A Three-Tier Architecture for Location Presentation

Christian Decker, Michael Beigl, Albert Krohn, Philip Robinson, Tobias Zimmer, Jun Ma
TecO, University of Karlsruhe
Vincenz-Priessnitz-Str.1
76131 Karlsruhe, Germany
{cdecker, beigl, krohn, zimmer, philip, junma}@teco.edu

ABSTRACT
We propose a generic architecture to utilize location systems with a coherent graphical user interface enabling users to present location of mobile objects in their environment and tracking them over time. Implementation relies on backend database and a series of java applets for an independent access and is evaluated using a cell-of-origin location system based on Smart-Its Particles.

Keywords
Location, RAUM, User Interface, Smart-Its Particles

INTRODUCTION

Past and recent developed location systems in Ubicomp are always integrated with their own user interfaces (UI) which integrate in the overall system. However, apart from specific elements for accessing special features all systems present their information in a similar way: Mobile objects which should be located are presented as markers on a floor plan. This motivates the separation between the location system and the location UI. While the location system is responsible for determining the position of objects in its own framework, the UI is expected to display this information for a user in a familiar way, mostly within an image of the real world. Prominent location systems include the Active Bat system [1] and the Cricket systems [2]. Both are technically based on devices and an infrastructure that is especially build to retrieve the location information. While Active Badge uses a geometric description of the location Cricket presents the information as intentional names (intentional naming system, INS)[3] in symbolic notation. In GIS (see e.g. [6]) hybrid systems mixing the advances of both ways to describe locations are used.

The presentation system architecture shown here allows to display location information of different types of location systems in a coherent way: geometric, symbolic or hybrid. It therefore enforces the split between the location monitoring system and the presentation. It is especially suited to also integrate location information retrieved via technology that is not build as a location information system as its primary use. Examples are location information from sensor networks or from data of WiFi access points (e.g. via field strength measurements or as cell of origin information).

The Location Presentation System has two views: first in the view of the administrator or maintainer and second the view of the user. Components used in each of the view are introduced. At the end the implementation and some conclusions are given.

MAINTENANCE VIEW

In this view three types of information have to be specified by a maintainer of a location presentation system.

- The graphical representation of the location map. This map describes the overall boundary of the space and additional information as landmarks. This also includes boundaries and restrictions that apply to the area as walls and doors. The graphical representation is done via a very simple graphical editor.
- The Location Data Model describes the syntax of the location data, e.g. NMEA for data from GPS receivers, GML for symbolic geographic descriptions or RAUM[4] for hybrid descriptions of indoor spaces. This part is special to each of the used location models. It parses the incoming data from the location system and presents them in a common format to the other components.
- The Location Link Service that contains rules to transfer location expressions delivered from the Location Data Model to the graphical representation. This part has to be adopted and written for each of the used location models.

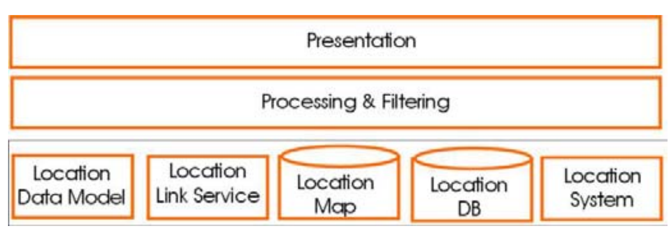

Figure 1.Three-Tier Architecture for Location Presentation

USER VIEW

The presentation part of the system uses a three tier architecture (Figure 1) to graphically show objects at their location. Our approach comprises the three components Information Base, Processing & Filtering and Presentation arranged in the following architecture.

Information Base. Information visualized can either come directly from an active location system or can be previous time-stamped data from a location DB. This information is interpreted and parsed using the Location Data Model and mapped to the graphical display using the Link Service.

Processing & Filtering. The middle tier computes the location information from location system or database using the Link Service and Location Data Model. Each object is then mapped to a distinct space or point following the rules stored in the Location Link Service. Further functionality includes filtering for certain objects and time intervals in order to support the presentation component.

Presentation. The presentation component contains the actual UI for interaction with the user. Using the Location Map and assignments from the layer below, the presentation layer generates graphical representation of the objects' location. The presentation serves further as input interface, so that the user can create and manipulate the Location Data Model as well as the map. Filters from in the "Processing & Filtering" layer allow tracking of single or all objects over time.

IMPLEMENTATION

The complete architecture was first implemented with Link Service and Location Model modules for the RAUM[4] system. This location model is optimized for information description of indoor environment as office spaces or home. RAUM coordinates are natively used and delivered from the Particle Smart-Its system [5] used in several application settings. RAUM represents locations in a hierarchical, tree-based naming scheme, where each location is represented as node in a tree. Starting from a root node a location is clearly described by concatenating node names on the path to the target node. The target node may also be a tuple of (x, y, z) coordinates describing additionally an optional geometric position. An additional descriptor also identifies the error of the position description. For example, a typical object location descriptor is

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(Root_ID, TecO, staff,office1,(23,123,100))
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where Root_ID is a unique 16 byte IPv6 identifier for the organization that owns the root tree.

Implemented application settings include several office space set-ups and demo-set-ups at fairs. Location is detected using Particles and forwarded to IP based services and programs using a Particle-to-Ethernet bridge infrastructure. This way location database service and the Processing&Filtering component of the Location UI receive the data. Data also include a unique identification (ID) of each Particle. The maintenance view of the system was implemented using several Java applets. One applet let a user create a tree of location descriptions and offers a way to assign those descriptions to bridges which add them to all data they forward into the network. When creating the map a user loads the map applet and draws polygons, representing the according space (see Figure 2 our office space). He assigns a node from the RAUM tree to parts of the drawn schema. The processing and filtering currently implements an aggregation function summarizing multiple sightings of one Particle within a short time frame to just one sighting. The presentation applet (Figure 2) uses the filtered information and the previously defined map to display Particles in their current or past locations. Replaying the location history over the time of a day allows to track them. Furthermore, the applet offers to possibility to query the location for a certain Particle using its ID.

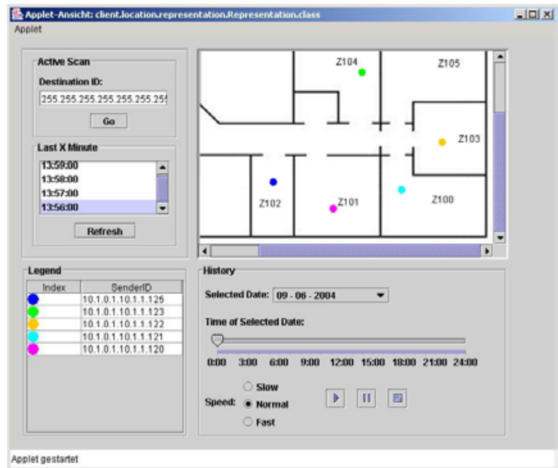

Figure 2. Location Presentation

CONCLUSION

With the about 100 devices in total use in the different settings we collected about 9 GB of location data. Analysis of this data with our system was of great help evaluating situations as preparation for designing context and situation aware applications. The proposed architecture is found generic. We work on extension of the system integrating other location data models, especially NMEA.

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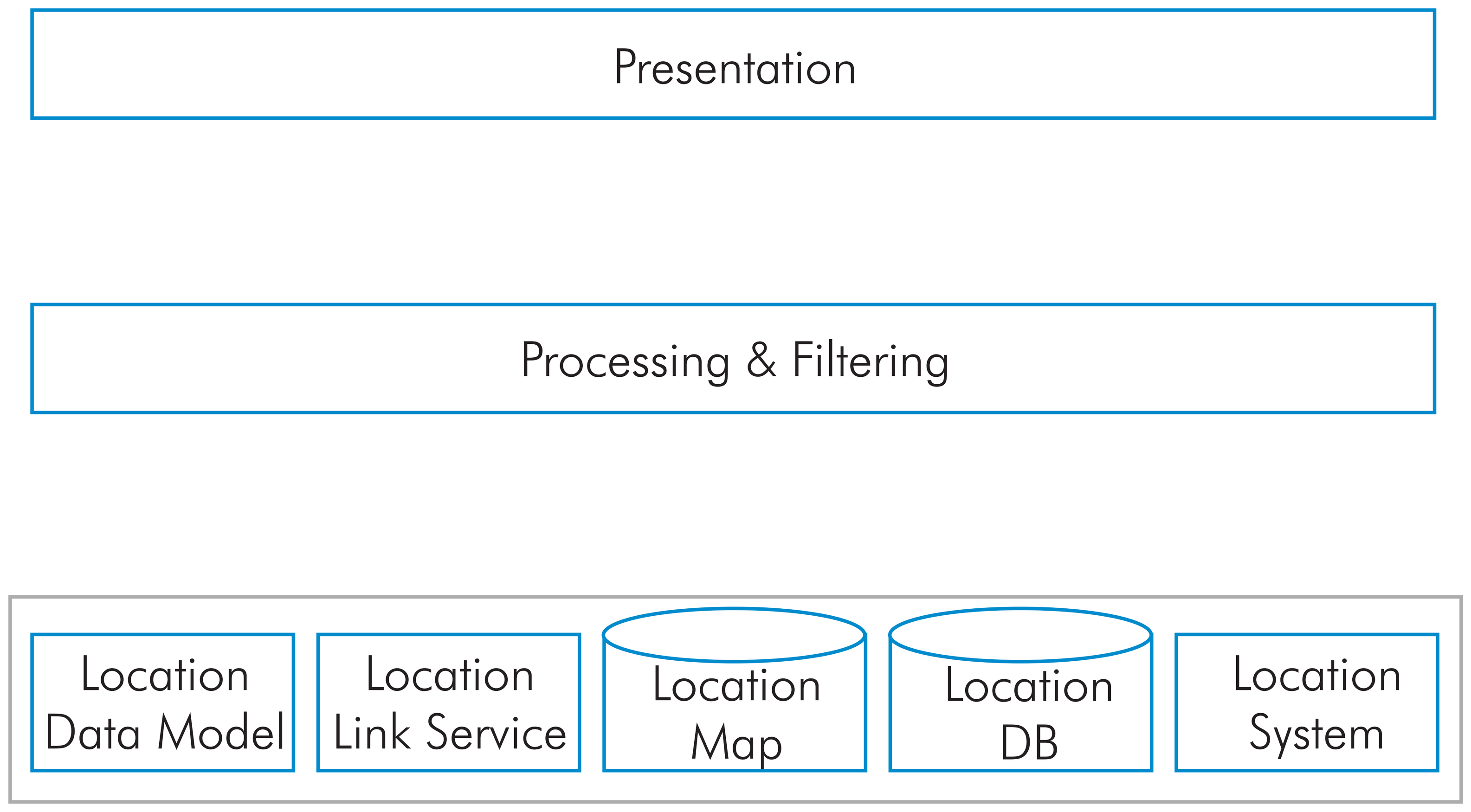
Christian Decker, Michael Beigl, Albert Krohn, Tobias Zimmer, Philip Robinson, Jun Ma
TecO, University of Karlsruhe – www.teco.edu

Abstract
- generic architecture
- utilize location systems with a coherent graphical user interface
- display location information for various environments
- object tracking

Architecture

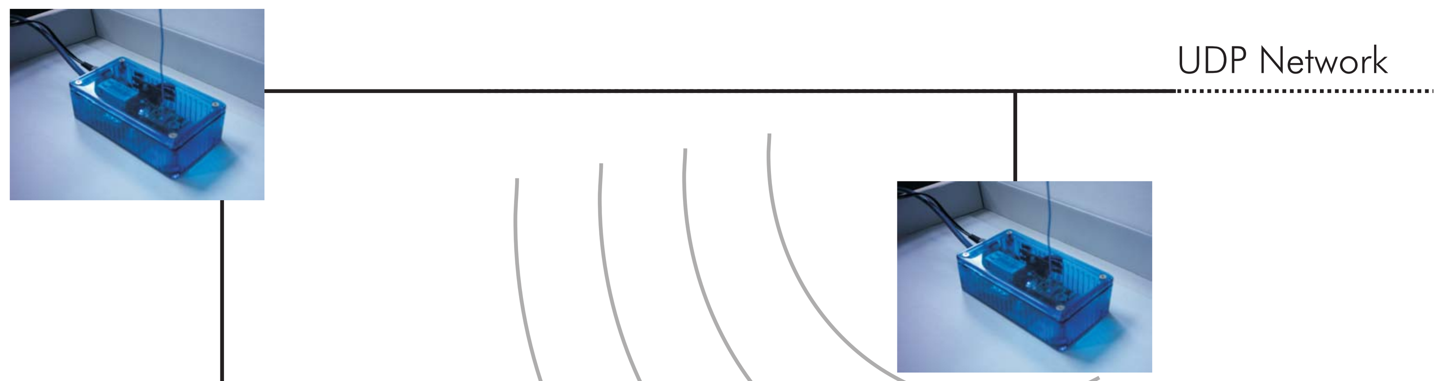


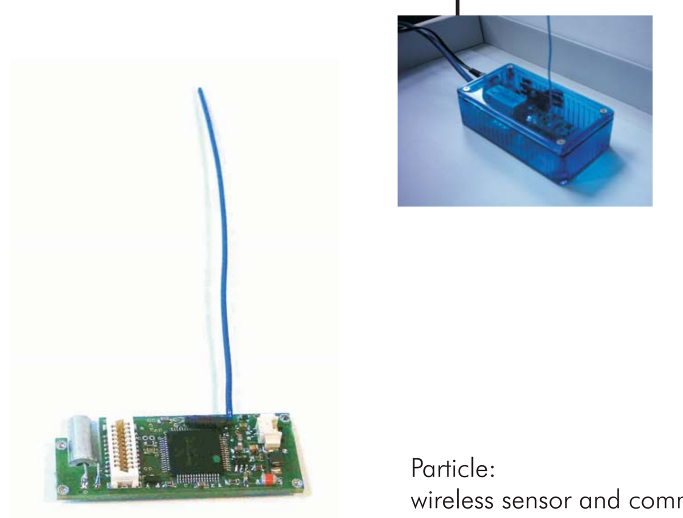
Presentation
- graphical representation of the objects' location
- input interface for creation and manipulation of the Location Data Model and Location Map
- tracking information of single or all objects over time

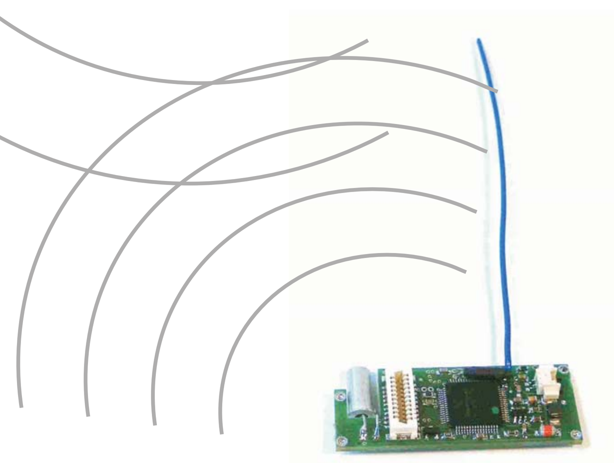
Processing & Filtering
- location information from location system
- executes rules from the Location Link Service
- Applies filters for certain objects and time intervals
- supports presentation

Information Base
- interface to an active location system
- stores time-stamped data in a location database
- stores various location data models (e.g. NMEA, GML, RAUM) and location maps (e.g. floor plan)
- Location Link Service contains rules for mapping location information to graphical representation

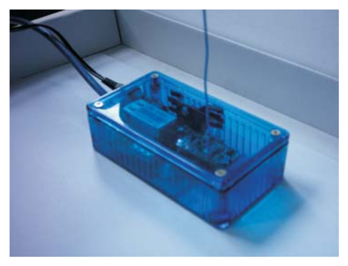
Enabling Technology





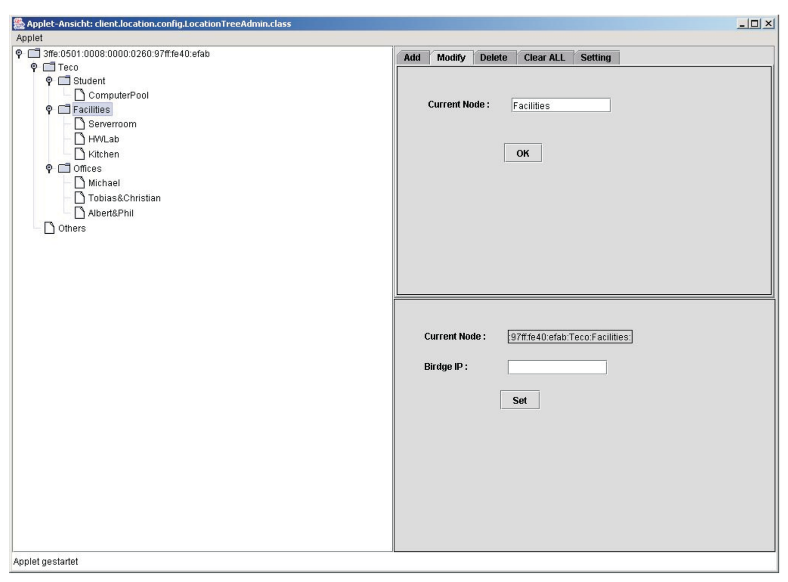


Particle:
wireless sensor and communication platform

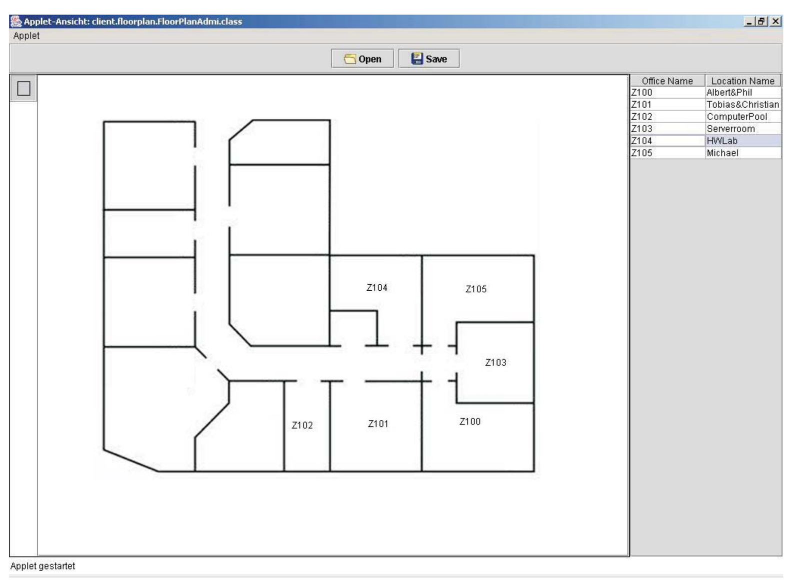


Xbridge:
forwards Particle data and location information to UDP network and vice versa

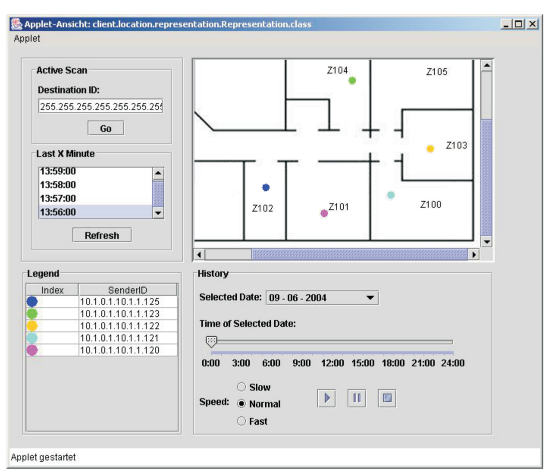
Implementation
- series of Java applets
- evaluated through a cell-of-origin location system for Smart-Its Particles



2. Location Map and Link Service:
- polygon based elements
- polygon RAUM node association



1. RAUM Data Model:
- representation of locations in a hierarchical, tree-based naming scheme
- assignment of location description to bridge



3. Presentation:
- current location
- tracking over a day
- active scan