Novel Architectures for Location-based Services

Jörg Roth

University of Hagen
Department for Computer Science
58084 Hagen, Germany
Joerg.Roth@Fernuni-hagen.de

Applications or services which take into account the current location will become increasingly popular in the future. Especially mobile phone providers expect a huge market for such services. Typical applications answer questions like “Where is the nearest hotel?” or “Who of my friends is in proximity?”. Further examples are city guides or navigation systems. Currently, the development of such services is cost-intensive due to the heterogeneity of positioning techniques, positioning systems and location data [3, 9].

To support developers of location-based services we created the *Nimbus* framework. Nimbus provides a common interface to location data and hides the position capturing mechanisms. To achieve an optimal flexibility, it provides physical coordinates as well as semantic information about the current location. With Nimbus, mobile users can switch between satellite navigation systems such as GPS, positioning systems based on cell-phone infrastructures, or indoor positioning systems without affecting the location-based service. As our infrastructure is self-organizing, it is flexible and easy to extend.

The concept of *semantic locations* heavily influenced the Nimbus framework. Semantic locations have a certain meaning for users or applications. Typical examples of such locations are "Campus, University of Hagen" or "City centre of Paris". The key idea of our location model was to strongly couple semantic and physical locations. Having both types of locations has a number of advantages:

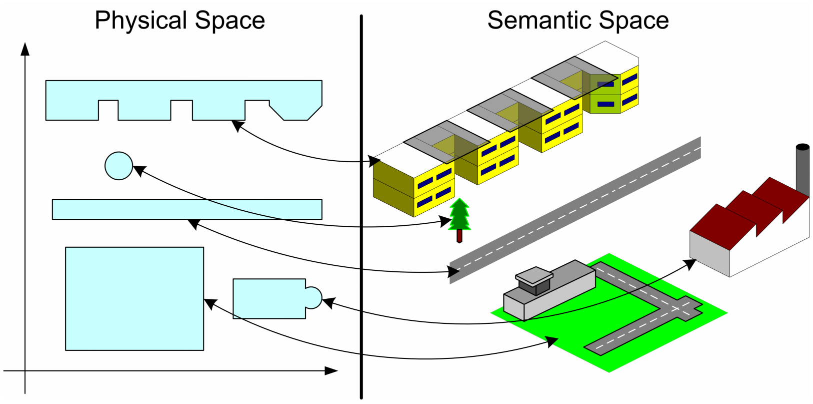

Fig. 1. Mapping between physical and semantic space

- Semantic locations have a meaning to the user and can be used to display information about locations. In addition semantic locations build according to a well-defined name space can easily be used as a search key for traditional databases, tables or lists.
- Physical locations on the other hand are useful for all kinds of geometric queries, e.g. asking for distances between locations, asking for directions.

We assume a tight relation between semantic and physical locations as presented in fig. 1. The duality of physical and semantic space is reflected by the Nimbus location model [7] which contains

- a formal specification of sets which describe locations,
- a set of rules that define the relations between these sets,
- a set of operations that process location data, and
- a set of rules to adapt the model according to scalability issues.

The Nimbus location model structures the space and relates physical to semantic locations. It lays the foundation to an efficient infrastructure to store and retrieve location data in a distributed environment. Having only one piece of location information (either physical or semantic), the resolution operations [1, 2, 7] retrieve the corresponding missing information. These operations especially work for a huge amount of location data sets.

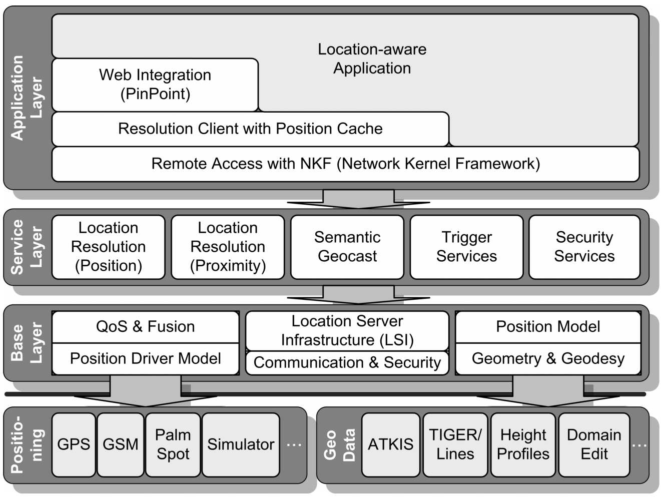

Fig. 2. The Nimbus framework

Fig. 2 shows the architecture of the Nimbus framework. Using this framework, developers can concentrate on the actual application function and can use location-dependent services of our platform. We distinguish three layers:

The *base layer* provides basic services related to positioning systems. The framework can use arbitrary positioning systems, ranging from satellite positioning systems, positioning with cell phone networks to indoor positioning systems, based on e.g. infrared or ultrasound. To achieve the required flexibility, we attach the positioning system via a driver interface. This interface allows the framework to switch between positioning systems at runtime. The *location model* contains a formalism to describe locations and a set of rules to model the world. Finally, the *Location Server Infrastructure* (*LSI*) [8] stores the location data and provides services to access these data. It mainly consists of a federation of so-called *location servers*, each storing a piece of the entire location model (fig. 3).

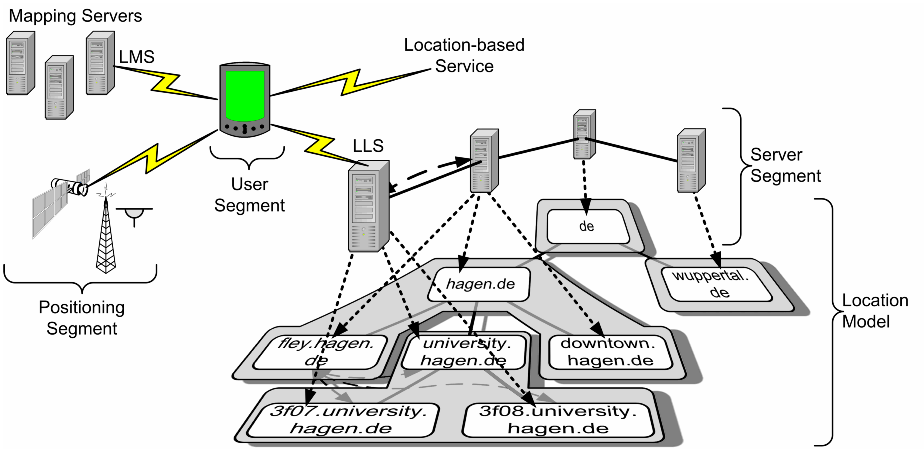

Fig. 3. The Location Server Infrastructure

The second layer, the *service layer*, provides higher-level location services. The most important service is the *location resolution* which allows an application to ask for the current location. In contrast to positioning systems, the location provided by this component contains globally unique physical as well as semantic locations. The application can specify requirements concerning precision and costs using quality of service parameters (QoS). If more than one positioning system is accessible at a certain location, the framework selects an appropriate system according to the specified parameters. An important service of this layer is the *semantic geocast* [6] which extends the original idea of geocasting. Trigger services inform the application when a certain location was reached. A set of security functions protect the users and the framework against attacks.

The *application layer* contains the actual location-aware application or service. A communication middleware called *Network Kernel Framework* (*NKF*) [4] was especially designed for small mobile devices such as PDAs or cell phones and offers communication primitives to access the servers. To develop location-aware Web applications we offer a high-level component called *PinPoint* [5]. The World Wide Web is a powerful platform to develop location-based services, but currently makes no use of the client's current position. PinPoint integrates location information into the HTTP data stream and still allows the usage of existing components such as Web browsers and Web servers without modifications. As an example application, we developed a Web-based tourist guide with PinPoint.

References

1. Hadig, T., Roth, J.: Proximity Services with the Nimbus Framework, IADIS International Conference Applied Computing 2004, Lisbon (Portugal), March 23-26, 2004, IADIS Press, 437-444
2. Hadig, T., Roth, J.: Accessing Location and Proximity Information in a Decentralized Environment, International Conference on E-Business and Telecommunication Networks, ICETE 2004, Setúbal (Portugal), Aug. 25-28, 2004, to appear
3. Roth, J.: Mobile Computing, dpunkt-Verlag, 2002
4. Roth, J.: A Communication Middleware for Mobile and Ad-hoc Scenarios, Int. Conf. on Internet Computing (IC'02), June 24-27, 2002, Las Vegas, Vol. I, CSREA press, 77-84
5. Roth, J.: Context-aware Web Applications Using the PinPoint Infrastructure, IADIS Intern. Conference WWW/Internet 2002, Lisbon, Portugal, Nov. 13-15 2002, IADIS press, 3-10
6. Roth, J.: Semantic Geocast Using a Self-organizing Infrastructure, Innovative Internet Community Systems (I2CS), Leipzig, June 19-21, 2003, Springer-Verlag
7. Roth, J: Accessing Location Data in Mobile Environments – the Nimbus Location Model, Mobile HCI 03 Workshop on Mobile and Ubiquitous Information Access, Udine (Italy), Sept. 8, 2003, LNCS 2954, Springer-Verlag, 256-270
8. Roth, J.: Flexible Positioning for Location-based Services, IADIS Journal on WWW/Internet, Vol. I, No. 2, Dec. 2003, IADIS Press, 18-32
9. Roth, J.: Data Collection, in Jochen Schiller, Agnès Voisard (eds), Location-Based Services, Morgan Kaufmann Publishers, in press