

Seamless Adaptive Location-Based Services using Heterogeneous Positioning Technologies and Multiple Location Servers

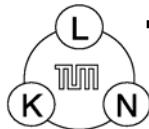
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Agenda

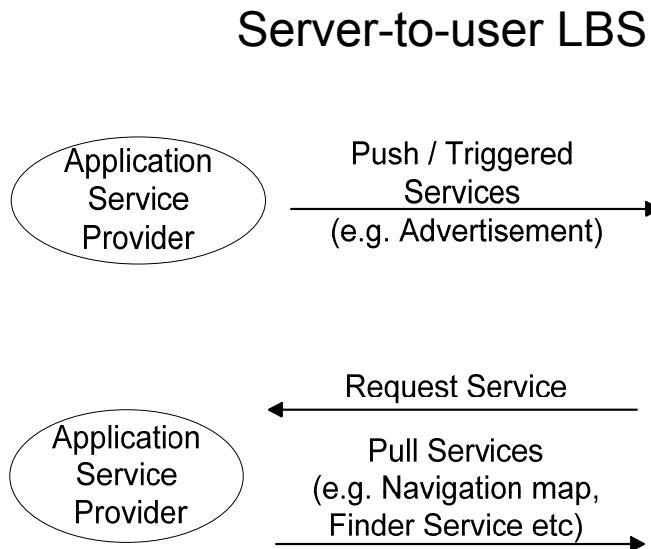
- Introduction
 - Location Based Services and their „environment“ (heterogeneous networks and positioning systems)
- Requirements of a seamless adaptive location-based service
- The LACBA approach
 - A distributed location service based on mobile communities and collaborative location information generation
- Current prototype and seamless navigation LBS implementation
- Summary and outlook on future work



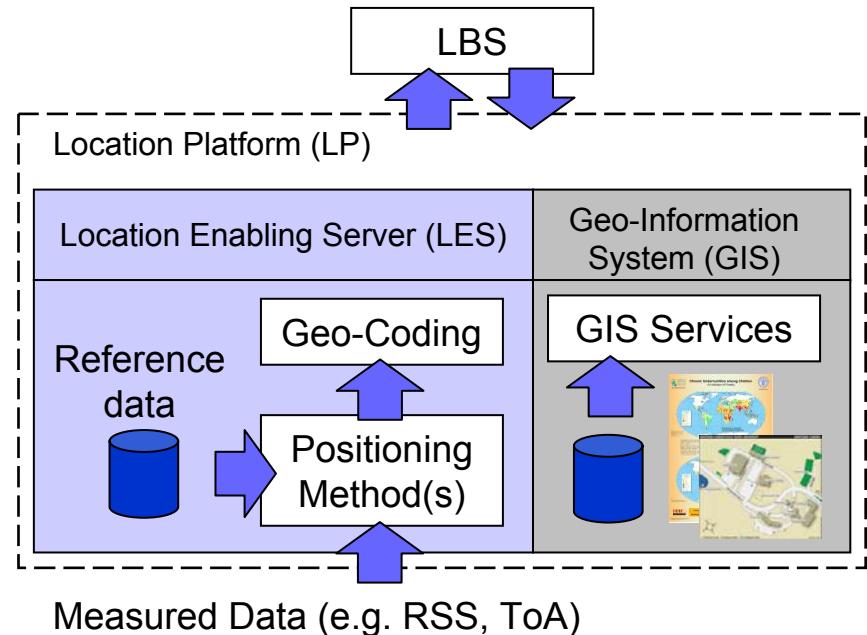
Location-Based Services

“Service provided either by network operator or a 3rd party service provider that utilizes the available location information of the mobile terminal” [3GPP]

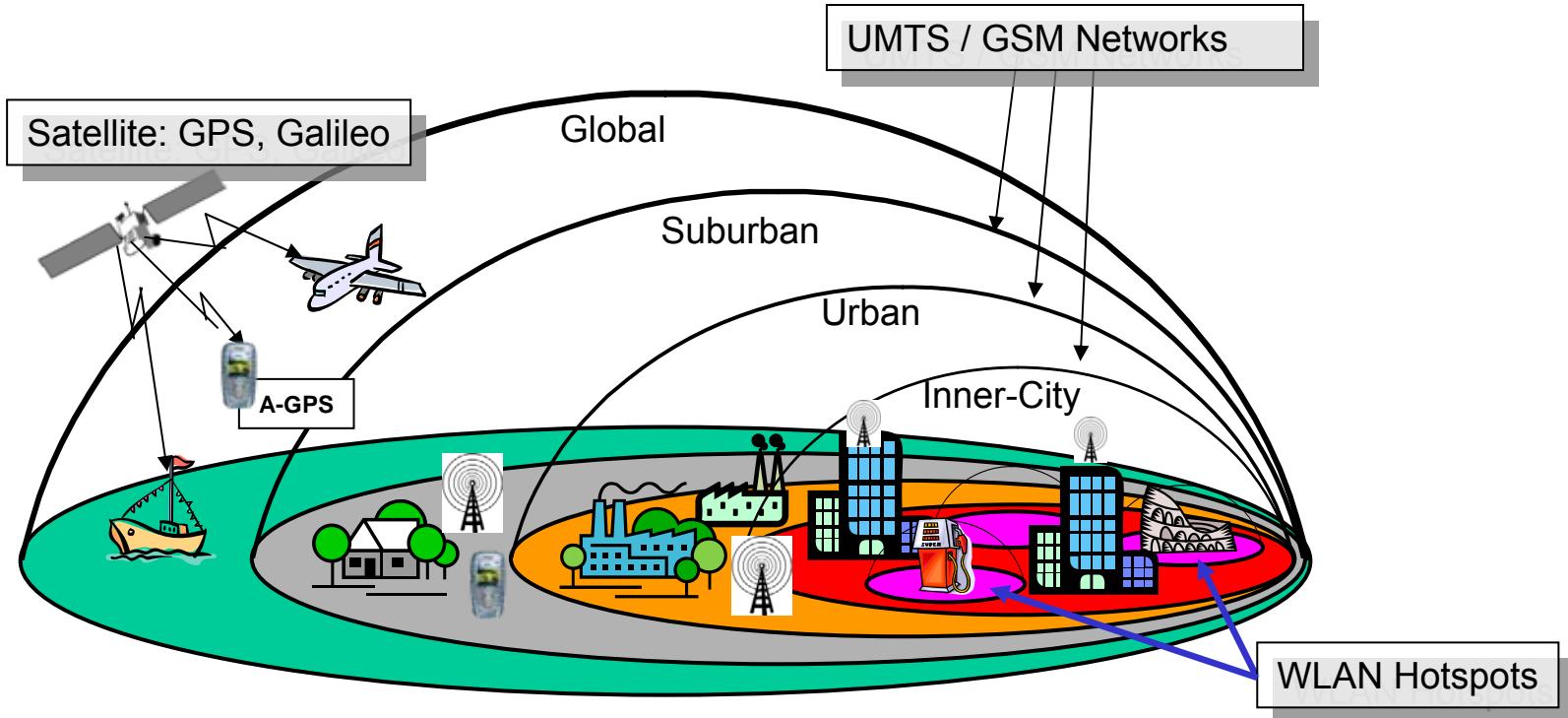
LBS Classifications:



Generic LBS System:



The Location-Based Service Environment



Stand-Alone Solutions



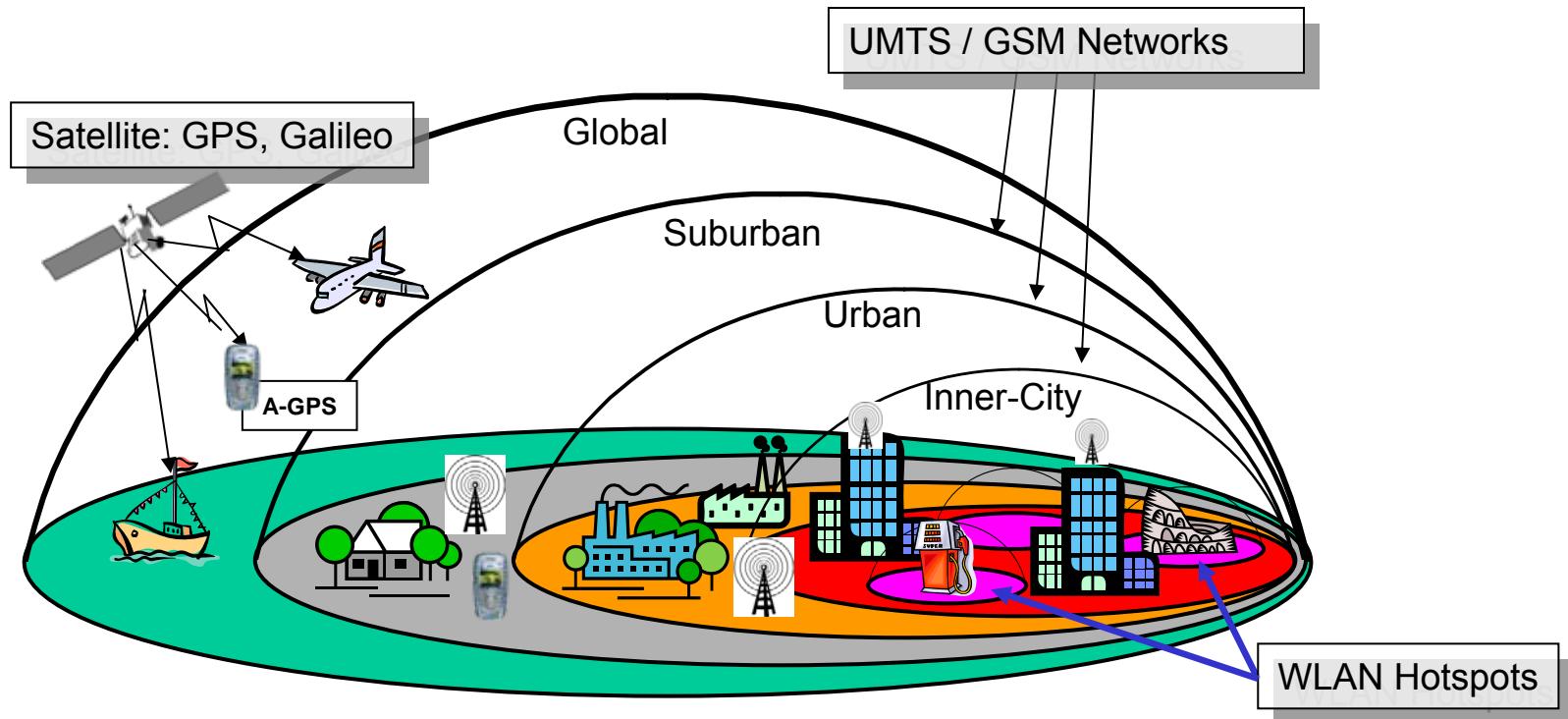
Mobile Operator LBS



In-house LBS solutions



The Location-Based Service Environment

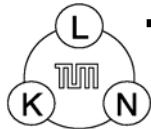


No positioning technology or provider can provide ubiquitous location information on his own for **all** LBS requirements

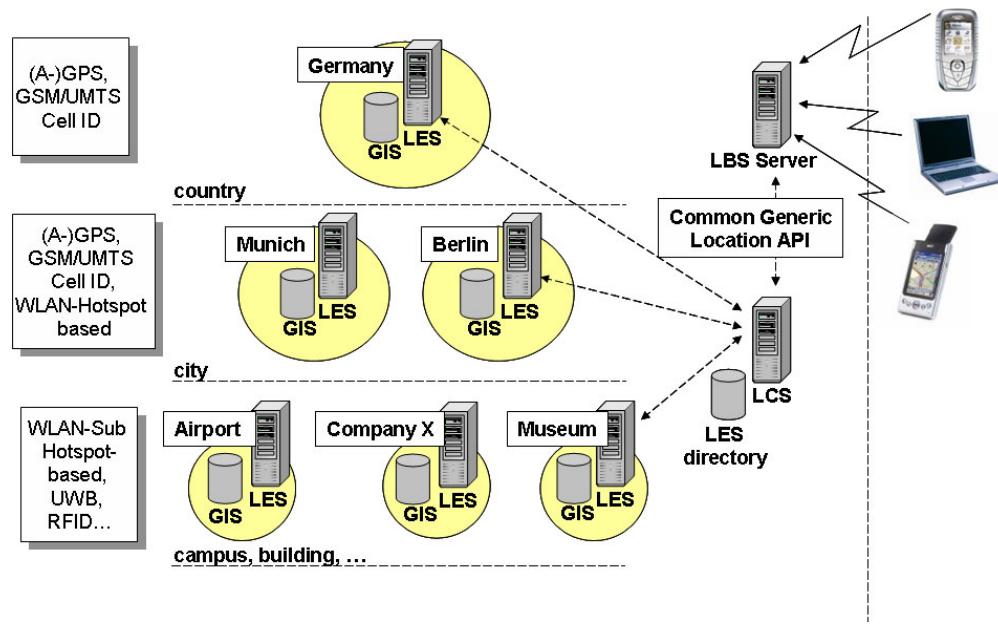
Ubiquity only by use of heterogeneous **communication networks** and readily available **positioning technologies**

Lack of Standardization and inter-working
→**Clients** as sensors in environment and centralized **knowledge databases**

Requirements of a Seamless Adaptive LBS



Providing Location Information and Positioning in a Heterogeneous Environment

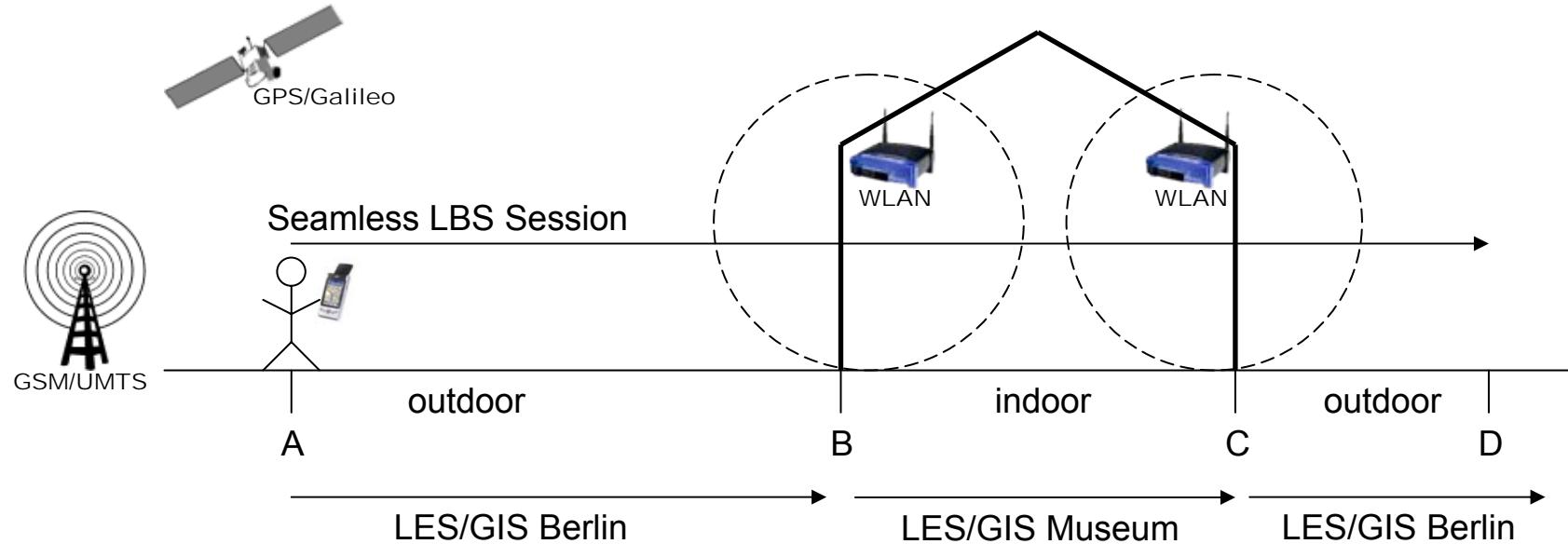


Key:

- Location Core Server (LCS)
- Location Enabling Server (LES)
- Geo-Information System (GIS)

- Multiple LES/GIS Servers
 - Scalability
 - Access to „site specific“ location information
 - Respective LES with site specific positioning means
- Central Location Provisioning (LCS)
 - Discovery and inter-working between LES/GIS entities
 - Location format transformation and adaptation
 - Privacy and access control
 - Location QoS and fusion

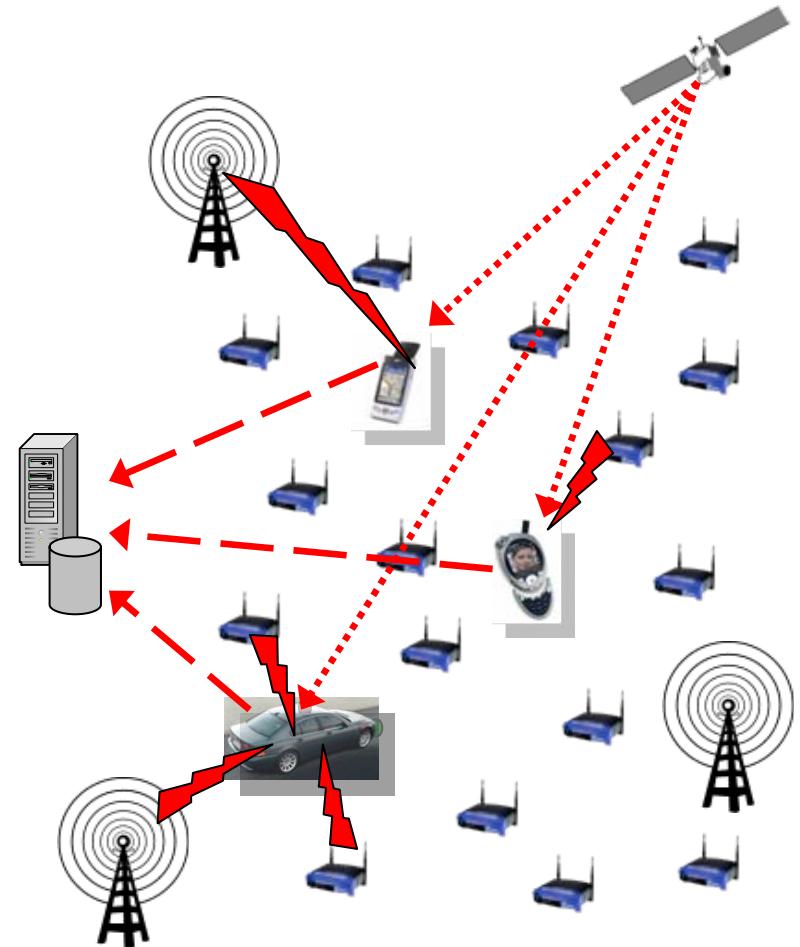
Seamless LBS Session Strategies



- Seamless LBS session issues ($A \rightarrow D$)
 - Transparent session information handling and AAA between LES/GIS
- Preparation and Propagation issues for LES/GIS handoff:
 - Advance calculation (route $A \rightarrow D$ known)
 - Proximity-based preparation (detection of points B and C)
 - Ad-hoc discovery and determination
- Service mobility across devices

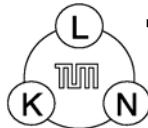
LES Discovery Mechanisms

- LES broadcast available in respective networks
- No broadcast:
 - A priori knowledge of heterogeneous networks
 - Client acts as sensor in environment
 - Centralized knowledge databases e.g. community models
 - LES matching by physical location (e.g. GPS) and location inference indicators (unique network IDs)
 - Needs LES hierarchy model and scopes of responsibility
 - DHT-based peer-to-peer approach (hierarchical Chord ring LES model)



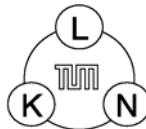
LES Handover Methods and Triggers

- Hard handover case
 - Causes “blind state”
 - Fallback to higher level LES essential at cost to potential lower positioning accuracy
- Soft handover
 - Pre-signaling to a new LES → proximity-based handoff signaling
 - “Make-before-break” principle
- Softer handover
 - Multiple simultaneous LES attachments
 - Filtering and selection of appropriate location data
- Handover Triggers
 - Manual user input is very valuable
 - Automatically via distinct (e.g. RFID tags, by user, swipe cards) or passive triggers (e.g. WLAN edge networks, loss of GPS signal)



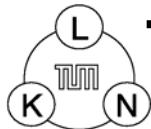
Adaptivity in Seamless LBS Scenarios

- Transformation and adaptation of heterogeneous positioning sources
 - Standardized vs. proprietary formats e.g. WGS84, Cartesian, indoor building model, object name
 - Geographic coordinate space \leftrightarrow local building coordinate system
 - Varying positioning accuracies
 - Location information formats and content
 - Location GIS data e.g. maps (SVG, JPEG, GIF)
 - Adaptation to device capabilities
- LBS system needs to appear monolithic to the end user



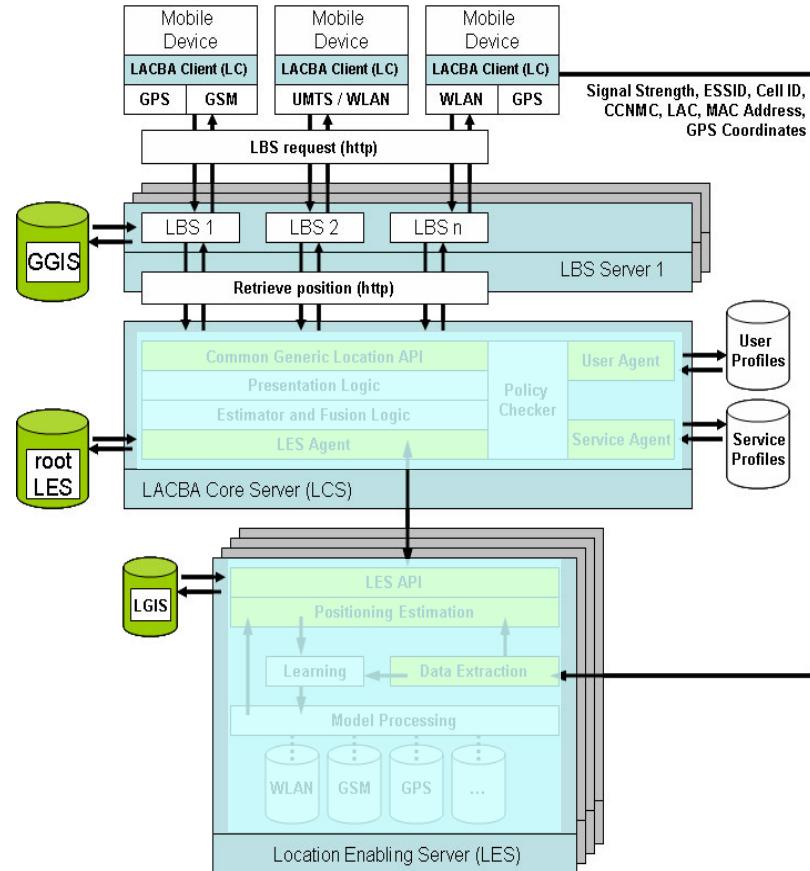
Implementation of a seamless LBS

- LACBA location system
- Ariadne seamless navigation LBS



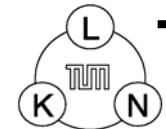
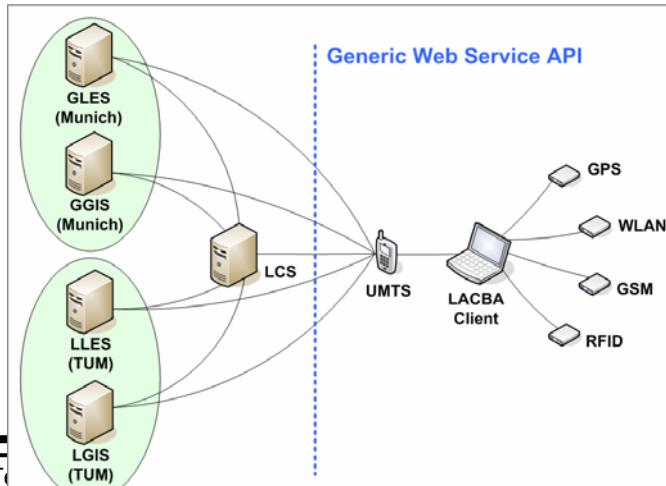
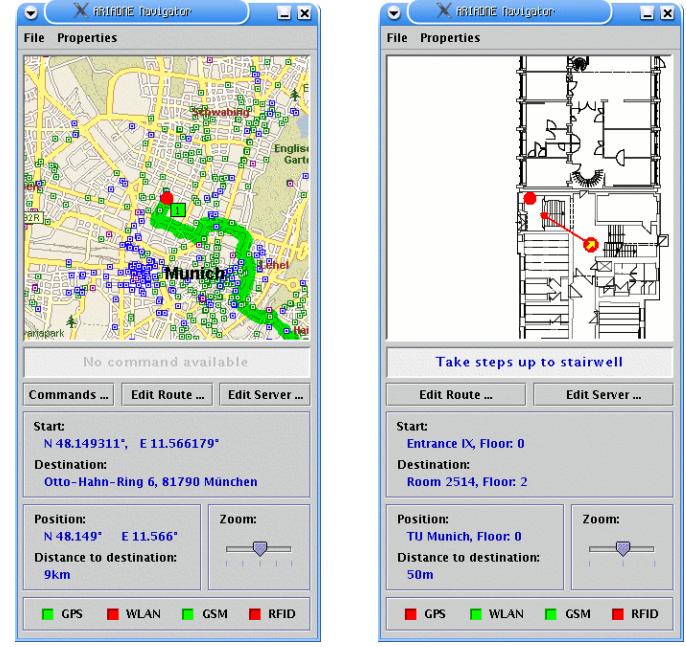
The Location-Aware Community-Based Architecture

- Open, collaborative location information generation and provisioning
- Centralized location provisioning
 - Similar to OMA LES standard
 - Location fusion and adaptation
 - Multiple LES & GIS support
- Generic LES framework
 - Self-learning community-based e.g. WLAN/GSM communities
 - Indoor positioning systems
- Support multimode as well as legacy devices
- Related Work:
 - Placelab, Nimbus, MagicMaps, Redundant Positioning Architecture

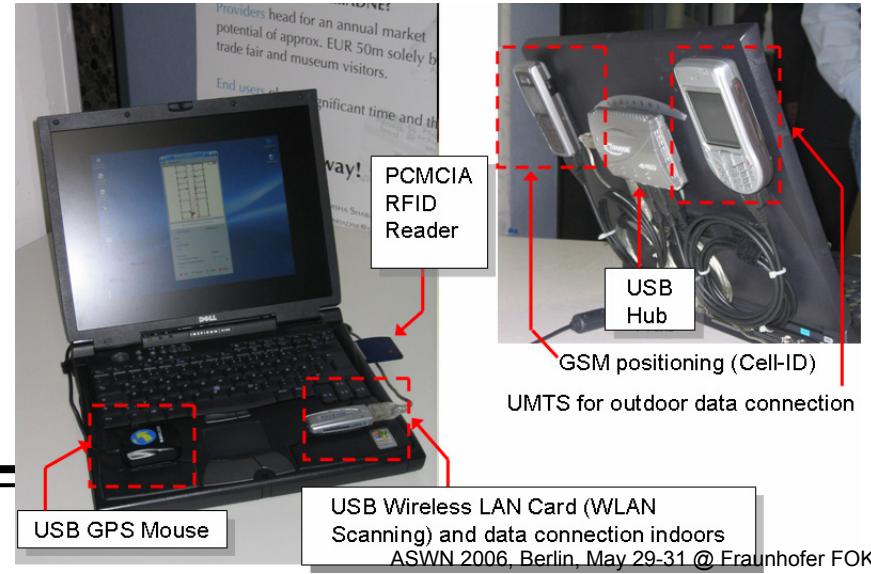


Seamless Navigation LBS

- LACBA Prototype
 - LCS User Profiles holding location information, simple access rights
 - Global LES (GPS, GSM Cell ID & WLAN hotspot-based positioning)
 - Global GIS (Microsoft MapPoint 2004)
 - Local LES (RSS-based WLAN positioning and RFID tags)
 - Local GIS (building maps from TUM construction office)

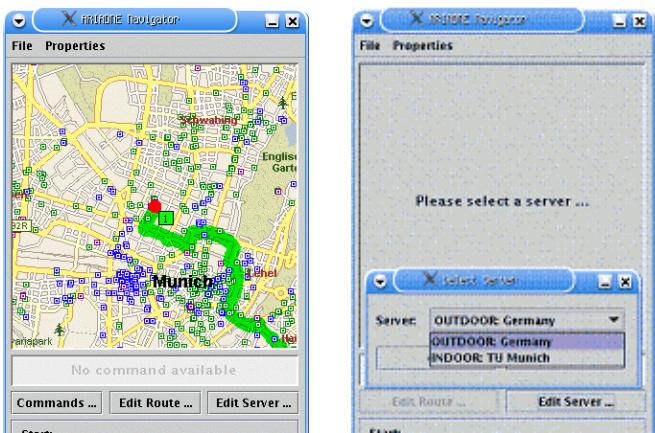
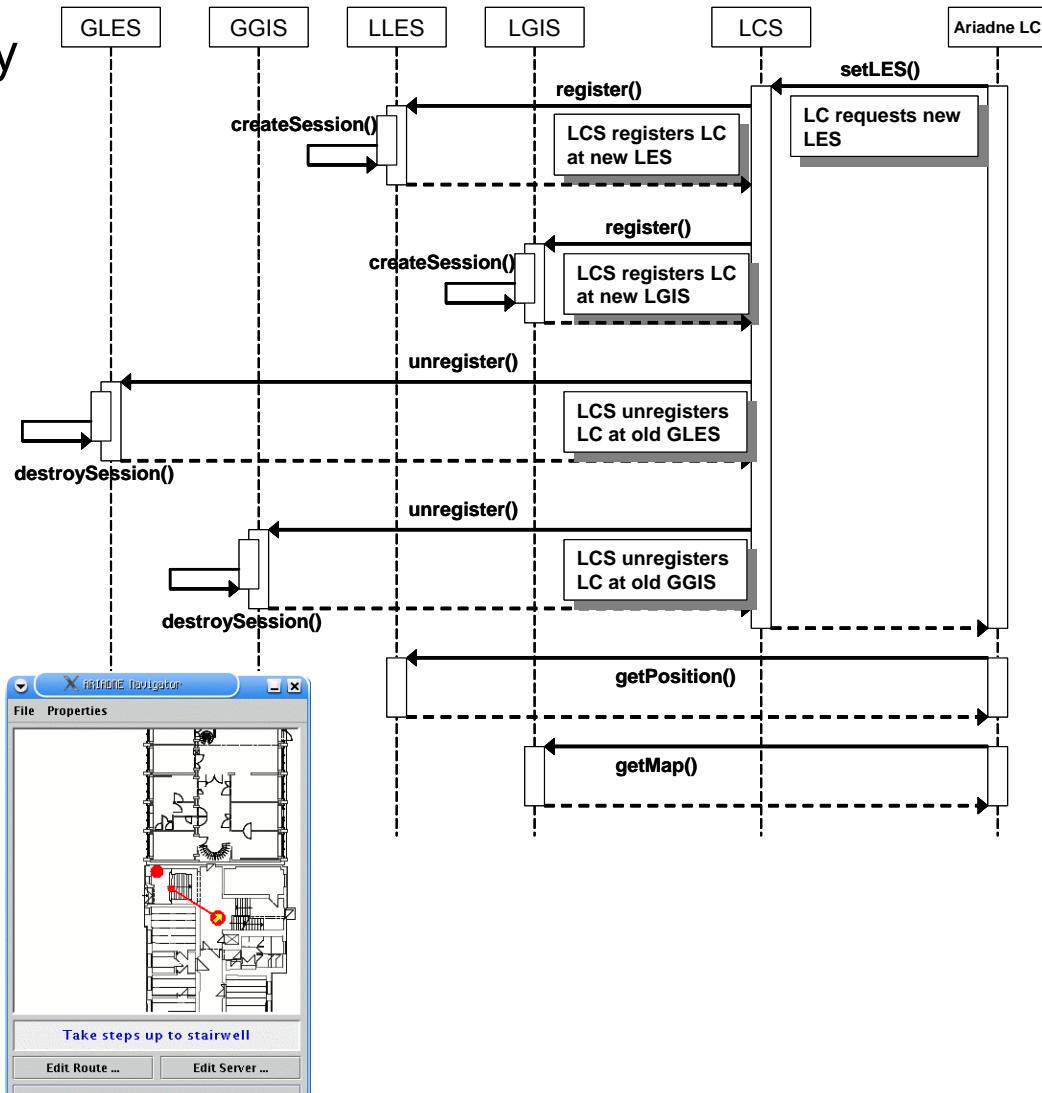


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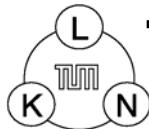
LES Discovery and Handover

- Proximity-based LES discovery and ad-hoc handover
 - WLAN edge networks
 - User is notified and triggers handover
- Handover delay more crucial
 - pre-signaling and caching



Summary and Outlook

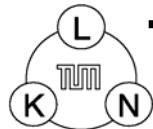
- Ubiquitous location information provisioning involves an interplay between heterogeneous networks and other dedicated positioning systems
- Seamless LBS issues:
 - LBS session construction and handover
 - LES handover triggers (e.g. proximity-based pre-signaling, other discrete signals)
 - Usability Issues
 - Location content and formats
- LES Discovery using P2P-System approaches (or even a complete adaptation)



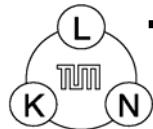
Thank you

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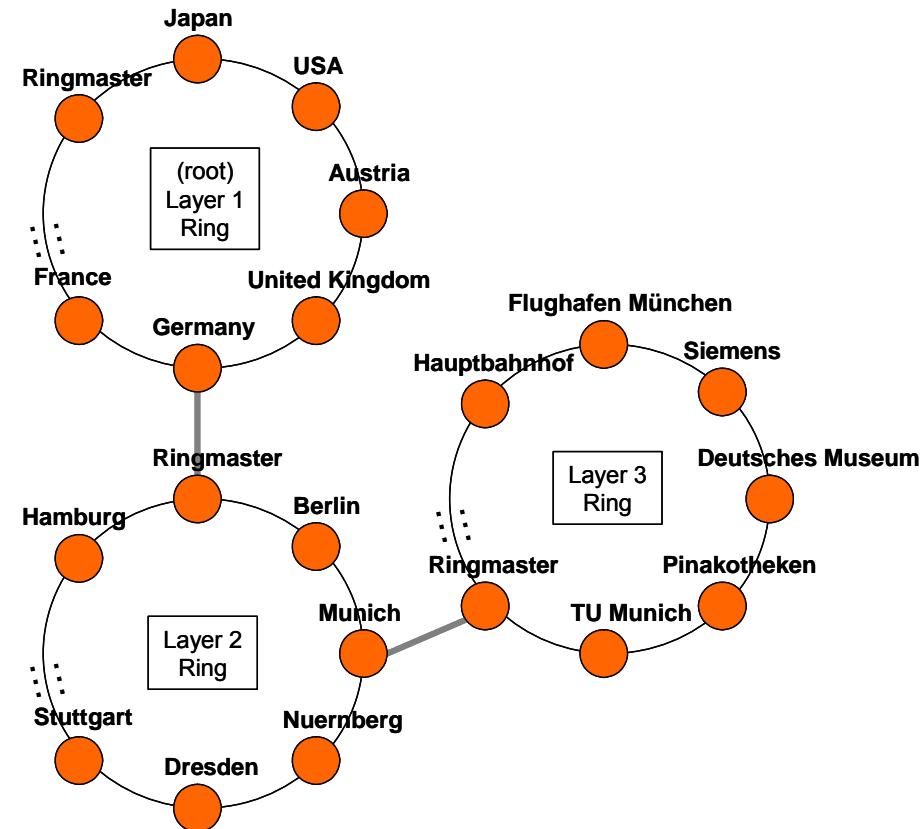


Backup



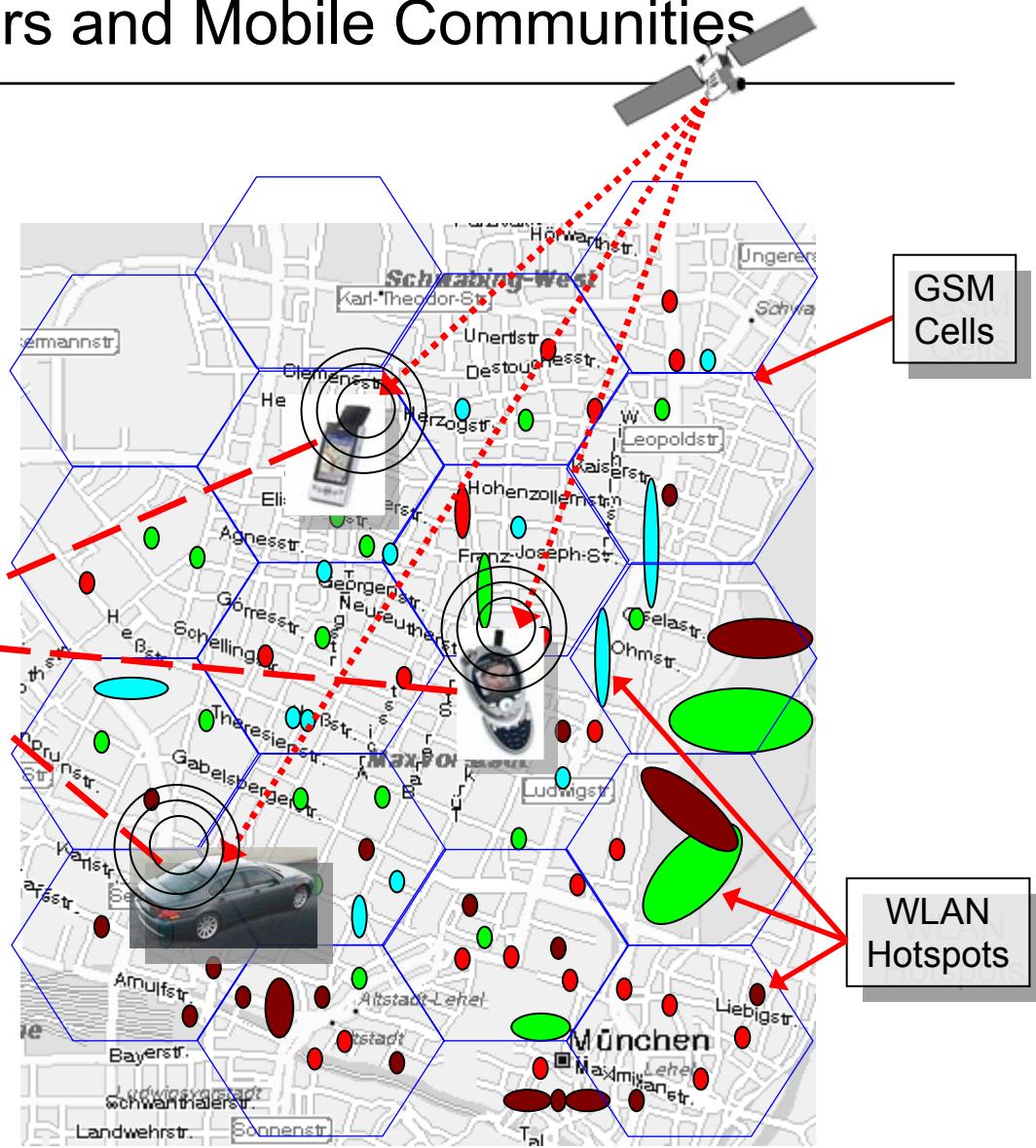
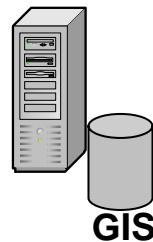
DHT-based peer-to-peer system for LES discovery

- Hierarchical ring LES organizational model
- Arbitrary number of independent Chord rings
- Ringmaster nodes manage respective Chord rings and routing between ring hierarchies
- Initialization phase: unique DHT entries generated from access network identifiers and designated LES server addresses
- Positioning mode: client discovers network and performs DHT query



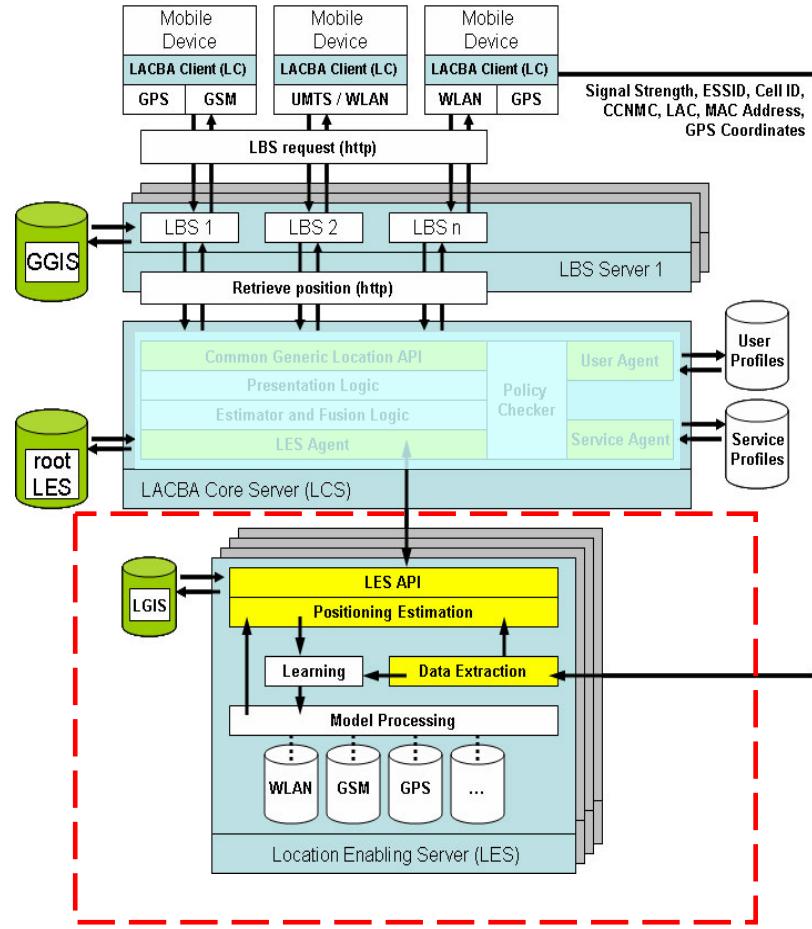
Clients as Sensors and Mobile Communities

- Clients as „autonomous“ sensors in environment
- Data collaboratively collected at common knowledge databases and shared by all members in the community
 - network effects, “open oasis”
- Intelligent filtering, normalizing, validation and anonymisation
- Needs (Re-)initialization
- Needs a “critical mass” of users
 - frustration/success rates



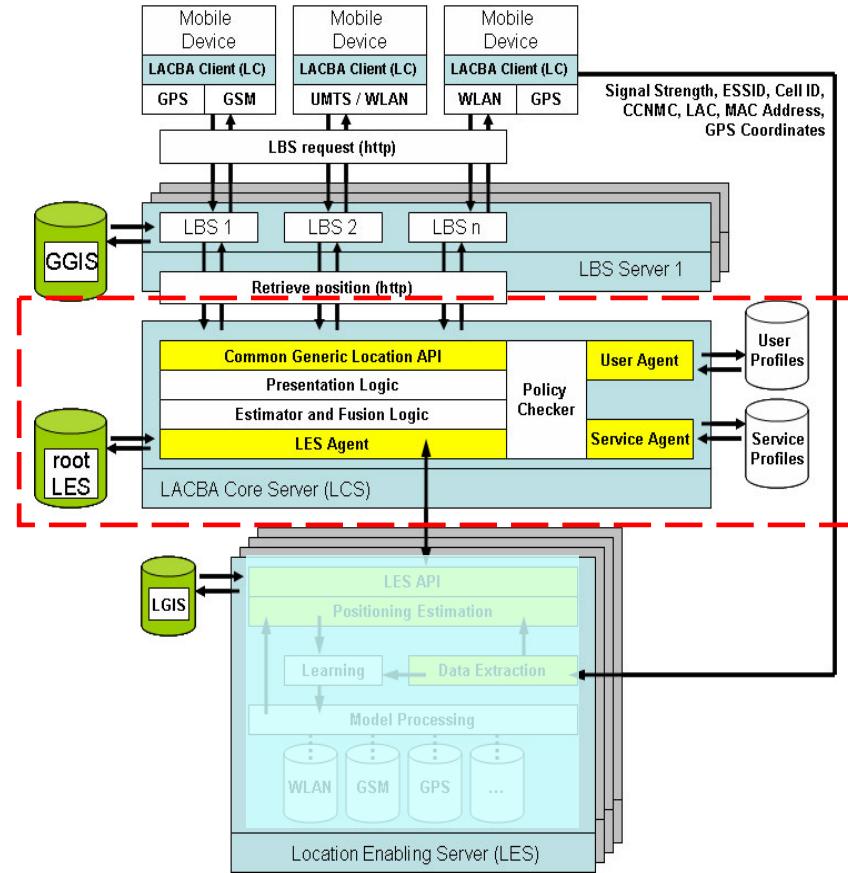
LACBA: The Location Enabling Server (LES)

- A generic framework and “toolkit” for deploying usage environment specific location service
- Collaborative initialization
 - Data extraction and “sanitizing”
 - Reference data buildup
 - User and system feedback
- Positioning and “Learning”
 - Positioning mismatch (feedback by user and system)
 - Nearest neighbor lookup
 - Reference data aging



LACBA: The Location Core Server (LCS)

- Provides generic location API for LBS providers
- Manages inter-working between and access to different LES
- Manages user location information, access control (services and other users)
- Manages service LBS requirements to available location data, session handling
 - Simple fusion
 - LBS initialization, negotiation, adaptation/ “graceful” termination



Applied Technologies

LCS, GLES, LLES, LGIS:

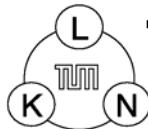
- Java
- MySQL databases
- Apache Axis Web Service engine (running on Apache Tomcat)

GGIS:

- Microsoft .NET Framework
- C#, Web Service running on IIS
- Data gathered from Microsoft MapPoint 2004 Europe

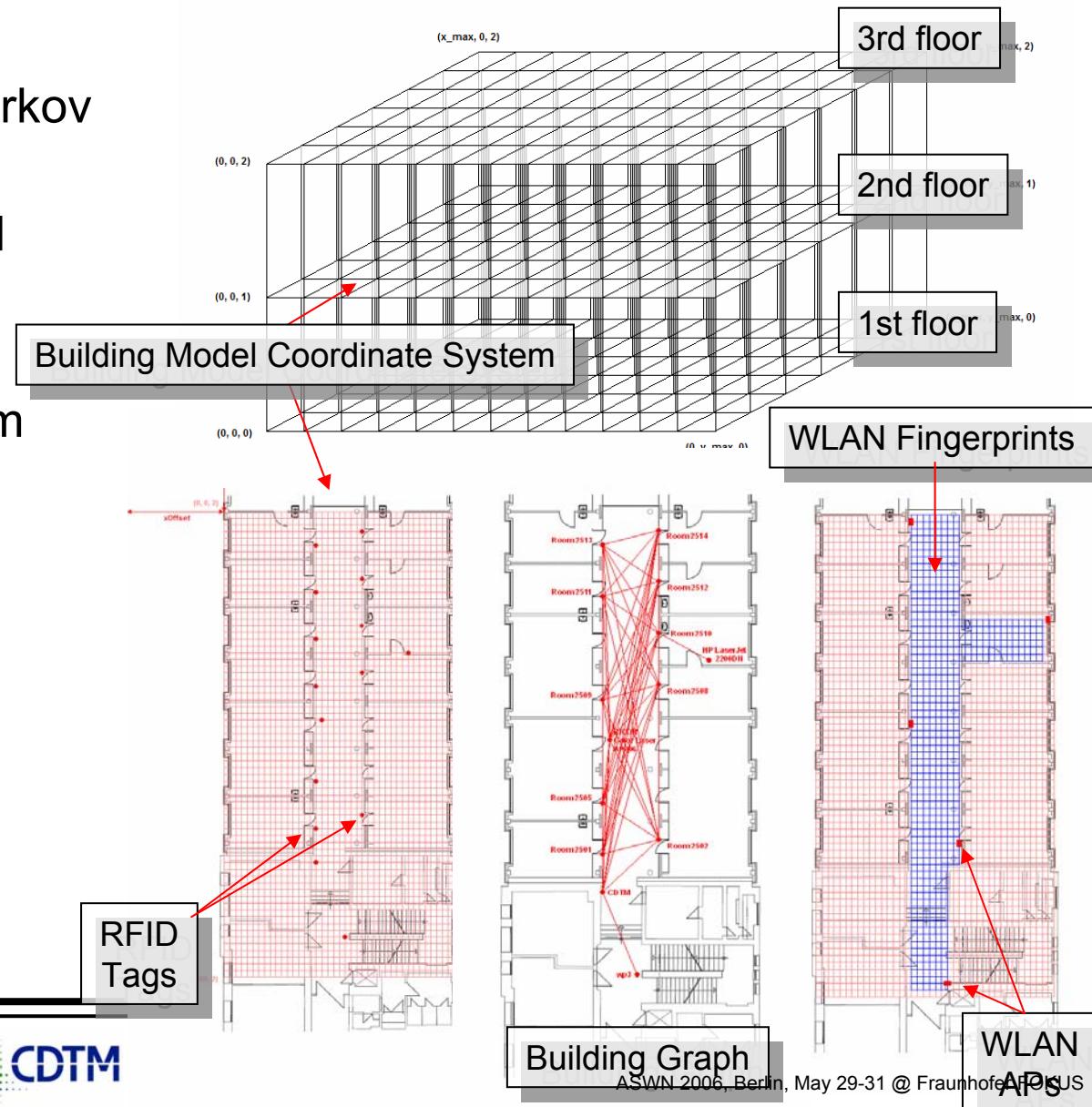
ARIADNE Location Client:

- Linux
- Java
- Scanner tools written in Perl



The Local LES (LLES)

- WLAN RSS-based positioning (Hidden Markov Model)
- 3D Building Model, grid mesh size 0,5m
- RFID tags for route calculation, device/room identification
- WLAN fingerprint checkpoints



Positioning Performance

- Outdoor:
 - GPS (Garmin GPS)
 - 5,8m CEP (Circular Error Prob., 50% of measured points)
 - 28,1m 2dRMS (two distance RMS error, 95% of measured points)
 - Gecoded WLAN Hotspot (#1323, 500x500m)
 - \leq 60,1m CEP radius, 50%
 - \leq 231m 2dRMS radius, 95%
 - Gecoded GSM Cell ID:
 - Average cell size 230-430m
- Indoor:
 - WLAN RSS-based positioning: 2-5m accuracy compared to building model (accurate to within few cm)

