic”. When appropriate, the value of the aspect can be customized by encoders.

Document-person-action-date (modeled as **DocPersonActionDate**) (see Figure 6.4) presents information of who did what actions for the plan at what time. For instance, Will County Planning Committee drafted a Comprehensive plan in the year 2005. It is required for document metadata. It could include one or more sets of “who-did-what-when information” (modeled as **DocPersonActionDateItem**).

- The “who” could be “a group of persons” (modeled as **PersonGroup**), “a group of organizations” (modeled as **OrganizationGroup**), or a combination of them. “Each person” (modeled as **Person**) must have a “last name” (modeled as **LastName**) and a “first name” (modeled as **FirstName**), and may have a “middle name” (modeled as **MiddleName**). “Each organization” (modeled as **Organization**) has its own name. The names of individuals in an organization are ignored given that they are not important enough to be encoded.
- The “did-what” (modeled as **Action**) is a string (e.g. draft, write, or adopt).
- The “when” (modeled as **Date**) could be presented as a date in specific year, month, and day. However, month and day are optional.

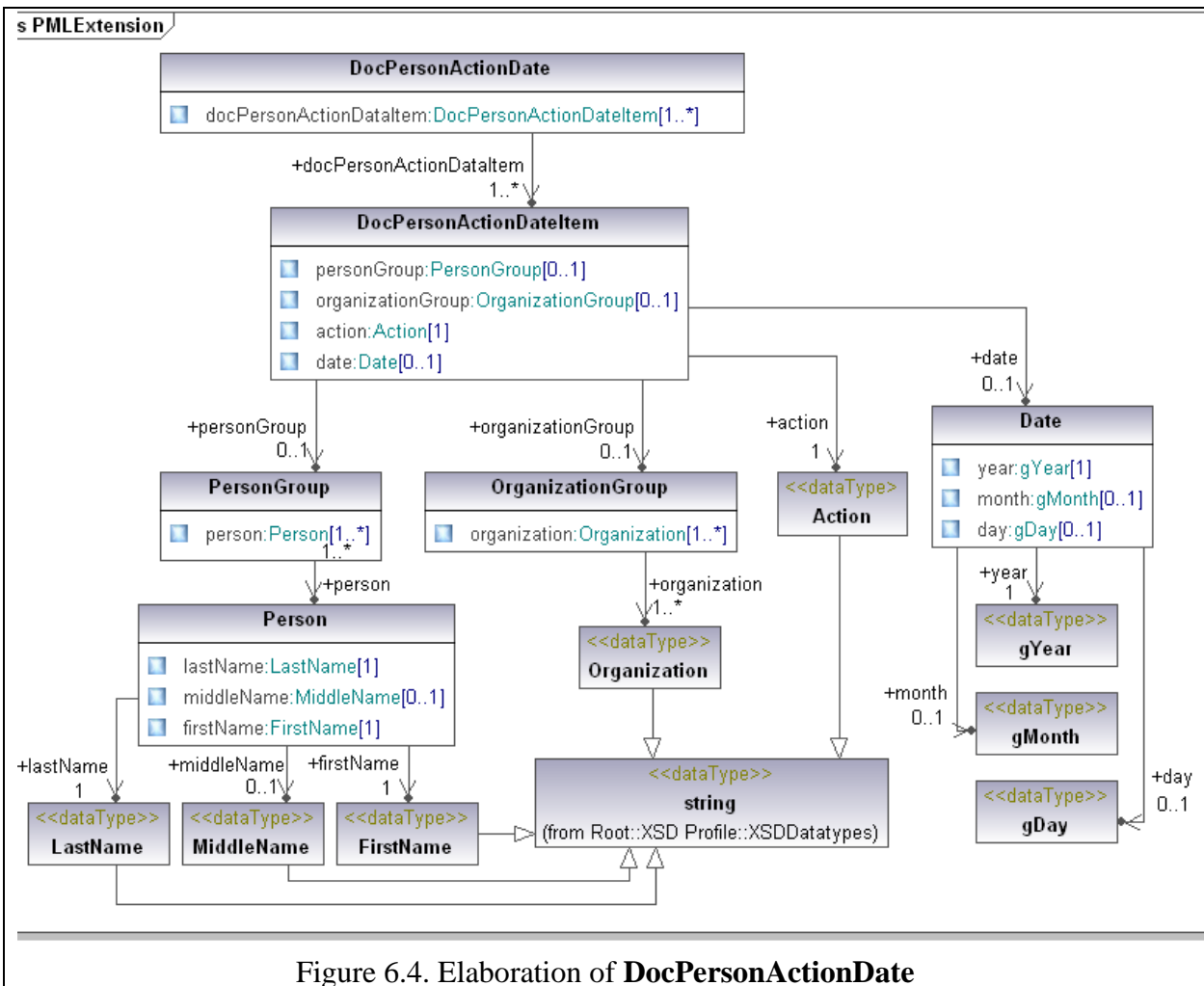
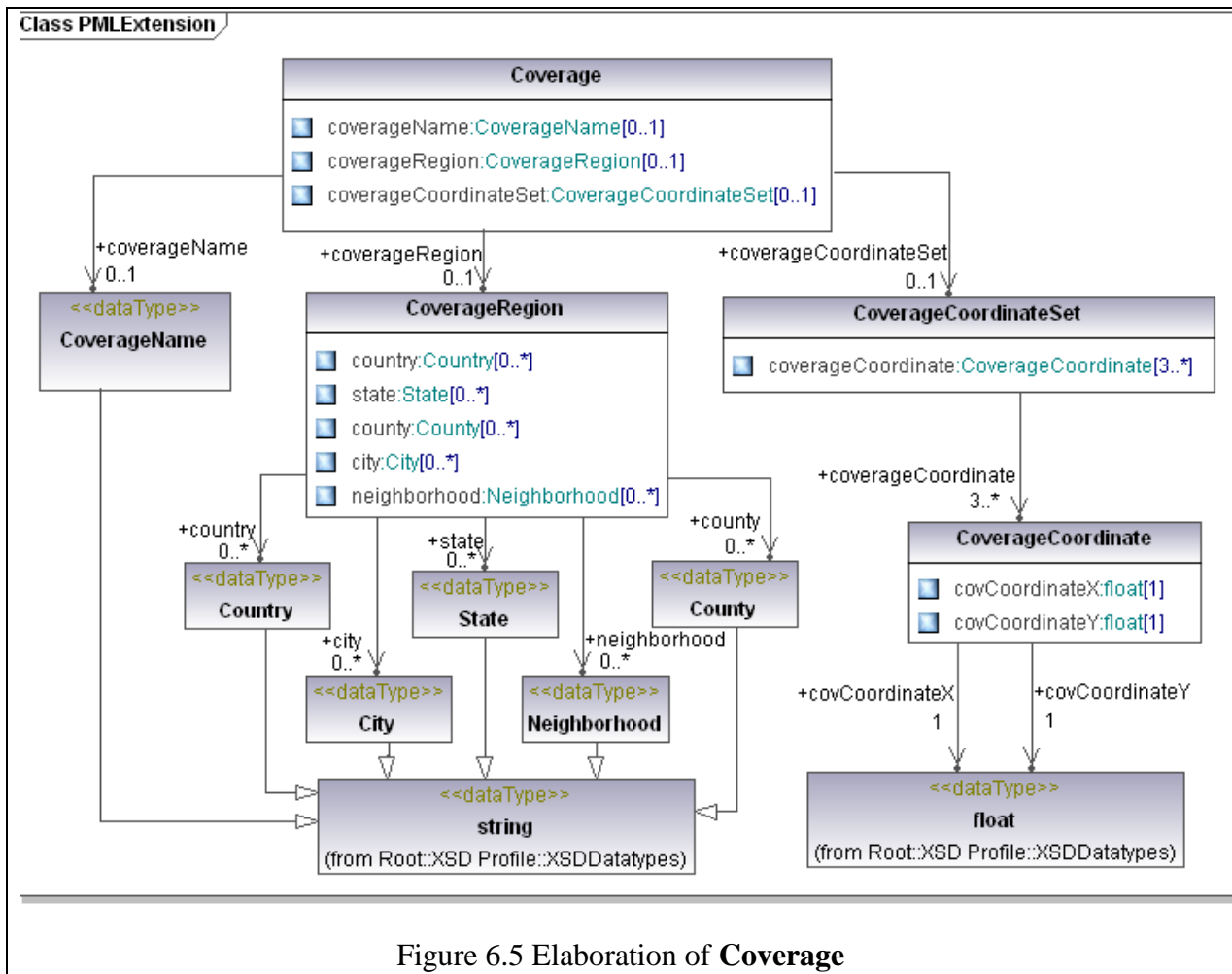


Figure 6.4. Elaboration of **DocPersonActionDate**



Coverage (see Figure 6.5) records the geographical range that the plan document intends to have an impact on. It is required for document metadata, since each plan document should always have an affected geographical range. The coverage could be defined in three ways:

- First, it could be identified by “its name” (modeled as **CoverageName**), such as Chicago metropolitan area.
- Secondly, it could be identified by named “geographical units” (modeled as **CoverageRegion**), which could include zero or more “neighborhood” (modeled as **Neighborhood**), “city” (modeled as **City**), “county” (modeled as **County**), “state” (modeled as **State**), and “country” (modeled as **Country**). For example, the coverage of 2005 Comprehensive Plan is **City**: Urbana, **State**: Illinois, and **Country**: U.S.
- Thirdly, it could be defined by “a set of coordinate pairs” (modeled as **CoverageCoordinateSet**), which includes one or more “coordinate pair” (modeled as

CoverageCoordinate). Each pair of coordinates is required to have two elements – X coordinate and Y coordinate. This method is feasible only when the coordinate data are available. It is the most accurate way to define an area, though it is not readable for human.

Table 6.1 presents document metadata of *2005 Comprehensive Plan* for City of Urbana, which conforms to the data model presented before. One thing to be noticed is there are two sets of who-did-what-when information in the third table:

- Urbana City Council, Community Development Services Department, Comprehensive Plan Steering Committee, and Urbana Plan Commission made the plan;
- Urbana City Council adopted the plan on April, 11, 2005.

Data Member	Value
docName	<i>2005 Comprehensive Plan</i>

Data Member	Value
docFunctionality	<i>The plan provides a vision statement for City of Urbana. The vision statement was crafted around four key themes: Who We Are, What We Value, Where We Want To Go, and How We Get There. These themes are an integral part of the comprehensive plan and serve as its guiding principles. The Vision offers the foundation for the Plan by identifying what Urbana is and what it can become. The ultimate goal is for Urbana to realize its full potential by sustaining community character, improving the quality of life, building stable neighborhoods, creating new and exciting opportunities, and achieving sensible growth.</i>

Data Member				Value
docPerson ActionDate	docPersonActionDateItem	organization Group	organization	<i>Urbana City Council</i>
			organization	<i>Community Development Services Department</i>
			organization	<i>Comprehensive Plan Steering Committee</i>
			organization	<i>Urbana Plan Commission</i>
	action			<i>contribute to make the plan</i>
	docPersonActionDateItem	organization Group	organization	<i>Urbana City Council</i>
			action	
		date	year	<i>2005</i>
month			<i>04</i>	
	day	<i>11</i>		

Data Member			Value
docCoverage	coverageRegion	city	<i>Urbana</i>
		state	<i>Illinois</i>
		country	<i>United States</i>

Data Member		Value
docAspectList	docAspectItem	<i>land use</i>
	docAspectItem	<i>transportation</i>
	docAspectItem	<i>infrastructure</i>
	docAspectItem	<i>quality of life</i>
	docAspectItem	<i>sensible growth</i>

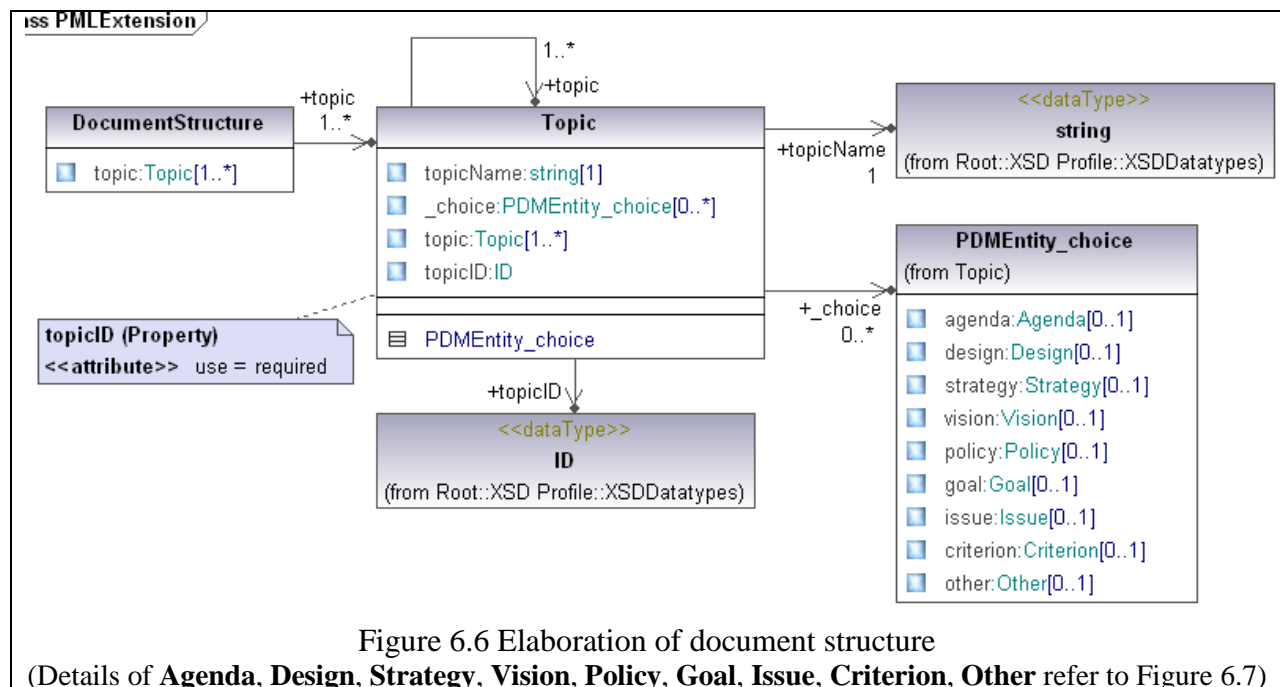
Table 6.1 Document metadata of 2005 Comprehensive Plan for City of Urbana

6.2 Document Structure

Generally, document structure presents the hierarchical structure of topics in a plan document that sets a framework of plan content, just like a skeleton for a human body. The hierarchical structure is significant for users to navigate and understand the plan content. By reviewing the framework at a quick glance, users could get a general sense of what the document is about. So, they can get hints of whether the whole document interests them or not, or which sections interests them most. When users navigate the detailed content, they can also better comprehend the content by browsing the overall document structure from time to time.

Under each topic, plan content is categorized into the plan-oriented entities (e.g. Agenda, Design, Strategy, and Vision) developed in the original PDM. It makes it feasible to search plan content in terms of these entities in the future if appropriate search engines are available. It also integrates the proposed PMLGraphics with the original PML .

The data model of “document structure” (modeled as **DocumentStructure**) is shown in Figure 6.6.



As we know, each plan document could include multiple chapters; each chapter could include multiple titles, and each title could include multiple subtitles, so on and so forth. Each chapter name and title could be viewed as a topic. Accordingly, the typical structure of a plan document is a tree-like hierarchical structure that organizes topics in orders. Consequently, document structure is defined to include one or more “topic” (modeled as **Topic**) that can refer to itself recursively.

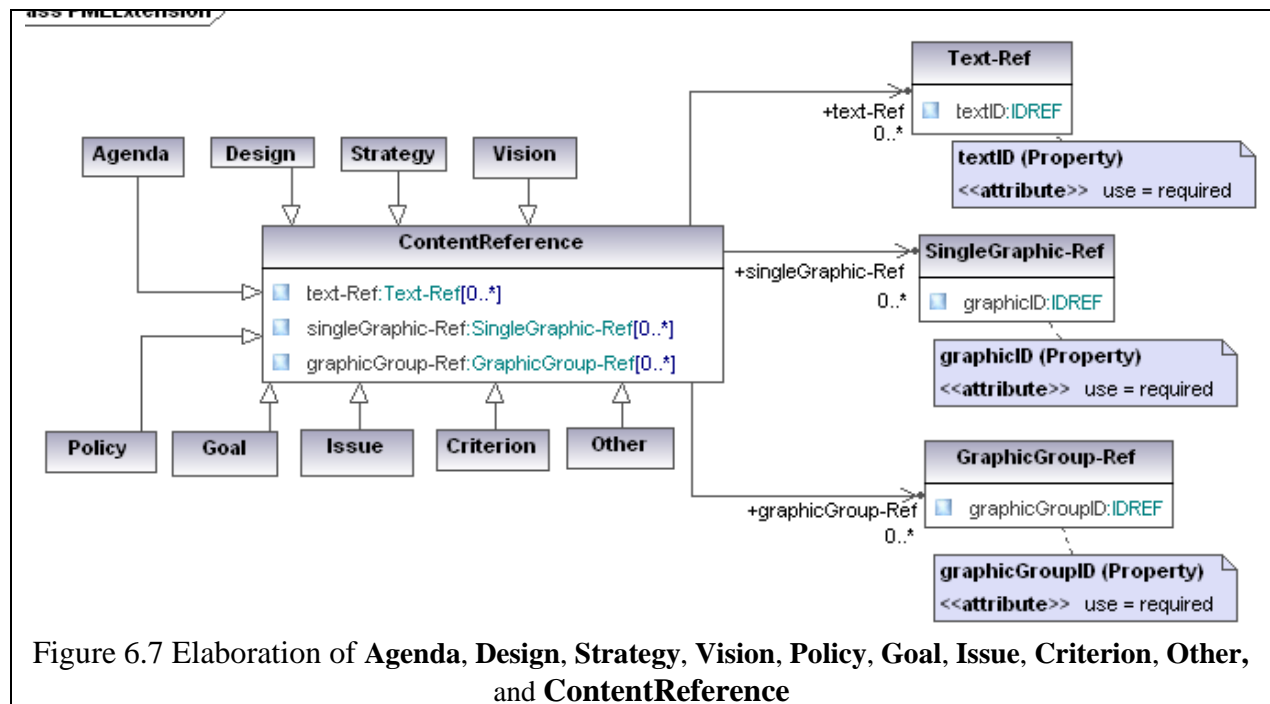
Each topic must include a unique ID and a topic name. Each topic (with **PDMEntities_choice** in between) could also include one or more **Agenda, Design, Strategy, Vision, Policy, Goal, Issue, Criterion, and Other**, which are to signify the category of plan content. The first eight originate from the eight entities that are defined as the most significant components of plans in the original PDM (Hopkins, Kaza, & Pallathucheril, 2005b). So the definitions of them refer to the explanations of the entities in the original PDM (see Table 6.2). The last one (**Other**) is created to contain the plan content that can not fit into the first eight.

Classes Originating from PDM	Explanation
Agenda	An agenda is a list of actions to be performed by actors.
Design	A design is work-out solution, which is a curious collection of amorphous relationships among actors, actions, assets, activities, and the relationships that bind them.
Strategy	A decision tree can be construed as a strategy.
Vision	Vision is an idea where one would like to be.
Policy	A policy is an if-then statement, which is applied repeatedly given a situation.
Goal	Goals are expressed as desired states of the world, or more specifically desired attributes of entities and relationships that define the state of the world.
Issue	Issues are about the difference between desirable states of the world and perceived existing states of the world.
Criterion	Criteria are indicators about existing or expected states of the world expressed in measurable terms.

Table 6.2 Explanation of eight classes originating from the original PDM

Notes: The explanations are from the paper “Representing urban development plans and regulations as data: a planning data model” (Hopkins, Kaza, & Pallathucheril, 2005b).

It is worth noting that the eight classes defined in this data model do not take over the built-in structures defined in the entities of the original PDM (Hopkins, Kaza, & Pallathucheril, 2005b). For instance, a piece of plan information related to a list of actions is encoded in an instance of **Agenda** as a whole. However, the whole piece is not further decomposed to make it fit into the child entities (that are, **action** and **future world**) of the original agenda. There are two reasons for this simplification. First, the built-in structures of the eight entities in the original PDM are still in the very early stage of development without being fully tested in practice. It is expected that PDM will keep evolving for years to come until it matures. Second, the main focus of my research is not on testing and revising the original PDM, but on developing data models to markup graphic content in plan documents.



As we mentioned, plan content, which is presented by text entity, single graphic entity, and graphic group entities, could be categorized into one of the nine groups (**Agenda**, **Design**, **Strategy**, **Vision**, **Policy**, **Goal**, **Issue**, **Criterion**, and **Other**). In other words, the three presentation types are common features of the nine classes. To model it, a super class **ContentReference** of the nine classes is built. The data members of the super class are inherited by the nine classes as shown in Figure 6.7. The super class could (however, is not required) include one or more references of text entity, single graphic entity, or graphic group entity,

which are modeled as **Text-Ref**, **SingleGraphic-Ref**, and **GraphicGroup-Ref** respectively. Each of the three types of references must have an ID to refer to the corresponding content entity.

In the process of encoding, references of content entities should be ordered to correspond to the original orders of plan content. Thus, references of the three types of content entity could be presented repetitively, and in any order as needed. The aim is to keep the built-in semantic logic in the order of the original plan content, which is important for users to navigate and understand the encoded plan content.

To further illustrate the data model, document structure of the section that describes the development form of town (p.15 - p.18) in *LRMP: Forms and Concepts Handbook* for Will County, Illinois is presented in Table 6.3.

It can be seen that the topic “Town” (with topicID = *topicFormsTownID_1*) is composed of two subtopics:

- “Background” (with topicID = *topicFormsTownBackgroundID_1*) and
- “Keystones” (with topicID = *topicFormsTownKeystonesID_2*).

The topic “Background” is represented by four text entities (with textID = *textFCTownID_1*, *textFCTownID_2*, *textFCTownID_3*, *textFCTownID_4*) and three single graphic entities (with singleGraphicID = *graphicFCTownID_1*, *graphicFCTownID_2*, *graphicFCTownID_3*) in a specific order. The topic “Keystones” is represented by one text entity (with textID = *textFCTownID_5*) and one single graphic entity (with singleGraphicID = *graphicFCTownID_4*).

Data Member			Value	
topic	<<attribute>> topicID		<i>topicFormsTownID_1</i>	
	topicName		<i>Town</i>	
topic	topic	<<attribute>> topicID		<i>topicFormsTownBackgroundID_1</i>
		topicName		<i>Background</i>
	policy	text-Ref	textID	<i>textFCTownID_1</i>
		text-Ref	textID	<i>textFCTownID_2</i>
		text-Ref	textID	<i>textFCTownID_3</i>
		text-Ref	textID	<i>textFCTownID_4</i>
		singleGraphic-Ref	singleGraphicID	<i>graphicFCTownID_1</i>
		singleGraphic-Ref	singleGraphicID	<i>graphicFCTownID_2</i>
singleGraphic-Ref	singleGraphicID	<i>graphicFCTownID_3</i>		
topic	<<attribute>> topicID		<i>topicFormsTownKeystonesID_2</i>	
	topicName		<i>Keystones</i>	
	policy	text-Ref	textID	<i>textFCTownID_5</i>
		singleGraphic-Ref	singleGraphicID	<i>graphicFCTownID_4</i>

Table 6.3 Document structure of the section that describes the development form of town (p.15 – p.18) in LRMP: Forms and Concepts Handbook.

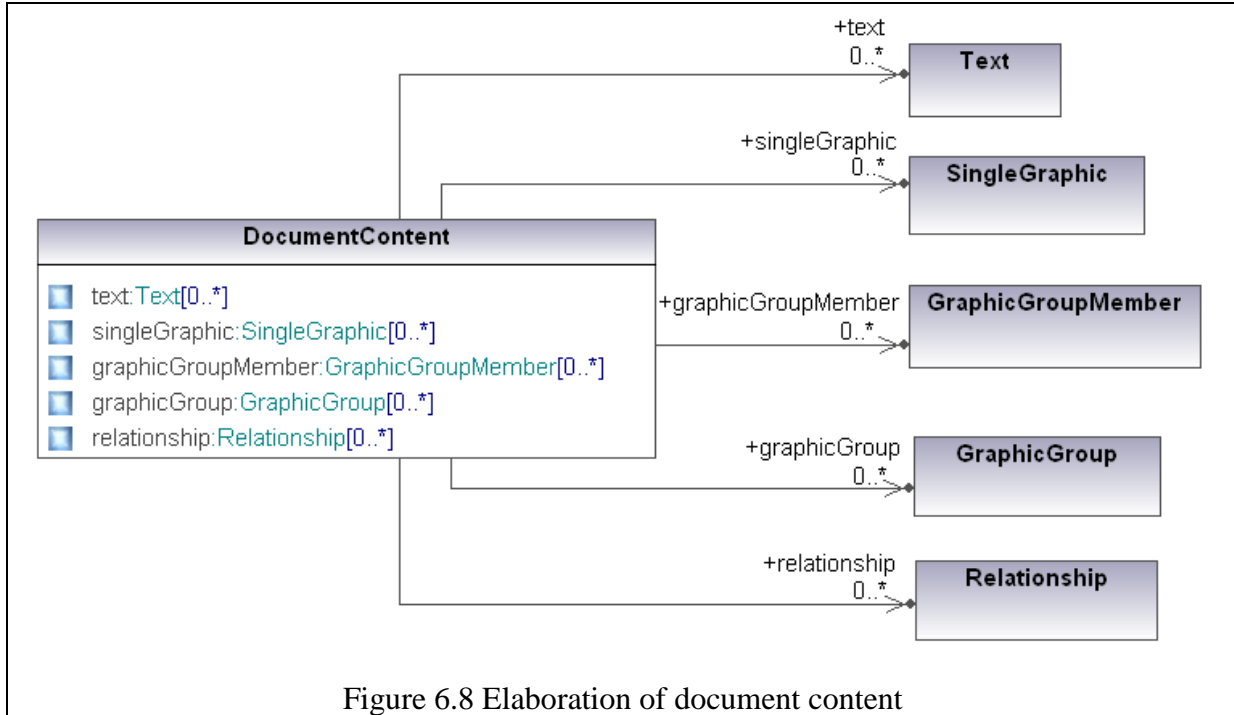
6.3 Document Content

“Content of a plan document” (modeled as **DocumentContent**) (see Figure 6.8) could be presented in

- “text” (modeled as **Text**),
- “single graphic” (modeled as **SingleGraphic**),
- “graphic group” (modeled as **GraphicGroup**) that includes two or more “members of the graphic group” (modeled as **GraphicGroupMember**), and
- “relationship among text entity, single graphic entity, and graphic group entity” (modeled as **Relationship**).

Part of the data model of single graphic and graphic group originates from the research in Chapter Four. The data model of relationships is based directly on the exhaustive discussion in Chapter Five.

The data model of text, single graphic, graphic group including group members, and relationship is illustrated and exemplified one by one in the following sections.



6.3.1 Text

Text (see figure 6.9) records one piece of textual content. It must have a unique ID, so it can be referred to in the document structure. It also includes a data member, textContent, for recording the textual content. The length of textual content can vary from very short (e.g. one or two sentences) to rather long (e.g. covering several paragraphs in the original document).

The following shows an example, which encodes a piece of textual content in page 23 of *2005 Comprehensive Plan* for City of Urbana (see Table 6.4).

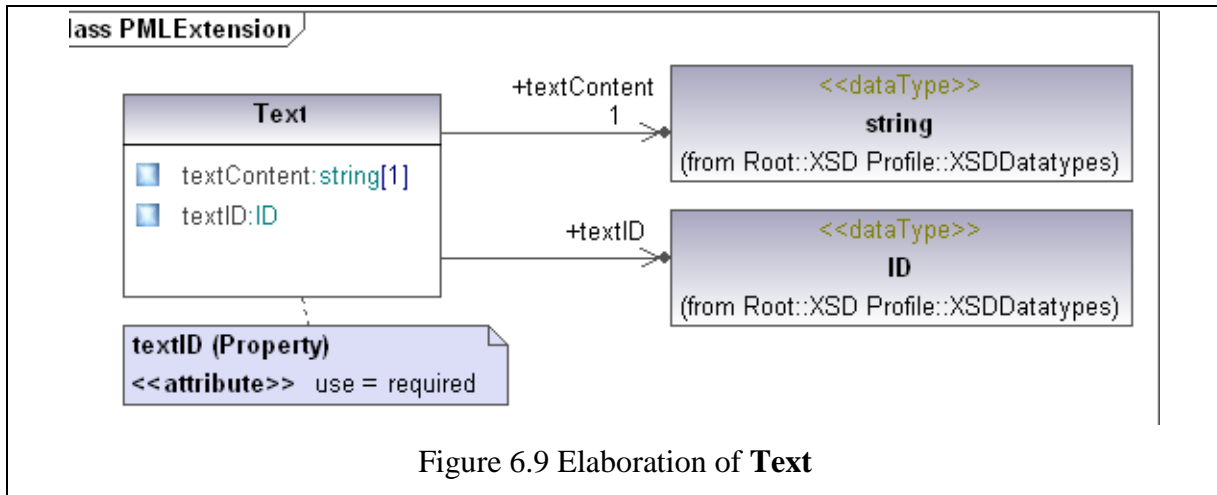


Figure 6.9 Elaboration of **Text**

Data Member	Value
<code><<attribute>> textID</code>	<i>textUrbanaTrendID_2</i>
<u>textContent</u>	<i>Urbana has experienced significant residential growth over the past several years. Since 1995 approximately 460 single-family homes have been constructed and over 1,200 multi-family units have been constructed. In 2002 an all time high 176 building permits were issued for single-family home construction. Most of the single-family construction has occurred in east and southeast Urbana, while most of the multi-family development has occurred close to campus.</i>

Table 6.4 An example of text entity

Based on my encoding experience, four principles of how to encode the continuous text in the original document into text entities are summarized below.

- 1) To facilitate users comprehension of plan content, keep the original text in document as much as possible. It is not suggested to summarize or extract textual content because both practices are very subjective to the styles or experiences of encoders, and it will be difficult to regulate the quality of encoding.
- 2) For simplicity, textual content in each original paragraph is regarded as the smallest encoding unit. That is to say, content in a single paragraph is coded as a whole. It is not suggested to further explore relationships among sentences in a paragraph or relationship among words in a sentence.
- 3) If textual content in a paragraph has relationships with other content entities (including text entity, single graphic entity, graphic group entity), that portion of the

paragraph should be encoded as an individual text entity, in order to conveniently identify the relationship.

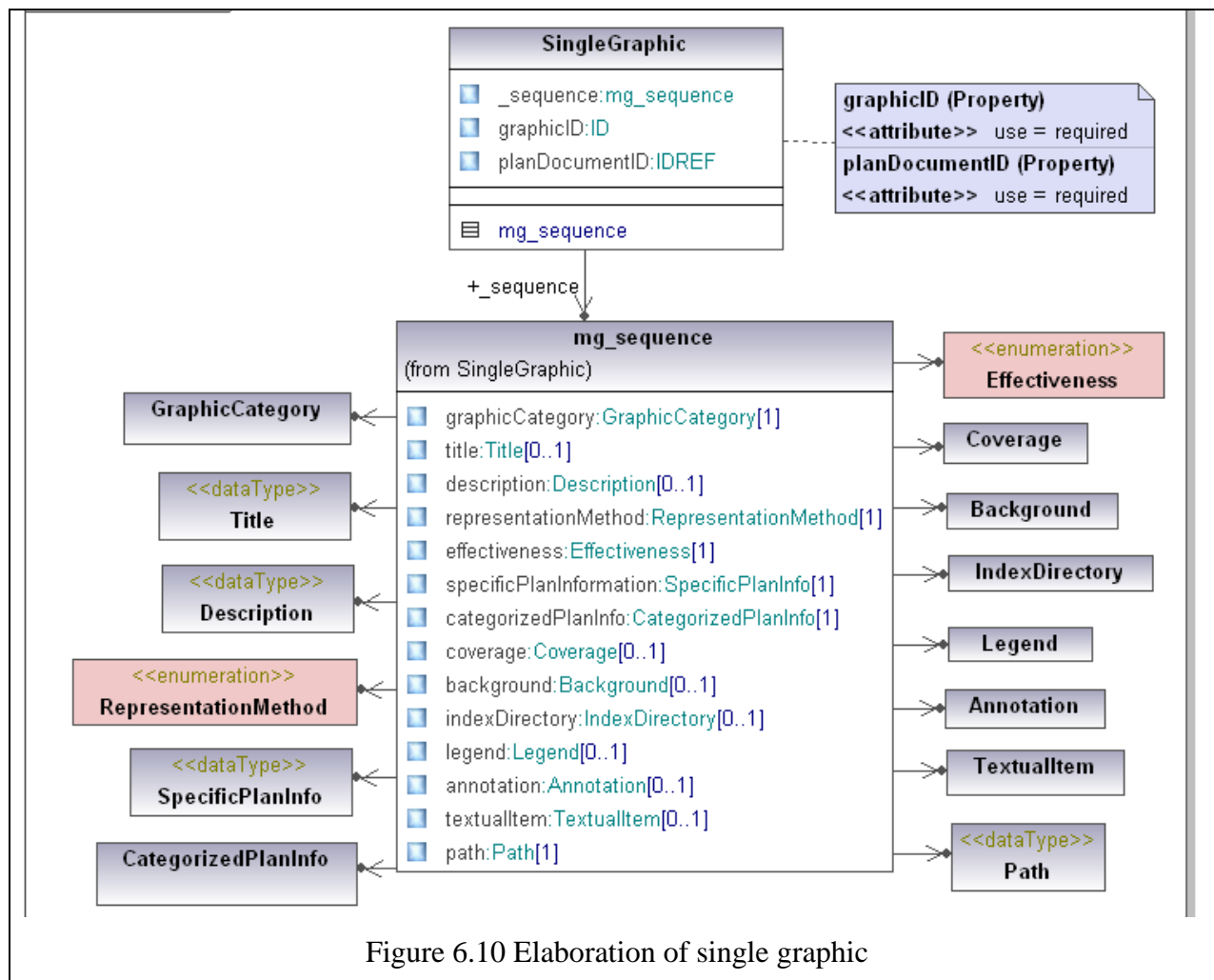
- 4) For simplicity, original text in several paragraphs could be encoded into one text entity.

6.3.2 Single Graphic

Data model of single graphic includes a collection of metadata for describing single graphic in plan documents. The metadata is specially designed for helping planning participants to retrieve graphic content in plan documents with the aid of intelligent information search engines. The metadata is developed by following three principles listed below.

- The metadata should index single graphics in “plan-usable” ways, so single graphics could be easily located by planning participants in appropriate ways.
- The metadata should be comprehensive and flexible to mark up a variety of single graphics in plan documents.
- The metadata should be manageable and feasible in the practice of encoding.

One thing that needs to be addressed is that the purpose of developing metadata of a single graphic is not to use textual tags to reproduce every detail of the graphic. It is not feasible or effective, because a graphic could be worth ten thousand words (Tufte, 1987, 1990, 1997; Larkin, & Simon, 1987). The metadata should be a set of indexes that effectively point to single graphics in “plan usable” ways so that the graphic itself can convey its full information content.



In the data model, a “single graphic” (modeled as **SingleGraphic**) must have a graphicID for identification, and a planDocumentID for signifying which plan document the graphic belongs to (see Figure 6.10). A single graphic could be described by at most fourteen metadata, which are modeled by fourteen classes respectively. In general, the fourteen metadata describe features of a single graphic in five perspectives, as Table 6.5 summarizes. Among the fourteen metadata, six of them (graphic category, representation method, specific plan information, categorized plan information, effectiveness, and path) are required for marking up a single graphic. The others are optional.

In the following, each of the fourteen metadata is defined one by one, and most of them are illustrated in details with examples. Five of them (graphic category, representation method,

categorized plan information, effectiveness, and index directory) are directly built on the theoretical study in Chapter 4.

Perspective	Class Name	Label Name	Required / Optional (O= Optional)
General information of single graphic	GraphicCategory	Graphic Category	Required
	Title	Title	O
	Description	Description	O
Single graphic and plan information it intends to convey	RepresentationMethod	Representation Method	Required
	SpecificPlanInfo	Specific Plan Information	Required
	CategorizedPlanInfo	Categorized Plan Information	Required
	Effectiveness	Effectiveness	Required
	Coverage	Coverage	O
Context of single graphic	Background	Background	O
	IndexDirectory	Index Directory	O
textual terms in single graphic	Legend	Legend	O
	Annotation	Annotation	O
	TextualItem	Textual Item	O
Physical location	Path	Path	Required

Table 6.5 Metadata of single graphic
(Label name is human-readable label assigned to the class name)

Graphic Category

“Graphic category” (modeled as **GraphicCategory**) identifies “graphic type of a graphic” (modeled as **Type**), as well as labels “whether it is an index graphic or not” (modeled as index) (see Figure 6.11). It is developed based on the theoretical study in Chapter 4.2, Taxonomy of Graphic Representation. A graphic category is required for marking up a single graphic.

The values of **Type** are limited to a set of predefined values -- “Ground-level Image”, “Aerial-level Image”, “Graph”, “Table”, “Non-spatial Diagram”, “Spatial Diagram”, “Site Plan”, and “Map”. The controlled predefined values correspond to the eight graphic types that have been illustrated in Chapter 4.2.1, “Graphic Types”. The values of **Type** are exclusive, since a single graphic can not have two or more graphic types at the same time.

The value of index is a Boolean, either true or false. True indicates that the graphic is an index graphic, and **IndexDirectory**, which is illustrated later, should be expected. False indicates that the graphic is not an index graphic, and **IndexDirectory** should not be presented.

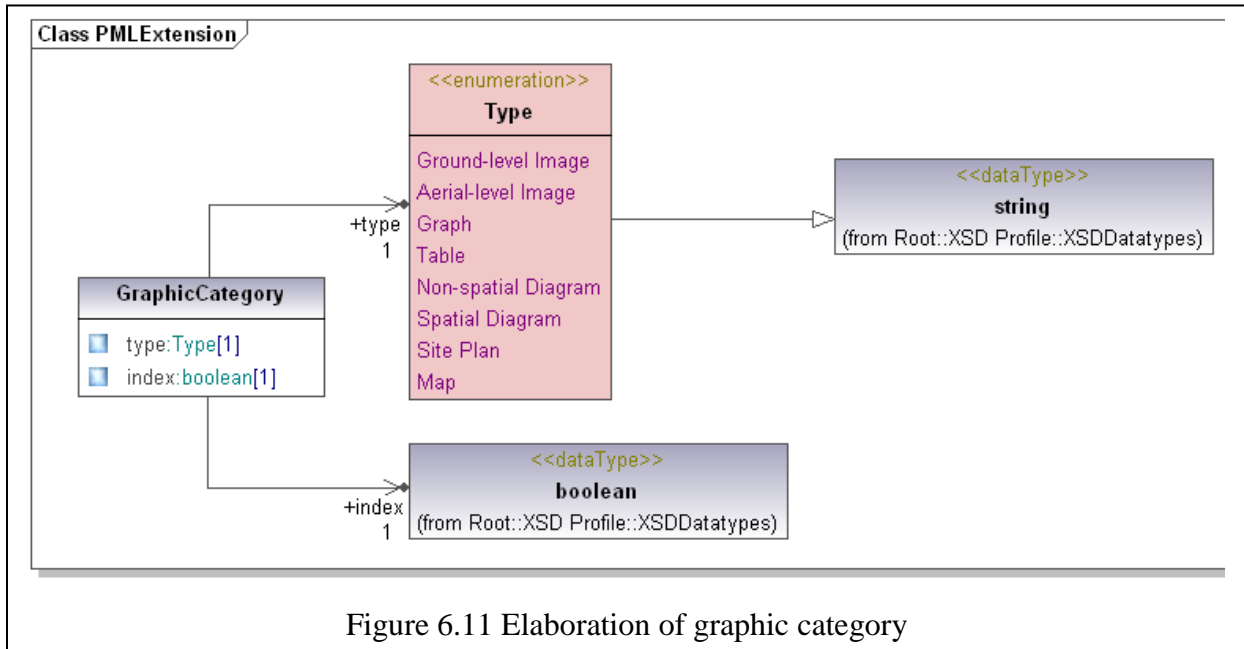


Figure 6.11 Elaboration of graphic category

Title

Title (see Figure 6.12) presents the caption or very brief description given to a graphic. Its value is a string, which usually comes from a caption or heading that is in print in the original document. Occasionally, it could be a short description written by encoders. A title is optional for marking up a single graphic.

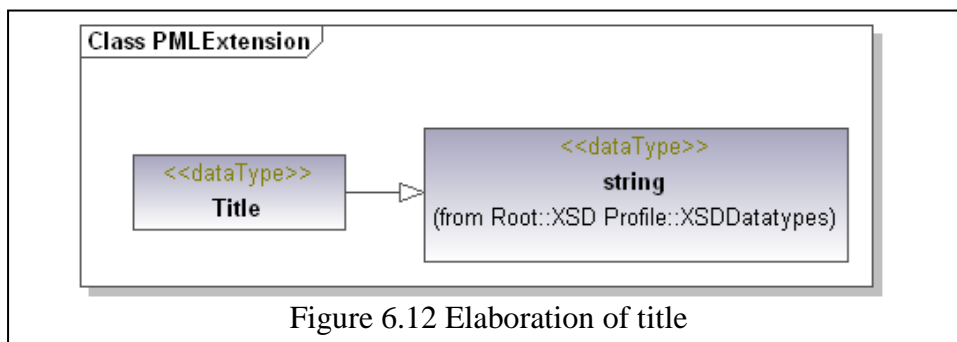
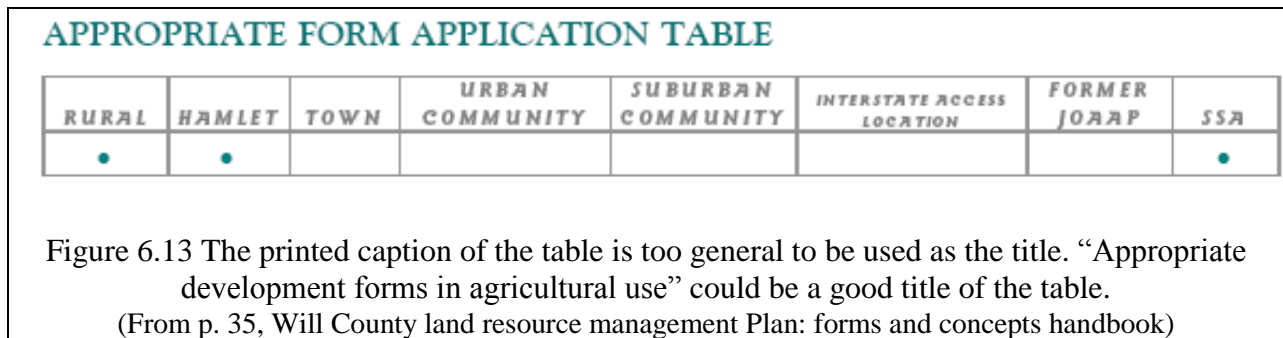


Figure 6.12 Elaboration of title

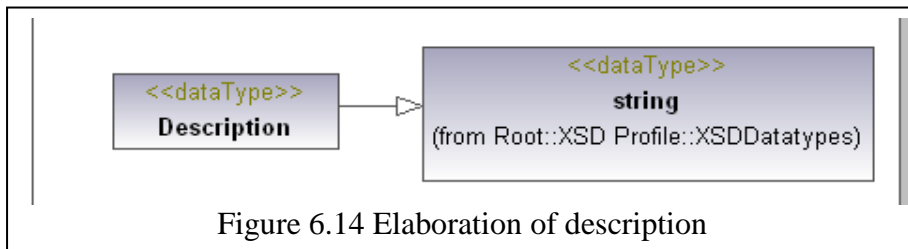
If appropriately defined, a title could help users to get a sense of graphic content before seeing a graphic. To identify title of a single graphic, a general suggestion is given below:

If there is a caption in print, and it presents graphic content precisely, directly use it as the title; otherwise, title can be left as blank.

One thing that needs to be mentioned is that not every caption in print is appropriate to be title of a graphic. For instance, the printed caption of the table in Figure 6.13, “appropriate form application table”, is too general to be used as the title. “Appropriate development forms in agricultural use” could be a good title of the table.



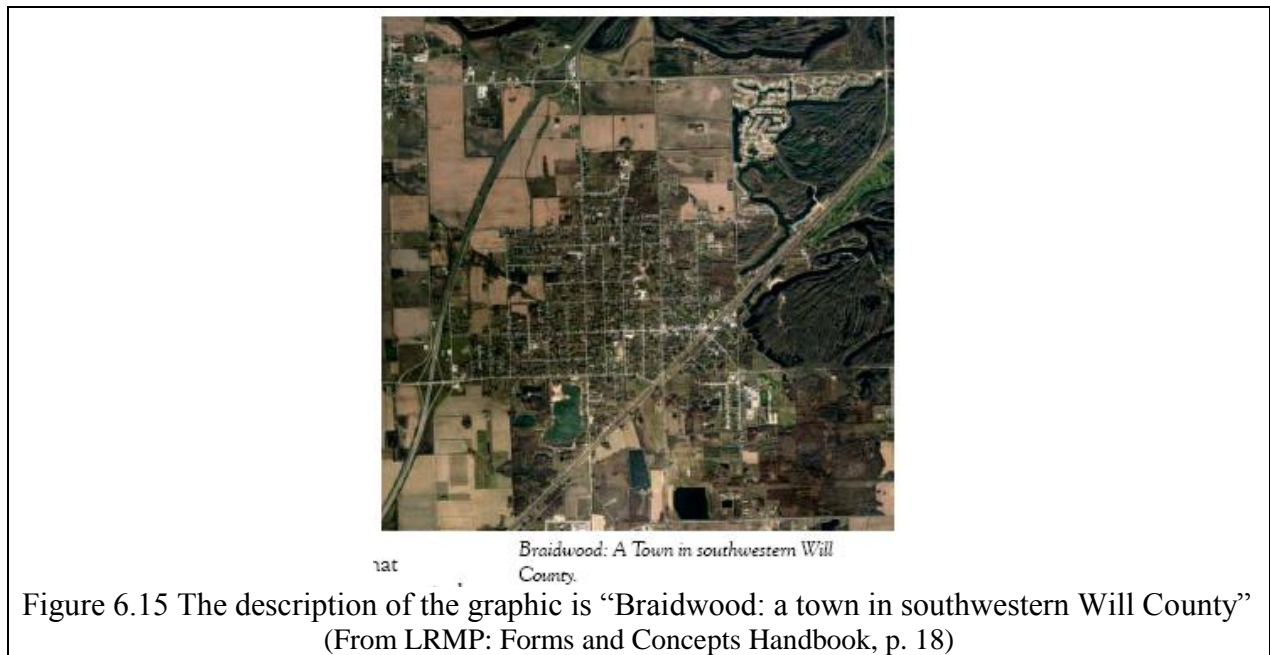
Description



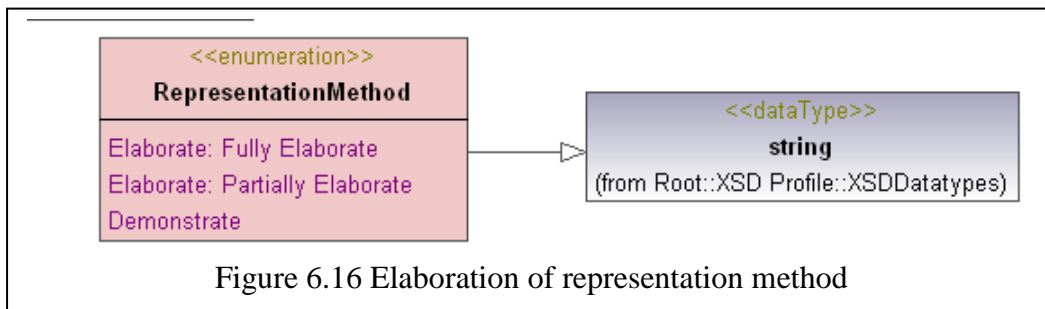
Description (see Figure 6.14) presents a general account of a graphic or explains elements in a graphic. Its value is a string. A description is optional for marking up a single graphic.

If description of a graphic is same as plan information conveyed by the graphic, the description could be omitted, because the same information must be included in another required metadata of a single graphic, Specific Plan Information, which is illustrated later. Otherwise, description is recommended.

Figure 6.15 is an example of description being desired. It presents “the layout of Braidwood, a town in southwestern Will County”, which could be regarded as the description, in order to illustrate “the structures of typical town development”, which is the plan information the graphic conveys. Obviously, the description is different from the plan information. Thus, a description is desired in this case.



Representation Method



“Representation method” (modeled as **RepresentationMethod**) (see Figure 6.16) presents how a single graphic communicates plan information. Its value is from a set of predefined values –

“Elaborate: Fully Elaborate”, “Elaborate: Partially Elaborate”, and “Demonstrate”. The three methods have been defined and illustrated in Chapter 4.4, “Representation Method”. The value is exclusive. That is, one graphic can not have more than one representation methods at the same time. Representation method is required for marking up a single graphic.

Specific Plan Information

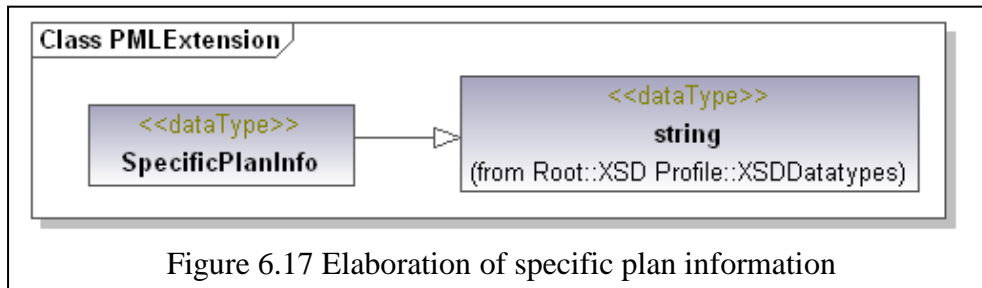


Figure 6.17 Elaboration of specific plan information

“Specific plan information” (modeled as **SpecificPlanInfo**) (see Figure 6.17) presents plan information that a graphic is supposed to convey. Its type is a string. It is required for marking up a single graphic. The rationale is that every graphic in a plan document is supposed to communicate a piece of plan information, and it is crucial to identify this information in order to understand plan content.

To identify specific plan info conveyed by a graphic, it is crucial to study the graphic content and embedded elements (e.g. annotations and comments), as well as the context. Isolating the graphic from its context could lead to information overload or information misunderstanding, which has been illustrated in Chapter 4.1, “Context of Graphic”.

Most times, plan information conveyed by a graphic is the same as the description of the graphic. However, occasionally the plan information differs from the description, which has been exemplified in Figure 6.15.

Plan information conveyed by a graphic could include several sentences, which narrate the same data or information in different ways. The table in Figure 6.18 is an example. It shows “at-place”

employment by county by economic sector versus the total workers per employment sector, and highlights the mismatch between where resident workers live and where they have opportunities for employment. We can see that the plan information is narrated in two ways -- the first part summarizes the data, and the second part highlights the key points.

Industry Type	2000				2010				2020			
	2000	2005	2010	2015	2000	2005	2010	2015	2000	2005	2010	2015
Total	1,247,095	1,475,587	1,618,000	1,680,000	1,247,095	1,475,587	1,618,000	1,680,000	1,247,095	1,475,587	1,618,000	1,680,000
Manufacturing	17,000	15,000	14,000	13,000	17,000	15,000	14,000	13,000	17,000	15,000	14,000	13,000
Construction	10,000	12,000	14,000	16,000	10,000	12,000	14,000	16,000	10,000	12,000	14,000	16,000
Transportation	10,000	12,000	14,000	16,000	10,000	12,000	14,000	16,000	10,000	12,000	14,000	16,000
Trade	10,000	12,000	14,000	16,000	10,000	12,000	14,000	16,000	10,000	12,000	14,000	16,000
Other	1,210,095	1,446,587	1,580,000	1,641,000	1,210,095	1,446,587	1,580,000	1,641,000	1,210,095	1,446,587	1,580,000	1,641,000

Figure 6.18 Plan information conveyed by a graphic could be narrated in several ways.
 (Full-size table refers to Figure 4.12)
 (From 2040 Regional Framework Plan, chapter 7, p. 153)

Categorized Plan Information

“Categorized plan information” (modeled as **CategorizedPlanInfo**) (see Figure 6.19) presents classified plan information conveyed by a graphic. It is required for marking up a single graphic.

Categorized plan information is developed based on the theoretical research in Chapter 4.3, “Plan Information Conveyed by a Graphic”. It could be “information being labeled with aspects” (modeled as **InfoWithAspect**), or “information not being labeled with aspects” (modeled as **InfoWOAspect**). For information with aspects, value of “the information” (modeled as **InfoWA**) is either “Goals and Desired Future” or “Implementation”, and value of “the aspect” (modeled as **Aspect**) is from a set of predefined values -- “Land Use”, “Transportation”, “Infrastructure”, “Environmental Preservation”, “Cultural Preservation”, and “Aspect Others”. For information without aspects, the value is from three predefined values – “Planning Process”, “Current Situation, Issue and Trend”, and “Information Others”. The predefined values correspond to the definitions and illustrations in Chapter 4.3. Categorized plan information is required for marking up a single graphic, because plan information conveyed by a graphic could be at least categorized into one group.

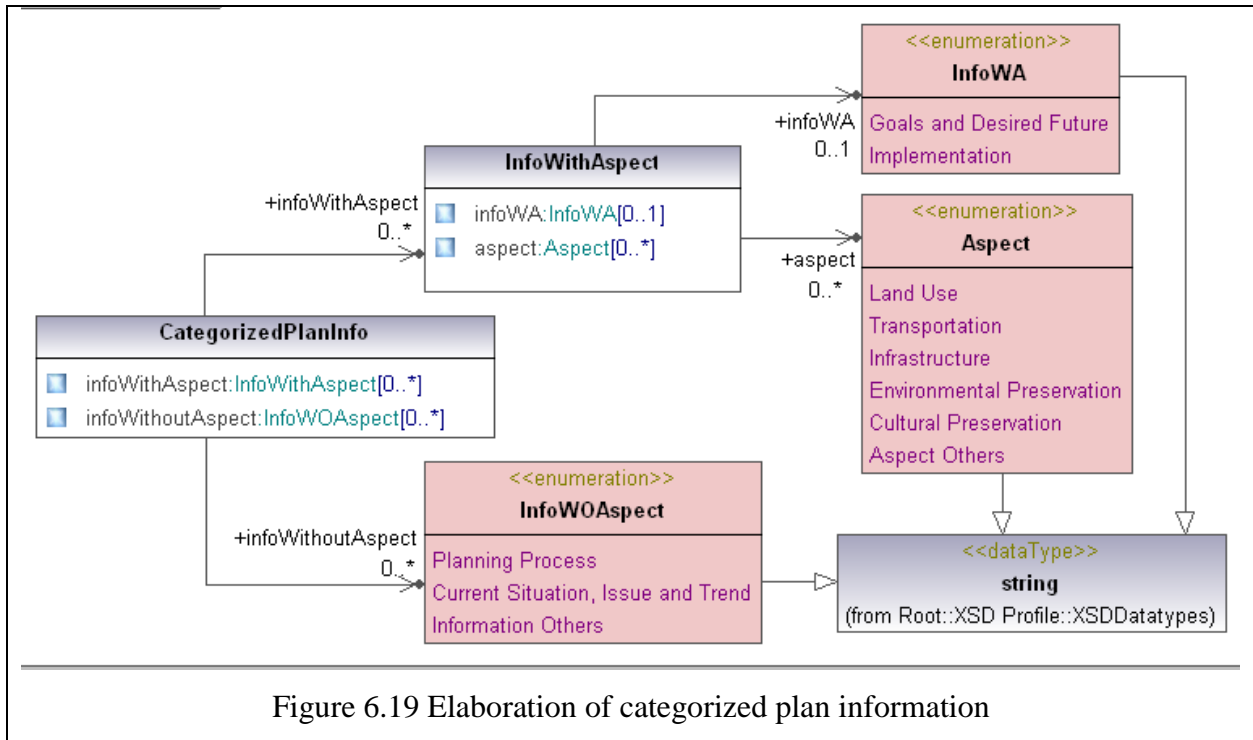


Figure 6.19 Elaboration of categorized plan information

In the data model, **CategorizedPlanInfo** could include zero or more **InfoWithAspect** and **InfoWOAspect**. That is to say, plan information could be concurrently categorized into more than one group (except for “Information Others”), either those groups with aspects, or those without aspects, or a combination of them. Figure 6.20, which has been illustrated in Chapter 4.3, is such an example. The map not only works as an agenda by listing proposed roadway projects, but also provides a vision of the future roadway network. Thus plan information conveyed by the graphic could be categorized into “Goals and Desired Future” and “Implementation” at the same time, which are related to “transportation” aspect. Encoding result of the example is shown in Table 6.6.

In the data model, **InfoWithAspect** could include more than one **Aspect**. That is to say, one piece of categorized plan information could associate with more than one aspect at the same time. Figure 6.21 shows such an example. The aerial-view image provides a vision of northeastern Illinois in 2040 by showing how major centers, corridors, and green areas generally fit into the regional context. The desired future conveyed by the image is related to three aspects, “land use”, “transportation”, and “environmental preservation”. Encoding result of the example is shown in Table 6.7.



Figure 6.20 The map works as an agenda, as well as provides a vision of the future roadway network. So the plan information of the map could be categorized into “Goals and Desired Future” and “Implementation” at the same time.

(Full-size map refers to Figure 4.21)

(From 2005 Comprehensive Plan for City of Urbana, p. 108)

Data Member			Value
categorizedPlanInfo	infoWithAspect	infoWA	Goals and Desired Future
		aspect	Transportation
	infoWithAspect	infoWA	Implementation
		aspect	Transportation

Table 6.6 Categorized plan information of the map in Figure 6.20

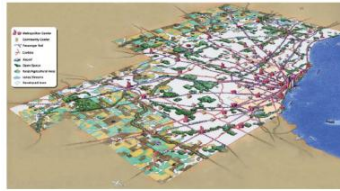


Figure 31 Regional Vision for 2040
This illustration shows how major centers, corridors, and green areas generally fit into the regional context.

Figure 6.21 The aerial-view image provides a vision of northeastern Illinois in 2040, which is related to “land use”, “transportation”, and “environmental preservation”.

(Full size image refers to Figure 4.5)

(From 2040 Regional Framework Plan, Chapter 2, p. 12)

Data Member			Value
categorizedPlanInfo	infoWithAspect	infoWA	Goals and Desired Future
		aspect	Land Use
		aspect	Transportation
		aspect	Environmental Preservation

Table 6.7 Categorized plan information of the image in Figure 6.21

Effectiveness

Effectiveness (see Figure 6.22) indicates how effective a graphic elaborates or demonstrates the plan information the graphic intends to convey. It also indicates whether the graphic is worthy to

be carefully studied or not. For details and examples of these concepts, refer to Chapter 4.5. Its value is either “high” or “low”. Effectiveness is required for marking up a single graphic.

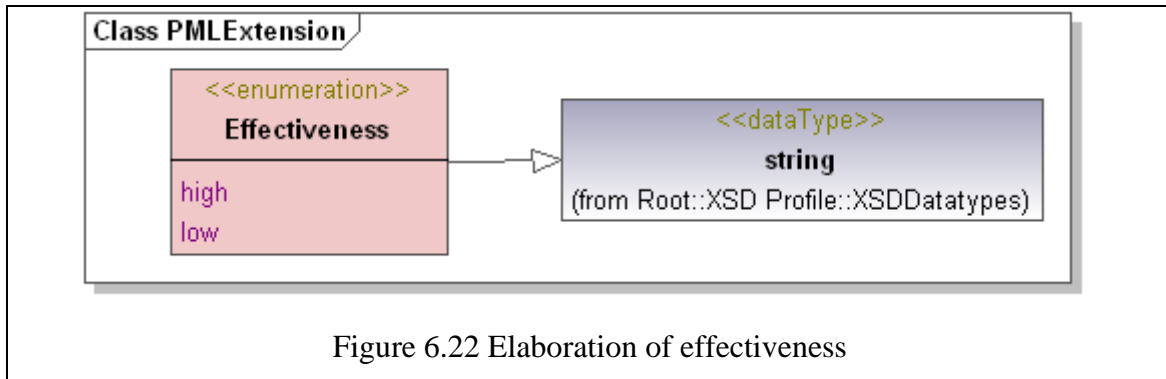


Figure 6.22 Elaboration of effectiveness

Coverage

Coverage (see Figure 6.23) presents the geographical range of plan information conveyed by a single graphic, especially for “map” or “site plan”. The data model of **Coverage** has been illustrated in Chapter 6.1, “Document Metadata”, since it is also used to present the geographical range of a plan document. Coverage could be a “user specified name” (modeled as **CoverageName**). For instance, coverage of plan information presented by the map in Figure 6.24 is “East Urbana”. Coverage could also be “a set of names of administrative entities” (modeled as **CoverageRegion**), which include Country, State, County, City, and Neighborhood, or “a set of geographical coordinates” (modeled as **CoverageCoordinateSet**). Coverage is optional for marking up a single graphic.

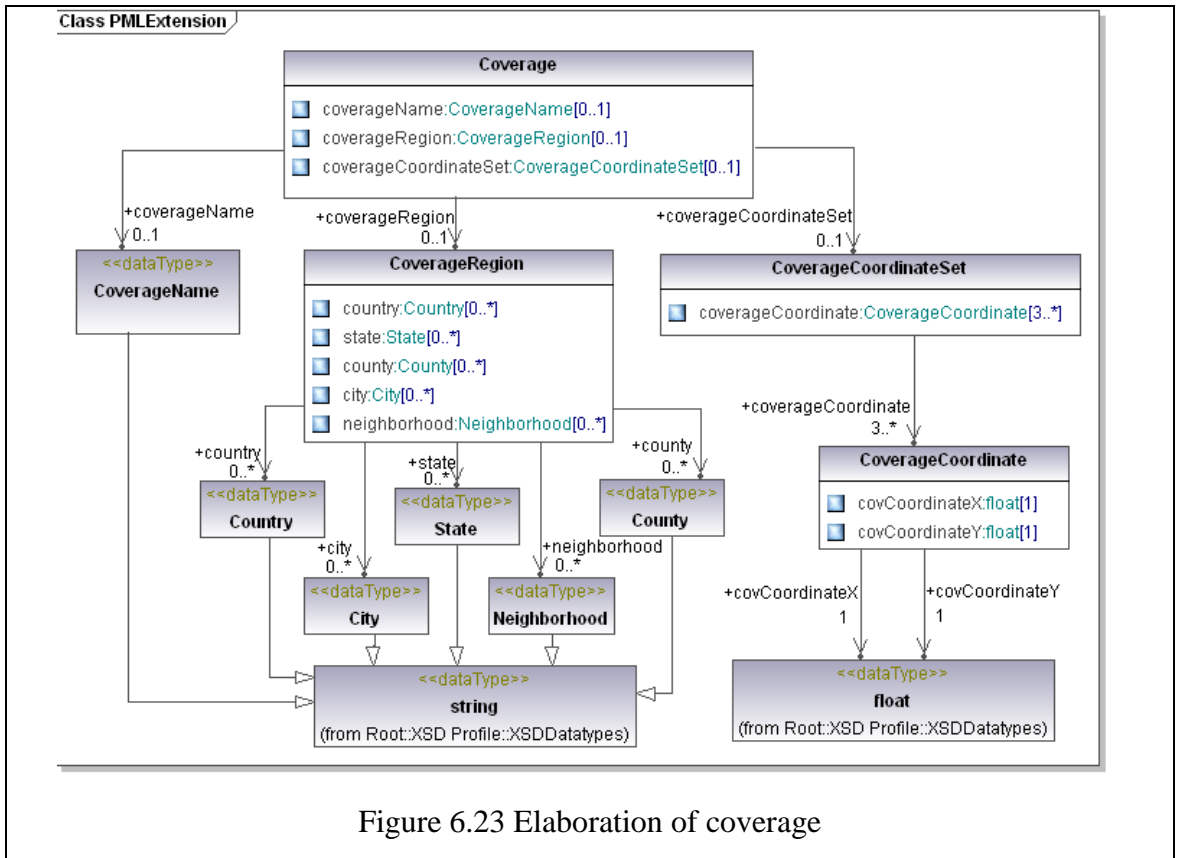


Figure 6.23 Elaboration of coverage

One thing that needs to be clarified is that coverage refers to the geographical range of the plan ideas that a graphic conveys, not just to the coverage of graphic itself. The difference does not matter when the range of a graphic is same as the range of the plan information, as in Figure 6.24. However, it does matter if the two ranges are not identical. For instance, graphic in Figure 6.25 depicts the layout of a community located around West Green Street and Elm Street corridors in City of Urbana, in order to illustrate general features of urban-pattern of mixed residential development as the concept applies to the entire City of Urbana. Coverage for the graphic itself is a small neighborhood, but coverage of the graphic idea should be “City of Urbana”.

Map #6
East Urbana

ADOPTED
April 11, 2005
Final Version of City of Urbana
Comprehensive Development Ordinance

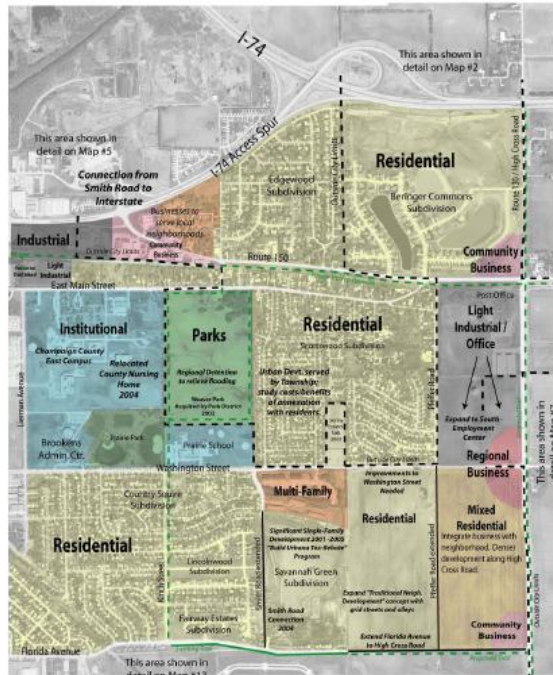


Figure 6.24 Coverage for the map is “East Urbana”
(From 2005 comprehensive plan for City of Urbana, p. 76)



Local Examples: West Green Street and Elm Street corridors

Figure 6.25 The graphic, depicting the layout of a community located around West Green Street and Elm Street corridors, is shown as a typical example to illustrate general features of urban-pattern mixed residential development in City of Urbana. So coverage for the graphic should be “City of Urbana”.

(From 2005 Comprehensive Plan for City of Urbana, p. 56)

Background

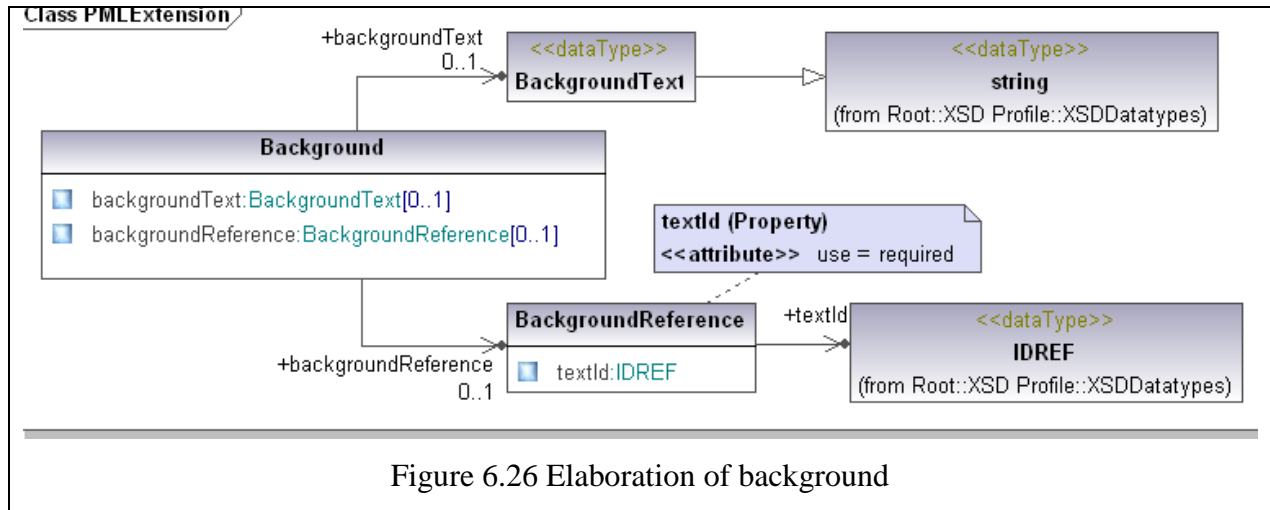


Figure 6.26 Elaboration of background

Background (see Figure 6.26) presents complementary information that includes

- those for providing social, historical and other antecedents or origins of an event or conditions presented by a graphic
- those for further explaining the keywords that are included in a graphic, or the plan information the graphic conveys.

It will help users to better understand the graphic and the plan information it conveys.

Background could be either a string (modeled as **BackgroundText**) or a reference of textual content entity (modeled as **BackgroundReference**). The background reference must have an ID referring to a text entity, in order to avoid information duplication. Background is optional for marking up a single graphic.

For instance, the table that is partially shown in Figure 6.27 presents the implementation strategies to achieve goals and objectives for City of Urbana. The background information of the table is shown below.

HOW TO READ THIS CHAPTER

Over the coming months and years, a number of specific steps can be taken to help realize the vision for our community as outlined in the Comprehensive Plan. The Implementation Program offers a means to achieve the goals and objectives

identified in the four cornerstone goal sections: Quality of Life, Sensible Growth, Services and Infrastructure, and Mobility. Implementation strategies will vary in scope depending on the intended result. For example, an implementation strategy can be very specific, such as “adopt lighting standards for commercial development,” or it can be more general, such as “work with the Urbana Park District to determine possible locations for new parks.” The Implementation Program also prioritizes the strategies and identify responsibility for achieving them.

TYPE OF STRATEGIES

Implementation Strategies are categorized into five different types:

Policy: Provides guidance on decisions

Action: Can be acted upon to produce a result

Council Action: Ultimately requires consideration and action from City Council

Special Study: Needs additional study to determine best course of action

Coordination: Requires ongoing coordination with other parties

RELATED GOALS / OBJECTIVES AND MAPS

Indicates from which goals, objectives and/or Future Land Use Maps the strategy is derived

TIMING

Indicates whether the strategy should occur in the near term (within 2 years), short term (2-3 years), long term (3-5 years), or is ongoing

RESPONSIBLE CITY AGENCIES AND OTHER ENTITIES

Lists the City department as well as other agencies/groups that will lead implementation of the strategy. (2005 Comprehensive Plan for City of Urbana, p.86)

Implementation Strategy	Type of Strategy	Related Goals / Objectives	Related Maps	Timing	Responsible City Agency	Other Responsible Parties
Develop a common format for neighborhood associations to discuss and coordinate issues facing their neighborhoods. Develop a model for neighborhood associations to have effective input in the decision-making process.	Coordination	1.0.1.1		Ongoing	Community Development	Neighborhood Associations
Develop educational tools and resources to allow neighborhood associations to understand and manage common neighborhood issues.	Coordination	1.0.1.1		Short Term	Community Development	Neighborhood Associations
Assess the Urban Zoning Map when zoning maps are amended to significantly consider the public, historic, and future land use goals of the Comprehensive Plan.	Special Study Council Action	1.0.1.5 4.0.4.1, 4.3 17.0.1.1 20.0.2.1 20.0.3.1	All Future Land Use Maps	1 Year Term	Planning Division	
Develop a neighborhood action plan for the "Historic East Urbana" neighborhood. The plan should address issues of zoning, transportation, infrastructure, engagement and strategies for zoning and improvement.	Special Study Council Action	1.0.1.1, 1.1, 1.3, 1.5 1.0.1.1, 1.4 1.0.1.1	20	1 Year Term	Community Development Public Works	"Historic East Urbana" Neighborhood Association HETSOA

Figure 6.27 A partial table presenting implementation strategies for City of Urbana (Full-size table refers to Figure 4.11) (From 2005 Comprehensive Plan for City of Urbana, p. 87)

Index Directory

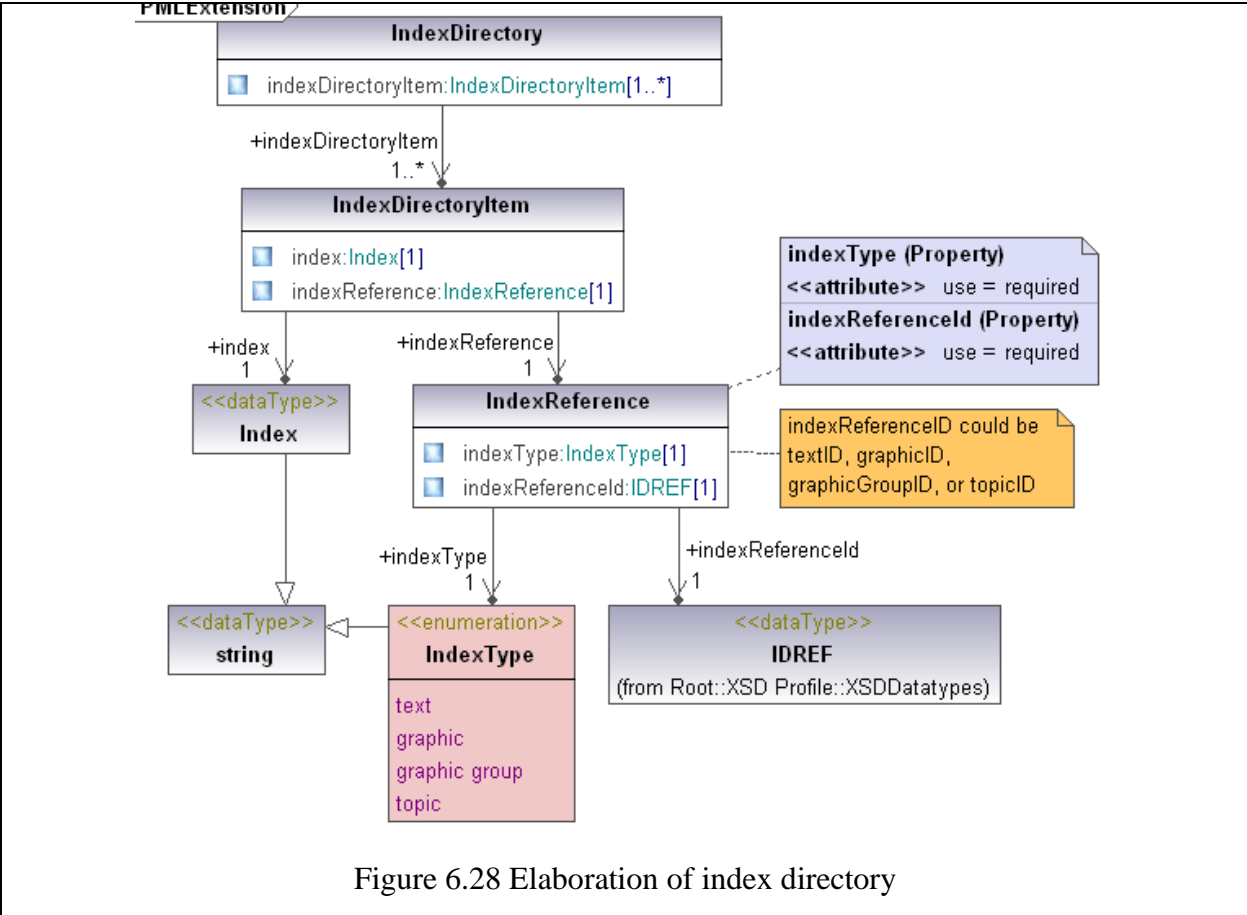
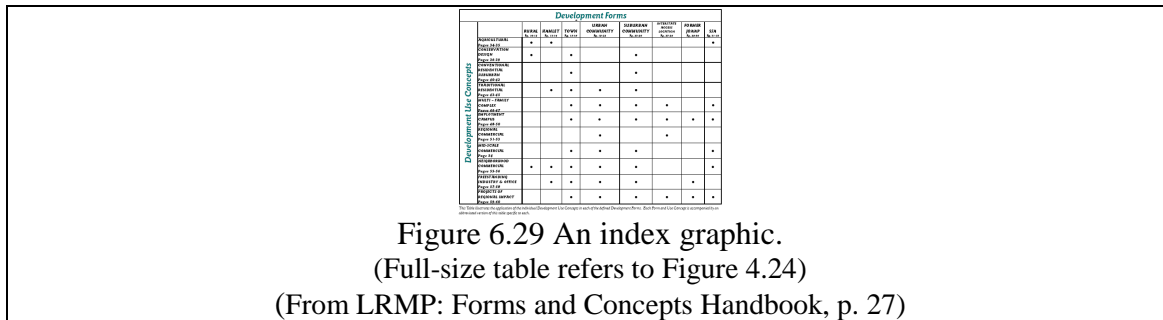


Figure 6.28 Elaboration of index directory

“Index directory” (modeled as **IndexDirectory**) (see Figure 6.28) presents a list of index items in an index graphic and the corresponding references directed by those items. It is only valid when a graphic is an index graphic, which is labeled by index in graphic category. Index directory is composed of one or more “pair of index-reference” (modeled as **IndexDirectoryItem**). And each pair of index-reference must include one “index item”

(modeled as **Index**), and one corresponding “index reference” (modeled as **IndexReference**). Index is a string. Index reference must have an ID referring to the reference, and a “label for identifying type of reference” (modeled as **IndexType**), which value is from a set of predefined vocabularies -- “text”, “graphic”, “graphic group”, and “topic”. An index directory is optional for marking up a single graphic.

For instance, the graphic in Figure 6.29 is an index graphic, in which eight development forms (e.g. rural, hamlet, and town) and eleven development use concepts (e.g. agricultural, conservation design, and conventional residential suburban) are the index items. Table 6.8 shows partial encoding result, which includes three index items (that is, rural, hamlet, and town) and their corresponding references.



Data Member			Value	
indexDirectory	indexDirectory Item	index	<i>rural</i>	
		indexReference	indexType	<i>topic</i>
			indexReferenceID	<i>topicFormsRuralID_1</i>
	indexDirectory Item	index	<i>hamlet</i>	
		indexReference	indexType	<i>topic</i>
			indexReferenceID	<i>topicFormsHamletID_1</i>
	indexDirectory Item	index	<i>town</i>	
		indexReference	indexType	<i>topic</i>
			indexReferenceID	<i>topicFormsTownID_1</i>
...	

Table 6.8 Partial index directory of the index graphic shown above

Legend

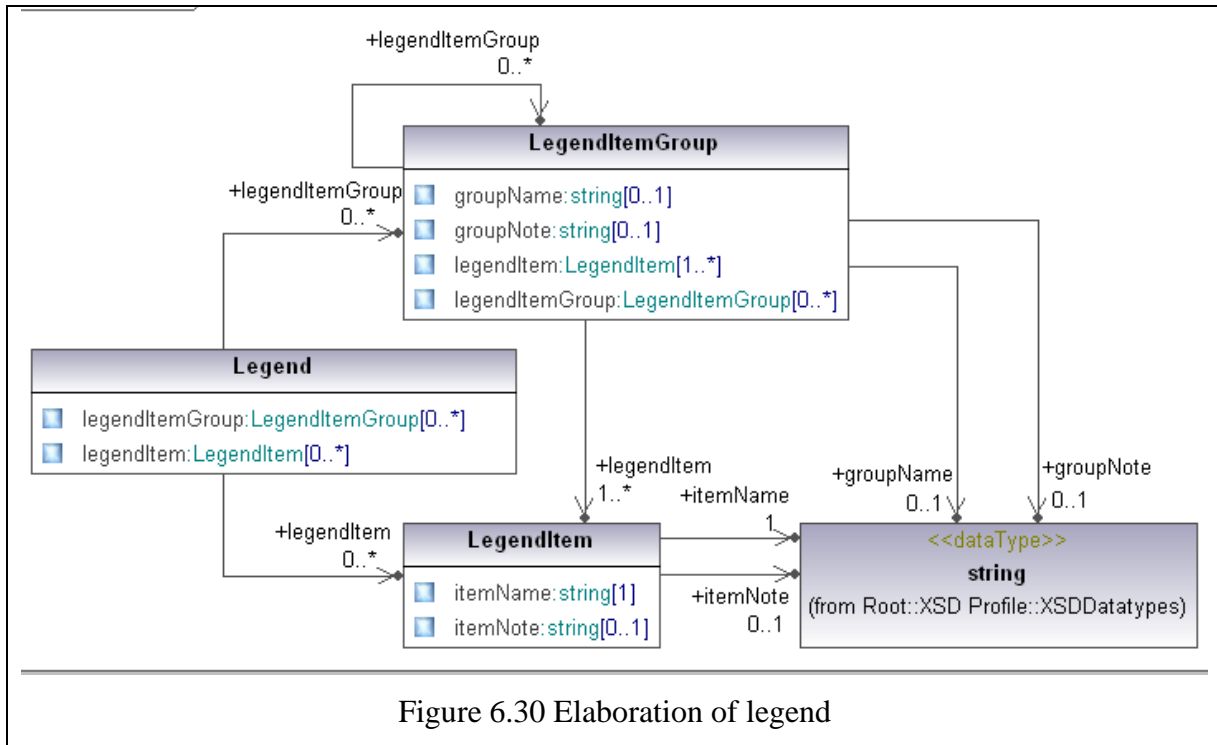
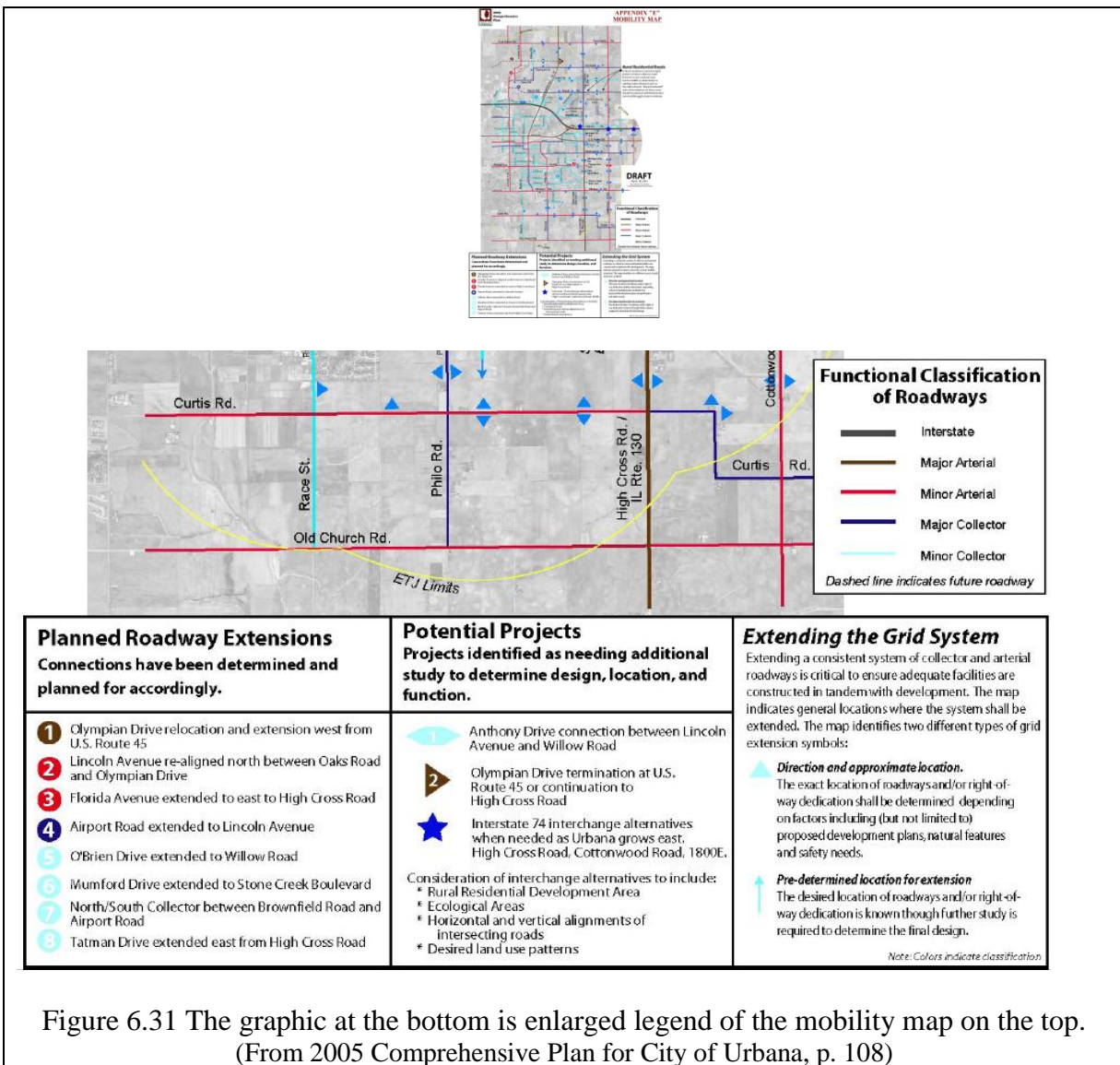


Figure 6.30 Elaboration of legend

Legend (see Figure 6.30) presents explanatory words for symbols or labels used on a graphic. A legend could include one or more “legend item” (modeled as **LegendItem**) or “group of legend items” (modeled as **LegendItemGroup**) or a combination of them. Each legend item must have an “item name” (modeled by itemName), and may include an “explanation of the legend item” (modeled by itemNote). Each group of legend items could include a “group name” (modeled by groupName), and an “explanation of the legend group” (modeled by groupNote). Each group of legend items could be composed of one or more legend items. It could also refer to itself recursively. That is, a legend could be in a tree-like structure. A legend is optional for marking up a single graphic, since not every graphic has legend.

Mostly, legend comes from the original legend of a graphic. Occasionally, it could be from textual content near the graphic.

In Figure 6.31, the graphic at the bottom is the enlarged legend of the mobility map, shown at the top of the figure. Encoding result of the legend is shown in Table 6.9.



Data Member			Value	
<u>legend</u>	<u>legendItemGroup</u>	<u>groupName</u>	<i>Functional Classification of Roadways</i>	
		<u>groupNote</u>	<i>Dashed line indicates future roadway</i>	
		<u>legendItem</u>	<u>itemName</u>	<i>Interstate</i>
		<u>legendItem</u>	<u>itemName</u>	<i>Major Arterial</i>
		<u>legendItem</u>	<u>itemName</u>	<i>Minor Arterial</i>
		<u>legendItem</u>	<u>itemName</u>	<i>Major Collector</i>
		<u>legendItem</u>	<u>itemName</u>	<i>Minor Collector</i>
	<u>legendItemGroup</u>	<u>groupName</u>		<i>Planned Roadway Extensions</i>
		<u>groupNote</u>		<i>Connections have been determined and planned for accordingly.</i>
		<u>legendItem</u>	<u>itemName</u>	<i>Olympian Drive relocation and extension west from U.S. Route 45</i>
		<u>legendItem</u>	<u>itemName</u>	<i>Lincoln Avenue re-aligned north between Oaks Road and Olympian Drive</i>
		<u>legendItem</u>	<u>itemName</u>	<i>Florida Avenue extended to east to High Cross Road</i>
		<u>legendItem</u>	<u>itemName</u>	<i>Airport Road extended to Lincoln Avenue</i>
		<u>legendItem</u>	<u>itemName</u>	<i>O'Brien Drive extended to Willow Road</i>
		<u>legendItem</u>	<u>itemName</u>	<i>Mumford Drive extended to Stone Creek Boulevard</i>
		<u>legendItem</u>	<u>itemName</u>	<i>North/South Collector between Brownfield Road and Airport Road</i>
		<u>legendItem</u>	<u>itemName</u>	<i>Tatman Drive extended east from High Cross Road</i>
	<u>legendItemGroup</u>	<u>groupName</u>		<i>Potential Projects</i>
		<u>groupNote</u>		<i>Projects identified as needing additional study to determine design, location, and function.</i>
		<u>legendItem</u>	<u>itemName</u>	<i>Anthony Drive connection between Lincoln Avenue and Willow Road</i>
		<u>legendItem</u>	<u>itemName</u>	<i>Olympian Drive termination at U.S. Route 45 or continuation to High Cross Road</i>

Table 6.9 (cont.)

		<u>legendItem</u>	<u>itemName</u>	<i>Interstate 74 interchange alternatives when needed as Urbana grows east. High Cross Road, Cottonwood Road, 1800E.</i>	
			<u>itemNote</u>	<i>Consideration of interchange alternatives to include:</i> <ul style="list-style-type: none"> - <i>Rural Residential Development Area</i> - <i>Ecological Areas</i> - <i>Horizontal and vertical alignments of intersecting roads</i> - <i>Desired land use patterns</i> 	
	<u>legendItemGroup</u>	<u>groupName</u>			<i>Extending the Grid System</i>
			<u>groupNote</u>		<i>Extending a consistent system of collector and arterial roadways is critical to ensure adequate facilities are constructed in tandem with development. The map indicates general locations where the system shall be extended. The map identifies two different types of grid extension symbols.</i>
		<u>legendItem</u>	<u>itemName</u>	<i>Direction and approximate location</i>	
			<u>itemNote</u>	<i>The exact location of roadways and/or right-of-way dedication shall be determined depending on factors including (but not limited to) proposed development plans, natural features, and safety needs.</i>	
		<u>legendItem</u>	<u>itemName</u>	<i>Pre-determined location for extension</i>	
			<u>itemNote</u>	<i>The desired location of roadways and/or right-of-way dedication is known though further study is required to determine the final design.</i>	

Table 6.9 Legend of the mobility map shown above

Annotation

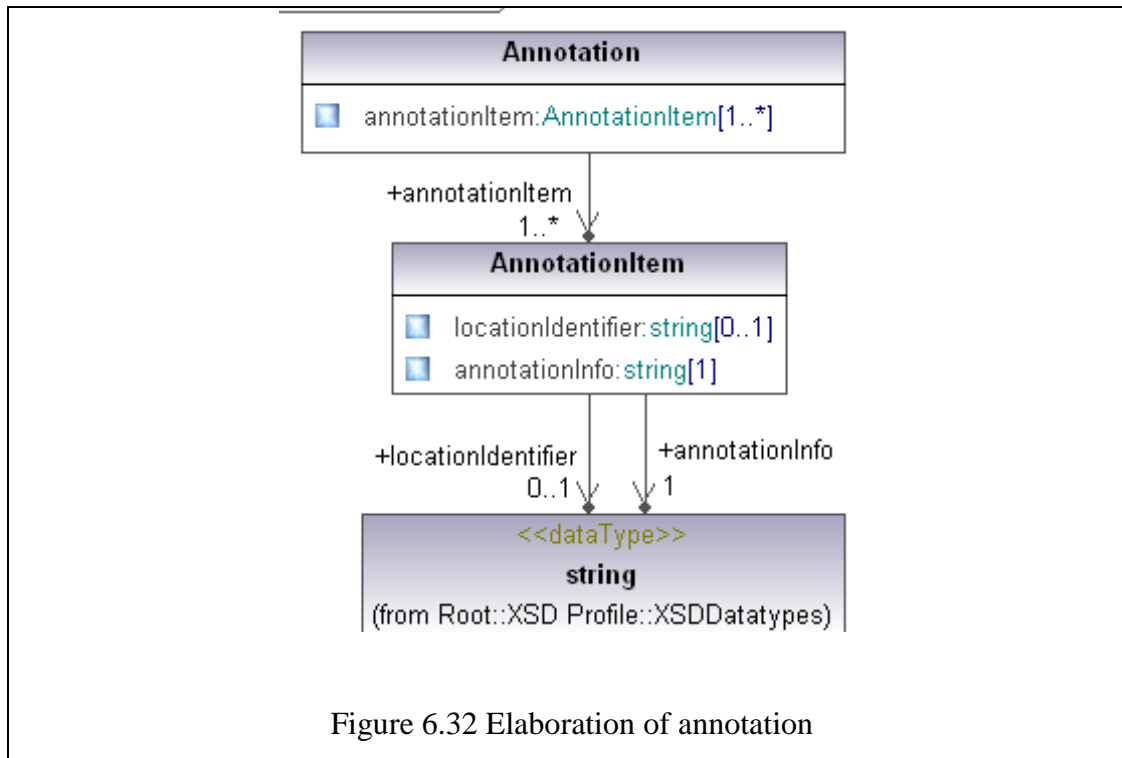


Figure 6.32 Elaboration of annotation

Annotation (see Figure 6.32) presents the notes superimposed on a graphic to provide explanations or comments associated with planning issues or activities. Annotation of a graphic is normally composed of one or more “annotation item” (modeled as **AnnotationItem**). Each annotation item presents one piece of plan information, which may associate with a particular object or region on the graphic. Accordingly, each annotation item must include a data member, annotationInfo, which presents a piece of annotation including (but not limited to) development issue, trend, proposed project, plan ideas or actions. An annotation item could, though not required, also include a “location identifier” (modeled as locationIdentifier), which identifies the object, location or area that a piece of annotation is associated with. The object and location could be specified by a name, and the area could be specified by a name and land use type. The location identifier is optional, because sometimes an annotation is not associated with any specific area or object, or the associated area or object does not have obvious label. An annotation is optional for marking up a single graphic.

In Figure 6.33, the map, which presents future land use in the northeast Urbana and surrounding Champaign County, includes some annotation items to identify development concerns or issues. Encoding result of the annotation is shown in Table 6.10.

One principle to be emphasized is that we will not encode pure geographical information (e.g. Oaks road, Cottonwood road, U of I in Figure 6.33) that has no association with any more substantive annotation. Thus, to encode annotation, first locate annotation items for planning, and then identify associated objects, locations or areas, if appropriate.

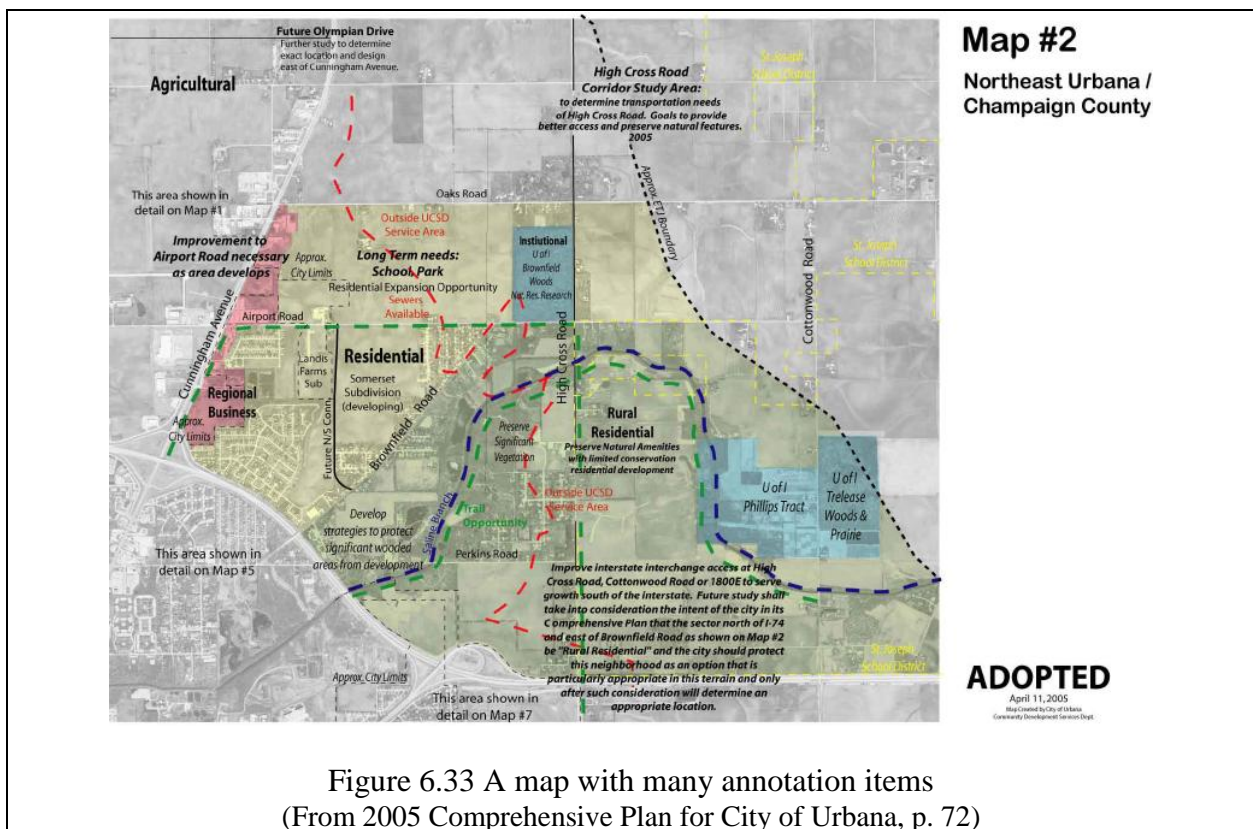


Figure 6.33 A map with many annotation items (From 2005 Comprehensive Plan for City of Urbana, p. 72)

Data Member		Value	
annotation	annotationItem	locationIdentifier	<i>Future Olympian Drive</i>
		annotationInfo	<i>Further study to determine exact location and design east of Cunningham Avenue</i>
	annotationItem	locationIdentifier	<i>High Cross Road Corridor study area</i>
		annotationInfo	<i>To determine transportation needs of High Cross Road. Goals to provide better access and preserve natural features. 2005</i>
	annotationItem	locationIdentifier	<i>Airport Road</i>
		annotationInfo	<i>Improvement to Airport Road necessary as area develops</i>
	annotationItem	locationIdentifier	<i>Residential area</i>
		annotationInfo	<i>Residential expansion opportunity</i>
	annotationItem	locationIdentifier	<i>Residential area</i>
		annotationInfo	<i>Long term needs: school, park</i>
	annotationItem	locationIdentifier	<i>Rural residential area</i>
		annotationInfo	<i>Preserve natural amenities with limited conservation residential development</i>
	annotationItem	locationIdentifier	<i>Rural residential area</i>
		annotationInfo	<i>Preserve significant vegetation</i>
	annotationItem	locationIdentifier	<i>Rural residential area</i>
		annotationInfo	<i>Develop strategies to protect significant wooded areas from development</i>
annotationItem	locationIdentifier	<i>High Cross Road</i>	
	annotationInfo	<i>Improve interstate interchange access at High Cross Road, Cottonwood Road or 1800E to serve growth south of the interstate. Future study shall take into consideration the intent of the city in its Comprehensive Plan that the sector north of I-74 and east of Brownfield Road as shown on Map #2 be "Rural Residential" and the city should protect this neighborhood as an option that is particularly appropriate in this terrain and only after such consideration will determine an appropriate location.</i>	

Table 6.10 Annotation of the map shown above

Textual Item

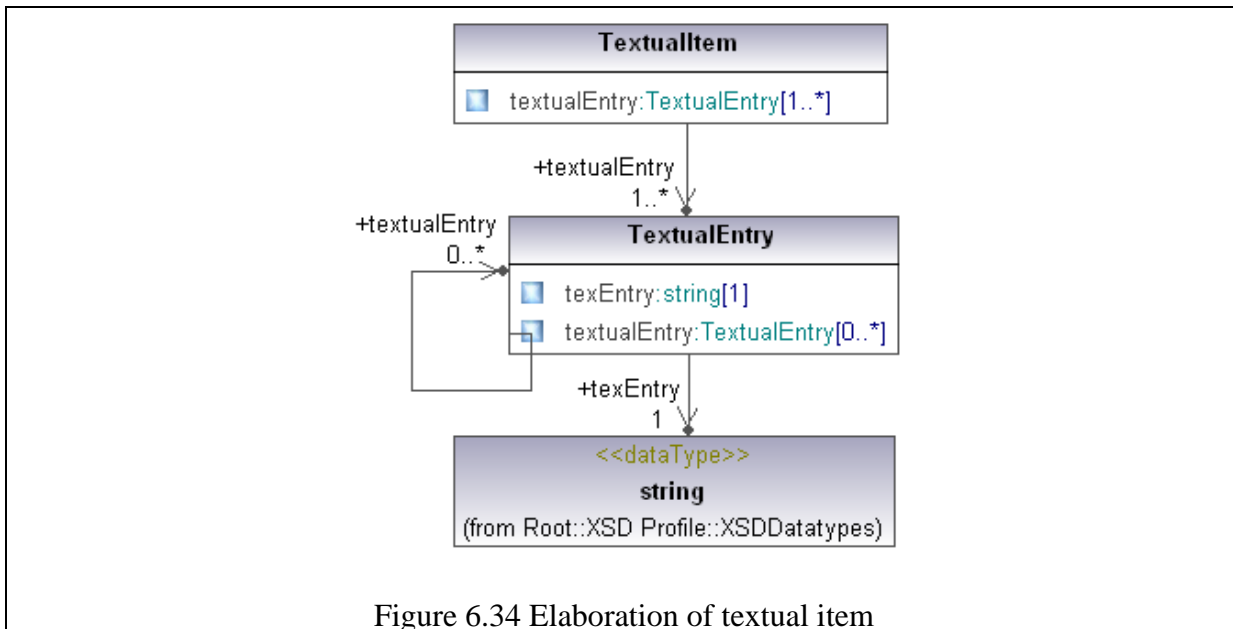


Figure 6.34 Elaboration of textual item

“Textual item” (modeled as **TextualItem**) presents the essential textual elements in certain types of graphic, table and non-spatial diagram, in which the textual elements are dominative essentials. It does not include annotations discussed before. Textual item must include at least one “textual entry” (modeled as **TextualEntry**). Each textual entry must have a data member, `texEntry`, to record what the textual entry is. A textual entry might (not required) include one or more textual entry, because textual entry can be nested recursively. A textual item is optional for marking up a single graphic.

In the following, four examples (two for table and two for non-spatial diagram) are presented to elaborate how to extract textual entries from a table and a non-spatial diagram.

For a table, extracting textual entries does not mean presenting every cell in the table, which is neither efficient nor plausible. For a simple table, in which data is viewed by one dimension, textual entries are column names or row names that label data entries. Figure 6.35 shows a typical simple table. Encoding result of its “textual item” is shown in Table 6.11. For a multi-dimensional table, in which data is viewed by multiple dimensions, textual entries include names of the multiple dimensions, as well as offspring included in each dimension that label data

entries. Figure 6.36 shows a three-dimensional table. Encoding result of its “textual item” is shown in Table 6.12.

For a non-spatial diagram, textual entries are textual elements in the diagram as well as their enclosure structure if there is one. Figure 6.37 and Figure 6.38 show two typical non-spatial diagrams. Encoding results of their “textual item” are presented in Table 6.13 and Table 6.14 respectively. It needs to be noticed that in Figure 6.38, the textual entry “5 Regional Themes” includes five sub entries – “Globally Competitive”, “Livable Communities”, “Healthy Natural Environment”, “Diversity”, and “Collaborative Governance”.

Implementation Strategy	Type of Strategy	Related Goals / Objectives	Related Maps	Timing	Responsible City Agencies	Other Responsible Entities
Develop a common frame for neighborhood associations to discuss and consider issues facing their neighborhoods. Discusses methods for neighborhood associations to form alliances across the city across entire process.	Coordination	10.1.1		Ongoing	Community Development	Neighborhood Associations
Develop educational tools and information to allow neighborhood associations to understand and manage common neighborhood issues.	Coordination	10.1.1		Short Term	Community Development	Neighborhood Associations
Assess the Urban Energy Utility where existing energy is consumed to neighborhood community for peak efficiency and energy use on maps of the Comprehensive Plan.	Special Study Council Action	10.1.1 10.4.2.4.3 10.1.1.1 10.1.1.1 10.1.1.1	All Future Land Use Maps	Five Year	Planning Division	
Develop a neighborhood action plan for the “Thematic Plan Urban” neighborhood. The plan should address issues of energy consumption, infrastructure improvements and strategies for long-term energy improvement.	Special Study Council Action	10.1.1.1.1.1.1.1.1.1.1 10.1.1.1.1	00	Short Term	Community Development Public Works	“Thematic Plan Urban” Neighborhood Association (MEL/NA)

Figure 6.35 Textual entries of the simple table are column names.
(Full-size table refers to Figure 4.11)
(From 2005 Comprehensive Plan for City of Urbana, p. 87)

	Data Member		Value
<u>textualItem</u>	<u>textualEntry</u>	<u>texEntry</u>	<i>Implementation Strategy</i>
	<u>textualEntry</u>	<u>texEntry</u>	<i>Type of Strategy</i>
	<u>textualEntry</u>	<u>texEntry</u>	<i>Related Goals / Objectives</i>
	<u>textualEntry</u>	<u>texEntry</u>	<i>Related Maps</i>
	<u>textualEntry</u>	<u>texEntry</u>	<i>Timing</i>
	<u>textualEntry</u>	<u>texEntry</u>	<i>Responsible City Agencies</i>
	<u>textualEntry</u>	<u>texEntry</u>	<i>Other Responsible Entities</i>

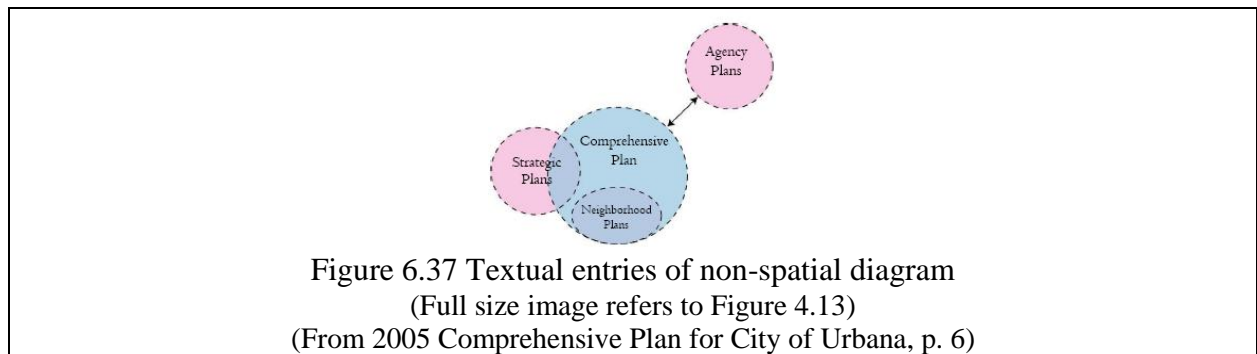
Table 6.11 Textual item of the simple table in Figure 6.35

Industry Type	2008			2009			2010		
	Jobs	Workers	Net jobs	Jobs	Workers	Net jobs	Jobs	Workers	Net jobs
Total	2,242,268	2,627,297	138,758	2,082,367	2,476,173	188,388	2,228,808	2,661,344	186,632
Agriculture	12,281	2,565	6,934	6,264	650	3,444	2,871	1,108	1,776
Construction	187,717	1,193,293	125,321	24,890	25,309	9,998	10,484	14,520	14,093
Manufacturing	286,703	1,942,472	15,971	81,498	74,462	10,862	47,148	48,792	688
Trade	228,827	1,624,885	18,167	47,361	28,274	16,987	48,808	8,861	15,933
Health*	186,951	1,071,693	148,211	184,821	892,708	98,122	47,198	37,465	6,281
Other**	132,242	218,821	12,427	38,982	48,214	8,291	9,700	13,411	13,711
Education	2,122,018	1,744,027	38,728	2,024,421	274,225	20,202	1,862,017	1,848,000	8,000
Government	108,228	88,471	68,648	22,277	11,224	11,253	11,421	5,154	6,267
Total	2,048,812	2,192,286	26,427	1,865,886	1,928,288	224,284	1,927,787	2,064,421	188,632
Agriculture	6,768	888	6,824	2,888	1,288	1,256	4,627	844	6,201
Construction	16,843	16,381	12,205	6,443	11,435	13,271	13,727	20,208	16,481
Manufacturing	127,749	42,201	13,642	22,712	28,989	38,244	28,252	38,948	17,493
Trade	70,284	11,020	1,920	9,211	6,927	13,769	19,208	18,441	16,229
Health*	83,241	381,867	32,663	21,888	22,266	1,027	38,428	38,369	18,348
Other**	74,891	28,428	18,842	2,411	19,248	38,282	4,827	19,227	17,429
Education	1,284,442	1,028,413	13,475	33,368	60,228	14,093	58,249	100,420	141,384
Government	71,228	68,871	7,227	6,281	9,181	1,482	9,448	8,427	1,288

Figure 6.36 Textual entries of a multi-dimensional table include names of the multiple dimensions, as well as offspring included in each dimension that label data entries.
(Full-size table refers to Figure 4.12)
(From 2040 Regional Framework Plan, chapter 7, p. 153)

Data Member			Value	
textualItem	textualEntry	texEntry		Industry Title
		textualEntry	texEntry	Total
		textualEntry	texEntry	Agriculture
		textualEntry	texEntry	Construction
		textualEntry	texEntry	Manufacturing
		textualEntry	texEntry	Transportation, Communications, and Utilities
		textualEntry	texEntry	Trade
		textualEntry	texEntry	Finance, Insurance, and Real Estate
		textualEntry	texEntry	Services
		textualEntry	texEntry	Government
	textualEntry	texEntry		County Name
		textualEntry	texEntry	Cook
		textualEntry	texEntry	DuPage
		textualEntry	texEntry	Kane
		textualEntry	texEntry	Lake
		textualEntry	texEntry	McHenry
		textualEntry	texEntry	Will
	textualEntry	texEntry		Concerned Factor
		textualEntry	texEntry	Jobs
		textualEntry	texEntry	Workers
textualEntry		texEntry	Net Jobs	

Table 6.12 Textual item of the multi-dimensional table in Figure 6.36



Data Member			Value
textualItem	textualEntry	texEntry	Comprehensive Plan
	textualEntry	texEntry	Strategic Plans
	textualEntry	texEntry	Neighborhood Plans
	textualEntry	texEntry	Agency Plans

Table 6.13 Textual item of the non-spatial diagram in Figure 6.37

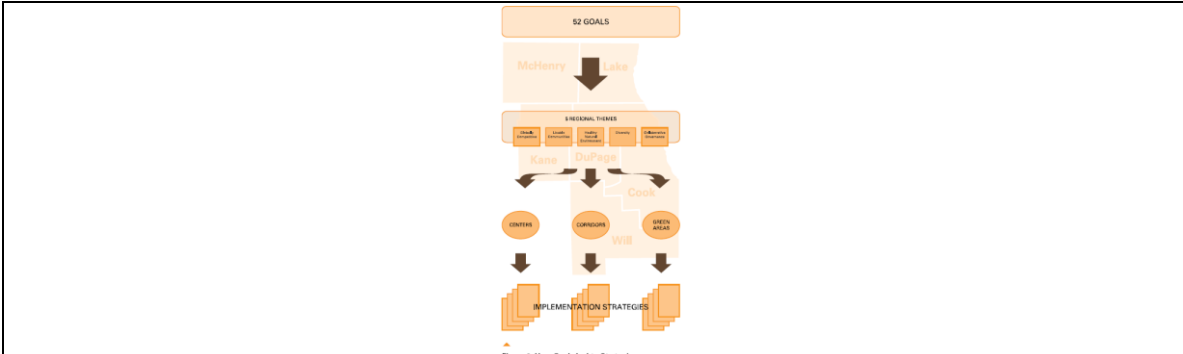


Figure 6.38 Textual entries of non-spatial diagram
 (Full size image refers to Figure 4.14)
 (From 2040 Regional Framework Plan, chapter 2, p. 13)

Data Member			Value	
textualItem	textualEntry	texEntry	52 Goals	
	textualEntry	texEntry	5 Regional Themes	
		textualEntry	texEntry	Globally Competitive
		textualEntry	texEntry	Livable Communities
		textualEntry	texEntry	Healthy Natural Environment
		textualEntry	texEntry	Diversity
		textualEntry	texEntry	Collaborative Governance
	textualEntry	texEntry	Centers	
	textualEntry	texEntry	Corridors	
	textualEntry	texEntry	Green Areas	
	textualEntry	texEntry	Implementation Strategies	

Table 6.14 Textual item of the non-spatial diagram in Figure 6.38

Path

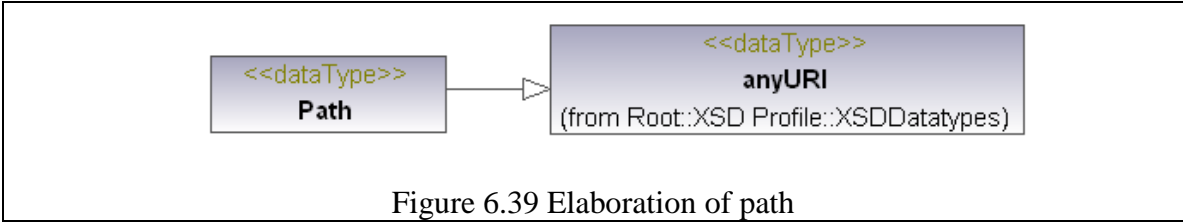


Figure 6.39 Elaboration of path

Path (see Figure 6.39) presents a string of characters that point to where a graphic is physically saved. A path could be a general form of a file or directory name that presents a file’s name and its unique location in a system. Example: file://c:/documents and settings/owner/jinghuan

dissertation/graphics/map1.jpeg. A path could also be a web address that is mapped to a location of a graphic on a server. Example: <http://jinghuanDissertation.com/graphics/map1.jpeg>. A path is required for marking up a single graphic. Without it, there is no way to know location of a graphic.

6.3.3 Graphic Group and Group Member

Having been illustrated in Chapter 4.6, “Single Graphic vs. Graphic Group”, a graphic group refers to a collection of two or more graphics being associated together to communicate certain plan information as a whole, with each component graphic having its own identities, such as title, comments, annotations, or description. Each graphic in a graphic group is termed as “group member” of the graphic group.

In this section, data model of graphic group is shown first, and data model of group member is presented after. Finally, encoding result of a graphic group example is presented to exemplify the two data models.

Graphic Group

Each “graphic group” (modeled as **GraphicGroup**) (see Figure 6.40) has two required data members – graphicGroupID for identification of the graphic group, and planDocumentID for identifying which plan document the graphic group belongs to. Besides, each graphic group (through inner class **mg_sequence**) also includes the following information,

- “metadata of the graphic group” (modeled as **GraphicGroupAttribute**), which is illustrated in the following paragraph,
- at least two “reference of group member” (modeled as **GraphicMember-Ref**), which refer to IDs of group members that are defined separately, and
- a “certain association among group members” (modeled as **GraphicMemberRelationship**), which value is either “Multiple-design Relationship” or “Coordinative Relationship”, which have been illustrated in Chapter 4.7.

Each graphic group could include at most seven metadata, which are respectively modeled by seven classes (see Figure 6.41). The seven classes are also used to model metadata of a single graphic, and have been illustrated before. Among the seven metadata, four of them are required for marking up a graphic group, while the other three are optional, as Table 6.15 summarizes.

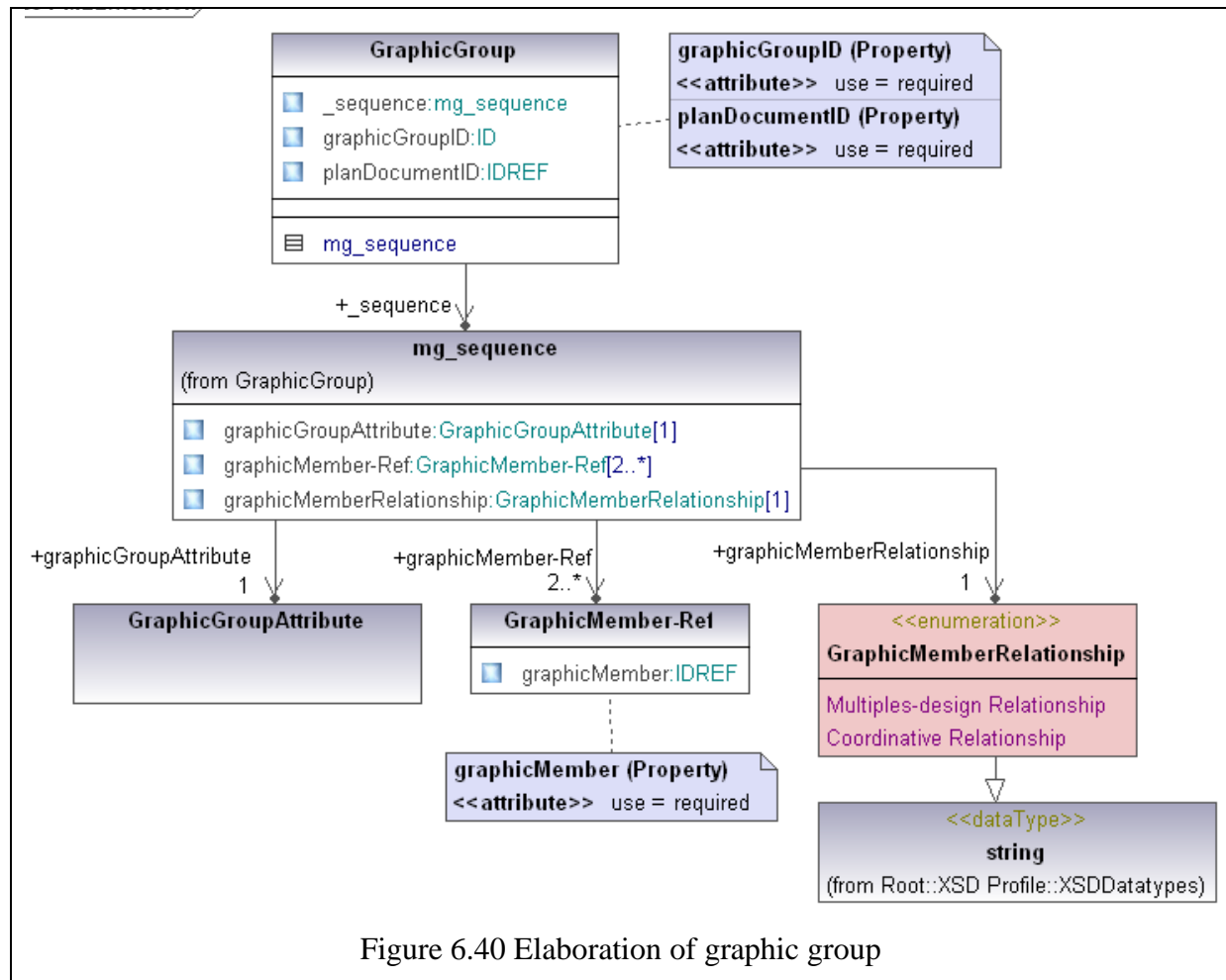
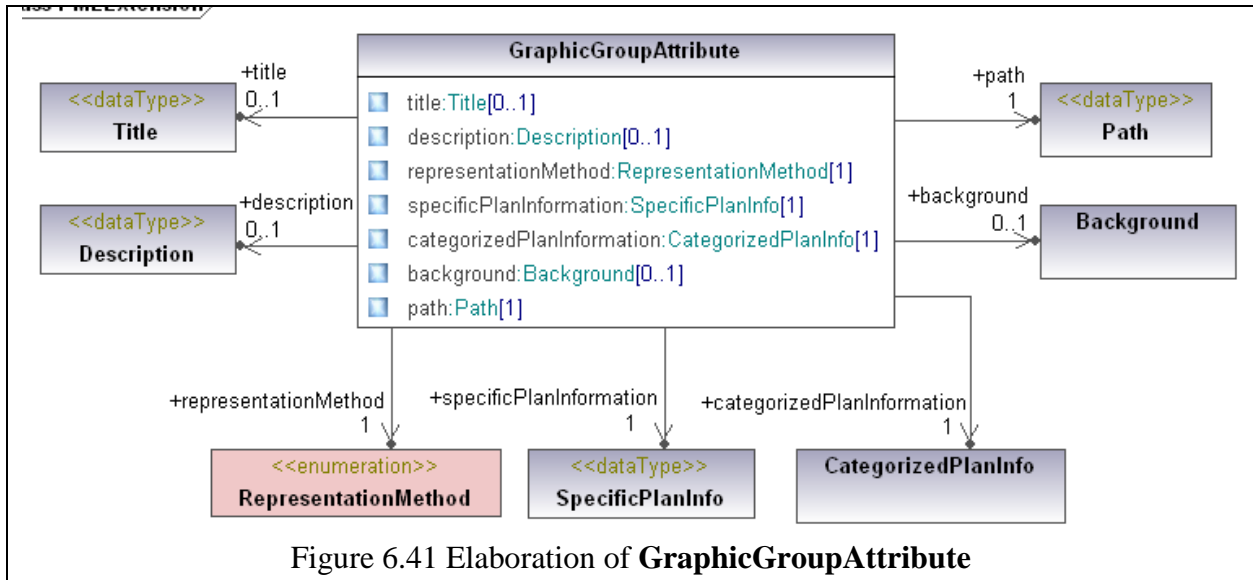


Figure 6.40 Elaboration of graphic group



Class Name	Label Name	Required / Optional (O)
Title	Title	O
Description	Description	O
RepresentationMethod	Representation Method	Required
SpecificPlanInfo	Specific Plan Information	Required
CategorizedPlanInfo	Categorized Plan Information	Required
Background	Background	O
Path	Path	Required

Table 6.15 Metadata of graphic group
(Label name is human-readable label assigned to the class name)

Graphic Group Member

Each “graphic group member” (modelled by **GraphicGroupMember**) (see Figure 6.42) has a required data member, graphicGroupMemberID, for identification. As we mentioned, ID of a group member refers to a graphic group, in order to identify which graphic group the member belongs to.

As mentioned before, each group member has its own individual features, which are different from features of the graphic group it belongs to. Thus, each group member could include at most twelve metadata, which are respectively modeled by twelve classes. Similarly, the twelve classes are also used to model metadata of a single graphic, and have been illustrated before. Among the

twelve metadata, two of them are required for marking up a group member, while the other ten are optional, as Table 6.16 summarizes.

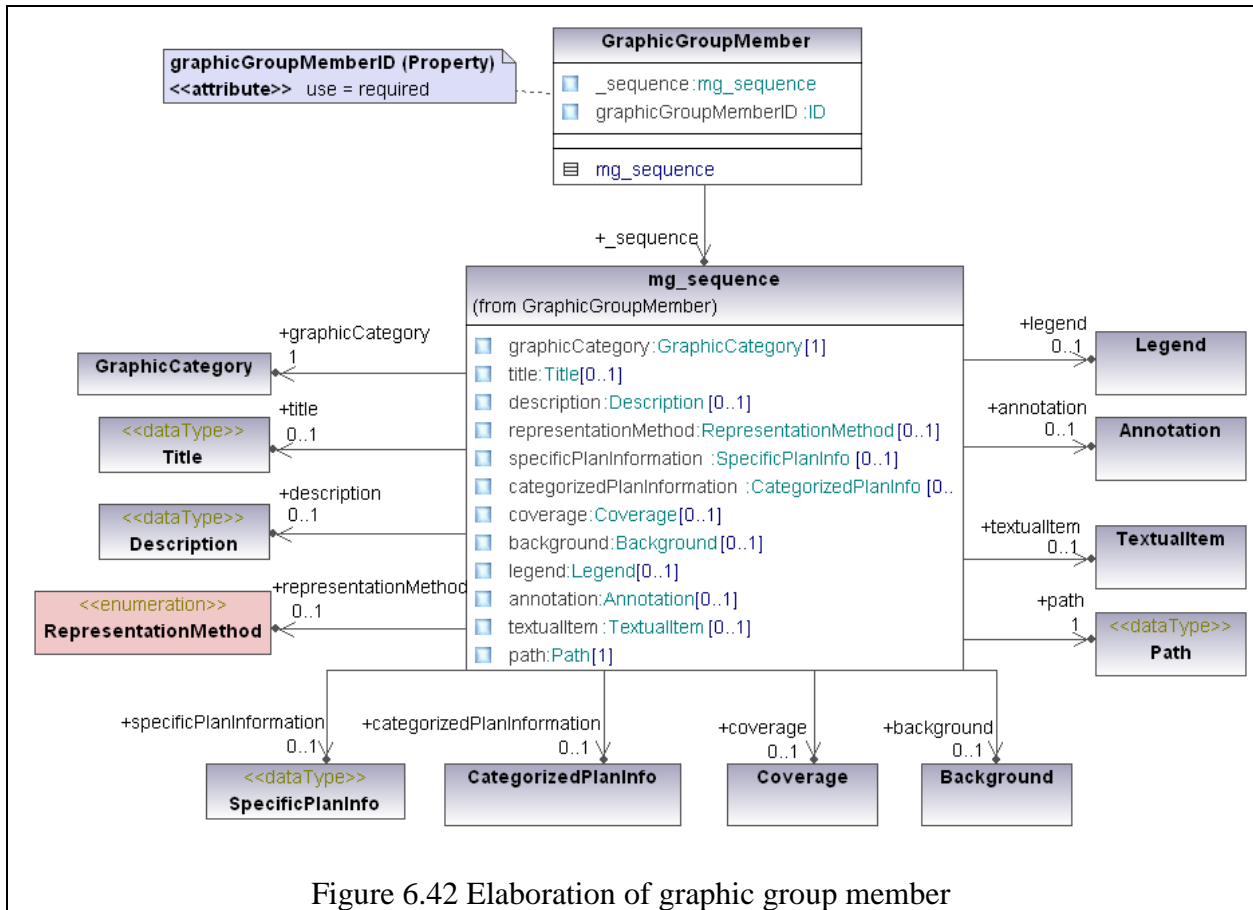


Figure 6.42 Elaboration of graphic group member

Class Name	Label Name	Required / Optional (O)
GraphicCategory	Graphic Category	Required
Title	Title	O
Description	Description	O
RepresentationMethod	Representation Method	O
SpecificPlanInfo	Specific Plan Information	O
CategorizedPlanInfo	Categorized Plan Information	O
Coverage	Coverage	O
Background	Background	O
Legend	Legend	O
Annotation	Annotation	O
TextualItem	Textual Item	O
Path	Path	Required

Table 6.16 Metadata of group member
(Label name is human-readable label assigned to the class name)

Example

To further explain the data model of graphic group and group member presented before, a graphic group (see Figure 6.43) that has been illustrated in Chapter 4.6 is taken as an example. The graphic group includes two graphic group members associated by “Multiples-design Relationship”. The encoding result is shown in Table 6.17, in which the first table encodes the graphic group, and the last two tables encode the two group members.

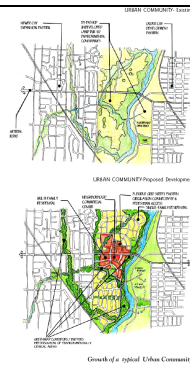


Figure 6.43 A graphic group
(Full-size image refers to Figure 4.54)
(From LRMP: Forms and Concepts Handbook, p. 19)

Data Member				Value	
graphicGroup	<<attribute>> graphicGroupID			<i>graphicGroupFCUrbanID_1</i>	
	<<attribute>> planDocumentID			<i>planFormsConceptsID_2</i>	
	graphic Group Attribute	representationMethod		<i>Elaborate: Fully Elaborate</i>	
		specificPlanInformation		<i>growth of a typical Urban Community</i>	
		categorizedPlanInformation	infoWith Aspect	infoWA aspect	<i>Implementation</i>
			path		<i>/planFormsConceptsID_2/UrbanGraphicGroup12.jpg</i>
	graphicMember-Ref			<i>graphicGMFCUrbanID_1</i>	
	graphicMember-Ref			<i>graphicGMFCUrbanID_2</i>	
graphicMemberRelationship			<i>Multiples-design Relationship</i>		

Data Member				Value
graphicGroup Member	<attribute>> graphicGroupMemberID			<i>graphicGMFCUrbanID_1</i>
	graphicCategory	<<attribute>> index		<i>false</i>
		type		<i>Site Plan</i>
	title			<i>existing urban community</i>
	representationMethod			<i>Elaborate: Fully Elaborate</i>
	specificPlanInformation			<i>existing urban community</i>
	categorizedPlanInformation	infoWithoutAspect		<i>Current Situation, Issue and Trend</i>
	annotation	annotationItem	annotationInfo	<i>newer city expansion pattern</i>
		annotationItem	annotationInfo	<i>by-passed undeveloped land due to environmental constrains</i>
		annotationItem	annotationInfo	<i>older city development pattern</i>
		annotationItem	annotationInfo	<i>arterial road</i>
		annotationItem	annotationInfo	<i>floodplain / open space</i>
		annotationItem	annotationInfo	<i>park</i>
	path			<i>/planFormsConceptsID_2/UrbanPhotoMember1.jpg</i>

Table 6.17 (cont.)

Data Member			Value	
graphicGroup Member	<attribute>> graphicGroupMemberID		<i>graphicGMFCUrbanID_2</i>	
	graphicCategory	<<attribute>> index	<i>false</i>	
		type	<i>Site Plan</i>	
	title		<i>proposed development of urban community</i>	
	representationMethod		<i>Elaborate: Fully Elaborate</i>	
	specificPlanInformation		<i>proposed development of urban community</i>	
	categorizedPlanInformation	infoWithAspect	infoWA	<i>Implementation</i>
			aspect	<i>Land Use</i>
	annotation	annotationItem	annotationInfo	<i>multi-family residential</i>
		annotationItem	annotationInfo	<i>neighborhood commercial center</i>
		annotationItem	annotationInfo	<i>flexible grid street pattern circulation connectivity and pedestrian access</i>
		annotationItem	annotationInfo	<i>single family residential</i>
		annotationItem	annotationInfo	<i>flood plain / open space</i>
annotationItem		annotationInfo	<i>park</i>	
path			<i>/planFormsConceptsID_2/UrbanPhotoMember2.jpg</i>	

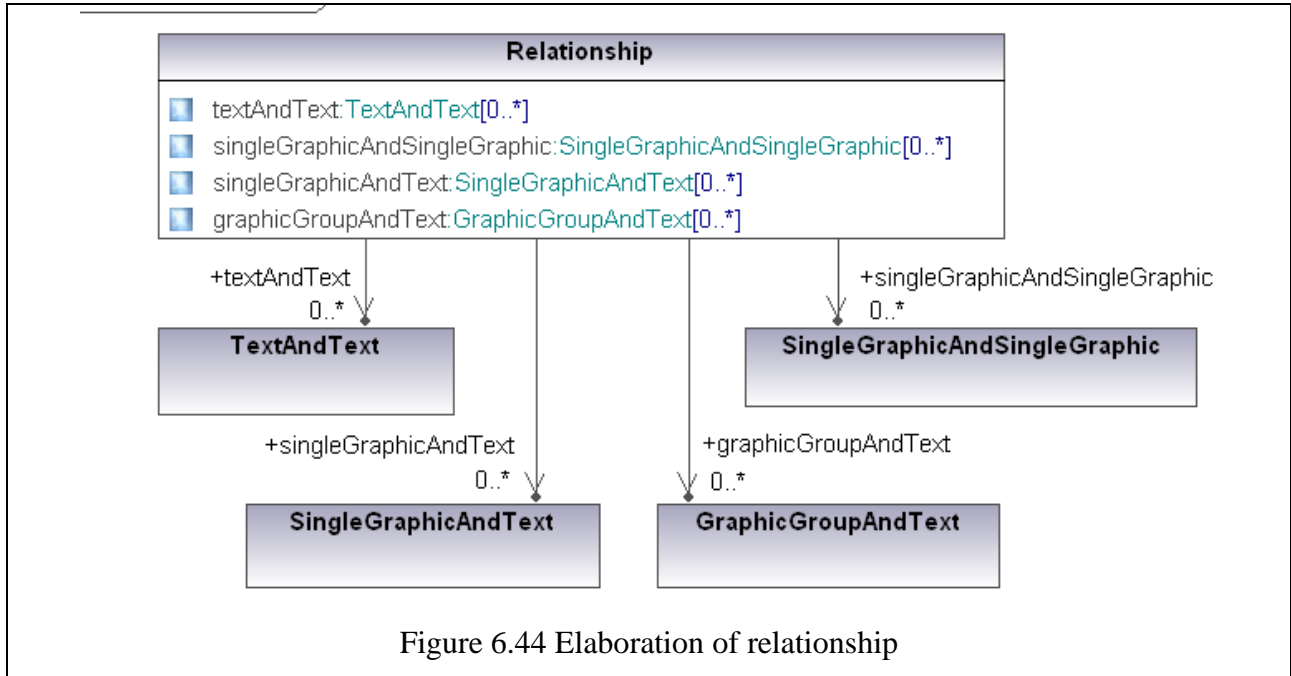
Table 6.17 Encoding result of the graphic group in Figure 6.43

6.3.4 Relationship

Relationship, abbreviation of “relationship between content entities”, refers to semantic or geographical relationship between two content entities. It has been illustrated comprehensively in Chapter 5. Standardizing the theoretical illustration leads to the data model of relationship (see Figure 6.44) shown in this section.

As illustrated before, relationship between content entities includes four types of relationship – relationship between two single graphic entities, relationship between a single graphic entity and a text entity, relationship between a graphic group entity and a text entity, and relationship between two text entities. They are respectively modeled as **SingleGraphicAndSingleGraphic**,

SingleGraphicAndText, **GraphicGroupAndText**, and **TextAndText**. Each of them is defined one by one below.



Relationship between Two Single Graphic Entities

“Relationship between two single graphic entities” is modeled as

SingleGraphicAndSingleGraphic (see Figure 6.45), which is based on the theoretical research in Chapter 5.1. Some label terms used to present the data model have been illustrated in Chapter 5.1, thus they are not defined again here.

Each relationship must have a graphicAndGraphicID for identification of the relationship. In addition, each relationship must include graphicARef and graphicBRef (modeled by **SingleGraphic-Ref**), which refer to IDs of two single graphic entities in order to identify which two are involved. Classification of the relationship is modeled by **GGRelationship**, which includes “non-directional relationship” (modeled as **GGNondirecRelationship**) and “directional relationship” (modeled as **GGDirecRelationship**). Value of non-directional relationship is limited to string “Adjacency” and “Other”, which correspond to “adjacency relationship” and “other” non-directional relationship. Value of directional relationship is from three predefined

constants -- “ZoomIn”, “WholePart”, “SemanticReferral” and “Other”, which corresponds to the four types, “zoom in relationship”, “whole-part relationship”, “semantic referral relationship”, and “other” directional relationship respectively.

To further explain the data model shown above, two examples (one for non-directional relationship, one for directional relationship), which have been illustrated in Chapter 5.1, are encoded. Table 6.18 shows encoding result of the example presented in Figure 5.2, in which there is “adjacency relationship” between map#1 and map #2, map#1 and map #3, and map#1 and map #4. Table 6.19 shows encoding result of the example presented in Figure 5.3, in which there is “zoom in relationship” from map A to map B, and from map A to map C.

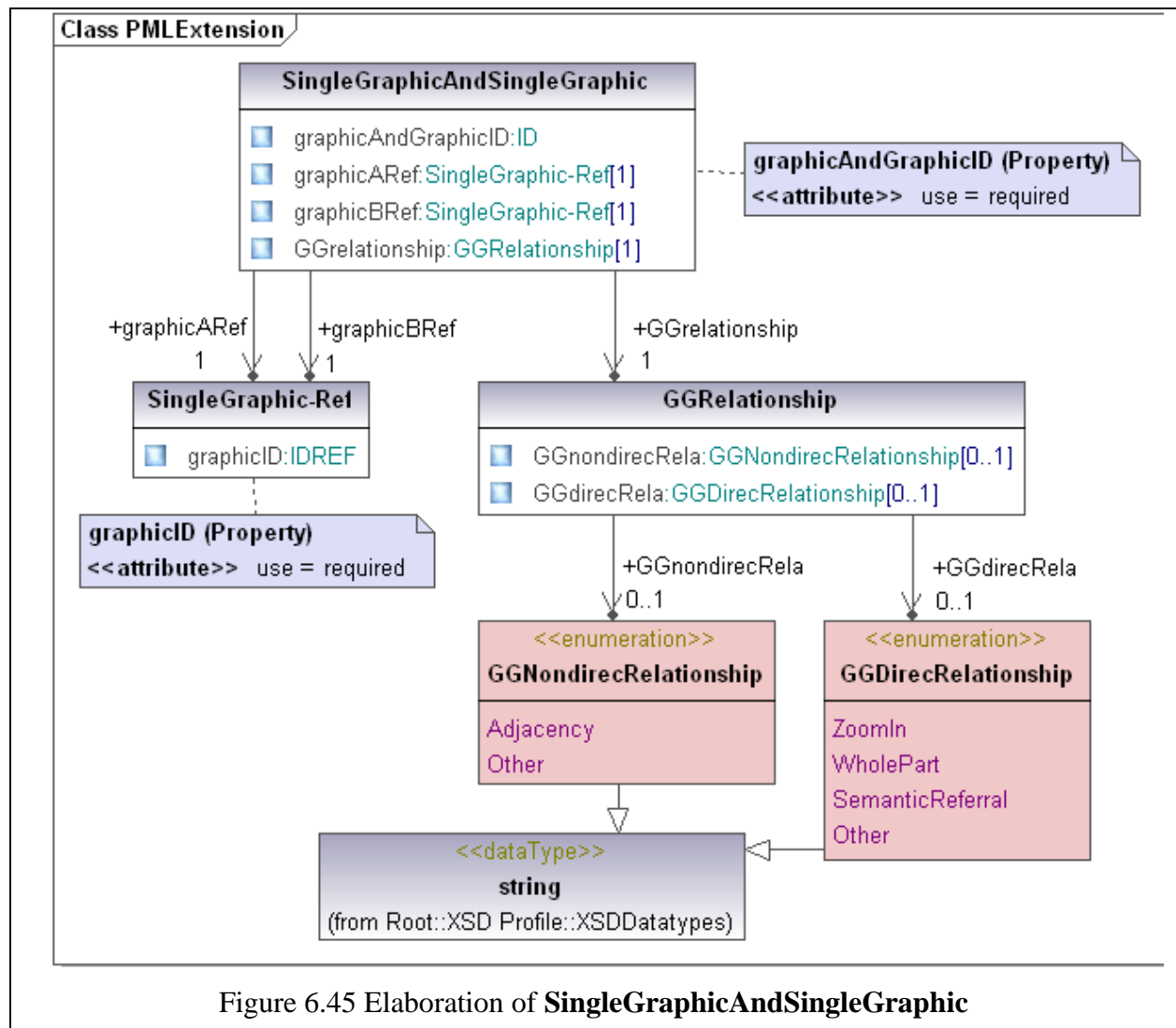


Figure 6.45 Elaboration of **SingleGraphicAndSingleGraphic**

Data Member		Value
singleGraphicAndSingleGraphic	<<attribute>> graphicAndGraphicID	<i>graphicGraphicID_12</i>
	graphicARef	graphicID <i>graphicMap_1</i>
	graphicBRef	graphicID <i>graphicMap_2</i>
	GGrelationship	GGdirecRela <i>Adjacency</i>
singleGraphicAndSingleGraphic	<<attribute>> graphicAndGraphicID	<i>graphicGraphicID_13</i>
	graphicARef	graphicID <i>graphicMap_1</i>
	graphicBRef	graphicID <i>graphicMap_3</i>
	GGrelationship	GGdirecRela <i>Adjacency</i>
singleGraphicAndSingleGraphic	<<attribute>> graphicAndGraphicID	<i>graphicGraphicID_14</i>
	graphicARef	graphicID <i>graphicMap_1</i>
	graphicBRef	graphicID <i>graphicMap_4</i>
	GGrelationship	GGdirecRela <i>Adjacency</i>

Table 6.18 Encoding result of adjacency relationship in Figure 5.2

Data Member		Value
singleGraphicAndSingleGraphic	<<attribute>> graphicAndGraphicID	<i>graphicGraphicID_1</i>
	graphicARef	graphicID <i>graphicMapAll_1</i>
	graphicBRef	graphicID <i>graphicMapRegion_1</i>
	GGrelationship	GGdirecRela <i>ZoomIn</i>
singleGraphicAndSingleGraphic	<<attribute>> graphicAndGraphicID	<i>graphicGraphicID_4</i>
	graphicARef	graphicID <i>graphicMapAll_1</i>
	graphicBRef	graphicID <i>graphicMapRegion_4</i>
	GGrelationship	GGdirecRela <i>ZoomIn</i>

Table 6.19 Encoding result of zoom in relationship in Figure 5.3

Relationship between Single Graphic Entity and Text Entity

“Relationship between a single graphic entity and a text entity” is modeled as

SingleGraphicAndText (see Figure 6.46), which is based on the theoretical research in Chapter 5.2. Some label terms used to present the data model have been illustrated in Chapter 5.2, thus they are not defined again here.

Each relationship must have a graphicAndTextID for identification of the relationship. In addition, each relationship must include an “ID reference of the single graphic entity involved” (modeled as **SingleGraphic-Ref**), and an “ID reference of the text entity involved” (modeled as **Text-Ref**). Classification of the relationship is modeled by **GTRelationship**, which includes “non-directional relationship” (modeled as **GTNondirecRelationship**) and “directional relationship” (modeled as **GTDirecRelationship**). Value of non-directional relationship is limited to string “semanticComplementarity” or “Other”, which represents “semantic complementary relationship” and “other non-directional relationship”. The directional relationship could include four data members -- exemplarIllustration, keywordDefining, semanticExtendedness, and other, which correspondingly represent “exemplar illustration relationship”, “keyword defining relationship”, “semantic extendedness relationship”, and “other” directional relationship. Among the four directional relationships, “keyword defining relationship” is different from the other three. It requires encoder to clarify which keyword(s) are being illustrated by single graphic. Correspondingly, the keywordDefining is modeled by **KeywordDefining**, which includes at least one data member, keyword, for presenting the keyword being illustrated. In contrast, values of the other three data members, exemplarIllustration, semanticExtendedness, and other, are String.

To further explain the data model shown above, three examples (one for non-directional relationship, two for directional relationship), which have been illustrated in Chapter 5.2, are encoded. Table 6.20 shows encoding result of the example presented in Figure 5.7, in which there is “semantic complementarity relationship” between single graphic and text entity. Table 6.21 shows encoding result of the example presented in Figure 5.8, in which there is “exemplar illustration relationship” from single graphic to text entity. Table 6.22 shows encoding result of the example presented in Figure 5.10, in which there is “keyword defining relationship” from single graphic to text entity.

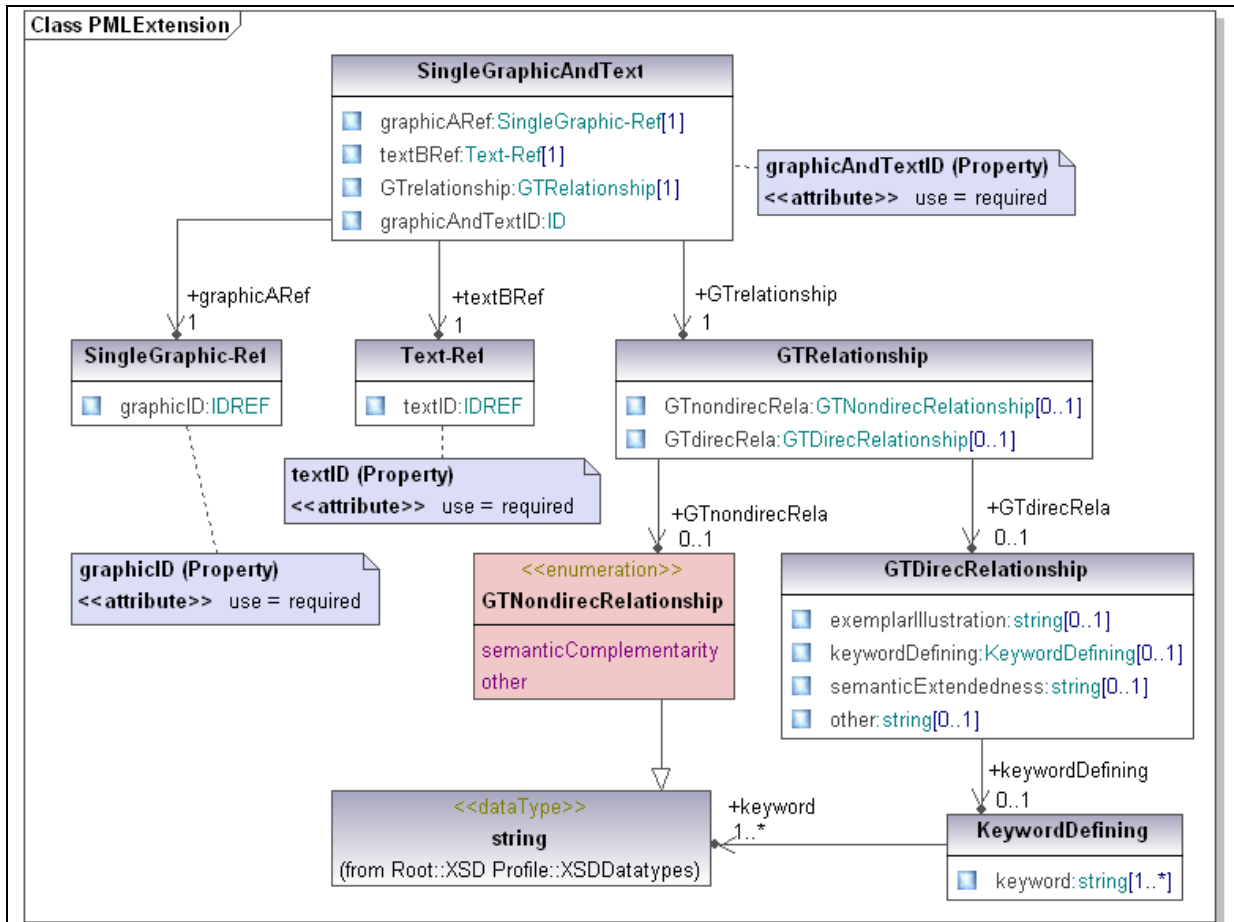


Figure 6.46 Elaboration of **SingleGraphicAndText**

	Data Member		Value
singleGraphicAndText	<<attribute>> graphicAndTextID		<i>graphicTextFCTownID_1</i>
	graphicARef	graphicID	<i>graphicFCTownID_1</i>
	textBRef	textID	<i>textFCTownID_2</i>
	GTRelationship	GTnondirecRela	<i>SemanticComplementary</i>

Table 6.20 Encoding result of semantic complementarity relationship in Figure 5.7

	Data Member		Value
singleGraphicAndText	<<attribute>> graphicAndTextID		<i>graphicTextFCSuburbanID_2</i>
	graphicARef	graphicID	<i>graphicFCSuburbanID_3</i>
	textBRef	textID	<i>textFCSuburbanID_6</i>
	GTRelationship	GTdirecRela	exemplarIllustration

Table 6.21 Encoding result of exemplar illustration relationship in Figure 5.8

	Data Member			Value	
singleGraphicAndText	<<attribute>> graphicAndTextID			<i>graphicTextNIPCC4ID_1</i>	
	graphicARef	graphicID		<i>graphicNIPCC4ID_1</i>	
	textBRef	textID		<i>textNIPCC4ID_3</i>	
	GTrelationship	GTdirecRela	keywordDefining	keyword	<i>52 regional goals</i>
				keyword	<i>five core themes</i>
keyword				<i>the themes were crafted to provide a condensed summary of the 52 goals</i>	

Table 6.22 Encoding result of keyword defining relationship in Figure 5.10

Relationship between Graphic Group Entity and Text Entity

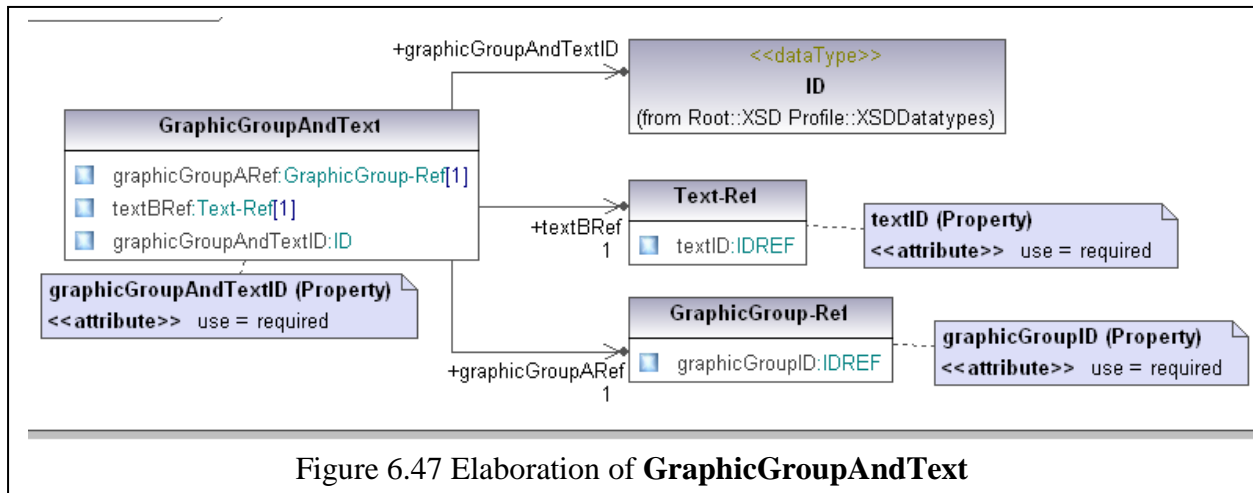


Figure 6.47 Elaboration of **GraphicGroupAndText**

“Relationship between a graphic group entity and a text entity” is modeled as

GraphicGroupAndText (see Figure 6.47), which is based on the theoretical research in Chapter 5.3.

Each relationship must have a graphicGroupAndTextID for identification of the relationship. In addition, each relationship must include an “ID reference of the graphic group entity involved” (modeled as **GraphicGroup-Ref**), and an “ID reference of the text entity involved” (modeled as **Text-Ref**). The purpose is to identify which graphic group and which text entity is included in the relationship.

To further explain the data model, the example (shown in Figure 5.14) that has been illustrated in Chapter 5.3 is encoded below.

Element		Value		
relationship	graphicGroupAndText	<<attribute>> graphicGroupAndTextID	<i>graphicGroupTextCPID_1</i>	
		graphicGroupARef	<<attribute>> graphicGroupID	<i>graphicGroupCPID_1</i>
		textBRef	<<attribute>> textID	<i>textCPID_1</i>

Table 6.23 Encoding result of relationship between the graphic group entity and the text entity in Figure 5.14

Relationship between Two Text Entities

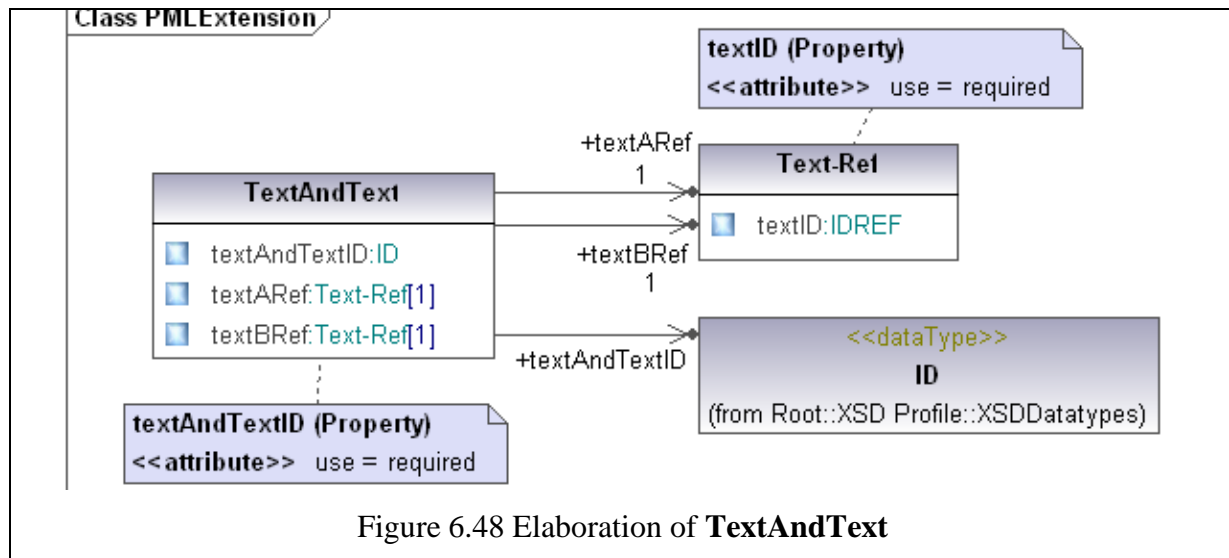


Figure 6.48 Elaboration of **TextAndText**

“Relationship between two text entities” is modeled as **TextAndText** (see Figure 6.48), which is based on the theoretical research in Chapter 5.4.

Each relationship must have a textAndTextID for identification of the relationship. In addition, each relationship must include two data members, textARef and textBRef (modeled by **Text-Ref**), which refer to IDs of the two text entities involved in the relationship.

To further explain the data model, the example that has been illustrated in Chapter 5.4 is encoded in Table 6.24. In the example, text entity *textFCID_1* has relationship with *textFCID_2*, and *textFCID_3*.

Data Member			Value	
relationship	textAndText	<<attribute>> textAndTextID		<i>textTextFCID_1</i>
		textARef	<<attribute>> textID	<i>textFCID_1</i>
		textBRef	<<attribute>> textID	<i>textFCID_2</i>
	textAndText	<<attribute>> textAndTextID		<i>textTextFCID_2</i>
		textARef	<<attribute>> textID	<i>textFCID_1</i>
		textBRef	<<attribute>> textID	<i>textFCID_3</i>

Table 6.24 Encoding result of relationship in the example in Chapter 5.4

6.4 Conclusion

In this chapter, the PMLGraphics has been presented in the UML class diagrams as well as illustrated with examples. The UML diagrams provide intuitive presentation forms for the PMLGraphics in XML schema shown in Appendix B. The proposed PMLGraphics data schema includes document metadata, document structure, and document content. The document content is the most important among these three parts, because it covers the data model that marks up single graphics, graphic groups, and relationship between content entities in plan-usable ways.

The next chapter presents design of the prototype for using the PMLGraphics and implementation of the prototype from a technical perspective. The prototype is explored in the use cases as shown in chapter eight.

7. Prototype Design and Implementation

This chapter introduces the prototype tool for using the PMLGraphics. The purpose of this prototype is to demonstrate procedural attributes of system, feasibility of encoding, and possibility of finding unexpected results. It is not a beta version of a PML system that could be used to observe how users will behave.

First, the prototype workflow and the rationale of the prototype design are described. Then the technical implementation is explained. The prototype tool is employed in three use cases, which are presented in Chapter 8, to demonstrate the feasibility and applicability of the PMLGraphics in planning processes.

7.1 Prototype Design

The prototype tool is designed in accordance with two considerations. First, functions of the tool should reveal in which ways the PMLGraphics could facilitate plan users easily accessing graphic contents in planning processes. Second, the tool should meet the needs of the three use cases as described in chapter eight.

The prototype includes two main features: Navigation Tool and Query Tool for Graphics (see snapshot in Figure 7.1). Each of them is illustrated in the following sub-sections.

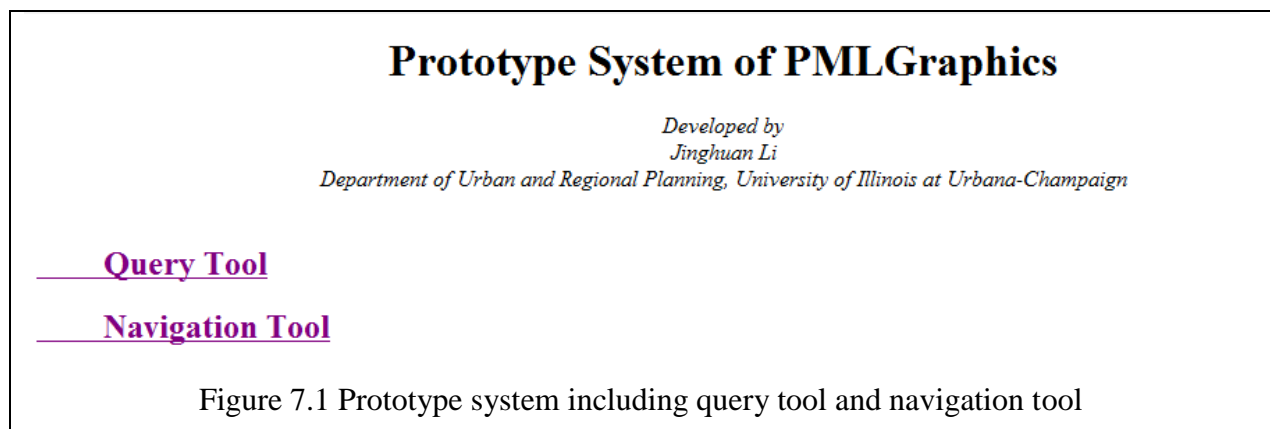


Figure 7.1 Prototype system including query tool and navigation tool

7.1.1 Navigation Tool

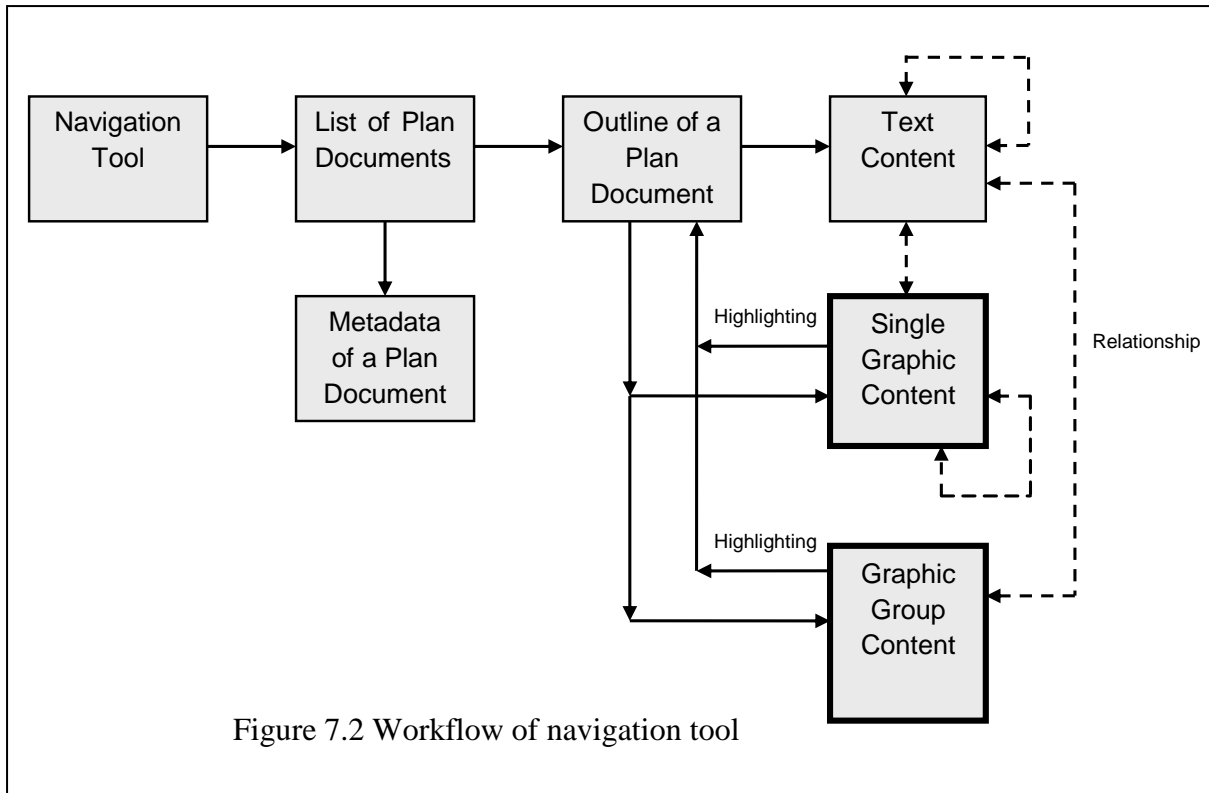
The workflow of the “Navigation Tool” is presented in Figure 7.2.

First, the plan documents stored in PML database are listed (see snapshot in Figure 7.3).

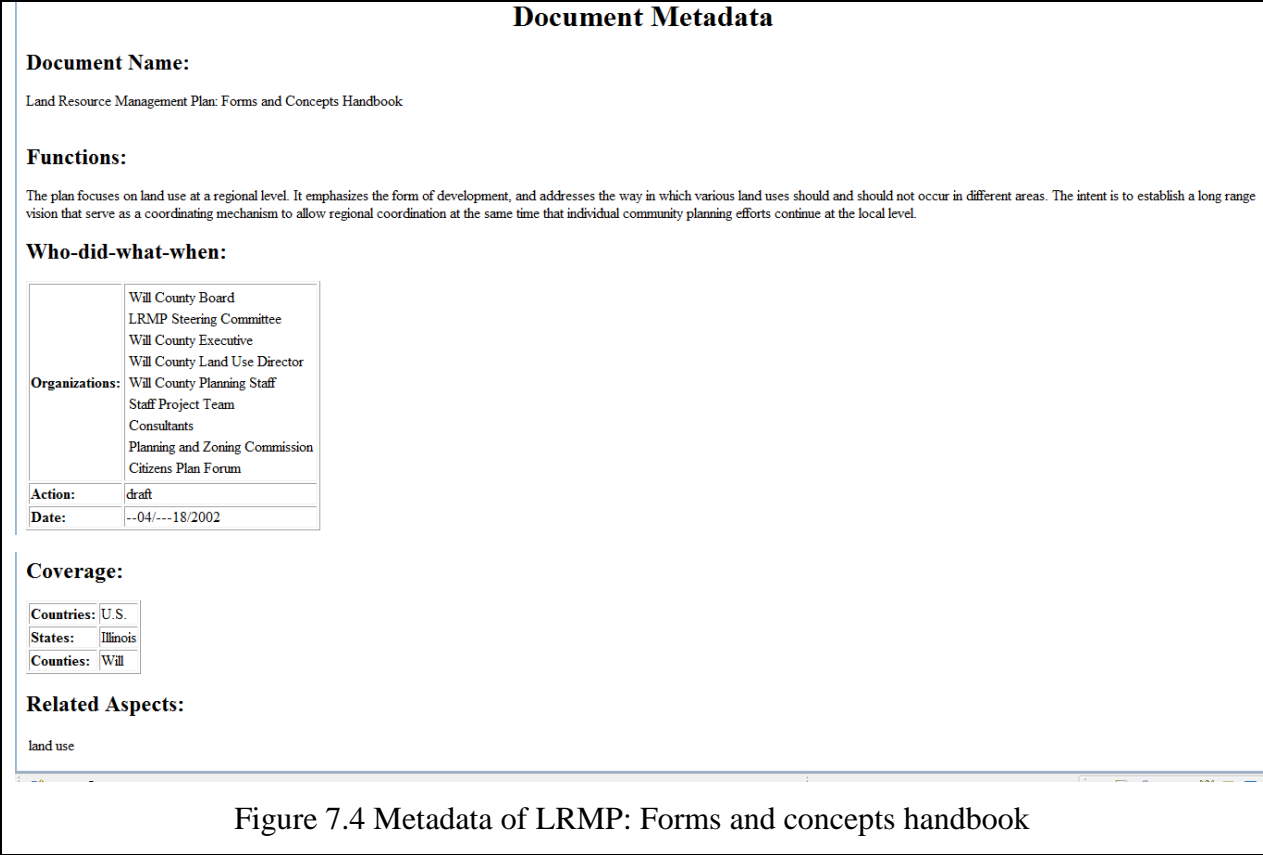
Metadata of each document could be accessed by clicking “[Meta Info]” after each document name. Figure 7.4 shows the metadata of the plan document *Land Resource Management Plan: Forms and Concepts Handbook*. Document metadata includes:

- document name,
- document functions,
- who-did-what-when,
- geographical coverage of document, and
- aspects covered by document.

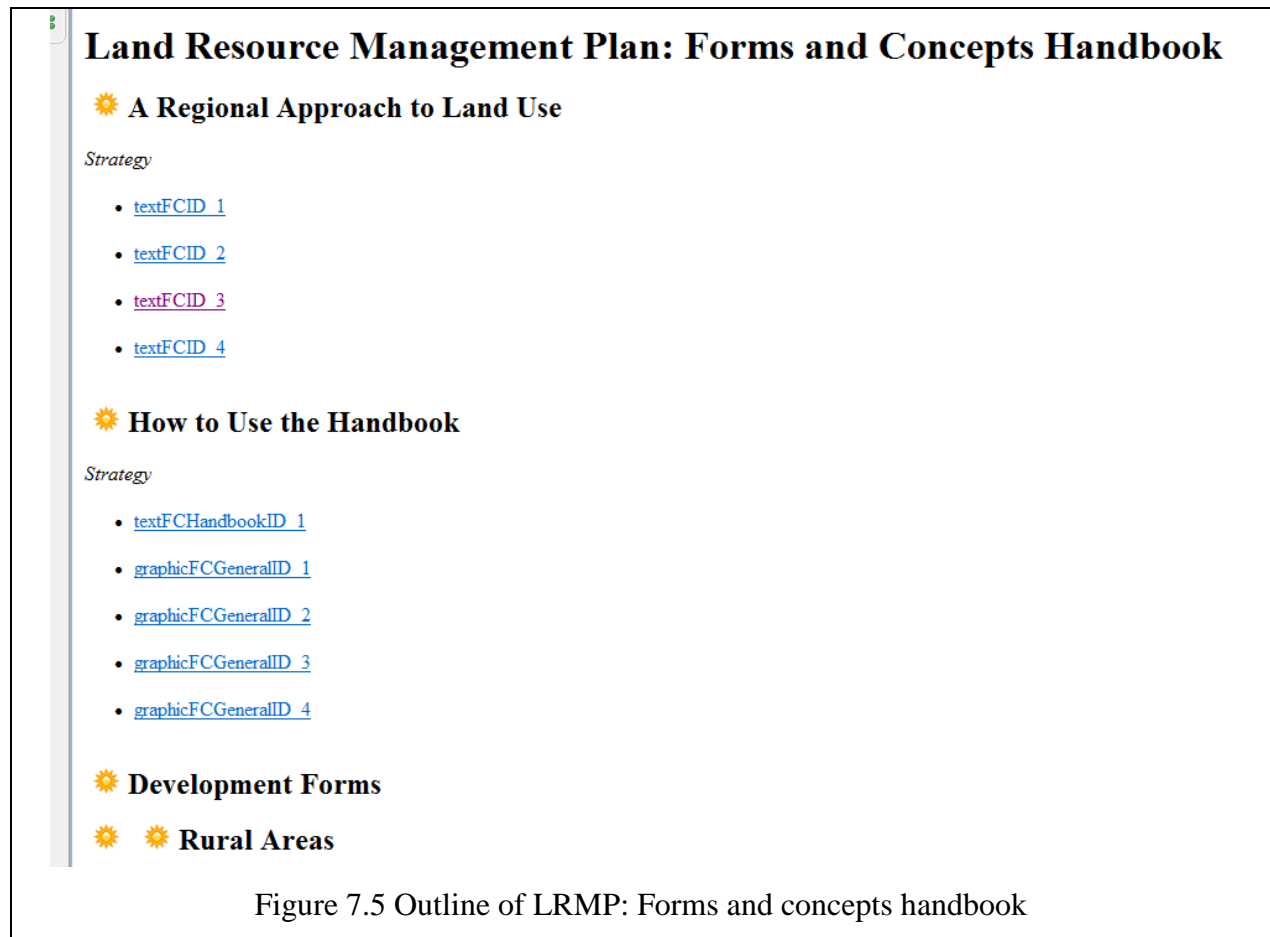
The metadata, which summarizes the plan document, helps users to make a good guess of what might be included in plan documents, and thus helps users choose the plan document that interests them most in a list.



- ### List of Plan Documents
- [Land Resource Management Plan: Policy Gateway](#)
[\[Meta info\]](#)
 - [Land Resource Management Plan: Forms and Concepts Handbook](#)
[\[Meta info\]](#)
 - [Land Resource Management Plan: Open Space Element](#)
[\[Meta info\]](#)
 - [2040 Regional Framework Plan](#)
[\[Meta info\]](#)
 - [2005 Comprehensive Plan, City of Urbana](#)
[\[Meta info\]](#)
- Figure 7.3 List of plan documents



Clicking each document name leads to an outline of each document. Figure 7.5 sketches the general framework of *Land Resource Management Plan: Forms and Concepts Handbook*. The outline clearly presents the titles in a hierarchical structure, lists IDs of content objects in three types (including text, single graphic, and graphic group) with embedded links, and labels content entities by elements rooted in PDM (e.g. policy, design, and strategy). Obviously, the type of each content object can be easily predicted by its identification -- ID starting with "text" implies that the content object is a text; ID starting with "graphic" implies that the content object is a single graphic; and ID starting with "graphicGroup" implies that the content object is a graphic group. The outline can not only help users to preview plan content in a glance, but also facilitate them to navigate content in a customized pattern matching their interests.



Clicking link of a content object in an outline leads to detailed plan content in a text, single graphic, or graphic group, as well as relationships with other content objects, if there are any. Each content object associated with the existing object has embedded links to drill down into detailed textual or graphical information. In the following, three snapshots (Figure 7.6, Figure 7.7, and Figure 7.9) are presented to illustrate the consequences of clicking embedded link of a text object, a single graphic object, and a graphic group object respectively. The content objects presented in Figure 7.6, 7.7, and 7.9 are all from the plan document *Land Resource Management Plan: Forms and Concepts Handbook*, the outline of which has been shown in Figure 7.5.

Text Content

[textFCTownID_1]

The Town Form of development includes larger communities such as Braidwood, Wilmington, Elwood, Peotone, and Beecher (compared to Hamlets) that are generally found in the southern half of Will County. Unlike their counterparts in the northern half of the County, the Urban Community Form, Towns are more geographically independent. They are typically surrounded by Agricultural or Rural Areas, rather than adjoining municipalities or Suburban Areas.

Relationship

Graphic And Text: [graphicFCTownID_3](#)

Figure 7.6 Detailed information of the text Object “textFCTownID_1”

Figure 7.6 shows detailed information of the text object “textFCTownID_1”. It also shows that there is a graphic and text relationship with single graphic object “graphicFCTownID_3”.

Detailed information of the single graphic could be accessed by its embedded link.

Figure 7.7 shows detailed information of the single graphic “graphicFCGeneralID_2”. The graphic is presented first, and then descriptive information for indexing the graphic is listed. A single graphic includes at most fifteen metadata:

- 1) graphic type,
- 2) index graphic or not,
- 3) title of the graphic,
- 4) description of the graphic,
- 5) representation method,
- 6) specific plan information the graphic intends to present,
- 7) categorized plan information with categorized aspects if they exist,
- 8) effectiveness of the graphic for presenting the intended information,
- 9) geographical coverage,
- 10) background,
- 11) index directory including index terms, objects being referred to and types (i.e., topic, text, single graphic, and graphic group), if the graphic is an index graphic,
- 12) legends, which could be in a tree-like structure, including legend names and comments for legends,
- 13) annotations,

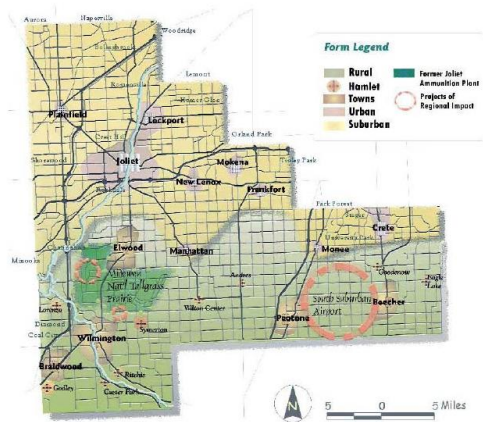
- 14) textual items, which could be in a tree-like structure, and
- 15) path.

Because Figure 7.7 is an index graphic, the topics for describing the seven development forms (e.g. rural, hamlet, towns, and urban) are referred to in the index directory. Clicking each of the embedded links of these topics, for instance, the link of “rural”, leads to the plan’s outline with one of the topics being highlighted (see Figure 7.8). Thus, plan users can easily navigate the content of the topic.

Following the descriptive information of the single graphic, relationships with other content objects are presented. Figure 7.7 shows semantic reference relationships between the graphic and dozens of other single graphics, as well as a keyword defining relationship between the graphic and other text illustrating the keyword “development forms”. Details of the associated graphics and text could be accessed by their embedded links. At the bottom of the page, the link “To Navigation” leads to outline of the plan document highlighting the graphic (see Figure 7.9). It facilitates users navigating the other content objects in the same topic or in the same plan document, after reviewing the detailed information of the single graphic object. Figure 7.8 and Figure 7.9 are different from Figure 7.5 presented before. Figure 7.8 and 7.9 highlight the topic being referred to or the graphic that is just navigated, whereas, Figure 7.5 does not include any highlight.

Single Graphic Content

< graphicFCGeneralID_2 >



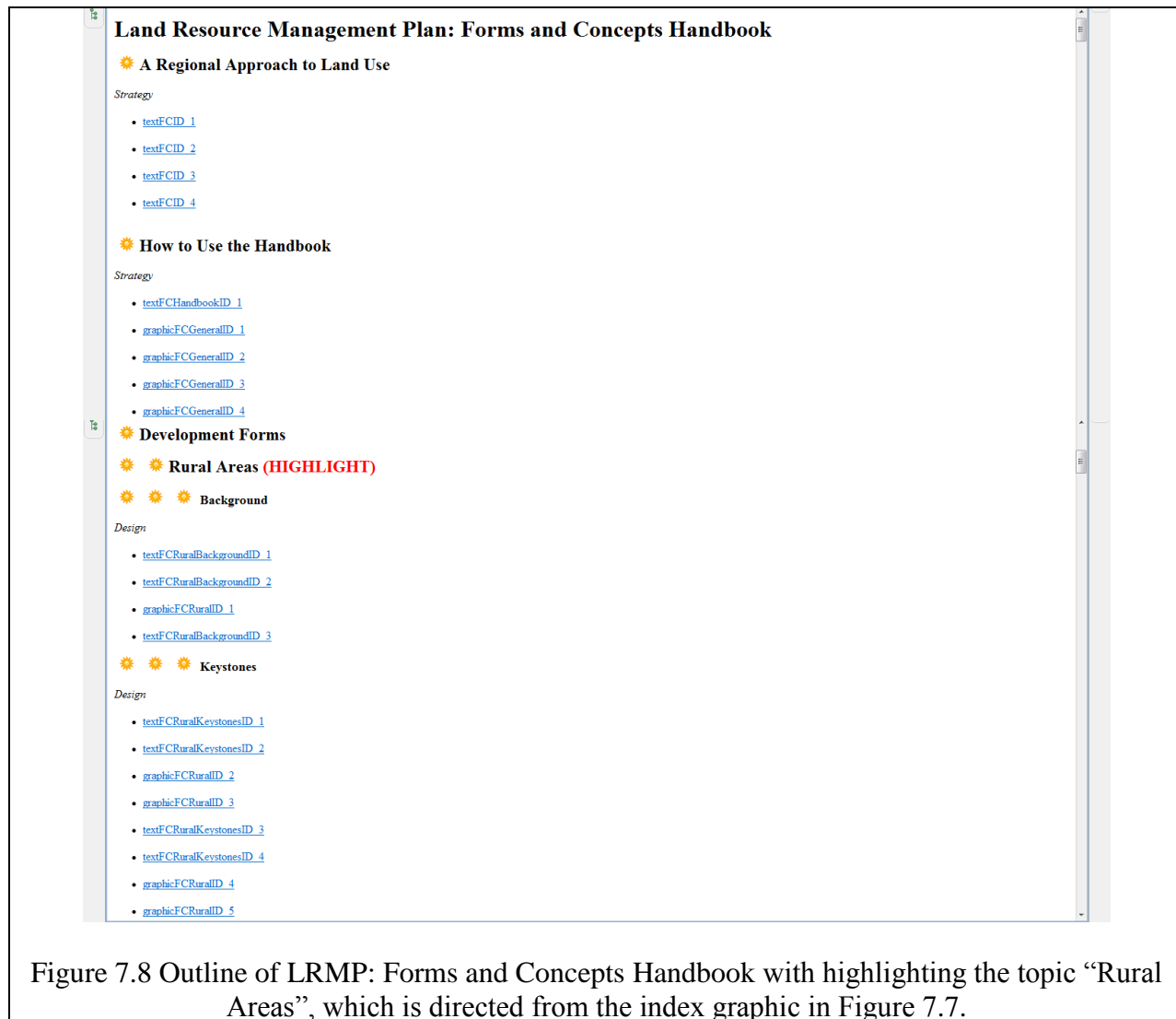
Graphic Type:	Map
Index Graphic:	true
Title:	development forms map
Representation Method:	Elaborate: Fully Elaborate
Specific Plan Info:	development forms
Categorized Plan Info:	Goals and Desired Future (Aspect: Land Use)
Effectiveness:	high
Coverage:	Illinois Will
Background:	Development Forms refer to the general character of large areas of the County. As contrasted with specific land uses, the identification of Forms is a way to identify distinguishable development patterns, or Forms at a countywide level, and to use these Forms as a way to manage the County's land resources.
Index Directory:	<ul style="list-style-type: none"> rural => topicFormsRuralID_1 [topic] hamlet => topicFormsHamletID_1 [topic] towns => topicFormsTownID_1 [topic] urban => topicFormsUrbanCommunitiesID_1 [topic] suburban => topicFormsSuburbanCommunitiesID_1 [topic] former Joliet ammunition plant => topicFormsJolietID_1 [topic] projects of regional impact => topicFormsAirportID_1 [topic]
Legend:	<ul style="list-style-type: none"> Form Legend Rural Hamlet Towns Urban Suburban Former Joliet Ammunition Plant Projects of Regional Impact
Path:	/planFormsConceptsID_2/LandResourceMap.jpg

Relationship:

Single Graphic And Single Graphic:	<ul style="list-style-type: none"> Directional SemanticReference graphicFCGeneralID_1 Directional SemanticReference graphicFCGeneralID_3 Directional SemanticReference graphicFCRuralID_5 Directional SemanticReference graphicFCHamletID_4 Directional SemanticReference graphicFCTownID_4 Directional SemanticReference graphicFCUrbanID_4 Directional SemanticReference graphicFCSuburbanID_6 Directional SemanticReference graphicFCInterstateID_3 Directional SemanticReference graphicFCJAAPID_5 Directional SemanticReference graphicFCSSAID_2 Directional SemanticReference graphicFCAgriculturalID_4 Directional SemanticReference graphicFCConservationID_3 Directional SemanticReference graphicFCResidentialSuburbanID_3 Directional SemanticReference graphicFCTraditionalResidentialID_4 Directional SemanticReference graphicFCMultiFamilyID_4 Directional SemanticReference graphicFCEmploymentID_3 Directional SemanticReference graphicFCRegionalCommercialID_4 Directional SemanticReference graphicFCMidScaleCommercialID_2 Directional SemanticReference graphicFCNeighborhoodCommercialID_2 Directional SemanticReference graphicFCIndustryID_2
Single Graphic And Text:	Directional Keyword Defining: Development Forms textFCID_2

[go to navigation](#)

Figure 7.7 Detailed information of the graphic “graphicFCGeneralID_2”



Land Resource Management Plan: Forms and Concepts Handbook

☀ A Regional Approach to Land Use

Strategy

- [textFCID_1](#)
- [textFCID_2](#)
- [textFCID_3](#)
- [textFCID_4](#)

☀ How to Use the Handbook

Strategy

- [textFCHandbookID_1](#)
- [graphicFCGeneralID_1](#)
- [graphicFCGeneralID_2](#) (HIGHLIGHT)
- [graphicFCGeneralID_3](#)
- [graphicFCGeneralID_4](#)

☀ Development Forms

☀ Rural Areas

Figure 7.9 Outline of LRMP: Forms and Concepts Handbook, with highlighting the single graphic presented in Figure 7.7

Details of the graphic group “graphicGroupFCUrbanID_1” are split into two figures, Figure 7.10 and 7.11, due to the limitation of the page size.

Figure 7.10 presents the graphic group first, and follows its descriptive information. Each graphic group includes at most seven metadata:

- 1) title of the graphic group,
- 2) description of the graphic group,
- 3) representation method,
- 4) specific plan information the graphic group presents,
- 5) categorized plan information, including categorized aspects if they exist,
- 6) background, and
- 7) path.

Then members in the graphic group and relationships among members are identified. In this case, the graphic group includes two members in multiples-design relationship, which present existing and proposed development of urban community respectively. After that, relationships

with other content objects are presented. The graphic group has no relationship with other content objects. The link “go to navigation” directs user to the outline of the plan document with the graphic group being highlighted.

Figure 7.11 presents detailed information of each group member in order. Each group member includes at most twelve items of descriptive information:

- 1) graphic type,
- 2) group member’s title,
- 3) description of group member,
- 4) representation method,
- 5) specific plan information,
- 6) categorized plan information,
- 7) geographical coverage,
- 8) background,
- 9) legend,
- 10) annotation,
- 11) textual item, and
- 12) path.

Graphic Group Content

< graphicGroupFCUrbanID_1 >



Representation Method:	Elaborate: Fully Elaborate
Specific Plan Info:	growth of a typical Urban Community
Categorized Plan Info:	Implementation (Aspect: Land Use)
Path:	/planFormsConceptsID_2/UrbanGraphicGroup12.jpg

Including Members

- existing urban community
- proposed development of urban community

Multiples-design Relationship

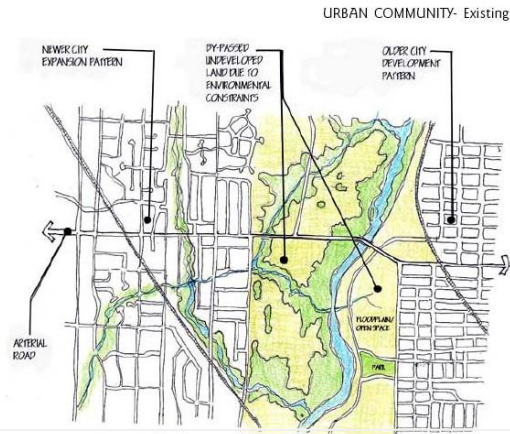
Relationship:

[go to navigation](#)

Figure 7.10 Upper part of details of the graphic group “graphicGroupFCUrbanID_1”

Group Member Content

< graphicGMFCUrbanID_1 >



Graphic Type:	Site Plan
Title:	existing urban community
Representation Method:	Elaborate: Fully Elaborate
Specific Plan Info:	existing urban community
Categorized Plan Info:	Current Situation, Issue and Trend
Annotation:	newer city expansion pattern by-passed undeveloped land due to environmental constrains older city development pattern arterial road
Path:	/planFormsConceptsID_2/UrbanPhoto/Member1.jpg

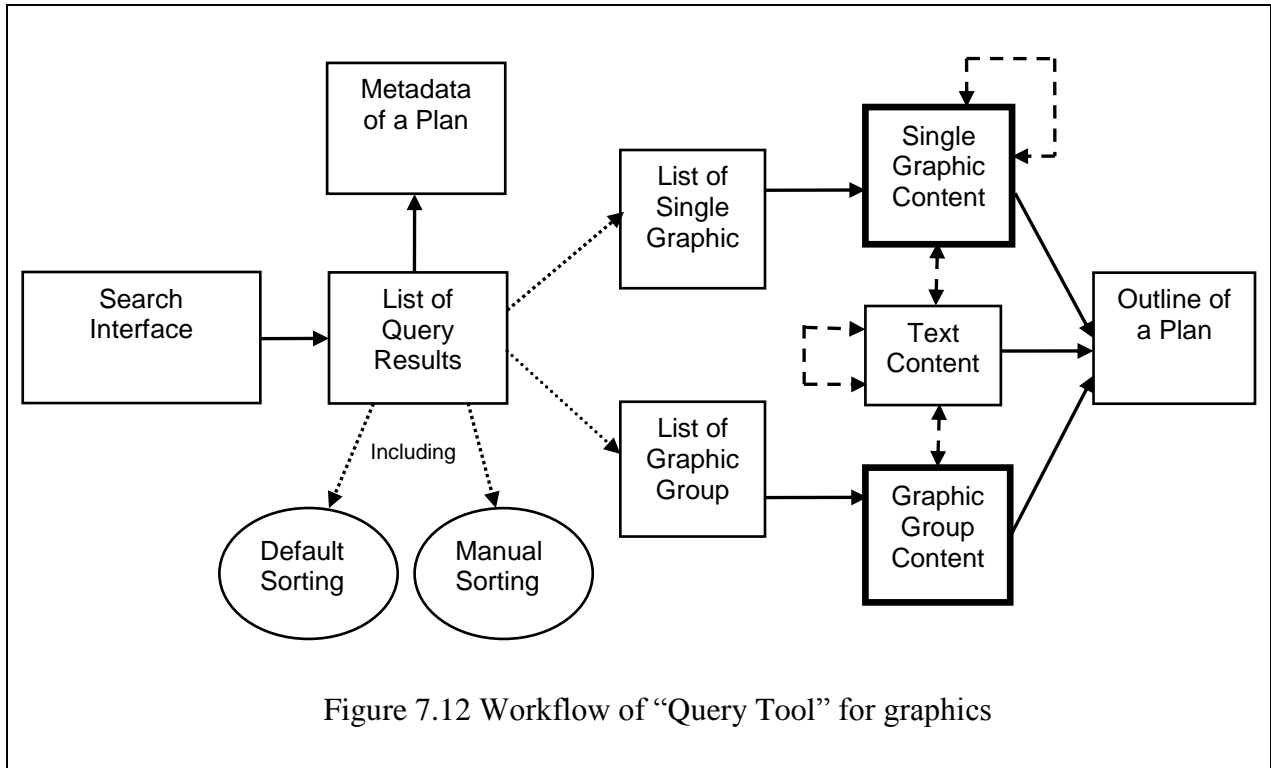
< graphicGMFCUrbanID_2 >



Graphic Type:	Site Plan
Title:	proposed development of urban community
Representation Method:	Elaborate: Fully Elaborate
Specific Plan Info:	proposed development of urban community
Categorized Plan Info:	Implementation (Aspect: Land Use)
Annotation:	multi-family residential neighborhood commercial center flexible grid street pattern circulation connectivity and pedestrian access single family residential greenway corridors or buffers, preservation of environmentally critical areas
Path:	/planFormsConceptsID_2/UrbanPhoto/Member2.jpg

Figure 7.11 Lower part of details of the graphic group “graphicGroupFCUrbanID_1”

7.1.2 Query Tool for Graphics



The general workflow of the “Query Tool” for graphics is presented in Figure 7.12.

The query tool starts with the search interface (see Figure 7.13). The interface can be divided into two sections based on their different types of user inputs.

The first section specifies a set of predefined vocabularies in three fields, “Plan Information”, “Aspect”, and “Graphic Type”, which match the controlled vocabularies of the corresponding elements defined in the proposed PMLGraphics. “Plan information” corresponds to the categorized plan information that is defined in the element “infoWA” and “infoWOAspect”, which present categorized plan information with aspects and without any aspect respectively. “Aspect” corresponds to the categorized aspects defined in the element “aspect”. The three elements, “infoWA”, “infoWOAspect” and “aspect”, are defined in the class “CategorizedPlanInfo” shown in Figure 6.19. “Graphic Type” corresponds to the classified graphic types defined in the element “type”, which is included in the class “GraphicCategory”.

In the first section, users have the flexibility to check zero, one, or more values in each of the three fields. If a user checks “Ground-level Image” in the field of graphic type, as well as “Land Use” and “Environmental Preservation” in the field of “Plan information”, the user intends to find graphics (including single graphics, graphic groups, and group members) that are in the type of ground-level image and related to the aspect land use or environmental preservation. Based on the user’s inputs, the corresponding elements are searched. If none of the values is checked, there is no restriction in the three fields.

The second section handles users’ inputs of “Coverage of Graphics” and “Keyword Search”, in which users can customize any word or phrase based on their needs. In the “Coverage of Graphics”, users can search graphics according to their coverage, specifically, names of State, County or City. The corresponding element “state”, “county” and “city” for describing coverage of single graphics and graphic members are modeled in class “Coverage” (see Figure 6.5). In the “Keyword Search”, users can input two sets of words or phrases, which are combined by either “AND” or “OR”. All of descriptive information of single graphics, graphic groups, and graphic members is searched accordingly. If there is no input in the coverage or the keyword search, there is no restriction in either of these fields.

The first section and the second section can be used together to construct search queries. Figure 7.13 shows such an example. The user intends to find single graphics, graphic groups, or group members whose metadata includes either “commercial” or “business” and contains the aspect land use or environmental preservation.

Retrieval results of queries are composed of two parts: a list of qualified single graphics and a list of qualified graphic groups. If a match lies in group members, then the graphic groups that include the qualified members are retrieved in the list of graphic groups.

Query Tool for Graphic Content

Plan Information

Planning Process Current Situation, Issue and Trend Goals and Desired Future Implementation Information Others

Aspect

Land Use Transportation Infrastructure Environmental Preservation Cultural Preservation Aspect Others

Graphic Type

Ground-level Image Aerial-level Image Graph Table Spatial Diagram Non-spatial Diagram Site Plan Map

Coverage of Graphics

State:

County:

City:

Keyword Search

keyword #1:

<>: OR AND

keyword #2:

Figure 7.13 Search interface

Query Result
List of Single Graphic












Icon	plan document	Matching Item	Graphic Type	Index Graphic	Representation Method	Specific Plan Info	Categorized Plan Info	Aspect	Effectiveness
	Land Resource Management Plan, Forms and Concepts Handbook	commercial (title, specificPlanInformation, annotation, path)	Site Plan	false	Elaborate: Fully Elaborate	typical Regional Commercial Center	Implementation	Land Use	high
	Land Resource Management Plan, Forms and Concepts Handbook	business (specificPlanInformation)	Ground-level Image	false	Elaborate: Partially Elaborate	Agricultural support businesses are critical to the viability of Agricultural Areas.	Implementation	Land Use	high
	Land Resource Management Plan, Forms and Concepts Handbook	commercial (title, specificPlanInformation, path)	Table	true	Elaborate: Fully Elaborate	appropriate Development Forms for Neighborhood Commercial	Implementation	Land Use	high
	Land Resource Management Plan, Forms and Concepts Handbook	commercial (title, specificPlanInformation, path)	Table	true	Elaborate: Fully Elaborate	appropriate Development Forms for Mid-Scale Commercial	Implementation	Land Use	high
	Land Resource Management Plan, Forms and Concepts Handbook	commercial (title, specificPlanInformation, path)	Table	true	Elaborate: Fully Elaborate	appropriate Development Forms for Regional Commercial	Implementation	Land Use	high
	2040 Regional Framework Plan	commercial (specificPlanInformation)	Ground-level Image	false	Elaborate: Fully Elaborate	Metropolitan Centers like Evanston are mixed-use hubs for commercial, employment, and institutional activities.	Implementation	Land Use	high
	Land Resource Management Plan, Forms and Concepts Handbook	commercial (description, specificPlanInformation, path)	Ground-level Image	false	Elaborate: Fully Elaborate	improved with landscaping measures and other design considerations to break-up the vast expanse of parking often associated with Regional Commercial uses.	Implementation	Land Use	high
	2040 Regional Framework Plan	business (specificPlanInformation, path)	Ground-level Image	false	Elaborate: Fully Elaborate	The City of Chicago's Central Business District is the Global Center in northeastern Illinois, tying the region and the United States to the world.	Implementation	Land Use	high
	Land Resource Management Plan, Forms and Concepts Handbook	commercial (description, specificPlanInformation, path)	Ground-level Image	false	Elaborate: Fully Elaborate	Mid-Scale Commercial uses should be located within easy access to an arterial roadway.	Implementation	Land Use	high
	2005 Comprehensive Plan, City of Urbana	commercial (annotation) business (legend)	Map		Elaborate: Fully Elaborate	future land use development of West Urbana (North Half)	Goals and Desired Future	Land Use Transportation Environmental Preservation	high
	2005 Comprehensive Plan, City of Urbana	commercial (legend) business (indexDirectory)	Map	true	Elaborate: Fully Elaborate	future land use of the City of Urbana	Goals and Desired Future	Land Use	high

Figure 7.14 List of qualified single graphics retrieved from the queries in Figure 7.13

Figure 7.14 shows a list of qualified single graphics retrieved from the queries in Figure 7.13. In the list, each single graphic is represented by a small-size icon. It provides a visual aid valuable for users to preview a single graphic and evaluate its relevance. Each single graphic is described by nine attributes. The nine attributes are illustrated below one by one. Among them, the last seven attributes are chosen from metadata of single graphics.

- “Plan Document”, which identifies the plan document that includes a graphic. Clicking document name leads to details of document metadata (shown in Figure 7.4).

- “Matching Item”, which displays the elements of data schema of a graphic that matches the search keywords. For instance, “commercial (annotation) business (legend)” indicates that the keyword “commercial” is included in the element annotation and the keyword “business” is included in the element legend.
- “Graphic Type”, which shows the type of a graphic.
- “Index Graphic”, which indicates whether a graphic is an index graphic or not.
- “Representation Method”, which shows the representation method used by a graphic to present intended plan information.
- “Specific Plan Info”, which shows the intended plan information presented by a graphic.
- “Categorized Plan Info”, which presents the plan information being categorized, such as “Planning Process”, “Current Situation, Issue and Trend”, “Goals and Desired Future”, and “Implementation”.
- “Aspect”, which presents categorized aspects, such as “Land Use”, “Transportation”, and “Infrastructure”.
- “Effectiveness”, which indicates how effectively a graphic communicates intended plan information.

The attributes mentioned above, along with the small-size icon, provide valuable hints for plan users to preview features of the graphics and make a good guess as to which graphics to look at further. Accordingly, users can quickly locate the most pertinent single graphics among a long retrieval list. Doing so can save much time of users having to navigate each qualified graphic in full-size and in details.

Moreover, the single graphics in the retrieval list are automatically ranked by default sorting rules from the most pertinent to the least. With the aid of the default sorting rules, plan users have a greater chance of finding the most pertinent single graphics among the top items of the list. The rules can save time of users having to preview each item in the retrieval list from the top to the bottom, especially when the retrieval list is quite long.

The default sorting rules of single graphics are as follows. The rules are applied in nested fashion, sorting first by rule 1, then by rule 2, and so on.

- 1) If value of the “effectiveness” is “high”, then the graphic is listed before others with “effectiveness” rated “low”.
- 2) If inputted keywords lie in the element “specificPlanInformation”, then the graphic is listed before others.
- 3) Next, graphics are sorted by a predefined order of values of the “Categorized Plan Info”.
The order is
 - a) “Goals and Desired Future”
 - b) “Implementation”
 - c) “Planning Process”
 - d) “Current Situation, Issue and Trend”
 - e) “Other”
- 4) For each value of “categorizedPlanInfo”, the graphics in “significant” types are listed before others. Table 7.1 shows significant graphic types for each type of plan information.

Categorized Plan Information	“Significant” Graphic Types
Goals and Desired Future	Map Aerial-level Image
Implementation	Map Non-spatial Diagram Site Plan
Planning Process	Non-spatial Diagram
Current situation, issue and trend	Map
Other	Map Non-spatial Diagram

Table 7.1 “Significant” graphic types for each type of plan information

The underlying principles for each rule of default sorting rules are presented below.

1. As illustrated in Chapter 4.5, “effectiveness” indicates how well a graphic elaborates or demonstrates the intended plan information. Thus “effectiveness” can also indicate whether a graphic is worthy to be studied or not. Thus, effectiveness is the first sort attribute. Obviously, the graphics with “high” effectiveness are more significant than the graphics with “low” effectiveness. Thus, graphics with “high” effectiveness should be listed first.

2. The element “specificPlanInformation” presents intended plan information conveyed by a graphic. The specific plan information carries more weight than other elements that present either non planning-oriented information (e.g. title and description) or supportive items included in a graphic (e.g. legend and annotation). Thus, specific plan information is the second sort attribute, and graphics with the specific plan information matching the keyword(s) should be listed first.
3. The ordering of categorized plan information is based on how important they are for plan users. As discussed in Chapter 4.3, “Goals and Desired Future” and “Implementation” are the most important information for plan users to make decisions and deliberate issues. So they are listed first and second respectively. “Planning Process”, which presents how a plan is created or the procedure of making a plan, and “Current Situation, Issue and Trend”, which provides background or rationale of desired futures and implementations, are supportive information. They are not, however, the essence of a plan document, so they are listed third and fourth. “Other” is listed last.
4. As illustrated in Chapter 4.3, the graphics in “significant” types for each type of plan information are more likely to convey crucial plan information than graphics in other types. Thus, graphics in significant types should be listed first.

The order of the four sorting rules is their priority order. That is to say, the first rule is prior to the second one, and the second one is prior to the third one, and so on. Their priority order is based on how powerful each sorting attribute is.

Besides the default sorting rules, single graphics in a retrieval list can be manually sorted on the basis of any of the following five elements – “Graphic Type”, “Index Graphic”, “Representation Method”, “Categorized Plan Info”, and “Effectiveness”. That is to say, plan users can choose which element is used as the sorting basis for the graphics. Table 7.2 shows the predefined sorting rules for each of the five elements. The sorting rules can list the more important graphics on the top, so that users can find the most pertinent graphics from the top of a list. The sorting can also serve the purpose of clustering graphics with same values of a particular element, so that users can find a particular cluster based on their needs.

Manual Sorting Rules for Single Graphics				
Graphic Type	Index Graphic	Representation Method	Categorized Plan Info	Effectiveness
1. Map <i>(alphabet order below)</i> 2. Aerial-level Image 3. Graph 4. Ground-level Image 5. Non-spatial Diagram 6. Site Plan 7. Spatial Diagram 8. Table	1. True 2. False	1. Fully Elaborate 2. Partial Elaborate 3. Demonstrate	1. Goals and Desired Future 2. Implementation 3. Planning Process 4. Current Situation, Issue and Trend 5. Other	1. High 2. Low

Table 7.2 Manual sorting rules for single graphics

The rationale of manual sorting rules is illustrated below one by one.

- **Graphic Type**

Generally, map is the most important graphic type among the eight graphic types. American Planning Association (2006) stated that “maps are a fundamental source of information for planning and design activities” (p. 527). Maps have the capacity of conveying plan information of a broad area. Map is among the significant graphic types for four types of plan information, “Goals and Desired Future”, “Implementation”, “Current situation, issue and trend”, and “Other” (see Table 7.1). Thus, map ranks first, and the other types are sorted in alphabet order.

- **Index Graphic**

As illustrated in Chapter 4.2.2, index graphic provides an easy-to-read framework to organize and relate the crucial plan concepts together. Elaboration and detailed illustration of the essential plan concepts could also be accessed from details of an index graphic, as introduced in Section 7.1.1. Thus, index graphic is, in general, more useful than other types of graphics. So index graphic ranks first.

- **Representation Method**

It is perceived that graphics are more frequently used to elaborate plan information than to make a convincing argument. “A graphic is worth ten thousands words”, which has been illustrated in Chapter 2.2, makes the graphics a good fit to elaborate plan information.

Therefore, the graphics can serve well the main purpose of a plan, “to guide public and private actions that affect the future” (American Planning Association, 2006, p.3). Graphics using “elaborate” method are thus listed before those using “demonstrate” method. Moreover, graphics using “fully elaborate” method are listed before those using “partially elaborate” because the former illustrate a whole piece of plan information, whereas the latter illustrate only a part or a section.

- Categorized Plan Info

The order of categorized plan information has been illustrated in the third rule of the default sorting rules of single graphics.

- Effectiveness

The order of effectiveness has been illustrated in the first rule of the default sorting rules of single graphics.

List of Graphic Group


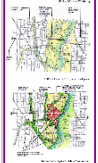



Graphic Icon	plan document	Matching Item	Representation Method	Specific Plan Info	Categorized Plan Info	Aspect	Graphic Member Relationship
	2005 Comprehensive Plan, City of Urbana	business (specificPlanInformation)	Elaborate: Fully Elaborate	typical features of regional business	Implementation	Land Use	Coordinative Relationship
	Land Resource Management Plan: Forms and Concepts Handbook	commercial (annotation<group member>)	Elaborate: Fully Elaborate	growth of a typical Urban Community	Implementation	Land Use	Multiples-design Relationship
	Land Resource Management Plan: Forms and Concepts Handbook	commercial (annotation<group member>)	Elaborate: Fully Elaborate	potential expansion of a typical Suburban Community	Implementation	Land Use	Multiples-design Relationship
	2005 Comprehensive Plan, City of Urbana	business (specificPlanInformation)	Elaborate: Fully Elaborate	typical features of community business	Implementation	Land Use	Coordinative Relationship
	2005 Comprehensive Plan, City of Urbana	business (specificPlanInformation)	Elaborate: Fully Elaborate	typical features of central business	Implementation	Land Use	Coordinative Relationship

Figure 7.15 List of qualified graphic groups retrieved from the queries in Figure 7.13

Figure 7.15 shows a list of qualified graphic groups retrieved from the queries in Figure 7.13. Each graphic group is represented by a small-size icon and connoted by seven attributes illustrated below. The attributes, together with the icon, facilitate plan users in making an educated guess about what might be included in a graphic group, and thus in locating the graphic

groups that interest them most. Among the seven attributes, the last five attributes are chosen from metadata of graphic groups.

- “Plan Document”, which shows the plan document that includes a graphic group. Clicking document name leads to document metadata shown in Figure 7.4.
- “Matching Item”, which displays the elements of data schema of a graphic group (including group members) that matches the search keywords. For instance, “business (specificPlanInformation)” shows that keyword “business” is included in the element specificPlanInformation of the graphic group; “commercial (annotation<group member>)” shows that keyword “commercial” is included in the element annotation of one of group members.
- “Representation Method”, which shows the representation method used by a graphic group to present plan information.
- “Specific Plan Info”, which shows the intended plan information presented by a graphic group.
- “Categorized Plan Info”, which presents the categorized plan information presented by a graphic group, including “Planning Process”, “Current Situation, Issue and Trend”, “Goals and Desired Future”, “Implementation”, and “Other”.
- “Aspect”, which presents the aspects of plan information presented by a graphic group.
- “Graphic Member Relationship”, which shows the relationship among graphic members.

Unlike single graphics, graphic groups don’t have default sorting rules in the current version. Because graphics groups occur much less frequently than single graphics do in the plan documents.

Graphic groups in the retrieval list can be manually sorted by any of the two attributes – “Representation Method”, and “Categorized Plan Info”. Table 7.3 shows the predefined sorting rules for each of them. The sorting rules can list the more important graphic groups on the top, so that users can locate the most pertinent groups from the top of a list. The sorting rules can also cluster graphic groups with same values of a particular element, so that users can find a particular collection based on their needs. The rationale of the sorting rules for graphic groups refers to that of the manual sorting rules for single graphics.

Manual Sorting Rules for Graphic Groups	
Representation Method	Categorized Plan Info
1. Fully Elaborate	1. Goals and Desired Future
2. Partial Elaborate	2. Implementation
3. Demonstrate	3. Planning Process
	4. Current Situation, Issue and Trend
	5. Other

Table 7.3 Manual sorting rules for graphic groups

7.2 Prototype Architecture

The prototype follows a three-tier architectural design (see Figure 7.16). It includes client tier, middle tier and data tier. This architecture design has gained popularity for many web-based applications. It hides complexity of distributed processing from the user while providing increased performance, flexibility, maintainability, reusability, and scalability from the system owner's point of view (Eckerson, 1995).

The client tier, in this prototype, is the web browser (e.g. Internet Explorer). The web browser is a thin user interface, which supports text, graphics, and other media via HTML/XHTML. The prototype allows a user to interact with the prototype by filling in text fields, selecting checkboxes, clicking on "search" button, and clicking through hyperlinks.

The middle tier deals with web processing and search logic. The technologies being employed include Apache Tomcat 6.0 web server, Java Servlet, JSP (JavaServer Pages), XQuery and Struts 2.0 framework. The basic workflows are as follows.

1. Grab the user's inputs from HTML forms.
2. Build XQuery clauses according to the inputs of keywords
3. Submit XQuery clauses to an embedded XQuery engine
4. Get query results in XML string
5. Construct in-memory data objects by parsing the XML string

6. Filter these data objects against additional restrictions from the inputs, including “Coverage”, “Plan Information”, “Aspect”, and “Graphic Type”
7. Sort the data objects based on default or manual sorting rules.
8. Pass the filtered/sorted data objects to web server.
9. Transform these data objects into HTML by JSP (within web server)
10. Send HTML back to the web browser.

The data layer is a XML file-based database. Currently, it covers three plans encoded in conformance with the schemas of the PMLGraphics. These plans are

1. *Land Resource Management Plan (LRMP)* with three documents: *Policy Gateway*, *Forms and Concepts Handbook*, and *Open Space Element*,
2. *2005 Comprehensive Plan* for City of Urbana, and
3. *2040 Regional Framework Plan* made by Northeastern Illinois Planning Commission (NIPC).

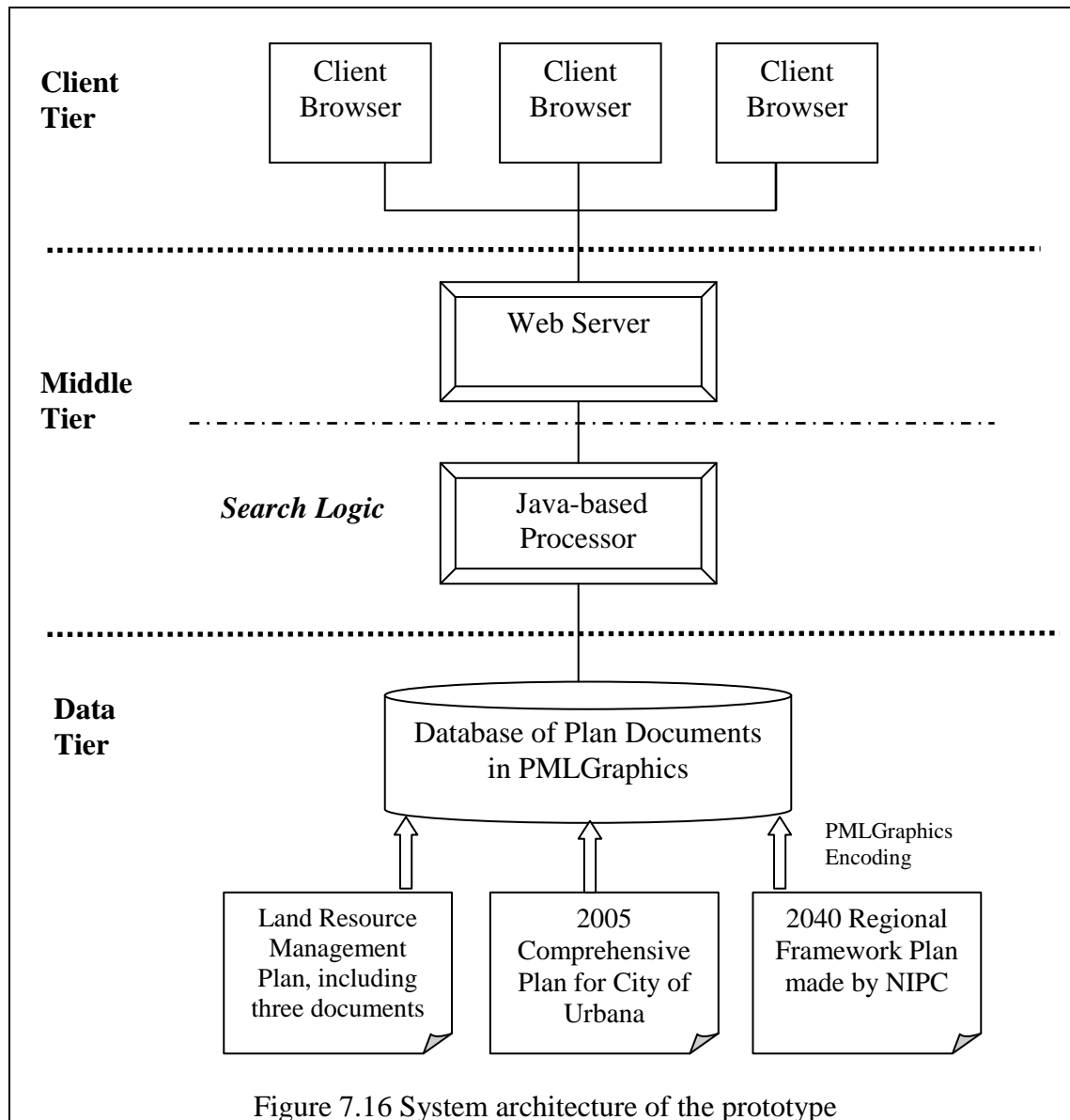


Figure 7.16 System architecture of the prototype

7.3 Conclusion

In this chapter, how the prototype works and the underlying principles of the prototype design are presented. The prototype shows how the ideas on the PMLGraphics proposed in the last chapter could be implemented to promote graphic content accessing in the planning processes. Then the software architecture of the prototype and latest web and XML technologies used for implementation are introduced.

The prototype is used in three use cases, which are presented in the next chapter, to demonstrate the feasibility and applicability of the PMLGraphics in accessing pertinent graphic plan content in the planning processes. The prototype is a proof-of-principle model to test feasibility of the PMLGraphics. It is not a beta version of a PML system that could be used to observe users' behaviors and collect their feedback.

8. Use Cases for Demonstration

The preceding two chapters illustrate the proposed PMLGraphics and the prototype. This chapter elaborates a set of use cases in which the feasibility and applicability of the PMLGraphics in accessing graphic plan content are demonstrated. Through database and the prototype, it shows the PMLGraphics can assist different stakeholders to easily access and conceive of pertinent plan information, especially graphic content, which could be scattered in different plan documents. Easily accessing plan information is fundamental and significant to later shape focus of attention, support discussion, and make decisions. Three use cases for demonstration are used to simulate practical scenarios in planning process. They are not meant to be exhaustive.

In this chapter, I first elaborate on the three use cases, in which stakeholders could formulate pertinent queries, sort a list of qualified graphics, browse the most pertinent graphic information, and extend navigation through certain associations between the graphic and other plan content. The actions of stakeholders in use cases, which are by no means absolute actions they must take, are ones among many possible alternatives. In each use case, I list what functions of the prototype are used, which indicate how the PMLGraphics could facilitate users to access graphic contents. At the end of each use case, I highlight the value of the PMLGraphics for enhancing users' ability to carry out the tasks by comparing the use case simulation to what would have happened without PMLGraphics.

8.1 Site Selection for an Office

An engineering company, which specializes in recovering data from hard disc of personal computer or notebook, intends to extend its services and open a branch office in Illinois. Before considering many other factors, such as competitors, market volumes, and building cost issues, the company works with consultants to locate a candidate list of sites where an engineering company office fits into the future land use development pattern.

To locate the candidate sites, the consultants need to access pertinent graphic plan contents, which could exist in several plan documents. The following shows how they could possibly make use in this case of the prototype illustrated in the last chapter. In description, more than a dozen screen snaps (shown from Figure 8.2 to Figure 8.18) are presented. To make the description more comprehensible, navigation logic of these screen snaps is shown in Figure 8.1.

To find candidate sites in compliance with future land use patterns, the consultants start by querying graphic contents with the following constraints (see Figure 8.2):

- Plan information conveyed by graphics including either “Goals and Future Design” or “Implementation”,
- Aspect of plan information conveyed by graphics including “Land Use”, and
- Any attribute of graphics including keyword “office”.

Qualified graphics are retrieved and presented as a list (see Figure 8.3).

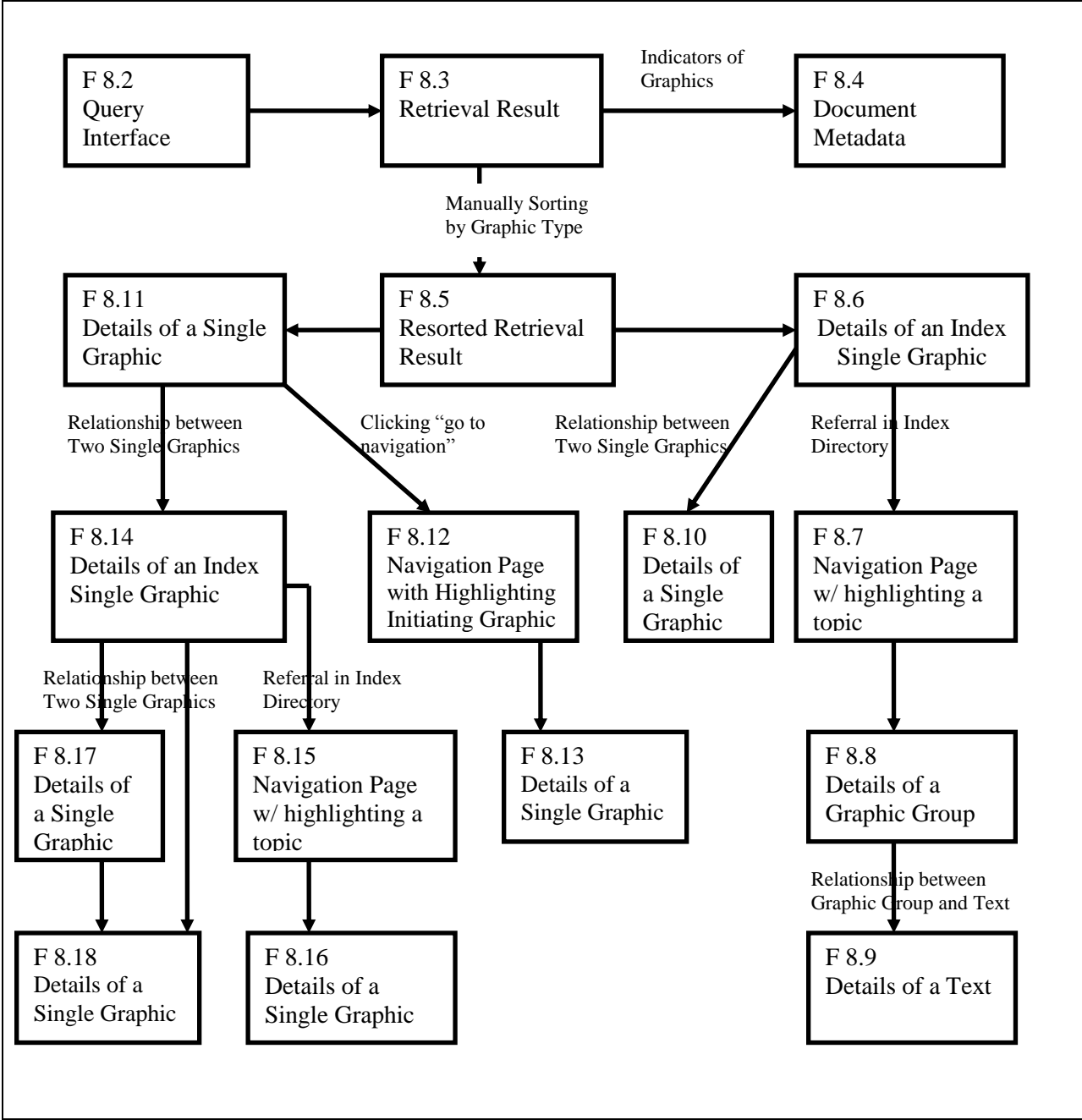


Figure 8.1 Navigation logic of the screen snaps in case one

Query Tool for Graphic Content

Plan Information

Planning Process Current Situation, Issue and Trend Goals and Desired Future
Implementation Information Others

Aspect

Land Use Transportation Infrastructure Environmental Preservation Cultural Preservation
 Aspect Others

Graphic Type

Ground-level Image Aerial-level Image Graph Table Spatial Diagram Non-spatial
Diagram Site Plan Map

Coverage of Graphics

State:

County:

City:

Keyword Search

keyword #1:

<>: OR AND












keyword #2:

SEARCH

Figure 8.2 Combination query for case one

Query Result

List of Single Graphic

Icon	plan document	Matching Item	Graphic Type	Index Graphic	Representation Method	Specific Plan Info	Categorized Plan Info	Aspect	Effectiveness
	Land Resource Management Plan: Forms and Concepts Handbook	office (title, specificPlanInformation)	Table	true	Elaborate: Fully Elaborate	appropriate Development Forms for Freestanding Industry and Office	Implementation	Land Use	high
	2005 Comprehensive Plan, City of Urbana	office (annotation)	Map		Elaborate: Fully Elaborate	future land use development of West Urbana (North Half)	Goals and Desired Future	Land Use Transportation Environmental Preservation	high
	2005 Comprehensive Plan, City of Urbana	office (indexDirectory, legend)	Map	true	Elaborate: Fully Elaborate	future land use of the City of Urbana	Goals and Desired Future	Land Use	high
	2005 Comprehensive Plan, City of Urbana	office (legend, annotation)	Map	false	Elaborate: Fully Elaborate	future land use map of North Lincoln Avenue / North Cunningham Avenue	Goals and Desired Future	Land Use Environmental Preservation	high
	Land Resource Management Plan: Forms and Concepts Handbook	office (annotation)	Site Plan	false	Elaborate: Fully Elaborate	typical Regional Commercial Center	Implementation	Land Use	high
	Land Resource Management Plan: Forms and Concepts Handbook	office (annotation)	Site Plan	false	Elaborate: Fully Elaborate	typical interstate access location	Implementation	Land Use	high
	Land Resource Management Plan: Forms and Concepts Handbook	office (indexDirectory)	Table	true	Elaborate: Fully Elaborate	Town Form appropriate Development Use Concepts	Implementation	Land Use	high
	Land Resource Management Plan: Forms and Concepts Handbook	office (indexDirectory)	Table	true	Elaborate: Fully Elaborate	Hamlet Form appropriate Development Use Concepts	Implementation	Land Use	high
	Land Resource Management Plan: Forms and Concepts Handbook	office (indexDirectory)	Table	true	Elaborate: Fully Elaborate	Suburban Community Form appropriate Development Use Concepts	Implementation	Land Use	high
	Land Resource Management Plan: Forms and Concepts Handbook	office (indexDirectory)	Table	true	Elaborate: Fully Elaborate	appropriate Development Use Concepts for Urban Community Form	Implementation	Land Use	high
	Land Resource Management Plan: Forms and Concepts Handbook	office (indexDirectory, textualItem)	Table	true	Elaborate: Fully Elaborate	application of the individual Development Use Concepts in each of the defined Development Forms	Implementation	Land Use	high
	Land Resource Management Plan: Forms and Concepts Handbook	office (indexDirectory)	Table	true	Elaborate: Fully Elaborate	Former JOAAP appropriate Development Use Concepts	Implementation	Land Use	high
	Land Resource Management Plan: Forms and Concepts Handbook	office (specificPlanInformation)	Ground-level Image	false	Elaborate: Fully Elaborate	Although freestanding these industrial and office uses should be held to a high development standard similar to that of Employment Campuses.	Implementation	Land Use	low

List of Graphic Group


Graphic Icon	plan document	Matching Item	Representation Method	Specific Plan Info	Categorized Plan Info	Aspect	Graphic Member Relationship
	2005 Comprehensive Plan, City of Urbana	office (specificPlanInformation)	Elaborate: Fully Elaborate	typical features of Light Industrial / Office land use	Implementation	Land Use	Coordinative Relationship

Figure 8.3 Retrieval results of query in case one

The list includes thirteen single graphics and one graphic group, which are marked by several important indicators. Browsing indicator “plan document”, the consultants get a clue that the qualified graphics are from two plan documents – (1) *2005 Comprehensive Plan for City of Urbana*, and (2) *Land Resource Management Plan: Forms and Concepts Handbook*. Suppose they want to know more from either or both of the two plan documents, clicking the plan names will do. For instance, clicking “2005 Comprehensive Plan, City of Urbana” results in Figure 8.4.

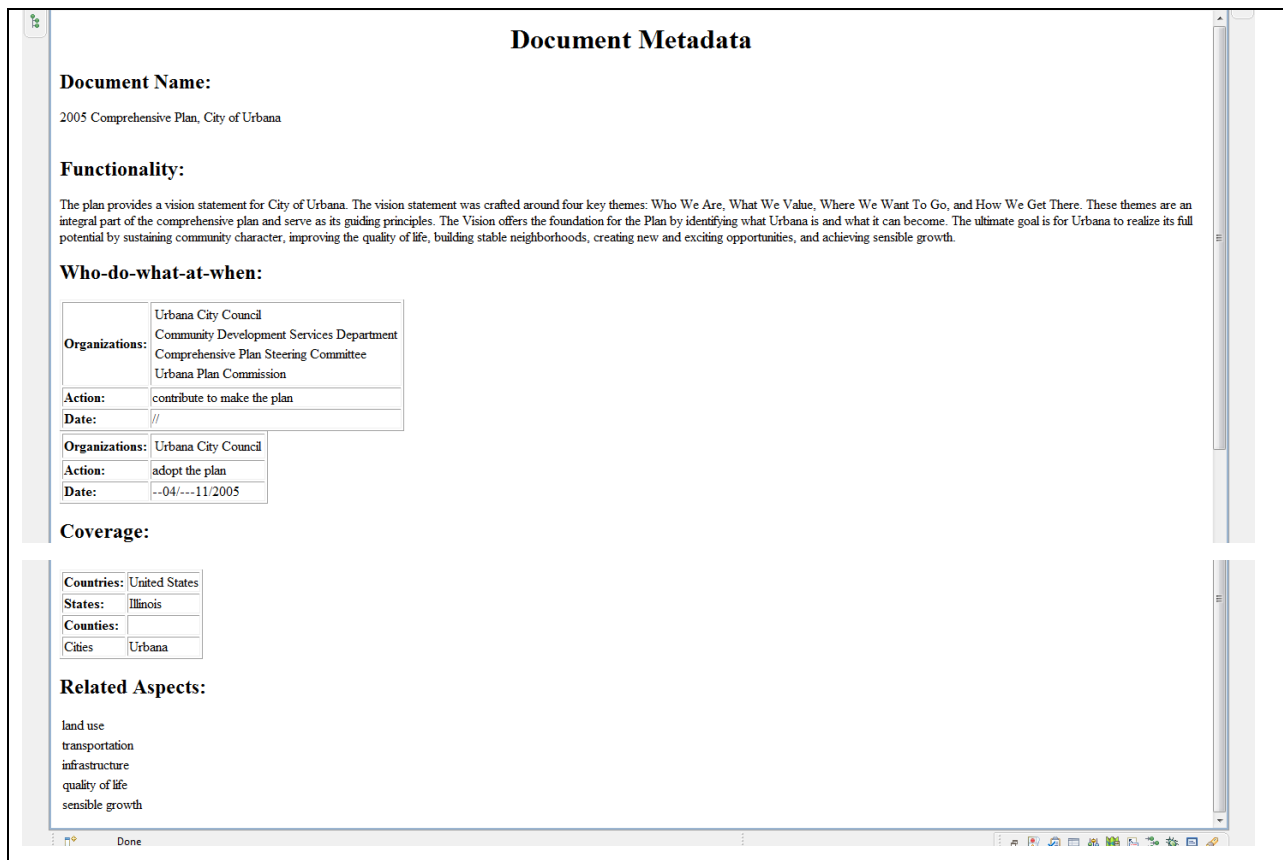















Figure 8.4 Document metadata of 2005 Comprehensive Plan for City of Urbana

Notice that the single graphics in the list are of various types -- map, site plan, table, or ground-level image. Suppose that the consultants think that map may be the most pertinent graphic type for site selection. Thus, they click indicator “Graphic Type” to utilize the manual sorting rule of graphic types (refer to Appendix C) to sort the single graphics by their types. As a result, three maps emerge on top of the list (see Figure 8.5).

By browsing indicator “Specific Plan Info” of the three maps, the consultants get to know that the map second in the list presents future land use of City of Urbana, whereas the first and third maps present future land use of two subdivisions of the city. Expecting that the one for broader area may deliver more information than the ones for narrower regions, consultants choose to navigate details of the second map first, and thus click small icon of the map. Details of the map are shown in Figure 8.6.

The map in Figure 8.6 shows the proposed future land use development patterns in City of Urbana. Moreover, because the map is an index graphic, descriptions of the various land use patterns (such as residential, regional business, campus mixed use, and light industrial / office) can be accessed easily by clicking topic links referred to by index terms of index directory of the map. Figure 8.7, for instance, shows navigation page with highlighting topic “Campus Mixed Use” referred to by the map. In the navigation page, a textual description and a graphic group for illustrating typical features of “Campus Mixed Use” pattern could be accessed by clicking their links. Figure 8.8 shows details of the graphic group, which includes two members associated with “coordinative relationship”. The graphic group also has relationship with a piece of text, details of which could be accessed by clicking its link (see Figure 8.9). Similarly, the consultants read through details of the various land use patterns in the map of Figure 8.6. In the process, graphic group for presenting “Light Industrial / Office” is navigated. It is by chance also in the retrieval list shown in Figure 8.5. At last, the consultants settle on “Campus Mixed Use” and “Light Industrial / Office”, as the proper land use patterns in City of Urbana to build the office.

In Figure 8.6, it can be noticed that the map has zoom in relationship (labeled as “GeoWholePart”) with three other graphics, <graphicUrbanaC8FutureMap1>, <graphicUrbanaC8FutureMap2>, and <graphicUrbanaC8FutureMap8>. For simplification, the three graphics are labeled as Map #1, Map#2, and Map #8 correspondingly hereafter. Clicking links of these graphics leads to future land use patterns and issues in subdivisions of City of Urbana. The consultants focus on studying land parcels proposed as “Campus Mixed Use” or “Light Industrial / Office”. As an example, Figure 8.10 presents details of the Map #1. Coincidentally, the Map #1 and Map #8 are also among the first three single graphics of the retrieval list shown in Figure 8.5.

Query Result									
List of Single Graphic									
Icon	plan document	Matching Item	Graphic Type	Index Graphic	Representation Method	Specific Plan Info	Categorized Plan Info	Aspect	Effectiveness
	2005 Comprehensive Plan, City of Urbana	office (annotation)	Map		Elaborate: Fully Elaborate	future land use development of West Urbana (North Half)	Goals and Desired Future	Land Use Transportation Environmental Preservation	high
	2005 Comprehensive Plan, City of Urbana	office (indexDirectory, legend)	Map	true	Elaborate: Fully Elaborate	future land use of the City of Urbana	Goals and Desired Future	Land Use	high
	2005 Comprehensive Plan, City of Urbana	office (legend, annotation)	Map	false	Elaborate: Fully Elaborate	future land use map of North Lincoln Avenue / North Cunningham Avenue	Goals and Desired Future	Land Use Environmental Preservation	high
	Land Resource Management Plan, Forms and Concepts Handbook	office (specificPlanInformation)	Ground-level Image	false	Elaborate: Fully Elaborate	Although freestanding these industrial and office uses should be held to a high development standard similar to that of Employment Campuses.	Implementation	Land Use	low
	Land Resource Management Plan, Forms and Concepts Handbook	office (annotation)	Site Plan	false	Elaborate: Fully Elaborate	typical Regional Commercial Center	Implementation	Land Use	high
	Land Resource Management Plan, Forms and Concepts Handbook	office (annotation)	Site Plan	false	Elaborate: Fully Elaborate	typical interstate access location	Implementation	Land Use	high
	Land Resource Management Plan, Forms and Concepts Handbook	office (title, specificPlanInformation)	Table	true	Elaborate: Fully Elaborate	appropriate Development Forms for Freestanding Industry and Office	Implementation	Land Use	high
	Land Resource Management Plan, Forms and Concepts Handbook	office (indexDirectory)	Table	true	Elaborate: Fully Elaborate	Town Form appropriate Development Use Concepts	Implementation	Land Use	high
	Land Resource Management Plan, Forms and Concepts Handbook	office (indexDirectory)	Table	true	Elaborate: Fully Elaborate	Hamlet Form appropriate Development Use Concepts	Implementation	Land Use	high
	Land Resource Management Plan, Forms and Concepts Handbook	office (indexDirectory)	Table	true	Elaborate: Fully Elaborate	Suburban Community Form appropriate Development Use Concepts	Implementation	Land Use	high
	Land Resource Management Plan, Forms and Concepts Handbook	office (indexDirectory)	Table	true	Elaborate: Fully Elaborate	appropriate Development Use Concepts for Urban Community Form	Implementation	Land Use	high
	Land Resource Management Plan, Forms and Concepts Handbook	office (indexDirectory, textualItem)	Table	true	Elaborate: Fully Elaborate	application of the individual Development Use Concepts in each of the defined Development Forms	Implementation	Land Use	high
	Land Resource Management Plan, Forms and Concepts Handbook	office (indexDirectory)	Table	true	Elaborate: Fully Elaborate	Former JOAAP appropriate Development Use Concepts	Implementation	Land Use	high


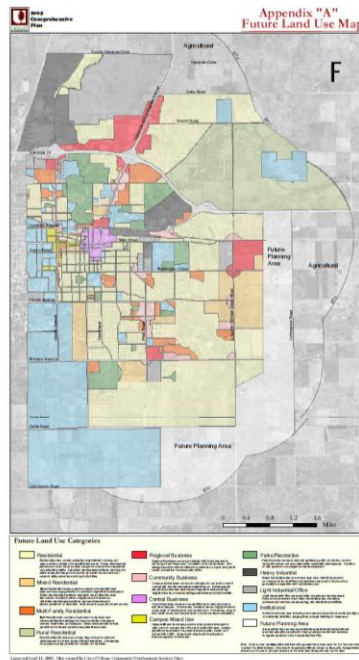
List of Graphic Group							
Graphic Icon	plan document	Matching Item	Representation Method	Specific Plan Info	Categorized Plan Info	Aspect	Graphic Member Relationship
	2005 Comprehensive Plan, City of Urbana	office (specificPlanInformation)	Elaborate: Fully Elaborate	typical features of Light Industrial / Office land use	Implementation	Land Use	Coordinative Relationship

Figure 8.5 Manually sorting single graphics by their graphic types

Single Graphic Content

< graphicUrbanaFutureLandUseMap >



Graphic Type:	Map
Index Graphic:	true
Representation Method:	Elaborate: Fully Elaborate
Specific Plan Info:	future land use of the City of Urbana
Categorized Plan Info:	Goals and Desired Future (Aspect: Land Use)
Effectiveness:	high
Coverage:	Illinois
Background:	The overall Future Land Use Map is a compilation of the 14 individual area maps in Chapter VII, and offers a view of how the City desires to grow in the future. The Comprehensive Plan states that the City...
Index Directory:	<ul style="list-style-type: none"> Residential => topicUrbanaC7UrbanResidential [topic] Mixed Residential => topicUrbanaC7UrbanMixedResidential [topic] Multi-Family Residential => topicUrbanaC7MultiFamilyResidential [topic] Rural Residential => topicUrbanaC7RuralResidential [topic] Regional Business => topicUrbanaC7RegionalBusiness [topic] Community Business => topicUrbanaC7CommunityBusiness [topic] Central Business => topicUrbanaC7CentralBusiness [topic] Campus Mixed Use => topicUrbanaC7CampusMixedUse [topic] Parks/Recreation => topicUrbanaC7Parks [topic] Heavy Industrial => topicUrbanaC7HeavyIndustrial [topic] Light Industrial Office => topicUrbanaC7LightIndustrial [topic] Institutional => topicUrbanaC7Institutional [topic] Future Planning Area => topicUrbanaC7Future [topic]
Legend:	<ul style="list-style-type: none"> Future Land Use Categories Residential Mixed Residential Multi-Family Residential Rural Residential Regional Business Community Business Central Business Campus Mixed Use Parks/Recreation Heavy Industrial Light Industrial Office Institutional Future Planning Area
Path:	planUrbana2005FutureLandMap.jpg

Relationship:

Directional Zooms [graphicUrbanaC7FutureMap1](#)
 Single Graphic And Single Graphic: [Directional Zooms graphicUrbanaC7FutureMap2](#)
[Directional Zooms graphicUrbanaC7FutureMap8](#)

[go to navigation](#)

Figure 8.6 Details of a single graphic that presents future land use of City of Urbana

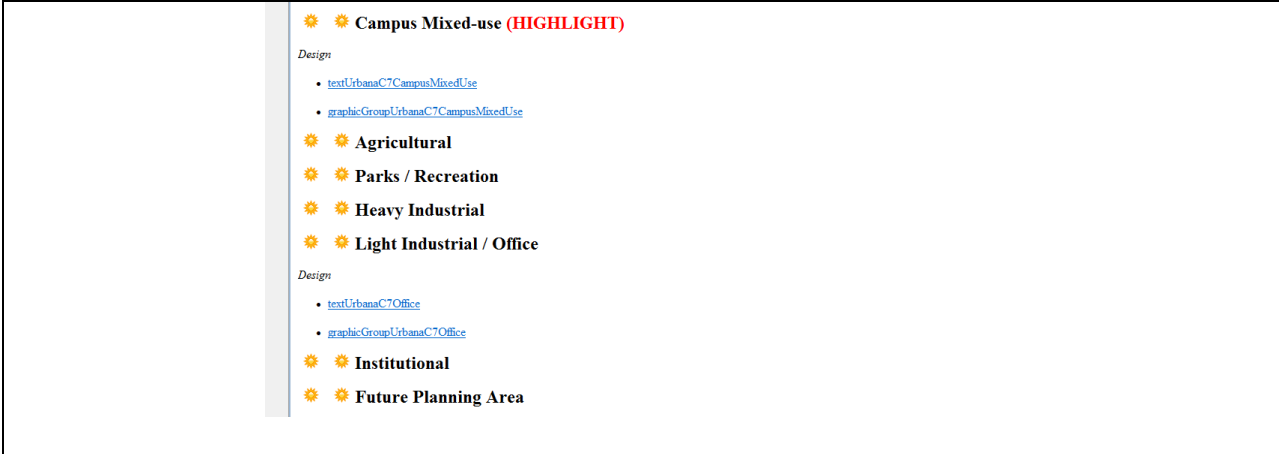


Figure 8.7 Navigation page with highlighting topic “Campus Mixed-use”

Graphic Group Content

< graphicGroup\Urban\C7\CampusMixedUse >

CAMPUS MIXED-USE

The Campus Mixed-Use classification is intended for limited areas that are close to campus. These areas promote urban-style private development with a mix of uses that commonly include commercial, office and residential. Design Guidelines shall ensure that development contains a strong urban design that emphasizes a pedestrian scale with buildings close to the street, wide sidewalks, and parking under and behind structures. The design and density of development should equate to existing and future transit routes in the area. Large-scale developments containing only single uses are discouraged within this classification.



Representation Method:	Elaborate: Fully Elaborate
Specific Plan Info:	typical features of campus mixed use
Categorized Plan Info:	Implementation (Aspect: Land Use)
Path:	plan\Urban\2005\CampusMixedUseGroup.docx

Including Members

Coordinative Relationship

Relationship:

Graphic Group and Text [text\Urban\C7\CampusMixedUse](#)

[go to navigation](#)

Group Member Content

< Member\Urban\C7\CampusPhoto >



Graphic Type:	Image: Ground-level Image
Title:	
Representation Method:	
Specific Plan Info:	
Categorized Plan Info:	
Annotation:	
Path:	plan\Urban\2005\CampusMixedUsePhoto.jpg

< Member\Urban\C7\CampusImage >



Graphic Type:	Image: Ground-level Image
Title:	
Representation Method:	
Specific Plan Info:	design control of campus mixed use
Categorized Plan Info:	
Annotation:	Buildings up to Sidewalk Residential above Retail
Path:	plan\Urban\2005\CampusMixedUseImage.jpg

Figure 8.8 Details of graphic group presenting “Campus Mixed Use” development pattern

Text Content

[textUrbanaC7CampusMixedUse]

The Campus Mixed-Use classification is intended for limited areas that are close to campus. These areas promote urban-style private development with a mix of uses that commonly include commercial, office and residential. Design Guidelines shall ensure that developments contain a strong urban design that emphasizes a pedestrian scale with buildings close to the street, wide sidewalks, and parking under and behind structures. The design and density of development should capitalize on existing and future transit routes in the area. Large-scale developments containing only single uses are discouraged within this classification.

Relationship

GraphicGroup And Text [graphicGroupUrbanaC7CampusMixedUse](#)

Figure 8.9 Details of a text having relationship with the graphic group in Figure 8.8

Map #1
North Lincoln Avenue / North Cunningham Avenue

Graphic Type:	Map
Index Graphic:	false
Representation Method:	Elaborate: Fully Elaborate
Specific Plan Info:	future land use map of North Lincoln Avenue / North Cunningham Avenue
Categorized Plan Info:	Goals and Desired Future (Aspect: Land Use, Environmental Preservation)
Effectiveness:	high
Annotation:	<ul style="list-style-type: none"> capitalize on Access to RR preserve stream corridor road connection crucial for fire protection determine appropriate "vegetative buffer" zone for Saline. Goals of buffer: 1. protects stream 2. provides trail area 3. buffers industrial and residential land uses Rural / Agri Business opportunities along U.S. 45, assist in marketing, assist in marketing explore future park acquisition small scale transition from heavy industry to light industry airport / business uses per agreement improve interstate visibility and access improve transit and pedestrian access
Path:	planUrbana2005/FutureLandMapFigure1.jpg

Relationship:

Single Graphic And Single Graphic: **Directional** ZoomIn [graphicUrbanaFutureLandUseMap](#)
Non-Directional Adjacency [graphicUrbanaC8FutureMap2](#)

[go to navigation](#)

Figure 8.10 Details of graphic that has relationship with the map in Figure 8.5

Having done an extensive navigation around the future land use map of City of Urbana, the consultants go back to the sorted retrieval list shown in Figure 8.5, in order to navigate to other

graphic contents. They notice that the first three maps having been navigated come from the same plan document, *2005 Comprehensive Plan* for City of Urbana. The other single graphics, which have not been navigated yet, are from the other plan document, *Land Resource Management Plan: Forms and Concepts Handbook* (LRMP: FCH). The next step for them is to look for interesting information from LRMP: FCH. By browsing indicators of the single graphics, they show interest in a simple table, directly under a ground-level image, which presents “appropriate development forms for Freestanding Industry and Office” (indicated by indicator “Specific Plan Info”). Clicking its small icon leads to details of the table shown in Figure 8.11. To further explore contents related to “Freestanding Industry and Office”, the consultants can click on the “go to navigation” link to navigate to page that highlights the initiating graphic (see Figure 8.12). From the navigation page, they can further explore other plan contents under the topic “Freestanding Industry and Office” by simply clicking the links. Figure 8.13, as an example, presents the ground-level image (with ID “graphicFCIndustryID_1”) under the subtitle “General Principles”. The image being navigated is also among the retrieval list shown in Figure 8.5. Going back to the table in Figure 8.11, they also notice that the table has whole-part relationship with a graphic with ID “graphicFCGeneralID_3” and semantic reference relationship with a graphic with ID “graphicFCGeneralID_2”. For purposes of simplicity, the two graphics are respectively represented as “graphic_3” and “graphic_2” below.

Single Graphic Content

< graphicFCIndustryID_2 >

APPROPRIATE FORM APPLICATION TABLE

RURAL	HAMLET	TOWN	URBAN COMMUNITY	SUBURBAN COMMUNITY	INTERSTATE ACCESS LOCATION	FORMER JOAAP	SSA
	•	•	•	•		•	

Graphic Type:	Table
Index Graphic:	true
Title:	appropriate Development Forms for Freestanding Industry and Office
Representation Method:	Elaborate: Fully Elaborate
Specific Plan Info:	appropriate Development Forms for Freestanding Industry and Office
Categorized Plan Info:	Implementation (Aspect: Land Use)
Effectiveness:	high
Index Directory:	Hamlet => topicFormsHamletID_1 [topic] Town => topicFormsTownID_1 [topic] Urban Community => topicFormsUrbanCommunitiesID_1 [topic] Suburban Community => topicFormsSuburbanCommunitiesID_1 [topic] Former JOAAP => topicFormsJolietID_1 [topic]
Path:	/planFormsConceptsID_2/IndustryTable.jpg

Relationship:

Single Graphic And Single Graphic:	Directional WholePart graphicFCGeneralID_3
	Directional SemanticReference graphicFCGeneralID_2

[go to navigation](#)

Figure 8.11 Details of table presenting “appropriate development forms for Freestanding Industry and Office”

Freestanding Industry and Office

Design

- [textFCIndustryID_1](#)

General Principles

Design

- [graphicFCIndustryID_1](#)
- [textFCIndustryID_2](#)

Appropriate Development Form Application Table

Design

- [graphicFCIndustryID_2 \(HIGHLIGHT\)](#)

Form Specific Principles

Hamlet Form Principles

Design

- [textFCIndustryID_4](#)


Town Form Principles

Design

- [textFCIndustryID_5](#)

Single Graphic Content

< graphicFCIndustryID_1 >



Although freestanding these industrial and office uses should be held to a high development standard similar to that of Employment Campuses.

Graphic Type:	Ground-level Image
Index Graphic:	false
Representation Method:	Elaborate: Fully Elaborate
Specific Plan Info:	Although freestanding these industrial and office uses should be held to a high development standard similar to that of Employment Campuses.
Categorized Plan Info:	Implementation (Aspect: Land Use)
Effectiveness:	low
Path:	/planFormsConceptsID_2/IndustryPhoto1.jpg

Relationship:

[go to navigation](#)

Figure 8.12 Navigation page highlighting the initiating graphic

Figure 8.13 Details of single graphic (with ID “graphicFCIndustryID_1”) directed from navigation page

The “graphic_3”, a table shown in Figure 8.14, illustrates application of the individual Development Use Concepts in each of the defined Development Forms. Since the table is an index graphic, descriptions of the various development use concepts could be accessed by clicking topic links being referred to in the index directory of the table. By comparing the different development use concepts, the consultants identify two of them, “Employment Campus” and “Freestanding Industry and Office”, as proper use concepts to build the branch office. Referring to the table, they further identify the development forms appropriate for developing the two use concepts. With the intention to explore these development forms in detail, they click on the corresponding topics being referred in the index directory of the table. “Town”, for instance, is a development form proper for both of the use concepts. To navigate the contents, they click on the topic link and go to navigation page by highlighting topic “Town” (see Figure 8.15). In the navigation page, clicking on links under the topic directs them to detailed page. Figure 8.16, for instance, shows details of single graphic “graphicFCTownID_1”, which presents typical features of a town.

Moreover, “graphic_3” has relationship with many other graphics (shown in Figure 8.14). Specifically, it has semantic referral relationship with graphic “graphicFCGeneralID_1” and “graphicFCGeneralID_2”, as well as has whole-part relationship with other graphics. The “graphicFCGeneralID_1” is labeled as “graphic_1” thereafter, and the “graphicFCGeneralID_2” is indeed the “graphic_2” mentioned before. Figure 8.17 shows details of the “graphic_1”. The graphic presents the steps for the Will County process of reviewing a development proposal. It also suggests the steps for a petitioner developing a proposal – first, locate site on Form Map and determine the Form Area in which the property is located; second, refer to LRMP Matrix to see which Development Use Concepts are appropriate for the area; third, select a listed Development Use Concept for application and apply to County. Indicated by the index directory, the first step refers to “graphic_2”; the second step refers to “graphic_3”; and the third step refers to “topicFCID_4”, “development use concepts”. Details of “graphic_2” are shown in Figure 8.18. The graphic presents the defined development forms in Will County.

After navigating through the plan contents mentioned above, the consultants finally locate several candidate sites in each of the two areas, City of Urbana and Will County. Thus, they draft a proposal for site selections, attaching useful graphic contents they found.

Single Graphic Content

< graphicFCGeneralID_3 >

Development Forms									
	RURAL Form 26.02	HAMLET Form 26.03	TOWN Form 26.04	URBAN COMMUNITY Form 26.05	SUBURBAN COMMUNITY Form 26.06	INTERSTATE ACCESS Form 26.07	FORMER JOAAP Form 26.08	SSA Form 26.09	ILR Form 26.10
Development Use Concepts	AGRICULTURAL Form 26.02	*	*						*
	CONSERVATION DESIGN Form 26.03	*	*	*	*				
	CONVENTIONAL RESIDENTIAL SUBURBAN Form 26.04			*	*				
	TRADITIONAL RESIDENTIAL Form 26.05		*	*	*				
	MULTI-FAMILY COMPLEX Form 26.06			*	*	*			*
	EMPLOYMENT CAMPUS Form 26.07			*	*	*	*	*	*
	REGIONAL COMMERCIAL Form 26.08				*	*	*	*	*
	MID-SCALE COMMERCIAL Form 26.09				*	*	*	*	*
	NEIGHBORHOOD COMMERCIAL Form 26.10	*	*	*	*	*	*	*	*
	FREESTANDING INDUSTRY & OFFICE Form 26.11		*	*	*	*	*	*	*
	PROJECTS OF REGIONAL IMPACT Form 26.12		*	*	*	*	*	*	*

The table illustrates the application of the individual Development Use Concepts in each of the defined Development Forms. Each Form and Use Concept is represented by an asterisk in the table.

Graphic Type:	Table
Index Graphic:	true
Description:	This table illustrates the application of the individual Development Use Concepts in each of the defined Development Forms.
Representation Method:	Elaborate: Fully Elaborate
Specific Plan Info:	application of the individual Development Use Concepts in each of the defined Development Forms
Categorized Plan Info:	implementation (Aspect Land Use)
Effectiveness:	high
Index Directory:	<ul style="list-style-type: none"> Rural => topic:FormRuralID_1 [topic] Hamlet => topic:FormHamletID_1 [topic] Town => topic:FormTownID_1 [topic] Urban Community => topic:FormUrbanCommunityID_1 [topic] Suburban Community => topic:FormSuburbanCommunityID_1 [topic] Interstate Access Location => topic:FormInterstateID_1 [topic] Former JOAAP => topic:FormJoAAPID_1 [topic] SSA => topic:FormSSAID_1 [topic] Agricultural => topic:ConceptsAgriculturalID_1 [topic] Conservation Design => topic:ConceptsConservationID_1 [topic] Conventional Residential Suburban => topic:ConceptsResidentialSuburbanID_1 [topic] Traditional Residential => topic:ConceptsTraditionalResidentialID_1 [topic] Multi-family Complex => topic:ConceptsMultifamilyID_1 [topic] Employment Campus => topic:ConceptsEmploymentID_1 [topic] Regional Commercial => topic:ConceptsRegionalCommercialID_1 [topic] Mid-scale Commercial => topic:ConceptsMidScaleCommercialID_1 [topic] Neighborhood Commercial => topic:ConceptsNeighborhoodCommercialID_1 [topic] Freestanding Industry and Office => topic:ConceptsIndustryID_1 [topic] Projects of Regional Impact => topic:ConceptsProjectsID_1 [topic]
Textual Item:	<p>DEVELOPMENT FORMS</p> <ul style="list-style-type: none"> Rural Hamlet Town Urban Community Suburban Community Interstate Access Location Former JOAAP SSA <p>DEVELOPMENT USE CONCEPTS</p> <ul style="list-style-type: none"> Agricultural Conservation Design Conventional Residential Suburban Traditional Residential Multi-family Complex Employment Campus Regional Commercial Mid-scale Commercial Neighborhood Commercial Freestanding Industry and Office Projects of Regional Impact
Path:	/planFormsConceptsID_2/LandResourceMatrix.jpg

Relationship:

Directional SemanticReference	graphic:FCGeneralID_1
Directional SemanticReference	graphic:FCGeneralID_2
Directional WholePart	graphic:FCRuralID_4
Directional WholePart	graphic:FCHamletID_4
Directional WholePart	graphic:FCTownID_4
Directional WholePart	graphic:FCUrbanID_4
Directional WholePart	graphic:FCSuburbanID_4
Directional WholePart	graphic:FCInterstateID_3
Directional WholePart	graphic:FCJoAAPID_2
Directional WholePart	graphic:FCSSAID_2
Single Graphic And Single Graphic	graphic:FCAgriculturalID_4
Directional WholePart	graphic:FCConservationID_3
Directional WholePart	graphic:FCResidentialSuburbanID_3
Directional WholePart	graphic:FCTraditionalResidentialID_4
Directional WholePart	graphic:FCMultifamilyID_4
Directional WholePart	graphic:FCEmploymentID_3
Directional WholePart	graphic:FCRegionalCommercialID_4
Directional WholePart	graphic:FCMidScaleCommercialID_2
Directional WholePart	graphic:FCNeighborhoodCommercialID_2
Directional WholePart	graphic:FCIndustryID_2

Single Graphic And Text: Directional Keyword Defining: Development Use Concepts [text:FCID_3](#)

[go to navigation](#)

Figure 8.14 Details of “graphic_3” that illustrates application of the individual Development Use Concepts in each of the defined Development Forms

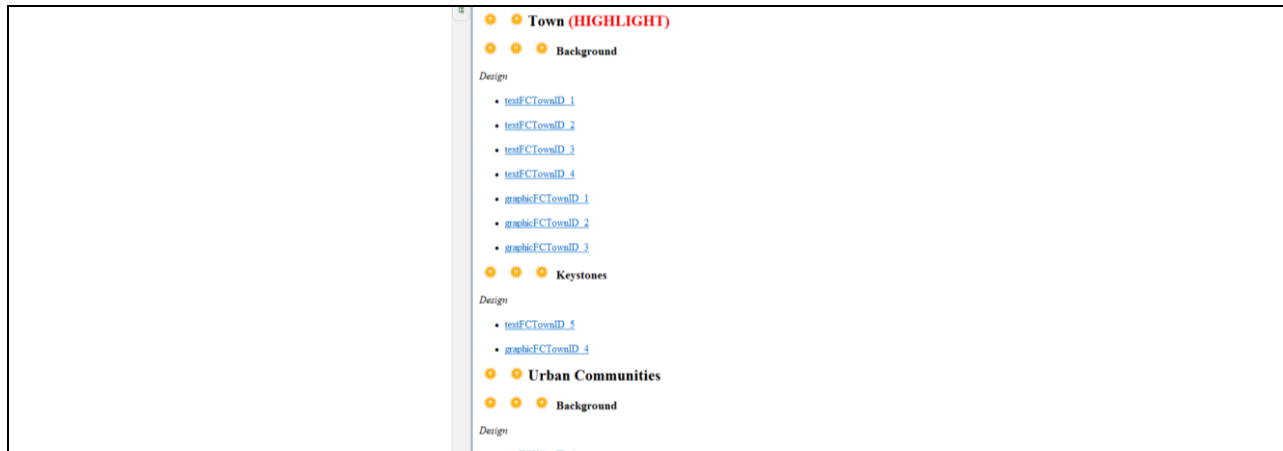


Figure 8.15 Navigation page with highlighting the topic “Town”

Single Graphic Content
 < graphicFCTownID_1 >

Town Diagram (Typical)

Graphic Type:	Site Plan
Index Graphic:	false
Title:	typical town diagram
Representation Method:	Elaborate: Fully Elaborate
Specific Plan Info:	typical town
Categorized Plan Info:	Implementation (Aspect: Land Use)
Effectiveness:	high
Annotation:	<ul style="list-style-type: none"> maximum limits of town expansion and growth multi-family residential existing town or commercial center potential school site greenway or open space system residential addition or conventional subdivision planned and controlled interchange development flexible grid street pattern commercial uses new and expanded mixed-use town center future growth area
Path:	/planFormsConceptsID_2/TownDiagram1.jpg

Relationship:

Single Graphic And Text: Non-Directional semanticComplementarity [textFCTownID_2](#)

[go to navigation](#)

Figure 8.16 Details of single graphic presenting typical features of town

Single Graphic Content

< graphicFCGeneralID 1 >

Figure 1: Process Flow Chart



Graphic Type:	Non-spatial Diagram
Index Graphic:	true
Title:	process flow chart for the Will County reviewing a development proposal
Description:	When a petitioner approaches the County with a development proposal, the steps that should be followed by the County when reviewing that proposal are: 1. Using the Development Form map, determine the Form Area in which the property is located. If the property is on a border, making an exact determination difficult, the staff should work with the petitioner to determine which Form best applies based on the circumstances associated with the property and surrounding areas. The Form boundaries are intended to be a flexible guide, not strict prescribed boundaries. The "keystone" policies for the Form Area are then used as an initial guide for the petitioner in formulating plans for the property. 2. The matrix should be consulted to determine the general land uses, or "Development Use Concepts" considered appropriate for the area. If the existing zoning permits the use desired by the petitioner, the zoning will of course take precedence. If the existing zoning does not permit the use desired by the petitioner, the Form map will be used as the guide for determining the advisability of a map amendment. 3. The principles for the appropriate Development Use Concept are consulted as a guide to the review of the petitioner's proposed use. 4. Staff reviews the proposed development for compliance with Form keystones and Use Concept principles, as well as the remainder of the Land Resource Management Plan. 5. Hearings and meetings of the Planning and Zoning Commission, Land Use and Zoning Committee, and County Board held as provided by the zoning and land use regulations.
Representation Method:	Elaborate: Fully Elaborate
Specific Plan Info:	process flow chart for the Will County reviewing a development proposal
Categorized Plan Info:	Implementation (Aspect: Land Use)
Effectiveness:	high
Index Directory:	locate site on Form Map and determine the Form to apply for => graphicFCGeneralID 2 [graphic] refer to LRMP Matrix to see which Development Use Concepts are appropriate => graphicFCGeneralID 3 [graphic] select a listed Development Use Concept for application and applies to County => topicFCID 4 [topic]
Textual Item:	1. Locate site on Form map and determine the Form to apply for. 2. Refer to LRMP Matrix to see which Development Use Concepts are appropriate. 3. Select a Listed Development Use Concept for application and applies to County. 4. Staff Checks for Compliance with: a. Guiding Principles, Goals and Strategies (in the LRMP Policy Gateway), b. Selected Form, c. Selected Development Use Concept. 5. Hearings and Meetings by PZC, LUZC and County Board.
Path:	/planFormsConceptsID_2/ProcessFlowChart.jpg

Relationship:

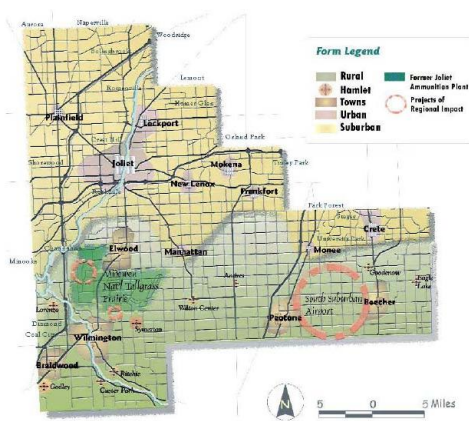
Single Graphic And Single Graphic:	Directional SemanticReference graphicFCGeneralID 2 Directional SemanticReference graphicFCGeneralID 3
---	--

[go to navigation](#)

Figure 8.17 Details of "graphic_1" that presents process flow chart for the Will County review of a development proposal

Single Graphic Content

< graphicFCGeneralID_2 >



Graphic Type:	Map
Index Graphic:	true
Title:	development forms map
Representation Method:	Elaborate: Fully Elaborate
Specific Plan Info:	development forms
Categorized Plan Info:	Goals and Desired Future (Aspect: Land Use)
Effectiveness:	high
Coverage:	Illinois Will
Background:	Development Forms refer to the general character of large areas of the County. As contrasted with specific land uses, the identification of Forms is a way to identify distinguishable development patterns, or Forms at a countywide level, and to use these Forms as a way to manage the County's land resources.
Index Directory:	<ul style="list-style-type: none"> rural => topicFormsRuralID_1 [topic] hamlet => topicFormsHamletID_1 [topic] towns => topicFormsTownID_1 [topic] urban => topicFormsUrbanCommunitiesID_1 [topic] suburban => topicFormsSuburbanCommunitiesID_1 [topic] former Joliet ammunition plant => topicFormsJolietID_1 [topic] projects of regional impact => topicFormsAirportID_1 [topic]
Legend:	<ul style="list-style-type: none"> Form Legend Rural Hamlet Towns Urban Suburban Former Joliet Ammunition Plant Projects of Regional Impact
Path:	planFormsConceptsID_2/LandResourceMap.jpg

Relationship:

Single Graphic And Single Graphic:	<ul style="list-style-type: none"> Directional Semantic:Reference graphicFCGeneralID_1 Directional Semantic:Reference graphicFCGeneralID_3 Directional Semantic:Reference graphicFCRuralID_5 Directional Semantic:Reference graphicFCHamletID_4 Directional Semantic:Reference graphicFCTownID_4 Directional Semantic:Reference graphicFCUrbanID_4 Directional Semantic:Reference graphicFCSuburbanID_6 Directional Semantic:Reference graphicFCInterstateID_3 Directional Semantic:Reference graphicFCJAAPID_5 Directional Semantic:Reference graphicFCSSAID_2 Directional Semantic:Reference graphicFCAgriculturalID_4 Directional Semantic:Reference graphicFCConservationID_3 Directional Semantic:Reference graphicFCResidentialSuburbanID_3 Directional Semantic:Reference graphicFCTraditionalResidentialID_4 Directional Semantic:Reference graphicFCMultifamilyID_4 Directional Semantic:Reference graphicFCEmploymentID_3 Directional Semantic:Reference graphicFCRegionalCommercialID_4 Directional Semantic:Reference graphicFCMidScaleCommercialID_2 Directional Semantic:Reference graphicFCNeighborhoodCommercialID_2 Directional Semantic:Reference graphicFCIndustryID_2
Single Graphic And Text:	Directional Keyword Defining: Development Forms textFCID_2

[go to navigation](#)

Figure 8.18 Details of “graphic_2” that identifies distinguishable development forms at a countywide level

A variety of functionalities of the prototype being utilized in this case are summarized and presented in Table 8.1. The practicability of the functionalities clearly demonstrates the applicability of making use of PMLGraphics to access plan contents, especially graphic contents, in many different ways.

Functionalities of the Prototype Being Used	Applicability of Utilizing PMLGraphics to Access Plan Contents
Predefined query of “Plan Information” presented by graphics	Predefined information in element “categorized plan information” of a single graphic or graphic group could be used for searching graphic contents.
Predefined query of “Aspect” of plan information presented by graphics	Predefined “aspect” in element “categorized plan information” of a single graphic or graphic group could be used for searching graphic contents.
Free-style query of “Keyword”	Any element of a single graphic or graphic group could be used for searching graphic contents in free-style.
Combination query combining the three queries above	Different types of predefined information search could be combined. Predefined information search and free-style information search could also be combined together.
Presenting a list of retrieval results in which single graphics and graphic groups are presented by small size icons, and described by different indicators	Small-size icons and indicators could be used to help users to choose what they might actually be most interested in.
Browsing document metadata, an indicator of graphics, to identify the most interesting graphic among a retrieval list	Document metadata, which summarizes the plan document a single graphic or graphic group comes from, can facilitate users to identify graphic content that most interests them.
Browsing specific plan information, an indicator of graphics, to identify the most interesting graphic among a retrieval list	Specific plan information presented by a single graphic or graphic group can facilitate users to identify graphic content that most interests them.
Manually sorting single graphics in retrieval list by their graphic types	Manual sorting rule of graphic types is useful for users to find single graphics that most interests them.
Navigating details of a single graphic, which is in a retrieval list	Presenting a single graphic along with its metadata facilitates users comprehension of the graphic in detail.

Table 8.1 (cont.)

Link of “go to navigation” directing details of a single graphic to navigation page highlighting the initiating graphic	Document structure that organizes texts, single graphics, and graphic groups in hierarchical topics facilitates users to identify location of a single graphic in plan document. So they can further navigate to other plan contents (a single graphic, for instance) by topics.
Navigating details of another single graphic in navigation page highlighting a initiating graphic	
Clicking link of a topic being referred to by an index graphic directing details of the single graphic to navigation page highlighting the topic	Corresponding association between index terms and links of topic in an index graphic, as well as document structure that organizes texts, single graphics, and graphic groups in hierarchical topics, facilitates users to identify location of the topic being referred. So they can further navigate other plan contents (a graphic group, for instance) in the same topic or any topic interests them. Presenting a graphic group and its members, along with their metadata, facilitates users comprehension of the graphic group in detail.
Navigating details of a graphic group from navigation page highlighting a topic being referred to by an index graphic	
Navigating details of a graphic via relationship between two single graphics	Relationship between two single graphics facilitates users to navigate from one single graphic to the other one.
Navigating details of a text via relationship between a graphic group and a text	Relationship between a graphic group and a text facilitates users to navigate from the graphic group to the text, or oppositely.

Table 8.1 Applicability of PMLGraphics demonstrated in case One

With the aid of the prototype, plan content being encoded by PMLGraphics can be easily searched by both predefined plan information conveyed by graphics and keyword matching, with the results being retrieved in seconds. The default and manual sorting rules implemented in the prototype as well as the indicators of single graphics and graphic groups can facilitate the consultants to easily and quickly identify graphic content that most interests them from a retrieval list. In a real case, there would be more plans from more communities so that consultants would be considering a wide range of possibilities. The larger number of results to each query would make the PMLGraphics much more valuable, and yield much greater efficiency gains than implied in this example with only two plans.

Without aids of the prototype and the data model PMLGraphics, the consultants in this case would have to deal with paper-based plan documents or digital documents without PMLGraphics tags. To find graphic content pertinent to site selection of the office, they would have to look through plans available to them and study every graphic being included to identify its intended plan information and details in order to evaluate whether it is related to the task. In this case, they would need to glance through all three plans: *Land Resource Management Plan, 2005 Comprehensive Plan* for City of Urbana, and *2040 Regional Framework Plan*, which occupy over 500 pages and include over 200 graphic representations. Doing so is quite time-consuming and labor-intensive even for a small set of plans. In a real case, there would be more plans from more communities for consultants to read through. Graphics in digital documents without PMLGraphics tags would be out of reach for keyword matching since the textual information of graphics is displayed in the pixel format.

It would be quite difficult for consultants to record and manage the pertinent graphic content found in the paper-based plan documents or digital documents without PMLGraphics tags. To trace what they had found interesting, they could add bookmarks on the original plans, or copy the related graphic content to a separate file. The former situation would result in pertinent graphic content scattered in different plans, which would make the pertinent content hard to manage and review; the latter situation would result in one bulky file in which graphics are quoted out of context, which would make it difficult for the consultants to review the graphics within context.

Through the prototype, the PMLGraphics provides a better solution for both situations. The qualified graphics are listed and annotated by indicators, which makes the retrieval results easy to read and review. The hierarchical structure of topics facilitates the consultants to browse context of a certain graphic. Besides, structure of index graphic and relationship between content entities make it possible for the consultants to explore other plan content related to a certain graphic.

8.2 Updating Plan Document

Recently, City of Plainfield, Illinois has been experiencing dramatic change. Population of the city has increased more than 45% in the five years, from 2005 to 2009. Residential neighborhoods and businesses seem to pop up everywhere. The rapid growth brings the city lots of economic opportunities. However, it also shows its negative impacts on the city. Farms and permanent open space are endangered. To respond to the change, planning staff of Plainfield plan commission needs to update local plan documents regarding land use to promote healthy and balanced growth while preserving open space and farmland in the city. To accomplish this desire, it is important to make sure future plans for the city are consistent with context of a broader area. Thus, planning staff need to look up plan contents regarding land use and environmental preservation in Will County or an even broader area.

The following shows how planning staff could possibly make use of the prototype in this case. In description, a dozen screen snaps (Figure 8.20 to Figure 8.31) are presented. To make the description more comprehensible, navigation logic of these screen snaps is shown in Figure 8.19.

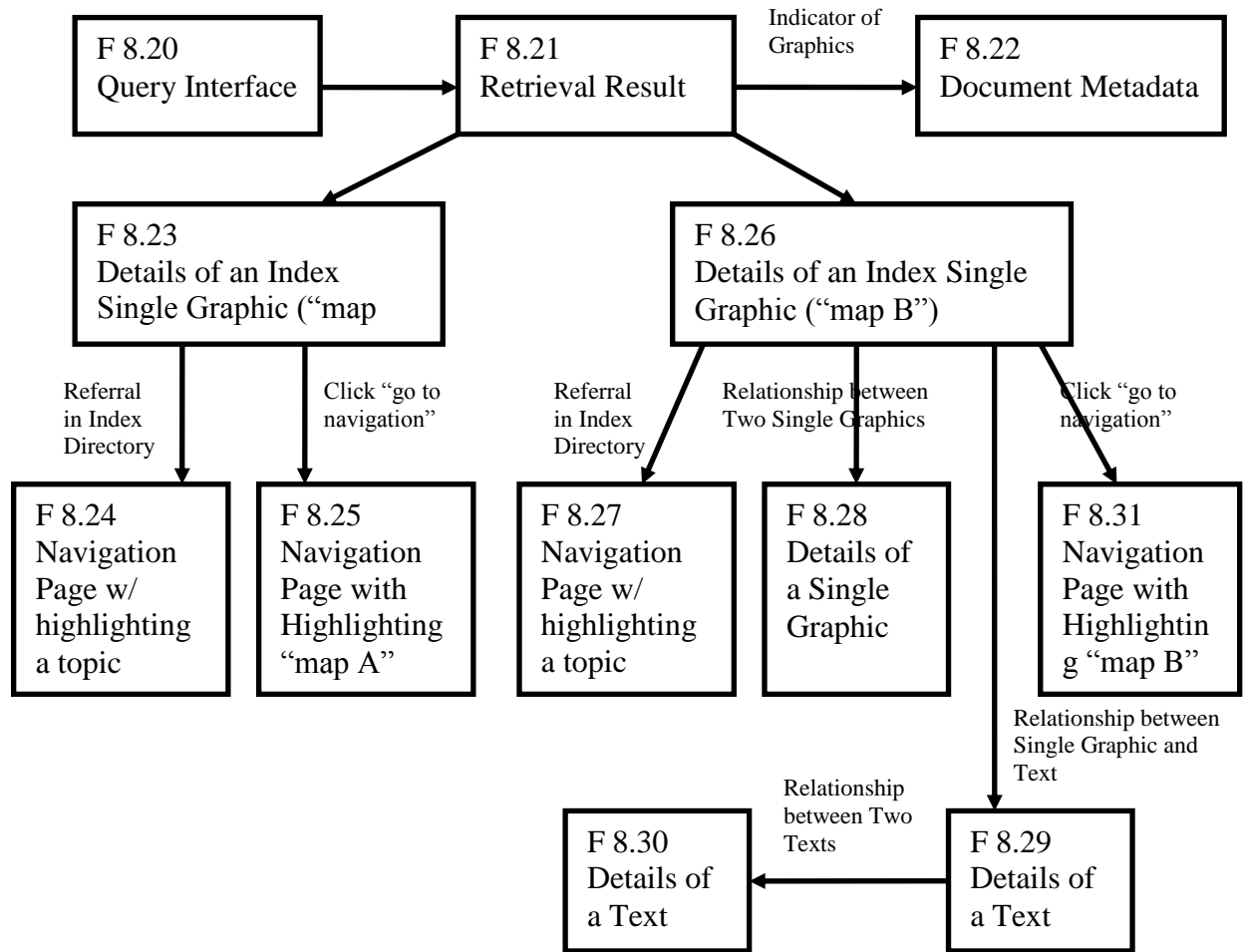


Figure 8.19 Navigation logic of screen snaps in case two

Query Tool for Graphic Content

Plan Information

Planning Process Current Situation, Issue and Trend Goals and Desired Future Implementation Information Others

Aspect

Land Use Transportation Infrastructure Environmental Preservation Cultural Preservation Aspect Others

Graphic Type

Ground-level Image Aerial-level Image Graph Table Spatial Diagram Non-spatial Diagram Site Plan Map

Coverage of Graphics

State:

County:

City:

Keyword Search

keyword #1:

<>: OR AND

keyword #2:

Figure 8.20 Combination query for case two



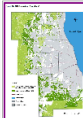









To search for plan contents regarding land use and environmental preservation in Will County or even broader area, planning staff start by querying graphic contents with the following constraints (see Figure 8.20):

- Aspect of plan information conveyed by graphics including either “Land Use” or “Environmental Preservation”, and
- Coverage of graphics including “Will County”.

Retrieval results of the query are shown in Figure 8.21.

Query Result

List of Single Graphic

Icon	plan document	Matching Item	Graphic Type	Index Graphic	Representation Method	Specific Plan Info	Categorized Plan Info	Aspect	Effectiveness
	2040 Regional Framework Plan		Map	true	Elaborate: Fully Elaborate	defined hierarchy of centers in the City of Chicago	Goals and Desired Future	Land Use	high
	Land Resource Management Plan: Open Space Element		Map	false	Elaborate: Fully Elaborate	proposed trail corridors and loops	Goals and Desired Future	Environmental Preservation	high
	2040 Regional Framework Plan		Map	false	Elaborate: Fully Elaborate	Agricultural Areas in 2004	Goals and Desired Future	Land Use Environmental Preservation	high
	Land Resource Management Plan: Open Space Element		Map	false	Elaborate: Fully Elaborate	the basic framework of the proposed open space system	Goals and Desired Future	Environmental Preservation	high
	2040 Regional Framework Plan		Map	false	Elaborate: Fully Elaborate	existing and proposed green areas in 2004	Goals and Desired Future	Environmental Preservation Land Use	high
	2040 Regional Framework Plan		Map	true	Elaborate: Fully Elaborate	the defined hierarchy of centers	Goals and Desired Future	Land Use Environmental Preservation	high
	2040 Regional Framework Plan		Map	true	Elaborate: Fully Elaborate	the defined hierarchy of centers, corridors and green areas that can be implemented at the facility level through the Chicago Area Transportation Study (CATS) Regional Transportation Plan (RTP) and at the community level through the measures identified in Chapter 7 of this plan	Goals and Desired Future	Land Use Transportation Environmental Preservation	high
	Land Resource Management Plan: Forms and Concepts Handbook		Map	true	Elaborate: Fully Elaborate	development forms	Goals and Desired Future	Land Use	high
	2040 Regional Framework Plan		Map	true	Elaborate: Fully Elaborate	Corridors in 2040	Goals and Desired Future	Transportation Land Use Environmental Preservation	high
	Land Resource Management Plan: Open Space Element		Map	false	Elaborate: Fully Elaborate	open spaces and county-wide trail systems	Goals and Desired Future	Environmental Preservation	high
	Land Resource Management Plan: Policy Gateway		Map	false	Elaborate: Fully Elaborate	development forms of Will County	Goals and Desired Future	Land Use	high
	Land Resource Management Plan: Policy Gateway		Map	false	Elaborate: Fully Elaborate	2020 Transportation Framework Plan	Goals and Desired Future	Transportation Land Use	high

List of Graphic Group

Graphic Icon plan document Matching Item Representation Method Specific Plan Info Categorized Plan Info Aspect Graphic Member Relationship

Figure 8.21 Retrieval results of query in case two

The retrieval list includes twelve single graphics, which are described by indicators. Browsing indicator “plan document”, planning staff get a clue that the qualified graphics are from four plan documents: (1) *2040 Regional Framework Plan*, (2) *Land Resource Management Plan: Open Space Element*, (3) *Land Resource Management Plan: Forms and Concepts Handbook*, and (4) *Land Resource Management Plan: Policy Gateway*. To know metadata about the four documents, they can click one of the document names. Figure 8.22 shows document metadata of *2040 Regional Framework Plan*. In document metadata, they get to know that *2040 Regional Framework Plan* is a comprehensive plan for future land use and development of Northeastern Illinois, which includes six counties – Will, Cook, DuPage, Kane, Lake, and McHenry. *Policy Gateway, Forms and Concepts Handbook, and Open Space Element*, which are three components of *Land Resource Management Plan (LRMP)*, are guiding policies for future growth of Will County on land use development pattern and open space preservation.

Document Metadata

Document Name:
2040 Regional Framework Plan

Functionality:
The plan is to guide the region's future land use and development, by coordinating local land-use plans and regional-level decisions in response to projected population and employment growth. The 2040 Plan details the ideas of thousands of northeastern Illinois residents who participated in the Common Ground process, as well as defines a vision in which: Northeastern Illinois will be a region of livable communities, built on the diversity of its people and known for its healthy natural environment, global competitiveness, and governed collaboratively. The legacy of the 2040 Framework Plan will be to make centers more vital, compact and diverse; to make corridors multi-modal and supportive of the transportation needs of all residents; and to protect, enhance and expand green areas and the important natural resources that these areas contain and represent.

Who-do-what-at-when:

Organizations:	The Northeastern Illinois Planning Commission (NIPCC)
Action:	draft
Date:	//

Coverage:
Name : Chicago region / Chicago metropolis / greater Chicago

Countries:	
States:	
Counties:	Will Cook DuPage Kane Lake McHenry

Related Aspects:
Land Use
Transportation
Environmental Preservation

Figure 8.22 Document metadata of 2040 Regional Framework Plan

By browsing indicators, such as “Specific Plan Info” and “Aspect”, of single graphics in the list, planning staff have an idea of what these graphics present. In most situations, doing that could help them to identify what they might be most interested in. However, in this case, they may be

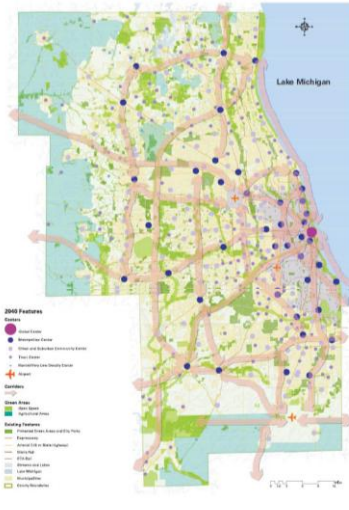
interested in all of the graphics in the retrieval list. Thus, they could navigate details of them one by one. For the sake of simplicity, not all of graphics will be presented. Instead, details of two of those graphics, as typical examples, are shown below, as well as other plan contents related to them.

Figure 8.23 shows details of the map with the 7th ranking order of the list (labeled as “map A” below). The “map A” presents defined hierarchy of centers, corridors and green areas that can be implemented at facility and community level. The plan information is related to three aspects, “Land Use”, “Transportation”, and “Environmental Preservation”. Since it is an index graphic, topic “Centers”, “Corridors”, and “Green Areas” are referred to in its index directory. Details of the topics could be navigated by clicking their links. Figure 8.24 shows navigation page highlighting the topic “Centers”. If planning staff would like to navigate more plan contents that is under the same topic as “map A”, or if they want to know more contexts of the map, they could click the link of “go to navigation” (shown in Figure 8.23), and perform extensive exploration in the navigation page by highlighting the initiating graphic (shown in Figure 8.25).

Single Graphic Content

< graphicNIPCC:FrameworkMap >

Figure 1: 2040 Regional Framework Map



Graphic Type:	Map
Index Graphic:	True
Title:	2040 Regional Framework Map
Representation Method:	Elaborate: Fully Elaborate
Specific Plan Info:	the defined hierarchy of centers, corridors and green areas that can be implemented at the facility level through the Chicago Area Transportation Study (CATS) Regional Transportation Plan (RTP) and at the community level through the measures identified in Chapter 7 of this plan
Categorized Plan Info:	Goals and Desired Future (Aspect: Land Use, Transportation, Environmental Preservation)
Effectiveness:	high
Coverage:	Illinois Will
Index Directory:	Centers => topicNIPCC:ID_2 [topic] Corridors => topicNIPCC:ID_3 [topic] Green Areas => topicNIPCC:ID_4 [topic]
Legend:	<p>2040 Features</p> <ul style="list-style-type: none"> Global Center Metropolitan Center Urban and Suburban Community Center Town Center Hamlet / Very Low Density Center Airport Open Space Agricultural Areas Protected Green Areas and City Parks Expressway Arterial (US or State Highway) Metra Rail CTA Rail Streams and Lakes Lake Michigan Municipalities County Boundaries County Boundaries <p>Existing Features</p> <ul style="list-style-type: none"> Protected Green Areas and City Parks Expressway Arterial (US or State Highway) Metra Rail CTA Rail Streams and Lakes Lake Michigan Municipalities County Boundaries
Path:	planNIPCC:FrameworkMap.jpg

Relationship:

[go to navigation](#)

Figure 8.23 Details of the “map A”

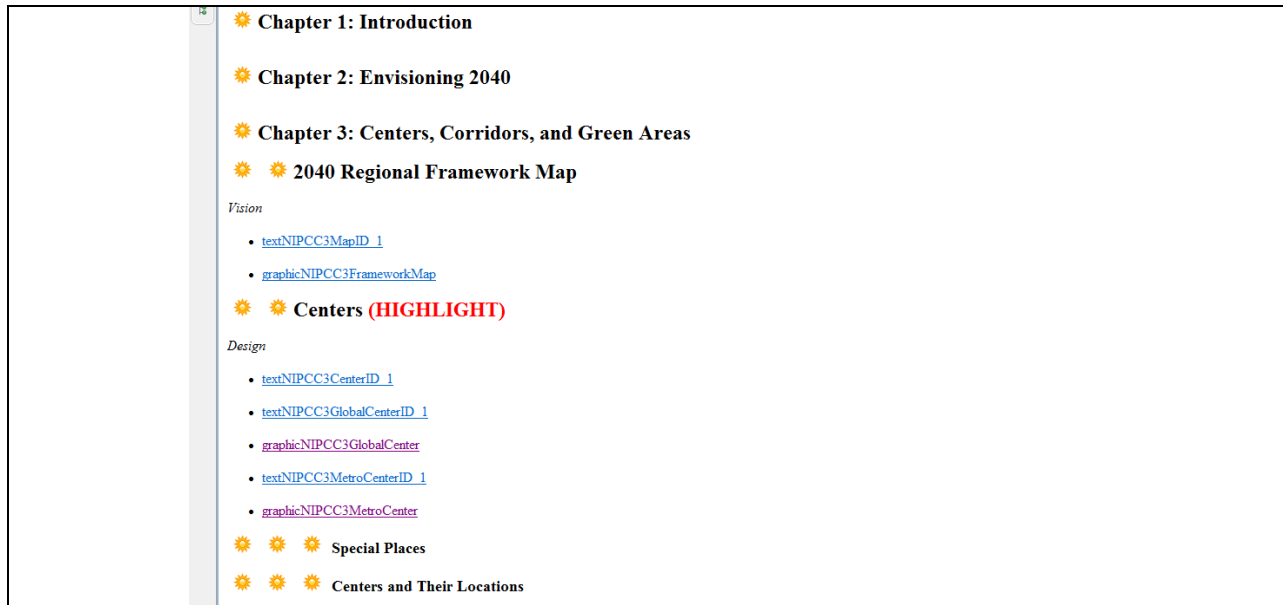


Figure 8.24 Navigation page with highlighting topic “Centers”, referred by “map A”

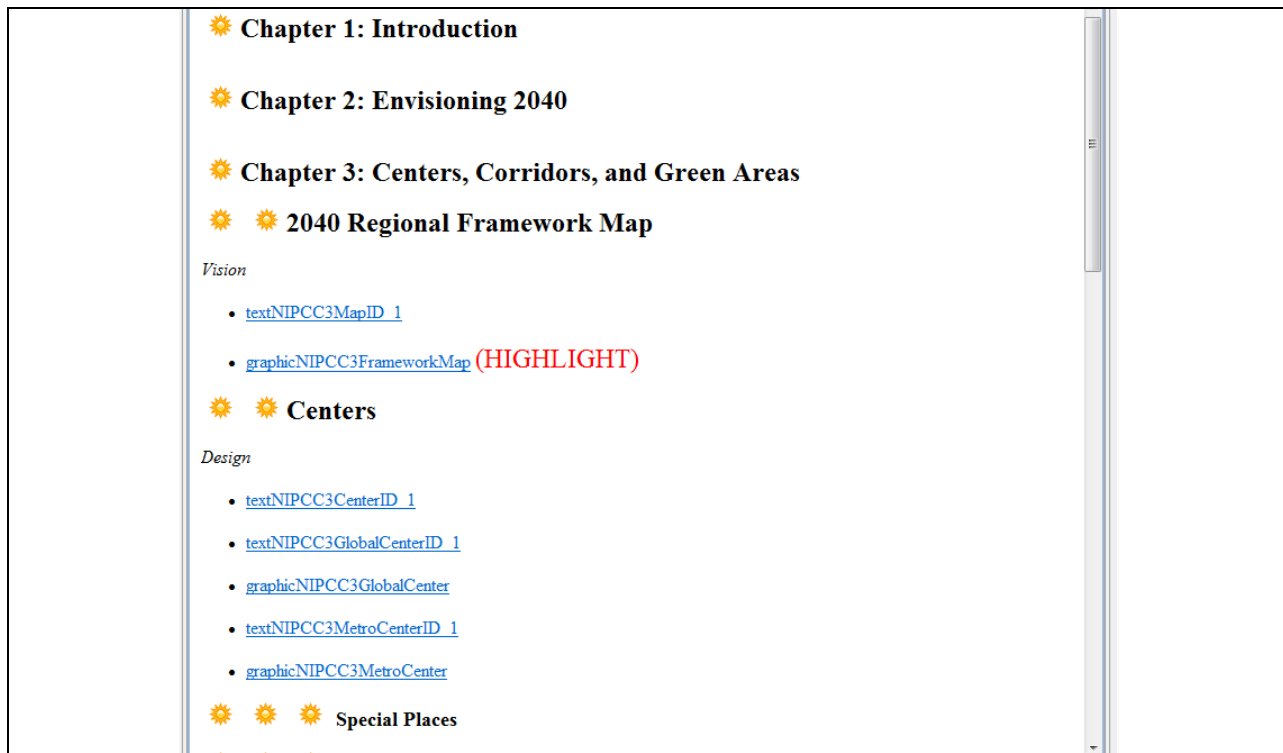


Figure 8.25 Navigation page with highlighting the initiating graphic, “map A”

Figure 8.26 shows details of the map with the 8th ranking order of the list (labeled as “map B” below). The “map B” presents proposed development forms or general character of Will County. The plan information is about “Land Use”. Since it is an index graphic, topic “Rural Area”,

“Hamlet”, “Towns”, “Urban Communities”, “Suburban Communities”, “Former Joliet Army Ammunition Plant Properties”, and “South Suburban Airport (projects of regional impact)” are referred to in its index directory. Details of the topics could be navigated by clicking their links. Figure 8.27 shows navigation page highlighting the topic “Rural Area”.

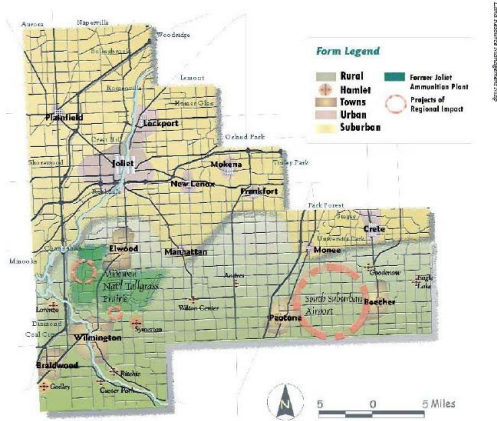
The “map B” also has relationships with one text and twenty other single graphics (shown in Figure 8.26). Via relationships, details of the text and the single graphics could be navigated by clicking their links. Figure 8.28, as an example, shows details of the single graphic, “graphicFCGeneralID_3”, which has relationship with the “map B”. The “graphicFCGeneralID_3”, a table, has been shown in Figure 8.14 before. It illustrates application of the individual Development Use Concepts in each of the defined Development Forms in Will County. As shown in the last section, descriptions of the various development use concepts could be accessed by clicking topic links being referred to in the index directory of the table. Figure 8.29 shows details of the text, “textFCID_2”, which has relationship with the “map B”. The text explains what “development forms” are and how they will be described in forthcoming passage. Via relationship between the text and another text “textFCID_1”, details of the other one could be accessed also (see Figure 8.30).

If planning staff would like to navigate more plan contents that is under the same topic as “map B”, or if they intend to know more contexts of the map, they could click the link of “go to navigation” (shown in Figure 8.26) and perform extensive exploration in the navigation page by highlighting the initiating graphic (see Figure 8.31).

Following similar sequences, planning staff navigate the graphics in the retrieval list one by one, as well as other plan contents associated with them. Accordingly, they become acquainted with the plan contents, with respect to land use and environmental preservation, for Will County and the Chicago Region. Doing so can ensure future plans for Plainfield are in compliance with context of broader areas.

Single Graphic Content

< graphicFCGeneralID_2 >



Graphic Type:	Map
Index Graphic:	true
Title:	development forms map
Representation Method:	Elaborate: Fully Elaborate
Specific Plan Info:	development forms
Categorized Plan Info:	Goals and Desired Future (Aspect: Land Use)
Effectiveness:	high
Coverage:	Illinois Will
Background:	Development Forms refer to the general character of large areas of the County. As contrasted with specific land uses, the identification of Forms is a way to identify distinguishable development patterns, or Forms at a countywide level, and to use these Forms as a way to manage the County's land resources.
Index Directory:	<ul style="list-style-type: none"> rural => topicFormsRuralID_1 [topic] hamlet => topicFormsHamletID_1 [topic] towns => topicFormsTownsID_1 [topic] urban => topicFormsUrbanCommunitiesID_1 [topic] suburban => topicFormsSuburbanCommunitiesID_1 [topic] former Joliet ammunition plant => topicFormsJolietID_1 [topic] projects of regional impact => topicFormsAirportID_1 [topic]
Legend:	<ul style="list-style-type: none"> Form Legend Rural Hamlet Towns Urban Suburban Former Joliet Ammunition Plant Projects of Regional Impact
Path:	planFormsConceptsID_2/LandResourceMap.jpg

Relationship:

Single Graphic And Single Graphic:	<ul style="list-style-type: none"> Directional Semantic:Reference graphicFCGeneralID_1 Directional Semantic:Reference graphicFCGeneralID_3 Directional Semantic:Reference graphicFCRuralID_5 Directional Semantic:Reference graphicFCHamletID_4 Directional Semantic:Reference graphicFCTownID_4 Directional Semantic:Reference graphicFCUrbanID_4 Directional Semantic:Reference graphicFCSuburbanID_6 Directional Semantic:Reference graphicFCInterstateID_3 Directional Semantic:Reference graphicFCJAAPID_5 Directional Semantic:Reference graphicFCSSAID_2 Directional Semantic:Reference graphicFCAgriculturalID_4 Directional Semantic:Reference graphicFCConservationID_3 Directional Semantic:Reference graphicFCResidentialSuburbanID_3 Directional Semantic:Reference graphicFCTraditionalResidentialID_4 Directional Semantic:Reference graphicFCMultifamilyID_4 Directional Semantic:Reference graphicFCEmploymentID_3 Directional Semantic:Reference graphicFCRegionalCommercialID_4 Directional Semantic:Reference graphicFCMidScaleCommercialID_2 Directional Semantic:Reference graphicFCNeighborhoodCommercialID_2 Directional Semantic:Reference graphicFCIndustryID_2
Single Graphic And Text:	Directional Keyword Defining: Development Forms textFCID_2

[go to navigation](#)

Figure 8.26 Details of "map B"

☀ Development Forms

☀ ☀ Rural Areas (HIGHLIGHT)

☀ ☀ ☀ Background

Design

- [textFCRuralBackgroundID_1](#)
- [textFCRuralBackgroundID_2](#)
- [graphicFCRuralID_1](#)
- [textFCRuralBackgroundID_3](#)

☀ ☀ ☀ Keystones

Design

- [textFCRuralKeystonesID_1](#)
- [textFCRuralKeystonesID_2](#)

Figure 8.27 Navigation page with highlighting topic “Rural Areas”, referred by “map B”

Single Graphic Content

< graphicFCGeneralID_3 >

	RURAL 7/1/17	HANLET 7/1/17	TOWN 7/1/17	URBAN COMMUNITY 7/1/17	SUBURBAN COMMUNITY 7/1/17	INTERSTATE ACCESS 7/1/17	FORMER JOAAP 7/1/17	SSA 7/1/17
AGRICULTURAL CONSERVATION PAGE 20-23	*	*						*
CONVENTIONAL RESIDENTIAL SUBURBAN PAGE 40-42			*		*			
TRADITIONAL RESIDENTIAL PAGE 40-42		*	*	*	*			
MULTI-FAMILY COMPLEX PAGE 40-42			*	*	*	*		*
EMPLOYMENT CAMPUS PAGE 40-42			*	*	*	*	*	*
REGIONAL COMMERCIAL PAGE 40-42				*	*	*	*	*
MID-SCALE COMMERCIAL PAGE 40-42			*	*	*	*	*	*
NEIGHBORHOOD COMMERCIAL PAGE 40-42	*	*	*	*	*	*	*	*
FREESTANDING INDUSTRY & OFFICE PAGE 40-42		*	*	*	*	*	*	*
PROJECTS OF REGIONAL IMPACT PAGE 40-42		*	*	*	*	*	*	*

The table illustrates the application of the individual Development Use Concepts in each of the defined Development Forms. Each Form and Use Concept is categorized as an alternative version of this table specific to each.

Graphic Type: Table

Index Graphic: true

Description: This table illustrates the application of the individual Development Use Concepts in each of the defined Development Forms.

Representation Method: Elaborate: Fully Elaborate

Specific Plan Info: application of the individual Development Use Concepts in each of the defined Development Forms

Categorized Plan Info: Implementation (Aspect: Land Use)

Effectiveness: high

Index Directory:

- Rural => [topicFormsRuralID_1](#) [topic]
- Hanlet => [topicFormsHanletID_1](#) [topic]
- Town => [topicFormsTownID_1](#) [topic]
- Urban Community => [topicFormsUrbanCommunitiesID_1](#) [topic]
- Suburban Community => [topicFormsSuburbanCommunitiesID_1](#) [topic]
- Interstate Access Location => [topicFormsInterstateID_1](#) [topic]
- Former JOAAP => [topicFormsJoiaapID_1](#) [topic]
- SSA => [topicFormsAirportID_1](#) [topic]
- Agricultural => [topicConceptsAgriculturalID_1](#) [topic]
- Conservation Design => [topicConceptsConservationID_1](#) [topic]
- Conventional Residential Suburban => [topicConceptsResidentialSuburbanID_1](#) [topic]
- Traditional Residential => [topicConceptsTraditionalResidentialID_1](#) [topic]
- Multi-family Complex => [topicConceptsMultifamilyID_1](#) [topic]
- Employment Campus => [topicConceptsEmploymentID_1](#) [topic]
- Regional Commercial => [topicConceptsRegionalCommercialID_1](#) [topic]
- Mid-scale Commercial => [topicConceptsMidScaleCommercialID_1](#) [topic]
- Neighborhood Commercial => [topicConceptsNeighborhoodCommercialID_1](#) [topic]
- Freestanding Industry and Office => [topicConceptsIndustryID_1](#) [topic]
- Projects of Regional Impact => [topicConceptsProjectsID_1](#) [topic]

DEVELOPMENT FORMS

Figure 8.28 Details of the graphic that has relationship with the “map B”

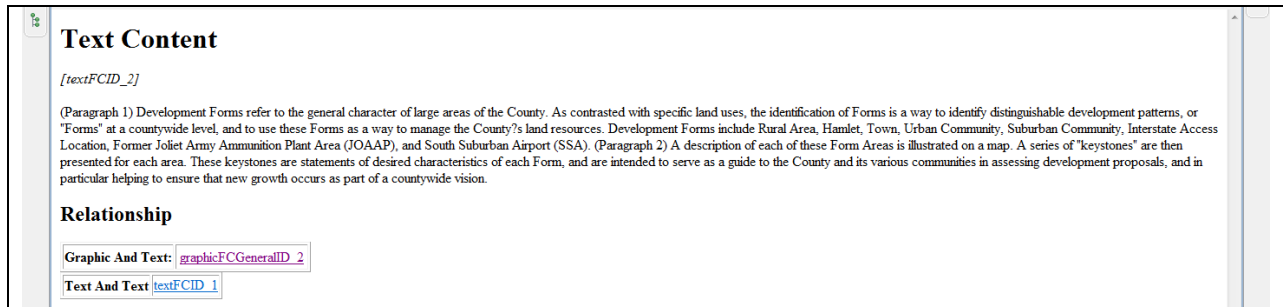


Figure 8.29 Details of text that has relationship with the “map B”

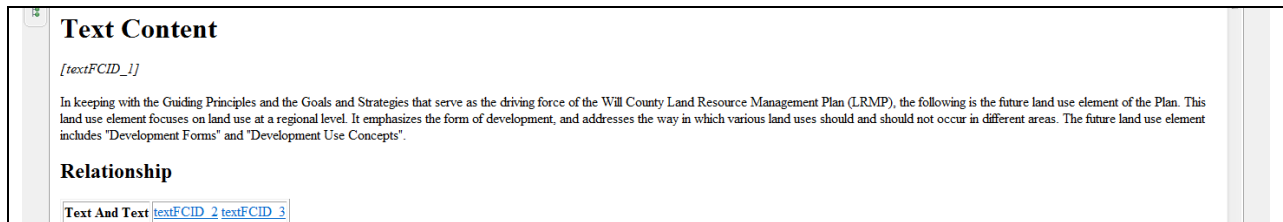


Figure 8.30 Details of text that has relationship with the text in Figure 8.29

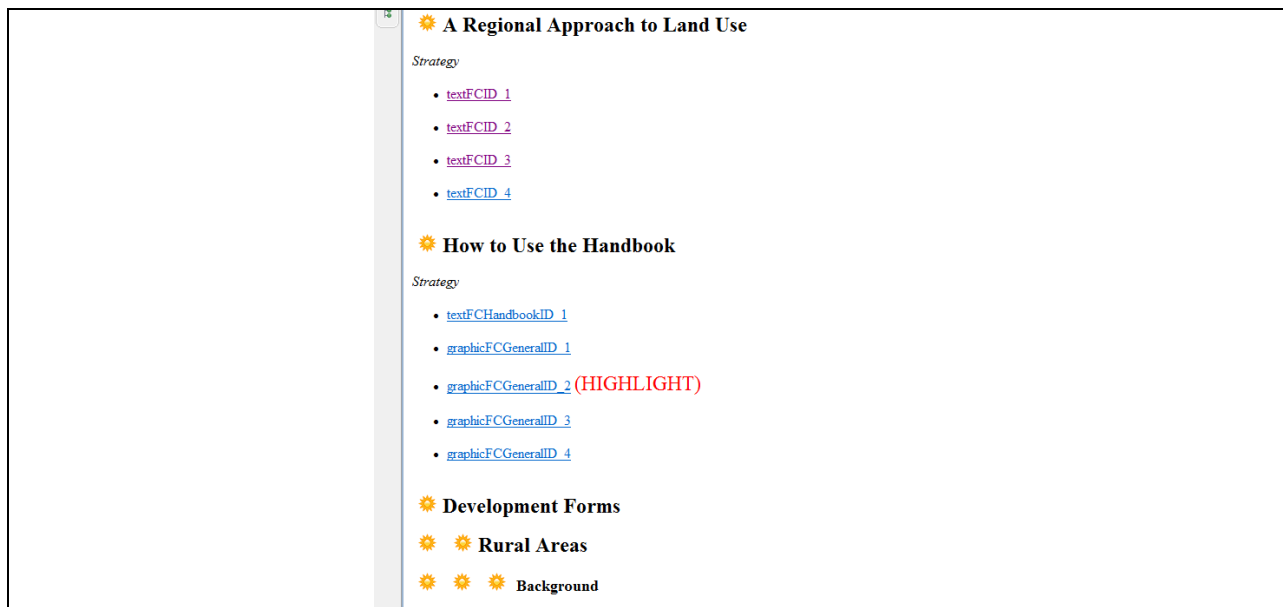


Figure 8.31 Navigation page with highlighting the initiating graphic, “map B”

As in the first case, a variety of prototype functionalities being utilized in this case are summarized and presented in Table 8.2. The practicability of the functionalities clearly demonstrates the applicability of making use of PMLGraphics to access plan contents, especially graphic contents, in many different ways.

Functionalities of the Prototype Being Used	Applicability of Utilizing PMLGraphics to Access Plan Contents
Predefined query of “Aspect” of plan information presented by graphics	Predefined “aspect” in element “categorized plan information” of a single graphic or graphic group could be used for searching graphic contents.
Free-style query of “Coverage of Graphics”	“Coverage” of a single graphic or graphic group member could be used for searching graphic contents.
Combination query combining the two queries above	Predefined query and free-style query could be combined together.
Presenting a list of retrieval results in which single graphics and graphic groups are presented by small size icons, and remarked by different indicators	Small size icons and indicators could help users predict graphic contents. So they could identify what they might actually be most interested in.
Browsing document metadata, an indicator of graphics, to identify the interesting graphics among a retrieval list	Document metadata, which summarizes the plan document a single graphic or graphic group comes from, can facilitate users to identify graphics of interest to them.
Browsing “specific plan information” and “aspect”, indicators of graphics, to identify the most interesting graphic among a retrieval list	Specific plan information presented by a single graphic or graphic group, as well as what aspects the information is about, can facilitate users to identify graphics of interest to them.
Navigating details of a single graphic, which is in a retrieval list	Presenting a single graphic along with its metadata facilitates users comprehension the graphic in detail.
Link of “go to navigation” directing details of a single graphic to navigation page by highlighting the initiating graphic	Document structure that organizes texts, single graphics, and graphic groups in hierarchical topics facilitates users to identify location of a single graphic in plan document so they can further navigate to other plan contents by topics.
Clicking link of a topic being referred to by an index graphic directing details of the single graphic to navigation page highlighting the topic	Corresponding association between index terms and links of topic in an index graphic, as well as document structure that organizes texts, single graphics, and graphic groups in hierarchical topics, facilitates users to identify location of the topic being referred to so they can further navigate to other plan contents in the same topic or any topic that interests them.

Table 8.2 (cont.)

Navigating details of a graphic via relationship between two single graphics	Relationship between two single graphics facilitates users to navigate from one single graphic to another one.
Navigating details of a text via relationship between a single graphic and a text	Relationship between a single graphic and a text facilitates users to navigate from the single graphic to the text, or vice versa.
Navigating details of a text via relationship between two texts	Relationship between two texts facilitates users to navigate from one text to another one.

Table 8.2 Applicability of PMLGraphics demonstrated in case two

With aid of the prototype, the PMLGraphics can enable graphic content made by different organizations at different times to be easily accessed and searched by predefined aspects of intended plan information and coverage of graphics, given that those plans are encoded by the PMLGraphics. The retrieval results are back in one or two seconds. The indicators of the qualified graphics and the default and manual sorting rules further assist the planning staff to locate the most pertinent graphics in a timely manner.

Without the PMLGraphics, the planning staff in this case has to look through every plan either in form of paper-based document or digital document in order to find graphic content regarding land use and environmental preservation in Will County or a broader area. As discussed in the case one, it is quite time-consuming and laborious even for a small set of plans. Not least to say, in a real case, personal knowledge of the relevant plans with respect to the task could be rather limited and out-of-date. The planning staff may overlook some plans drafted or updated by various authorities and organizations, including non-governmental organizations (NGO) and volunteer groups. Those plans may produce significant effects on updating the plans for City of Plainfield.

When the planning staff find a certain graphic that interests them, they desire to navigate plan content relating to the graphic simultaneously, if there are any, so as to fully understand the graphic and the intended plan information. If what the planning staff deals with is paper-based documents or digital documents without PMLGraphics tags, it becomes quite challenging for them to promptly identify the related content to a certain graphic unless they are quite familiar with the whole document. If the plan documents are encoded in PMLGraphics, through the

prototype, the planning staff can locate and navigate the related plan content without difficulty. For instance, they can easily navigate the plan content being referred to by an index graphic or explore the other related plan content via the relationship between two single graphics, the relationship between a single graphic and a text, or the relationship between a graphic group and a text.

8.3 Developing a Commercial Center

In past five years, City of Aurora has been experiencing a remarkable growth of population. A dozen new residential communities are under construction. Three of them are mega communities with more than one thousand households. However, there is still unmet demand for a large-scale commercial center for the whole area. To fit the need, city council has located an available parcel for building the commercial center, and started to develop the project. This project needs to engage participants from various disciplines. Urban designers are needed for site plan of the commercial center. Architects are needed for architectural designs of commercial buildings. For both of them to do quality work, pertinent graphic contents from many plan documents have to be examined from multiple perspectives.

The following shows how the urban designers and architects could separately make use of the prototype to find the graphic contents based on their different needs. In both of the scenarios, several screen snaps are presented – Figure 8.33 to Figure 8.38 for urban designers, and Figure 8.39 to Figure 8.41 for architects. To make the scenarios more comprehensible, navigation logic of those screen snaps is shown in Figure 8.32.

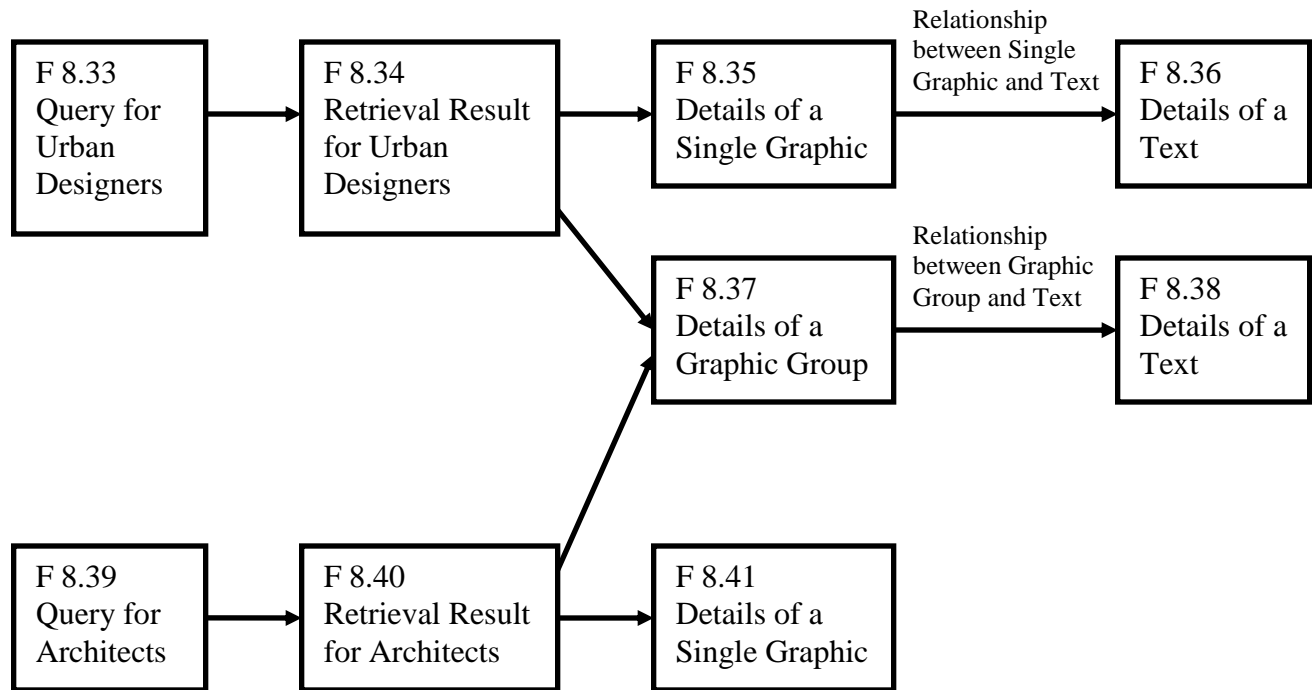


Figure 8.32 Navigation logic of screen snaps in case three

Urban Designers

To search for graphic references regarding site plan of a commercial center, the urban designers start with a combination query (shown in Figure 8.33):

- Type of graphics is “Site Plan”, AND
- Any attribute of graphics includes keyword “commercial” or “business”

The query results in a retrieval list, shown in Figure 8.34.

The retrieval list includes three single graphics and six graphic groups. Indicator “plan document” shows that they are from two plan documents: *2005 Comprehensive Plan, City of Urbana*, and *Land Resource Management Plan: Forms and Concepts Handbook*. Examining other indicators, especially small icon of the graphics and “specific plan info”, the urban designers identify one single graphic (the first single graphic) and three graphic groups (the first, second, and last graphic group) as the most interesting information they want to navigate in detail first. It is worth mentioning that the second rule of default sorting rules for single graphics

-- “If matching item lies in ‘specific plan information’ or ‘categorized plan information’, then the graphic should be on top” -- pop the first single graphic on top of the list. Default sorting rules for single graphics can be found at Appendix C.

How the urban designers could explore the first single graphic and the first graphic group, as well as other plan contents related to them, is shown below.

The first single graphic is shown in Figure 8.35. The graphic along with annotations shows typical layout of a regional commercial center and its distinguishing features. Noticing the single graphic has relationship with another text, the urban designers decide to explore the text in detail (shown in Figure 8.36). The textual description on characteristics of regional commercial center makes them understand the single graphic better.

Query Tool for Graphic Content

Plan Information
 Planning Process Current Situation, Issue and Trend Goals and Desired Future Implementation Information Others




Aspect
 Land Use Transportation Infrastructure Environmental Preservation Cultural Preservation Aspect Others

Graphic Type
 Ground-level Image Aerial-level Image Graph Table Spatial Diagram Non-spatial Diagram
 Site Plan Map

Coverage of Graphics
State:
County:
City:

Keyword Search
keyword #1:
<>: OR AND
keyword #2:

Figure 8.33 Query of urban designers

Query Result									
List of Single Graphic									
Icon	plan document	Matching Item	Graphic Type	Index Graphic	Representation Method	Specific Plan Info	Categorized Plan Info	Aspect	Effectiveness
	Land Resource Management Plan Forms and Concepts Handbook	commercial (title, specific:PlanInformation, annotation, path)	Site Plan	false	Elaborate: Fully Elaborate	typical Regional Commercial Center	Implementation	Land Use	high
	Land Resource Management Plan Forms and Concepts Handbook	commercial (annotation)	Site Plan	false	Elaborate: Fully Elaborate	typical interstate access location	Implementation	Land Use	high
	Land Resource Management Plan Forms and Concepts Handbook	commercial (annotation)	Site Plan	false	Elaborate: Fully Elaborate	typical town	Implementation	Land Use	high







List of Graphic Group							
Graphic Icon	plan document	Matching Item	Representation Method	Specific Plan Info	Categorized Plan Info	Aspect	Graphic Member Relationship
	2005 Comprehensive Plan, City of Urbana	business (annotation<group member>, path<group member>)	Elaborate: Fully Elaborate	typical features of regional business	Implementation	Land Use	Coordinative Relationship
	Land Resource Management Plan Forms and Concepts Handbook	commercial (annotation<group member>)	Elaborate: Fully Elaborate	growth of a typical Urban Community	Implementation	Land Use	Multiples-design Relationship
	2005 Comprehensive Plan, City of Urbana	commercial (annotation<group member>)	Elaborate: Fully Elaborate	typical features of Light Industrial / Office land use	Implementation	Land Use	Coordinative Relationship
	Land Resource Management Plan Forms and Concepts Handbook	commercial (annotation<group member>, annotation<group member>)	Elaborate: Fully Elaborate	potential expansion of a typical Suburban Community	Implementation	Land Use	Multiples-design Relationship
	2005 Comprehensive Plan, City of Urbana	business (path<group member>)	Elaborate: Fully Elaborate	typical features of community business	Implementation	Land Use	Coordinative Relationship
	2005 Comprehensive Plan, City of Urbana	business (annotation<group member>, path<group member>)	Elaborate: Fully Elaborate	typical features of central business	Implementation	Land Use	Coordinative Relationship

Figure 8.34 Retrieval results for urban designers

Single Graphic Content

< graphicFCRegionalCommercialID_2 >

The diagram is a site plan for a regional commercial center. It features a central area with various land use quadrants: 'Main-Street' / Life-Style Commercial, Hospitality-Hotel / Food, General-Commercial, and 'Big-Box' Commercial. Key infrastructure includes a Gateway Interchange with landscape improvements, a Signalized Intersection (TYP.), and an Expressway. Other features include Coordinated Circulation, Traffic Circles, Future Access/Road Network Extension (TYP.), Corporate Image Office Tower, and a Signalized Intersection (TYP.).

Graphic Type:	Site Plan
Index Graphic:	false
Title:	typical Regional Commercial Center
Representation Method:	Elaborate: Fully Elaborate
Specific Plan Info:	typical Regional Commercial Center
Categorized Plan Info:	Implementation (Aspect: Land Use)
Effectiveness:	high
Annotation:	<p>gateway interchange landscape improvements</p> <p>coordinated circulation establishes defused areas for development and offers high degree of access</p> <p>traffic circles enhance character, help orientation, and quality image</p> <p>"big-box" commercial</p> <p>future access or road network extension</p> <p>corporate image office image</p> <p>land use quadrants: "main-street" or life-style commercial, hospitality-hotel or food, general commercial, "big-box" commercial</p> <p>signalized intersection</p>
Path:	planFormsConceptsID_2/RegionalCommercialPhoto2.jpg

Relationship:

Single Graphic And Text: Non-Directional semanticComplementarity textFCRegionalCommercialID_1

[go to navigation](#)

Figure 8.35 Site plan presenting typical layout of a regional commercial center

Text Content

[textFCRegionalCommercialID_1]

The Regional Commercial Use Concept includes either a single use or conglomeration of commercial uses and/or sites that serve as a distinct destination for traffic from a large geographic area. Specific uses in this concept vary widely, but include general commercial retail uses, offices, personal services, restaurants, automotive related businesses, and related uses. These include enclosed shopping malls, strip centers, and freestanding stores. The chief characteristic of Regional Commercial is that it has a scale and magnitude that serves a regional market, and they are usually destination locations for shoppers. They are heavily oriented to the automobile, with very little pedestrian circulation between uses.

Relationship

Graphic And Text: graphicFCRegionalCommercialID_2

Figure 8.36 Text presenting features of a regional commercial center

The first graphic group is shown in Figure 8.37. It shows an existing business center in City of Urbana as an example, in order to illustrate typical features of regional business center. The graphic group is composed of two members, associated with coordinative relationship. One group member, including three photos, portrays architectural details of business buildings. The

other one, a site plan, sketches general layout of the business center. Obviously, the latter one interests the designers most. Noticing the graphic group has relationship with another text, the designers decide to explore the text in detail (shown in Figure 8.38). The text highlights features of a regional business center as well as issues about compatibility with transportation and other facilities. This information is not only quite valuable for urban designers to design the site plan, but also helps them understand the graphic group better.

Graphic Group Content

< graphicGroupUrbanaC7ReBusiness >

REGIONAL BUSINESS

Regional Business centers are intended to serve regional as well as local demand. Typically located in a high visibility area, their efficient convenient access and parking. The amount of development may range from large scale "big box" centers to smaller scale buildings supporting smaller business opportunities. Although Regional Business areas are typically oriented primarily to automobile traffic, their design should include adequate facilities for pedestrians, bicyclists and public transit.



Local Examples: Cunningham Avenue and Interstate 74, E. Route 130 and US Route 130

Representation Method:	Elaborate: Fully Elaborate
Specific Plan Info:	typical features of regional business
Categorized Plan Info:	Implementation (Aspect: Land Use)
Path:	planUrbana2005RegionalBusinessGroup.jpg

Including Members

Coordinative Relationship

Relationship:

Graphic Group and Text: [textUrbanaC7ReBusiness](#)

[go to navigation](#)

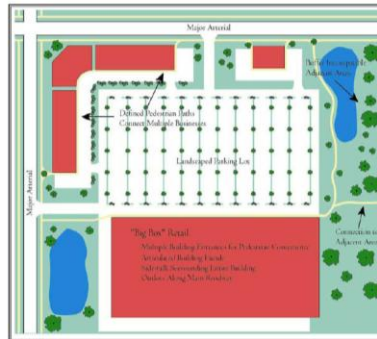
Group Member Content

< MemberUrbanaC7ReBPhoto >



Graphic Type:	Image: Ground-level Image
Title:	
Representation Method:	
Specific Plan Info:	
Categorized Plan Info:	
Annotation:	
Path:	planUrbana2005RegionalBusinessPhotos.jpg

< MemberUrbanaC7ReBLayout >



Site Plan

Graphic Type:	
Title:	
Representation Method:	
Specific Plan Info:	
Categorized Plan Info:	
Annotation:	<p>Defined Pedestrian Paths Connect Multiple Businesses</p> <p>Landscaped Parking Lot</p> <p>Buffer Incompatible Adjacent Areas</p> <p>Connection to Adjacent Areas</p> <p>"Big Box" Retail - Multiple Building Entrances for Pedestrian Convenience - Articulated Building Facade - Sidewalk Surrounding Entire Building - Outlots Along Main Roadway</p>
Path:	planUrbana2005RegionalBusinessLayout.jpg

Figure 8.37 Graphic group presenting typical features of regional business center

Text Content

[textUrbanaC7ReBusiness]

Regional Business centers are intended to serve regional as well as local demand. Typically located in a high-visibility area that offers convenient access and parking. The intensity of development may range from large-scale "big box" uses to smaller-scale buildings supporting outlet business opportunities. Although Regional Business areas are typically oriented primarily to automobile traffic, their design should include adequate facilities for pedestrians, bicyclists and public transit.

Relationship

GraphicGroup And Text [graphicGroupUrbanaC7ReBusiness](#)

Figure 8.38 Text briefly introducing features of regional business center

Architects

To search for graphic references regarding architectural design of a commercial center, the architects start with a combination query (shown in Figure 8.39):

- Type of graphics is “Ground-level Image”, AND
- Any attribute of graphics includes keyword “commercial” or “business”

The query results in a retrieval list, shown in Figure 8.40.

Query Tool for Graphic Content

Plan Information

Planning Process Current Situation, Issue and Trend Goals and Desired Future Implementation Information Others

Aspect

Land Use Transportation Infrastructure Environmental Preservation Cultural Preservation Aspect Others

Graphic Type

Ground-level Image Aerial-level Image Graph Table Spatial Diagram Non-spatial Diagram
 Site Plan Map

Coverage of Graphics

State:

County:

City:

Keyword Search

keyword #1:

<>: OR AND

keyword #2:

Figure 8.39 Query of architects










Query Result									
List of Single Graphic									
Icon	plan document	Matching Item	Graphic Type	Index Graphic	Representation Method	Specific Plan Info	Categorized Plan Info	Aspect	Effectiveness
	Land Resource Management Plan: Forms and Concepts Handbook	business (specificPlanInformation)	Ground-level Image	false	Elaborate: Partially Elaborate	Agricultural support businesses are critical to the viability of Agricultural Areas.	Implementation	Land Use	high
	2040 Regional Framework Plan	business (specificPlanInformation, path)	Ground-level Image	false	Elaborate: Fully Elaborate	The City of Chicago's Central Business District is the Global Center in northeastern Illinois, tying the region and the United States to the world.	Implementation	Land Use	high
	Land Resource Management Plan: Forms and Concepts Handbook	commercial (description, specificPlanInformation, path)	Ground-level Image	false	Elaborate: Fully Elaborate	Mid-Scale Commercial uses should be located within easy access to an arterial roadway.	Implementation	Land Use	high
	2040 Regional Framework Plan	commercial (specificPlanInformation)	Ground-level Image	false	Elaborate: Fully Elaborate	Metropolitan Centers like Evanston are mixed-use hubs for commercial, employment, and institutional activities.	Implementation	Land Use	high
	Land Resource Management Plan: Forms and Concepts Handbook	commercial (description, specificPlanInformation, path)	Ground-level Image	false	Elaborate: Fully Elaborate	Parking lots in Regional Commercial could be improved with landscaping measures and other design considerations to break-up the vast expanse of parking often associated with Regional Commercial uses.	Implementation	Land Use	high
	2040 Regional Framework Plan	business (specificPlanInformation, path)	Ground-level Image	false	Elaborate: Partially Elaborate	Coordinated regional efforts such as improved transportation choices for workers, improved rail and road network for freight, high technology communications facilities, and other infrastructure support can attract businesses and employment opportunities to northeastern Illinois.	Implementation	Aspect Others	low
List of Graphic Group									
Graphic Icon	plan document	Matching Item	Representation Method	Specific Plan Info	Categorized Plan Info	Aspect	Graphic Member Relationship		
	2005 Comprehensive Plan, City of Urbana	business (path<group member>)	Elaborate: Fully Elaborate	typical features of regional business	Implementation	Land Use	Coordinative Relationship		
	2005 Comprehensive Plan, City of Urbana	business (path<group member>)	Elaborate: Fully Elaborate	typical features of community business	Implementation	Land Use	Coordinative Relationship		
	2005 Comprehensive Plan, City of Urbana	business (path<group member>)	Elaborate: Fully Elaborate	typical features of central business	Implementation	Land Use	Coordinative Relationship		

Figure 8.40 Retrieval results for architects


The retrieval list includes six single graphics and three graphic groups. Indicator “plan document” shows that they are from three plan documents: *2005 Comprehensive Plan* for City of Urbana, *2040 Regional Framework Plan*, and *Land Resource Management Plan: Forms and Concepts Handbook*. Browsing other indicators, especially small icon of the graphics, “Representation Method”, “Specific Plan Info”, the architects identify two single graphics (the single graphics ranking third and fourth) and the three graphic groups as the most relevant information. The three graphic groups are also among the retrieval list for urban designers. It is worth mentioning that the first rule of default sorting rules for single graphics -- “If weight of a single graphic is high, then the graphic should be on top” -- pop those single graphics with high weight on top, and push the single graphic with low weight to bottom.

In the following, how the architects could explore the single graphic ranking third and the graphic group ranking first is shown.

The single graphic is shown in Figure 8.41. It is originally for presenting a piece of plan information, “Mid-Scale Commercial uses should be located within easy access to an arterial roadway”. The plan information does not interest architects, but the photograph does because the photograph illustrates what buildings in a mid-scale commercial center look like, which is exactly what the architects are trying to find.

Single Graphic Content

< graphicFCMidscaleCommercialID_1 >



Mid-Scale Commercial uses should be located within easy access to an arterial roadway.

Graphic Type:	Ground-level Image
Index Graphic:	false
Description:	Mid-Scale Commercial uses should be located within easy access to an arterial roadway.
Representation Method:	Elaborate: Fully Elaborate
Specific Plan Info:	Mid-Scale Commercial uses should be located within easy access to an arterial roadway.
Categorized Plan Info:	Implementation (Aspect: Land Use)
Effectiveness:	high
Path:	/planFormsConceptsID_2/MidscaleCommercialPhoto1.jpg

Relationship:

[go to navigation](#)

Figure 8.41 Single graphic illustrating architectural styles in mid-scale commercial center

Details of the graphic group have been shown in Figure 8.37. Even though the graphic group interests both architects and urban designers, they view it in totally different perspectives. The architects focus on examining the three photos that portray architectural designs, whereas the urban designers focus on examining the site plan that sketches general layout of regional business center. The text having relationship with the graphic group (shown in Figure 8.38) is obviously more useful for urban designers than for architects, since the content is about site plan.

As in the first two cases, varieties of prototype functions are utilized in this case and are summarized and presented in Table 8.3. The practicability of the functionalities clearly

demonstrates the applicability of making use of PMLGraphics to access plan contents, especially graphic contents, in many different ways.

Functionalities of the Prototype Being Used	Applicability of Utilizing PMLGraphics to Access Plan Contents
Predefined query of “Graphic Type”	Predefined “graphic type” of a single graphic or graphic group member could be used for searching graphic contents.
Free-style query of “Keyword”	Any element of a single graphic or graphic group could be searched in free-style.
Combination query combining the two queries above	Predefined query and free-style query could be combined together.
Presenting a list of retrieval results in which single graphics and graphic groups are presented by small size icons, and described by different indicators	Small size icons and indicators could help users predict graphic contents so they could identify what they might actually be most interested in.
Browsing “representation method” and “specific plan information”, indicators of graphics, to identify the most interesting graphic among a retrieval list	Specific plan information presented by a single graphic or graphic group, as well as the representation method the graphic uses, can facilitate users to identify graphics that interest them.
Default sorting rules for single graphics, especially the first and second rule, ranking relative important single graphics on top of the list.	Default sorting rules, which are founded on attributes of single graphics, rank relatively important single graphics on top of a list, and thus facilitate users to find the most interesting ones, especially if the retrieval list is long.
Navigating details of a single graphic, which is in a retrieval list	Presenting a single graphic along with its metadata facilitates users comprehension of the graphic details.
Navigating details of a graphic group, which is in a retrieval list	Presenting a graphic group and its members, along with their metadata facilitates users comprehension of the graphic group.
Navigating details of a text via relationship between a single graphic and a text	Relationship between a single graphic and a text facilitates users to navigate from the single graphic to the text, or vice versa.
Navigating details of a text via relationship between a graphic group and a text	Relationship between a graphic group and a text facilitates users to navigate from the graphic group to the text, or vice versa.

Table 8.3 Applicability of PMLGraphics demonstrated in case three

Through the prototype, the PMLGraphics can facilitate different stakeholders to search graphic reference more efficiently. In this case, the interests of those urban designers and architects rest on two predefined graphic types, site plan and ground-level image, respectively. The search

based on the predefined graphic types and keyword matching facilitates either urban designers or architects to access what they need in seconds at any time. In addition, the indicators of the qualified graphics facilitate them to easily and quickly locate the most pertinent graphics. Without the prototype and the PMLGraphics, it may take several days or even longer for either urban designers or architects to look for the references across the paper-based documents or digital documents without aid of PMLGraphics tags, even for a small set of plans. Not least to say, in a real case there would be much larger set of plans that should be referred to. The larger number of plan documents would make the PMLGraphics much more valuable, and yield much greater efficiency gains.

Through the prototype, the PMLGraphics facilitates the users to do query at any time and receive the follow-on reference instantly. It saves lots of money and time being spent on hard copying the pertinent graphics if the users have to deal with the paper-based documents, and avoids hassles in adding bookmarks on digital documents or copying and pasting the related content if users have to deal with the digital documents without the aid of PMLGraphics tags. In addition, getting the retrieval results instantly guarantees the users always access to the up-to-date plan documents.

8.4 Discussion and Conclusion

This chapter elaborates three hypothetical use cases, which simulate practical scenarios in planning processes. The use cases illustrate through the prototype that the PMLGraphics can assist different stakeholders to easily search and navigate graphic content scattered in different plan documents that are pertinent to their needs in the planning process. The use cases demonstrate the feasibility and applicability of the PMLGraphics in accessing graphic plan content.

The applicability of the PMLGraphics is summarized as below.

- 1) A controlled vocabulary of “categorized plan information”, “aspect”, and “graphic type” of graphics (including single graphics and graphic groups) can be used for querying graphics.

- 2) The “Coverage” of graphics can be used for geometry-oriented query.
- 3) Any element of graphics can be searched by keywords entered by a user.
- 4) Elements of graphics, as well as document metadata, can be used as indicators to facilitate users to identify the most interesting graphics among a list.
- 5) Elements of single graphics can be used to generate default sorting rules of single graphics that rank important ones on top of a list.
- 6) Elements of single graphics and graphic groups can be used to generate manual sorting rules that facilitate users to choose which element is used as the sorting basis for the graphics.
- 7) Association between index terms and references of content in an index graphic facilitates users to navigate referenced plan content.
- 8) Document structure highlights position of a single graphic or a graphic group just being navigated, and thus facilitates users to further navigate to other plan content by topics.
- 9) Relationship between two content entities facilitates users to navigate from one entity to the other.

Among them, the power of the keyword search, as shown in the third item of the list, needs to be further discussed. The keyword search has been included in the queries of the first case and the third case. However, the keywords being used, “office”, “commercial” or “business”, are somewhat general and the keyword search combines with the predefined search in both cases. The example shown in Figure 8.42 and 8.43 provides a better demonstration of the keyword search, since the inputted keyword “gateway” is more specific and it was randomly proposed by committee members in the middle of my dissertation defense. In this example, only keyword search function is demonstrated. Figure 8.42 shows the query interface with “gateway” as the keyword. Figure 8.43 shows the query results, which include graphics in different types, including “ground-level image”, “map”, “non-spatial diagram” and “site plan”. This example shows that the prototype, even with a small set of plans, can already handle relatively free form queries and yield results across a range of graphic types that are not easy to realize by searching paper-based documents.

At the end of the use cases, I have discussed in which ways the PMLGraphics enhances users' ability to carry out the tasks by comparing to what would have happened without the data model. The PMLGraphics would be much more valuable and the gains would be much more evident with a larger set of plans, compared to the three plans included in the current database of the prototype.

Query Tool for Graphic Content

Plan Information
 Planning Process Current Situation, Issue and Trend Goals and Desired Future Implementation Information Others

Aspect
 Land Use Transportation Infrastructure Environmental Preservation Cultural Preservation Aspect Others

Graphic Type
 Ground-level Image Aerial-level Image Graph Table Spatial Diagram Non-spatial Diagram Site Plan Map

Coverage of Graphics
State:
County:
City:

Keyword Search
keyword #1:
<>: OR AND
keyword #2:

Figure 8.42 “Gateway” keyword search

Query Result

List of Single Graphic

Icon	plan document	Matching Item	Graphic Type	Index Graphic	Representation Method	Specific Plan Info	Categorized Plan Info	Aspect	Effectiveness
	Land Resource Management Plan: Forms and Concepts Handbook	gateway (description, specific:PlanInformation)	Ground-level Image	false	Elaborate: Partially Elaborate	Vehicular entrances to Towns act as a gateways which set a tone for the Town. Special attention should be paid to the character of these areas to improve the image of the Town.	Implementation	Land Use	high
	Land Resource Management Plan: Forms and Concepts Handbook	gateway (description, specific:PlanInformation)	Ground-level Image	false	Elaborate: Fully Elaborate	Gateways like this one give the community a sense of identity that sets it apart from the surrounding areas for residents and visitors	Implementation	Land Use	high
	2005 Comprehensive Plan, City of Urbana	gateway (annotation)	Map	false	Elaborate: Fully Elaborate	future land use development of West Urbana (North Half)	Goals and Desired Future	Land Use Transportation Environmental Preservation	high
	Land Resource Management Plan: Forms and Concepts Handbook	gateway (textualitem)	Non-spatial Diagram	true	Elaborate: Fully Elaborate	process flow chart for the Will County reviewing a development proposal	Implementation	Land Use	high
	Land Resource Management Plan: Forms and Concepts Handbook	gateway (annotation)	Site Plan	false	Elaborate: Fully Elaborate	typical Regional Commercial Center	Implementation	Land Use	high
	Land Resource Management Plan: Forms and Concepts Handbook	gateway (annotation)	Site Plan	false	Elaborate: Fully Elaborate	typical interstate access location	Implementation	Land Use	high

List of Graphic Group

Graphic Icon plan document Matching Item Representation Method Specific Plan Info Categorized Plan Info Aspect Graphic Member Relationship

Figure 8.43 Result of “gateway” keyword search

9. Conclusions and Future Works

The current PML framework, which is proposed to represent the underlying structure of plans and regulations, deals only with text-based content in plans and regulations (Hopkins, Kaza, & Pallathucheril, 2005b). To address this limitation, this dissertation developed a PML extension, PMLGraphics, to mark up graphic content of plan documents and demonstrated its feasibility and practicability in hypothetical planning practice situations.

The PMLGraphics is built upon theoretical exploration of numerous examples of graphic representations in formal plans. The study focused on:

- Summarizing typical graphic types in plan documents, representation methods used by graphic representations, and plan information presented by graphics,
- Identifying existence of graphic group as a unified mechanism for communication,
- Exploring association among group members in a graphic group, and
- Exploring relationship among different presentation media -- text, single graphic and graphic group, especially relationship between two single graphics and relationship between single graphic and text.

Developed through this research, the PMLGraphics includes three parts: document metadata, document structure, and document content. Among them, the most important is document content part, which lays out the framework and specifications for marking up single graphics, graphic groups, text, as well as relationships among them, in a plan usable way. To test the feasibility of the PMLGraphics, *Land Resource Management Plan* composed of three documents was fully encoded. In addition, two more plan documents, *2040 Regional Framework Plan* and *2005 Comprehensive Plan* for City of Urbana, were partially encoded. All of the encoded plan information served as database of use cases for demonstrating the feasibility of the approach. A prototype for using the PMLGraphics was developed by using the latest web and XML technologies. As proof of concept, the prototype was tested against three use cases based on realistic situations, which involve various stakeholders in the planning domain. The experiences with the use cases demonstrated that the PML graphic extension could facilitate users in

querying and accessing pertinent graphic content scattered in multiple documents in many different ways.

The PMLGraphics, especially when it is well developed and widely accepted, will lead to significant impacts on how plans are made and used in practice. It could facilitate participants in accessing easily and deeply plan content pertinent to their interests when they discuss, deliberate, and make decisions in daily planning activities. It could serve as a well-shared representation essential to plan making processes. It could also promote public participation in planning practice by enabling the public to equally access appropriate content of many different plans, and to easily comprehend plan information they have accessed.

This research is but one of the first steps to mark up and represent graphic representations in the planning domain as part of an XML-compatible schema. The plan documents being studied in this research were formal plans focusing on land use, transportation, and environmental preservation. The PML graphic extension will certainly evolve as other types of plan documents, such as urban design plan, community charrette reports, and informal meeting notes, are encoded. Development of a robust, widely shared data model will also call for long-term collaborative efforts by many scholars and practitioners who will revise the model and test it in planning practices iteratively. The process of maturity and standardization could take a rather long time, similar to geographic information system (GIS) data models that have gone through more than thirty years from an inspiration of codifying geographic phenomena in time and space to recent object-oriented models and the Geography Markup Language (GML) (Peucker & Chrisman, 1975; Chrisman, 2002; Longley et al., 2001).

A visual editing tool for the PMLGraphics will be urgently desired, aimed at planning staff who normally does not have the computer engineering backgrounds to encode plan content. It will allow users to enter values into preset fields that match the framework and element sets of the PMLGraphics. The template tool will then generate a PML-formatted set of the elements and their corresponding attributes. The tool should be user-friendly, as well as intuitive, so that encoders do not have to deal with the details of PML syntax or XML formats if they do not want to. Meanwhile, the tool should also provide the flexibility to enable encoders, if they wish to

directly customize PML syntax. Just like in some HTML editors (e.g. Dreamweaver), users can customize their web pages by intuitively drawing, dragging, or filling, even if they do not understand HTML syntax; meanwhile, they also have the option to work on the HTML codes directly.

As discussed, the prototype in this research is a proof-of-concept application. In the short run, it can be extended in the following dimensions in order to be a viable implementation for planners in practice.

- 1) The implementation should be open to plan information from a wide variety of sources. That is, it should accommodate multiple plan servers and encoders. Each plan server could cover one or more planning databases, whereas each database could be fed by one or more encoders.
- 2) The implementation should be able to search plan information in a real-time manner. Whenever a new plan is uploaded into a database by some encoder, the information contained by this new plan should immediately become eligible for searching.
- 3) A continuum from “wall-mounted touch screen” (Hopkins, Kaza, & Pallathucheril, 2005b, p. 17), desktop, and laptop to a smart-phone could be used to display the search results and support user interaction.

In the long term, as a domain-specific search engine and decision making tool PMLGraphics based implementation could evolve in the following directions:

- 1) It needs to address the issue about how to help users to intuitively build and refine query, especially when they are not sure what exactly they want to search. Drawing on the experience of Bing’s Visual Search, an image gallery holds more promise than text links to help users to formulate and refine queries (VisualSearch -- Bing). Imagine that in a PMLGraphics based implementation a search for “commercial” returns a gallery of thumbnail pictures of commercial sites. The search results can be refined by graphic types (e.g. ground-level image, site plan, and map), displaying a new set of images. The PMLGraphics based implementation should be not only a search engine but also a decision engine for users by dealing with plan information overload with an intuitive user interface.

- 2) It is desirable to equip the implementation with the ability to learn rules for sorting results. Rather than a fixed set of rules, a dynamic set of rules can be learned from collecting and analyzing usage patterns and history. Some pioneering work in this respect was done by Amazon (amazon.com). It uses a customer's history to help find related items that might be of interest, and provides recommendations based on when the customer purchases or rates a new item as well as changes in the interests of similar customers. For the same spirit, the PMLGraphics based implementation could use user's profile and preferences to presort retrieval results and present information in a personalized way.
- 3) In the implementation, users should be able to comment on the graphics from the retrieval results. These comments should be saved into database and be ready for other users to view and search. Similar instances, such as customer's reviews and ratings regarding items purchased, have been implemented in many e-commercial websites, for example, Amazon.com.
- 4) It is desirable to incorporate intuitive graphic-based inputs and outputs into the implementation. A typical example is that a user clicks a region painted in red on a sample map to express his search intention of finding commercial areas in the form of map, and this search results in qualified commercial areas being highlighted on maps. In addition, a user could directly draw a boundary on a map to express a geographical range of his search.

The Figure 9.1 shows the expected system architecture of PMLGraphics based implementation. Compared to the system architecture of the prototype shown in Figure 7.16, the architecture of the implementation is more comprehensive so that it is able to handle advanced requirements and future developments as discussed above. The system architecture still follows a three-tier design: client tier, middle tier and data tier. The client tier is extended to include a spectrum of display devices from wall-mounted touch screen to smart phone. The middle tier has a handful of additions. Within web server, two modules ("Input Interpreter" and "Output enhancer") are introduced. The "Input Interpreter" module is designed to understand graphic-based user input info such as mouse click on a graphical map. The interpreted user input is fed into the implementation with a machine-friendly format. The "Output enhancer" is the other way around.

It transforms traditional search results into a graphic representation (e.g. “areas of interest” visual metaphor in a map) and enhances user experience. Along with all-important “searching processor”, two auxiliary processors are introduced to deal with “learning of sorting rules” and “commenting”, respectively. The “learning center for sorting” is a processor which monitors the user’s preferences with respect to sorting. The users can be profiled into “public audience”, “developer”, “architect”, and “urban planner”, etc. A certain profile is coupled with a particular pattern of sorting orders. The patterns will be learned by this processor and the results of this machine learning are stored in the “database of rules”. The “comment processor” extracts comments from the user interface, records the association between a particular piece of comment and relevant plan information, and stores them into “database of comments”. The “searching process” is enhanced with the further capability of retrieving comments via “comments server”. In the data tier, the data sources are greatly extended to multiple plan servers and multiple encoders. The cardinality relationships among plan servers, encoders and database are quite flexible. One plan server can work with one or more databases. Several encoders can feed one or more databases via an “encoder coordinator”.

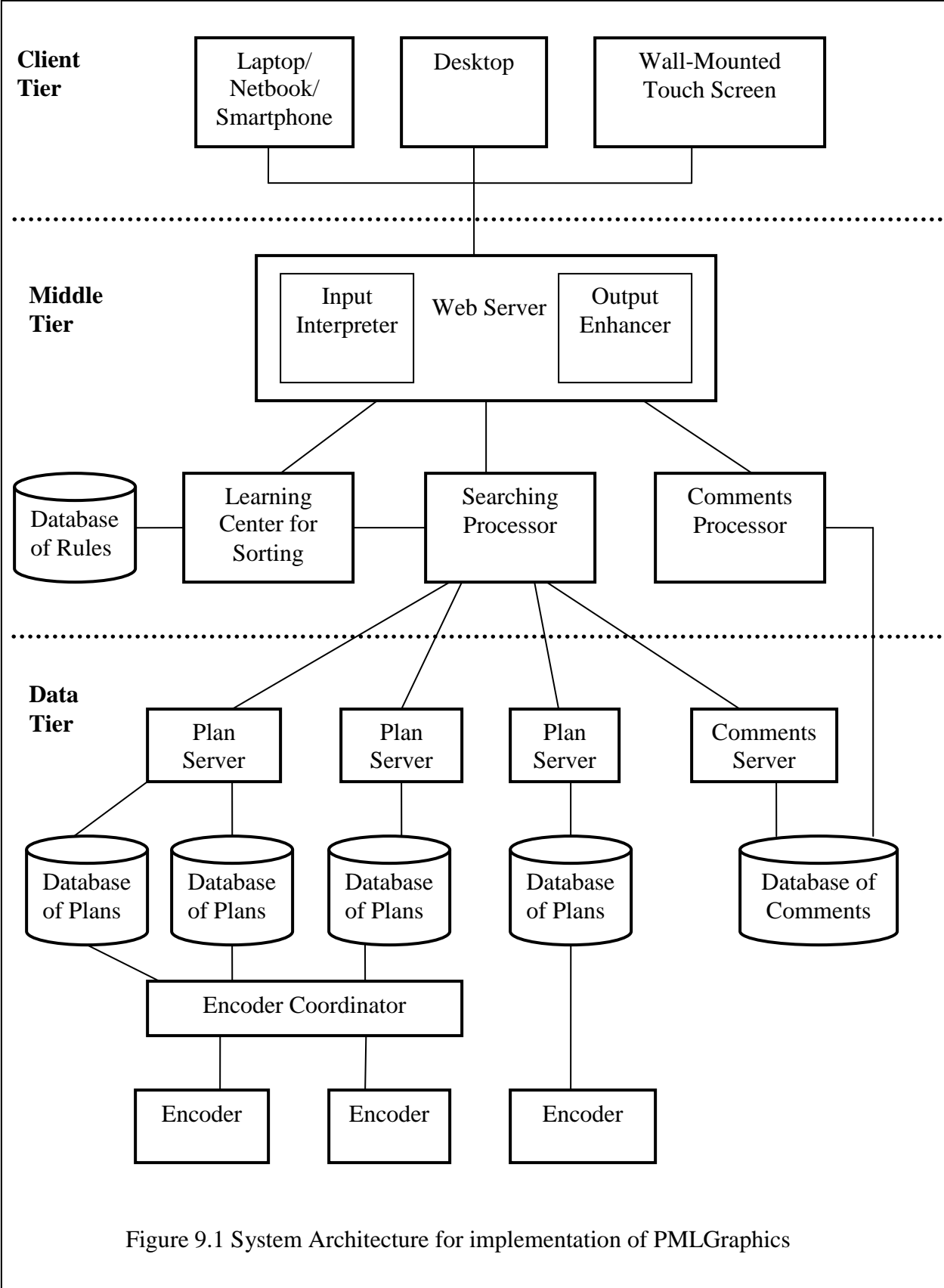


Figure 9.1 System Architecture for implementation of PMLGraphics

There are two more thoughts about how to enrich the PMLGraphics. One is to broaden the scope of the PML by integrating continuous media (e.g. audio, video and animation), given that graphic representations are regarded as static media. The other one is to explore data models that present the underlying structure of inherent information contained in graphic representations of plan documents.

Exploring framework and specifications of continuous media is desirable in planning processes because, since the 1990s, more and more hypermedia systems (including text, graphics, sound and video) have been developed and used in planning practice (Choate, 1994; Jones et al., 1994; Shiffer, 1995a, 1995b, 1995c, 1998, 2001). This trend is due to more and more scholars agreeing that rich presentation ability of multimedia can make everyone in a deliberation work from a common understanding of planning information (for example, Cămara et al., 1991; Choate, 1994; Fonseca et al., 1993; Jones et al., 1994; Laurini & Raffort, 1990; Polyorides, 1993; Shiffer 1994).

This dissertation will provide valuable experiences and knowledge as a basis for work on marking up continuous media. First of all, the methodology used in this research is appropriate for the new study. That is to say, the new study could be explored in five steps:

- A. analyze “plan-usable” features of the continuous media and how they communicate plan information,
- B. propose data model capable of marking up the continuous media,
- C. encode sample data by the data model,
- D. design and implement a prototype, and
- E. test the feasibility of the data model by using the prototype in use cases.

Second, the knowledge built in this research is valuable as building blocks. For instance, with the PMLGraphics as a foundation, elements distinctively describing continuous media will be added, whereas, elements from static graphics that are applicable also to continuous media will be retained. The ways of facilitating use of the PMLGraphics can be similarly extended and modified for continuous media. The technology used in implementing the prototype is also applicable in the new study.

Besides integrating continuous media, the other important next step is to structure inherent significant plan information presented in graphic representations in depth. This advance would enable detailed plan information depicted by graphic representations to be easily searched and accessed. As an example, the plan information “Olympian Drive relocation and extension west from U.S. Route 45” presented in the mobility map of City of Urbana (shown in Figure 4.21) could be encoded as follows:

```
<project>
  <projectCertainty>planned project</projectCertainty>
  <actionGroup>
    <action>relocate</action>
    <action>extend west from U.S Route 45</action>
  <actionGroup>
    <object type="road">
      <ObjectName>Olympian Drive</ObjectName>
      <ObjectClassification>Collector</Classification>
      <ObjectLocation>City of Urbana</ObjectLocation>
    </object>
  </project>
```

In this illustration planning projects are classified into two types, “planned project” and “potential project”, in terms of planning certainty. Roads are classified into five types, interstate road, major arterial road, minor arterial road, major collector road, and minor collector road, in terms of functionalities of roadways. Planned project refers to those already determined and planned for accordingly; whereas, potential project refers to those needing additional study to determine design, location, and function. If planning participants needed to know about plan content concerning “planned project” for “collector” road in “City of Urbana”, they could directly and easily locate the mobility map with the aid of an appropriate search tool.

In conclusion, this research has developed a PML graphic extension, PMLGraphics as well as implemented a prototype to demonstrate the feasibility and effectiveness of the PMLGraphics in the context of using plans. A framework has been laid out to model graphic content in plan documents in “plan-usable” ways, so that plan users can easily and precisely locate graphic

content pertinent to their needs. This research work sets a solid foundation on which the further works can be built.

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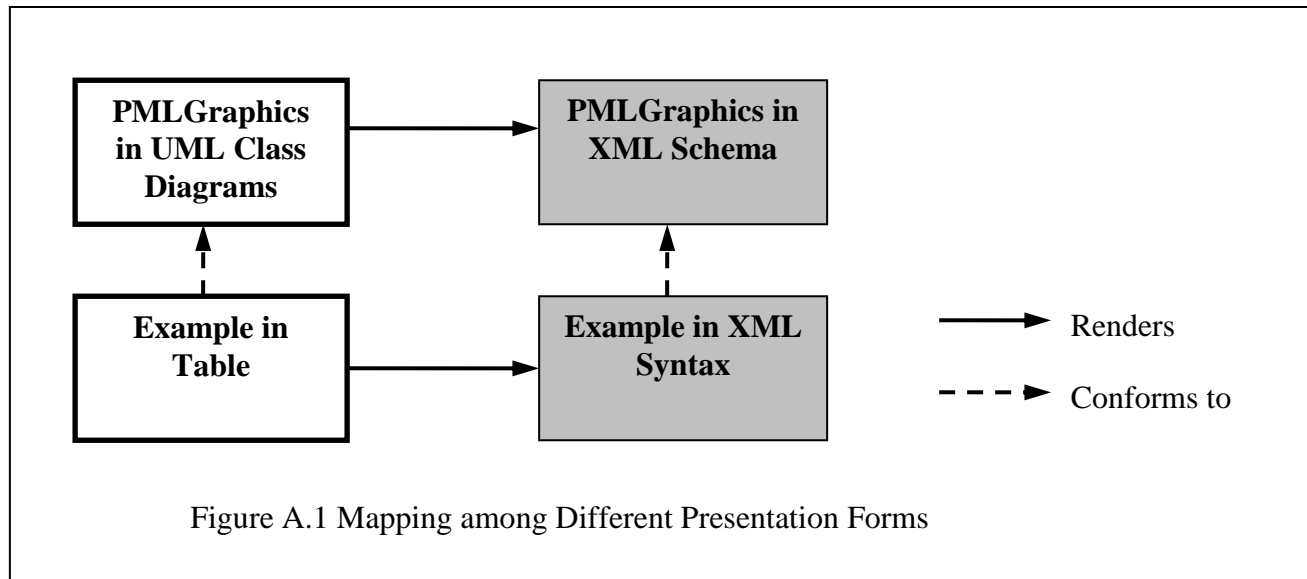
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Appendix A: Mapping among Presentation Forms



In Chapter Six, UML class diagrams are used to present the proposed PMLGraphics, and tables are used to present the corresponding examples to illustrate the PMLGraphics. The UML diagrams and the tables respectively provide easily readable presentation forms for the PMLGraphics in XML schema and the XML syntax conforming to the XML schema. Figure A.1 summarizes mapping relationship of the four types of presentation forms. How exactly they map to each other is illustrated below.

More precisely, the UML class diagrams for presenting the PMLGraphics are XML schemas in UML, a special UML diagram, which renders XML schemas of the PMLGraphics (refer to Appendix B) in a format similar to UML class diagrams. Simple types and complex types being defined in XML schema, as well as those built-in data types, are presented as classes in UML. Local elements and element attributes included by complex type in XML schema are presented in the data members or properties compartment of classes in UML. Meanwhile, element attributes are labeled as <<attribute>> in attached comments to distinguish them from other elements. The operations compartment of classes is empty, since the XML schema specification has no corresponding feature. For the sake of simplification, the three types of model groups (that is, xs:sequence, xs:all, and xs:choice) in schema, which indicate the structure and order in which child elements can appear within their parent element, are not, in most cases, shown in UML diagrams. Only when the number of child elements is somewhat large, the model groups are shown as inner class.

Below is a small portion of the PMLGraphics in UML class diagrams (see Figure A.2), which exactly corresponds to the XML schema following it.

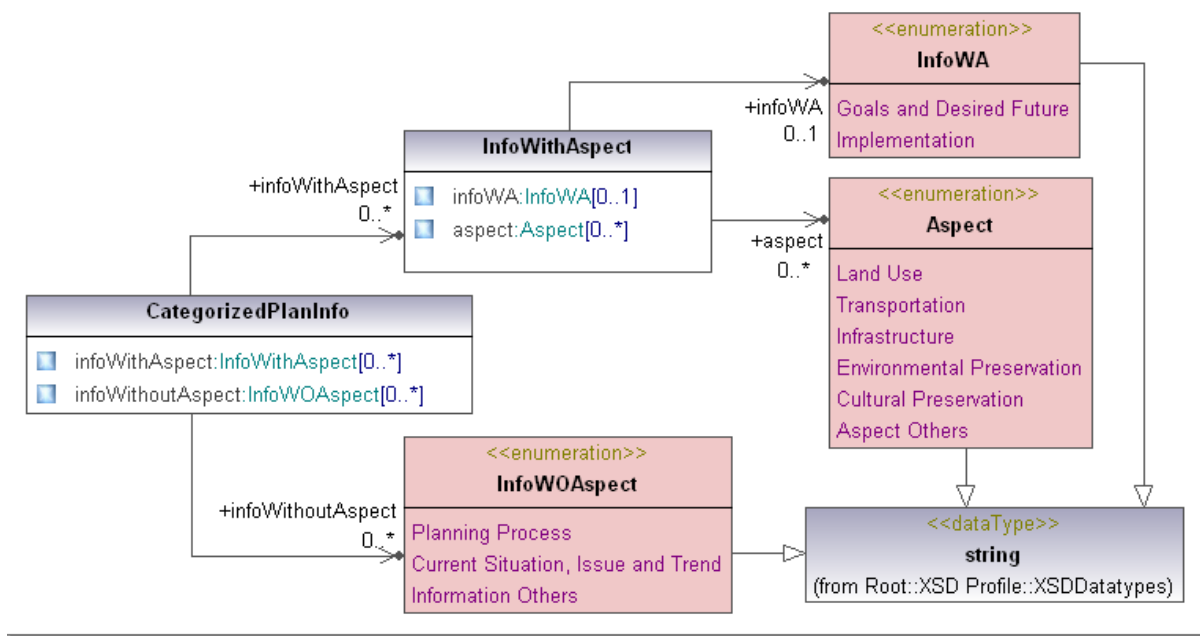


Figure A.2 A Small Portion of the PMLGraphics in UML

```

<xs:complexType name="CategorizedPlanInfo">
  <xs:sequence>
    <xs:element name="infoWithAspect" type="InfoWithAspect" minOccurs="0"
maxOccurs="unbounded"/>
    <xs:element name="infoWithoutAspect" type="InfoWOAspect" minOccurs="0"
maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
<xs:simpleType name="InfoWOAspect">
  <xs:restriction base="xs:string">
    <xs:enumeration value="Planning Process"/>
    <xs:enumeration value="Current Situation, Issue and Trend"/>
    <xs:enumeration value="Information Others"/>
  </xs:restriction>
</xs:simpleType>
<xs:complexType name="InfoWithAspect">
  <xs:sequence>
    <xs:element name="infoWA" type="InfoWA" minOccurs="0"/>
    <xs:element name="aspect" type="Aspect" minOccurs="0" maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
<xs:simpleType name="Aspect">
  <xs:restriction base="xs:string">
    <xs:enumeration value="Land Use"/>
    <xs:enumeration value="Transportation"/>
    <xs:enumeration value="Infrastructure"/>
    <xs:enumeration value="Environmental Preservation"/>
    <xs:enumeration value="Cultural Preservation"/>
  </xs:restriction>
</xs:simpleType>

```

```

        <xs:enumeration value="Aspect Others"/>
    </xs:restriction>
</xs:simpleType>
<xs:simpleType name="InfoWA">
    <xs:restriction base="xs:string">
        <xs:enumeration value="Goals and Desired Future"/>
        <xs:enumeration value="Implementation"/>
    </xs:restriction>
</xs:simpleType>

```

In order to further illustrate the PMLGraphics, some examples conforming to the XML schema presented by the UML class diagrams are provided. The examples are shown in the form of tables, which intends to provide an easily readable description of XML syntax. Each table is generally composed of two fields – the left field shows elements and element attributes in XML syntax (that is, the data members in UML classes), and the right field shows values of them. The left field could be further divided, and the cells in the left field may be grouped, segmented, or arranged in many different ways. The arrangement of elements in the left field indicates relations among elements and element attributes. Precisely, an element is the parent of those elements in the same row on its immediate right column, if there is one; if a child element is an element attribute, it is an attribute of the parent element on its immediate left. The table in Table A.1, as an example, provides an intuitive presentation of the following XML syntax.

Element / Attribute	Value
customer_name <<attribute>>	001
customer_ID	
last_name	Li
first_name	Jinghuan
customer_name <<attribute>>	002
customer_ID	
last_name	Justin
first_name	Meng

Table A.1 Table as intuitive presentation of XML syntax

```

<customer_name customer_ID= "001">
    <last_name>Li</last_name>
    <first_name>Jinghuan</first_name>
</customer_name>
<customer_name customer_ID= "002">
    <last_name>Meng</last_name>
    <first_name>Justin</first_name>
</customer_name>

```

Table A.2 shows an example that conforms to the XML schema in UML presented in Figure A.2. It renders the following XML syntax in an easily readable way.

Data Member			Value
categorizedPlanInfo	infoWithAspect	infoWA	<i>Goals and Desired Future</i>
		aspect	<i>Land Use</i>
		aspect	<i>Transportation</i>
		aspect	<i>Environmental Preservation</i>

Table A.2 An example conforming to the XML schema in UML shown in Figure 6.2

```

<categorizedPlanInfo>
  <infoWithAspect>
    <infoWA>Goals and Desired Future</infoWA>
    <aspect>Land Use</aspect>
    <aspect>Transportation</aspect>
    <aspect>Environmental Preservation</aspect>
  </infoWithAspect>
</categorizedPlanInfo>

```

Appendix B: PMLGraphics in XML Schema

```
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified"
attributeFormDefault="unqualified">
  <!-- Framework of the PMLGraphics -->
  <!-- root element -->
  <xs:element name="PMLgraphics" type="PMLGraphics"/>
  <xs:complexType name="PMLGraphics">
    <xs:sequence>
      <xs:element name="documentInPMLGraphics" type="DocumentInPMLGraphics"
maxOccurs="unbounded"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="DocumentInPMLGraphics">
    <xs:sequence>
      <xs:element name="documentMetadata" type="DocumentMetadata"/>
      <xs:element name="documentStructure" type="DocumentStructure"/>
      <xs:element name="documentContent" type="DocumentContent"/>
    </xs:sequence>
    <xs:attribute name="planDocumentID" type="xs:ID" use="required"/>
  </xs:complexType>
  <!-- Document Metadata -->
  <xs:complexType name="DocumentMetadata">
    <xs:all>
      <xs:element name="docName" type="DocName"/>
      <xs:element name="docFunctionality" type="DocFunctionality" minOccurs="0"/>
      <xs:element name="docPersonActionDate" type="DocPersonActionDate"/>
      <xs:element name="docCoverage" type="Coverage"/>
      <xs:element name="docAspectList" type="DocAspectList" minOccurs="0"/>
    </xs:all>
  </xs:complexType>
  <xs:simpleType name="DocName">
    <xs:restriction base="xs:string"/>
  </xs:simpleType>
  <xs:simpleType name="DocFunctionality">
    <xs:restriction base="xs:string"/>
  </xs:simpleType>
  <xs:complexType name="DocAspectList">
    <xs:sequence>
      <xs:element name="docAspectItem" type="DocAspectItem" maxOccurs="unbounded"/>
    </xs:sequence>
  </xs:complexType>
  <xs:simpleType name="DocAspectItem">
    <xs:restriction base="xs:string"/>
  </xs:simpleType>
  <!-- Elaboration of the class DocPersonActionDate -->
  <xs:complexType name="DocPersonActionDate">
    <xs:sequence>
      <xs:element name="docPersonActionDateItem" type="DocPersonActionDateItem"
maxOccurs="unbounded"/>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="DocPersonActionDateItem">
    <xs:sequence>
      <xs:element name="personGroup" type="PersonGroup" minOccurs="0"/>
    </xs:sequence>
  </xs:complexType>
</xs:schema>
```

```

        <xs:element name="organizationGroup" type="OrganizationGroup" minOccurs="0"/>
        <xs:element name="action" type="Action"/>
        <xs:element name="date" type="Date" minOccurs="0"/>
    </xs:sequence>
</xs:complexType>
<xs:complexType name="PersonGroup">
    <xs:sequence>
        <xs:element name="person" type="Person" maxOccurs="unbounded"/>
    </xs:sequence>
</xs:complexType>
<xs:complexType name="OrganizationGroup">
    <xs:sequence>
        <xs:element name="organization" type="Organization" maxOccurs="unbounded"/>
    </xs:sequence>
</xs:complexType>
<xs:complexType name="Person">
    <xs:sequence>
        <xs:element name="lastName" type="LastName"/>
        <xs:element name="middleName" type="MiddleName"/>
        <xs:element name="firstName" type="FirstName"/>
    </xs:sequence>
</xs:complexType>
<xs:simpleType name="Organization">
    <xs:restriction base="xs:string"/>
</xs:simpleType>
<xs:simpleType name="Action">
    <xs:restriction base="xs:string"/>
</xs:simpleType>
<xs:complexType name="Date">
    <xs:sequence>
        <xs:element name="year" type="xs:gYear" minOccurs="0"/>
        <xs:element name="month" type="xs:gMonth" minOccurs="0"/>
        <xs:element name="day" type="xs:gDay" minOccurs="0"/>
    </xs:sequence>
</xs:complexType>
<xs:simpleType name="LastName">
    <xs:restriction base="xs:string"/>
</xs:simpleType>
<xs:simpleType name="MiddleName">
    <xs:restriction base="xs:string"/>
</xs:simpleType>
<xs:simpleType name="FirstName">
    <xs:restriction base="xs:string"/>
</xs:simpleType>
<!-- coverage -->
<xs:complexType name="Coverage">
    <xs:sequence>
        <xs:element name="coverageName" type="CoverageName" minOccurs="0"/>
        <xs:element name="coverageRegion" type="CoverageRegion" minOccurs="0"/>
        <xs:element name="coverageCoordinateSet" type="CoverageCoordinateSet"
minOccurs="0"/>
    </xs:sequence>
</xs:complexType>
<xs:simpleType name="CoverageName">
    <xs:restriction base="xs:string"/>
</xs:simpleType>

```

```

<xs:complexType name="CoverageRegion">
  <xs:sequence>
    <xs:element name="country" type="Country" minOccurs="0"
maxOccurs="unbounded"/>
    <xs:element name="state" type="State" minOccurs="0" maxOccurs="unbounded"/>
    <xs:element name="county" type="County" minOccurs="0" maxOccurs="unbounded"/>
    <xs:element name="city" type="City" minOccurs="0" maxOccurs="unbounded"/>
    <xs:element name="neighborhood" type="Neighborhood" minOccurs="0"
maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
<xs:simpleType name="Country">
  <xs:restriction base="xs:string"/>
</xs:simpleType>
<xs:simpleType name="State">
  <xs:restriction base="xs:string"/>
</xs:simpleType>
<xs:simpleType name="County">
  <xs:restriction base="xs:string"/>
</xs:simpleType>
<xs:simpleType name="City">
  <xs:restriction base="xs:string"/>
</xs:simpleType>
<xs:simpleType name="Neighborhood">
  <xs:restriction base="xs:string"/>
</xs:simpleType>
<xs:complexType name="CoverageCoordinateSet">
  <xs:sequence>
    <xs:element name="coverageCoordinate" type="CoverageCoordinate" minOccurs="3"
maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="CoverageCoordinate">
  <xs:sequence>
    <xs:element name="covCoordinateX" type="xs:float"/>
    <xs:element name="covCoordinateY" type="xs:float"/>
  </xs:sequence>
</xs:complexType>
<!-- End of Coverage -->
<!-- Document Structure-->
<xs:complexType name="DocumentStructure">
  <xs:sequence>
    <xs:element name="topic" type="Topic" minOccurs="0" maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="Topic">
  <xs:sequence>
    <xs:element name="topicName" type="xs:string"/>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element name="agenda" type="Agenda" minOccurs="0"/>
      <xs:element name="design" type="Design" minOccurs="0"/>
      <xs:element name="strategy" type="Strategy" minOccurs="0"/>
      <xs:element name="vision" type="Vision" minOccurs="0"/>
      <xs:element name="policy" type="Policy" minOccurs="0"/>
      <xs:element name="goal" type="Goal" minOccurs="0"/>
      <xs:element name="issue" type="Issue" minOccurs="0"/>
    </xs:choice>
  </xs:sequence>
</xs:complexType>

```

```

        <xs:element name="criterion" type="Criterion" minOccurs="0"/>
        <xs:element name="other" type="Other" minOccurs="0"/>
    </xs:choice>
    <xs:element name="topic" type="Topic" minOccurs="0" maxOccurs="unbounded"/>
</xs:sequence>
<xs:attribute name="topicID" type="xs:ID" use="required"/>
</xs:complexType>
<!-- Elaboration of Agenda, Design, Strategy, Vision, Policy, Goal, Issue, Criterion, Other, and
ContentReference -->
<xs:complexType name="Agenda">
    <xs:complexContent>
        <xs:extension base="ContentReference"/>
    </xs:complexContent>
</xs:complexType>
<xs:complexType name="Design">
    <xs:complexContent>
        <xs:extension base="ContentReference"/>
    </xs:complexContent>
</xs:complexType>
<xs:complexType name="Strategy">
    <xs:complexContent>
        <xs:extension base="ContentReference"/>
    </xs:complexContent>
</xs:complexType>
<xs:complexType name="Vision">
    <xs:complexContent>
        <xs:extension base="ContentReference"/>
    </xs:complexContent>
</xs:complexType>
<xs:complexType name="Policy">
    <xs:complexContent>
        <xs:extension base="ContentReference"/>
    </xs:complexContent>
</xs:complexType>
<xs:complexType name="Goal">
    <xs:complexContent>
        <xs:extension base="ContentReference"/>
    </xs:complexContent>
</xs:complexType>
<xs:complexType name="Issue">
    <xs:complexContent>
        <xs:extension base="ContentReference"/>
    </xs:complexContent>
</xs:complexType>
<xs:complexType name="Criterion">
    <xs:complexContent>
        <xs:extension base="ContentReference"/>
    </xs:complexContent>
</xs:complexType>
<xs:complexType name="Other">
    <xs:complexContent>
        <xs:extension base="ContentReference"/>
    </xs:complexContent>
</xs:complexType>
<xs:complexType name="ContentReference">
    <xs:sequence>

```

```

        <xs:choice minOccurs="0" maxOccurs="unbounded">
            <xs:element name="text-Ref" type="Text-Ref" minOccurs="0"/>
            <xs:element name="singleGraphic-Ref" type="SingleGraphic-Ref"
minOccurs="0"/>
            <xs:element name="graphicGroup-Ref" type="GraphicGroup-Ref"
minOccurs="0"/>
        </xs:choice>
    </xs:sequence>
</xs:complexType>
<!-- xs:IDREF refers to "textID" -->
<xs:complexType name="Text-Ref">
    <xs:attribute name="textID" type="xs:IDREF" use="required"/>
</xs:complexType>
<!-- xs:IDREF refers to "graphicGroupID" -->
<xs:complexType name="GraphicGroup-Ref">
    <xs:attribute name="graphicGroupID" type="xs:IDREF" use="required"/>
</xs:complexType>
<!-- xs:IDREF refers to "graphicID" -->
<xs:complexType name="SingleGraphic-Ref">
    <xs:attribute name="graphicID" type="xs:IDREF" use="required"/>
</xs:complexType>
<!-- End of Elaboration of Agenda, Design, Strategy, Vision, Policy, Goal, Issue, Criterion, Other, and
ContentReference -->
<!-- Document Content -->
<xs:complexType name="DocumentContent">
    <xs:sequence>
        <xs:choice maxOccurs="unbounded">
            <xs:element name="text" type="Text" minOccurs="0"/>
            <xs:element name="singleGraphic" type="SingleGraphic" minOccurs="0"/>
            <xs:element name="graphicGroupMember" type="GraphicGroupMember"
minOccurs="0"/>
            <xs:element name="graphicGroup" type="GraphicGroup" minOccurs="0"/>
            <xs:element name="relationship" type="Relationship" minOccurs="0"/>
        </xs:choice>
    </xs:sequence>
</xs:complexType>
<!-- Elaboration of Text -->
<xs:complexType name="Text">
    <xs:all>
        <xs:element name="textContent" type="xs:string"/>
    </xs:all>
    <xs:attribute name="textID" type="xs:ID" use="required"/>
</xs:complexType>
<!-- End of Elaboration of Text -->
<!-- Elaboration of Single Graphic -->
<xs:complexType name="SingleGraphic">
    <xs:sequence>
        <xs:element name="graphicCategory" type="GraphicCategory"/>
        <xs:element name="title" type="Title" minOccurs="0"/>
        <xs:element name="description" type="Description" minOccurs="0"/>
        <xs:element name="representationMethod" type="RepresentationMethod"/>
        <xs:element name="effectiveness" type="Effectiveness"/>
        <xs:element name="coverage" type="Coverage" minOccurs="0"/>
        <xs:element name="specificPlanInformation" type="SpecificPlanInformation"/>
        <xs:element name="categorizedPlanInformation" type="CategorizedPlanInformation"/>
        <xs:element name="background" type="Background" minOccurs="0"/>
    </xs:sequence>
</xs:complexType>

```

```

        <xs:element name="indexDirectory" type="IndexDirectory" minOccurs="0"/>
        <xs:element name="legend" type="Legend" minOccurs="0"/>
        <xs:element name="annotation" type="Annotation" minOccurs="0"/>
        <xs:element name="textualItem" type="TextualItem" minOccurs="0"/>
        <xs:element name="path" type="Path"/>
    </xs:sequence>
    <xs:attribute name="graphicID" type="xs:ID" use="required"/>
    <xs:attribute name="planDocumentID" type="xs:IDREF" use="required"/>
</xs:complexType>
<!-- End of Elaboration of Single Graphic -->
<!-- graphic category -->
<xs:complexType name="GraphicCategory">
    <xs:all>
        <xs:element name="type" type="Type"/>
    </xs:all>
    <xs:attribute name="index" type="xs:boolean"/>
</xs:complexType>
<!-- type declarations -->
<xs:simpleType name="Type">
    <xs:restriction base="xs:string">
        <xs:enumeration value="Ground-level Image"/>
        <xs:enumeration value="Aerial-level Image"/>
        <xs:enumeration value="Graph"/>
        <xs:enumeration value="Table"/>
        <xs:enumeration value="Non-spatial Diagram"/>
        <xs:enumeration value="Spatial Diagram"/>
        <xs:enumeration value="Site Plan"/>
        <xs:enumeration value="Map"/>
    </xs:restriction>
</xs:simpleType>
<!-- End of Graphic Category -->
<!-- Title -->
<xs:simpleType name="Title">
    <xs:restriction base="xs:string"/>
</xs:simpleType>
<!-- End of Title -->
<!-- Description -->
<xs:simpleType name="Description">
    <xs:restriction base="xs:string"/>
</xs:simpleType>
<!-- End of Description -->
<!-- Representaton Method -->
<xs:simpleType name="RepresentationMethod">
    <xs:restriction base="xs:string">
        <xs:enumeration value="Elaborate: Fully Elaborate"/>
        <xs:enumeration value="Elaborate: Partially Elaborate"/>
        <xs:enumeration value="Demonstrate"/>
    </xs:restriction>
</xs:simpleType>
<!-- End of Representation Method -->
<!-- Specific Plan Information -->
<xs:simpleType name="SpecificPlanInformation">
    <xs:restriction base="xs:string"/>
</xs:simpleType>
<!-- End of Specific Plan Info -->
<!-- Categorized Plan Information -->

```

```

<xs:complexType name="CategorizedPlanInformation">
  <xs:sequence>
    <xs:element name="infoWithAspect" type="InfoWithAspect" minOccurs="0"
maxOccurs="unbounded"/>
    <xs:element name="infoWithoutAspect" type="InfoWOAspect" minOccurs="0"
maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="InfoWithAspect">
  <xs:sequence>
    <xs:element name="infoWA" type="InfoWA" minOccurs="0"/>
    <xs:element name="aspect" type="Aspect" minOccurs="0" maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
<xs:simpleType name="InfoWOAspect">
  <xs:restriction base="xs:string">
    <xs:enumeration value="Planning Process"/>
    <xs:enumeration value="Current Situation, Issue and Trend"/>
    <xs:enumeration value="Information Others"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="Aspect">
  <xs:restriction base="xs:string">
    <xs:enumeration value="Land Use"/>
    <xs:enumeration value="Transportation"/>
    <xs:enumeration value="Infrastructure"/>
    <xs:enumeration value="Environmental Preservation"/>
    <xs:enumeration value="Cultural Preservation"/>
    <xs:enumeration value="Aspect Others"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="InfoWA">
  <xs:restriction base="xs:string">
    <xs:enumeration value="Goals and Desired Future"/>
    <xs:enumeration value="Implementation"/>
  </xs:restriction>
</xs:simpleType>
<!-- End of Categorized Plan Info -->
<!-- Effectiveness -->
<xs:simpleType name="Effectiveness">
  <xs:restriction base="xs:string">
    <xs:enumeration value="high"/>
    <xs:enumeration value="low"/>
  </xs:restriction>
</xs:simpleType>
<!-- End of Effectiveness -->
<!-- background -->
<xs:complexType name="Background">
  <xs:all>
    <xs:element name="backgroundText" type="BackgroundText" minOccurs="0"/>
    <xs:element name="backgroundReference" type="BackgroundReference"
minOccurs="0"/>
  </xs:all>
</xs:complexType>
<xs:simpleType name="BackgroundText">
  <xs:restriction base="xs:string"/>

```



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</xs:simpleType>
<xs:complexType name="BackgroundReference">
  <xs:attribute name="textId" type="xs:IDREF" use="required"/>
</xs:complexType>
<!-- End of BackGround -->
<!-- Index Directory -->
<xs:complexType name="IndexDirectory">
  <xs:sequence>
    <xs:element name="indexDirectoryItem" type="IndexDirectoryItem"
maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="IndexDirectoryItem">
  <xs:all>
    <xs:element name="index" type="Index"/>
    <xs:element name="indexReference" type="IndexReference"/>
  </xs:all>
</xs:complexType>
<xs:simpleType name="Index">
  <xs:restriction base="xs:string"/>
</xs:simpleType>
<!-- indexReferenceId could be graphicID, graphicGroupID, textID, topicID, -->
<xs:complexType name="IndexReference">
  <xs:attribute name="indexType" type="IndexType" use="required"/>
  <xs:attribute name="indexReferenceId" type="xs:IDREF" use="required"/>
</xs:complexType>
<xs:simpleType name="IndexType">
  <xs:restriction base="xs:string">
    <xs:enumeration value="text"/>
    <xs:enumeration value="graphic"/>
    <xs:enumeration value="graphic group"/>
    <xs:enumeration value="topic"/>
  </xs:restriction>
</xs:simpleType>
<!-- End of Index Directory -->
<!-- legend -->
<xs:complexType name="Legend">
  <xs:sequence>
    <xs:element name="legendItemGroup" type="LegendItemGroup" minOccurs="0"
maxOccurs="unbounded"/>
    <xs:element name="legendItem" type="LegendItem" minOccurs="0"
maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="LegendItemGroup">
  <xs:sequence>
    <xs:element name="groupName" type="xs:string" minOccurs="0"/>
    <xs:element name="groupNote" type="xs:string" minOccurs="0"/>
    <xs:element name="legendItem" type="LegendItem" minOccurs="0"
maxOccurs="unbounded"/>
    <xs:element name="legendItemGroup" type="LegendItemGroup" minOccurs="0"
maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="LegendItem">
  <xs:sequence>

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        <xs:element name="itemName" type="xs:string"/>
        <xs:element name="itemNote" type="xs:string" minOccurs="0"/>
    </xs:sequence>
</xs:complexType>
<!-- End of Legend -->
<!-- annotation -->
<xs:complexType name="Annotation">
    <xs:sequence>
        <xs:element name="annotationItem" type="AnnotationItem" maxOccurs="unbounded"/>
    </xs:sequence>
</xs:complexType>
<xs:complexType name="AnnotationItem">
    <xs:sequence>
        <xs:element name="locationIdentifier" type="xs:string" minOccurs="0"/>
        <xs:element name="annotationInfo" type="xs:string"/>
    </xs:sequence>
</xs:complexType>
<!-- End of Annotation -->
<!-- Textual Item -->
<xs:complexType name="TextualItem">
    <xs:sequence>
        <xs:element name="textualEntry" type="TextualEntry" maxOccurs="unbounded"/>
    </xs:sequence>
</xs:complexType>
<xs:complexType name="TextualEntry">
    <xs:sequence>
        <xs:element name="texEntry" type="xs:string"/>
        <xs:element name="textualEntry" type="TextualEntry" minOccurs="0"
maxOccurs="unbounded"/>
    </xs:sequence>
</xs:complexType>
<!-- End of Textual Item -->
<!-- Path -->
<xs:simpleType name="Path">
    <xs:restriction base="xs:anyURI"/>
</xs:simpleType>
<!-- End of Path -->
<!-- graphic group -->
<xs:complexType name="GraphicGroup">
    <xs:sequence>
        <xs:element name="graphicGroupAttributes" type="GraphicGroupAttributes"/>
        <xs:element name="graphicMember-Ref" type="GraphicMember-Ref" minOccurs="2"
maxOccurs="unbounded"/>
        <xs:element name="graphicMemberRelationship" type="GraphicMemberRelationship"/>
    </xs:sequence>
    <xs:attribute name="graphicGroupID" type="xs:ID" use="required"/>
    <xs:attribute name="planDocumentID" type="xs:IDREF" use="required"/>
</xs:complexType>
<!-- xs:IDREF refers to "graphicGroupMemberID" -->
<xs:complexType name="GraphicMember-Ref">
    <xs:attribute name="graphicMember" type="xs:IDREF" use="required"/>
</xs:complexType>
<xs:simpleType name="GraphicMemberRelationship">
    <xs:restriction base="xs:string">
        <xs:enumeration value="Multiples-design Relationship"/>
        <xs:enumeration value="Coordinative Relationship"/>
    </xs:restriction>
</xs:simpleType>

```

```

        </xs:restriction>
    </xs:simpleType>
    <!-- End of Graphic Group -->
    <!-- Graphic Group Attribute -->
    <xs:complexType name="GraphicGroupAttributes">
        <xs:sequence>
            <xs:element name="title" type="Title" minOccurs="0"/>
            <xs:element name="description" type="Description" minOccurs="0"/>
            <xs:element name="representationMethod" type="RepresentationMethod"/>
            <xs:element name="specificPlanInformation" type="SpecificPlanInformation"/>
            <xs:element name="categorizedPlanInformation" type="CategorizedPlanInformation"/>
            <xs:element name="background" type="Background" minOccurs="0"/>
            <xs:element name="path" type="Path"/>
        </xs:sequence>
    </xs:complexType>
    <!-- End of Graphic Group Attribute -->
    <!-- graphic group member -->
    <xs:complexType name="GraphicGroupMember">
        <xs:sequence>
            <xs:element name="graphicCategory" type="GraphicCategory"/>
            <xs:element name="title" type="Title" minOccurs="0"/>
            <xs:element name="description" type="Description" minOccurs="0"/>
            <xs:element name="representationMethod" type="RepresentationMethod"
minOccurs="0"/>
            <xs:element name="specificPlanInformation" type="SpecificPlanInformation"
minOccurs="0"/>
            <xs:element name="categorizedPlanInformation" type="CategorizedPlanInformation"
minOccurs="0"/>
            <xs:element name="coverage" type="Coverage" minOccurs="0"/>
            <xs:element name="background" type="Background" minOccurs="0"/>
            <xs:element name="legend" type="Legend" minOccurs="0"/>
            <xs:element name="annotation" type="Annotation" minOccurs="0"/>
            <xs:element name="textualItem" type="TextualItem" minOccurs="0"/>
            <xs:element name="path" type="Path"/>
        </xs:sequence>
        <xs:attribute name="graphicGroupMemberID" type="xs:ID" use="required"/>
    </xs:complexType>
    <!-- End of Graphic Group Member -->
    <!-- Relationship -->
    <xs:complexType name="Relationship">
        <xs:sequence>
            <xs:choice minOccurs="0" maxOccurs="unbounded">
                <xs:element name="textAndText" type="TextAndText" minOccurs="0"/>
                <xs:element name="singleGraphicAndSingleGraphic"
type="SingleGraphicAndSingleGraphic" minOccurs="0"/>
                <xs:element name="singleGraphicAndText" type="SingleGraphicAndText"
minOccurs="0"/>
                <xs:element name="graphicGroupAndText" type="GraphicGroupAndText"
minOccurs="0"/>
            </xs:choice>
        </xs:sequence>
    </xs:complexType>
    <!-- End of Relationship -->
    <!-- Relationship among Texts-->
    <xs:complexType name="TextAndText">
        <xs:all>

```

```

        <xs:element name="textARef" type="Text-Ref"/>
        <xs:element name="textBRef" type="Text-Ref"/>
    </xs:all>
    <xs:attribute name="textAndTextID" type="xs:ID" use="required"/>
</xs:complexType>
<!-- Relationship among Graphics -->
<xs:complexType name="SingleGraphicAndSingleGraphic">
    <xs:sequence>
        <xs:element name="graphicARef" type="SingleGraphic-Ref"/>
        <xs:element name="graphicBRef" type="SingleGraphic-Ref"/>
        <xs:element name="GGrelationship" type="GGRelationship"/>
    </xs:sequence>
    <xs:attribute name="graphicAndGraphicID" type="xs:ID" use="required"/>
</xs:complexType>
<xs:complexType name="GGRelationship">
    <xs:choice>
        <xs:element name="GGnondirecRela" type="GGNondirecRelationship"/>
        <xs:element name="GGdirecRela" type="GGDirecRelationship"/>
    </xs:choice>
</xs:complexType>
<xs:simpleType name="GGNondirecRelationship">
    <xs:restriction base="xs:string">
        <xs:enumeration value="Adjacency"/>
        <xs:enumeration value="Other"/></xs:enumeration>
    </xs:restriction>
</xs:simpleType>
<xs:simpleType name="GGDirecRelationship">
    <xs:restriction base="xs:string">
        <xs:enumeration value="ZoomIn"/>
        <xs:enumeration value="WholePart"/>
        <xs:enumeration value="SemanticReference"/>
        <xs:enumeration value="Other"/></xs:enumeration>
    </xs:restriction>
</xs:simpleType>
<!-- graphic and text relationship -->
<xs:complexType name="SingleGraphicAndText">
    <xs:sequence>
        <xs:element name="graphicARef" type="SingleGraphic-Ref"/>
        <xs:element name="textBRef" type="Text-Ref"/>
        <xs:element name="GTrelationship" type="GTRelationship"/>
    </xs:sequence>
    <xs:attribute name="graphicAndTextID" type="xs:ID" use="required"/>
</xs:complexType>
<xs:complexType name="GTRelationship">
    <xs:choice>
        <xs:element name="GTnondirecRela" type="GTNondirecRelationship"/>
        <xs:element name="GTdirecRela" type="GTDirecRelationship"/>
    </xs:choice>
</xs:complexType>
<xs:simpleType name="GTNondirecRelationship">
    <xs:restriction base="xs:string">
        <xs:enumeration value="semanticComplementarity"/>
        <xs:enumeration value="other"/>
    </xs:restriction>
</xs:simpleType>
<xs:complexType name="GTDirecRelationship">

```

```

    <xs:choice>
      <xs:element name="exemplarIllustration" type="xs:string"/>
      <xs:element name="keywordDefining" type="KeywordDefining"/>
      <xs:element name="semanticExtendedness" type="xs:string"/>
      <xs:element name="other" type="xs:string"/>
    </xs:choice>
  </xs:complexType>
  <xs:complexType name="KeywordDefining">
    <xs:sequence maxOccurs="unbounded">
      <xs:element name="keyword" type="xs:string"/>
    </xs:sequence>
  </xs:complexType>
  <!-- graphic group and text relationship -->
  <xs:complexType name="GraphicGroupAndText">
    <xs:all>
      <xs:element name="graphicGroupARef" type="GraphicGroup-Ref"/>
      <xs:element name="textBRef" type="Text-Ref"/>
    </xs:all>
    <xs:attribute name="graphicGroupAndTextID" type="xs:ID" use="required"/>
  </xs:complexType>
</xs:schema>

```

Appendix C: Sorting Rules for Single Graphics and Graphic Groups

The default sorting rules of single graphics are as follows. The rules are applied in nested fashion, sorting first by rule 1, then by rule 2, and so on.

- 5) If value of the “effectiveness” is “high”, then the graphic is listed before others with “effectiveness” rated “low”.
- 6) If inputted keywords lie in the element “specificPlanInformation”, then the graphic is listed before others.
- 7) Next, graphics are sorted by a predefined order of values of the “Categorized Plan Info”.
The order is
 - f) “Goals and Desired Future”
 - g) “Implementation”
 - h) “Planning Process”
 - i) “Current Situation, Issue and Trend”
 - j) “Other”
- 8) For each value of “categorizedPlanInfo”, the graphics in “significant” types are listed before others. Table C.1 shows significant graphic types for each type of plan information.

Categorized Plan Information	“Significant” Graphic Types
Goals and Desired Future	Map Aerial-level Image
Implementation	Map Non-spatial Diagram Site Plan
Planning Process	Non-spatial Diagram
Current situation, issue and trend	Map
Other	Map Non-spatial Diagram

Table C.1 “Significant” graphic types for each type of plan information

The manual sorting rules for single graphics are as follows.

Manual Sorting Rules for Single Graphics				
Graphic Type	Index Graphic	Representation Method	Categorized Plan Info	Effectiveness
1. Map <i>(alphabet order below)</i> 2. Aerial-level Image 3. Graph 4. Ground-level Image 5. Non-spatial Diagram 6. Site Plan 7. Spatial Diagram 8. Table	3. True 4. False	4. Fully Elaborate 5. Partial Elaborate 6. Demonstrate	6. Goals and Desired Future 7. Implementation 8. Planning Process 9. Current Situation, Issue and Trend 10. Other	1. High 2. Low

Table C.2 Manual sorting rules for single graphics

Unlike single graphics, graphic groups don't have default sorting rules in the current version. The manual sorting rules for graphic groups are as follows.

Manual Sorting Rules for Graphic Groups	
Representation Method	Categorized Plan Info
4. Fully Elaborate 5. Partial Elaborate 6. Demonstrate	6. Goals and Desired Future 7. Implementation 8. Planning Process 9. Current Situation, Issue and Trend 10. Other

Table C.3 Manual sorting rules for graphic groups