Context- and Situation-Awareness in Information Logistics

(Extended Abstract)*

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Abstract. In order to deliver relevant information at the right time to its mobile users, systems such as event notification systems need to be aware of the users' context (e. g., time, location, used devices). Many context frameworks have been introduced in the past few years. However, they usually do not consider the notion of characteristic features of contexts that are invariant during certain time intervals. This paper presents a model to handle various contexts and situations in information logistics. A context is defined as a collection of values usually observed by sensors, e. g., location . A situation builds on this concept by introducing semantical aspects defined in an ontology.

1 Introduction

Information logistics aims at providing a subscriber with the right information at the right time and at the right place (see for instance [2]). Two of its representative applications are ongoing projects at Fraunhofer ISST, namely *Personalized Web Services for the Olympic Games 2008 in Beijing* [5] and *MeLog* ("Message Logistics") [7], which consists in delivering mobile users their personal electronic messages according to their relevance with respect to the users' current *situation*. In such applications, beyond the classical dimensions of time and place, content represents a major challenge. Indeed, the information need that will turn into delivered content is a dynamic concept, i. e., a function of time, space, and preferences of the user, among other parameters.

This paper focuses on a model to handle user situations as well as the surroundings of the user – including time and current location – and other attributes referred to as the *context* of the user. The idea is to abstract from sensors and derive semantics as much as possible. Only then the user demand may be satisfied, i. e., information filtered and personalized. Even though some of these notions have been studied in the past few years, we are not aware of any model that encompasses all these notions in a unified framework. The notion of situation has been studied in different fields of computer science such as computational linguistics (situation theory [1]) and robotics (situation

* A full version of this paper is published in [8].

calculus [6]). Although there are similarities to our situation definition, the scope of application of these approaches is different. Our situation model complements the area of information logistics [2] by a formal description of the user's environment and its influences on the information need of the user. The definition of our situation model is based on definitions that had been established in the fields of artificial intelligence [6] and context awareness [3]. Research done in the field of semantic networks and ontologies [4] plays an essential role in our model, in order to interpret real situations.

2 Situation Model

A situation is defined in [6] as "the complete state of the universe at an instant of time". However, in order to describe someone's individual situation we do not need the whole state of the universe but rather use a subset that is considered relevant [3]. A state – called *context* in our model – is a collection of *context variables*, each representing one relevant observable real world parameter, e. g.,

$$\texttt{gpsLocation} = (52.5264, 13.4172) \ ,$$
$$\texttt{velocity} = 1.8\,\mathrm{km/h} \ .$$

A context can be considered as a snapshot or instantiation of all context variables at some point in time. The observation may physically be done via any kind of sensor function which do not play any role here. The value of a context variable (e. g., gpsLocation) will slightly change from time to time, i. e., from context to context, whereas we would not say that a slight movement of a participant within the conference room really affects the situation of the people attending the meeting. We use the notion of *characteristic features* of a context to get properties that are more stable over time. A characteristic feature – or *characteristic* for short – is a logical proposition about a context or a subset of its components, i. e., its context variables:

$$\texttt{organizationalLocation}\,(\texttt{conferenceRoom}) \ ,$$
$$\texttt{kindOfMovement}\,(\texttt{slow}) \ .$$

The mapping between context variables (e. g., velocity) and characteristic features (e. g., kindOfMovement) is defined using application-dependent aggregation rules which are also not discussed in detail here. From the examples used in the previous sections one can see the possible existence of a generalization/specialization relation. That means, one characteristic feature can be inferred when knowing another one. If we know, for example, that a project meeting takes place Tuesday, we can say also that it takes place weekdays. To utilize this, we use concept graphs (directed acyclic graphs), where the nodes are connected by *subsumes*-relations (Fig. 1). We utilize these kind of graphs or taxonomies because they are simple and reflect common ways of human thinking and structuring. Throughout this paper we will refer to such kind of graphs as *dimension structures*. Context and its characteristics encompass many *dimensions* or aspects , e. g., time, location, activities, or kind of movement, which should be handled separately. A dimension can be viewed as the type of a characteristic feature and is represented by a

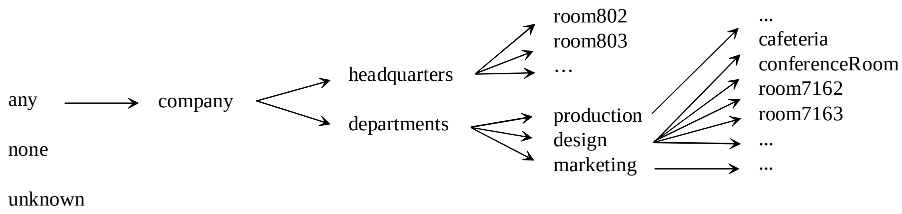

Fig. 1. Example of a dimension structure.

predicate and a dimension structure. For many of these aspects ontologies representing common knowledge already exist and can be used to express context characteristics.

We are now able to give a more formal definition of situation. We use the concept of characteristic features described previously. A situation in our model will be formed by a sequence of contexts with invariant characteristics and is described as a triple

$$S = (t_{\text{beg}}, t_{\text{end}}, cs)$$

where

t_{beg} is the starting time of the situation (i. e., the time of the first context of the sequence),

t_{end} is its end time (i. e., the time of the last context of the sequence), and

cs is a set of characteristic features which are invariant throughout the sequence. cs is interpreted as the conjunction of all characteristic features: $cf_1 \wedge \ldots \wedge cf_n$.

This definition offers a rich concept that enables us to describe the activity and the location of the user, such as being "at home", "at the office", "in the train", or "on the phone". We would like to emphasize two major features. First, the notion of situation may encompass many dimensions as one can be both in a taxi and on the phone. To handle this aspect efficiently we chose not to mix dimensions and to consider them separately. Second, the generalization/specialization notions of our characteristics enable the description of situations on different levels of granularity. It can be general, e. g., "traveling", or more precise, e. g., "in a taxi going down the Champs Elysees".

Situation Awareness. Recognizing and identifying situations is a central requirement for applications in information logistics. Applications that make use of situations and are able to handle changes such as entering or leaving a situation are denoted *situation-aware applications*. There are two ways for such an application to utilize the situation model: (1) Analysis of past and current situations, where context information is available. (2) "Situation construction" or planning of situations with assumed characteristics, where context information is not available, but where the characteristics (which are propositions about the contexts) impose restrictions on context variables. These restrictions can be used afterwards to check whether the planned situation actually takes or took place, or not. In addition, one can define *typical situations* and check whether an actual situation complies with a certain definition.

Operators. To handle situations we defined a set of operators, whereby we we distinguish operators that manipulate whole situations from the ones that work on their characteristics.

Operators on Characteristics. The following three operators have in common that they deal with similarities or analogies between characteristics:

`generalize` $(cs_1, cs_2) \rightarrow cs_{\mathrm{r}}$: takes two sets of characteristics cs_1, cs_2, and finds the most specific set of characteristics cs_{r} that is common for both.

`fulfills` $(cs, p) \rightarrow \{$`true, false`$\}$: determines whether a set of characteristics cs complies to the conditions of a situation pattern p.

`compare` $(cs_1, cs_2) \rightarrow [0, 1] \subset \mathbb{R}$: computes the similarity between two given sets of characteristics cs_1, cs_2 by applying a similarity metric on the subsumes-paths within the dimensions).

Operators on Situations. We use the notion of *situation sequences* to denote a series of directly subsequent situations.

`previous` $(s) \rightarrow s_{\mathrm{p}}$: determines the predecessor s_{p} of a given situation s .

`next` $(s) \rightarrow s_{\mathrm{s}}$: determines the successor s_{s} of a given situation s .

`combine` $(seq) \rightarrow s_{\mathrm{r}}$: finds a generalized situation s_{r} covering the whole time interval of a situation sequence seq.

3 Conclusion

This paper presented a model to handle various contexts and situations in information logistics. A context is defined as a collection of values extracted from the environment at a certain time (e. g., location and speed extracted by sensors). A situation builds on this concept by introducing propositions about context data, which form characteristic features that are stable over a time interval. Semantical aspects in form of ontologies are used to enable interpretation of situations by applications. When the system is able to deduce situations from the context, it is implicitly able to infer the user's information demand. This enables the delivery of information relevant at a certain point in time.

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