Semantic Graph Visualisation for Mobile Semantic Web Interfaces

Daniel Sonntag and Philipp Heim

German Research Center for Artificial Intelligence
66123 Saarbrücken, Germany
sonntag@dfki.de

Abstract. Information visualisation benefits from the Semantic Web: multimodal mobile interfaces to the Semantic Web offer access to complex knowledge and information structures. Natural language dialogue systems are ideal interfaces to personal digital assistants (PDAs) or other handheld clients. We explore more fine-grained co-ordination of multimodal presentations as answers to natural language questions about a specific domain by graph-based visualisation and navigation in ontological RDF result structures. Semantic Navigation on mobile devices leverages graphical user interface activity for dialogical interaction in mobile environments. Constraint-based programming helps to find optimised multimedia graph visualisations.

Introduction For every specific type of information there are certain categories of visual representations that are more suitable than others. The use of a graph for the visualisation of information has the advantage that it can capture a detailed knowledge structure. Therefore graphs are suitable for conveying semantic relations between individual information items and for providing an understanding of the overall information structure. Apart from that dialogue systems are very useful for interacting with Web-based information services in mobile environments.

The challenge we address is the intuitive navigation in a structured, semantically organised information space on small interaction devices such as PDAs. Our aim is to implement and evaluate mobile Semantic Web interfaces by application of direct structure mapping from RDF[1] graphs toward their multimedia visualisations. Displaying RDF data in a user-friendly manner is a problem addressed by various types of applications using different representation paradigms [1]. At least the following types can be identified: keyword search, e.g. Swoogle[2], faceted browsing [2], explicit queries, e.g. Sesame[3], and graph visualisations. In our approach we use an automatic layouter for dynamic constrained graph display tailored to suit small displays as valuable extension to other graph visualisation techniques. By additional graph presentation capabilities in a primary

[1] http://www.w3.org/RDF/
[2] http://swoogle.umbc.edu/
[3] http://www.openrdf.org/

Fig. 1. Graphical user interface and semantic navigation (centre and right).

linguistic question answering scenario, the users would become more engaged in the dialogue, navigate through the incrementally presented result space, and would be encouraged to pose follow-up questions in natural language. In our most recent dialogue system project SmartWeb [3] following experiences in [4–6], we try to provide intuitive multimodal access to a rich selection of Web-based information services; especially the handheld scenario is tailored toward multimodal interaction with ontological knowledge bases and Semantic Web services [7] in the football domain. For example, the user can ask questions like *How many goals has Michael Ballack scored this year?* or *How did Germany play against Argentina in the FIFA World Cup?* The summarised answer to the last question, SmartWeb provides and synthesises, is *5 Spiele* (5 matches). Figure 1 shows the PDA interaction device. When the structure of the dynamic graph changes, a new optimal layout is computed server-side. A further click on the *Ergebnis* (result) node results in displaying the information: **5:3** n. E., 1:1 n. V. (**1:1**, **0:0**), *Ereignis* (incidence) reveals red card for player *Cufre*, for example. A shared representation and a common ontological knowledge base ease the data flow among components and avoid costly transformation processes [8]. This applies to the visualisation process, too. We use the ontological RDF metadata to arrange information pieces in automatically layout graphs with respect to their semantic relations extracted from RDF results obtained from our knowledge servers. Humans themselves may encode information based upon its meaning [9]. Users feel familiar with this way of information arrangement at least.

Integration We integrated the semantic graph visualisation approach into our distributed dialogue system. In SmartWeb, the graph-based user interface on the client is connected to the automatic graph layouter that resists on the server. All data transfer between server and client is organised by special XML structures transmitted over socket connections in both directions. We extended this XML structure by an new *dynamic graph* environment, for the graph structure data to be exchanged, the graph node layout positions, and the user interactions. The data flow is shown in figure 2. The presentation capabilities after integration

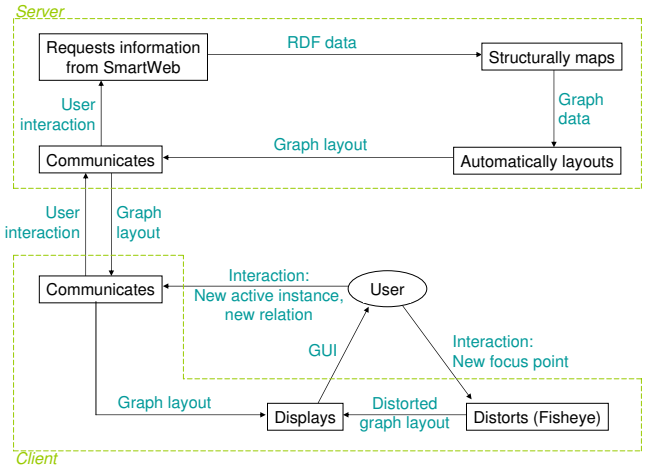

Fig. 2. Semantic graph visualisation data flow. Graph layouts for arbitrary RDF graph data are calculated on the server.

include (1) summarising multimodal result and finding an appropriate mapping toward a lower-level visual object and its attributes which we model in the interaction ontology, (2) finding out visual pattern interrelationships, (3) automating the visualisation of multimodal graph information which complements natural language generation output, and (4) provide consecutive information displays communicated from the server to the client for semantic navigation.

Conclusion and Future Work Semantic graph visualisation as presented relies on ontological formulation of interaction and presentation constraints, as well as on highly structured RDF data as result structures in the question answering scenario we model. Since the RDF result data are already in a graph-like format, we explored how to map this RDF data into a graph structure and how the resulting graph can be visualised, as an example of how to visualise the Semantic Web. During the development of our system, we used two evaluation phases that involved 20 users in testing design ideas and to get their feedback at an early stage of development. These feedbacks were useful sources of suggestions for the

further improvement of our graph presentation system, and show additionally, that graph visualisations and interactions are generally welcomed alternatives for highly structured result data in question answering scenarios; 85% describe the graph interaction possibilities as easy to understand (after an initial demonstration), 95% easily understand the difference between instance nodes and relation nodes. We conclude by further motivating the use of ontologies and Semantic Web data structures [10] for multimodal interaction design and implementation, and in particular, for visualising graph-like information spaces on mobile PDA devices. We hope that in the future graph visualisation approaches as presented here can help to provide an answer to the question how conceptual data models facilitate the generation of semantic navigation structures on mobile devices.

Acknowledgements The research presented here is sponsored by the German Ministry of Research and Technology (BMBF) under grant 01IMD01A (SmartWeb). We thank our project partners, our research assistants, and the evaluators. The responsibility for this papers lies with the authors.

References

1. Pietriga, E., Bizer, C., Karger, D., Lee, R.: Fresnel: A browser-independent presentation vocabulary for RDF. In: International Semantic Web Conference. (2006) 158–171
2. Yee, K.P., Swearingen, K., Li, K., Hearst, M.: Faceted metadata for image search and browsing. In: CHI '03: Proceedings of the SIGCHI conference on Human factors in computing systems, New York, NY, USA, ACM Press (2003) 401–408
3. Wahlster, W.: SmartWeb: Mobile Applications of the Semantic Web. In Dadam, P., Reichert, M., eds.: GI Jahrestagung 2004, Springer (2004) 26–27
4. Wahlster, W., ed.: VERBMOBIL: Foundations of Speech-to-Speech Translation. Springer (2000)
5. Wahlster, W.: SmartKom: Symmetric Multimodality in an Adaptive and Reusable Dialogue Shell. In Krahl, R., Günther, D., eds.: Proc. of the Human Computer Interaction Status Conference 2003, Berlin, Germany, DLR (2003) 47–62
6. Wahlster, W.: SmartKom: Foundations of Multimodal Dialogue Systems (Cognitive Technologies). Springer-Verlag New York, Inc., Secaucus, NJ, USA (2006)
7. Sonntag, D., Engel, R., Herzog, G., Pfalzgraf, A., Pfleger, N., Romanelli, M., Reithinger, N.: Smartweb handheld–multimodal interaction with ontological knowledge bases and semantic web services. In: Proceedings of the International Workshop on Artificial Intelligence for Human Computing at IJCAI 2007. (2007)
8. Oberle, D., Ankolekar, A., Hitzler, P., Cimiano, P., Sintek, M., Kiesel, M., Mougouie, B., Vembu, S., Baumann, S., Romanelli, M., Buitelaar, P., Engel, R., Sonntag, D., Reithinger, N., Loos, B., Porzel, R., Zorn, H.P., Micelli, V., Schmidt, C., Weiten, M., Burkhardt, F., Zhou, J.: Dolce ergo sumo: On foundational and domain models in SWIntO (SmartWeb Integrated Ontology). Technical report, AIFB, Karlsruhe (July 2006)
9. Myers, D.G.: Psychology. Worth Publishers (2004)
10. Fensel, D., Hendler, J.A., Lieberman, H., Wahlster, W.: Spinning the Semantic Web: Bringing the World Wide Web to Its Full Potential. The MIT Press (2005)