Map-based Mobile Services

Theories, Methods and Implementations

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1. Auflage 2004. Buch. XII, 260 S.
ISBN 978 3 540 23055 7
Format (B x L): 15,5 x 23,5 cm
Gewicht: 600 g

3 Activity and Context - A Conceptual Framework for Mobile Geoservices

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Abstract. This chapter unfolds a theoretical-based conceptual framework to describe and model activity and context as essential parameters for mobile geoservices. It gives an introduction in the general ideas of activity theory and shows how these ideas can be transferred to mobile geoservices. The proposed concept points out how activities supported by geoservices can be defined and structured, it gives an idea how to model users of mobile geoservices and shows what social and spatial context parameters have to be considered.

3.1 Mobile Geoservices

Digital services provided via the internet present a fast growing trend. The services support specific tasks as well as everyday tasks. According to their functionality high-level and low-level services as well as smart web services are to differentiate. Smart web services are aware of user attributes like identity, role, or preferences; they form the basis for more personalized services like mobile geoservices.

Geoservices as a subgroup of internet services support spatial tasks, for example way finding or navigating from one place to another. A comprehensive description of geoservices is given by Meng and Reichenbacher (2003), they characterise them as “web services which provide, manipulate, analyse, communicate and visualise any kind of geographic information”. Different geoservices already exist, e.g. catalogue service, feature access service, map service or geocoding service.

Mobile geoservices are a special type of geoservices. They operate with mobile devices and mobile networks; they can be used during mobility and be applied at any place and time. Because of their mobile and ubiquitous use mobile geoservices bring about an application situation which is quite different to that of stationary services: A user’s position, as well as his or her surroundings change during the application, and also the activities of a user alter. Mobile geoservices have to take into account these alterations and adapt the presented information to the different context and activity.

The most well-known mobile geoservices are location-based services (LBS) which are aware of user’s current spatial position and provide specific, relevant information according to this position. Examples are city- and tourist guides (*Gartner and Uhlirz* 2001, *Zipf* 2002) or weather information services (*Meissen and Pfennigschmidt* 2002) that give information related to a specific place. Also in the field of professional work LBS support indoor and outdoor activities (*Heidmann and Hermann* 2003).

LBS use „location“ as context parameter to which the presented information is referred. However, context is much more than location; it is the complete situation in which a user acts and requires spatial information. Mobile geoservices have to adapt their information to this entire situation. This challenge is pointed out by Reichenbacher (2004): “The vision of a mobile cartography is to present the user always the right spatially related information at the right moment at the right place. Whoever the user is, he/she will always get the information related to his or her current context and interests, knowledge and skill level, presented in a way he/she is used to.” Accordingly, the core-idea of mobile geoservices “is not only to make information available to people at any time, any place, and in any form, but to reduce information overload by making information relevant to task-at-hand and to assumed background knowledge of the users.” (Fischer 2001, in *Reichenbacher* 2004).

Offering information with the greatest relevance to users requires a comprehensive understanding of users’ situations: what do mobile persons do, how do they act, what context parameters influence their decisions or actions, and what user characteristics are to consider. Activity and context are the key elements for presenting the most relevant spatial information. For that reason, it is necessary to take a closer look at these components.

3.2 Concepts of activity and context

In order to use activity and context effectively, we must understand what they are and how they can be used. As Dey and Abwod (1999) pointed out in their paper most people have a general idea about what context is. However, “a vague notation is not sufficient; in order to effectively use context, we must attain a better understanding of what context is.” Some different approaches are developed to describe and formalise the parameters that characterise a certain situation of application (*Dey and Abwod* 1999). They differ in description of context (e.g. description by example, by synonyms) as well as in parameters they use. Some approaches are restricted to measurable, automatically detectable physical parameters as context elements, others include “activity” as a further context element. Activity and context are in strong relationship; they cannot be separated and have to be regarded in the whole. The following paragraphs unfold a concept about activity, context and their relations.

3.2.1 Activity

In common sense, activity means all what we do; for example driving a car, planning a route to a selected destination, looking for a place in a map, or detecting a map symbol on a mobile device. On a more precise look the given examples show that activities are different not only in their doing but also on a formal level. They can be differentiated in manual and cognitive actions and they can be described at different hierarchical levels. “Planning a route to a destination” is more complex than “detecting a map symbol”. Also, activities are influenced by several constraints like legal or social rules, for example the one-way rule of a road, or choosing particular social meeting points. Activities are directed by a person’s attitude and they are guided by other persons.

Regarding activities in more detail makes apparent, that they are not a trivial thing; on the contrary, they are a complex component we have to handle. Dealing with activity arises following questions: How can activities be described and how are they executed? What parameters influence an activity? How can an acting person be modelled?

A good framework to answer these questions is provided by the activity theory. This theory was developed to explain human activities and related processes. It has been applied in many disciplines which deal with activities, for example, psychology, sociology, work organisation, geography, and computer science, especially in human computer interaction. Recently it was applied as well to cartography (*Dransch* 2002).

Activity theory broadens the behaviouristic approach on action, which explains activities as a sequence of stimulus and reaction. It postulates that an activity is more than a reaction; it is a conscious and directed act that is executed to reach a defined goal. According to this concept the goal a person pursues determines his or her activity. Activity in this sense can be described as a process of planning (according to cognitive action plans), executing and evaluating. The cognitive action plans which consist of goals, sub-goals, and actions organize the structure of an activity. Goals and sub-goals are in a hierarchical order, actions, which are executed to attain the goal or sub-goal, are sequentially organized. For example an employee of a power authority has the goal “to plan a gas service pipe”. Sub-goals are “to locate the pipe’s route” and “to define all technical and cost parameters”. “Locating the route” can be divided further in “to get an overview about the situation of the intended route” and “to decide where the pipe’s route should exactly run”. To achieve the sub-goal “to get an overview about the situation of the intended route”, different indoor and outdoor actions are necessary like “identifying and recording barriers for example trees or technical devices, making out the quality of the ground, locating other service pipes, and identifying the ownership of properties which are crossed by the route”. Figure 3.1 shows the hierarchic-sequential structure of goals, sub-goals and actions.

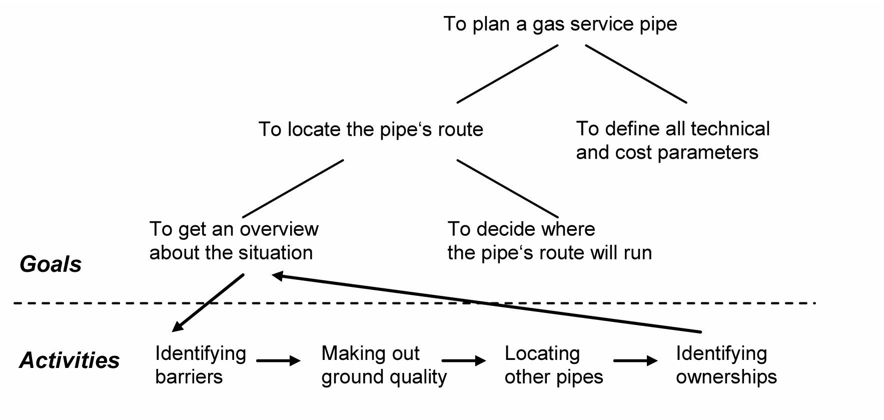

Fig. 3.1. Hierarchic-sequential structure of an activity

A further relevant aspect in activity theory are artefacts. Artefacts are used as tools to execute an activity. In the mentioned example of planning a gas service pipe the artefacts can be traditional paper maps, interactive geoinformation systems or mobile geoservices for outdoor work that help the employee to get all information he needs. Artefacts are created to support persons achieving their goal; as "functional organs" (*Kaptelinin* 1996) they improve the execution of an activity. Artefacts and activities are in a mutual relation: On the one side, the properties of an artefact are determined by an activity, thus, the artefact keeps implicitly an activity's structure. On the other hand, the artefact's properties influence the way in which an activity is executed. For that reason, a modification of the artefact causes a modification of goals and activities and, vice versa, a change of goals and activities changes the artefact. The strong relationship between artefacts and activities is also described by Norman (1986). He points out the problem to execute a person's action plan by an artefact. The action plan has to be transferred to an artefact; the so called "gulf of execution" has to be bridged. Only artefacts which are well related to an action plan allow crossing this gulf without any problem. In the case of planning a gas service pipe, all actions the employee has to fulfil have to be supported by the maps, information systems or mobile geoservices. The artefacts' mediating role is emphasised in following remark: "If we want to study artefacts, we cannot study them as things, we need to look how they mediate use. Artefacts are not just means for individuals, they also carry with them certain ways of sharing and dividing work. Furthermore, the artefacts have no meaning in isolation; they are given meaning only through their incorporation into social practice." (*Bannon and Bodker* 1991).

Activities always take place in a certain situation with a specific context. This context influences an activity as an exterior frame. Engeström (1987) formulated activity context as a network of different parameters that influence each other. This network is structured as following: An *acting person* who wants to achieve a specific *activity goal* belongs to a *community* with *rules*. The activity goal and the social position in the community define a person's *role*. The community to which an acting person belongs to, creates, offers and uses *artefacts* which also influence how a person acts. In our example the employee who has to plan a gas service pipe is enclosed in the power authority's community which has certain rules, e.g. to locate services pipes to specific principles. He has a certain role in the community, e.g. planner, technician or information specialist that guides his work and his knowledge. To perform his work, he can use the artefacts the power authority company makes available; this can be a paper map, an interactive geoinformation system or also a mobile geoservice for outdoor activities. The framework shown in Figure 3.2 describes the social context of an activity and makes apparent social parameters that influence an acting person and his/her activity.

In activity theory acting persons are described in the way: "You are what you do". This statement bases on activity theory's postulation that consciousness is shaped by activities and, vice versa, activities are directed by consciousness, by mental action plans. Accordingly, there are two components in a person's activity enclosed: the action plans, which are the internal (mental) component of an activity, and the actions themselves which are the exterior component.

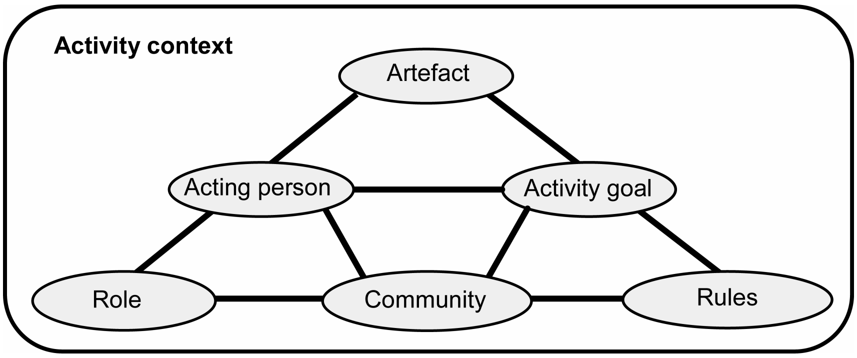

Fig. 3.2. Activity context (after *Engeström* 1987)

Action plans are always determined by a specific activity goal, for that reason, action plans of different people may differ in detail but they correspond in their main structure. This relationship makes apparent that we do not have to deal with individual people but with types of people or "roles" that can be characterised by their activities e.g. "planner", "technician", or "car driver". The consciousness or mental action plans related to a role can be defined as role-specific knowledge. "You are what you do" intends that first of all an acting person can be characterised according to his or her activity; individual attributes are less important when we regard people in action.

3.2.2 Activity and Mobile Geoservices

Activity theory identifies the items which are essential when dealing with activities. The concept clarifies the framework we need to handle mobile activities and geoservices. The most relevant ideas of the framework are: Activities which are supported by mobile geoservices are directed to specific goals. The goal guides how a mobile user acts and it also determines the structure of an activity. The structure is organized in a hierarchic-sequential way with goal, sub-goals and actions. It reflects a mobile user's mental action plan. Mobile geoservices as artefacts have to meet all the goals and sub-goals and they have to mediate all related actions. Mobile activities are not isolated, they are integrated in a social context, for example the related activity community and its rules. Users of a mobile geoservice are characterized predominately in respect to their activity goals, and their role, not accordingly to their individual characteristics.

The mentioned framework forms a suitable basis to design mobile geoservices. It helps to answer following questions which are important for the design of appropriate mobile geoservices.

- What activities, goals and sub-goals have to be supported by the service?
- What social context parameters have to be considered?
- How can users of mobile geoservices be modelled?

What activities, goals and sub-goals have to be supported by the service?
According to activity theory mobile geoservices are regarded as artefacts that mediate activities which are related to or executed during movement. They can either be used continuously throughout a mobile activity, like a service that supports navigation and presents information continuously related to changing spatial context. Or they can be applied discretely during a mobile activity at a special place or/and time to get information about nearby spatial objects. The leading idea of mobile geoservices is presenting information with relevance to a user in a specific mobile activity and context. This goes far beyond the possibilities of a traditional analogue or digital map. Mobile geoservices are a new type of artefact.

Activity theory postulates that artefacts and activities are in a mutual relation. Therefore, new artefacts cause new or changed goals and activities. Current application situations are not adequate to formulate all activities that could be supported by mobile geoservices. For this reason, it is necessary to describe new situations to acquire the full variety of possible applications and to get the range of activities and contexts that have to be assisted. A suitable method for this is scenario description. A scenario is "a possible set of events that might reasonably take place. … The main purpose of developing scenarios is to *stimulate thinking* about possible occurrences, assumptions relating these occurrences, possible opportunities and risks, and courses of action." (*Jarke et al.* 1999). The strong point of the scenario method is its focus on a changed application situation: What is the current-state scenario and what will the future-state scenario be? "With a wide range of possible user situations, we need to have a way for the services to adapt appropriately." (*Dey and Abowed* 1999). Scenarios for mobile geoservices have been defined by Reichenbacher (2004), Zipf (2002), Heidmann and Hermann (2003). They indicate how mobile geoservices can assist users in private, tourist or work situations.

However, it is not sufficient to know all activities on a general level. Activities consist of goals, sub-goals and actions which have all to be supported by mobile geoservices. Therefore, it is necessary to know the detailed structure of an activity. Scenarios are also good means to this structure. The textual scenario can be transferred into a more abstract description by the hierarchic-sequentially organized activity goals and actions. This abstract model can form a good basis to derive activity typologies or ontologies. Some approaches have been conducted for specific application fields like that of McCullough (2001) who proposed a typology related to everyday situations.

The hierarchic-sequentially structured activity model derived from a scenario can also be used as a description of a mobile user's spatially-related action plan. Action plans are essential because they guide how a person acts. They have to be transferred to the mobile geoservice as mediating artefact during activity. For that reason, they are a good basis to make clear what spatial related information, functionality, interaction, and adaptation are necessary in a mobile geoservice for a specific activity. The action plans derived from scenarios as well as the properties of a designed geoservice artefact have to be verified in practice with prototypes of mobile geoservices. This is essential because artefacts always have to be studied in use; they can be evaluated only according to the criteria how they mediate use.

Regarding mobile geoservices as artefact requires a differentiation between activities performed in real world space (e.g. way-finding) and activities accomplished in map space (orientating in a map, extracting map symbols). To reach an intended activity goal in real world with the help of a map-based mobile geoservice, e.g. to navigate from a place A to a place B, or to find a location, a person has to act in different "spaces". He or she has to orientate, to find specific objects and to move in real world. The person has also to do these activities on the map; he or she has to orientate, to find objects, to discriminate map symbols and to move on the map. Mobile geoservices have to support both types of activity. This is especially important in the mobile application situation with its specific characteristics: the user is mobile, often he or she is in a hurry, the surroundings are very dynamic, and the user has to treat a lot of changing information simultaneously.

Figure 3.3 shows a map that supports a mobile person to localize where he/she has to go, how to navigate to the place and to identify a specific location. The map is an example from "Berlin-Adlershof", an area where university departments, research institutes and business companies are established. The area is a very new one, it is still in expansion and not finished yet. Because of this, traditional city maps do not show it correctly, street names cannot be find completely in the map. Orientation as well as navigation is difficult for that reason. The map in our example, a potential map of a mobile geoservice, may support a person in the following way: At first it helps to localise the chosen place by highlighting the object. Next it informs about the way a person has to take from the urban railway station "Adlershof". It gives the direction where to go outside the station, and depicts the route. Lastly, when the person is close to the final destination it shows the building realistically to identify the correct object.

What social context parameters have to be considered?

Engeströms' concept of social activity context (1987) mentioned above gives a framework of different social parameters that influence an activity. Some of these parameters are discussed separately in this section like activity and acting person. The parameter "community", which is strongly related to all the others, will be investigated now.

Fig. 3.3. Example of a mobile map for orientation and way finding

Activities which are to be supported by mobile geoservices cannot be regarded in isolation, they are integrated in a social context. Even users of mobile geoservices are mostly single persons they belong to a social community on behalf of the activity they carry out. For example a service pipe planner belongs to the power authority's community, a car driver is part of the community of people involved in traffic like other car drivers, pedestrians or bicycle drivers, and a visitor of a museum belongs to the group of people visiting or running museums. In these communities rules are established that influence a person's activity, e.g. planning principles determine the planning process and decision, traffic rules direct how we drive, a museum's opening hours guide when we can visit the museum. Mobile geoservices that intended to give the most relevant information at any place and time to a user have to consider these rules when presenting information.

Acting persons are also part of a particular community because of their attitude. These communities have a sort of social rules, too. They guide the interest, the places a person goes to, or the events he or she prefers. Social guidelines effect our activities, therefore, they are also relevant for mobile geoservices.

How can users of mobile geoservices be modelled?

One characteristic of mobile geoservices is their ubiquitous use. Because of this, the application field as well as the amount of potential users is huge. Mobile geoservices should support users with relevant information, i.e., with personalized or egocentric information. However, individuals are so different that it is almost impossible to do this individually for each single person. A more reasonable way would be defining user groups. User groups can be described by social parameters like age, sex, culture and interest. Groups can also be formed by users' behaviour like highflier, trendsetter, poser, or social contact seeker. Certainly, these characteristics are of relevance; however, they are not the most important criteria which define user groups. Users of mobile geoservices are first of all acting persons. Activity theory postulates: You are what you do. Thus, the activity and the related objective are the essential criteria when defining user groups. Bearing this in mind, geoservices should be designed e.g. for "mobile spatial information seekers" or for "spatial navigators". A user attains a particular role because of his or her activity, like "car driver". Roles are related to a role-specific knowledge. This type of knowledge can be regarded as a user's pre-knowledge which has to be considered when designing mobile geoservices. In the field of mobile geoservices activities change over time and therefore, a user's role and role-specific knowledge modifies, too. Geoservices have to regard this and adapt to these changing user parameters.

3.2.3 Context

Context in common sense means surroundings. What "context " or "surroundings" exactly covers, is difficult to describe. "While most people tacitly understand what context is, they find it hard to elucidate" (*Dey and Abowd* 1999). Many papers in the area of mobile and ubiquitous computing gave descriptions and definitions of context: "Context [is] a collection of relevant conditions and surrounding influences that make a situation unique and comprehensible" (*Brezillon* 2003). "Context is generally defined as physical parameters (location, temperature, time, etc.) obtained from sensors. However, the user is not considered in this approach. … Conversely, there is another approach, in which the user (through his knowledge and reasoning) is central in the modelling of context." (*Kouardi et al.* 2003). "Our consideration of context moves from the nature of underlying infrastructure context to consider the overall system context, the broader application domains context, and finally the actual physical context. " (*Dix et al.* 2000). "The principle of context tells us to go to the customer's workplace and see the work as it unfolds." (*Beyer and Holtzblatt,* 1998). "Important aspects of context are: where you are, who you are with, and what resources are nearby." (*Shillit et al.* 1994, in *Dey and Abowd* 1999) "Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and application themselves." (*Dey and Abowd,* 1999).

All these definitions and explanations characterise "context" in different ways; they alter in description as well as in parameters they consider. The most comprehensive approach to define context comes from Dey and Abowd, they describe context as any information that can be used to characterize the situation of an entity and that is relevant to the interaction between a user and an application. This description is a good basis to formulate and model context; however, "*any information*" is a very broad and hazy term that has to be made more concrete. A suitable completion to Dey and Abowd's description is the concept of Dix et al. (2000). It differentiates between several types of context and makes clear what sort of information is necessary to give a complete description of context. They distinguish a more technical context (infrastructure and system context), a domain context, and a physical context. The technical context includes all technical parameters of the infrastructure and the computer system. The domain context can be described by all components and relations that are outlined in the previous section about activity. This includes the activity that has to be supported by the computer system with its goal, structure, action plans and strong relationship to artefacts; the social community in which the activity is performed and its rules; and the users, the acting persons with their specific role and role-related knowledge. The physical context finally, covers all parameters derived from physical environment.

3.2.4 Context and Mobile Geoservices

The context categories mentioned above can be a suitable basis for the design of mobile geoservices. Technical, domain and physical context consider all parameter which are important for mobile geoservices.

The technical context of geoservices has to deal with hard- and software parameters like mobile devices, mobile networks, positioning techniques, OGC-services, standards etc. It will not be regarded here in more detail because it goes beyond the focus of this paper.

The domain context of geoservices is pointed out in the previous section about activity and mobile geoservices. It gives insight in those parameters which describe and influence domain context of mobile geoservices.

The physical context of mobile geoservices involves parameters like location, time, temperature, light etc. As Dey and Abowd (1999) pointed out some parameters are more important than others. In the field of mobile geoservices location and time are the most important physical context parameters. Because of its eminence for mobile geoservices location will be examined more precisely.

Location is always defined in a particular system that describes space. The most common are geographical and geodetical coordinate systems that give the absolute location of an object. Another idea of space is a more topological description of space where location is not considered in an absolute sense but in relation to other objects. Both concepts treat space and location from a mathematical point of view. Despite their widespread use, they are not the only possible schemes to express space and location. Other concepts define space in a more human-related way. They regard space as spatial structure that is arranged by persons and their activities. According to this concept space is only determined by activities; they form specific spatial areas, the physical objects in these areas get importance and meaning only through an acting person and his or her action (*Werlen* 1997).

Geoservices should support the mathematical as well as the human-related concepts of space. Mathematical concepts are necessary to fix a person's absolute or relative spatial position, e.g. to support place finding or navigation. A more human-related idea of space can help to determine personalized, egocentric activity areas, e.g. "activity zones" or "social zones" (*Reichenbacher* 2004, *von Hunolstein and Zipf* 2003). Egocentric structures of space can be a good basis to select and present the most relevant spatial information to an acting person. In a recent paper about space and location in mobile systems Dix et al (2000) claim to combine "the real with the virtual". Geoservices should do this, too. They should combine real mathematical space with the virtual person- and activity-related space.

3.3 Conclusion

Mobile geoservices differ from traditional maps or stationary geo-information services. Their mobile and ubiquitous use produces an application situation that is characterized by changing user positions, changing surroundings and changing activities. A suitable mobile geoservices should take into account these alterations and adapt the presented information to the different context and activity. These requirements make it necessary to take a closer look to activity and context, and to develop a framework to describe and model both. Activity theory as well as some recent descriptions of context form a good basis for such a framework which is outlined in this paper.

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