Planning Markup Language: Representing the Meanings of Plans and Regulations

Lewis D. Hopkins, Nikhil Kaza, and R. Varkki George Pallathucheril

University of Illinois at Urbana-Champaign

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Abstract

Access to many sources of data and information is essential to supporting the use and making of plans for urban development. This information includes plans and regulations of many different players, both private sector and public agencies. It includes the data inputs and analytical outputs of planning analysis models. In order to take advantage of current information technology, web-based access will be particularly effective. To achieve this kind of wide access will require a reference data model for the contents and meaning of plans and regulations and an implementation of this data model in web compatible form such as XML. This paper presents an initial version of such a data model, use cases that set the scope of such a data model, and the beginnings of an XML implementation, a Planning Markup Language.

When deliberating and making urban development decisions in a world in which authority and influence are distributed, it is essential to be able to access information from many sources. These sources include formal and informal models of how the world works, forecasts, plans, and regulations. In making decisions or shaping the focus of attention in community charettes, planning commission meetings, and expert collaborations, participants should be able to access the content of many different plans made by different agencies at different times, including “plans in the making”. Plan making—decision making focused on combinations of decisions over time and space—requires representations within which ideas can be created, communicated, and tested. When modeling urban development for forecasting scenarios contingent on possible actions, using more than one model increases the scope of analysis and enables consideration of contending views of what is important and how the world works. A shared data model—a common reference schema for data access—will enable access to these many information sources. This data model should encompass representation of the phenomena of urban development, the phenomena of plans and regulations, and the manipulation of these phenomena when using and making plans.

Developing such a data model will require concerted, long-term effort by many active users who will generate ideas and test them. This paper describes an initial version of such a data model for urban development planning. First, we explain what such a data model might accomplish based on precedents in other fields and in planning and how such a data model can be implemented using XML to create a Planning Markup Language or PML. Second, we identify three specific application tasks as “use cases” to test the scope and capabilities of versions of the data model. Third, we describe and explain the current version of an evolving data model. Fourth, we present specific instances of the application tasks to illustrate the scope of the current data model. Finally, we conclude by identifying next steps in building on this work.

Ideas to Build On

The development of a Planning Markup Language builds on four threads of previous work: the logic of making and using plans, planning support systems, geographic information science, and urban development modeling and forecasting. All of these threads are couched within the contemporary perspective of urban planning as collaborative activity in a world of distributed authority and influence.

The Logic of Using and Making Plans. Hopkins (2001) argues that there are several different ways in which plans work, that each of these is distinct from ideas of regulation, collective action, and collective choice, and that all of these concepts are important in expressing the meanings and content of plans and regulations. In practice, many plans are made by many agencies. They are made with different functional, geographic, and organizational scopes and at different times. Many different decision situations arise, most of which can benefit from access to the information in many of these plans, not just from one plan of one particular organization. But just being able to get these plans and information would be information overload. We need a way to represent the content of plans, the meaning, so that indexes and search tools can find and display the information that is likely to matter in particular situations. We are using the concepts of agenda, policy, vision, design, and strategy as ways in which plans work, and the concepts of interdependence, irreversibility, indivisibility, and imperfect foresight as underlying relationships that make plans useful.

Other precedents for this work include research on the language of planning by Guttenberg (1993), which was originally published in the 1960s and the strategic choice approach as described in Friend and Hickling (1987), also derived from work initiated in the 1960s. The former considers the language needed to describe plans and land use and the latter describes languages for thinking about and developing plans. Alexander's rules based systems (Alexander, 1964; Alexander, 1966; Alexander, Ishikawa, and Silverstein, 1977) provide precedents for both the data model and its emergence from collaborative work.

Planning Support Systems. Planning Support Systems (PSS) are tools and techniques to enhance the effectiveness of planning through information technologies. Ironically perhaps, most PSS work, as presented for example in Brail and Klosterman (2001), focuses on the task of making plans rather than on the tasks of using plans. The activity of making plans is infrequent, dispersed, idiosyncratic, and highly unstructured in practice despite codified procedures in textbooks such as Kaiser, Godschalk, and Chapin (1995). Making plans is, however, amenable to claims of support through providing separate, well-defined tools for forecasting or accounting for land use change. The activity of using plans, on the other hand, is frequent (arguably ubiquitous) and in many cases is carried out within the semi-structured deliberations of planning boards, community meetings, city council meetings, or court proceedings. From conventional arguments that computer enhanced support systems are most likely to be valuable in repetitive, incompletely-structured situations, PSS are perhaps more likely to be successful if they support planners, legislators, and citizens in using plans in deliberative decision making rather than in making plans.

Although there are many computing tools and models that might be used to support planning, none of them at present can be used in combinations sufficient to gain significant use in the open-ended situations faced in practice (Brail and Klosterman, 2001). Although PSS focused on collaboration have been developed (Shiffer, 1992; Armstrong, 1994; Shiffer, 1995; Jankowski, Nyerges, Smith et al., 1997; Jankowski and Nyerges, 2001), these systems also face the problem of accessing information beyond that specifically built into the systems by their developers for specific clients.

Hopkins (1999) sets out a framework from which a data model for planning support systems might be developed. A crucial aspect of this framework is that the data model should include the phenomena of plans, plan making, and plan using as well as the phenomena of urban development about which plans are being made. Although many aspects of the latter are closely related to geographic features as developed in geographic information science, aspects of the former are fundamentally different. Working from the geographic information science perspective, Couclelis (1991) and Worboys (1994) identified key concepts of situation versus site and time, contingency, and expectations, which will be central in representing plans. Laurini (2001) reviews data models currently used in planning support systems.

The basic purpose of a Planning Markup Language is highlighted in the system architecture diagram in Figure 1. The three major tiers in this diagram are 1) the input and output mechanisms, 2) the servers to support visualization, collaboration, and modeling tools, and 3) the data and information sources. The thick connecting lines show that PML is the means of communicating among the tool servers and data sources. In practice, we should not assume that we could achieve complete PML compliance, so some data sources that are not PML compliant will require an encoder or reference schema. This system architecture could support the three applications (use cases) described in the next section.

This basic system architecture enables us to go beyond the single source, single purpose, single tool limitations of current planning support systems (see e. g., Brail and Klosterman, 2001). It enables us instead to create web interfaces as workspaces—CollaborationSpaces—in which participants can use the many tools and information sources available (Hopkins, Johnston, and George, 1999; Hopkins, 2001; Hopkins, Ramanathan, and George, 2001). To realize this potential, however, we need to devise and implement a common data model that will enable relatively easy encoding and accessing of these types of information. Such a data model must be sufficiently open that most plans and regulations can be successfully encoded and must have sufficient acceptance that most plans and regulations will be encoded.

Geographic Information Science. What geographic information systems are able to do now rests on a long history of fundamental intellectual developments (see e.g.Chrisman, 1997; Longley, Goodchild, Maguire et al., 2001). One version might start with Berry (1964) codifying geographic phenomena in time and space, include the idea of topological data structures (Peucker and Chrisman, 1975), and move on to more recent object oriented models (Worboys, 1994; Worboys, 1995; Zeiler, 1999).

The OpenGIS Consortium has developed a reference data model for geographic information, which is described in detail at http://www.opengis.org/info/orm/03-040.pdf. This data model has been expressed in XML to create a Geography Markup Language or GML, schema specifications for which are given at http://www.opengis.org/techno/documents/02-023r4.pdf. The widely accepted data model and the Geography Markup Language (GML) as a means for implementing it on the web (Lake, 2000) are just now enabling the kind of wide accessibility for geographic data that we might eventually achieve for planning information with a Planning Markup Language.

XML (eXtensible Markup Language) is used to represent data in a meaningful fashion by attaching specifically defined tags. As a text representation of data, GML defines a set of mark up tags to describe geometry. XML was developed primarily for transporting data over the internet and separating its content from its presentation, unlike HTML. XML was created to structure, store, and transport information, not to process it. As Lake (2000) emphasizes, GML is a text representation consistent with OpenGIS Consortium's model for geometry and the W3 Consortium standards for XML. The proposed Planning Markup Language will be expressed in XML and can thus directly incorporate GML schema specifying geographic entities or geographic aspects associated with other entities. There is no need to recreate these capabilities, which are useful in but not sufficient for a Planning Markup Language.

Urban Modeling and Forecasting. Deliberations and decisions about urban development should be able to access various analytical models of urban development processes and forecasting. The data model, therefore, should include within its scope the representation of inputs and outputs from such models and, ideally, many of the internal variables so that plans and regulations can be embedded in the processes represented in the model. Many of the data entities in these models are also necessary to describe plans and regulations. For this reason, we focus first on urban development models such as UrbanSim (http://www.urbansim.org/) and LEAM (http://www.rehearsal.uiuc.edu/projects/leam/). UrbanSim is a combination of models that forecast urban growth, land use, and transportation. It is object oriented and thus immediately amenable to comparison with a reference data model of a Planning Markup Language. LEAM relies on a cell based differential equation models. Other models are described in (Brail and Klosterman, 2001). Eventually the scope of a planning data model could include regional economic forecasting models, demographic forecasting models, and urban development models. Modeling of ecological systems should also be included within the scope of a PML, but we have set this aspect aside for the moment. Building on other work on modeling ecological systems (e.g., Westervelt, 2001; Deal and Hannon, Forthcoming), PML could expand to include such models. PML compliant inputs and outputs will make it possible to use several models by linking them or by comparing their results.

Use Cases: Using Plans, Making Plans, and Modeling Urban Development

The current planning data model is built to support three closely related tasks: using plans, making plans, and modeling urban development. Explanations of each demonstrate the relationships among them and frame the implied scope of a PML based on the data model. Staff planners use plans when consulting with those proposing a development project and developing a staff recommendation. Planning commissioners use plans when deliberating as a commission and voting on a recommendation to the city council. Making plans is in some ways similar to any other decision situation and thus has the characteristics just described for using plans. Crucially, however, plans involve multiple actions and decisions, and thus require means for representing "plans in the making" as more complex than a single decision. To evaluate alternative actions or discover the implications of an action for evolution of a human settlement system, we need to use some model, some abstracted representation, of the system. Each of these use cases is presented here as a story.

Using Plans. A landowner and a developer who has acquired an option on the land propose a mixed use development in an area currently zoned for residential. Having noted that the current comprehensive plan sets compact development and reduced auto use as goals, and that recent planning commission discussions have considered mixed use as a strategy, they consult informally with planning staff about the potential for rezoning (or perhaps handling under special provisions such as Planned Unit Development or Special Use provision). Planning staff consider the comprehensive plan, a recent neighborhood plan that identifies densification and lack of retail services as an issue, a Mass Transit District proposal for increased service in this area, and a University plan to acquire additional land south of the neighborhood preventing further development in that direction. After informal neighborhood meetings by the developer and planning staff, staff develops a recommendation to the planning commission for approval of a modified form of the proposal. The planning commission holds a public hearing at which neighbors and the developer refer to all these plans and others, as well as to the zoning and subdivision ordinance and the capital improvements program to argue their views. The planning commission considers all of this in its deliberation, and makes a decision to recommend to the council a further modified version of the proposal.

Similar plan use examples include deliberations about a capital improvements program within the budget and public works departments, planning commission, and city council; deliberations by the Mass Transit District about an investment in fixed guideway transit; and deliberations by the designated Metropolitan Planning Organization about transportation projects. The last carries over to the task of making plans because it usually involves many interrelated projects, which are interdependent, irreversible, indivisible, and face imperfect foresight and thus decisions about these projects constitute plans (Hopkins, 2001).

Making Plans. Outlying residents express increasing concern about directions of future development. Many retail activities and the associated tax revenue have recently moved to locations in an adjacent city. New interest from developers in major projects is apparent in recent land acquisitions. The city staff recognizes that although they have made several area plans recently, these plans are inadequate to address the issues and decisions arising in the current situation. They initiate a work program for a major revision of the comprehensive plan. This work program includes creation of a citizens steering committee, a round of neighborhood meetings, a round of technical focus group meetings, frequent reporting to the planning commission and the city council on the status of the work, and eventually deliberation, public hearings, and a planning commission recommendation on a plan. Another view of this process is that it creates and sustains an evolving set of planning issues, goals, ideas, and evaluative criteria, which are discussed in light of an evolving set of pertinent data organized from existing sources or collected to respond to particular questions. The staff keeps track of converging and contradictory ideas and evaluations of these ideas so that plans eventually emerge and are catalogued for use.

Similar plan making examples arise from state mandates to make plans of particular kinds with particular frequency, Federal requirements for transportation planning and related land use, a project proposal for a site that begged a revised area plan for its neighborhood, a lack of capacity in sanitary waste treatment that forced a plan for plant expansion, and concern about a neighborhood "in transition" that led to city council members requesting a neighborhood plan to satisfy constituents. The diverse scopes of these situations require modeling of human settlements that encompasses a similar scope of actors, activities, and facilities.

Modeling Human Settlements. In the above stories about using and making plans, it is essential to be able to describe proposals, consider how each fits into the current and evolving situation, and keep track of multiple evaluations of each. We put models to work to accomplish these tasks. The developer uses a model of predicted demand for particular uses and configurations of these uses as well as a model of costs of development. The neighbors, implicitly at least, use models of property value change, local revenue generation, and service cost predictions. The city or special districts use models of traffic, revenue generation, services costs, sanitary waste capacity, runoff and drainage, and school capacity. The Metropolitan Planning Organization (MPO) uses transportation network models in relation to land use. All these model users are trying to understand how variables of interest to them might change with or without a proposed project or regulation.

Similar model using examples occur when an MPO makes a transportation plan, a city devises a neighborhood rejuvenation plan, a mass transit district reroutes or adds bus lines, a sanitary district decides when and where to build a plant of what size, a state agency assesses habitat fragmentation, or a regional agency develops a water quality plan. To relate these models to the fundamental question of how the world will evolve with or without a proposed action, the models must be able to communicate in a common way with a representation of the proposal as input and the concerns as output. Ideally, in order to sustain deliberations, I should be able to run my model to address your concerns and you should be able to run your model to address my concerns.

The current version is based on these three use cases: using plans, making plans, and modeling consequences of actions. Using plans requires representing the content of plans in relation to decisions that can be made so as to choose among alternatives in light of expected consequences. Making plans requires representing ideas that may become components of plans and the manipulations of these ideas through which plans emerge. System modeling requires representation of pertinent aspects of states of the world, including dynamic states of predictable change. Many of the data model entities to support these three use cases are common across all three.

A Planning Data Model

The current version of the data model is presented in three levels of detail with associated definitions and examples. The first level describes the relationships among entities representing the world, entities representing changes in that world, and entities representing plans. Figure 2 shows the underlying idea: a state of the world, planning about actions and actions that change that state, and another state of the world as a consequence of those actions. The actions and thus the consequences might be hypothetical, as in devising scenarios when making plans. Or, the actions and consequences might be realized, as in monitoring the evolving state of the world.

Figure 3 uses icons and Figure 4 uses UML diagramming (Booch, Rumbaugh, and Jacobson, 1999) to identify the same abstract object classes and their relationships. These diagrams simplify the entities and relationships in order to emphasize the overall structure. In terms of Figure 2, the entire system described in Figures 3 and 4 is a state of the world and the approximately the right half of Figures 3 and 4 describes planning and actions. That is, planning and action are embedded in states of the world and change states of the world.

First we define the entities in Figures 3 and 4 and then elaborate further each of the major entities. Entity labels are in different typeface to distinguish them: **Actors**. **Actors** include **persons**, **organizations**, or **populations** of persons or organizations. Any individual is a **person**, who may have multiple roles as elaborated later. A group of persons organized in roles, responsibilities, and decision rules is an **organization**. So, for examples, households, firms (in the economic sense), neighborhood groups, government agencies; and city councils are **organizations**. **Populations** are collections of actors without organizational structure, such as the population of persons in a census tract or the population of firms in a municipality. **Assets** include buildings, networks (such as streets), and designated areas such as land zoned industrial. **Investments** change the state of **assets**, creating, destroying, expanding, or contracting them. **Actors** "do" **activities** such as residing, producing, or recreating in or on **assets**. **Activities** are one way of defining land uses to be allocated in space. **Actors** have c**apabilities**, including **preferences**, **authorities** or **rights**, **skills**, **financial capacity**, and **behavioral norms**. **Learning**, **regulation**, and **transactions** change **capabilities** of **actors**. **Plans** are primarily about **investments** (changing assets) and changing **capabilities**. **Actors** make plans, perceive particular **issues**, make proposals for **action**, and have **authority** and **influence** in **decision situations**. **Decision situations** use **plans**, confront **issues** and **alternatives**, and result in **decision**s for **action**.

Note that these object classes can be used to describe states of the world, the content of plans, and the decision situations in which plans are used. The current state of urban development can be described with these entities, including dynamic descriptions of current trends or mechanisms of change. These descriptions can be data about reality or states as expressed in urban development models. Ideas for plans, such as changes in buildings, land use activities, transportation capacities can be described and as plans are being made and recorded so that plans can be used. These object classes are elaborated in the following diagrams.

Figure 5 elaborates the description of **Actors** as **Persons**, **Organizations**, and **Populations**. **Actors** have **Roles** and many of the **capabilities** of **Actors** are associated with **Roles** rather than directly with **Actors**. For example, the **Authority** of a mayor goes with the **Role**, not the **Person**. Also **Roles** can exist without an **Actor** associated with them, so that the **authority** of a Mayor is defined regardless of the **Person** holding the office, but the influence a particular mayor may have depend both on the **Role** and the **Person**. Similarly an **Actor** can have multiple **roles** whose combination will determine the set of **capabilities** the **actor** possesses. **Organizations** are groups of persons with a particular structure of roles and capabilities associated with those **roles**. **Populations** by contrast are actors or roles that are grouped for descriptive purposes, and have at least one common attribute, space and time chief among them. **Populations** can be of **persons**, of **organizations**, of **roles**, or of **populations** themselves. **Actors** have **capabilities** either directly as **actors** or through the **roles** they play. These **capabilities** include **authority** (e. g. Ownership), **influence** (e.g. major donor to political campaign of mayor), **knowledge** (e.g. awareness of neighborhood issues), **skill** (e. g. technical competence in financial analysis), and **resources** (e. g. Access to finances).

Figure 6 elaborates the description of **Assets**. Assets can be **Facilities**, **Equipment**, **Consumables** or **Intangible**. **Facilities** are Physical objects such as building **Structures** or **Networks** such as streets. They can also be Virtual Networks such as microwave networks or **Designated Areas** such as land zoned for development or protected habitats. **Assets** are related to other **assets**. For example, **equipment** may be assigned to a particular **facility**. Land or water in a river could be defined as an **asset** from which resources are used. Buildings could be located on a site or a dam on a river at a location at a time or for a period of time. **Actors** in their roles can own, lease, hold government **jurisdiction** over, have maintenance **responsibility** for, or have other use **rights** in **Assets**.

Figure 7 elaborates **Actions**. **Actions**, not be confused with **Activities**, change **Assets** themselves or their relationships to **Activities** or **Actors**. **Actions** are central to the planning domain and include **decisions** and **realized actions**. **Decisions** are commitments to **actions** that have not yet been realized. Thus a **decision** by a city council to invest in a road project is distinct from the realization of that road project on the ground. **Decisions** and **realized actions** include **regulations**, **investments** and **transactions**. **Actions** can also **change capabilities** of Actors and include **changing rights** and **responsibilities**. It is useful to distinguish between **realized actions** and **decisions** as commitment to **actions**, because responses to **actions** by other actors may be based on **decisions** or **expected actions** before an **action** is realized. **Actions** have consequences either realized or expected, which are generally distributed over space as well as time.

Activities occur on **Assets** and are performed by **Actors**. Traffic flow on a street network (commuting), shopping by a **Person**, and retail services in a building are **activities**. **Activities** are different from **actions** in that activities describe aggregates of behaviors that are not fundamental changes to the system of **Assets** and **Capabilities** and for which **Decisions** to Act are not explicit. **Activities** are also constrained by **capabilities** of **actors** but it might not always be possible to identify a one to one relationship between **activities** and **actors**. **Activities** may be considered loosely coupled with the notion of **actors**. An **Activity** may have effects on **Assets**, notably depreciation. **Activities** are also subject to capacity constraints and congestion relative to **Assets**.

Figure 8 elaborates **Decision Situations**. **Decision Situations** consist of **Authorities**, **Influences**, **Issues**, **Alternative Actions**, and **Plans** all of which are associated with **Roles** and **Actors**. These concepts in combination set the nature of a particular Decision Situation. In particular, **Authority** defines who has what authority to make or participate in making decisions about what **Assets**, **Activities**, **Actors**, **Plans**, **Regulations**, and so on.

Figure 9 elaborates Plans as composed of **Visions**, **Agendas**, **Policies**, **Designs**, and Strategies. Each of these defines a particular kind of relationship among **Actions** and among **Actions** and Consequences in a Plan: expected Consequences, lists of **Actions**, if-then conditions for **Actions**, interdependence among **Action**s with respect to Consequences, and decision tree contingencies among **Actions** and Consequences. Some elements of plans may be represented in more than one way. For example, particular Investments in roads might be represented as an **Agenda** in a capital improvements program and as a **Design** for a Network in a transportation plan. Plans also incorporate **indicators**, including **issues**, **goals**, and **criteria**, which serve to assess consequences. A **Strategy** might be expressed in relation to **goals** that are responsive to **issues** and measured by **criteria**. Each of these concepts can be elaborated further based on Hopkins (2001).

Agenda. An **Agenda** is a list of **Actions** to be performed by **Actors**. The list itself has no internal relationships; it is unordered. However, items in an Agenda may have attributes that could create order, such as date of completion or a priority rank. Agendas could also account for constraints, such as cumulative costs relative to a budget constraint.

Policy: A **Policy** is an If-Then statement, which is applied repeatedly given a situation. The given situation (the If clause) could be about attributes of **states of the world**, **Action** by an **Actor**, or a collection of these. The policy to be applied (the Then clause) also depends on **capabilities** of the policy following **Actor**. The "then" statement is taken by the **actor** to whom the policy applies, who may be different from the **actor** who created the **policy**.

Strategy: A decision tree can be construed as a **strategy**. **Strategy** involves uncertain outcomes and contingent **actions**. The initial node of the **strategy** is an **action** contemplated by the **actor**. Because of uncertainty of expected consequences of the **action**, planning would necessarily involve considering various unrealized but possible consequences. At a decision node the actor can list a choice of **actions** that will be available to be taken and the uncertain consequences for each of those choices. A preferred choice of action based on a preferred expected consequences from each decision node should be identified based on **issues**, **goals**, and **criteria**. It should, however, be noted that listing all possible outcomes is unrealistic and hence a strategy is always incomplete at best.

Design: Unlike the other aspects of plans, **design** is a curious collection of amorphous relationships among **actors**, **actions**, **assets**, **activities** and the **relationships** that bind them. Hence, design could be considered a collection of **meta-relationships**. Design for urban systems is not elaborated as a situation that needs to be solved, but as a solution that has already been worked out. **Designs** could be about **actions** of **actors** or **expected outcomes** of those **actions**. Alexander's work in pattern languages provides on basis for defining designs(Alexander, Ishikawa, and Silverstein, 1977). Rowe (1991) has argued that design has to be cognizant about relationships between entities that are not physical.

Building upon these arguments we can classify the **relationships** between **action** and their outcomes into three types, **spatial**, **temporal** and **functional**. A proximity relationship between schools and residential land use is a **spatial relationship**. Adjacency is also another example of a **spatial relationship**. A construction management plan for highway project is a design primarily consisting of **temporal relationships** about **actions**. Temporal relationships can include collections of sequences of actions or outcomes that are, or need to be, realized. **Functional relationships** could be about interdependent outcomes or actions. Compatibility of activity is a functional relationship. A transit-oriented design would include relationships of travel and wait time to the density of population it serves and the extent of service. A bubble diagram of circulation corridors and functional spaces is a design representation of a set of **functional relationships**.

Vision: **Vision** is an idea of where one would like to be. It serves as motivation and a guiding principle for making decisions. Are the expected consequences of a **Decision** consistent with the **vision**? It is a collection of formal or figural statements about the idea of an envisioned scenario.

Issues, Goals, and Criteria are all Indicators of the state of the world, generally in relation to the perspective of particular actors. The intent of **Agendas**, **visions**, **policies**, **designs** and **strategies** can be expressed in relation to these indicators.

Issues: **Issues** are about the difference between desirable states of the world and perceived existing states of the world. It is imperative to note that perception is individual and hence **issues** are strongly linked to actors. Issues cannot exist without existing for at least one **actor**. As mentioned earlier, **decision situations** arise when **issues** exist, there are at least two alternative actions available for the actor in question, and there is an **authority** and **influence** structure to frame the deliberation and the decision making.

Goals: **Goals** are expressed as desired state of the world, or more specifically desired attributes of entities and relationships that define the state of the world. They are not necessarily consistent and different **goals** of one **actor** may be contradictory as well as **goals** among different **actors**.

Criteria: **Criteria** are indicators about existing or expected **states of the world** expressed in measurable terms. **Criteria** can be effects, such as the level of air pollutants, or value statements, such as a preference ordering among levels of pollutants. **Criteria** could be attributes of entities describing states of the world or they could be computed from such attributes. **Preferences** are in relation to particular actors.

This data model can be implemented as an extension of XML (Extensible Markup Language). Figures 10 through 13 show the XML schema diagrams for Agenda, Policy, Design and Strategy. These are initial attempts to demonstrate the feasibility of encoding the current data model in XML. The XML schemas and some instantiations can be found at [http://www.rehearsal.uiuc.edu/projects/pml/]. More complete specification of the data model and XML schema will be required to create sample applications, but even at the current level of abstraction it is possible to consider the plausibility of supporting the intended use cases.

Assessment of the Data Model with respect to Use Cases

Does the proposed data model encompass the entities pertinent to the use cases? We consider here two more specific instances of the use cases: using plans in plan commission meetings and modeling with UrbanSim. These specific cases are indicative of other cases within each of the three more general use cases—using plans, making plans, and modeling urban systems. The content and processes for making plans are in many ways a combination of what is required for using plans and modeling urban systems.

To assess whether the proposed data model could support using plans in a planning commission process, we break the case described above into subtasks and identify the data class types that would enable support for that task. The subtasks are given in italics in the following paragraphs.

A developer who has acquired an option on a parcel of land proposes a mixed-use development in an area currently zoned for residential. The proposal itself is expressed primarily in terms of **Investments**, changes in **Assets** including **Buildings**, **Networks**, and **Designated Areas**. The argument for rezoning is based on the **Activities** proposed for these **assets** and the **Regulations** applying to those **Activities** when carried out in the proposed **Assets** at the particular parcel location.

Having noted that the current comprehensive plan sets compact development and reduced automobile use as goals, and that recent planning commission discussions have considered mixed use as a strategy, the developer consults informally with planning staff about the potential for rezoning (or perhaps handling the proposal under special provisions such as Planned Unit Development or Special Use provision). These ideas in plans are accessible as **Policies**, **Visions**, and **Designs** expressed in formal plans and informal discussions. The idea of mixed use is expressed as a mix of **Activities** in close proximity, probably on different floors of the same Building.

The planning staff considers the comprehensive plan, a recent neighborhood plan that identifies densification and lack of retail services as an issue, a Mass Transit District proposal for increased service in this area, and a University plan to acquire additional land south of the neighborhood preventing further development in that direction. These plans of other agencies (**organizations**) are also accessible because they are expressible as aspects of **plans**. Density is units of **Actors**, **Activities**, or **Assets** per unit area: population density, employment density, or dwelling unit density. Transportation analysis can be undertaken based on **Actors**, Trips (as **Activities** of **Actors** on **Networks**), Network capacity, and Actor attributes and **Capabilities** affecting mode choice.

After informal neighborhood meetings by the developer and planning staff, the staff develops a recommendation to the planning commission for approval of a modified form of the proposal. The staff recommendation is developed in a **Decision Situation**, the staff's decision about the recommendation. It is formatted for use in another **Decision Situation**, the planning commission meeting. The recommendation is presented in terms of **Issues** and **Alternatives** with reference to **Plans** and **Regulations**.

The planning commission holds a public hearing at which neighbors and the developer refer to all these plans and others, as well as to the zoning and subdivision ordinance and the capital improvements program to argue their views. The public meeting depends on the same sources expressed in the same entities as the staff recommendation, and is open to additional aspects of **Plans** and **Regulations**. The capital improvements program is expressible as an **Agenda**, but specific projects may be expressed as **Designs** and some projects may relate to each other as **Strategies**.

The planning commission considers all of this in its deliberation, and makes a decision to recommend to the council a further modified version of the proposal. The planning commission **Decision Situation** plays out and creates the inputs to another **Decision Situation**, the city council meeting.

At the current level of abstraction, the data model appears sufficient in scope for this use case. The next step in developing the data model will be to apply it more specifically in a particular plan commission case.

To illustrate the use of this data model for modeling urban environments, we choose the UrbanSim model. UrbanSim (Waddell, 2000; Noth, Borning, and Waddell, 2003; Waddell, Borning, Noth et al., 2003)(Waddell et. al 2003) is Open Source software, which is available at http://www.urbansim.org. It is designed to better coordinate land use and transportation models. This model is object oriented and has a separate object store for its data, which includes not only statistical data such as households and jobs, but also policy overlays that specify rules of development. This modeling structure makes it relatively straightforward to compare the object store with the proposed planning data model. The extensible architecture of the model is particularly useful in demonstrating the ideas of PML classes.

The table below describes the equivalent classes in PML and UrbanSim objects. It should be noted, however, that this table includes only representative object classes and is not exhaustive. Further, different connotations of the UrbanSim objects might imply different classes in the planning data model, implying ambiguities that we have not yet resolved. Commercial space, for example, could be at least two different things. When Commercial refers to a zoning category in a Zoning ordinance, it is an **Activity** subject to a **regulation** that restricts an **Activity** by particular **actors** who have **authority** on particular parcels based on a **regulation** enacted by other **actors** who have **authority** in a particular **jurisdiction**. Similarly, if commercial is to be allocated among locations, then Commercial is an **Activity**. If, commercial space is a square footage of existing building type, however, it is an **Asset** of a particular **Actor**. The Zoning category regulates the proposed use of the **designated area**, but the realization of the **asset** is a distinct phenomenon and is dependent on a variety of factors including enforcement of the **regulation** by one actor and private **investment** by another **actor**. Decision making capabilities exist only in actors, and this distinguishes them from the rest of the classes that describe the world. Hence, if individual businesses are considered to have location choice capability then they should be considered **actors**. If they exist only as entities at different locations, however, then they are **activities** occurring in an **asset**.

Indicators are important attributes of the world based on which the UrbanSim simulates decisions and urban development processes. For example, vacancy rate can be calculated from the attributes of the occupancy rates by **actors** (households) of **assets** (dwelling units) or of the level of **activity** (number of employees) at each **asset**. Similarly for regional planning purposes, the location choices of industries could be modeled by accessibility to the various resources. Accessibility would be a criterion that could be calculated from other entities describing the state of the world at the time step in the model at which such location decisions are simulated.

Table 1 compares the major object classes in UrbanSim with the proposed data model and shows that the objects classes in UrbanSim are generally encompassed by the planning data model. The next step will be to specify a run of UrbanSim in which the initial dataset and the scenario dataset are expressed in terms of the planning data model. This task also presents an opportunity to express the data model in XML and test that implementation with UrbanSim, which already uses XML schema for its data input. In particular, it may be possible to express more complex policies than can currently be expressed as input to UrbanSim, such as capacity expansion strategies contingent on future states of the world or on future forecasts of states of the world.

<table>
<tr><th colspan="2">UrbanSim Object</th><th>PML equivalent class</th></tr>
<tr><td colspan="2">Persons</td><td>Actor:: Person</td></tr>
<tr><td colspan="2">Households</td><td>Actor::Oganisation</td></tr>
<tr><td colspan="2">Buildings</td><td>Asset::Facility::Structure</td></tr>
<tr><td rowspan="2">Businesses</td><td>Individual or organized collection</td><td>Actor::Oganisation</td></tr>
<tr><td>Entities at locations</td><td>Activity</td></tr>
<tr><td colspan="2">Jobs</td><td>Activity Collection</td></tr>
<tr><td colspan="2">Housing preferences</td><td>Capability::Preference of an Actor</td></tr>
<tr><td colspan="2">Housing stock</td><td>Activity Collection</td></tr>
<tr><td colspan="2">Business Sector</td><td>Activity Collection</td></tr>
<tr><td rowspan="2">Commercial Space</td><td>Zoning Category</td><td>Activity constrained by limitation of Capability::Authority of Actor by Action::Regulation of Actor::City government</td></tr>
<tr><td>Existing land use</td><td>Asset::Facility::DesignatedArea</td></tr>
<tr><td colspan="2">County area</td><td>Capability::Jurisdiction of Actor::Organization::county government</td></tr>
<tr><td colspan="2">Urban Growth Boundary</td><td>Asset::Facility::DesignatedArea created by Action:: Regulation under the Capability:: Authority of Actor::City government in Capability::Jurisdiction</td></tr>
<tr><td colspan="2">Transport Link</td><td>Asset:: Facility::Network::Link</td></tr>
<tr><td colspan="2">Trip</td><td>Activity</td></tr>
<tr><td colspan="2">Vacancy rate</td><td>Indicators</td></tr>
<tr><td colspan="2">Access to the nearest airport</td><td>Indicators</td></tr>
</table>

Table 1 Comparison of UrbanSim Objects and Planning Data Model classes

Conclusions

This paper is our first report of work on a planning data model intended to frame the schema for a Planning Markup Language. Recognizing that we still have a long way to go and that many gaps and ambiguities will be discovered, this initial data model appears to have the scope to address the intended use cases. It is, however, still at a very abstract level. Elaboration to greater detail will be necessary before substantially better assessments of the data model can be made. The data model will certainly evolve, perhaps in its basic structure, as we begin encoding instances and creating PML compliant datasets and software tools. Our immediate focus will be on a fully specified case of planning commission plan use and fully specified inputs to UrbanSim.

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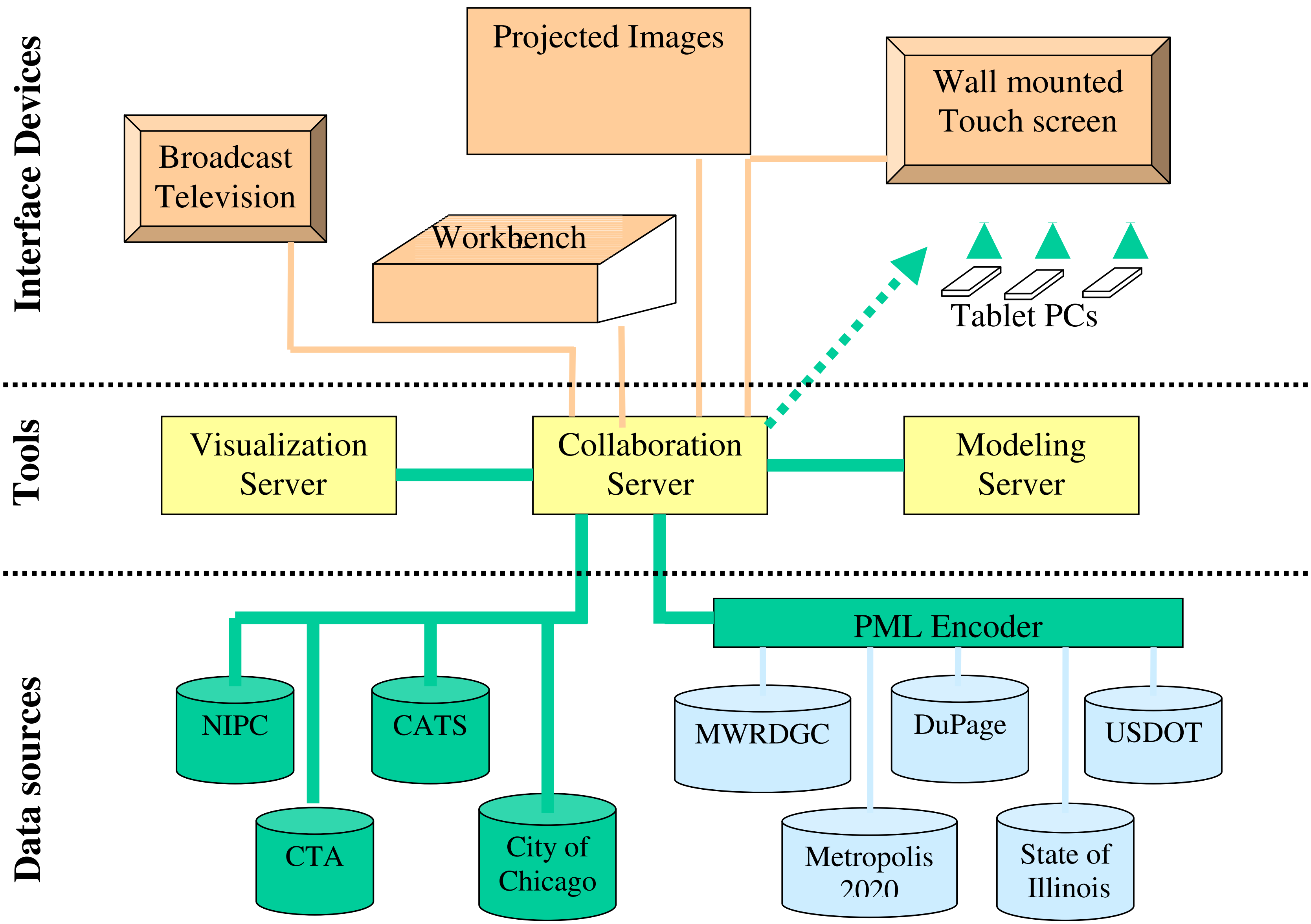

Figure 1 System architecture for uses of PML

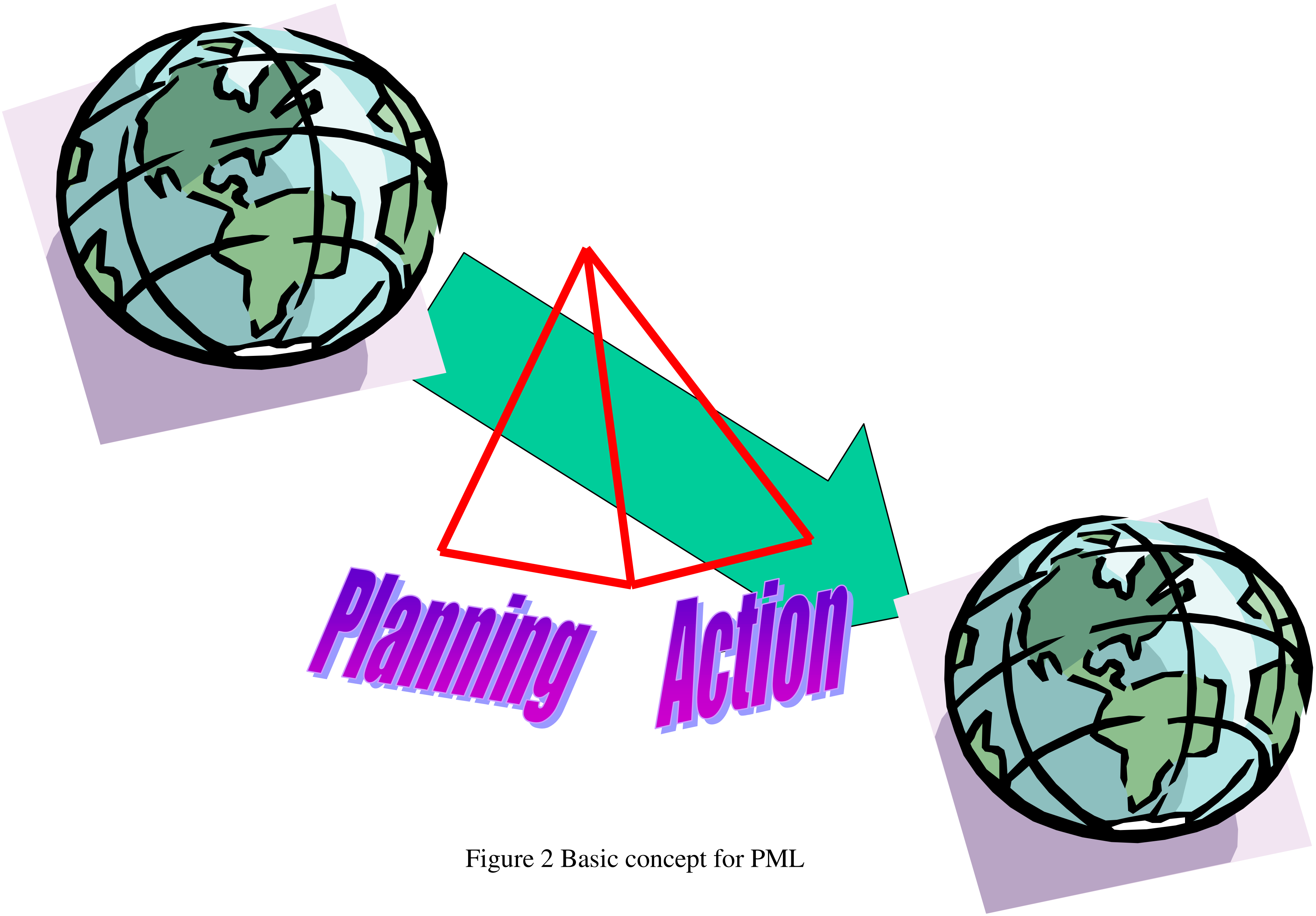

Figure 2 Basic concept for PML

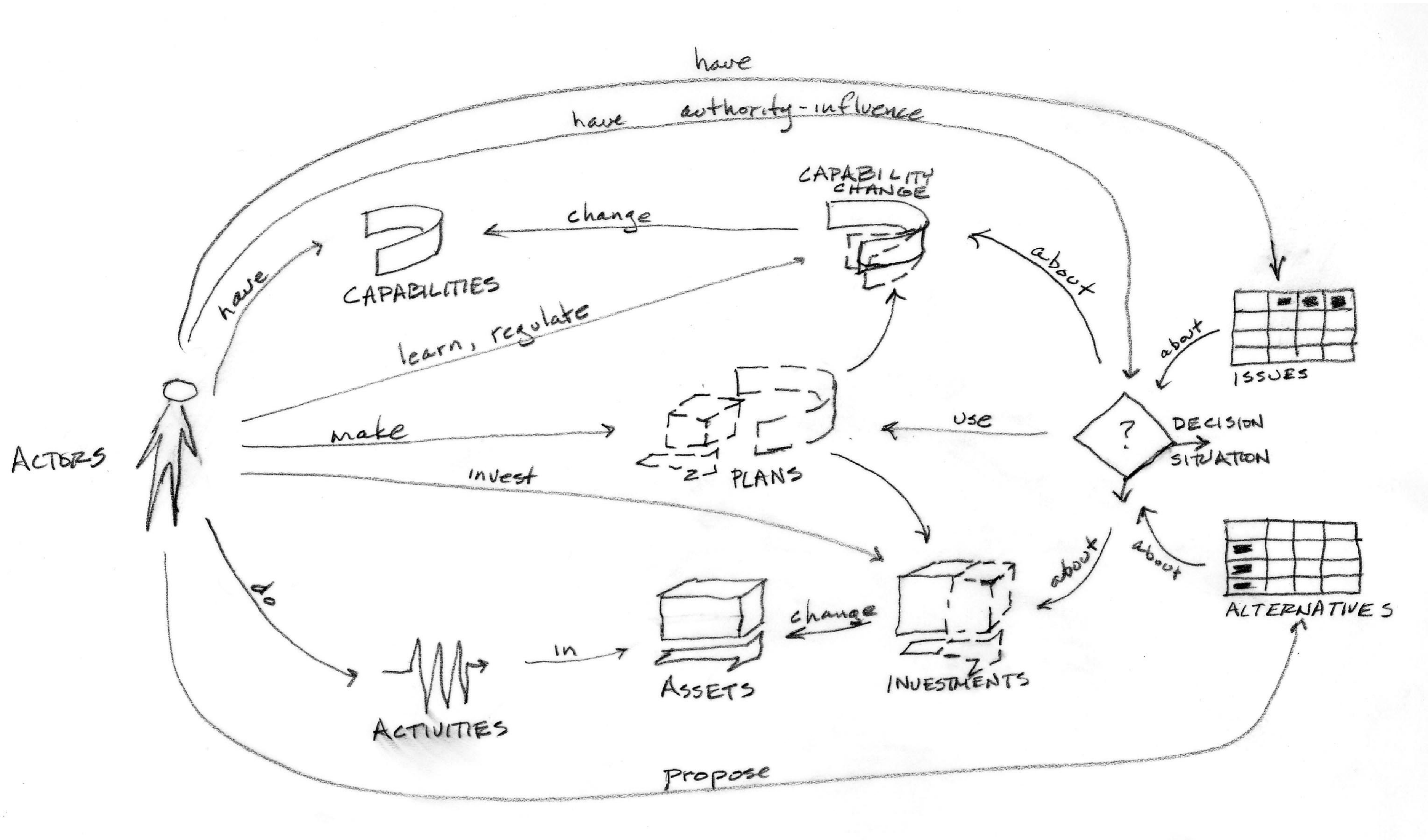

Figure 3 PML icon based diagram

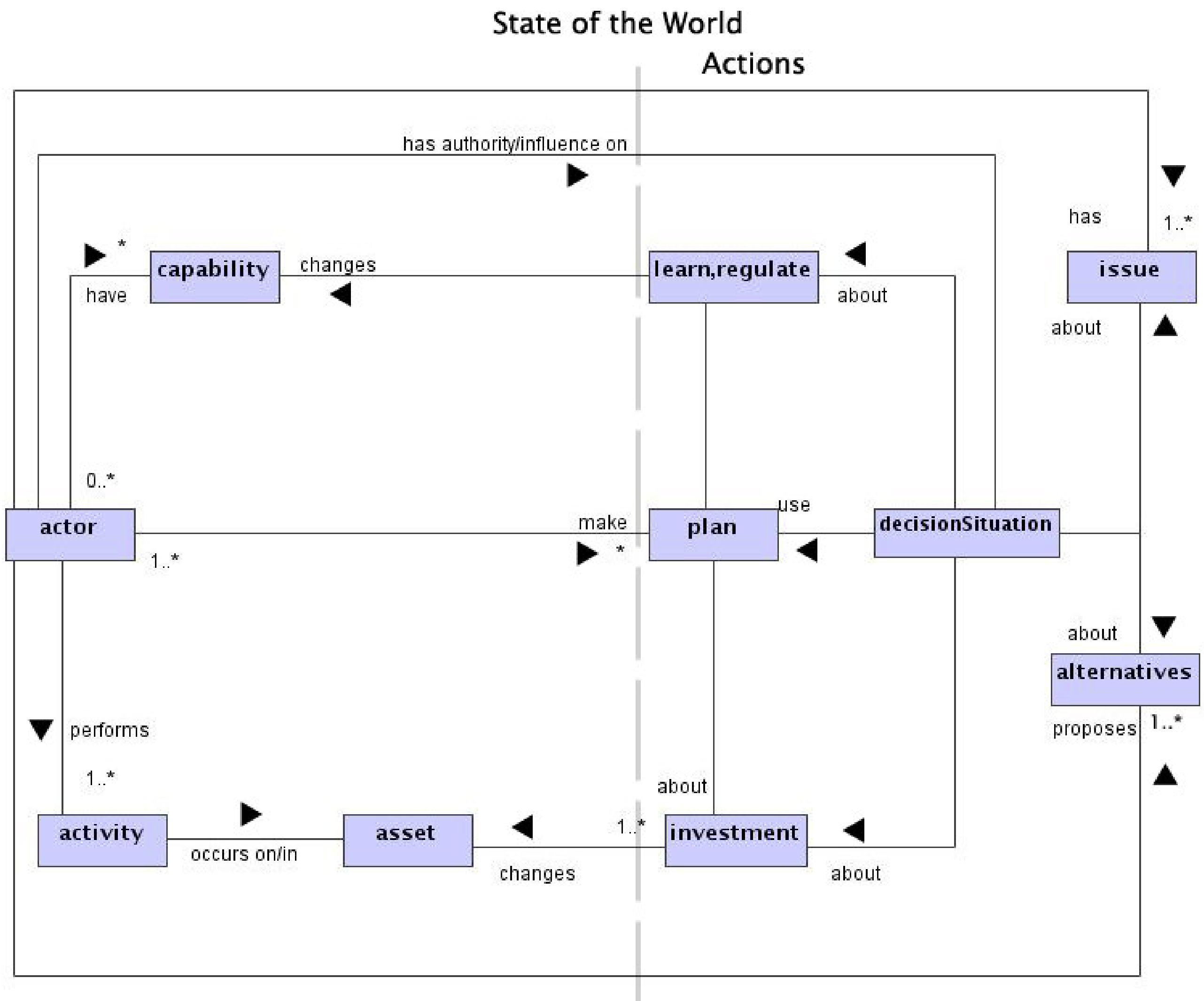

Figure 4 PML general class diagram

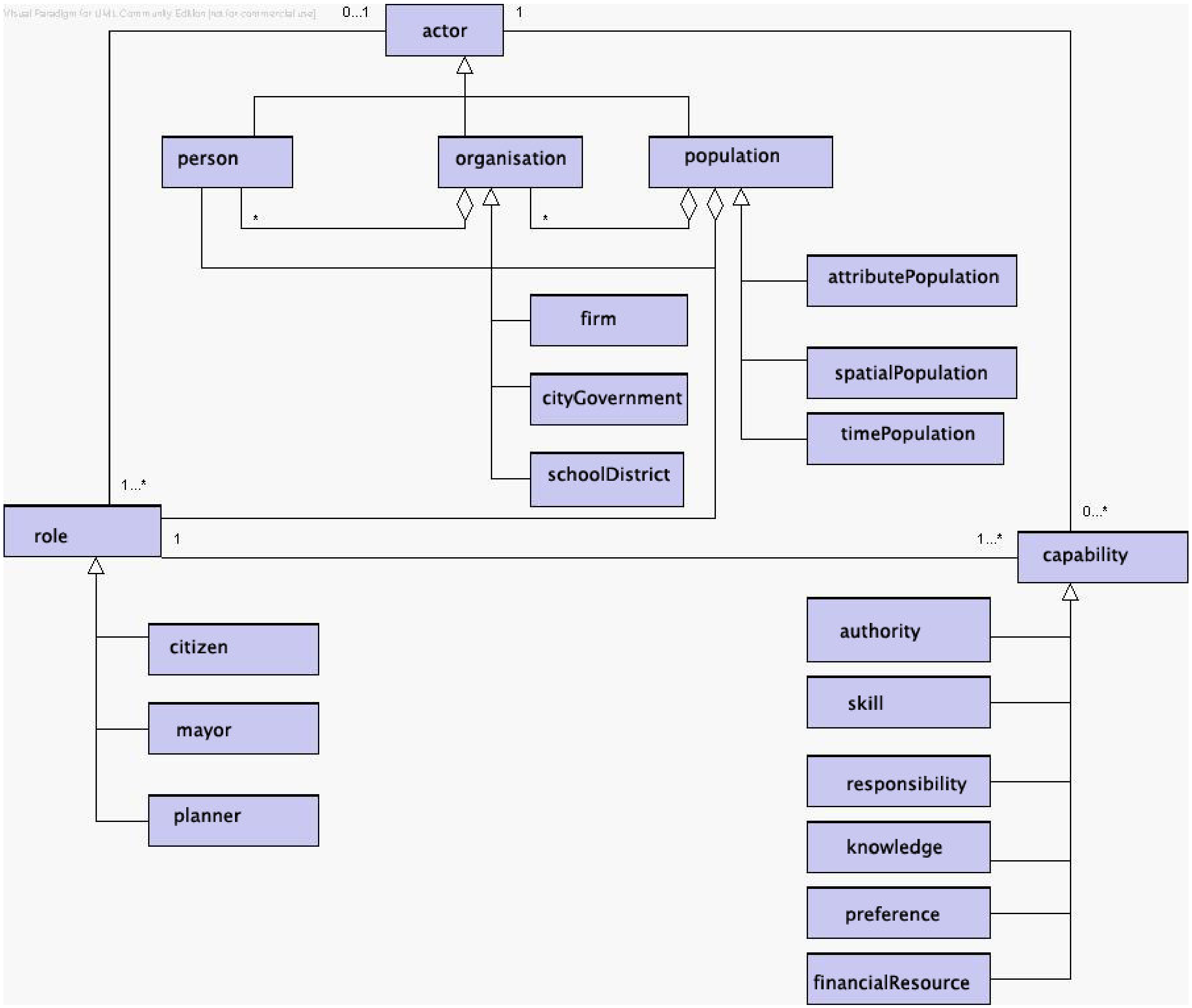

Figure 5 Actors

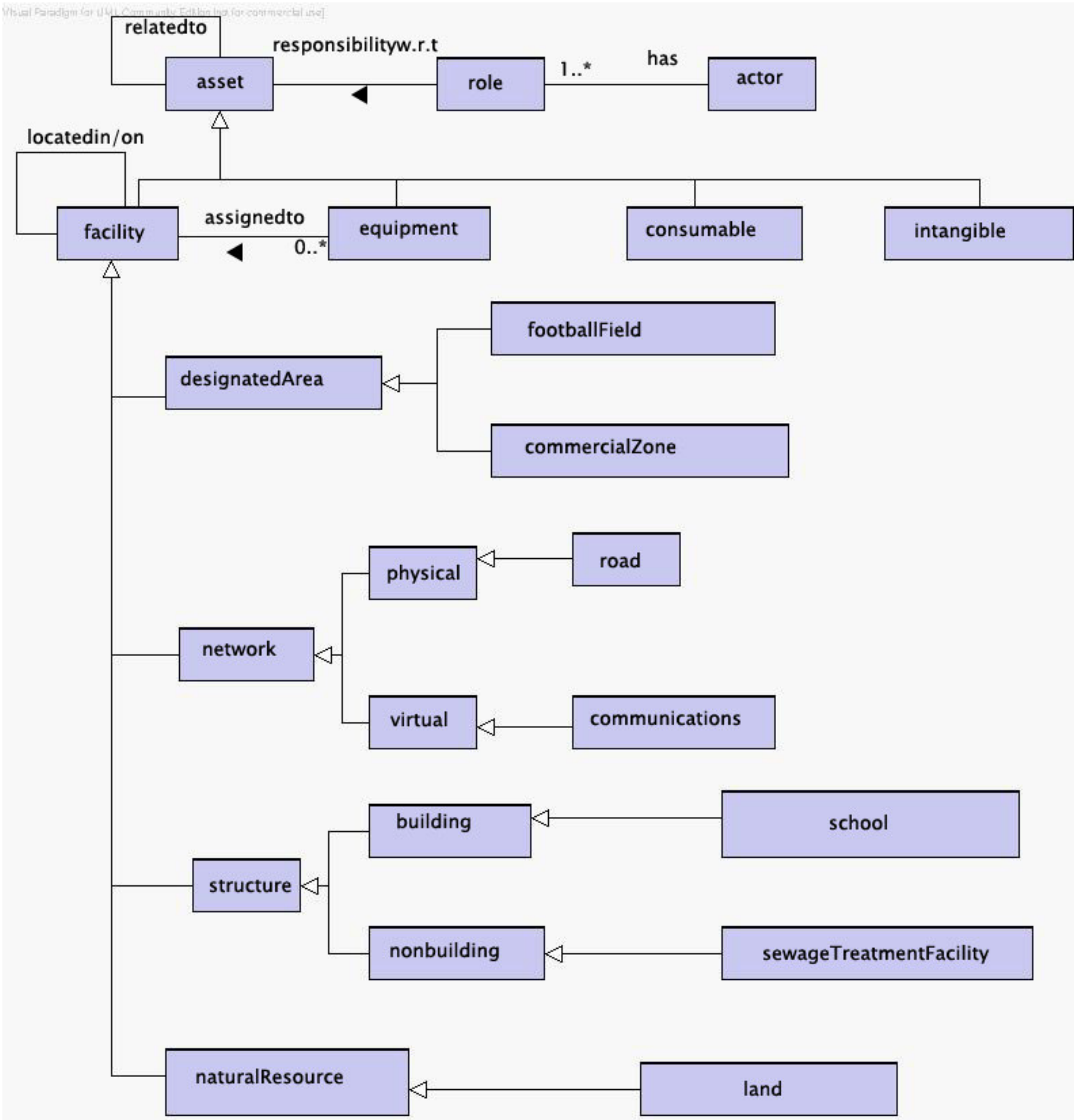

Figure 6 Assets

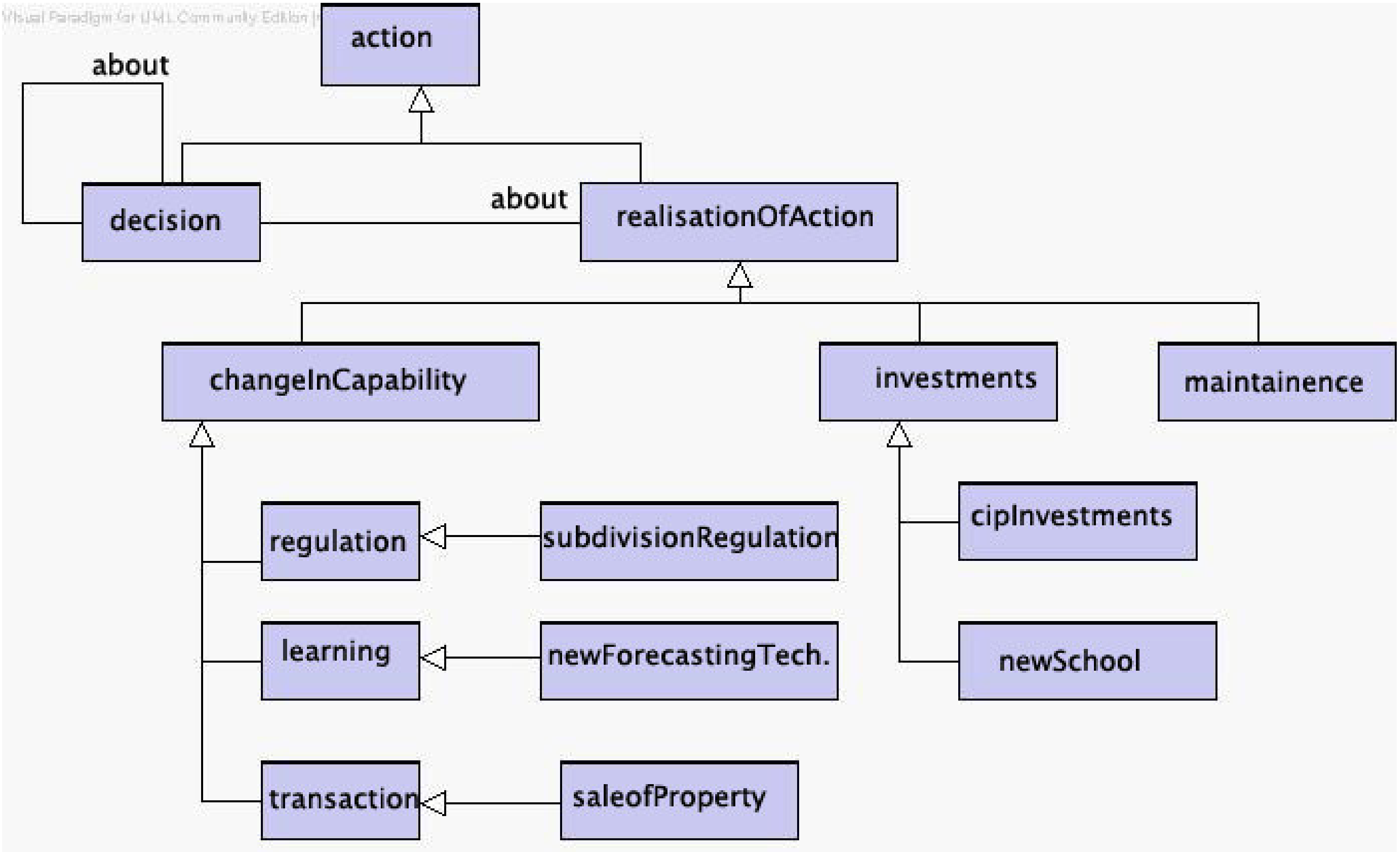

Figure 7 Actions

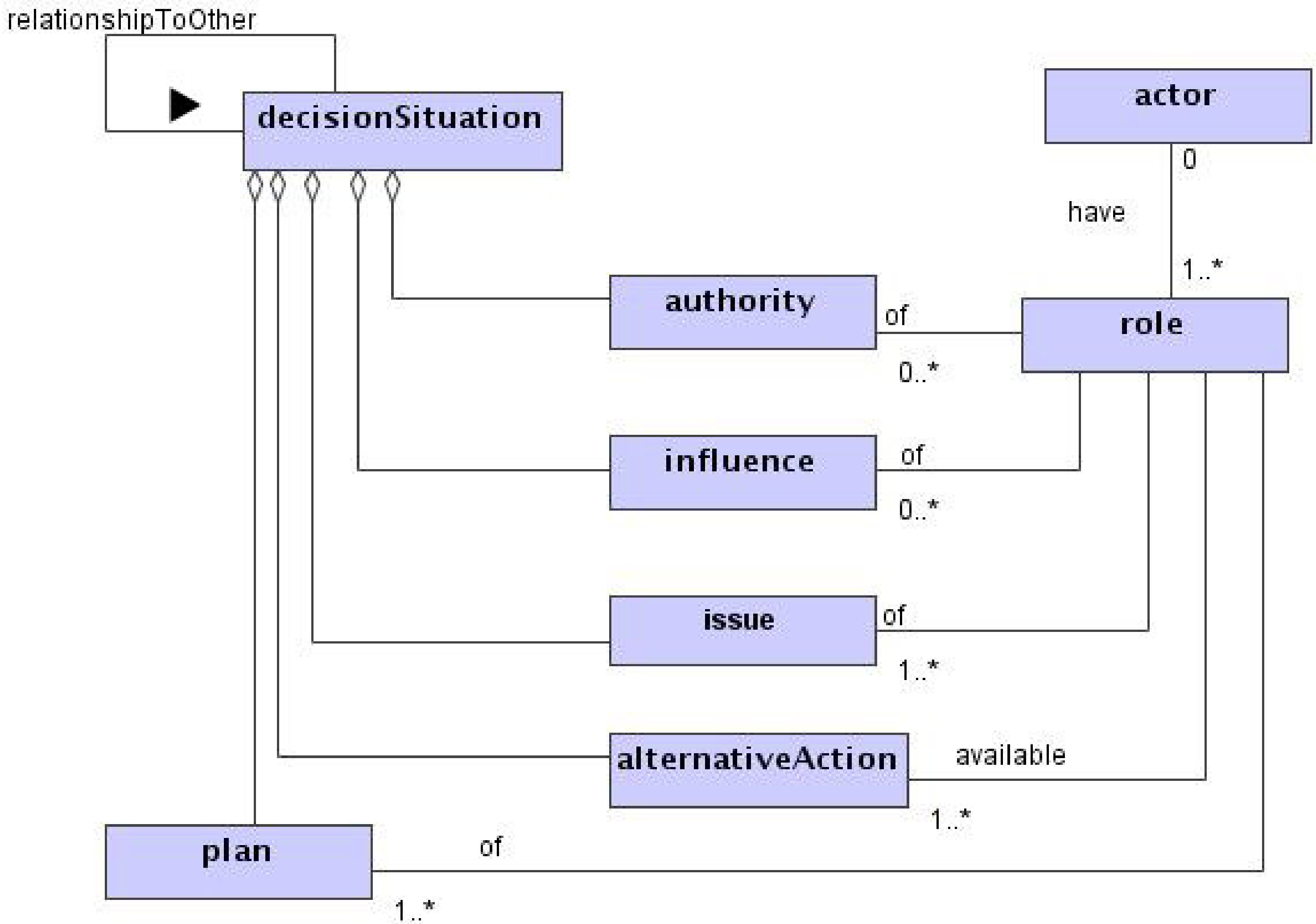

Figure 8 Decision Situations

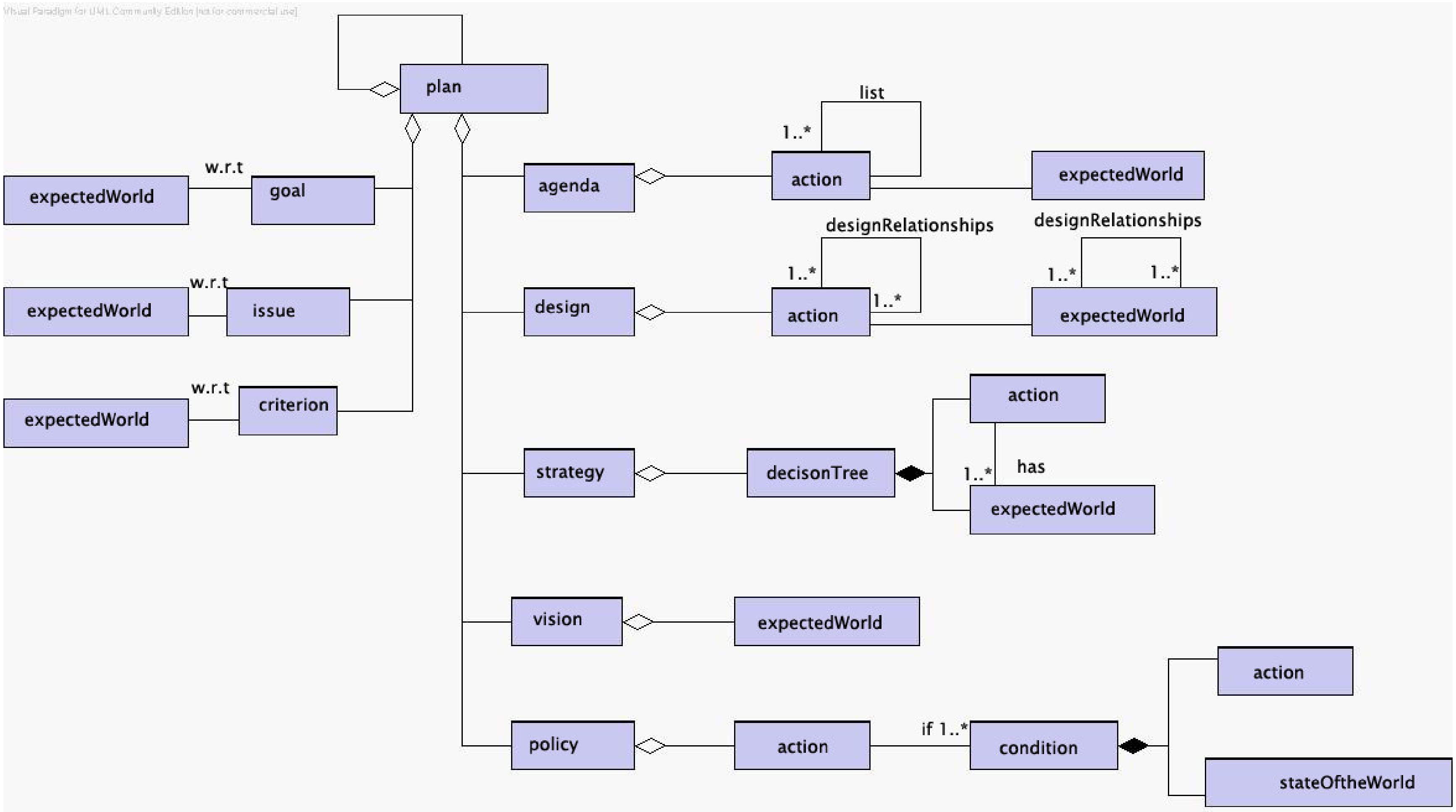

Figure 9 Aspects of Plans

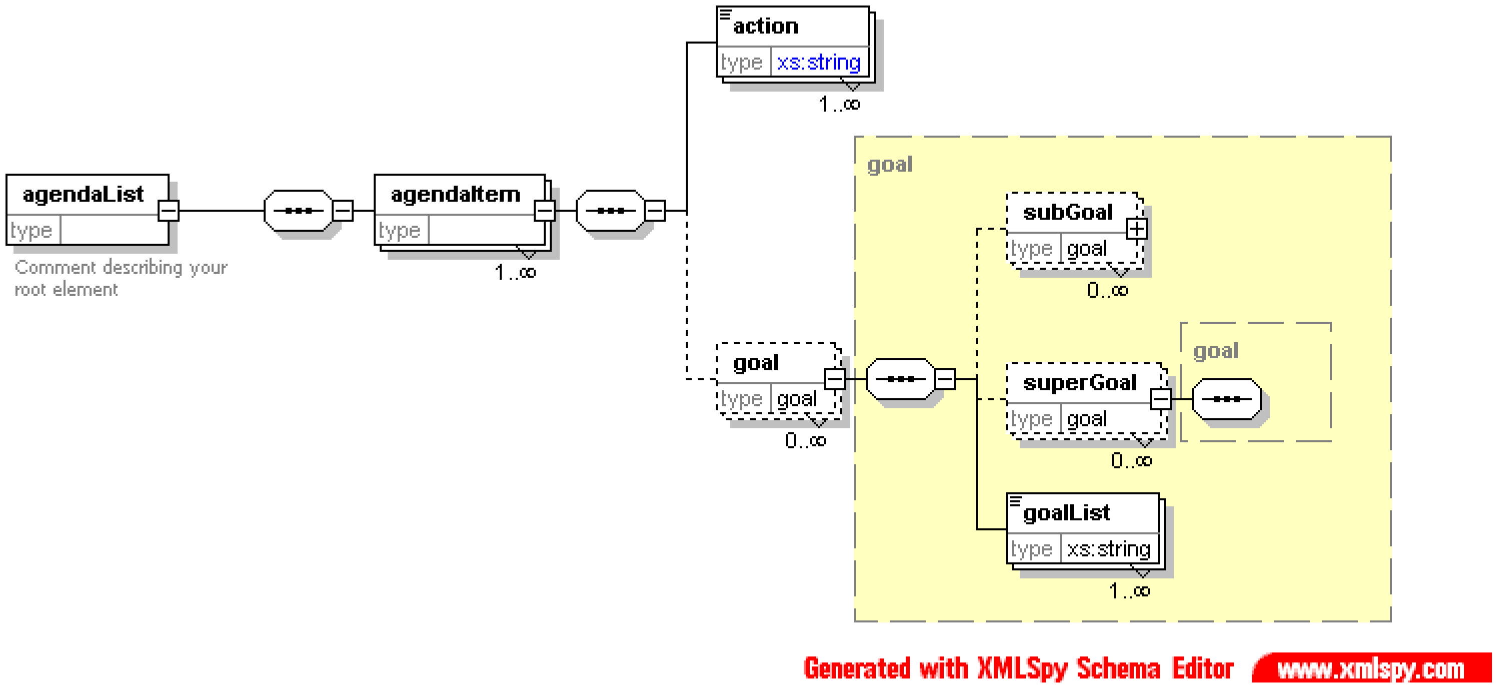

Figure 9 Agenda schema in XML

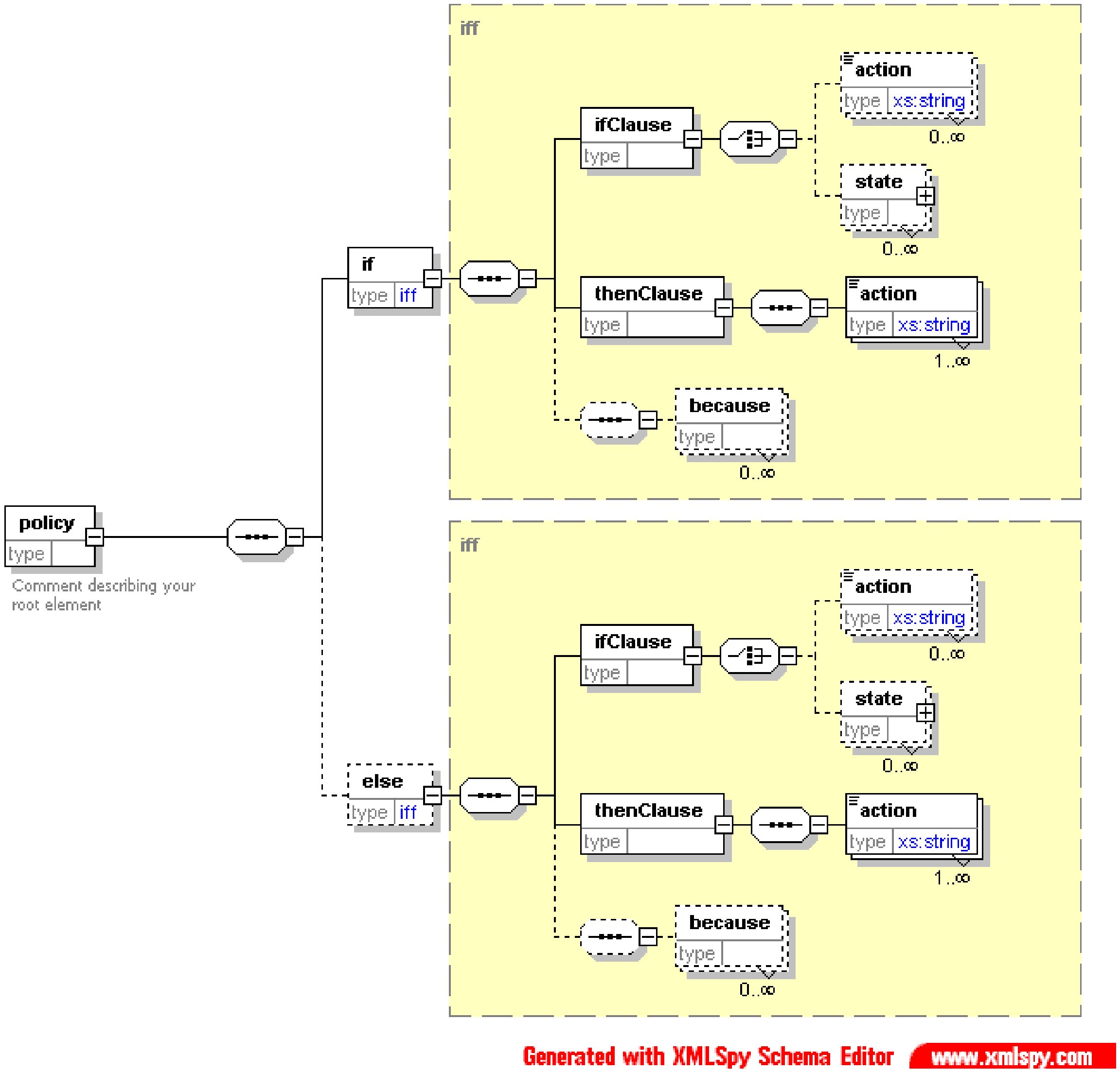

Figure 10 Policy schema in XML

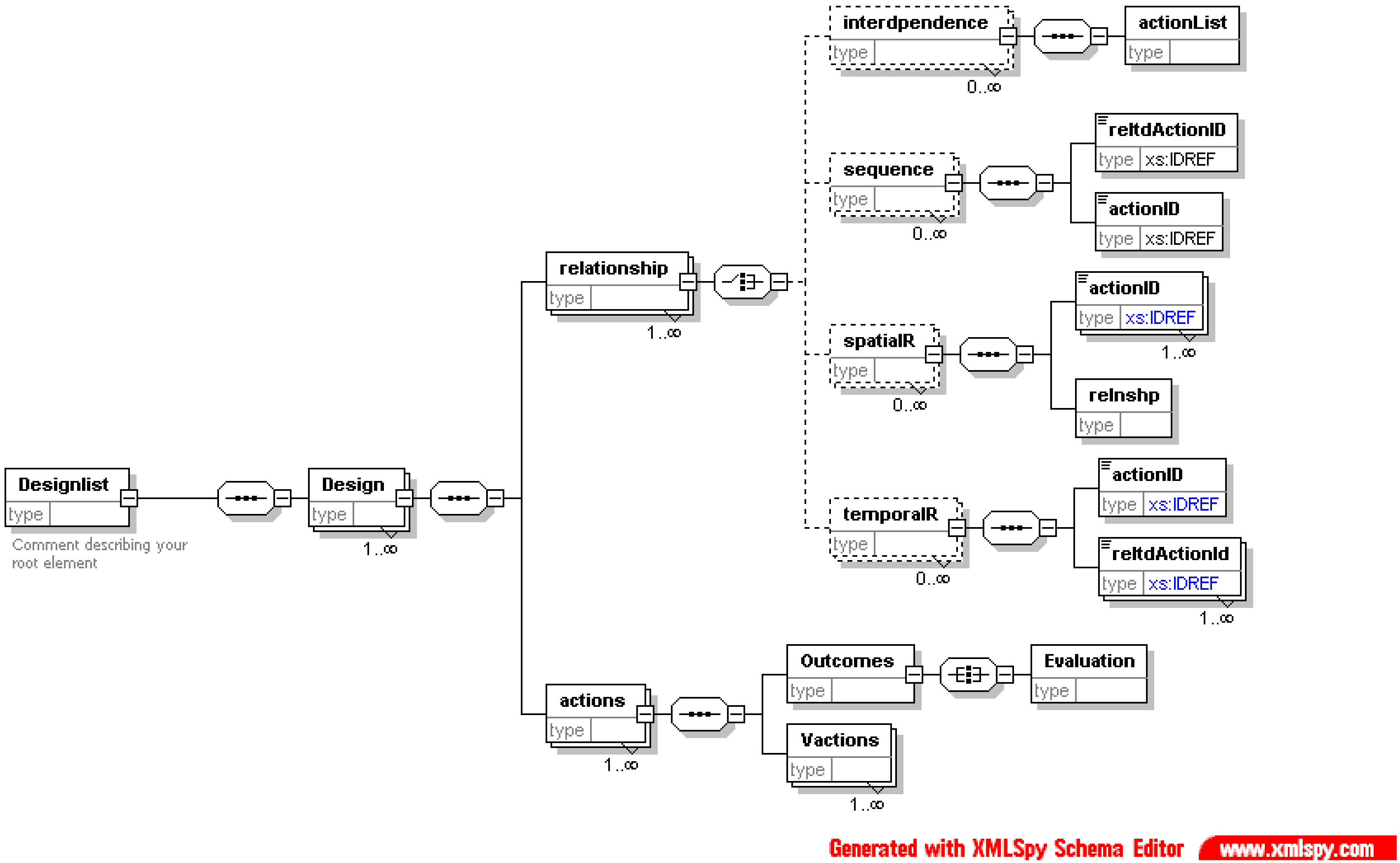

Figure 11 Design schema in XML

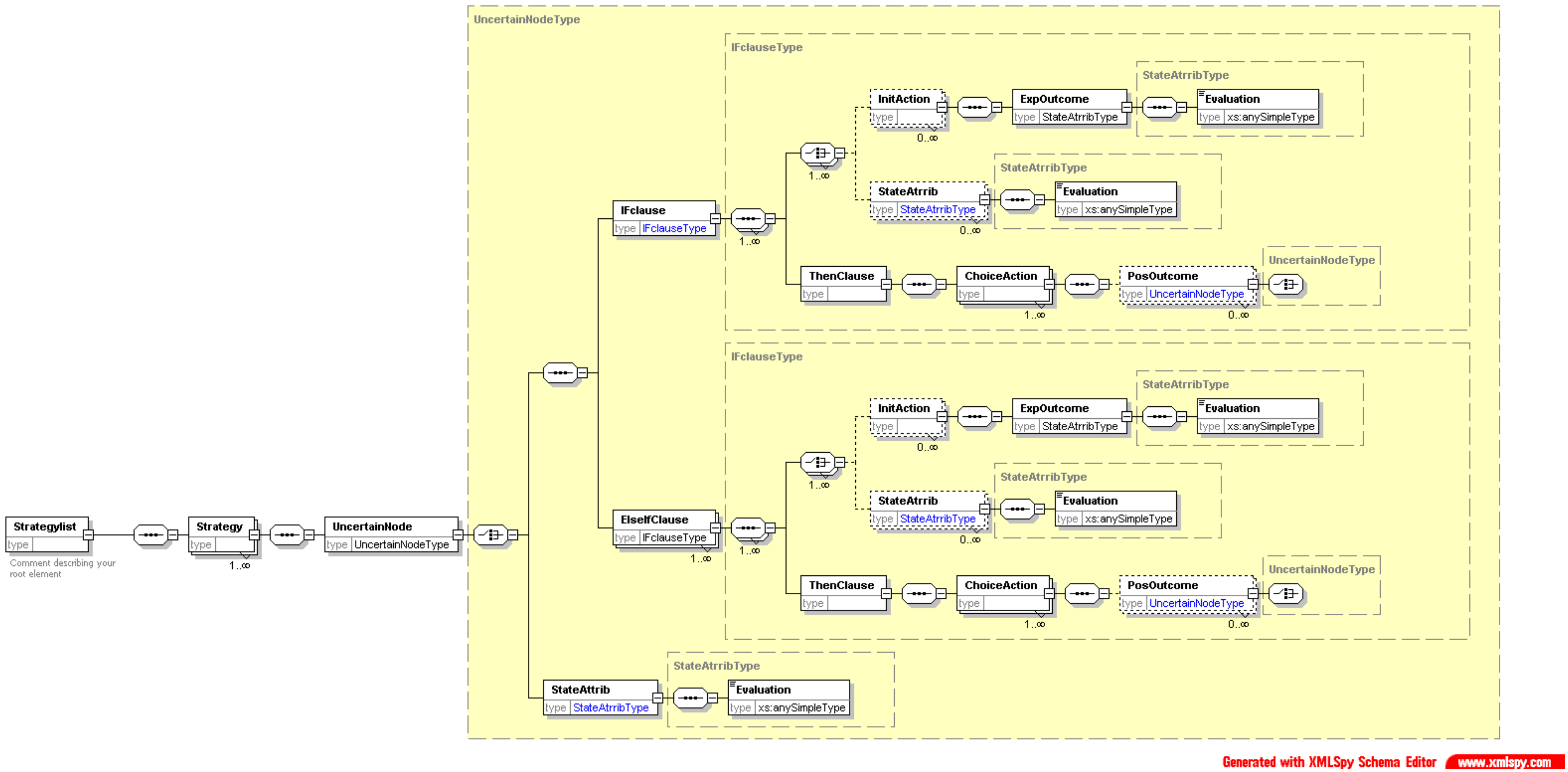

Figure 12 Strategy schema in XML