Deliberations among Experts and Laity
An approach to building planning information systems*†

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Abstract

The cooperative work process, which involves deliberations between experts and laity, is restricted by its access to spatial and aspatial information. This paper addresses these concerns as to how a planning information system can be fashioned to support such deliberations. In particular, by identifying the kinds of questions that come up in deliberations about institutional knowledge—relationships within the current state of the world, permissions, intentional changes to the world—tied to locations. Identifying what actions are permitted, prohibited, or have contingencies depends on expert inference that considers overlapping regulations and intentions of other strategic players like governments, their hierarchies (Federal, state, local etc.), developers, and interest groups, in the process. This knowledge necessary in conducting meaningful deliberations is not adequately addressed in systems, including participatory Geographic Information Systems. This paper focusses on specific semantic relationships—complementarity, substitutability, alternatives and interdependence—that need be considered in design of a system that supports deliberations about making plans, using plans and enforcing regulations, among different groups with various levels of expertise.

Keywords : Urban Ontology, Planning Praxis, Information Systems, Deliberations

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1 Supporting Deliberation

Participatory Geographic Information Systems (PGIS) have to date focussed on the widening of accessibility of geographic information beyond the expert groups (Jankowski and Nyerges 2001) and involving deep participation of community groups in the production of the geographic knowledge (Peluso 1995). However, Harris and Wiener (forthcoming) note that as social and cultural contexts cannot be sufficiently represented in a GIS, designing an effective PGIS becomes problematic. This paper contends that the problem of such representation is the problem of ontology, or vocabulary if you will, which relies on all too restrictive a set of geographic relationships that a GIS focusses on. This paper identifies the kinds of relationships an information system ought to focus on, by designing the specific ontologies required for each particular discipline and by leveraging the research on GIS.

Deliberations among experts, or among laity[1] and experts[2], about urban development processes are often in want of at least four kinds of knowledge : 1) What is the current state of the world and what are the possible future states? 2) What are the regulatory or incentive or institutional devices in place, that make some future states more likely than others? 3) What are the intentions of other strategically important players in the process? 4) What are the possible responses available, given the institutional environment, to those intentions? These questions are about rights, regulations, intentions and the interdependence relationships among these.

To represent this information, this work builds upon the ontology[3] developed for representing urban development processes in Hopkins, Kaza, and Pallathucheril (forthcoming) and elaborated for land use regulations in Kaza (2004). Plans are intentional actions directed towards change, and explicitly recognise of relationships—agenda, design, policy and strategy—among actions (Hopkins 2001). The intellectual development of GIS over the past decade has provided useful grounding for representing spatial and temporal entities and changes. Couclelis (1991) and Worboys (1994; forthcoming) identified key concepts of situation versus site and time, contingency, and expectations, which will be central in representing plans. Al-Taha (1992) describes an information system that is suited to changing boundaries, which is useful to describe changes in rights about a location. Westervelt (1996) describes modelling of objects in motion thus providing a basis for representing intentional actions that actively precipitate changes to a dynamic system.

A "web of plans" and a "web of regulations" could be a prototypical case for design of an information system that will capture the essential elements of a planning information system that is required for deliberations, whilst not purporting to be complete. A single plan, nor a single set of regulations about a particular issue is not very useful because there are competing intentions of various actors†, overlapping issues and hierarchies of regulations. Laurini (2001, p 158-160) describes how different regulations which are overlapping in jurisdictional† scope necessitates the application of different rules. Using a legacy planning cases for McHenry County, Illinois, this paper describes a "System of Plans" (SoP) approach towards planning

[1] Laity, here, is construed in a wide sense to include interested parties, lobby groups, neighbourhood organisations etc. which are not necessarily recognised as experts in the traditional sense.

[2] Experts, on the other hand, are parties that have substantial substantive expertise about a particular problem or facets of it such as planners, developers, lawyers, scientists, economists etc.

[3] Some terms are used with specific meaning are listed in the incomplete glossary at the end of the paper and are noted with a † the first time they appear in the paper. For detailed object class diagrams see references

and the beginnings of an information system that is needed to support the planning procedure whereby multiple plans of different agencies and goals are considered. The SoP approach to urban development planning thus focuses on creating information systems to support different groups, with varying expertise, to access information from these plans in their deliberations.

Quine and Ullian (1978) make the case that we as individuals, structure our beliefs in a coherent web. Any contradictions in the implications of beliefs are brought forth only when we experience cognitive dissonance. However, we do not discard the complete web, but we change certain beliefs, discard some and then readjust some so as to eliminate dissonance. To seek *a priori*, to discover contradictions is a futile quest for logical omniscience. In the same way a "web of plans and regulations" strives not for internal consistency of the information as the end goal, but for bringing forth agreements, disagreements and other assorted contradictions between different plans and regulations to enable further planning building upon earlier efforts in planning.

In using the content of these plans and regulations, in a deliberative setting, one must recognise structural relationships of actions within and among plans, among plans and regulations, and within and among regulations. To this effect, the subsequent section describe the object classes of actions and their attributes. Section 3 describes how relationships among actions can be represented in multiple ways within a plan. we should be able to determine whether actions—including actions structured in policies, strategies, or designs—discussed in two different plans, for example, are mutually exclusive alternatives by competing for the same budget resource. They could be partially substitutable in achieving certain desired criteria, synergetic in achieving objectives, incompatible, or otherwise interdependent (see e.g. Friend and Hickling 1997). These relationships are identified in the second part of the paper. The third part discusses, the interdependence between rights and plans and the representation of regulations. The unifying theme of the paper is how the different groups would recognise the relationships between actions in a deliberative setting and what questions are asked, or ought to be asked of experts and how the experts would get at the diverse set of information in a world of distributed authority and overlapping plans.

2 Actions

Actions are fundamental to the planning domain. Disagreements about the 'State of the World' and how it is perceived and represented are fundamental. They are disagreements about ontological and epistemological representations and to resolve them would require profound changes in the way we acquire knowledge. On the other hand, the disagreements about what kinds of actions one should pursue is subject of many a public deliberations. The crucial task of public deliberations in the planning domain is to seek to resolve different preferences about actions of different groups.

Actions are events. Worboys and Hornsby (2004), describe events as entities that are *occurrents*. A difference that is crucial to the urban planning purposes is that actions are intentional events. They are precipitated by an intentional system (actor) deliberately. To distinguish, a flood is an event, whereas a flood relief effort is an action. For urban planning purposes we are concerned with both actions and events. Plans, however, are necessarily relationships between actions and how these actions are contingent, interdependent, complementary or substitutable. For example, a design is either a temporally contingent system of actions (a construction plan), a functionally interdependent system (circulation spine connecting the functional spaces) or a collection of mixed spatio-temporal relationships (trip planning on a rapid transit system).

Urban development actions often, have locational attributes. Realignment of a road and location of new rapid transit stations have specific locations attached to the proposals. However, there could also be plans and regulations that depend on spatio-temporal relationships of particular entities, that have not been geographically identified. For example, the height of a cell phone tower is regulated if the proposed locations fall within airport approach corridors. Proposed airports would bring along with them, the approach corridors, which affects the decisions about locations and heights of the towers. In deciding about the design of the network, one ought to be cognisant of the regulations that affect the heights and the plans of other actors about airports. These regulations and proposals are useful information, even when the specific airport or tower locations to which the regulation will apply are not identified. Thus, in deliberations, spatial, topological and mereological, functional and institutional knowledge is as important as geographical knowledge.

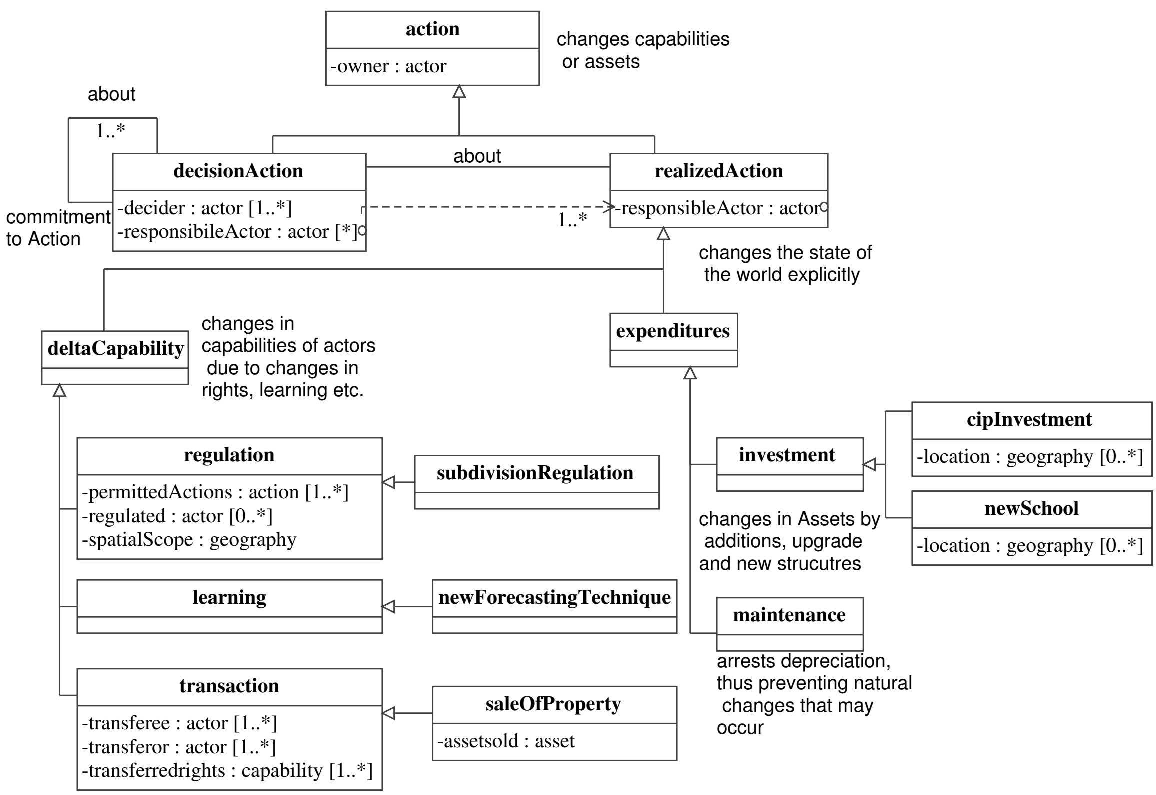


Figure 1: Action object class diagram — Source Hopkins et al. (forthcoming)

Plans of actors are intentions about changes in regulations or changes in the physical assets (investments†) themselves. The situating of actions in spatio-temporal context has to be tightly linked with, decisions to act and the realisation of actions themselves. Figure 1, represented in UML (Booch et al. 1999), describes the object classes of actions and relationships between decisions and actions. Decisions are commitment to actions. In deliberations, different groups are interested in what decisions are already been made because they shape expectations, even when the action is not yet realised. A realised action on the other hand can change capabilities† or can change assets† (investment). Hopkins (2001) argues that plans spell out these intentions ahead of time, thereby providing public justification for taking these actions. Deliberations, when making and using plans, will have to consider relationships among actions and their intents and effects.

3 Relationships within a plan

When deliberating about plans for urban development, one of the primary questions is about a list of proposed actions, such as transportation improvements, changes to land use designations, or allocation of resources to a particular program in a plan. Possible actions in a plan are related as agendas, policies, designs and strategies (see figure A.II). Elsewhere, the abstract data model that is required to describe plans has been elaborated (Hopkins, Kaza, and Pallathucheril forthcoming).

Agenda is a list of actions with attributes like responsible actor, beginning date, and other attributes of a task list. Policy is an 'If-then' rule that is used for repeated applications. Strategy on the other hand is about uncertain resultant states and contingent actions. Designs are relationships—spatial, temporal, functional—between actions or resultant states worked out *a priori*. A simplified relationships of actions within a plan is diagrammed in figure 2

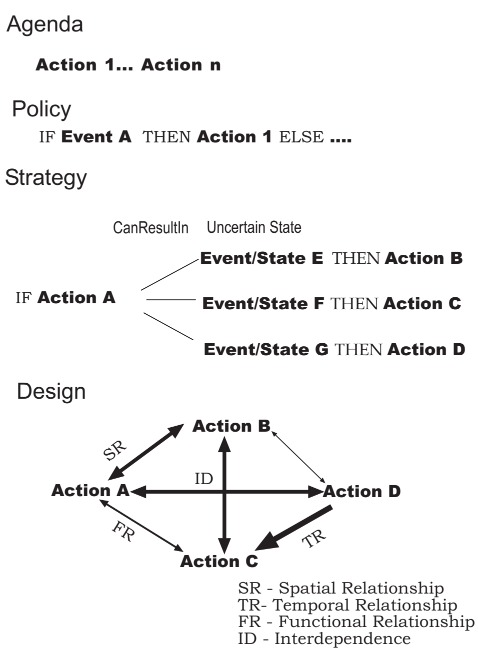


Figure 2: Relationships among actions within a plan

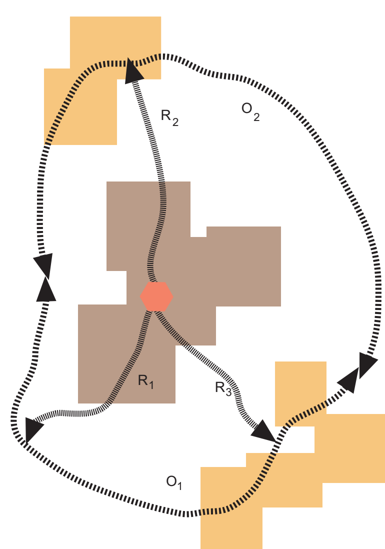


Figure 3: Infrastructure investments as Agenda, Design or Strategy

A plan for capital improvements in figure 3 can be represented as an Agenda, a Design, or a Strategy. Say that four new highway links are planned by a regional transportation agency as part of a long range transportation plan. Two of these links (O_1 and O_2) contribute to a ring road and three links (R_1,R_2 and R_3) increase radial capacity to and from the city center. The plan's intent is expressed as strengthening the core through increased access, then enabling peripheral interaction if and when the suburban area grows to sufficient size.

A simple approach is to model this plan as an Agenda with five Actions. In order to account for budgets and financing , the attributes of these Actions would include costs, revenue sources, and expected times of construction for each project. The Actions would be linked to a geography data set, which would be a network feature with each highway defined as a link. An agenda is a list of network connections

`NetworkConnect(`O_1, O_2`),`
`NetworkConnect(`R_3, R_1`),`
⋮

`NetworkConnect(`R_1, R_2`)`

This transportation improvements plan could also be modelled as a Design. In this case, the three radial links would be considered as a single design because they would be effective in strengthening the core if only all the links were built. Also the two ring road links would be considered a cohesive set because they would be effective in improving peripheral access if only both were built. The response or anticipation of developers would then consider the construction or anticipated completion of combinations of links rather than individual links. A design consisting of all the roads is a design of designs. A representation of such design would entail, that R_1, R_2 and R_3 has to be done in conjunction with the O_1 and O_2

`ActionSet1(`O_1, O_2`), ActionSet2 (`R_1, R_2, R_3`)`
`NetworkConnect(`O_1, O_2`),`
⋮

`NetworkConnect(`R_1, R_2`)`
`Connect(ActionSet1, ActionSet2)`

Finally, this plan could be represented as a Strategy. In this case, the anticipated construction of the ring road links would depend on the prior construction of the radial links and the realization of the expected suburban growth because of the radial links. The timing of the construction of links and even the estimates of timing are dependent on the realisation of some state. A representation of strategy would include temporal precedence of the radials over the outer ring road.

`ActionSet1(`O_1, O_2`), ActionSet2 (`R_1, R_2`), Action(`R_3`)`
`NetworkConnect(`O_1, O_2`)`
⋮

`NetworkConnect(`R_1, R_2`)`
`Event`R_3` 'Succeeds' Event(ActionSet2)`
`Build(`O_1`) 'Succeeds' EventResidentialDevelopment(`X`) & Event(`R_1`) & Event(`R_2`)`

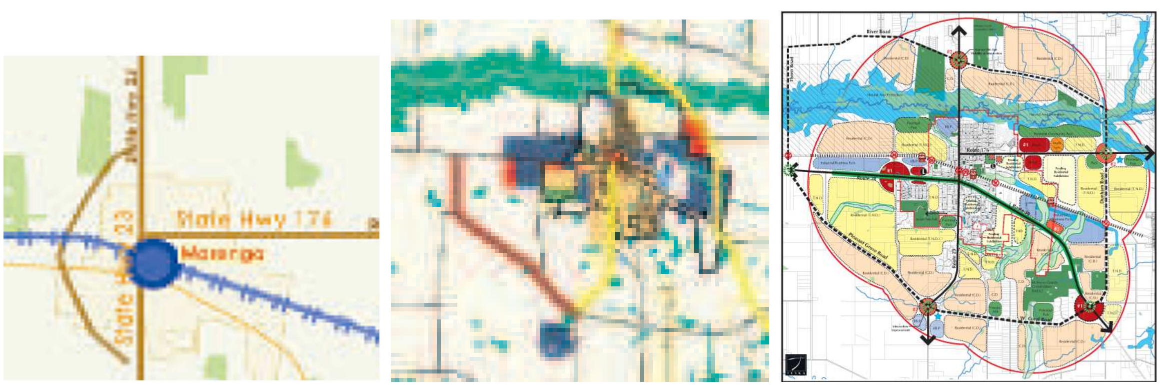
While many other relationships are apparent in the design and strategy, the key relationships are depicted here. 'Succeeds' is an event-event relationship which can be generalised from temporal relationships. The action of building the outer ring road is contingent upon certain level of residential growth in the periphery and is preceded by the building of radials. Any argument about a peripheral road must consider its relationship with the radials and the other peripheral. The designs and strategies that the peripheral is a part of can now be discovered in an information system that adequately represented these relationships. The radials can be considered independent actions in thinking about these investments as a strategy but not in the case of design.

Planners with knowledge about the situation would recognise the necessity of both the ring roads and the radials and their event sequences from a static diagram of relationships which may be found in maps or alternative representations. However, these relationships are not so clear to laity or other experts unless there is an explicit recognition of the relationships in an information system, either through inference from a mereological, topological or other perspectives. Once they are determined, the complete design or strategy can be viewed as a single coherent object along with individual actions in deliberations.

Actions may be interdependent in additional ways, most importantly across plans or regulations from different sources, which means that they have not been resolved within the prior planning processes. Some actions are contingent on other actions in time or space even when they are not part of a coherent strategy of a single actor. Recognition of these relationships are the focus of next part of the paper.

4 Relationships among plans

Within a single plan, action sets and their relationships have been coherently thought out and described along with the intent. A single plan is not entirely capable of dealing with the range of interconnected issues. A planning problem should then consider the plans of other strategically important players in the process and discover whether one plan is consistent or even synergistic with others. (Marengo 2004).



(a) Source NIPC (2005) (b) Source McHenry (2005) (c) Source Marengo (2004)

Figure 4: Agreements and Disagreements among plans

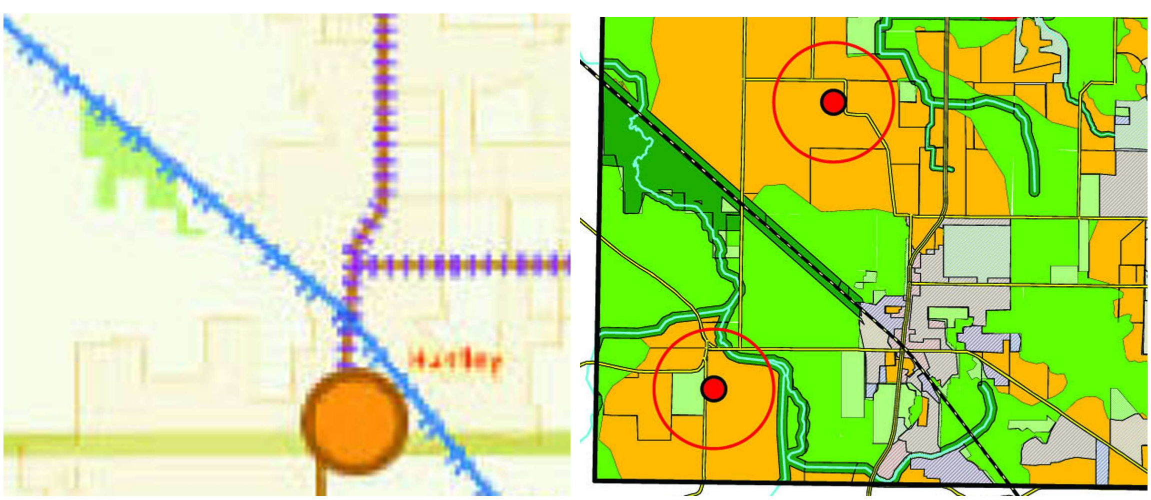
Figure 4 shows the agreements and disagreement between two plans about the same issue. The connectivity of the bypass around the Village of Marengo is depicted differently in different plans. The Regional Framework plan of the Northeastern Illinois Planning Commission depicts the connectivity on the west of the Village (NIPC 2005), whereas the Unified Plan of McHenry

County (within which the village lies) prefers it along the southwest and the northeast portion (McHenry 2005). On the other hand, the Marengo Comprehensive Plan prefers it all around the city with growth restricted well inside the bypass It is interesting to note that none of the agencies that are planning, has the authority alone, to build the road. The others are planning contingent on, or for other actor's decisions. While the plans may not be about who will build the road or even when it will get built, each actor who is planning, is basing its other decisions, such as land use patterns on the configuration of the road. Thus it is vital to recognise such contingencies across plans.

The semantic relationships that are apparent across plans are alternatives, partial substitutability and interdependence including complementarity. Each of these relationships are the focus of the subsequent sections.

5 Alternatives

Alternatives are actions that are mutually exclusive. The exclusivity arises because of capability constraints of actors or locational constraints of situating the action in the spatio-temporal settings. For example, a proposal for a shopping center and a proposal for residential development at the same location are alternatives. Chicago Area Transportation Study in its Regional Transportation Plan recommends to build extra lanes on I-90 (CATS 2003). This is specifically rejected by the Metropolis 2020 plan (Commercial Club of Chicago 2000). Thus to build or not to build could be alternatives as well.



(a) Source NIPC (2005)

(b) Source CRI et al. (2001)

Figure 5: Alternative Plans

Figure 5(a) is plan by NIPC where the region of the village of Huntley is presumed to be a node for a community center development. The plan for the region by a consortium of non profit groups is shown in figure 5(b), It instead recommends the strengthening of the protective regulations around Huntley depicted in the green areas and widening the Route 47 along with a buffer to protect the ecologically sensitive resources. At a location either one set of actions could be implemented. Working groups discussing issues in the region, should be cognisant of these alternatives that are being proposed by different groups in their deliberations. If an information system could represent of plans in a distributed setting, then different groups would have access them not as separate documents, but as specific intentions that are related to each other.

If a plan specifies an alternative action specifically in recognition of other intentions, then the planning process has recognised the other plan and represented it in their knowledge base. For example a plan A might specify building extra lanes on an interstate, whereas Plan$B$ in a direct confrontational approach specifies that the rail network be strengthened instead of building the lanes. When Plan$B$ recognises that Plan$A$ includes an action set then any locational query could easily recognise the semantic relationship of alternatives.

While different actions at a location are alternatives, there could be other kinds of alternatives as well. Different locations for the same action could be considered alternatives. They are mutually exclusive in the sense that the actions, while being perfectly feasible do not make sense when both are carried out. A plan might also specify multiple possible locations for the same road. While the recognition of "sameness" of between two proposals is not a trivial endeavour,(e.g. Wiggins 1980, Mark and Smith 1998), it is possible that the plans might recognise these actions as 'same' either in their intent or effect. Thus intentions or effects can be used to identify the alternatives.

However, in most cases, plans are circumspect about alternatives. To recognise that two actions are alternatives, expert knowledge about the situation is required. It would involve, for example recognition of budgetary constraints, which precludes pursuing one kind of action, when pursuing another. It would involve the knowledge of 'priors' that would be necessary, and cannot be pursued simultaneously. However, we can begin to attempt the recognition of alternatives from the issues of location in a geographic context, location in a temporal context and the recognition of the responsible actors and their capabilities including jurisdictions.

Assume Action A is identified in Plan A and Action B in Plan B
`Plan(A) : Action(A)`
`Plan(B) : Action(B)`

A and B are possible alternatives when:

- `Location(A) IS Location(B) & Event(A)` ⇔ ¬ `Event(B)`
- `Location(A) ISWITHIN a Buffer(Location(B))`
- `Location(B) ISWITHIN a Buffer(Location(A))`
- `Outcome(A) IS Outcome(B)`
- `Intent(A)IS Intent(B)`

This listing is neither an exhaustive list of possible cases of alternatives, nor a perfect recognition of alternatives. For example, zoning a parcel B-1 and expanding a Tax Increment Financing (TIF) district to include the parcel are not alternatives, but may be synergistic. These examples illustrate the kinds of ontological constructs in terms of relationships of objects, events in spatio-temporal and functional contexts required to recognise the semantic relationships.

One of the first steps in recognising actions as alternatives is by asking if they share some key attributes. For example if Marengo Comprehensive Plan prescribes a station at location L_1 and the Long Range Transportation Plan specifies the same station at location L_2 one might recognise intuitively that these actions are substitutes. Note that both projects share the same attributes, both are Railroad Projects, their locations fall within Area A. The presumption here is that L_1 and L_2 fall within the area A which is large enough to find reasonable alternative proposals.

The Query mechanism for this would be
`Marengo Comprehensive Plan (MCP::Agendalist) --> Agenda Item 235:`
`Action: Build ‘‘station A" (asset::facility::Railstation) at site ‘‘`L_1`"`
`(Location) at 2009`

`Long Range Transportation Plan (LRTP::Agenda list) --> Agenda Item 345:`
`Action: Build ‘‘station A" (asset::facility::Railstation) at location ‘‘`L_2`"`
`between 2010-2012`
⋮

Query `: Identify all Rail station projects with in an area` A `scheduled before 2015`
Response `:`
`LRTP:AgendaList:Agenda Item 345`
`MCP:AgendaList:Agenda Item 235`
⋮

Groups should have access to the proposals from both the plans to weigh upon the merits of each as compared to another. However two actions may not be completely substitutable, and the recognition of partial substitutes is detailed next.

5.1 Partial Substitutes

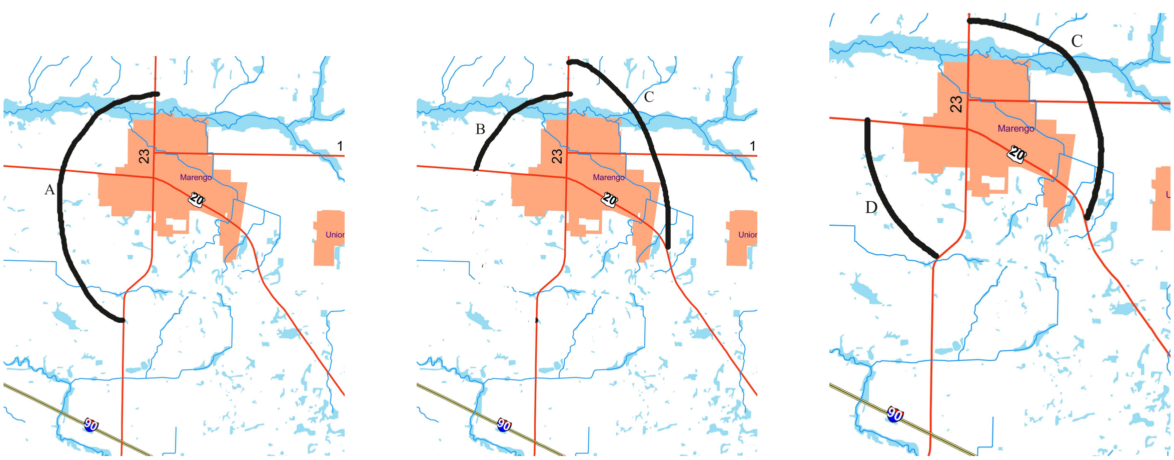


Figure 6: Partial Substitutability of Actions

Partial substitutes differ from alternatives in that the actions are substitutable with respect to some purposes, not all. Alternatives are complete substitutes. A policy of subsidy for pollution abatement programs, or a tax on pollution volume are partial substitutes.

An action A_1 is substitutable with an action A_2 if they result in the 'same' state Ω. To get at substitutability we may have to rely on intuition, and on previous cases in which substitutability was recognised and established — Case Based Reasoning (see for e.g. Haigh and Veloso 1995). To illustrate an example of partial substitutability where projects of similar nature compete for approval, consider proposals A, B, C and D in different plans as depicted in figure 6. The intent of A is to create a bypass for the traffic on IL 23. C and D create a bypass for US 20 both east and west of Marengo to IL 23, but not a bypass for IL 23. Thus they are only partially substitutable. In a similar fashion B and C are partially substitutable with A. Even when, as in the more interesting cases, actual locations of B is different from that of A, they are partially substitutable with each other. To recognise the substitutability of the two designs one has to abstract the network of roads into a network on links and nodes with traffic patterns and query if both proposals accomplish at least some of the same purposes.

```
Plan1 :Agenda 12:  Improve B
Plan2 :Design 1:  Build A.
Plan3 :Design 4:  Build D and C
Plan4 :Design 3:  Improve B and Build C
⋮
```

Query1 : `Find proposals that link IL 23 and US 20`
Response
```
Plan1:  Agenda 12
Plan2:  Design 1
Plan3 :Design 4
⋮
```

Query2 : `Find proposals that will reduce the traffic on IL 23 in Southern part of the City`
Response
```
Plan1:  Agenda 12
Plan4 :Design 3
Plan2 :Design 1
⋮
```

Query2 : `Find proposals that will increase the traffic on US 20 by at least 20%`
Response
```
Plan3:  Design 4
Plan4 :Design 3
⋮
```

To get at the semantic relationship of partial substitutability between the two ring roads, query 2 and 3 have to trigger a traffic simulation model for each of the available transportation projects and check if the traffic on IL 23 would be reduced. However if query 1 were to be asked, the recognition of topological relationship of connectivity is sufficient to recognise the substitutability. Thus the question of substitutability becomes a question of substitutes with respect which attribute. If mere connectivity is the issue, then all the proposals are partial substitutes. However, if the intent is to find substitutes of an action that result in a state, in this case volume of traffic, then we arrive at different results. Alternatively the query could also be about the development pattern instead of a pure traffic volume, in which case land use simulation coupled with traffic model should be triggered.

6 Interdependent actions

Many actions have to be taken in concert to achieve a result. Actions, thus are interdependent with others. Two of the striking types of interdependence among actions are "complementarity" and "priority". Complementarity is the case when they mutually enhance each other with respect to a particular goal. Neither is dependent on the other in a functional sense. 'Prior' actions are those actions that are strictly necessary before the action is taken. For example, the existence of a "Right of Way" is necessary when a new road is proposed. Priority and sequence could be functional or temporal. Recognition of interdependence is necessary in deliberations, because an action cannot be considered separately from its interdependent actions in deliberations. Experts should be able to recognise the various interdependencies of actions based on their expertise and are able to make the entire group conscious of the issues. To illustrate the concepts of interdependence take the following example.

Metra, the regional rapid transit agency, has decided to extend the Milwaukee District-Northwest Line to Marengo and service is scheduled to begin within the next year. Both Marengo and Huntley are designated as the only new stops along the line. Metra requires both villages to build a station and provide adequate parking surrounding that station. Marengo builds its station just west of US 20, as identified in their comprehensive plan. Parking is provided south of the rail line adjacent to the station, and commercial uses surround the area. Local roads are extended to provide a grid system north of the rail line, and promote traditional residential neighborhood design. Railroad crossings are constructed just east of the station and a half-mile west of the station. Huntley builds its station southeast of the downtown, in an area devoted to industrial uses. Parking is yet to be determined. A single road provides ingress and egress from the site, and the village does not construct additional roads to support the station.

In this case the `ConstructNewStation(Huntley)` and `ConstructNewStation(Marengo)` is strictly interdependent with `ExtendTrainService(MD-NW)` and vice versa. A commitment to build either the stations or extend the service is not possible without the commitment to the other by different actors. The interdependence of actions is between the plans of three different actors. Further, the extension of train service has to have as a 'necessary prior' the existence of a sufficiently serviceable track. The construction of new stations at each location can only be a 'sequent' to availability of a site on the tracks for which the ownership rests with the Villages. The availability of the railroad crossings are necessary for the commencement of service.

Mitigating actions are also interdependent actions, in that the ill-effects of a particular action are remedied by other actions. The action set has to be pursued in a holistic fashion, at least to preserve the *status quo ante*. This interdependence is often seen in the accompanying environmental reports of transportation proposals or noise buffers between incompatible landuses.

6.1 Complementary Actions

Actions are complementary when their effect is synergistic. While the actions may not 'require' their complements, the actions tend to amplify the intended effect. As is the case with all other relationships among plans, the actions are deemed complementary when the effect caused, or specific intention is synergistic. The effect could be measured as a single attribute of the world or as the weighted average of a multiple attribute set. A highway proposal accompanied by a zoning change from AG to B4 on the parcels near the interchange could be considered complementary actions if the intended development is of such pattern. However neither is dependent on the other. A case of complementary actions is illustrated in the figure 7.

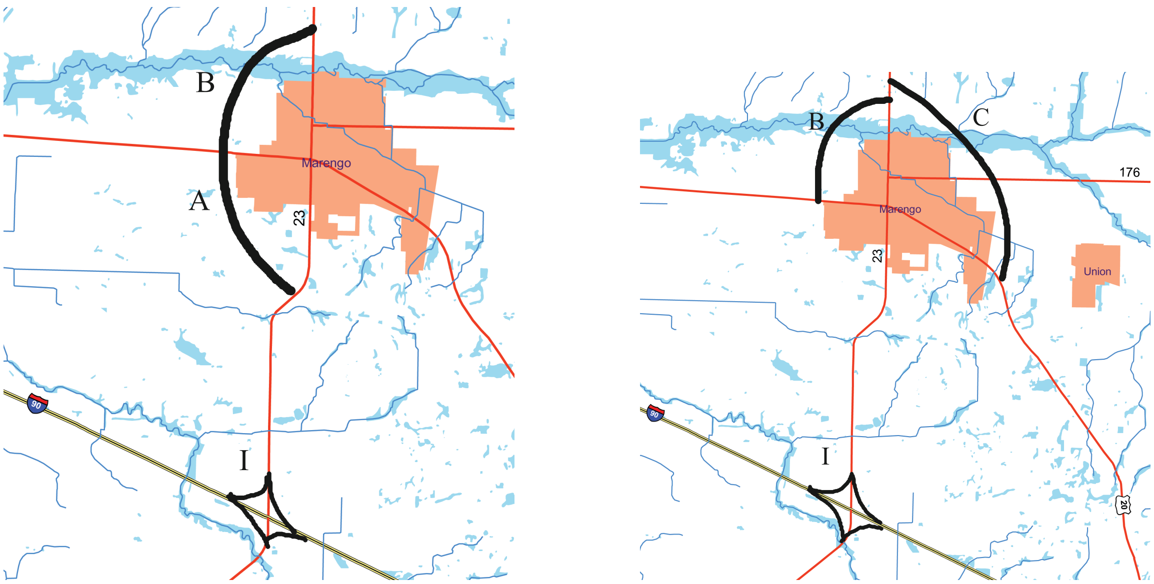


Figure 7: Complementary actions — Interchange and Peripheral Road

Interstate 90 runs south of Marengo and the proposal to connect IL-23 with it is I. Proposals for peripheral roads A and B are complementary actions to I because the traffic on IL 23 which increases through the interchange, is re-routed away from the city either onto US20 West or further onto IL 23 North. However the proposals B and C are not complementary with I because they do not accomplish the same objective. They can be complementary with changes to the interchange between US 23 and I-90 outside the county in re-routing the increases traffic on US 20, around the city.

To discover the question of complementarity, if it is not mentioned in intent explicitly in a plan, a simulation model needs to be triggered as in the case with discovery of alternatives. The model in this case is used to see if two actions result in an amplified intended effect.

7 Regulations

Regulations define rights. Or they re-define them. One reason why planning is contentious, is because it provides justification for changes in rights (Hopkins 2001). A change in the zoning ordinances is justified by future land use maps in plans to avoid spot zoning claims. Thus deliberations of different groups often focus on the implied changes in rights, in the plans. The rules and sanctions have spatial implications (see figure 8). They could be about where the rules will apply as in a geographical scope (city, county, nation etc.) or based on interrelationships between rights that manifest in spatial terms.

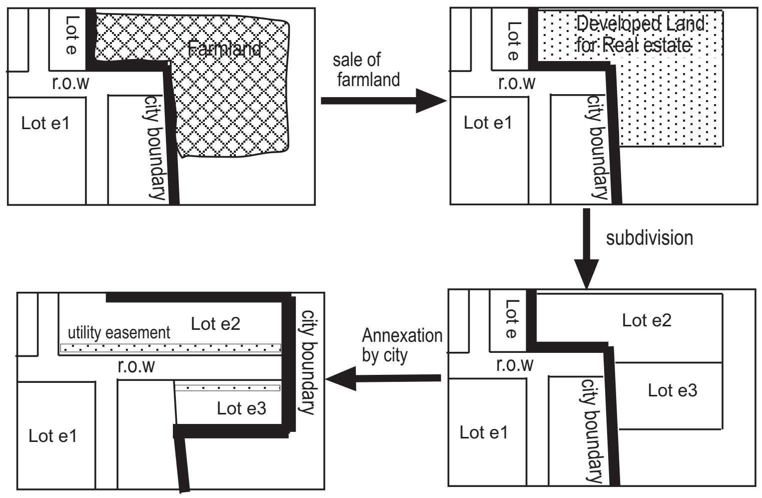


Figure 8: Rights change, crystallizing spatial changes

A simple case of regulations that are useful in deliberations is the zoning classification of a particular location or adjacent locations. The uses that are permitted, conditionally or otherwise is specified in the zoning ordinance, which is applicable at that time. The spatial extent of the jurisdiction of the zoning ordinance would be a determinant in deciding whether the ordinance is applicable to a particular parcel or not. However, as figure 8 shows, subdivision regulations might apply to parcels within the ETJ of a city, . Subject to annexation, they are also susceptible to changes in rights, manifested as changes to physical boundaries due to creation of new rights of way, merging of parcels and creation of utility easements etc.

Some regulations are based upon interrelationships between different entities. The following regulation, as shown in UML in figure 9, is applicable to parcels only when they are classified as R-4 or R-5 and if they are adjacent to a parcel that is appropriately classified. This regulation also supercedes any other regulation about the side yards in R-4 districts. Defeasible logic has to be applied in the form of facts, strict rules and defeasible rules and superiority relationships as specified in Antoniou et al. (1999).

> *The required side yard of a lot in the R-4,R-5 District shall have a minimum depth of 10' if it immediately adjoins the property in R-1,R-2 or R-3 district. In addition a landscape buffer of a minimum depth of 5' should be provided in the said yard.*
> excerpt from Urbana (2003)

In a public hearing about whether a proposed building plan could be approved under the current zoning classification, the interest groups must have access to this information about the zoning classification of proposed parcel, zoning classification of adjacent parcels and identification of 'adjacency' relationship. The following sequence of questions will identify the appropriateness of regulation in a particular decision situation.

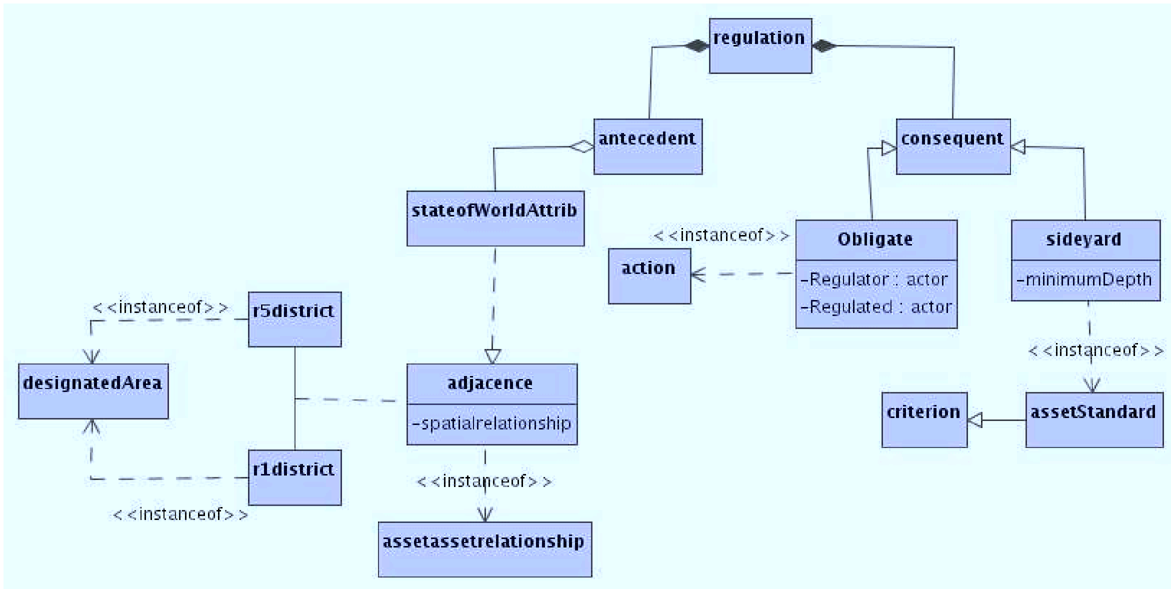


Figure 9: Regulation involving relationship between assets

Query1: `ZoningClass(x)`
Response: `R-4`

Query2: `Regulations(R-4)`
Response:
```
Permitted Uses ...
Conditional Uses ...
Special Uses ...
Yard requirements
Side yard adjacency
⋮
```

Query3: `AdjacentParcel(x)`
Response: `#1 #2 #3 ...`

Query4: `ZoningClass(#1, #2, #3)`
Response: `R-1, R-4, R-5`

Once the determination is made about which side of the particular parcel is adjacent to parcel of R-1 category, then the side yard required by this particular regulation is applicable to that boundary.

7.1 Interdependence between Regulations and Plans

To propose a change in an alignment of a road, or to increase the number of lanes, there should already be a public right of way in that particular place, so that the proposals can be built. The rights of way are defined in the official maps of the city and are easily representable in geographic data structures. The key is to connect the dots between the intentions and rights of way, and it is in such cases, expert's knowledge would be very helpful in directing the questions that people ought to ask in deliberations.

The case of a plan to create a TIF district is illustrative. A TIF district can be created only if the responsible actor has the right to create the TIF. In Illinois, the right is granted by the State of Illinois to what are defined as "municipalities". Other local taxing bodies are not permitted to create nor benefit from the increments of property taxes. The implementation of the TIF district freezes the revenue of the other local taxing agencies such as School Districts, Sanitary Districts at the levels of enactment period.Thus, while a plan for TIF can be in plans of voluntary groups of special districts, it is under the capabilities of a municipality. The plan to create a TIF would require enactment of an ordinance designating a certain geographical area within the jurisdiction. State law requires that enacting such ordinance would require a complete evaluation of the parcels to be designated as either "blighted" or as "conservation area" and findings of various other 'But for' clauses and adoption of a "Redevelopment Plan". For extended discussion on TIF districts see Weber (2003).

A strategy for economic development of a downtown district by creating a TIF presumes that another plan about the particular district would be made. It appeals to the capability of the municipality, granted by the state, to create the District. It seeks to curtail the rights of other other taxing bodies with respect to tax collection. The act under which this district can be created imposes restrictions on which parcels can be included or not based on certain conditions such as conservation, age of structure etc. In opposing or promoting this idea of redevelopment, the access to these kinds of information, tied to spatio-temporal context, is necessary.

8 Further Work

The relationships described here are only a beginning of the complex relationships that are present in plans and are available to different experts in their repertoire of knowledge. The key questions for further research are sketched below.

- Actions can be compositions of other actions. A `CreateTifDistrict` action can be viewed as a single action or a collection of `CertifyTaxBase` → `NotifyPublic` → `AdoptRedevelopmentPlan` → `SellBonds`. The issue of granularity of actions may prove crucial in deliberations depending on the expertise of the participants. (e.g. Worboys and Hornsby 2004)
- The relationships between events are defined to a reasonable abstraction in Allen and Ferguson (1997) and between spatial objects in Casati and Varzi (1999). Relationships should, however, be made specific to planning domain such as asset-asset relationships like "access requirements of a parcel".
- The object class hierarchy of relationship classes themselves should be identified. Differentiating between substitutability of actions structured, for example, in designs and strategies, should be pursued.
- Multiple representations of time as argued by Frank (1998) should be considered for sequences of actions, which matter for plans.

- A querying mechanism based on distributed, sparse databases, which is loosely coupled with different kinds of urban models, should be fashioned.

It is evident that the information systems and ontologies that support deliberations have to be designed in an user centric fashion. The questions people ask or ought to ask, were it possible, to an information system during deliberations should be the central theme of further research. It will involve procedural expertise about the nature of deliberations and substantive expertise about the content. In doing so, information systems have to be geared towards a specific field of application and should have the flexibility to interact with other systems. It is also evident from this paper that sequences of questions are crucial and the identification of pertinent relationships between actions can only be achieved through human expertise. Support systems ought to aim not to replace experts in their conversations with the laity, but to seek to recognise the pertinence of information available in distributed settings about spatial and aspatial information and to make the conversations meaningful.

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Appendix

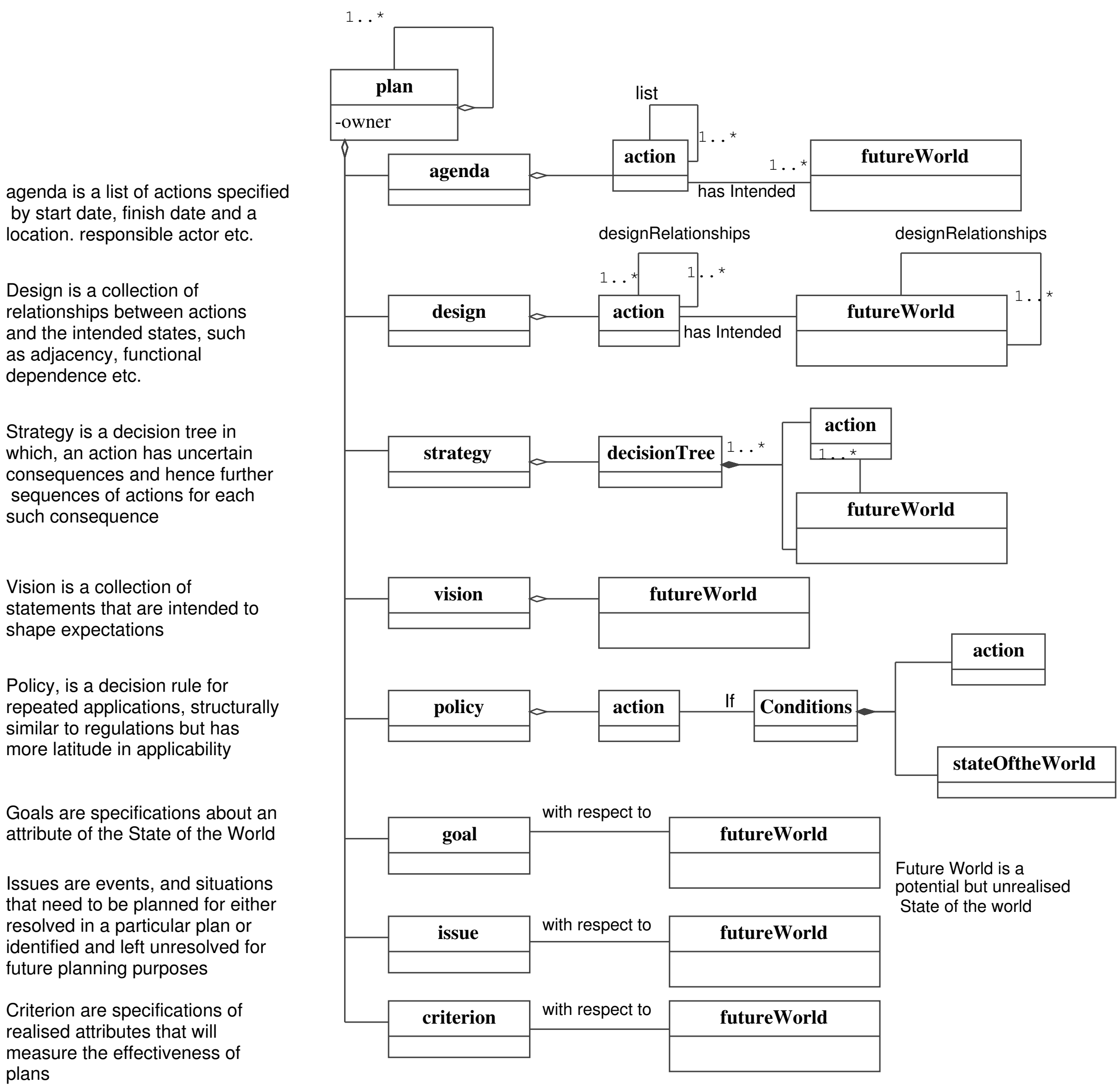

Figure A.I: Elements of plan — Source Hopkins, Kaza, and Pallathucheril (forthcoming)

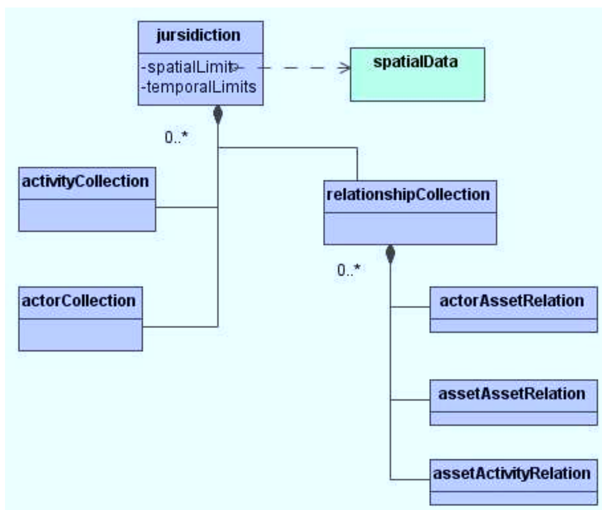

Figure A.II: Class Diagram of Jurisdiction

Glossary of Terms

Some terms are used in the paper with a specific meaning. An incomplete list is below. More complete definitions and object class diagrams are available in Hopkins et al. (forthcoming),

- *Actor* is a decision maker, who is not tied to location and has capabilities. Actors can be persons, organisations or populations
- *Roles* define specific capabilities of a particular actor, for e.g. Mayor
- *Asset* are entities that are situated in the spatio-temporal context and are subject to intentional change and used for activities. Assets can be facilities or equipment or intangible.
- *Activity* is aggregation of behaviour on an asset like traffic on a network etc.
- *Action* is the intentional event of an actor aimed at a particular objective to change the 'State of the World'
- *State of the World* is an all encompassing term to include, actors, their activities, their actions, the regulations in place and assets and changes to these.
- *Location* taken to be broadly construed to situate an asset in a context (spatial, temporal or functional).
- *Investment* are types of actions that specifically change assets.
- *Capabilities* are available to Actors based on their roles. Rights are of capabilities, Skills being one other.
- *Jurisdiction* is specific collection of objects (activity, assets, actions) in the spatio-temporal context, an authority of regulations is applicable.