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UPDATING PLANS: A HISTORIOGRAPHY OF DECISIONS OVER TIME

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EDITORS: Teller J, Billen R, Cutting-Decelle A-F

Nikhil Kaza
University of North Carolina at Chapel Hill, NC, USA
nkaza@unc.edu

Donovan Finn
University of Illinois at Urbana Champaign, IL, USA
dfinn@illinois.edu

Lewis D. Hopkins
University of Illinois at Urbana Champaign, IL, USA
ldhopkin@illinois.edu

SUMMARY: *Plans provide information about how multiple decisions are structured over time, and what the intentions of a particular actor are. As and when these decisions get made, or not made, some parts of plans become irrelevant, while some other new relationships are discovered and considered. Recognising this provides a useful way to interpret the changes in plans by tracking the decisions and vice versa. In this paper, we illustrate the complexities of an ontology of urban systems which are needed to ensure the currency of plans, so that they could be effectively used in urban decision making. Especially, when actors are numerous, jurisdictions overlap, actions are interdependent and interests are unstable, this framework enables us to think about plans in a complex and changing urban environment and make them so that they remain useful.*

KEYWORDS: *Plans, Ontology, Decision Sequences*

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1. MANY PLANS OVER TIME AND OF MANY ACTORS

Plans are useful because they consider interdependent sets of decisions ahead of time. These decisions taken at various scales and various times by multiple actors shape the aggregate pattern of cities both geographically and socially (Bourne 1976). Decisions about infrastructure investments or regulatory changes in urban settings are made by groups of actors who are partially cognisant of the intentions of others both within and outside the group. Thus, some of these decisions are informed by multiple plans of multiple actors. However, in making these decisions over time, the plans that inform them also are modified, thus fundamentally altering the relationships between current decisions and those that come after them. Furthermore, the decisions that are made represent a choice among the alternatives delineated within the plans, thus rendering some portions of the plan obsolete. Viewing plans as information that is useful in making decisions demands that the information within them be current and relevant. In this paper, we explore ontological approaches to keeping track of decision histories of various actors over time thus simultaneously modifying and updating plans that inform them.

The paper uses ongoing examination of planning, plan making and use of plans in Champaign, IL to illustrate how tracking and accessing the changing information in plans over time and among actors can help understand how urban development decisions are made. Specifically, we will use plans relating to downtown revitalisation, campus planning and community safety to illustrate how plans can and should consider the inherent interdependence of relationships in decisions and policy making within the urban landscape. In doing so, we look for information in plans that are situated *backward* and *forward* in time and *outward* in space and function with respect to other plans and those of other actors, by using both stylised and real cases. We extend previous work to provide illustrations of how an ontology of decisions which accounts for relationships among decisions, actions, and intentions helps us in maintaining the currency of plans.

In subsequent sections, we elaborate on the contingency relationships of decisions within a plan (typified by strategy) and interdependence relationships (typified by design). We then derive the temporal and other orderings of decision chains from these strategies and designs. By observing the decisions that are made and their situatedness in these plans, we archive some portions of the plan material as irrelevant to future decision making. This allows us to explore further relationships between decisions and their outcomes, which have not been envisaged in the previous versions of the plans. We then also touch upon situations in which a subsequent plan completely overrides a previous plans due to fundamental changes in the perceived importance of the relationships and other values which are inherently political. In doing so, we provide yet another justification for developing an ontology for plans in urban situations that is cognisant of the complexities of multiplicities of actors, intentions, goals, decisions and interactions.

2. EXAMPLES OF PLANS OVER TIME

The 1974 City of Champaign Comprehensive Plan addresses the city's core downtown area on less than three pages. Despite noting that Market Place Mall is set to open on the city edge, the authors of the plan emphasize only that the imminent creation of a covered pedestrian mall on Neil Street is an "obtainable and reasonable solution to the problem of maintaining a strong tax base in the Central Business District (CBD) and preserving it as a viable part of the community's cultural life,"(Champaign County Regional Planning Commission 1974, p.87). The only other downtown-oriented actions suggested in the plan are to 'curtail'(p. 87) certain commercial uses on the edge of downtown and to replace a medium density residential district west of downtown with higher density uses to "buffer low density residential uses from the Central Business District," (p. 84).

By the next Comprehensive Plan six years later the attitude toward the downtown has shifted (City of Champaign 1980, Champaign County Regional Planning Commission 1979). No longer just a brief mention, retention of existing users and attraction of new ones has become a more important aspect of the plan. The downtown is mentioned throughout the plan, under topic headings such as 'Growth' (p. 1-2), and 'Commercial Development' (p. 1-4), in which the issue of facilitating a more vibrant downtown through active government intervention is a primary focus, resulting in objectives such as, "Encourage downtown redevelopment and allow flexibility in building codes, but without jeopardizing life safety," (p. 1-5), and "Direct a substantial percentage of new development to areas inside the existing City limits, particularly to the downtown core", (p. 1-2).

By 1992, preservation and revitalization of downtown had emerged as a prominent enough issue to warrant creation of the 1992 Downtown Comprehensive Development Plan (Urbanics and BRW 1992), followed by the more detailed Downtown Plan in 2006 (City of Champaign 2006). Both argue for the focus of substantial city efforts on the limited geographic area of the Downtown, in order to create a space that will benefit the city as a whole. As circumstances and stakeholders change over time, plans change, too. However, certain elements of old plans may have gained traction and persist in reality even as they are omitted from newer plans. The 'stickiness' of these schemes has implications for urban development and there is utility in tracking them through time.

Now that we can update single plans as and when decisions get made, we must consider the idea of multiple plans informing a single decision situation. Different actors have concurrent plans, some of which are interdependent. For the purposes of brevity, we consider here only those plans where explicit relationships between plans are acknowledged in plans which are still 'valid'. In such cases, the actor responsible for the decision is an attribute of the decision situation and thus the reasoning is no different from earlier sections. If one plan specifies a decision is subsequent to decisions of other actors, and if such other actors identify other contingencies between those actions, then we can begin to reason about further interdependencies between decisions of one actor and actions of another. What becomes interesting, however, is that this provides another

justification of the ontology as a standard representational device to encode the plans of all these actors so that such connections can be made.

The University of Illinois Campus Area Transportation Plan (CATS) (University of Illinois 1999) argues for enhancing multi-modal transportation access in and around the campus. Some tactics, however, extend well beyond the spatial extent of the campus. On page 74, the plan suggests widening Springfield Avenue where it connects the southern tip of downtown to the northwest portion of campus between Neil and Wright Streets. "In order to widen portions of Springfield Avenue," the plan notes, "it would be necessary to replace the existing viaduct at the railroad tracks to accommodate additional travel lanes and semi trucks. The City of Champaign and the University should work with [Illinois Department of Transportation] regarding the replacement of this viaduct." To increase multi- modal access within the campus, the Universitys plan is contingent on the plans and actions of other actors well outside the campus; this is not an unusual situation.

Actor `University` has a plan which identifies `Widen Road` as decision contingent on `Replace Viaduct` . However, the actor who is responsible, or has the capability to replace the viaduct is the group of actors consisting of the `City` and the, `Dept. of Transportation` . If either actor balks at replacing the viaduct, then the University cannot expand the road. This has a cascading effect on other plans of the university which were contingent on the expansion of the road, such as if and where to build a parking structure or transit transfer station. Thus, the decision by the Dept. of Transportation, indirectly changes the plans of the University.

Likewise, actors may make plans that directly attach their own future actions to existing or planned actions of other actors. The Champaign Police Department, for instance published a Five Year Community Safety Plan (Champaign Police Department 1995). The first goal in the plan was to address the issue of "Total Crime" in the community; the first strategy to address that goal was, "To comprehensively address infrastructure and service needs in threatened areas," (p. 28). The first action under this goal is to "Combine efforts between police and planning departments in the on-going evaluation of neighborhoods in which to begin to develop specific improvement plans," (p. 28), and to "Integrate neighborhood needs into the multi-year strategy for infrastructure improvement included in the [Capital Improvements Program] and public works maintenance programs throughout the city" (p. 28). By integrating land use and service provision within a policing and safety plan, the Police Department illustrates the utility of being able to track the plans and decision of other actors when making a plan; the police department is relying on the actions of the planning department as a way to combine these two currently unconnected activities in order to serve their own needs.

The indeterminacy of relationships of all actions in plans, provides useful opportunities to expand on existing plans. It is imperative to acknowledge that, to consider and encode 'all' possible contingencies and interdependencies between various sets and subsets of actions is unreasonable expectation of plans and planners. The plans specify only relationships between specific combination of actions that are of particular interest to the decision maker. As and when some alternatives and decisions recede from the decision situations, they provide opportunities to add or reconsider other actions and decisions and how they might relate to decisions that are being considered and yet to be taken.

3. DECISIONS AND PLANS

Plans provide guidance to decisions that are to be taken in different circumstances (Friend and Hickling 1997). Different actors have many plans, which change over time. Each plan considers interdependencies and contingencies among decisions by different actors at the particular time point and provide useful indicators about commitment. Decisions themselves are types of actions (Kaza and Hopkins 2007), made by an intentional actor prior to action. In this paper, we conflate actions and public decisions.

One of the key claims of Hopkins et al. (2005) is that information in plans is organised according to relationships between sets of decisions and actions. Two such kinds of relationships are particularly important to us: Strategy and Design. Strategy deals with uncertainty of actions and outcomes, whereas designs deal with interdependence and complementarity between actions. Such structuring of relationships between decisions helps us understand if and how plans are being used when the decisions get made. In subsequent sections, we elaborate on these relationships and use them to identify how decisions that are based on them could be used to update plans.

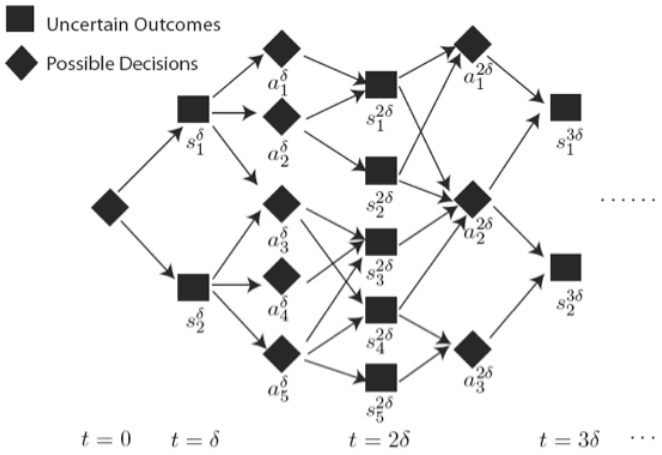

FIG. 1: Relationships between decisions in a strategy

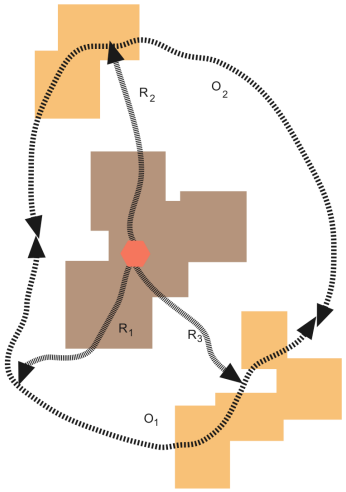

FIG. 2: Infrastructure Investments as a strategy or a design

3.1 Strategy

The most complicated and useful exercise of planning is to recognise uncertainty of outcomes of actions and plan strategically with respect to goals and criteria. Thus in a particular plan, strategies specify to sufficient depth (Fig. 1), possible outcomes as well as possible actions in response to those outcomes (Friend and Hickling 1997). If two actions (or sets of them) are considered substitutable with respect to a particular outcome then the resolution of which action to pursue has been left for a future time. These actions are in response to an uncertain situation that characterises the decision situation.

The strategy could thus be represented as a directed graph delineated by events. The representation in Fig. 1 uses time as opposed to events. Passage of time is one kind of event. The occurrence of any state could be an event (Worboys 2005). In case there is only one such outcome, such as taking action, there strategy merely represents contingency relationship between two actions. Thus, contingency is a crucial relationship made explicit by the strategy. When only one such contingency relationship is delineated between two actions, (Hopkins et al. 2005) call it Policy.

The transportation improvements plan in Fig. 2 could be modelled as a Strategy. For instance, it may be the plan of the central city to first connect the suburbs to the central city and if and only when there is enough demand between the suburbs, connect it via the ring roads.

ActionSet1(R_1,R_2,R_3),
NetworkConnect(R_1,R_2,R_3)
Precedes (ActionSet1, O_1), Precedes(ActionSet1, O_2)
…
If Population(Suburb1) > D_1 then Build(O_1)
If Population(Suburb2) > D_2 then Build(O_2)
…

Thus, the building of the ring road is contingent on which suburb reaches a population threshold, however, building of the radials is not contingent. They are pursued regardless of the circumstances.

3.2 Design

Fundamentally, design is a tightly worked out set of actions which sit in relation to other actions and when taken together achieve a desirable result. Design can thus be thought of, as an intentional action set, whose member actions are related to each other and the make up is deliberate, and are to be taken in concert to bring about a particular state of the world. Such relationships that are of particular interest in urban planning are spatial relationships such as `adjacency` and `distance` , functional relationships such as `connectivity` , actor-asset relationships such as `ownership` or other actor-action relationships such as `responsibility` .

A familiar example of a design is the design of a building. It can be viewed as an outcome, where the constituent parts fit together coherently. A key point, however, is the design could be that of a building or more elaborately could be that of actions that bring into being the constituent parts (see Fig. 3). In other words, a construction management plan of a building is also a design, as are the architect's conceptual relationship diagrams, or the detailed construction diagrams. On the other hand, we are also interested in designs which draw from a social science perspective. Excellent examples include the hierarchical structure of an organisation (e.g. firm). A division of labour in a group working on a project, coherently specified, is a design. Lest it be taken that designs are necessarily static in nature, that need not be so. Any process can be viewed as a state or an outcome and thus specified relationships between outcomes could be relationships between processes.

The transportation improvements plan in Fig. 2 could be modelled as a Design. In this case, the three radial links would be considered together because they would only be effective in strengthening the core if all the links were built. And the two ring road links would be considered together because they would only be effective in improving peripheral access if 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. This is a very simple instance of design relationship.

A design, however would be that the combinations of R_1,R_2 and R_3 has to be done in conjunction with the O_1 and O_2
ActionSet1(R_1,R_2,R_3),
ActionSet2 (O_1,O_2)
NetworkConnect(R_1,R_2,R_3)
…
NetworkConnect(O_1,O_2)
Precedes (ActionSet1, ActionSet2)
Connect(ActionSet1, ActionSet2)

Broadly construed, we are concerned with the design relationships which are spatial, functional, temporal and mereological in nature. Spatial relationships include distance or qualitative spatial relationships such as front and back (Freksa 1992). Functional relationships are the actor- asset relationships such as ownership, or asset-asset relationships such as connectivity (Kaza 2004). Mereological relationships such as parthood or membership and subset relationships are treated naively without references to the topological issues raised by Casati and Varzi (1999).

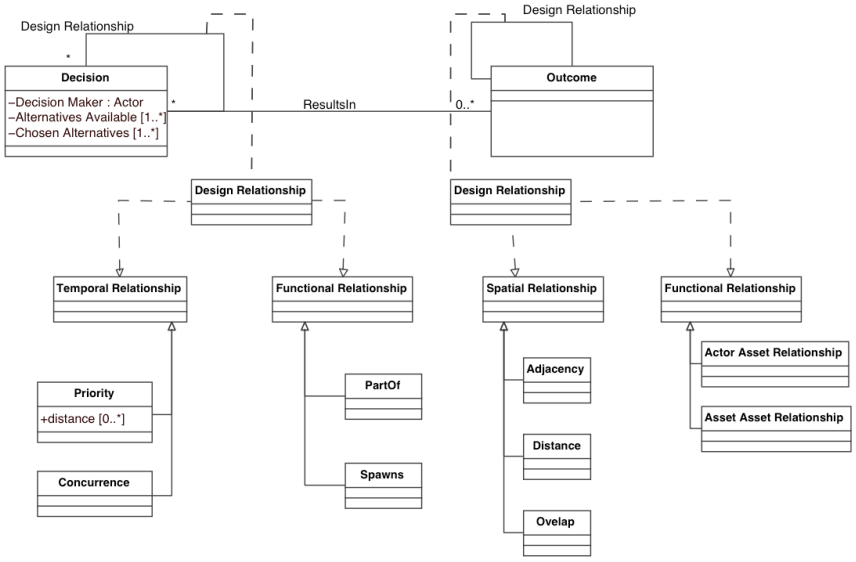

FIG. 3: Incomplete design relationships

Fig. 3 specifies an incomplete list of design relationships. Though contingency could also be a design relationship, since it is explicitly dealt within strategy we do not represent it in this diagram. This, however, points out to an important idea. Plans do not specify a pure design or a pure strategy. In fact, an action which is a part of a design could very well be contingent upon another or substitutable with another. Or the action that is specified as a response to an uncertain outcome in a strategy is a composite action which on close inspection turn out to be a design. For example, if building the a ring road and expanding the transit system are two possible reactions to an increase in traffic volume in the city, each of these seemingly monolithic actions are truly designs.

4. PRIORITY & CONTINGENCY

Following the characterisations of (Worboys and Hornsby 2004) and (Kaza and Hopkins 2007), decisions are events not necessarily rooted in time. Just as we need to divorce the notions of Assets and Actors from location, we also need to divorce events from inherent underlying framework of time. In this paper, we are limit our scope to decisions that are instantaneous in nature, that is they do not occupy an interval in the characterisation of (Allen and Ferguson 1997). However, the decisions may produce effects that unfold and endure over time. For example, a decision to `build (Road)` brings an `asset` into existence, which endures over its lifespan or till another action deliberately brings about its destruction.

Grenon and Smith (2004) and Worboys (2005) distinguish two different modes of representing event relationships. One is SNAPshots of states arranged on the temporal axis, and the other which is primarily focussed on the processes (existence, modification etc.) that occur in a SPAN of time. Both kinds of representation are useful and in fact reasoning for urban systems should consider both modes of representation without too much emphasis on the rigorous and exact translations between the two. Activities, such as shopping, travel, residing etc. are processes and the level of activity — volume of sales transactions, traffic count on a link etc.— are also Snapshots of states.

Since plans are made for contingent futures, the occurrence (or non- occurrence)of a particular future is an event the plan is supposed to address, irrespective of its location on the temporal axis. The temporal location of the event is useful only for the purposes of discerning relationships to other events. Thus, an event set can compose of temporal relationships such as `before` , `lag` , and `temporal adjacency` as primitives, without inferring them from location on the temporal scale.

Furthermore, these relationships are ephemeral and particularistic. For example, a plan of city government may suppose event *A* is prior to *B* (building the ring road first and expanding the connectors to the center later in the figure 2) and choose to plan for such a future (by scheduling the capital improvements plan and budgets accordingly). However, the suburban development at the fringes may suppose the opposite precedence relationship – it may be more useful to get to the employment center in the city first than to connect to other fringe development. Especially when the issue is who gets to act on which subset of actions in the design, plans of multiple agents may presume incongruent event relationships. Furthermore, different plans of the same agent may prescribe different courses of actions for event sets, which in different futures may be related differently.

To update plans using histories of decisions and actions, we consider two relationships that are closely tied to each other but nevertheless offer sharp distinction on reasoning about updating plans. They are contingency and priority. An action is prior to another temporally. If action *A* occurs before or after *B*, then they share a temporal relationship. Temporal priority is a binary relationship that arranges actions on a temporal scale. The crucial difference is that we have to observe the occurrence of both *A* and *B* to make judgements about such arrangements. Functional priority implies temporal priority, while not the other way round. Functional priority is contingency. An action *A* is functionally prior if it is necessary before the occurrence of *B*. In other words, if we decide to do *B*, we have implicitly decided to bring about *A* or at least observe that *A* has occurred. If a soil conservation group recognises the contingency of a corridor study and its recommendations as necessary for the building of an interchange *I* and if it believes that building *I* is inimical to its goals, then it could reason that lobbying for strong representation of its concerns during the study process would produce an unfavourable recommendation, and thereby not bring about *I*. This course of action when it is made explicit in their negotiations with the County, which favours the interchange, could enact regulations that conserve the farmland to assuage the concerns of the conservation group.

5. DECISION HISTORIES & CHANGING PLANS

Partial Orders thus frame the reasoning for decisions within a plan on the temporal scale. Keeping in mind the adequatist, fallibilist and particularlist model of reasoning and representation (to use the words of Grenon and Smith, 2004), partial orders are sufficient for the purposes of this paper. For example for actions *A,B* and *C*, `precedes(A, B)` and `precedes(C, B)` taken together make no claim about the precedence or any other relationship of *A* and *C*. If these two relationships are apparent in a plan, an action *X* is contingent on occurrence of *B* is also contingent on occurrence of *A* and *C*. When decisions are set in the indeterminate future, they are set typically without any reference to the underlying temporal structure but are ordered by the relationships among them.

However, when decisions are taken/observed they are situated in a well-ordered temporal axis. That is, each decision is time stamped. This allows us to reason with the actions and compare them to their situation, set in plans. If a plan *A* specifies `Contingent (C, D)` , we can infer the temporal relationship `precedes (C, D)` . However,if we observe C_{t1} and D_{t1}, thus deducing the temporal relationship `concurrent (C, D)` , then the plan is not useful in guiding us with the reasoning about intended actions and thus need to be updated.

On observing a sequence of decisions by an actor, we can match them to the plans of the actor. In particular, if any of these actions are specified in a strategy, then we can trace the contingency relationships by traversing the directed graph backward to see if any of the previous decisions are identified by this strategy. Furthermore, even when the decisions are not observed, but the outcomes are, then we can speculate on the actions that were taken that led to the outcome[1] . The subgraph that is rooted at the current decision node traversed backward is useful only for archival purposes and does not contribute to any future decision making. Thus, the strategy can be updated by archiving the subgraph.

If any of these decisions match a decision node of a strategy, we should look for decisions/actions that are forward from that node on to consider the effect of the current decision on the future decisions. That is the subgraph of the strategy that is rooted at the current decision node and traversed forward is most useful for determining the contingent decisions. The other uncertain outcomes and decisions that are not a part of either of the two subgraphs are still useful to maintain as a separate strategy for they may be useful in other decision making when such state of the world occurs.

Thus, a particular strategy would undergo transformation into multiple strategies, some useful for their historical relevance and others useful for decision making. In particular, the two strategies that are still yet useful could be further elaborated to consider other uncertain outcomes that were not yet identified in the previous version of the strategy. This process maintains the currency of the strategies and therefore that of plans.

If any of the subset of decisions/actions match a part of design, then we can recognise that all the other actions that are part of the design when taken follow the 'design relationships' within the design. That is for assets, O_1 and O_2 `Network Connect(`O_1,O_2`)` , specifies a design relationship. Even when O_1 occurs without O_2, we can deduce that, if the design is followed, if and when O_2 occurs, O_1 and O_2 are related through a `connectivity` relationship. If, however when O_2 occurs and connectivity is not satisfied then the value of the design lies in identifying how such change affects all the other design relationships, in particular the connectivity relationships, between R_1,R_2 and R_3. Thus, the design is modified to suit the circumstances.

On the other hand, when the plan does get updated, due to a change in circumstances, then previously known contingency and priority relationships may be discarded and new ones are specified. When plans are changed in this fashion, they are changed either due to change in composition of actors who make the decisions, change in direction of policies and strategies or different modes of evaluation of the contingencies and interdependencies. Such changes, though not anticipated from a logical system point of view, once made, provide useful information about the relationships between decisions. In this case, the new plan supercedes the old plan by keeping some actions, discarding some, and changing some relationships between them. A case in point is the example below.

If a strategy A is present in a plan P_{t1} and B is present in that of plan P_{t2} with explicit provision that P_{t2} supercedes P_{t1} in informing decision making. However, A is only superceded by B only if the same decision node occurs in both A and B. If the subgraph that contains all the decision nodes forward from the all common decision in A be called T, then the directed $A \setminus T$ is still useful information for other contingencies and uncertainties that are not considered in B. Thus, some portions of previous plan are still relevant for decision making.

In the case of design, however, inferring these changes in relationships is a more onerous task. One design may be alternative to another as a whole even if they do not share any constituent action items. Such alternatives are decided based on capability or location constraints or substitutability with regards to intentions (Kaza 2008). In such cases, the subsequent plan which explicitly supercedes the original plan, completely replaces the design. Further elaborations are left for future work.

6. ENCODING PLANS

The paper's descriptions of the nature of reasoning with plans and updating them once the information is structured in the plans using the ontology, depends crucially on the interpreting and encoding the unstructured plans in the first place.

The dissertation assumes that some plans of organisations would be public. This assumption is widely supported by empirical observations in urban settings. However, some plans of organisations are also necessarily secret (Kaza & Hopkins 2009). The willingness to share the information in a plan, let alone in a structured way, is dependent not only on the strategic nature of the purpose of information, but also on the charge and culture of the organisation involved.

The structure described in this paper is for accessible plans. In other words, no consideration is given to the degree of accessibility, to whom the plans are accessible and control of such. One can only look at other information systems such as spatial data infrastructure and management information systems to acknowledge the trials of getting organisations to share and use information. One of the key components that needs to be addressed in future work is the question of granting privileges to particular information to particular kinds of actors.

Even when such information is accessible, the timeliness of the information within the plans is always questionable. Plans do not record actions that are already taken. They portend possible action, and thus, there is inherent uncertainty about whether the actions will be taken or not. Plans are continually changing due to

changes in circumstances, planning processes that never stop, and modifications to account for interdependencies discovered after a plan is authored. The proposed data structure does account for these changes by encoding plans not as monolithic documents but as a web of relationships that can be woven and re-woven as and when it becomes necessary.

However, the particular organisation whose plan it is always has a strategic advantage as to whether the relationships specified in the plan still hold. It may or may not be in the organisation's interest to make this information widely available. Nevertheless, the dissertation sidesteps the question of whether organisations have incentives to maintain the timeliness of the information over which they have control. Furthermore, it does not address the question of how one should account for the relevance of information. Is a plan made a few months ago more relevant and more accurate information about current intentions than a plan made a few years ago?

While plans may be made public by the author or the owner of the plan, one can also observe others' actions and infer their plans. In such cases, one can identify particular relationships among decisions, actions, and intentions of others and interpret them. Such interpretations depend on the cognitive capacity and organisational ability of the interpreter.

Structurally such interpretations and inferences of plans are no different from the plans that are made public. Nevertheless, added uncertainty about interpretation to represent `true' intentions, should figure into the need to qualify the discovered relationships of substitutability and interdependence based on these interpretations as opposed to owner published and maintained plans. Irrespective of whether the plan-owner makes the relationships explicit or one infers these relationships (substitutes, interdependence etc.) between actions through interpretations, the relationships are still useful in deciding what one should do and how these decisions are affected by the actions, or possible decisions of others.

7. CONCLUSION

We have illustrated some ways in which keeping track of the decision histories of various actors over time can help inform decisions within urban development situations. These arguments provide a rationale for development of an ontology of plans that recognizes the complexity of decision- making in towns and cities. Subsequent stages of this work must overcome the obstacles to development of such an ontology when multiple plans do not acknowledge one another's existence, yet are nevertheless contingent and/or interdependent. This situation is common, yet requires a system for unmasking these hidden connections if the system is to be useful (Kaza 2008). Nevertheless, maintaining the currency of plans is an important application of the ontology of urban systems, so that these different plans over time can be used in decision making by various agencies.

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