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
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)

- Radio Interface (sensor)
- Data Model
- Access Selection Decision
- Position Sensor (e.g. GPS)
- Terminal
Spacial and temporal separation of data acquisition and decision

Model-based Access Discovery could be seen as an application of a context-based information system

Model-based Access-Discovery consumes as little resources as possible
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
Distributed Data Acquisition

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- 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

Distributed data acquisition

Field Strength Values

Report Database

Context-Server

coverage estimation

Polygons
Distributed Data Acquisition

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- A value has the form (technology, cell ID, signal strength, position)
- Upload of values
  - individual values
  - list of values, when a hotspot is reached
- Conversion to polygons
- Transfer to a Context Server
- Terminals query the Context Server for coverage information
Architecture (4)

Distributed data acquisition
- Report Database
- Field Strength Values
- Coverage estimation

Central data acquisition
- Context-Server
- Network Planning Data
- Nexus Federation

Query

Polygons
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**

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<th>euclidean distance</th>
<th>slope</th>
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- **Result**
  - distance-based Algorithms perform better
  - the error increases superproportionally with the number of reduced vertices
Data Storage

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

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
  - maxNumberOfUsers
  - load

- **AccessNetwork**
  - operatingState

- **RadioCell**

- **WLANCell**
  - macAddr

- **GPRSCell**

- **WLANExtendedServiceSet**
  - essid

- **GPRSNet**
  - mcc
  - mnc

Data Storage and Retrieval (2)
Schema of access networks and services

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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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