SPATIAL RELATIONS AND INFERENCES FOR CONTEXT AWARE VISUALIZATION

O. Akcay and O. Altan

ITU, Faculty of Civil Engineering, Department of Geomatic Engineering, 34469 Maslak Istanbul, Turkey - akcayoz@itu.edu.tr, oaltan@itu.edu.tr

Commission II, WG II/5

KEY WORDS: Ontology and Concepts in GIS, Location-Based Services, Web and Wireless Applications in GIS

ABSTRACT:

Data submission and refreshment, e.g. sensors, continuously feed a distributed information system. The system has to interpret incoming data in order to get valuable information which comes from different sources. Mobile users need more adaptive visualized spatial data according to location, device, personal profile, intention etc. In a semantic approach, an ontological model provides an intelligent system which is capable of extracting implicit information from explicit one. In this paper, some spatial concepts and properties have been defined for mobile devices and their users so as to produce context-aware visualization. The aim of these mobile contextual ontologies is to obtain a semantic model which inferences some parameters for an appropriate visualization.

1. INTRODUCTION

Advanced wireless technologies enable smart applications on Location Based Services (LBS). These smart applications are capable of doing some inferences in order to obtain a visualization which is relevant to the user situation. A Geographical Information System (GIS) continuously receives various kind of data and the system always updates itself. Especially in systems like LBS, there are a lot of instant changes that affect decision process. To evaluate effects of instant changes accurately, knowledge-base systems should be established. Establishing an appropriate knowledge-base system requires some steps: Determining context, ontological approach on the context and composing knowledge-base.

According to the context, a context aware system can be provided. A context aware system is a system uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task (Dey and Abowd, 2000). Ontological approach of the context should be implemented so as to provide a system which can be interpretable by computers. Ontological concepts and relations are coded with ontological languages. A consistent knowledge-base provides a system which is sensible and capable of showing reaction to the instant changes.

In this paper some spatial concepts and their relation have been investigated in order to obtain relevant visualisation on small mobile devices. Small mobile devices are not able to handling huge amount of data. A simple computing environment structure is necessary to process spatial data on tiny mobile devices. Next section presents some related works. Section 3 then explains some concept, their relations and their some simple inferences. Concluding remarks are discussed in last section.

2. RELATED WORK

Scientifically, LBS is not only a spatial topic. Computer Sciences also contribute to LBS, because they are pervasive computing environment. Pervasive computing environments gracefully integrated networked computing device - with people and their ambient environments. A room, for example, might be saturated with a lot of devices that provide information to people without needing their active attention (Zhu et al., 2005). Establishing a pervasive computing application has become one of the major tasks in computer sciences. In particular, pervasive computing demands applications that are capable of operating in highly dynamic environments and of placing fewer demands on user attention. In order to meet these requirements, pervasive computing applications will need to be sensitive to context.

Depending on the advancement of pervasive computing, geoinformation researches have tended to focus on context-aware and semantic modelling. Hong et al., 2005 proposed an adaptive location data management strategy in order to support adaptivity and scalability of the location based system using a variety of context which can be accessed in the ubiquitous computing environment. Hong et al., 2005, however, ignored the need for a semantic projection of the context model in order to obtain a ubiquitous computing system.

Kim et al., 2005 presented the architecture of tour information services based on semantic web technologies. The aim of the service is to provide the exact tour information and interoperability between the server systems. Nevertheless, the definition of the ontologies of the tour information explains only a small part of the location based services. It does not provide a whole semantic system design. The tour ontology should be integrated to user, device and spatial ontology and relations with each other. Another ontology-based approach is personalized situation-aware mobile service supply (Weissenberg et al., 2006). The research, however, does not include the visualisation styles of any spatial entity that obtained at the context-aware service.

Chen et al., 2004 designed a context-aware architecture so as to create intelligent spaces. They established a broker federation formed by multiple brokers. Gu et al., 2004 also presented a detailed context-aware architecture for smart home applications.

Christopoulou et al., 2004 defined an ontology-based context model. Lutz and Klien, 2006 explained an ontology-based Geographical Information retrieval contributes to solving existing problems of semantic heterogeneity and hides most of the complexity of the required procedure from the requester. In this paper, as a different approach, modeling spatial visualisation has been considered for any scale of a smart application of LBS.

Ontological knowledge-based systems are composed with ontology languages. Ontology Web Language (OWL) has been accepted as a standard language of ontology (McGuinness and van Harmelen 2004). The Semantic Web Rule Language (SWRL) is another specification to extract implicit information from explicit ones. SWRL concludes acquired knowledge with a rule based XML syntax language. Therefore it can be perceived a different kind of OWL-DL specification. In any case, SWRL is based on a combination of the OWL-DL and OLW-Lite sublanguages of OWL with the Unary/Binary Datalog RuleML sublanguages of the Rule Markup Language (RML) (Horrocks et al., 2004).

3. SPATIAL RELATIONS AND INFERENCES

Basic spatial objects are polygons, polylines and points. Ontological perception of spatial objects should base on these basic shapes. In two dimensional representation, buildings, regions, territories, areas can be shown with polygons. Roads, rivers, borders can be drawn with lines. Any other object can be represented with point such as a bus station, a person and a vehicle. Figure 1 depicts a simple map with basic spatial objects.

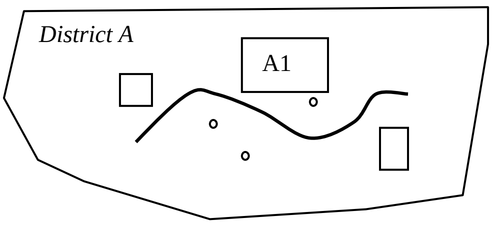

Figure 1. A basic map.

A1 is an instance of Building Concept. A1 building has to be in a district of the city. Building A1, therefore, is subsumed by a region. Let us assume that District A subsumes Building A1. A district is subsumed by a city. A city is subsumed by a country. A country is subsumed by a continent. A continent is subsumed by the world. Consequently everything which has dimensions is a part of the world. This ontological concept can be extended to three dimension.

LBS is a smart environment which can be established in different scales. It can be valid for either a home or a city. Smart environments are so complex for wide areas. It needs well organised ontological relations. Otherwise computer cannot handle huge amount of interactions occurred at the same time.

Let us assume that person A stays in the conference room. He or she wants to go to a theatre close to him. Spatial concepts connected each other with relation of isPartOf. Person A isPartOf Conference Room. Conference Room isPartOf Building A. Building A isPartOf District A. District A isPartOf City A. Theatre A isPartOf District A. Theatre B isPartOf District A and Theatre C isPartOf District C (Figure 2). We are able to inference that Theather C and Person A are not at the same district.

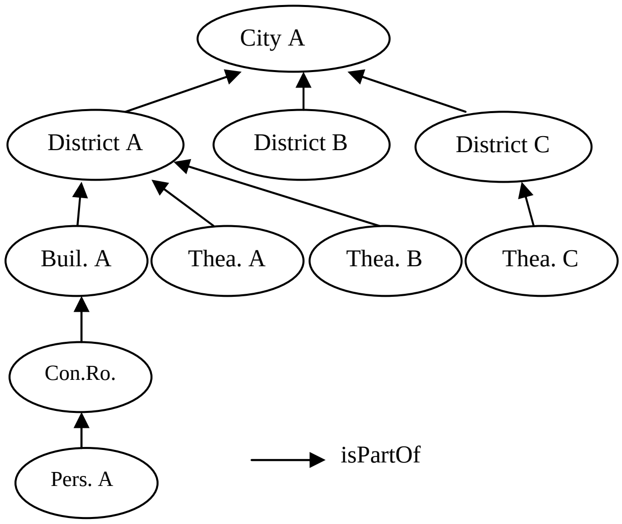

Figure 2. Ontological relations.

District A is the lowest common level of the Person A, Theatre A and B. Theatre C isPartOf District C. Theatre A and Theatre B are the closest theatres to Person A. Now one question remain that which theatre is the closest to Person A in District A. To answer this question by ontologically, smaller entities than a district should be created. partsIn this method, areas (polygons) should be divided small parts to get realistic results to the queries (Figure 3).

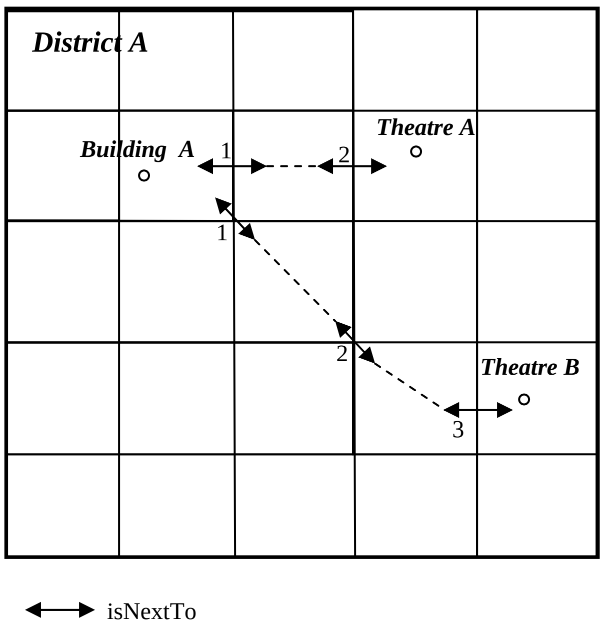

Figure 3. Retrieving the neighbours of Building A by using isNextTo in District A.

isNextTo relation defines neighbours of small District parts. Building A has two isNextTo relation to Theatre A whereas there is three relation to Theatre B. The fewer relation numbers show the closest places. Consequently Theatre A therefore can be obtained as the closest to Building A.

4. CONCLUSION

Ontological approach including concepts, relations and instances is essential for smart environments like LBS. This paper presents a simple spatial ontology in order to provide a location sensitive context aware computing system. System enables a solution for finding closest place at the smart environments. The solution differs from distance based solutions because of its applicable data structure to an ontological context aware system.

This ontological structure should be extended to handle more LBS components such as navigation and meeting queries. Ontological inferences provide implicit context so as to obtain additional information about the situation.

Statistical analyses of the ontological concepts and their relations have not been completed yet. After the analysis, some obvious benefits of the knowledge base also will be shown later. This paper also ignores roads to determine closest place. To obtain more accurate result road entity should be also added to knowledge base.

REFERENCES

Chen, H., Finin, T. and Joshi, A., 2004. An ontology for context aware pervasive computing environments. Knowledge Engineering Review 18, pp. 197–207.

Christopoulou, E., Goumopoulos, C., Zaharakis, I. and Kameas, A., 2004. An ontology-based conceptual model for composing context-aware applications. Workshop on advanced context modeling, reasoning and management, 6th International Conference on ubiquitous computing, Nottingham, England.

Dey, A. and Abowd, G., 2000. Towards a better understanding of context and context-awareness. CHI'2000 Workshop on the What, Who, Where and How of Context Awareness, The Hague, The Netherlands.

Gu, T., Wang, X., Pung, H. and Zhang, D., 2004. An ontology based context model in intelligent environments. Proceeding of Communication Network and Distributed Systems Modeling and Simulation Conference, San Diego, California, USA.

Hong, D., Kim, D., Yun, J. and Han, K., 2005. An adaptive location data management strategy for context-awareness in the ubiquitous computing environment. Proceedings of International Symposium on Spatio-temporal Modeling, Spatial Reasoning, Spatial Analysis, Data Mining and Data Fusion, Beijing, China pp. 57–62.

Horrocks, I., Patel-Schneider, P.F., Boley, H., Tabet, S., Grosof, B. and Dean, M., 2004. SWRL: A semantic web rule language combining OWL and RuleML, http://www.w3org/Submission/SWRL, May 2004.

Kim, J., Kim, J., Hwang, H. and Kim, C., 2005. Location sensitive tour guide services using the semantic web. Lecture Notes in Computer Sciences 3682, pp. 908–914.

Lutz, M. and Klien, E., 2006. Ontology-based retrieval of geographic information. International Journal of Geographical Information Science 20, pp. 233–260.

McGuinness, D.L. and van Harmelen, F., 2004. OWL web ontology language overview, W3C Recommendation, http://www.w3.org/TR/owl-features/, 2004.

Weissenberg, N., Gartmann, R. and Voisard, A., 2006. An ontology-based approach to personalized situation-aware mobile service. GeoInformatica 10, pp. 55–90.

Zhu, F., Mutka, M. and Ni, L., 2005. Service discovery in pervasive computing environments. Pervasive Computing 4, pp. 81– 90.