Enhancing personal information management tools with spatio-temporal information. (Research Report)

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Abstract. Personal information management tools, such as todo-lists or calendars, are commonly used to schedule, plan or remember future intended activities. The spatio-temporal dimension of these activities has attracted researchers in the field of GIScience, using time-geographic notions of accessibility, space-time stations or prisms, to develop theories and methods enhancing the capabilities of personal assistant applications. This work is an attempt to enable a multi-dimensional representation of activities from an personal perspective. It allows for space, time and other dimensions to be incorporated. The framework is then employed to propose a formal definition of intended activities; the concepts ought to be stored in personal information management tools.

1 Introduction

Calendars or todo-lists are tools developed with the aim to store information externally, in order to ease the cognitive workload for remembering everything. Norman [29] termed such tools *cognitive artefacts* and their main purpose is to extend our cognitive abilities. In times of mobile and ubiquitous computing scheduling tools became digitally available. Still, as a recent study has shown the acceptance of digital calendars is not considerably high [37]. In fact most people prefer traditional paper tools. One reason (amongst various others) for this, might be the fact that the digital portations are in most cases simple copies of the analogue ones. They are in general *horseless carriages* [1], not actually making use of the computing/sensoring power available on modern mobile phones or tablet computers. Space and time are important structuring principles for human knowledge representation [18] and as prior work [2,33] has shown, the abilities of task-planning applications can be enhanced by contextualizing tasks and events by their spatio-temporal dimensions. Time geographic concepts, such as space-time stations, space-time paths, trip-chains or space-time prisms play a significant role for reasoning about people's schedules and their translation into spatio-temporal movement [32].

Nevertheless, looking at the advance in mobile computing, it appears that the time geographic framework will not be sufficient to develop next generation personal information systems. Many of our personal tasks involves the movement of

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[1] http://en.wikipedia.org/wiki/Brass Era car

small objects, like groceries, laptops, books and the like; "objects of human scale" [30]. In a recent paper, Goodchild [9] suggested that *"...it will be possible to know where everything is, at all times"*. Considering RFID sensors or object recognition capabilities of future wearable devices[2] [3] this assumptions is not too far fetched. Hence, future systems might be able to incorporate object requirements into task representations. On the other hand it is suggested [38,39,4,41] that people conceptualize space into places ,i.e., discretize space. Therefore, places have to be in focus rather than space, leading towards a "Place-time Geography".

Another point not explicitly discussed in literature is the distinction between activities and intentions. Activities modeled are assumed to be relatively well defined and the question of how exactly the activities are generated is hardly addressed.

In brief, the past developments in mobile computing led to the use of time geography as a framework to model and reason about human activities from a user-centered perspective (e.g., can I do this after that?). But, future prospects suggest that the *space-time cube* will not suffice to model and reason about user activities, once more dimensions than space and time are incorporated. At the same time, there is no thorough discussion about the deriving process of intended or planned activities. In personal assistant tools *intended activities* are essential concepts that need to be stored and reasoned about. Henceforth, a clear understanding of their structure and how they come into being is necessary.
Therefore, the contribution of this work is twofold: (1) A framework that abstracts time-geography into a multi-dimensional, potentially extendible, discrete space that allows for (2) a formal definition of *intended activities*.
The paper is structured as follows: Section 2 reviews prior work in the GIScience community and discusses the nature of intended activities. In the 3. section we introduce an abstraction of the space-time cube, which is then extended to contain multiple dimensions. Section 4 shows how intended activities can be formally represented. Finally the last section concludes the work and discusses the lessons learned and potential future research questions.

2 Related Work

2.1 Human Activities in Time Geography

Human activities and their unfolding in space and time has been and still is a major topic of investigation for geographers [10,7,20,23]. In particular the work of Haegerstrand [10] and Chapin [5] are considered starting points for the study of human individual or group behavior in space and time. Hagerstrand's seminal work [10] put emphasis on constraints that reduce the potential choices of activities to be conducted. In Millers words :

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[2] http://www.google.com/atap/projecttango/

[3] http://www.google.com/glass/start/

> Time geography highlights necessary conditions for participating in activities distributed sparsely with respect to space and available only limited durations.

Among those constraints are naturally, but also socially or institutionally imposed ones. The framework is very well suited for describing *potential activities*, i.e., the opportunities to complete a task under certain constraints in space and time [42]. Recent work took a more rigorous stance by developing formal models that allow for precise definitions of, and computation with, the prior informal concepts (i.e., Space-time prisms, -paths, -stations) developed in time geography [21]. The concepts are basically modelled as subsets of a n-dimensional space that forms a metric. The sets then are either used as a representation of a human activity (i.e., a space-time path) or a space within which some human activity has to take place (i.e., space-time station) or can take place (i.e., space-time prism). Many more notions are available that add complexity to the possible configurations of activities, such as flexible space-time stations or space-time projects [6]. However, in the wake of information and communication technologies (ICT), researchers have realised the need for an extension of the framework to include activities that cut through space. ICT allows people to communicate and participate in activities in virtual space despite being at physically disjoint

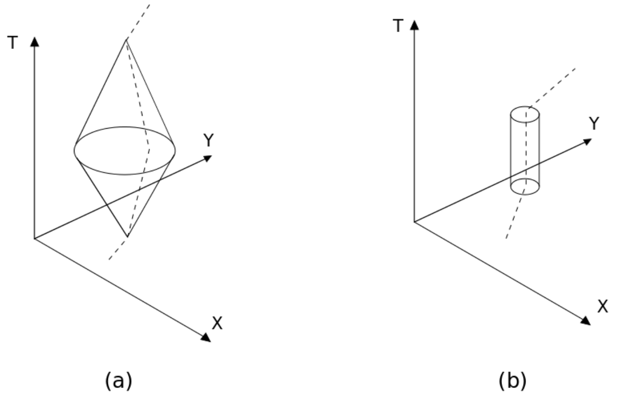

Fig. 1. Examples of core concepts in time geography: (a) A space-time prism with a space time path going through it. (b) A space-time station equally having a space-time path running through it.

locations. Therefore the notion of *tele-presence* was introduced by Janelle and Hodge [17]. Miller put forward a formal theory to add space-time portals that allows to model access to virtual space [23]. In the context of the current paper the most important point though is, that the underlying definition of *human activity* basically is a space-time path. That is formally "*a list of measured control points strictly ordered by time; and inferred path segments between temporally adjacent control points*" [23]. Time geography therefore takes a rather *physical* perspective on activities and does ignore many of the *meta* attributes (e.g., motivation, needs, purpose) related to activities. Addressing this issue, Raubal et. al [32] developed a theory that extends the merely *spatio-temporal* view on activities and incorporate social and cognitive factors, leading to a user-centered theory of location based services (see Figure 2.1). The authors discuss how spatio-temporal but also social constraints affect the set of possible configurations of activities. The model they developed would then allow sophisticated queries and allow for task scheduling and constraints. In other work, Raubal et. al [33] explored the use of time geographic constraints for group task planning. Apart from the theoretical approaches, work can be found that implement some of the ideas. The prototypical "LatYourLife"-application [1] time geographic constraints were used as a theoretical underpinning to compute dynamic alerts based on a user's position in relation to an upcoming event; a feature by now implemented in the Google Now[4] service. More sophisticated systems, such as presented by Steward et al. [36], use an ontological representation of calendar events incorporating spatio-temporal information, that allows to reason about

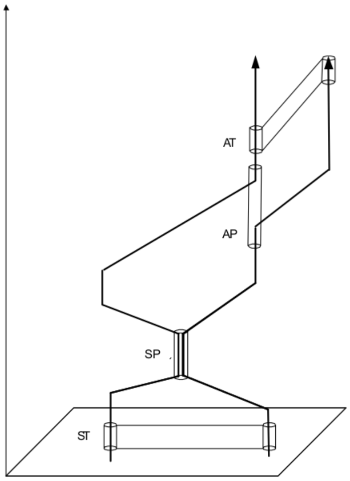

Fig. 2. Presence and Telepresence. Taken from Raubal et al. [32].

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[4] http://www.google.com/landing/now/

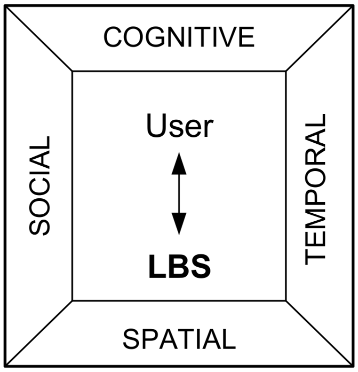


Fig. 3. The cube illustrates the dimensions along which the activities are modelled. Taken from Raubal et al. [32].

constraints that derive from it. The representation in the work, though, neglects the varying semantics of activities. A flight exhibits a different structure than a lecture. A system capable of handling varying *shapes* of activities needs to be able to understand the difference. Furthermore, often there are conditions that need to be met in order to achieve tasks, such as bringing a laptop etc...

To conclude this section, it is safe to say that the time geographic view on activities allows for reasoning and inferencing about the potential of activities. On the other hand, it narrows the understanding of activities to mere physical movement in space and time, thereby ignoring many of the additional semantics activities exhibit.

2.2 Understanding Plans and Intended Activities

Planning still is and has been a subject of investigation in several scientific fields, such as AI, Psychology, Cognitive Science or Urban Planning. In classical AI, planning is treated as a search problem, that is, finding a solution from a given state to reach a goal state [31]. In urban planning some stress to investigate the inner workings of plans, such as their agendas, the policies or their visions [15]. In cognitive science, a plan is put in the context of the more general problem-solving process that includes monitoring and execution. Hayes & Hayes ([11],p. 2) provide the following definition of problem solving:

> ...the predetermination of a course of action aimed at achieving some goal. It is the first stage of a two-stage problem solving process. The second stage entails monitoring and guiding the execution of the plan to successful conclusion. We refer to these two stages as planning and control.

Thus definitions can be based on different aspects of planning (e.g: goal-definition, plan-formulation, monitoring, plan-adaption, etc...)[35]. So there seems to be little consensus on what *plans* exactly are. In general, though it can be said that

planning expresses goal-directed behavior [35], distinguishing it from unconscious behavior of a physical object.
Investigating the motivational antecedents of plans, Kreitler and Kreitler [19] use the term *'Behavioral Intentions'*, referring to a concept that represents the answer to the question of "What will I do?". A behavioral intention leads to the selection of an appropriate pre-defined *behavioral program*. In case such a behavioral program is not found, a plan is formed. Intentions, therefore, play a crucial role for the formation of plans. Thus, a meaningful representation of intentions is a prerequisite to planning.

Gollwitzer [8] distinguishes between *goal intentions* and *implementation intentions. Goal intentions* come in the form of "I want to reach x"; *implementation intentions* specify the situation related to the behavior leading to the goal, such as "When time = x, then do y (to reach z)". In that sense, implementation intentions are specifications of the former goal intentions.
In conclusion, for a system to be able to reason, monitor or conduct automated planning, a clear formal definition of an *intention* has to be developed; a task the remainder of this paper is concerned with.

3 A discrete Framework for spatio-temporal activity representation

3.1 Discretizing Space Time Geography

The aim of this work is to propose a formal definition of an *intended activity* in a multi-dimensional space that incorporates more then only space and time. We start by looking at the agent representation from a discrete perspective by defining a set of 2 dimensional states:

$$AS = (P \times T) \tag{1}$$

P is a finite set of places to be considered and T a set of time-points at a certain granularity (i.e., minutes, 5 minute intervals or hours). T forms a totally ordered set $\langle T, \leq \rangle$ and thus is antisymmetric, transitive and total (e.g.: Integers).

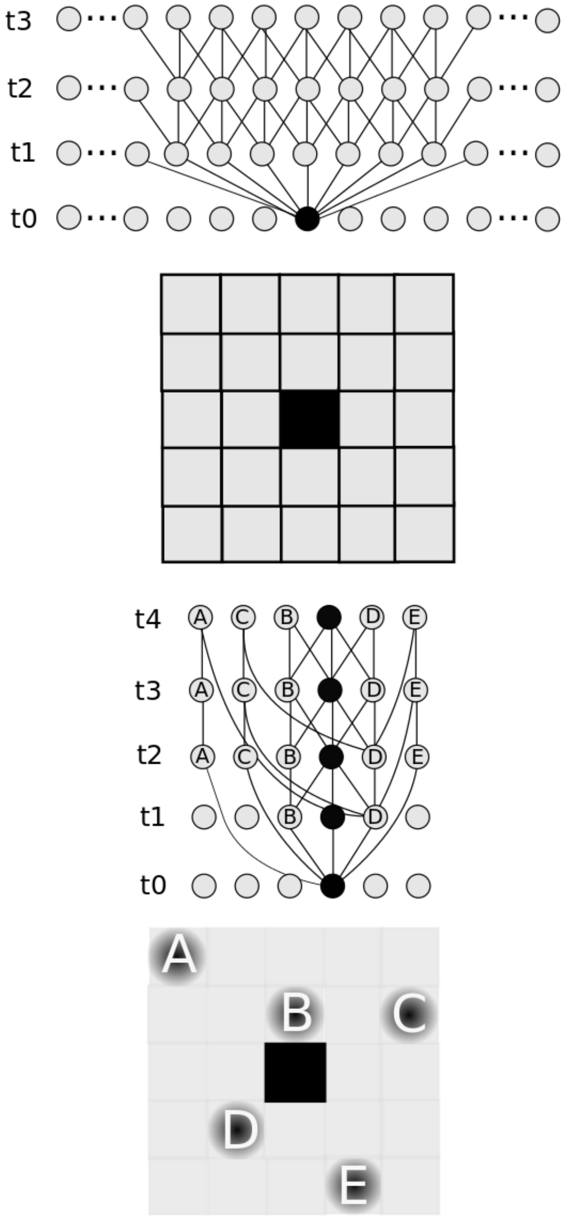


Fig. 4. A schematic visualization of the state-space created by two differing views on the environment. (a) The state-space in homogeneous and isotropic space. For an agent to reach any point at t_n a point at t_{n-1} has to be passed. (b) In a "place" based model relations between non-contiguous time steps can exist.

An agent-state $a_s \in AS$ therefore is a pair of place and time, similar to the model of spatial lifelines [16]. It emphasises the "user-centered" perspective this work confines itself to.

We write $time(s)$ to return time $t \in T$ and $place(s)$ to get a place $p \in P$ for $s \in AS$. Further we introduce an ordering relation $\preceq$ that stands for "is possible before" and it's converse $\succeq$ "is possible after". For $s, p, e \in AS$ it holds that:

- $s \preceq s$ and $s \succeq s$ (Reflexivity);
- $(s \preceq p, p \preceq s) \Rightarrow (p = s)$ and $(s \succeq p, p \succeq s) \Rightarrow (p = s)$ (Antisymmetry);
- $(s \preceq p, p \preceq e) \Rightarrow (s \preceq e)$ and $(s \succeq p, p \succeq e) \Rightarrow (s \succeq e)$ (Transitivity);
- s is comparable to p, if and only if $time(s) \neq time(p)$ or $s = p$

Thus, $\preceq$ defines a partial ordering over the set A and therefore forms the poset $\langle S, \preceq \rangle$. To define such a relation an external environment representation EX is required that contains the information about travel times between places and objects that can be obtained at them (e.g., a graph that contains object-sets in its nodes).

An important fact that differs when using place instead of space, is the break of continuity. It means that, by using the relation $\preceq$ we can construct space-time paths that skip certain time-steps. While in a field based view, the extend of the potential path area, i.e., the 2D projection of a space-time prism, grows by a continuous expansion, in a discrete (e.g., graph based representation) environment there are holes in space. Thus, it is possible to reach places at time-step t without crossing places at time-step $t-1$. Vice-versa it means, there are places at time-step t that cannot be reached from time-step $t-n$, while they could from $t-m$ with $m > n$. Fig 4 provides a schematic illustration of the above statements. Finally, we are able to define the equivalents to time geographic concepts in the discrete state-set.

A space-time prism (STP) between $s, e \in AS$ with $time(s) \leq time(e)$, for example, forms a lattice (see Figure 5) $\langle STP, \wedge, \vee \rangle$ with a lower bound of $s \in STP$, an upper bound of $e \in STP$ and $STP \subset AS$ a poset (under $\preceq$) such that $\forall p_1, p_2 \in STP$:

$$p_1 \wedge p_2 = s \tag{2}$$

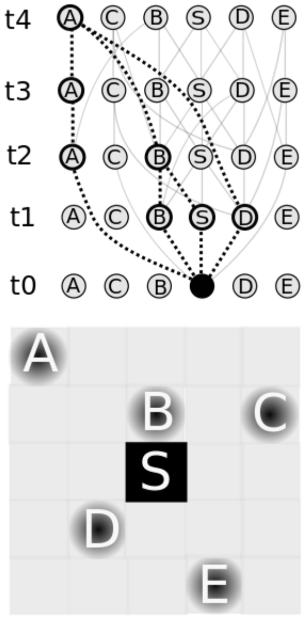
$$p_1 \vee p_2 = e \tag{3}$$

A space-time station (STS) forms a totally ordered set within which states share the same place (see Figure 6), such that $STS \subset AS$ and:

$$\forall p \in STS : (s \preceq p) \ \wedge \ (p \preceq e) \ \wedge \ (place(p) = place(s) = place(e)) \tag{4}$$

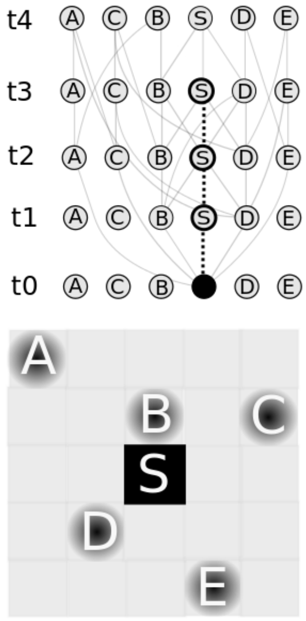
$s, e \in STS$ form the lower and upper bound of the set STS. Besides reflexivity, antisymmety and transitivity it is total:

$$\forall s, e \in STS \text{ either } s \preceq e \text{ or } e \preceq s$$



(b)

Fig. 5. A space-time prism as a lattice structure between the agent-states (S,t0) and (A,t4).



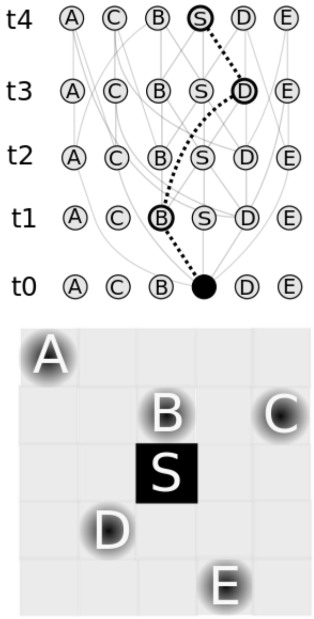
(c)

Fig. 6. A space-time station is a sequence of contiguous agent-states sharing the same place.

A space-time path (STPath) (see Figure 7) is represented by a totally ordered set $\langle STPath, \preceq \rangle$, with a lower bound s. For $STPath \subset AS$ it holds that:

$$\forall p \in STPath : s \preceq p \tag{5}$$

Apart from reflexivity, antisymmetry and transitivity, totality holds for $\langle STPath, \preceq \rangle$. For an illustration of the defined concepts, refer to Figure **??**.



(a)

Fig. 7. A space-time path equivalent modeled as a sequence of agent-states.

Still, there is not additional information that can be gained from this perspective, than from the classical space-time cube.

The major advantage, though, is the abstract and dimension independent representation discrete states offer.

3.2 From space and time to multiple dimensions

One goal of the current work is to develop a framework capable of representing activities from an agent perspective by considering more than only spatio-temporal factors. We use the example of a mobile task planning application that represents an agent-state by Place, Time and Objects. Thus we extend the agent-state-set AS from (1) to:

$$AS^{external} = (P \times T \times \mathcal{P}(O)) \tag{6}$$

It stands for the *external* physical states an agent can take. O represents a complete set of objects that are available to an agent in a given world, the power-set $\mathcal{P}(O)$ therefore produces all subsets that can occur in an agent representation. Note that there are physical restrictions on how many objects an agent can carry, so the complete power-set $\mathcal{P}(O)$ is an over-estimation. To return the object set $o \in \mathcal{P}(O)$ of a given agent-state $s_{agent} \in AS^{external}$ we write $obj(s_{agent})$. Again we need a $\preceq$ (and $\succeq$) relation that indicates whether a transition is possible between two arbitrary states. It is important to note here, that the notion of *possible* has changed. While before it was a question of "Can I reach this point/place in a given amount of time-steps ?"; now the object dimension added complexity to that question. Answering the question "Can I be there with *something*?" might involve topological dependencies between objects, such as the need for money before I can buy something (refer to [2] for a discussion of this problem).

Furthermore, introducing the additional dimension, simultaneously introduces an additional activity (i.e.,a "pick-up" or "drop" activity). Thus, it can no longer be assumed that a change in the agent-state does not result in a change of the external environment EX. This leads to a break of the traditional time geographic assumption, that is, the environment does not change by the movement of an agent. Subsequently, a relation $\preceq$ is not possible any more. Henceforth, it necessary to take the environment-state along the state transitions, effectively tracking the changes that happened in the environment. Only this way, feasible future states can be determined. Since the agent for future projections does not actually change the physical environment, the set E of all possible environment-states to simulate future actions is introduced. The agent-state-set $AS_{external}$ now becomes:

$$AS^{complete} = (P \times T \times \mathcal{P}(O) \times E) \tag{7}$$

An agent-state $a_{state} \in AS^{complete}$ now is represented by a place, time, set of objects and a *mental model of an environment-state*, i.e., an internal image of the environment at state $a \in AS^{external}$. If the agent moves from one state to another by picking up an object for example, the mental model of the world is updated accordingly. This way future activities can be simulated by the agent. Again, the model represents an agent perspective, so the agent finds herself at a certain time in a certain state, takes the external environment to simulate future states of herself and the changes in the environment. In fact, E can also be replaced by the sequence of actions that are taken. By ordering $AS^{complete}$ with the "is possible before" ($\preceq$) relation, a poset is obtained. Note, that by replacing AS by $AS^{complete}$ the definitions (2)-(5) are still valid, except that the space-time station (4) does not necessarily form a totally ordered set any more. In brief, a poset $\langle AS^{complete}, \preceq\rangle$ that contains all agent-states possible and the relations between them was defined. This is achieved by using the $\preceq$ relation that captures the logic of the transitions from one agent-state to another. It

ensures that requirements and constraints that exceed spatio-temporal factors are incorporated into the model (e.g., Can I get from home to work in three time-steps and have my laptop with me?). The functions $time'$, $place'$, obj' and $world$ return time, place, objects and the corresponding mental environment state.
In the next section we will illustrate how the framework can be utilized to model intended activities.

4 Intended activity representation in a n-dimensional space

Intentions can be seen as projections of future desired states. In section 2.2 a distinction between *implementation* and *goal* intentions was made. It is argued that the two concepts subsume the objects usually stored in scheduling or task planning applications. Implementation intentions correspond to planned activities, i.e., activities that are clearly delineated by geographic and temporal boundaries. Goal intentions are far more general and can mean a plethora of things. Table 1 gives informal examples for each of the concepts.

Table 1. Corresponding examples of planned activities or errands for goal- and implementation intentions

Implementation Intentions	Goal Intentions
Attend lecture from 9:00 am to 11:00 am	Return the book to the library before the deadline
Meet me there at 1:00pm	Be at home before 8:00 pm
Take the bus at 10:00 to arrive at 11:00	I want to attend the conference

In the following a formal definition is given that narrows down the meaning of the terms. Having such a formal description is a first step towards the integration of varying planned/intended activities (such as trips, lectures or errands).

Implementation Intention An implementation intention is any pair (s_{start}, s_{end}) with $s_{start}, s_{end} \in AS^{complete}$ for which $s_{start} \preceq s_{end}$ holds true. The set of states that an agent can take forms either a n-dimensional *place*-time prism or *place*-time station as in (2)-(3) or (4). In case $s_{start} = s_{end}$ the set contains a single agent-state that needs to be achieved. Unfortunately, sticking to this *strict* definition causes a problem. s_{start} and s_{end} are elements of $AS^{complete}$, meaning that the world state (or rather the mental image of it) before and after the intention is included in the definition. The exact world-state might not be of relevance though, since the primary goal is to achieve the *external* agent properties (i.e., Place, Time or Objects). Simultaneously, there is a semantic ambiguity inherent in the representation. If an agent-state in the pair asserts an empty set of objects, i.e., no object is required for the accomplishment of that task, does carrying an object render the task unfeasible? To solve both of the problems a relaxation of the definition is required. Therefore, an equivalence relation '$\sim$' is introduced, defining equivalence between states in $AS^{external}$ and $AS^{complete}$. For $s \in AS^{external}$ and $t \in AS^{complete}$, $s \sim t$ if and only if:

$$(place(s) = place'(t)) \wedge (time(s) = time'(t)) \wedge (obj'(t) \supseteq obj(s)) \qquad (8)$$

In words, s '*is equivalent to*' t if they share the same place, time and if the object-set in t is a super-set of the object-set defined in s. Note that the relation is antisymmetric $(s \sim t) \neq (t \sim s)$. The relaxed definition of an implementation intention becomes a pair (s_{start}, s_{end}) with $s_{start}, s_{end} \in AS^{external}$. To determine the set $I_{intention} \subset S^{complete}$ containing all states the agent can possibly take to complete the intended activity; first the set of possible start and end states $SS, ES \subset AS^{complete}$ is defined:

$$SS = \{\ ss \in AS^{complete} \mid ss \sim s_{start}\ \} \qquad (9)$$

$$ES = \{\ es \in AS^{complete} \mid es \sim s_{end}\ \} \qquad (10)$$

Finally, for the set $I_{intention}$ forming a poset under $\preceq$ it holds that:

$$\forall i \in I_{intention} : \exists ss \in SS \wedge es \in ES \text{ such that } ss \preceq i \preceq es \qquad (11)$$

This structure can be understood as a *place*-time prism or *place*-time station in the multi-dimensional agent-state representation $AS^{complete}$.

Goal Intention The great challenge in formalizing goal intentions is their generality. As in table 1 illustrated, examples include things like: "I want to be successful". For the purpose of this work, only goal intentions that can be expressed in terms of the dimensions introduced are considered. Thus, a goal intention can be understood as a conjunction of constraints imposed on the agent-state-set $AS^{complete}$, reducing the complete set to states that represent the *implementation* of the goal. In other words, goal intentions are a collection of implementation intentions. An important observation is the fact that an environment state can be part of the definition. An environment state expresses a future desired state that is independent of the actual agent state. Subsequently, how the state is reached is not so much of a concern. Since this work is only concerned with a single agent perspective, the implications of this fact are less dramatic. In a model that adopts an external view that contains multiple agents, it would lead to many interesting questions. So the goal intention "Return the book to the library", for example, can be expressed by:

$$\forall gi \in GI : time'(vs) < closinghour \wedge world(vs) = es \qquad (12)$$

$es \in E$ stands for a desired future state of the environment in which the book is at the library at a time step before the closing hour. The set $GI \subset AS^{complete}$

contains all agent-states that represent the completion of the goal. Figure 8 illustrates the varying structures that represent implementation or goal intentions.

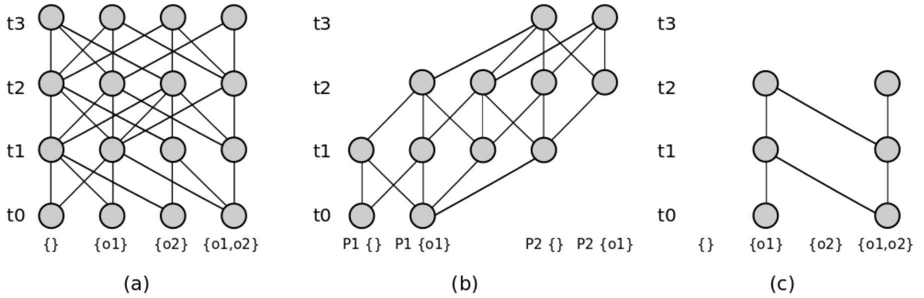


Fig. 8. Schematic illustrations of the structures the definitions given in section 4 are creating. (a) A task with the same start- and end-place and a given time interval. (b) A task with a given time interval but differing start- and end-places. (c) A flexible task with a given location, constrained time and an object requirement o1 (i.e., goal intention).

4.1 Reasoning

Now that a clear notion of goal- and implementation intentions is defined, reasoning is possible (see Figure 9 for a schematic illustration). Since a formal description of the reasoning process exceeds the scope of the current work, a informal discussion about the process will be given here. There are two major cases that need to be handled:

- Matching two implementation intentions;
- Combining a goal- and an implementation intention.

The case of two goal will be ignored in here, since the concepts are so flexible that in most cases it will not make much sense to combine them. Given implementation intention A and B to check whether **B can be conducted within A** the following steps are taken:

1. Compute the start and end-states of B
2. If at least one start state and at least one end state is contained in the state-set of A, B is doable within A

To check whether **B is possible after A**:

1. Compute end states of A and start states of B

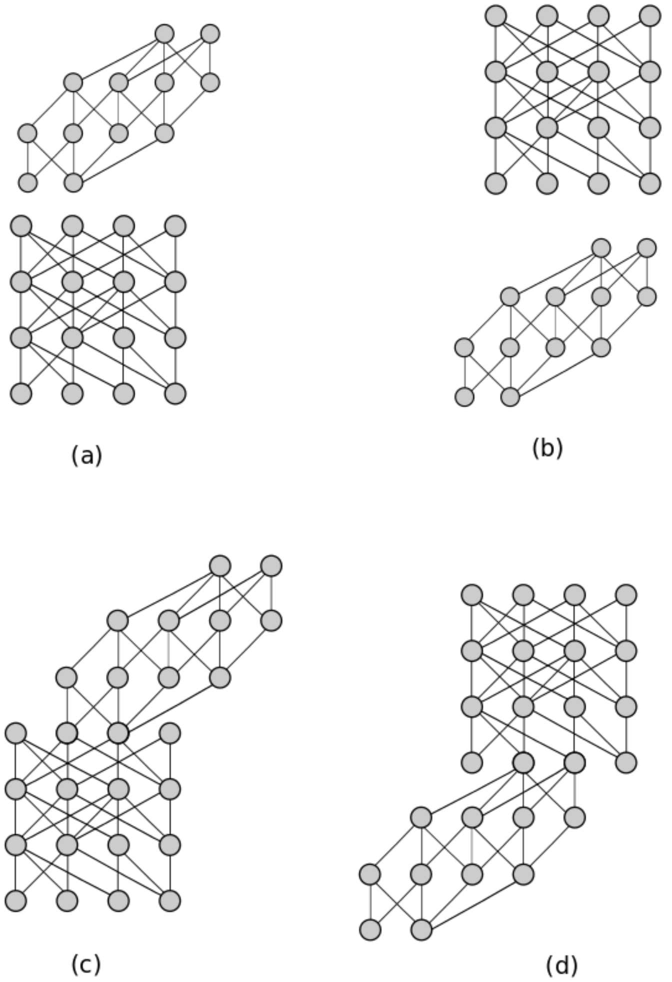


Fig. 9. Schematic illustrations of the structures representing various constellations of two implementation intentions.

2. If at least one end state of B is achievable from at least one end state of A, B is doable after A

To check whether **B is possible before A**:

1. Compute start-states of A and end-states of B
2. If at least one start-state of A is achievable from at least one end-state of B, B is doable before A

It goes without saying that these processes can be reversed. Combining implementation intentions and goal intentions is straight forward. Given an implementation intention A and a goal intention C, to check whether **C can be conducted within A** the following has to be done:

1. Intersect A with C
2. If the intersection does not result in an empty set, C can be done within A

Can **C be conducted before/after B**:

1. Compute start/end states of A
2. See if any state of C can be reached from the end states, or any of the start-states can be reached froma ny state in C.

5 Conclusion

In this work a formal framework for representing intended activities has been developed. Starting with a three dimensional space-time cube, a discrete representation in form of a poset was defined and extended into a multi-dimensional state representation. Within this framework a formal definition of *intentions* was proposed that can be used to reason over a variety of activities. So the focus of this work, was not as in classical planning how to find a solution to a problem or how activities can be sequenced/ombined, rather it was an attempt to answer: What is it exactly that we want to do or reach? This paper is part of a wider attempt aiming at a better semantic description for intended activities, including definitions of operations to combine or aggregate them. The work is motivated by outcomes of a recent study conducted [3].

There were two main findings: (1) Extending the time geographic framework by other dimensions might imply a break with the initial assumption of monotonicity (i.e., adding new knowledge of an agent action can negate facts that were true prior to the action); (2) The structure of the added dimension plays an important role in the logic of how a state can be reached and whether a state can be considered a goal state or not (e.g., does an additional object render a task infeasible?).

Several questions need to be answered. For example, how does the extend of time steps (i.e., minutes, 10/15/30 minute intervals, hours, days) or the change in spatial granularity (i.e., buildings, places,cities,...) affect the representation of intentions and how can we switch between them?

The work's focus was on a single agent perspective. However, the question of how to integrate other agents into the model is crucial. In particular, the incorporation of other agents into the solution states for a goal intention. *Cognitive transactions* and a representation of the other agents mental image might be necessary to do so, similar to concepts proposed in recent work [40].

On the implementation level, several refinements of the model are necessary before such a framework can be of use. Foremost: combinatorial explosion. Obviously, the complete computation of posets is not practical. Thus, *state abstraction* [31] needs to be employed to reduce the amount possible states. "Tagging" as argued by Holland [13] is a method commonly employed by humans to group objects in order to simplify complexity. It is a method that suggests itself to reduce possibilities by looking at categories of objects rather than individual instances (e.g., "Groceries" instead of "Milk"). Hence, a typology of objects needs to be developed/found.

The work presented is a first step towards a dimension-independent, potentially extendible representation of future tasks or plans.

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