Universität Stuttgart

**INSTITUTE OF
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An Architecture for Acquisition and Provision of Hotspot Coverage Information

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Outline

- **Introduction to Model-based Access Discovery**
- **Architecture for Acquisition and Provision of Coverage Information**
- **Algorithms to Convert Field Strength Values to Polygons**
- **Information Storage and Retrieval**
- **Conclusions and Outlook**

Access Discovery (1)

Heterogeneous Access Networks

- **cellular**
- **WiMAX**
- **WLAN Hotspot**
- **PAN**

coverage   bitrate per user

➡ **Selection of the "best" access for a given application required**

➡ **Access Discovery delivers information needed for access selection**

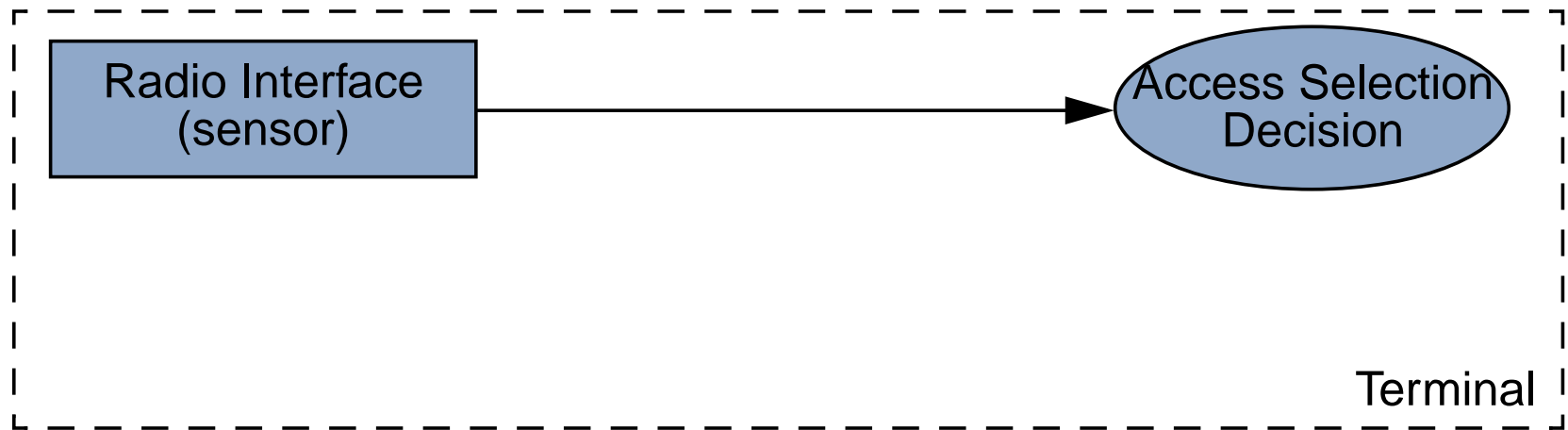## Measurement-based Access Discovery

- **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**

- **can discover distant hotspots, which are not detected by measurements**

- **Challenges**

  - acquisition of information to be stored in context-based information systems

  - making information available to terminals

  - overhead should be small

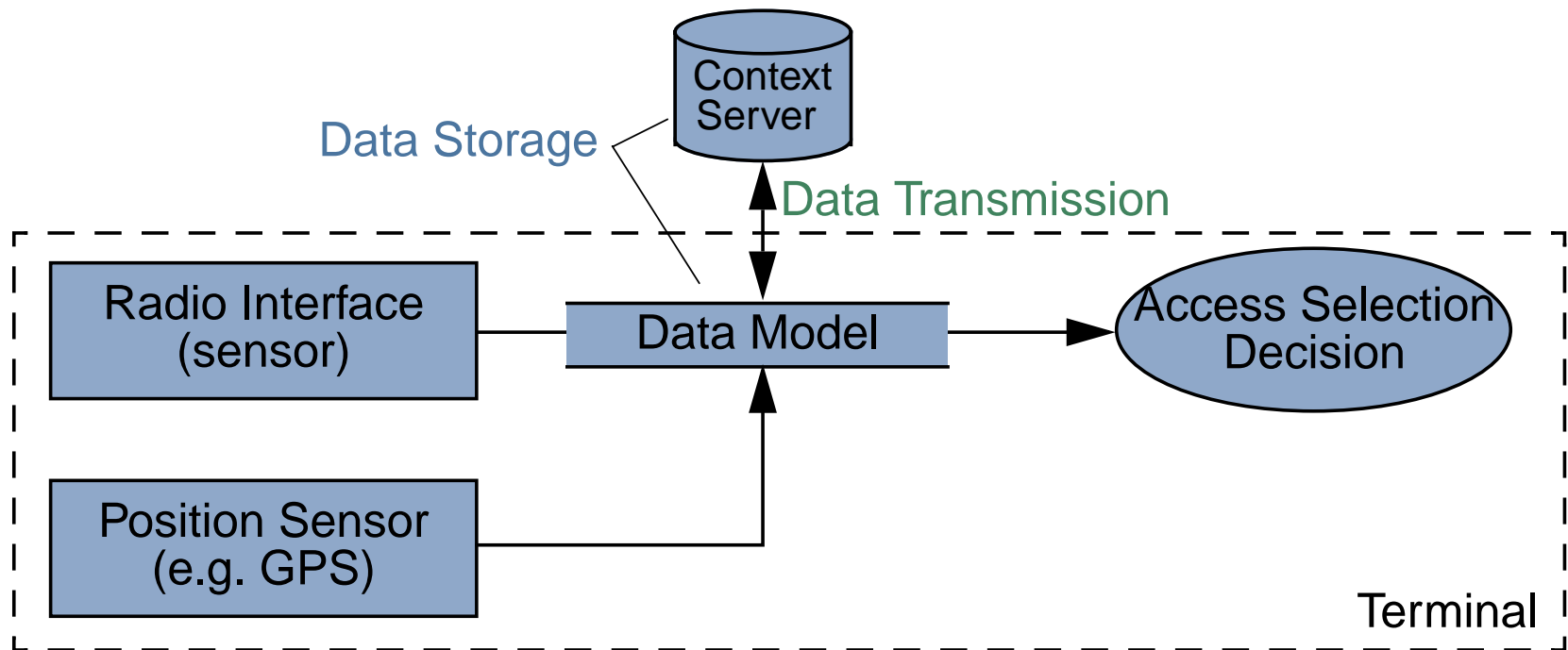 - information should be simple to process by terminals
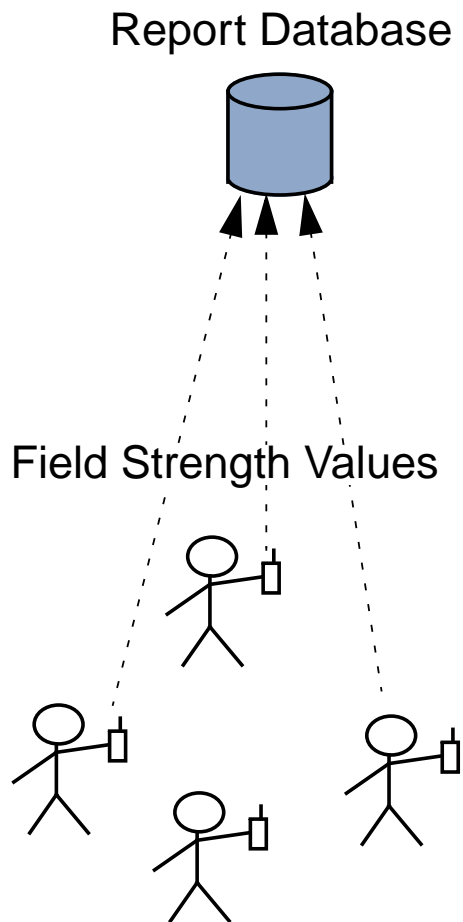
Access Discovery (3)
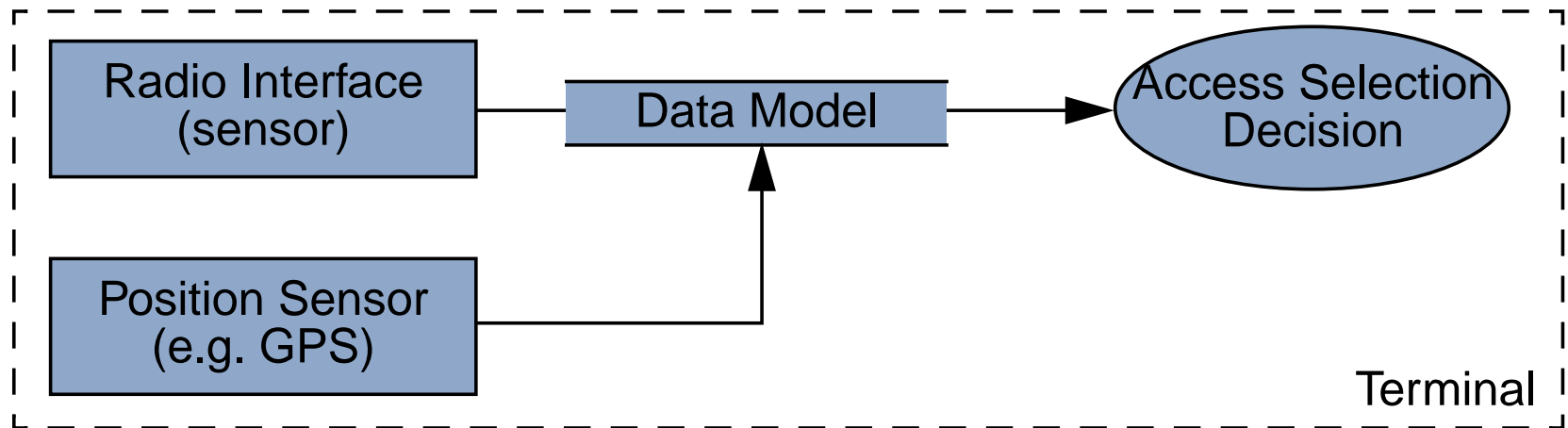
Access Discovery (3)

- Spacial and temporal separation of data aquisition and decision
- Model-based Access Discovery could be seen as an application of a context-based information system
- Model-based Access-Discovery cosume as little resources as possible

Architecture (1)

Report Database

Field Strength Values

Distributed Data Acquisition

- **Mobile Terminals collect field strength values**

- **A data record has the form (technology, cell ID, signal strength, position)**

- **Upload of values**
  - individual values
  - list of values, when a hotspot is reached

Architecture (2)
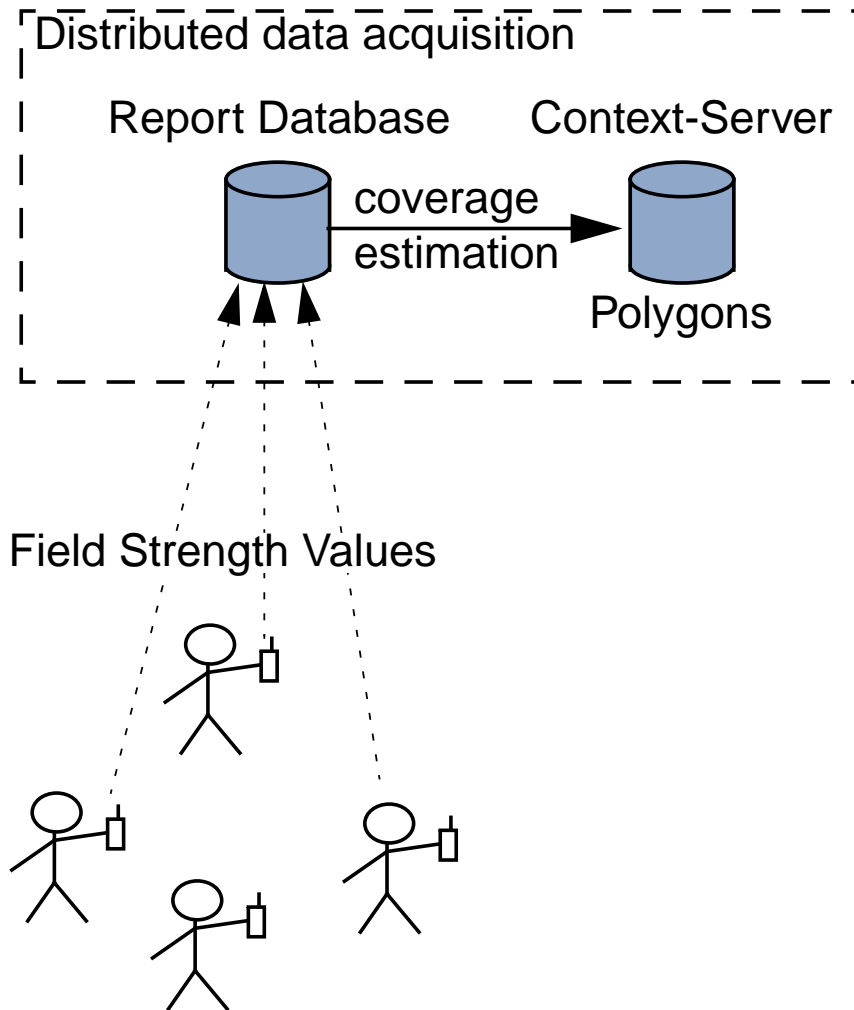
Distributed Data Acquisition

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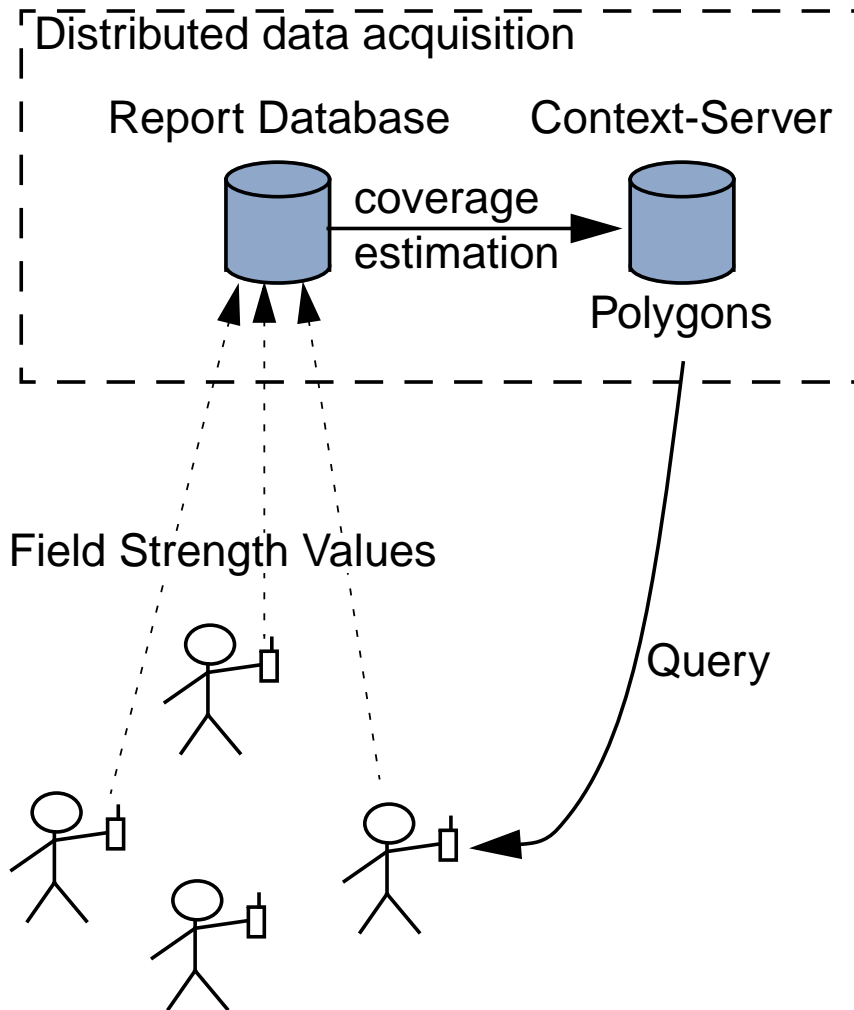 - list of values, when a hotspot is reached

- **Conversion to polygons**

- **Transfer to a Context Server**

Architecture (3)

Distributed data acquisition

Report Database   Context-Server

coverage estimation

Polygons

Field Strength Values

Query

Distributed Data Acquisition

- **Mobile Terminals collect field strength values**

- **A value has the form (technology, cell ID, signal strength, position)**

- **Upload of values**
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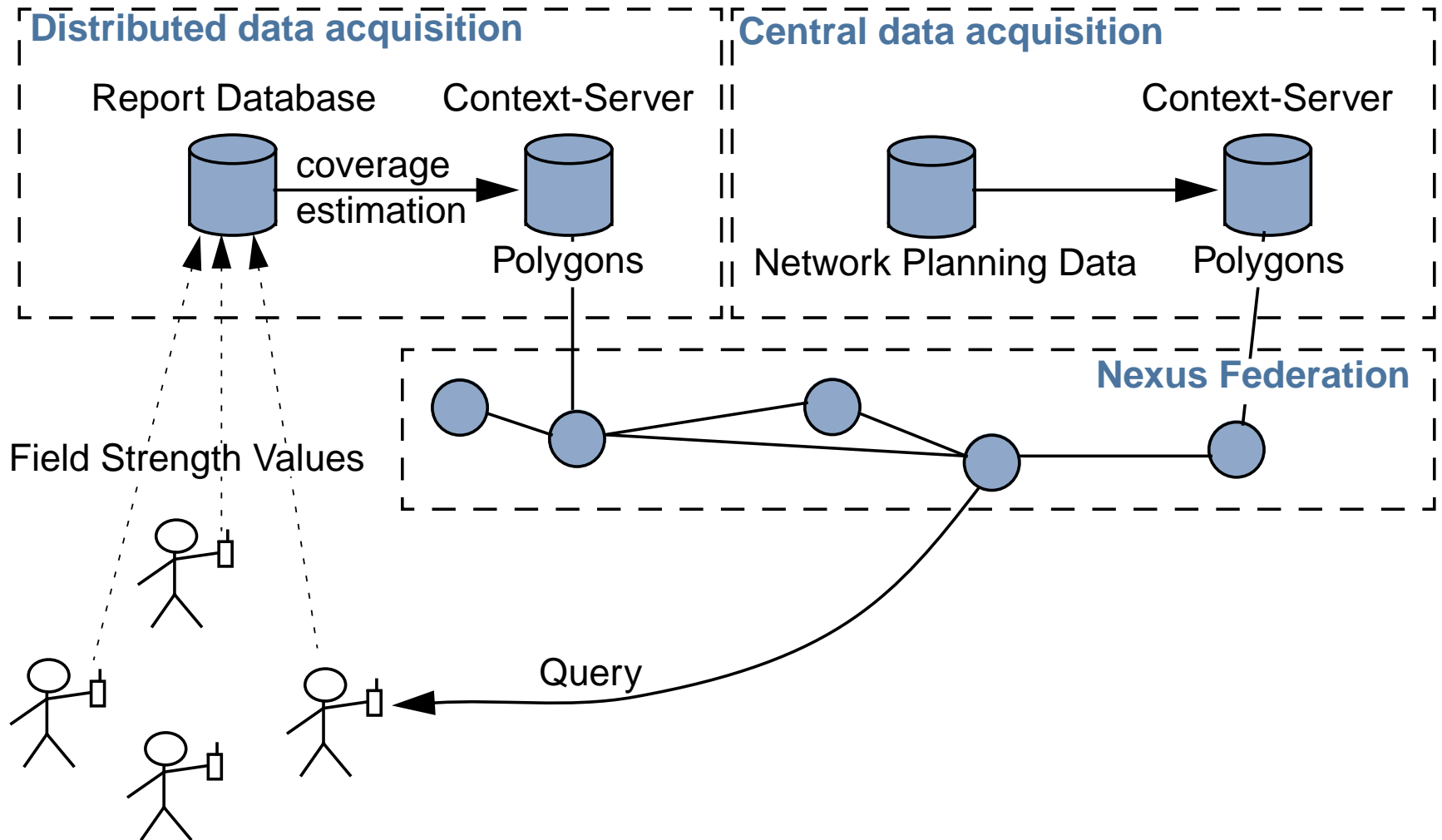- **Conversion to polygons**

- **Transfer to a Context Server**

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

Architecture (4)

Distributed data acquisition

Report Database   Context-Server

coverage estimation

Polygons

Field Strength Values

Central data acquisition

Context-Server

Network Planning Data   Polygons

Nexus Federation

Query

Algorithms (1)

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**
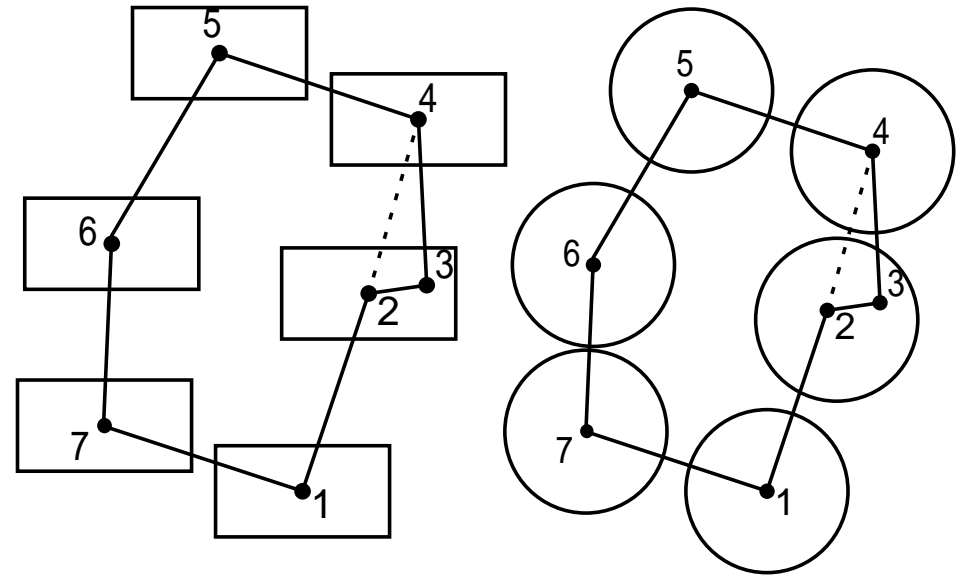   - uses a contour line algorithm
   - yields complex polygons

4. **Polygon Simplification**
   - Removal of irrelevant vertices
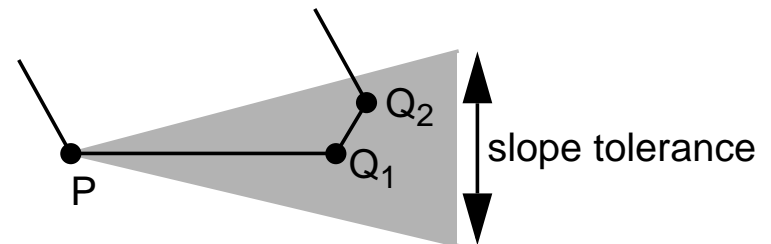   - Aim: reduce size of data records

Algorithms (2)

Simplification Algorithms

- **Distance-based**
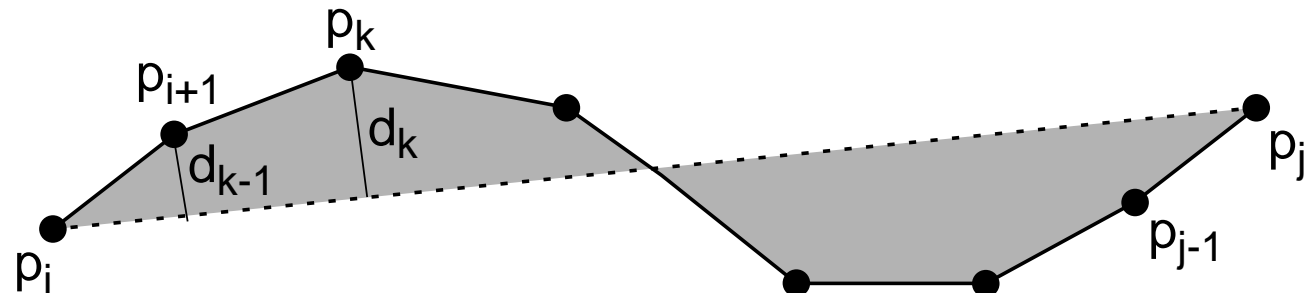 - "simple distance"
  - "Euclidean distance"

- **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
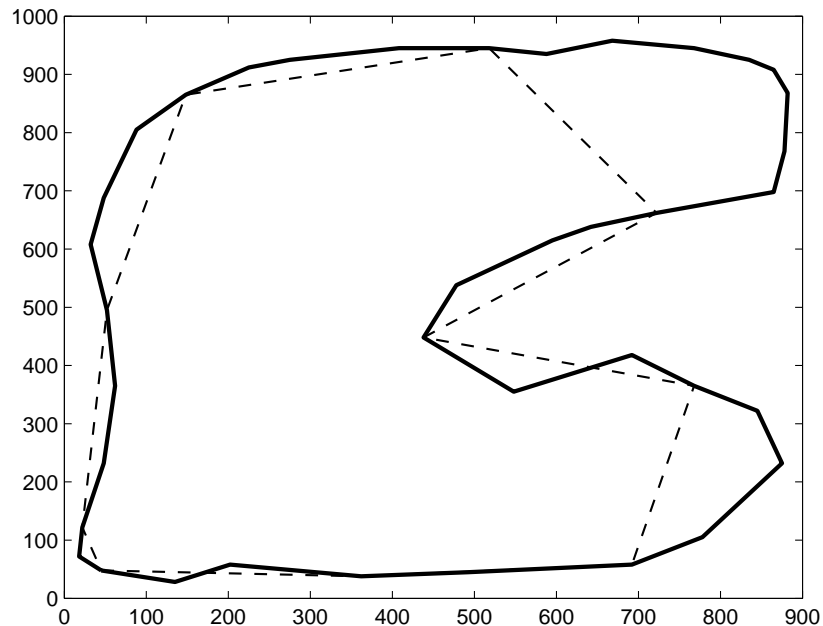

- **Variants**
  - mean (square) distance between vertices of the original polygon and the edge of the simplified polygon
  - area enclosed by original and simplified polygon

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

Data Storage and Retrieval (1)

Data Storage

- **Nexus Augmented World Model (AWM)**
  - Object oriented data model used to describe spatial information
  - Contains classes that represent access networks

Reale Welt

Umgebungs-modell

Informations-räume
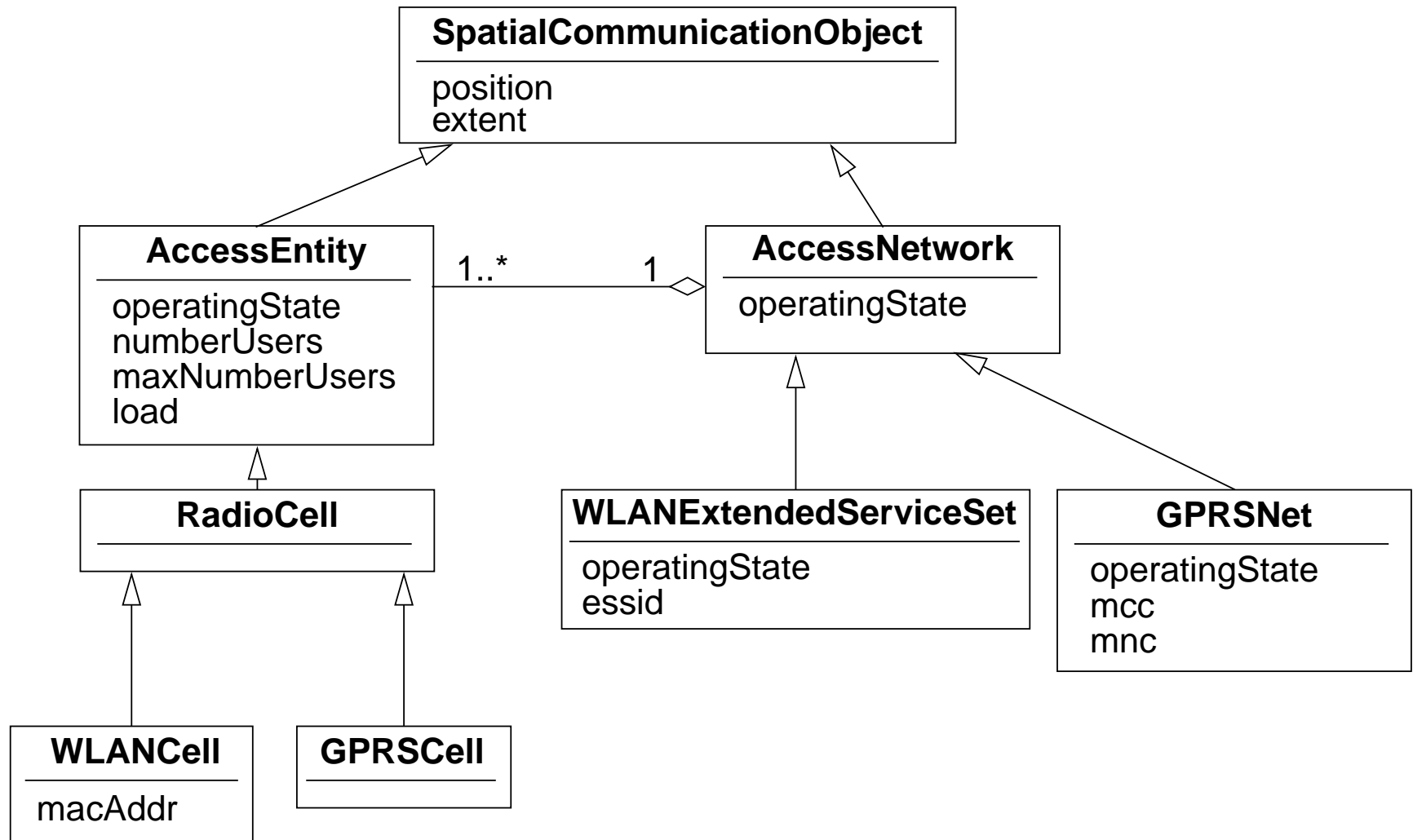
Multimedia   WWW   Digitale Bibliotheken
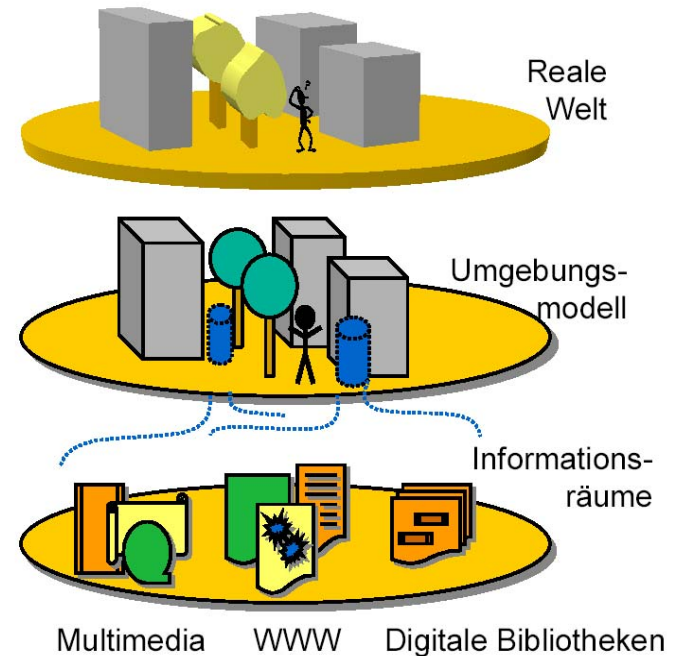
Data Retrieval

- **Representation of AWM objects: AWML (Augmented World Modelling Language)**
- **Query Language: AWQL (Augmented World Query Language)**
  - Query objects within a given area
  - Restrict returned objects to a given type of information, for example access discovery information
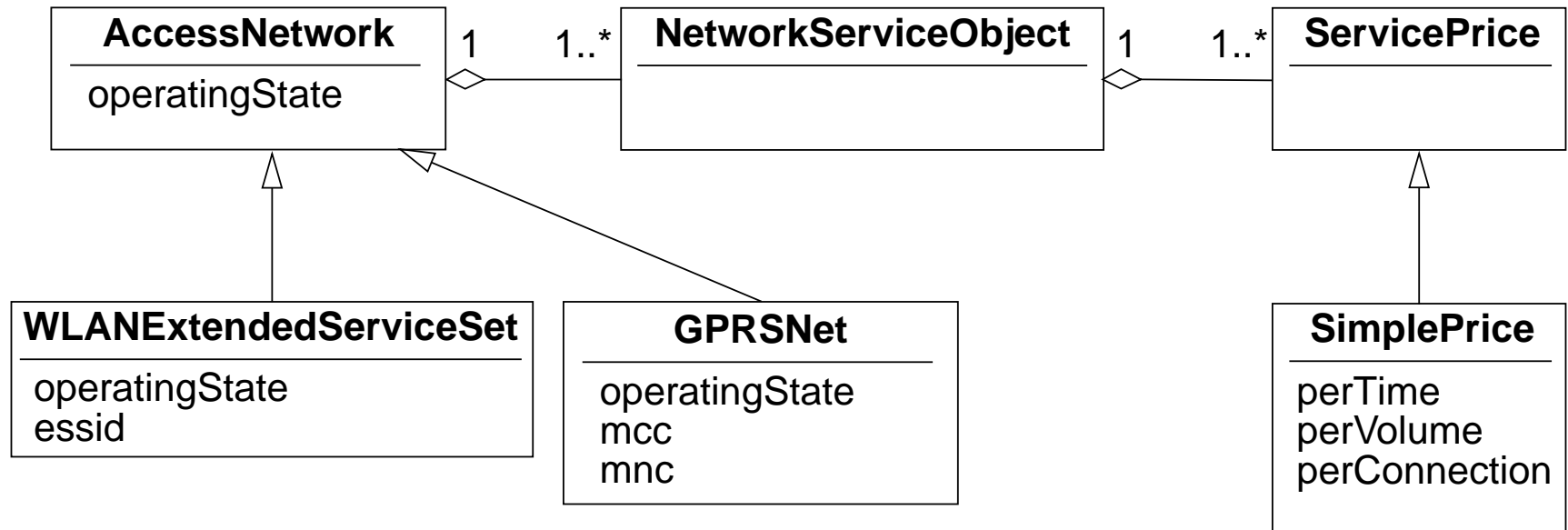
Schema of access networks and access entities

SpatialCommunicationObject
position
extent

AccessEntity
operatingState
numberUsers
maxNumberUsers
load

1..*   1

AccessNetwork
operatingState

RadioCell

WLANExtendedServiceSet
operatingState
essid

GPRSNet
operatingState
mcc
mnc

WLANCell
macAddr

GPRSCell

Schema of access networks and services

Conclusions and Outlook

Conclusions

- **Model-based Access Discovery can complement measurement-based access discovery**

  - to get position and extent of Hotspots

  - to determine other information about Hotspots

- **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 behaviour of coverage estimation**
- **Algorithms to merge coverage information within the Federation**

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