Design Principles for Spatio-Temporally Enabled PIM Tools: A Qualitative Analysis Of Trip Planning

Amin Abdalla, Paul Weiser, Andrew U. Frank

Vienna University of Technology, Department of Geodesy and Geoinformation, Research Group Geoinformation, Gusshausstr. 27-29, 1040 Vienna
{abdalla|weiser|frank}@geoinfo.tuwien.ac.at

Abstract Current personal information management (PIM) tools do not sufficiently recognize the spatio-temporal, hierarchical, or conceptual relations of tasks that constitute our plans. Using behavioral observation methods we analyzed people planning a trip to attend a conference taking place in a region they had little or no prior familiarity with. The resulting open-ended records were coded into higher-level segments and categories. These served as a basis for a cognitive engineering approach, to propose better design principles for spatio-temporally enabled PIM-tools.

1 Introduction

Research on personal information management (PIM) is concerned with the *"[...] effort to establish, use and maintain a mapping between need and information."* (Jones and Teevan, 2007). Traditionally, research in this field was very much concerned with the organization of documents, pictures, bookmarks, etc. (Barreau and Nardi, 1995; Jones and Tevaan, 2007). But more recently voices called for a focus on "*prospective memory*" (Sellen and Whittaker, 2010), i.e., the memory that stores the tasks and errands we are supposed to do in future. Tools that support our prospective memory are applications like calendars, todo-lists, etc. Such tools are, according to Norman (1991), cognitive artifacts, i.e.,*"artificial device(s) designed to maintain, display, or operate upon information in order to serve a representational function"*.

Currently, these tools are relatively passive, because they provide little support in planning or monitoring our tasks. Their capabilities are mostly limited to the storage and display of information. Interactive features, such as alarms, do not take contextual changes into account. A dynamic notification in contrast, would automatically modify a set alarm if necessary. For example, in case of a traffic delay, it would tell the user to depart earlier. Research has shown that PIM-tools can greatly benefit from the integration of spatio-temporal and semantic information (Raubal et al., 2004; Raubal and Winter, 2010; Janowicz, 2010; Abdalla and Frank 2012). Calendars, for example, could be improved if they had a sense of space-time built into them. Currently, they allow creating two events that are geographically unreachable within the specified time the events are apart (e.g., Event A, 01.02.2013, 10 a.m. in New York & Event B, 01.02.2013, 3 p.m. in Berlin).

We argue that current PIM-tools require a change in representation, i.e., get a sense of space, to allow for a proactive support of our daily activities. The goal of this work was to gain valuable insights into the cognitive nature of the planning process and try to infer important principles that can serve as a basis for the design of spatial PIM-tools. This can be seen as a cognitive engineering approach, proposed by Norman (1986). The aim is to *"devise systems that are pleasant to use-the goal is neither efficiency nor ease nor power, although these are all to be desired, but rather systems that are pleasant, even fun."*

In this work we analyzed people planning a trip to a scientific conference, applying behavioral observation methods. The results, open-ended records, were coded and provided a semi-formal segmentation and categorization of the planning process as the basis of our study.

The main questions we addressed are:

1. What are the (prominent) activities people carried out to plan the trip?
2. Do people share a common temporal ordering of their planning activities?
3. What is the nature of the information people used?
4. How can (computational) tools help to overcome difficulties during the planning of a trip and its execution?

The remainder of the work is structured as follows: In section 2 we discuss relevant theories of planning from the cognitive sciences. Section 3 gives a detailed account of our study design and section 4 explains the methods underlying our data analysis. Section 5 presents the result of the analysis and the last chapter lists the proposed design principles that stem from our findings.

2 Related Literature

From a cognitive standpoint, trip planning is the solving of a problem with an initial state, a set of transformations, and a goal state. Mayer (1990) defines problem solving as "cognitive processing directed at transforming a given situation into a goal situation when no obvious method of solution is available to the problem solver". By doing so, we usually transfer information from past experiences or general knowledge onto the current problem to be solved. As a consequence, there is a considerable overlap between problem solving and transfer (Eysneck and Keane, 2010). More knowledge in a given domain increases the effectiveness of problem-solving (expertise). This also plays a role in selecting the best option among several choices.

In general, problems can be classified into well-defined and ill-defined problems. Well-defined problems are those in which the initial state, all possible steps to achieve a solution are clearly laid out and the final goal state is specified (Eysneck and Keane, 2010). The board game Backgammon is an example for a well-defined problem. There is only one start configuration, a finite set of legal moves and only one goal state (first to remove all their pieces from the board is to win). In contrast, trip planning is an ill-defined problem. Although, start and goal state are clearly laid out, the number of possible solutions to reach it is potentially infinite.

If one is to decide upon a possible solution to a plan, or a part thereof, different strategies may be applied. One of them is the domain principle (Gilhooly, 1996) stating that "if option A is at least as good as option B in all respects and better than B in at least one aspect, then A should be preferred to B". However, this is not always the case. As Kahneman and Tversky (1979, 1984) have shown, people are potentially more sensitive to losses than to gains (loss aversion). This may influence decision making and produce results that stand in contrast to the domain principle. Similarly, the "sunk cost effect" lets people often continue an endeavor once an investment in money, effort, or time has been made (Arkes and Ayton, 1999) even if it would be economically better to abandon the plan.

If there is more than one possible solution one might apply one of two strategies: Multi-attribute theory (Wright, 1984) or elimination by aspects (Tversky, 1972). The former lets people weight attributes relevant to a decision, finally selecting the solution that offers the highest summed weight. The latter lets decision makers eliminate options by considering one relevant attribute after another. For example, consider all the hotels of a city you are interested in, and then eliminate the ones that are not within walking distance from a particular place. Then further reduce the number of options by specifying a price limit. Continue until you have found one solution.

Also, some problems cannot be solved at all, because they are represented in a way that makes it impossible or very hard to retrieve a possible set of actions towards the goal. This mental block can only be broken if the representation is changed (Knoblich et al., 1999). Ohlsson (1992) in his representational change theory noted that such a change of representation can be achieved by (1) adding new problem information, (2) re-encoding of information, or (3) constraint relaxation (what was not allowed before is now permitted). We argue that current PIM tools need a change of representation to allow for a better support in problem solving and plan execution.

3 Study Design

Our study investigated the process of planning a trip to attend a scientific conference. It was organized and hosted by the University of Tartu, Estonia and took place from the 22nd of August until the 25th of August 2012. The venue seemed particularly interesting, since only one of the participants has visited the country before and hence was familiar with its geography or transportation network. Detailed information about the conference was provided by the official conference website[1]. This included textual information on how to get there, a range of hotel options, the time table, etc. The participants were asked to plan the trip minimizing costs and time. The study was conducted around two weeks ahead of the conference. Participants were asked to comment and justify the actions they were carrying out, so their intentions became clear to the authors. Also, they were provided with pencil and paper. The computer screen was filmed and notes were taken by the authors throughout the entire process. To simulate the booking of flights or hotels the participants indicated to the observing person whenever they had made a final decision.

3.1 Study Participants

The subjects of the study (N = 10) were recruited from staff members of our institute and from the authors' family and friends. Half of the participants had a background in geospatial technologies. The age ranged from around 20 – 50 years and the sex ratio was 50:50. Experience in travelling and conference attendance among the participants varied from close to zero (never planned a trip abroad themselves) to very experienced (regular traveler to foreign places). Only one of the subjects has actually ever been to the country the conference took place. All other participants had no prior familiarity with the region of interest.

4 Data Pre-Processing

The observations resulted in a set of videos, transcripts and notes by both the participants and the observers. Because such kind of qualitative data is rather unstructured, the first task was to decide upon a rigorous analytical framework that allowed breaking the content into units that could be quantified. We followed the "*coding*" approach described by Montello and Sutton (2006). The method develops incrementally beginning with a "*segmentation*" of the raw data (videos) into

[1] http://www.ut.ee/mobiletartu/2012 (last accessed on 9th of November 2012)

"minimum meaningful entities". These can vary in nature, e.g. they can be words, phrases, sentences, situations, or actions (See section 4.1 for a list of the segments). Once the minimum meaningful entities are defined they are grouped together into conceptually related categories. This resulted in analyzable quantifiable data.

4.1 Segmentation

For the segmentation we defined units that constitute the *meaningful entities*. Considering the questions posed in the first section and intensive preliminary analysis of the videos and transcripts led to the identification of a number of cognitive activities that constitute our segments. The following paragraphs describe them in detail:

- **Information-extraction:** Whenever a participant acquires information relevant for the planning process. It is indicated by looking at a text or browsing through a list or table. Additional hints for an ongoing information extraction are comments made by the subjects, e.g., *„[...] now I'm trying to find out what time the flight leaves"*. Information-extraction increases the person's knowledge based on existing information. *Information-extraction* does not represent a single segment, but is an umbrella term for a group of segments. Each of these segments is determined by the kind of information extracted. Because we cannot explicitly list all segments subsumed by the term, they are represented by the lattice structure shown in Figure 1. For example, information can be extracted *about* an event, a connection, or a place. Each of these can further be instantiated by a more specific description, e.g., event-conference, connection-flight, place-hotel. On the most detailed level, each instance of information can be of a specific *type, e.g.* temporal, spatial, price, or place name. For example, the segment "information extraction – connection-flight-price" refers to extracting price information about a specific flight connection. This way we obtain a more nuanced view on extraction activities.

- **Information-input:** Whenever a participant feeds information into a data processing system (e.g. website) based on personal preferences and the task description. For example, selecting the departure date for a connecting flight.

- **Comparison & Ranking:** In this segment, the subject considers different options and attempts to rank one over the other and may apply some of the strategies mentioned in section 2. This activity is indicated by verbal expression and / or by a constant back and forth switching between websites with comparable content.

- **Spatial-/Temporal-/Spatio-Temporal Inference:** An inference is mainly noticeable through verbal comments made when a participant concludes that something is relevant to the planning process based on observed facts. For example, *"[...] because the flight arrives very late and there are no connecting buses, I need to book a hotel for the night"*. Inferences increase the subject's knowledge by inferring facts from given information.

- **Postponement:** This is the case when certain tasks are decided to be conducted in-situ (e.g., buy tickets on the bus) or shortly before departure (e.g., order an airport shuttle) instead of planning them in advance.

- **Booking:** This is the activity of a final decision. Participants in the study were asked to clearly state when and what they were about to "book", e.g. a train ticket.

- **Consideration:** The act of determining a possible solution to a part of the plan. This is indicated by taking notes, possibly used for later comparison, and / or verbal comments.

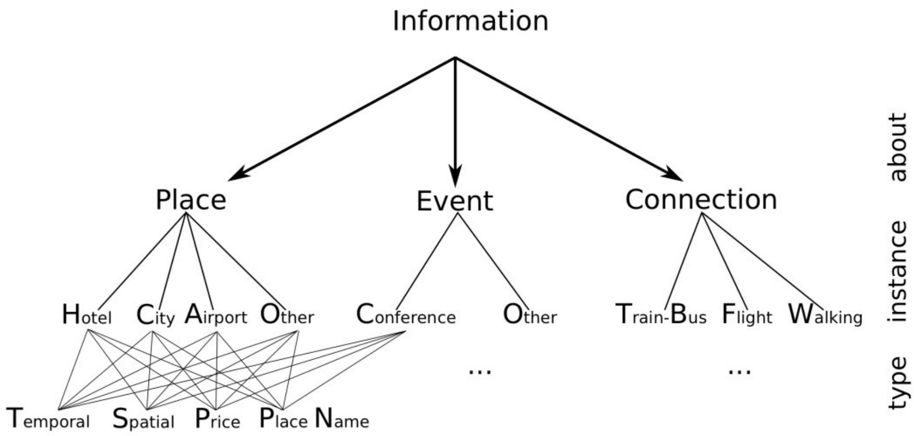

Fig. 1. The lattice structure illustrates all the different segments grouped under the term Information-Extraction

4.2 Categorization

In the next stage, we grouped conceptually related segments together. We opted for a two level categorization. On the lowest level, 9 mutually exclusive categories cover the range of all segments. On the second level, three categories entail the lower category level (see Table 1). Higher order goals (category level 1 and 2) are achieved by lower level activities. As mentioned in the section before, we distinguish between different forms of *Information-Extraction*. In general, it has the goal to form an understanding or a description of a situation. We defined four different forms of understanding and one description:

- Event Understanding
- Network Understanding
- Place Understanding
- Spatial Understanding
- Task Description

For example, extracting information about the conference contributes to the *task description*. Extracting spatial information (i.e.: looking at a map) contributes to *Spatial Understanding*. The three types of inferences (i.e.: spatial, temporal and spatio-temporal) are grouped into the *Inference* category. All forms of inputs are categorized as *Query*, and the activities of *Comparing&Ranking* as well as *Consideration* fall into the *Filtering/Storing* category. Finally, the segments *Booking* and *Postponement* form the *Decision* category. Table 1 gives a structured overview of the grouping mechanism applied to the segments. Please note the special syntax for the segments:

SegmentName – IsAbout, OfInstance, Type

The symbol "[…]" indicates that all subsequent levels are included. For example:

> "Info Extraction – Place, Hotel, […]" refers to "Info Extraction – Place, Hotel, [Temporal, Spatial, Price, Place Name]".

The symbol " \ " stands for without. For example:

> "Info Extraction – Place, Hotel, […] \ spatial" refers to "Info Extraction – Place Hotel, [Temporal, Price, Place Name]".

Segments (isAbout, InstanceOf, Type)	Category Level 1	Category Level 2
Info Extraction – event, conference, […]	Task Description	Knowledge Aquisition
Info Extraction – event, […] \conference	Event Understanding	
Info Extraction – connection, […] \spatial	Network Understanding	
Info Extraction – place, […] \spatial	Place Understanding	
Info Extraction – […], spatial regional Info Extraction – […], spatial local	Spatial Understanding	
Info Input – […]	Query	
Spatial Inference Temporal Inference Spatio/Temporal Inference	Inference	Reflection & Evaluation
Comparison & Ranking Consideration	Filtering & Storing	
Booking Postponement	Decision	

Table 1. Activity Categorization

5 Analysis

5.1 Data Analysis

Generating discrete data sets allowed us to aggregate and analyze it. The first question we addressed was "Are there any prominent activities evident?" Figure 2 illustrates the absolute number of the activities (See Section 4.2) per subject. It shows that the amount of effort spent for the task varied tremendously. It can be seen that experienced travelers (Subjects D, F, and G) tended to conduct less activities than the others. This can be explained by their strategy of postponing parts of the planning process to be carried out shortly before the trip started, e.g., how to get from the hotel to the conference. But there are outliers that do not support the statement, such as subject A, who can be considered to be an experienced traveler but nevertheless put much effort into the planning, as well as subject "B" who does not belong to the group of experienced travelers, but still was very brief.

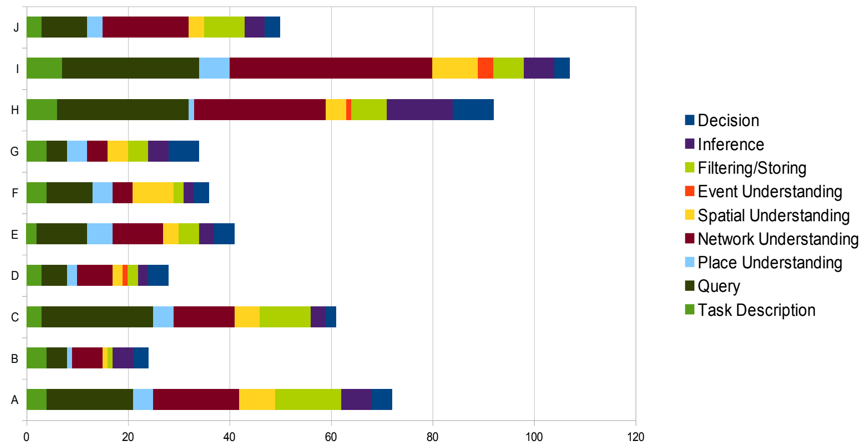

Fig.2. Absolute number of segmented activities for each participant.

In Figure 3 each individual activity is shown relative to the sum of all activities. At that point it is important to state that the activities do not say anything about the temporal extent of the process.

The prevalence of certain activities varies from subject to subject, although some seem to be consistently prominent. Those are *network understanding* and *querying*. Thus, a lot of effort is put into understanding the transportation network that serves as a basis for the trip. The second important activity is querying databases to seek information that provides the foundation for the various *understandings* as defined in level 1 of the categorization table (See Table 1). In contrast, there are activities that are sometimes not present at all, such as *event understanding*. We believe that this is due to the simulated character of the study, resulting in most of the participants to consider it not necessary to check any temporal overlaps with their real schedule.

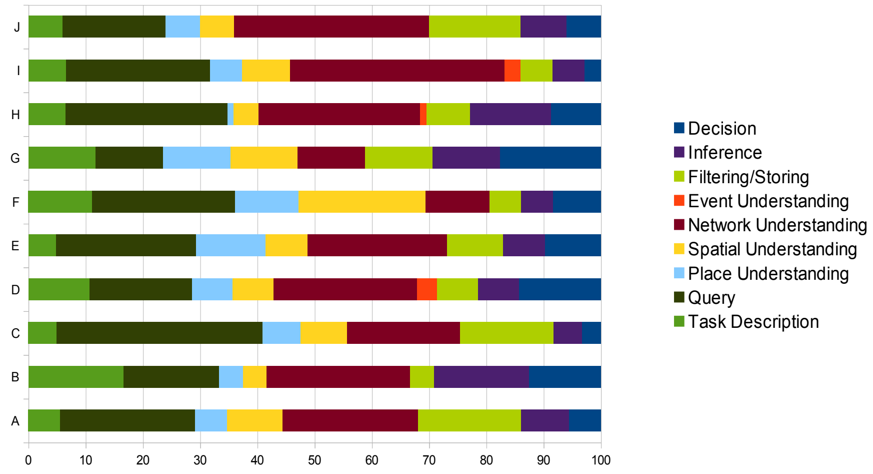

Fig. 3. Relative number of segmented activities for each participant.

Another dimension of interest is the temporal ordering (See Question 2 in Section 1). Many of the activities were conducted in an unordered manner and were reoccurring. Thus, we used a method that allowed to make assertions about the general ordering of the activities. For each activity a number was assigned, representing its position in the ordered sequence of activities. We then took the first occurrence of each activity, i.e., the minimum value of all the positions that are occupied by it. That gave us the first occurrence of every activity in the complete list, from which we were then able to compute the relative order in comparison to the other activities. This was done for each subject. The result is visualized in Figure 4.

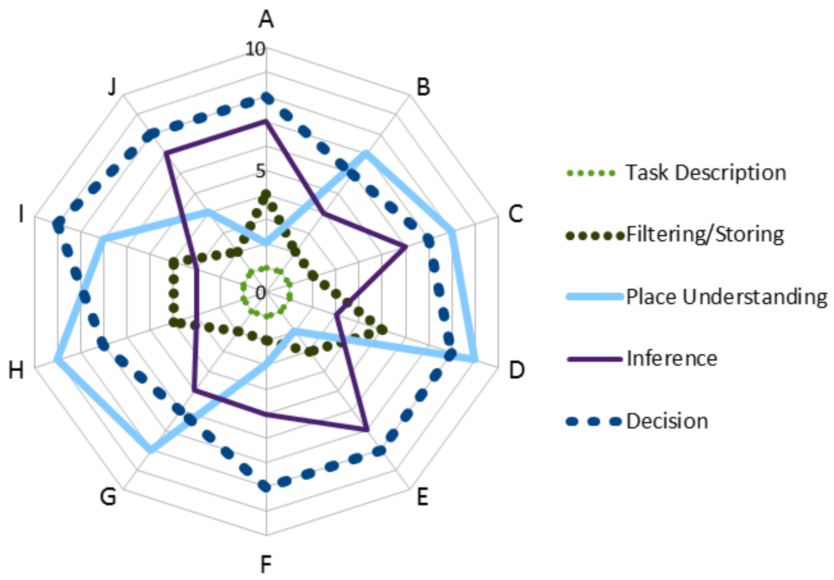

Fig. 4. Temporal order (first occurrence) of the various segments for each subject.

Each line depicts an activity, while the axes stand for the subjects. The closer to the center a line is, the earlier the activity had its first occurrence in the overall process. Obviously, the activity that for all the participants has been the first thing to do, was to define the goal (task description). From there on the picture appears to be more complicated and a clear delineation of the ordering is hard to find. Although the subjects vary in their sequential ordering, some of the activities took place before others. The first *Query-activity*, that is the second closest to the center, was by every subject conducted before the *filtering and storing* as well as the *Decision-activities*. Mostly *decisions* were made after each of the other activities was conducted at least once. We conclude that some of the activities imply functional dependencies. An activity that seems to vary strongly is *Place Understanding*.

A question we posed in Section 2 was concerned with the nature of information utilized to solve the problem. We recognized soon, in conformance with previous research (Timpf et al., 1992), that people plan on different levels of granularity. Therefore, we differentiated between two scales of spatial information, that is, local and regional. Figure 5 shows the absolute amount of times a map was looked at, distinguished by local (street level) and regional scale (country level).

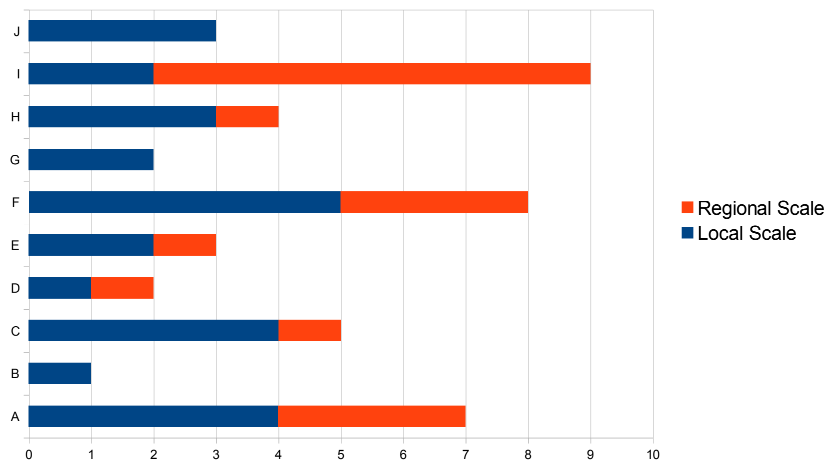

Fig. 5. Number of times subjects looked at a map, divided in regional and local scale.

Three of the subjects (B,G,J) did not look at a *regional scale* map at all. Hence, they did not build up a large scale spatial/topological representation of the region and places relevant for their search. It is interesting to note that none of them had a detailed familiarity with the region of interest.

Just like spatial information, temporal information was used on different granularities. Every subject started noting the temporal extension of the conference on a coarse *date*-level (i.e: 22^{nd} -25^{th} of September). However, at the point of looking for a flight, subjects refined the task description to an exact time on an hourly basis (i.e.: 22^{nd} at 11 am). Only one subject did book a flight based on dates, assuming one day before and after the conference allows for sufficient time to reach the conference and return to the airport on time. Hotels were only looked at based on date information, check-in times were hardly considered.

5.2 Observation based findings

The process of coding allowed us to quantify an open ended data-set, by cutting the continuous stream of information into discrete entities. Information as relations between the different activities or valuable insights became apparent throughout the observation. In the following we present the findings that are based on the observations made by the authors while conducting the study.

Information Transfer: The most striking cognitive activity was the extraction and feeding of information from different sources into various query interfaces. It was also one of the most error prone activities. 4 out of the 10 participants did err in the querying and booking process of flights, caused by wrongly put date information. This problem often accumulated throughout the process into a vast amount of different websites that contained relevant or irrelevant information. Some subjects, had at times, up to 20 tabs opened in the browser, among they attempted to extract or feed information.

Comparison and Inference: The next (related) evident problem was the comparison of different options that had to be done by constant back and forth switching between the tabs or websites. At some points subjects had opened two separate online maps, each of it containing a point of interest (such as a hotel- and conference venue). By back and forth switching between the maps they tried to see whether the points were close to each other. Inference was yet another activity, by examining a situation subjects inferred the need for something and defined subtasks. For example, by noticing that the flight departs early in the morning, it was inferred that there is a need for a hotel to stay overnight.

Place based vs. Geographic Understanding: In Figure 5 we showed that some subjects did not build up a geographic representation of the region. This lack of spatial knowledge resulted in a narrowed approach to the search for possible connections to Tartu. Almost all of those who had looked at a large scale map recognized that Riga is as close to Tartu as Tallin. Thus, they were able to look for solutions involving a flight to Riga and a connecting bus/train to Tartu. Those who did not bear such knowledge were not able to make that inference. This gap in geographic understanding of the situation even lead one subject to book a flight to Tallin, unaware of the fact that Tallin and Tartu are two different entities. The subject simply assumed that there is a taxi going from the airport to Tartu's city center. Interestingly, all of those who planned their trip solely based on city names, did not have an educational background in geospatial technologies.

Opportunities: Hayes-Roth and Hayes-Roth (1979) shaped the term "*opportunistic planning*", describing the fact that people often recognize an opportunity in a plan to conduct a related or unrelated task. In our study it appeared that some subjects recognized such opportunities. In one case, it was noticed that there is a flight going via Brussels, what could have been an opportunity to meet friends who live there. Consequently, such opportunities played a role in their weighing of a solution in comparison to others.

Assumptions: They build the basis for a lot of queries in the planning process. When people were unsure about things, they made assumptions. Facing a query interface of a flight search engine the following was stated: "[…] normally Tallin is cheaper, the capital is always cheaper". Since the subject was not sure what city to select, an assumption was made.

Postponement: When explaining the participants what to do, we always stated that they should plan the trip until they *feel* that it is "done". It occurred that for things which are still part of the trip and might have needed some prior preparation, people tended not to take care of it until very shortly before departure. Most of the subjects were satisfied by having a flight and hotel booked. They were not concerned on how to exactly get from the hotel to the conference venue, or how to go to the airport in their hometown.

Cognitive artifacts: In the observational part, we did not explicitly ask the subjects to use any sort of tools to support their planning. In fact, only very few used a calendar or similar tool. On the other hand, almost all of the subjects took notes on the provided sheet of paper. The purpose of the notes seemed to be twofold: (1) writing down the details of the conference (i.e., date, venue, etc...) and (2) comparing possible solutions.

6 Conclusion and Future Work

The aim of this study was to acquire a deeper understanding of a planning process that involves a clear set of spatio-temporally constraining factors. In this section we give a set of implications for the design of spatio-temporally enabled PIM-tools. We found 4 points that need to be addressed:

Goal based planning: Planning is a goal directed activity. It is therefore crucial that the goal is represented and defined well (task description), in order to come up with a successful plan. An application supporting the user needs to be able to store an (sufficiently) accurate representation of the goals. Both the temporal and spatial dimension plays an important role finding a good solution to the problem. As a result, an ideal application would let users set a task freely, but constrain them to choose only amongst solutions that "make sense". This helps to avoid errors, as those mentioned above, e.g., when users confused dates or places.

Planning is an evolving process: In general, several (evolving) plans are created during the problem-solving process. As an attempt to properly sequence or compare different legs of the trip people used cognitive artifacts (e. g, a piece of paper) to help them store spatial, temporal, or cost-related information. It is therefore crucial that an application is capable of storing a partial (incomplete) plan. With this capability, other (reasonable) parts of a plan can be added, removed, replaced, or simply compared to each other. Also, it is important that the system is able to determine gaps or missing links in the plan (e.g., due to postponement by the user). Thus, a formal description for "*partial plans*" might be helpful, similar to the model proposed by Weiser et.al (2012).

Recognizing opportunities: An application should be able to recognize opportunities for other tasks, or simply suggest things based on other data sources. The example we presented in Section 5 showed that spatial information about a friend (her/his home address) was matched with a possible travel route and hence perceived to be an opportunity. Since such opportunities play an important role in the weighing of a solution it needs to be incorporated in the representation.

Planning over multiple granularities: Throughout the planning process subjects reasoned over multiple temporal and spatial granularities. As a result, a supporting system should be able to reason over coarse granularities (date or city level) but also be able to look into more detailed parts of the plan. This affords a way of grouping lower level into higher-order tasks that can be reasoned over. This is something well known in Artifical Intelligence (AI) (Sacerdoti, 1977; Tate 1975b).

We expect that implementing the above mentioned features will give PIM-tools a better representation of spatio-temporal tasks and plans. This will help us with prior planning but also support us along the way of complementing and executing a plan, i.e., support our prospective memory. To achieve this goal, several open questions need to be tackled. Research in GIScience must increasingly address the issue of formal models of processes (plans) that can account for multiple levels of granularities (spatial and temporal). One of the crucial findings of the study was that **information transfer,** as described in section 5.2, is a main issue that can be supported by computational tools. For the future we would like to take a closer look at the amount of time people spend for planning and examine the participants' notes. Building on the findings of this and future studies, we aim to implement a prototype PIM-tool.

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References

Abdalla A. & Frank A. (2012). Combining Trip and Task Planning: On How to get from A to Passport. 7th International Conference, GIScience 2012, Columbus, Ohio.

Arkes, H. R., & Ayton, P. (1999). The sunk cost and Concorde effects: Are humans less rational than lower animals?. Psychological Bulletin, 125(5), 591.

Barreau, D. and Nardi, B. A. (1995). Finding and reminding: File organization from the desktop. ACM SIGCHI Bulletin, 27(3):39-43.

Eysneck M.W. and Keane M.T. (2010). Cognitive Psychology, 6th Edition, Psychology Press.

Gilhooly, K.J. (1996). Thinking: Directed, Undirected and Creative (3rd Ed.) London: Academic Press.

Hayes-Roth, B., & Hayes-Roth, F. (1979). A cognitive model of planning. Cognitive science, 3(4), 275-310.

Janowicz, K. (2010). The role of space and time for knowledge organization on the semantic web. Semantic Web, 1(1):25-32.

Jones, W., Teevan, J. (2007). Personal information management PIM, 14 p. Univ. of Washington Press.

Kahneman D. and Tversky A. (1979). Prospect Theory: An Analysis of Decision under Risk . Econometrica, Vol. 47, No. 2., pp. 263-292.

Kahneman D. and Tversky A. (1984). Choices values and frames. American Psychologist 39, 341-350.

Knoblich G., Ohlsson, S., Haider H., Rhenius D.(1999). Constraint relaxation and chunk decomposition in insight problem solving. Journal of Experimental Psychology: Learning, Memory, and Cognition, Vol 25(6), Nov 1999, 1534-1555.

Mayer R.E. (1990). Problem Solving, in M.W. Eysneck (Ed.), The Blackwell Dictionary of Cogntive Psychology, Oxford, UK:Blackwell.

Montello D. R. and Sutton P. C. (2006). An introduction to Scientific Research Methods in Geography. Sage Publications.

Norman D.A. (1986). Cognitive Engineering. In: Norman D.A and Draper S. (Eds) User Centred System Design. Lawrence Erlbaum Assoc., Hillsdale 31-61.

Norman D.A. (1991). Cognitive Artifacts, in John M. Carroll (eds). Designing interaction. Cambridge University Press. Cambridge.

Ohlsson, S. (1992). Information-processing explanations of insight and related phenomena. Advances in the Psychology of Thinking. Harvester Wheatsheaf.

Raubal, M., Miller, H., Bridwell, S. (2004). User-centred time geography for location-based services. Geografiska Annaler: Series B, Human Geography 86(4), 245–265.

Raubal, M., Winter S. (2010). A Spatio-Temporal Model Towards Ad-Hoc Collaborative Decision-Making. In Geospatial Thinking. Lecture Notes in Geoinformation and Cartography Volume 0, pp 279-297.

Sacerdoti, E.D., (1977). A structure for Plans and Behavior. Elsevier/North-Holland.

Sellen, A. and Whittaker, S. (2010). Beyond total capture: A Constructive Critique of Lifelogging. Communications of the ACM, 53(5):70-77.

Tate, A. (1975). Using Goal Structure to Direct Search in a Problem Solver. Ph.D. Thesis, University of Edinburgh.

Timpf S., Volta G. S., Pollock D.W., Egenhofer M. J., (1992). A Conceptual Model of Wayfinding Using Multiple Levels of Abstraction. In: A U Frank, I Campari and U Formentini (eds), Theories and Methods of Spatio-Temporal Reasoning in Geographic Space. Lecture Notes in Computer Science 639: 348-367.

Tversky A. (1972). Elimination by aspects: A theory of choice. Psychological Review, Vol 79(4), Jul 1972, 281-299.

Weiser P., Frank A.U, Abdalla A., (2012). Process Composition And Process Reasoning Over Multiple Levels Of Detail. 7th International Conference, GIScience 2012, Columbus, Ohio.

Wright, G. (1984). Behavioral decision theory: An introduction. Sage Publications.