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Acquisition, Storage, and Provision of Access Network Information with Nexus

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Outline

- **Overview of Nexus**
- **Model-based Access Discovery**
 - Architecture for acquisition and provision of coverage information
 - Data Model of Access Networks
 - Algorithms to calculate coverage information of wireless Hotspots
- **Conclusions and Outlook**



Center of Excellence (SFB 627)

“Spatial World Models for Mobile Context-Aware Applications”

- **Technological trends**

- Mobile and wireless data communication at high bit rates
- Powerful handheld computers with communication interfaces
- Sensors, in particular location sensors (e.g. GPS)

- ➔ **Context-aware Applications become possible**

- **Issues of context-aware systems addressed by the Nexus-Project**

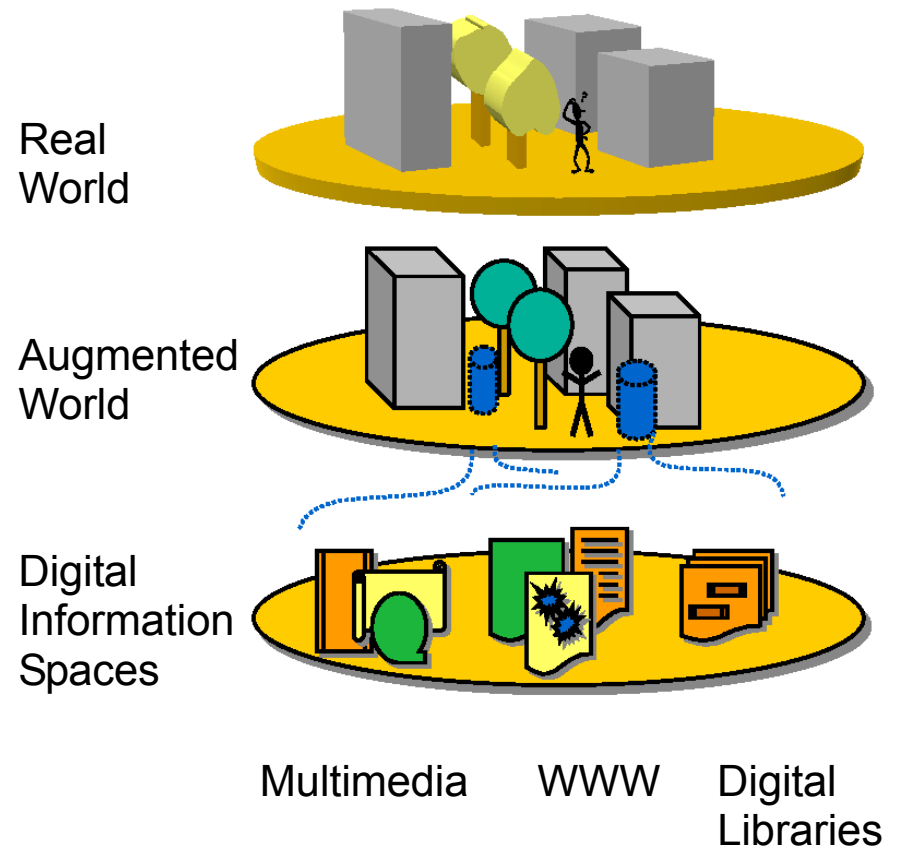
- Management of context information
 - Nexus Augmented World Model
- Communication and security
 - Using context information to improve communication
 - Privacy and Trust in context-aware systems
- Context presentation and sensors
- Applications, social and judicial aspects

- ➔ **Interdisciplinary research project**



Augmented World Model

- **Object oriented data model to describe real world objects**
- **Contains links to digital information spaces**
- **Extensible**
 - Standard class schema
 - Application-specific extensions
- **Federated**
 - Multiple information sources
 - Combining of information originating from different sources



(Source: IPVS, Universität Stuttgart)

➔ **The Augmented World Model forms a link between the real world objects, data model objects, and digital information spaces**

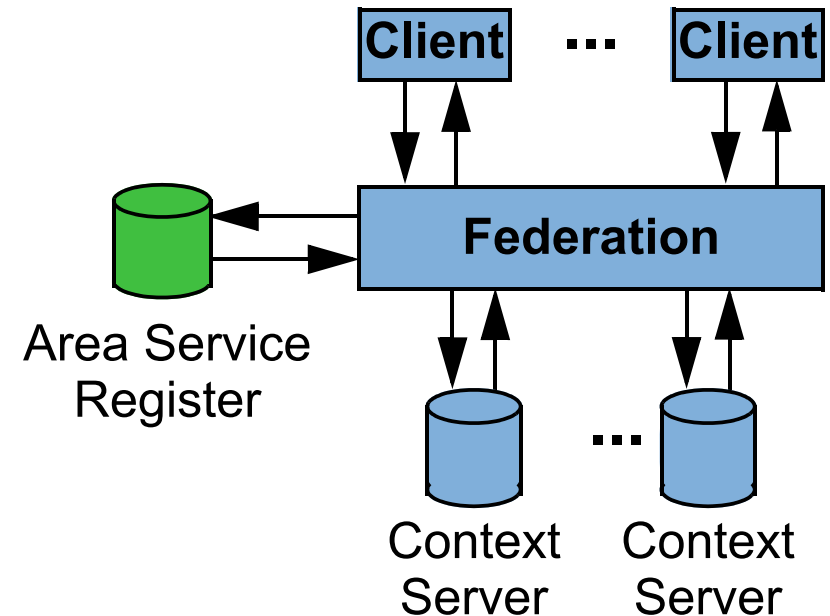
Data Processing

- **Three Layer Architecture**

- Clients
- Federation
 - Collects data from context servers
 - Area Service Register, which knows the area served by each context server
- Context Servers, which store world model information

- **Support for multiple providers**

- Each provider owns one or more context servers
 - Federation merges data from different context servers
 - Identification of identical real world objects stored on different context servers
 - Merge operators
- ➔ Application specific plugins within the federation



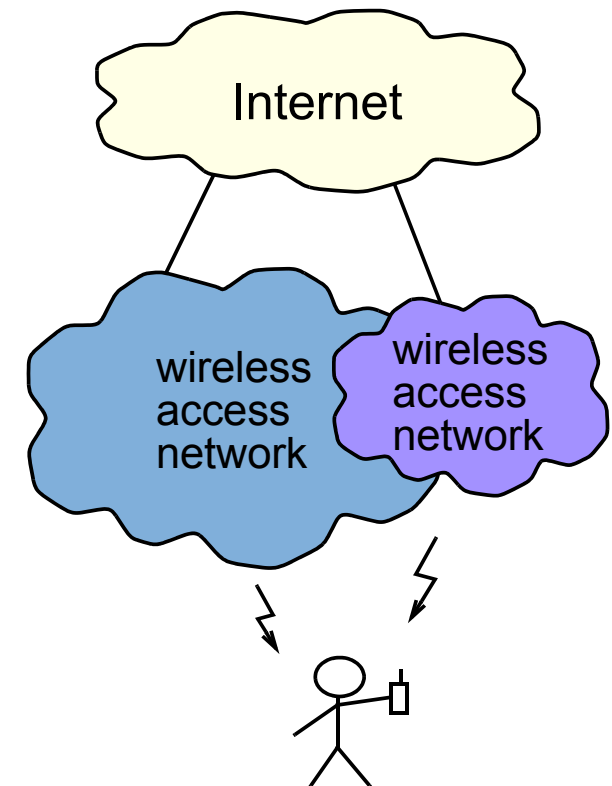
Heterogeneous Access Networks

- Different radio access technologies are available, for example

- Cellular
- WiMAX
- Wireless LAN
- PAN

coverage,
costs

bitrate
per user



- ➔ Selection of the “best” access for a given application required
- ➔ Access Discovery delivers information needed for access selection

Measurement-based Access Discovery

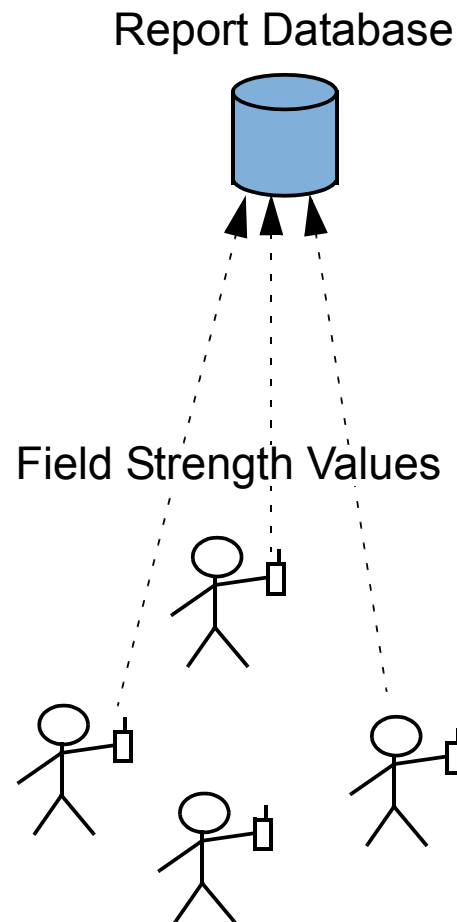
- Classical approach: uses measurements on the physical layer
- Requires **time and energy intensive scanning** procedures
- Some technologies do not very well support **scanning while communicating**
- Amount of obtainable information is limited

Model-based Access Discovery

- Uses location-based and context-based information systems
- Provides with additional, often technology independent, information: load, prices, coverage
- Challenge: **acquisition**, **storage**, and **provision** of network-related context information
 - ➔ **Architecture** to acquire and provide with context information necessary
 - ➔ Data scheme for access network required => **world model extension**
 - ➔ **Algorithms** to generate context information needed



Architecture for coverage acquisition and provision

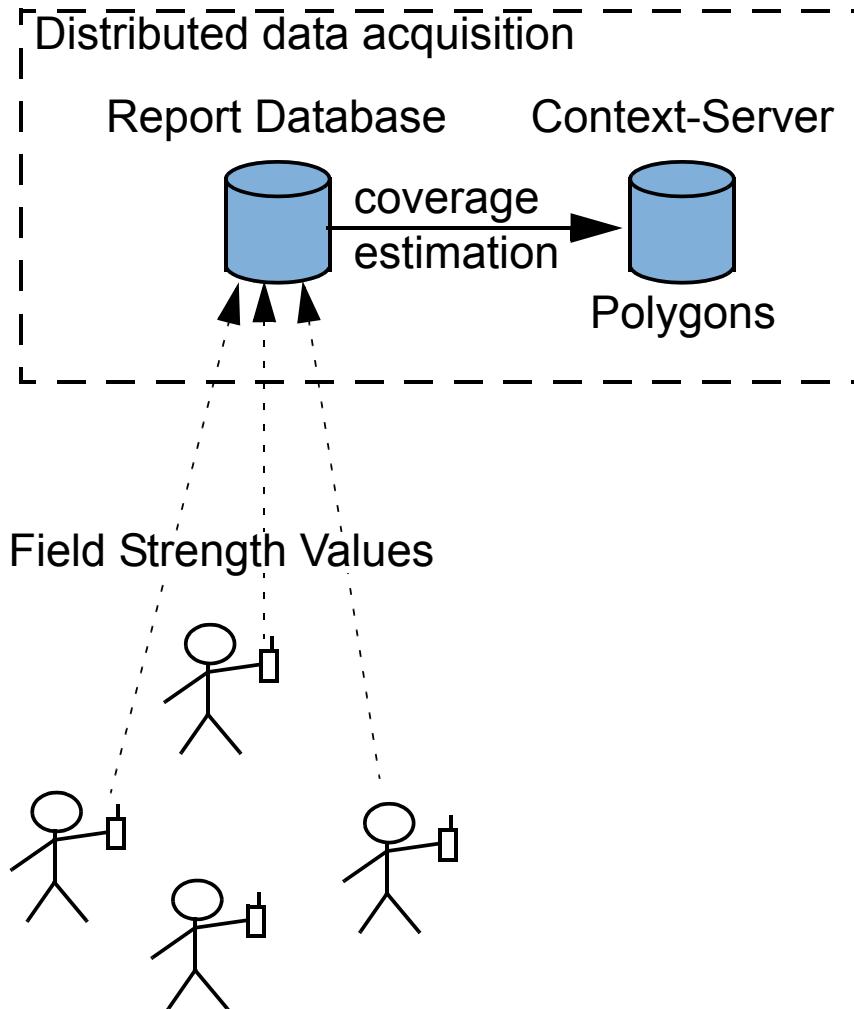


Distributed Data Acquisition

- **Mobile Terminals collect field strength values**
- **A value has the form (technology, cell ID, signal strength, position)**
- **Upload of values**
 - Individual values
 - List of values, when a hotspot is reached



Architecture for coverage acquisition and provision

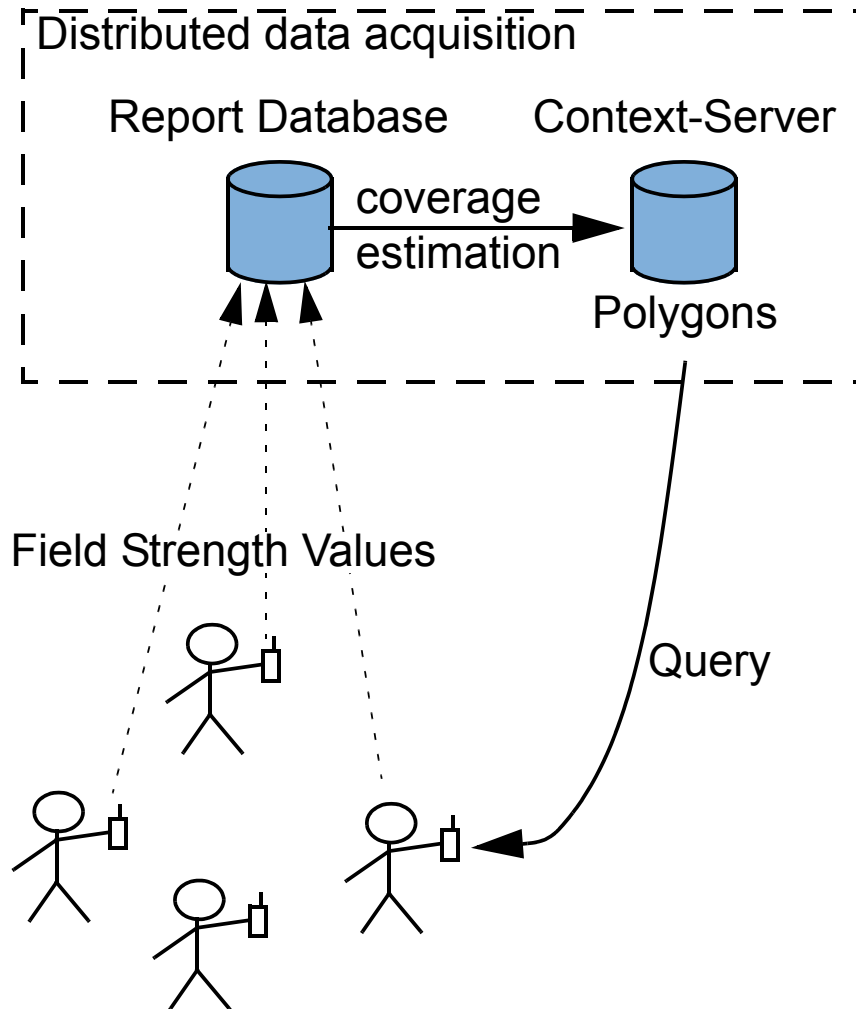


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- **Conversion to polygons**
- **Transfer to a Context Server**



Architecture for coverage acquisition and provision

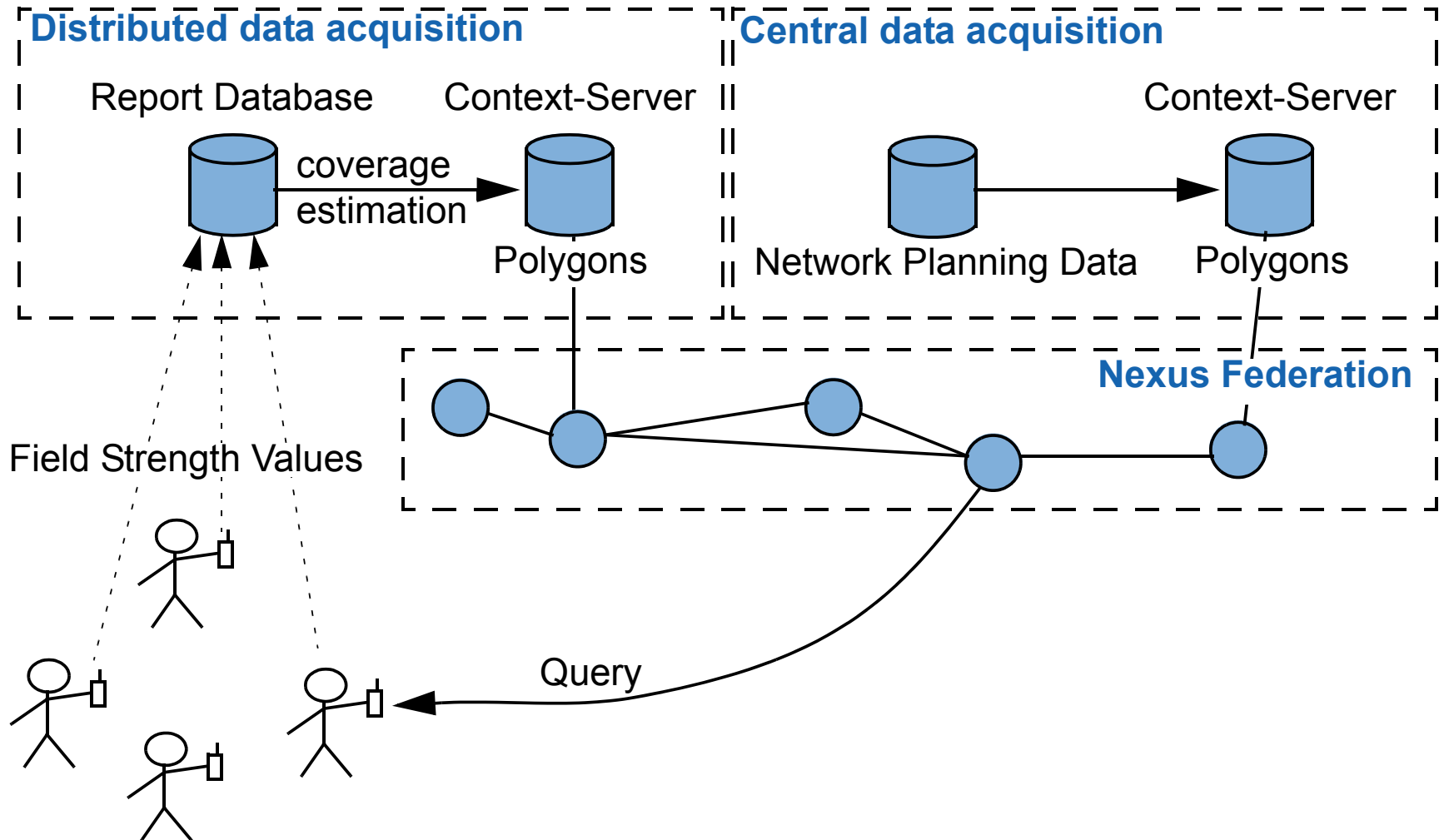


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- **Terminals query the Context Server for coverage information**

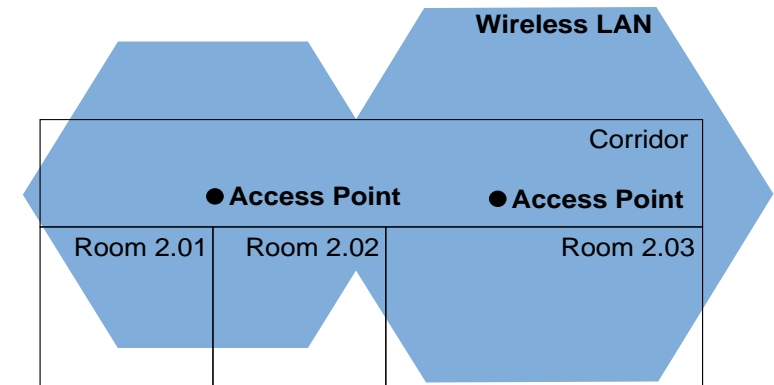


Architecture for coverage acquisition and provision

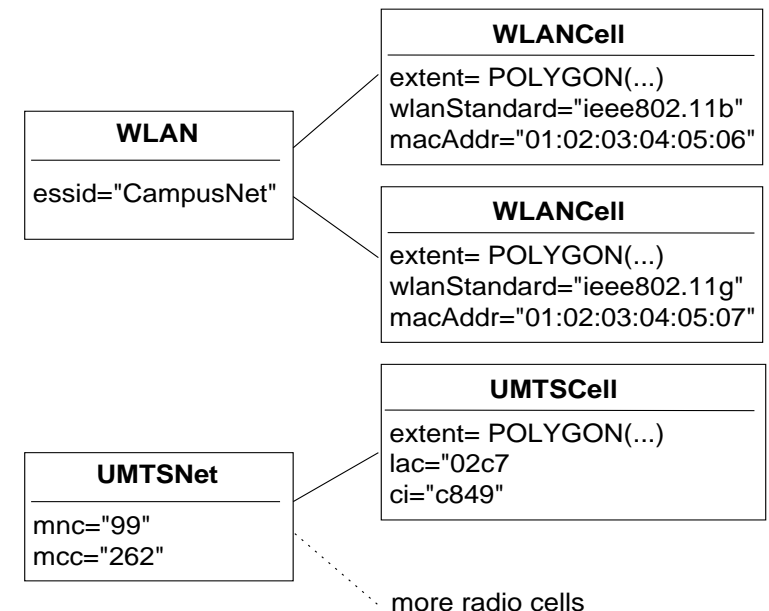


World Model Extension for Access Networks

- **Considered Information**
 - Static network-related parameters
 - Coverage of wireless access entities
 - Maximum data rate
 - Dynamic network-related parameters
 - Load
 - Number of users
 - Information about available services and prices
- **Design principle: Separation of**
 - Logical **Access Networks** (WLAN service sets, cellular networks, etc.)
 - Physical **Access Entities** (radio cells, wall sockets, etc.)



● UMTS base station



Conversion of Field Strength Values to Polygons

1. Rasterization

- Alignment of field strength values to a grid of equidistant points
- Conversion from a list of field strength records to a matrix representation

2. Interpolation

- Improves vectorization results if only a small amount of data is available

3. Vectorization

- Uses a contour line algorithm
- Yields complex polygons

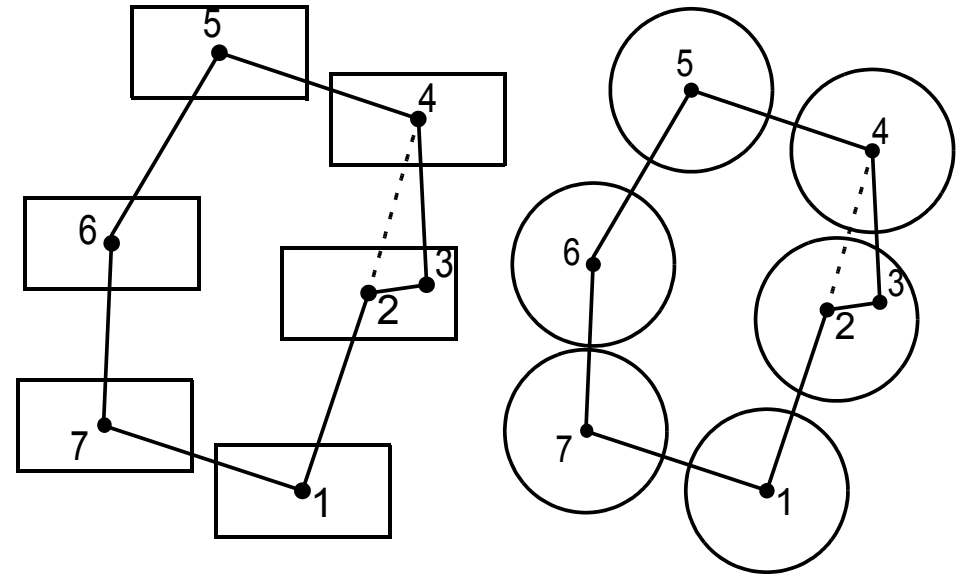
4. Polygon Simplification

- Removal of irrelevant vertices
- Aim: reduce size of data records

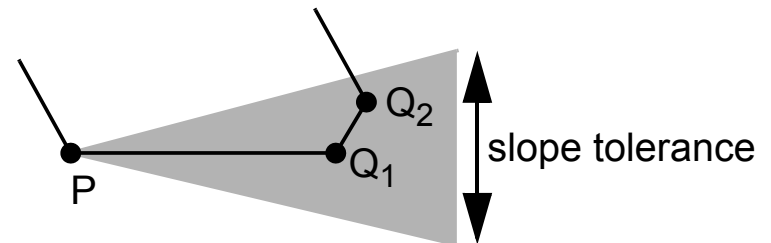


Simplification Algorithms

- **Distance-based**
 - “simple distance”
 - “Euclidean distance”



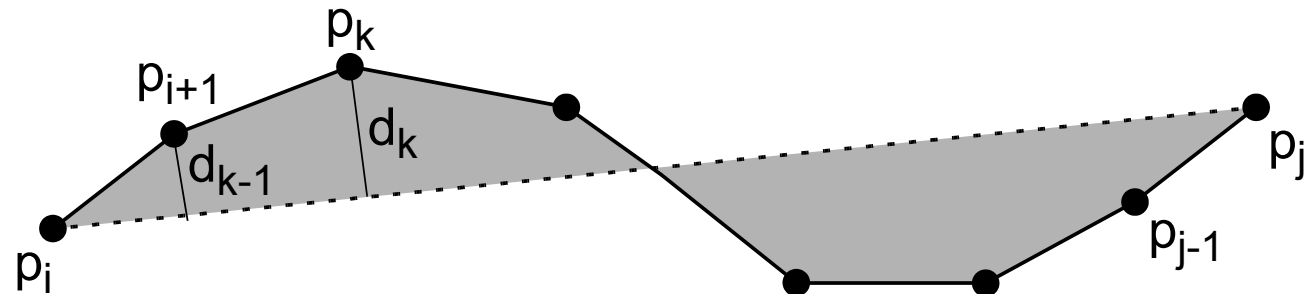
- **Slope-based**



Error measures

- **Functions of error measures**

- Allows to compare the simplification algorithms
- Helps to find a trade-off between accuracy and size of data records

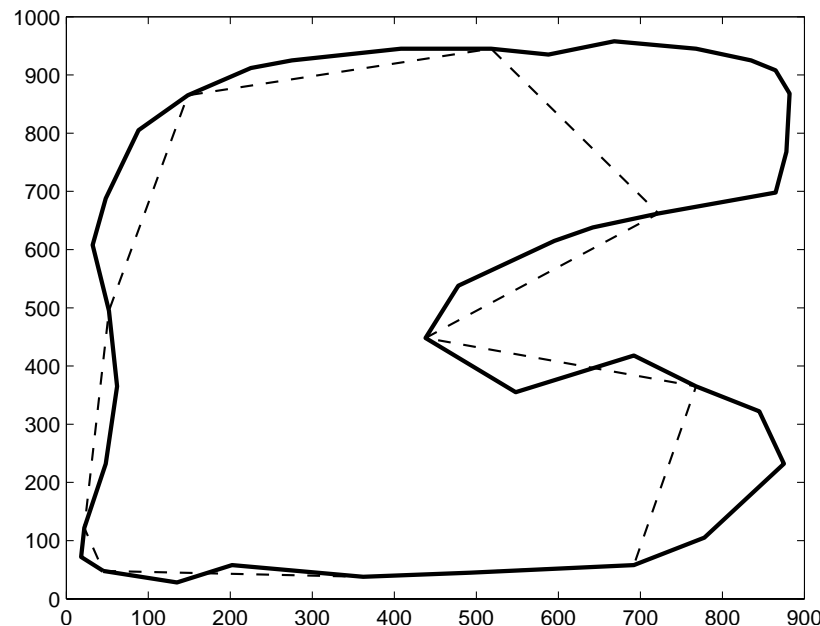


- **Variants**

- Mean (square) distance between vertices of the original polygon and the edge of the simplified polygon
- Area enclosed by original and simplified polygon

Evaluation

- **Simplification of a 39-vertices-polygon**



vertices	simple distance	euclidean distance	slope
39	0	0	0
25	17	17	37
15	58	65	86
10	95	120	151
5	217	237	296

- **Result**

- Distance-based Algorithms perform better
- The error increases superproportionally with the number of reduced vertices



Conclusions and Outlook

Conclusions

- **The Center of Excellence is an interdisciplinary research project, which covers many aspects of context-aware systems**
- **Model-based access discovery can complement measurement-based access discovery**
- **The Nexus platform allows to define an architecture, which supports model-based access discovery**
 - Distributed data acquisition and central data acquisition
- **Field strength values are converted to polygons**
 - to keep data records to be transmitted to the terminal small
 - to simplify processing within the terminal

Outlook

- **Investigation of time-dependent behavior of coverage estimation**
- **Algorithms to merge coverage information within the federation**

