A P2P Control Architecture Supporting Vertical Handover Decisions

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Carrier-Grade Peer-to-Peer (CaPi) Project

- from 10/2004 – 09/2005

  SIEMENS

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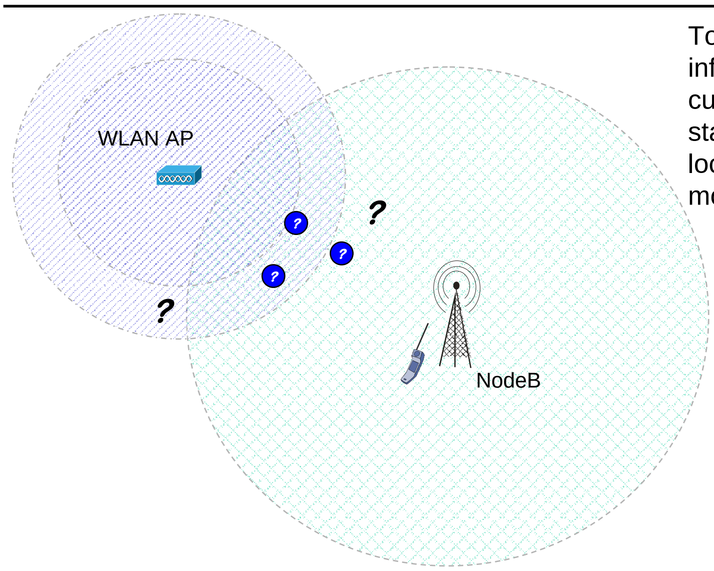
- One of two investigated applications (Location Based Vertical Handover and Easy Configuration of Attachment Points)

Content

- Introduction: Vertical Handover
- Design of a distributed database
- Performance evaluation
- Conclusion

Vertical Handover



To conduct VHO, information on the current network status at the location of the mobile is needed

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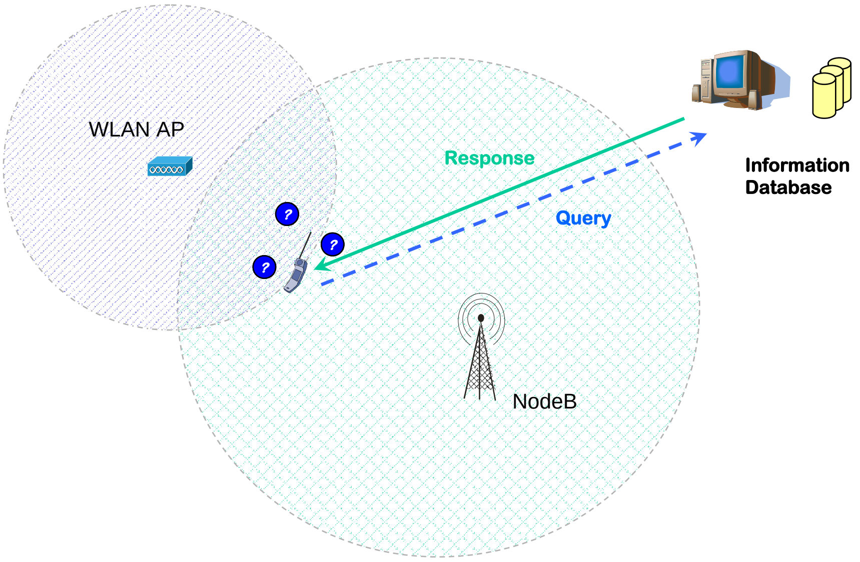
Problem formulation

- Locality-bound measurement information has to be made available (i.e., signal strength)
- The information is very time-dependent (changing network situation)
- A large number of handover requests has to be served
- Fast response times are needed for viable handover

Querying a database for information



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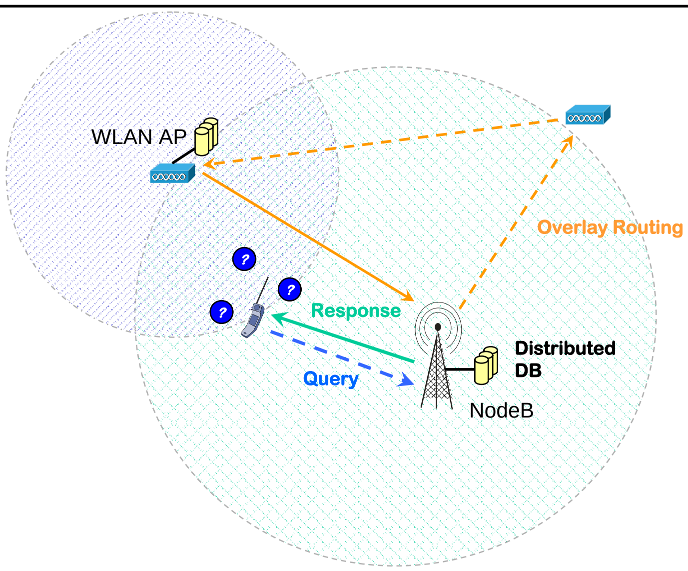
Example: HIS

- The Hybrid Information System (HIS) is a database that stores measurements of radio systems
- Result of the WINNER project (IST/EU), Partners: Siemens, RWTH Aachen
- Saves scanning effort of the mobile devices
- Provides vital information for handover decisions (i.e., is handover possible/to be advised)
- One possible information service

Distribution of the database



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Distribution of the database

- Basic idea: the database is split up among the peers
- Each NodeB and WLAN Access Point in the access network is a peer
- Each peer only stores a segment of the ‘information map’
- To interconnect all the parts of the database, a structure is needed **(overlay network)**
- Structured Peer-to-Peer algorithms implement such an overlay

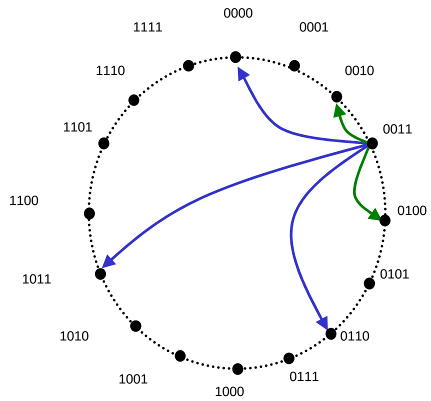
Why Peer-to-Peer?

A peer-to-peer system might offer several advantages:

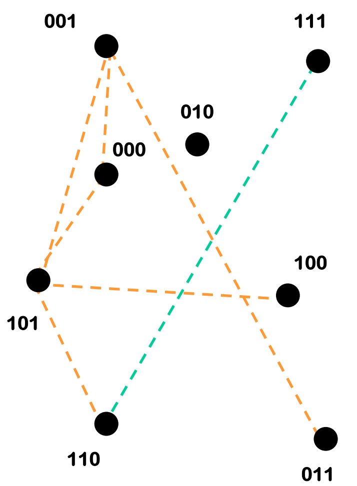
- Scalability (ability to handle a large number of nodes, requests)
- Load distribution
- Fault tolerance (no central point of failure)
- Self-organization
- Network can be made up of inexpensive components

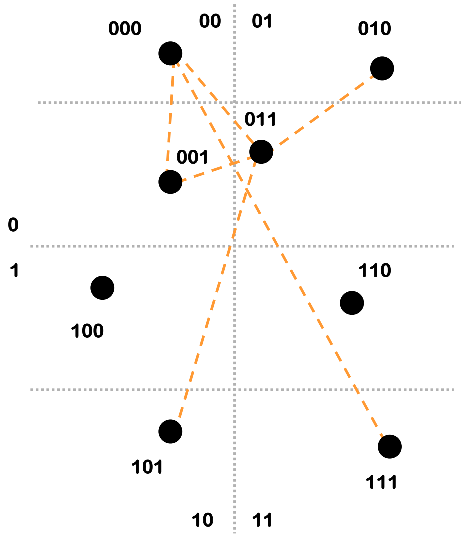
Pastry

- **Pastry** was developed by Rowstron and Druschel in 2001
- Structured peer-to-peer (P2P) architecture
- Unique IDs are used to route messages in the overlay (**prefix-matching**)
- Offers **object location** and **routing**
- Each peer is responsible for one portion of the information stored in the network



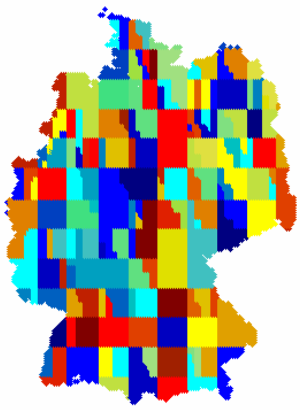
Pastry and its modifications



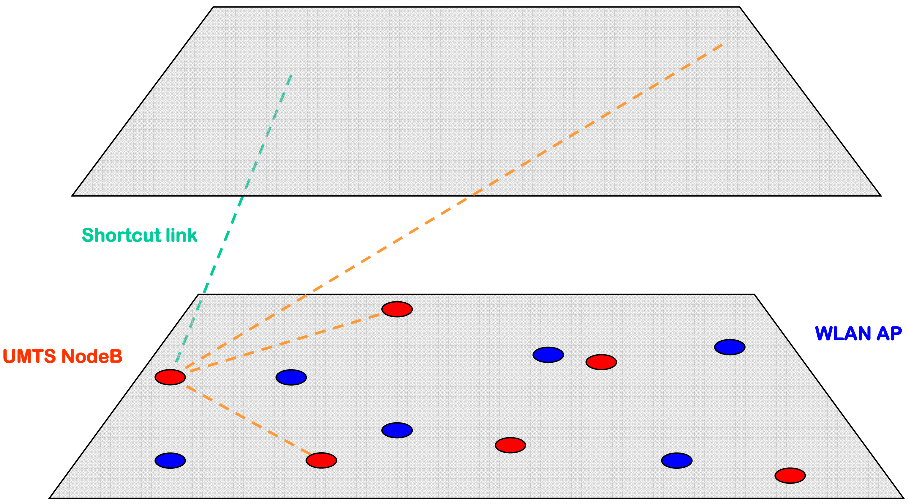


Responsibility areas

- Idea: assign each peer ‚his' area (i.e., measurements that were done closest to him)
- UMTS NodeBs only store UMTS measurements, WLAN AP only WLAN measurements
- Replacement of the standard Pastry ID (SHA-1 hash) by a location- and technology-aware ID
- Result: overlay structure is adapted to physical network layout



Shortcut links



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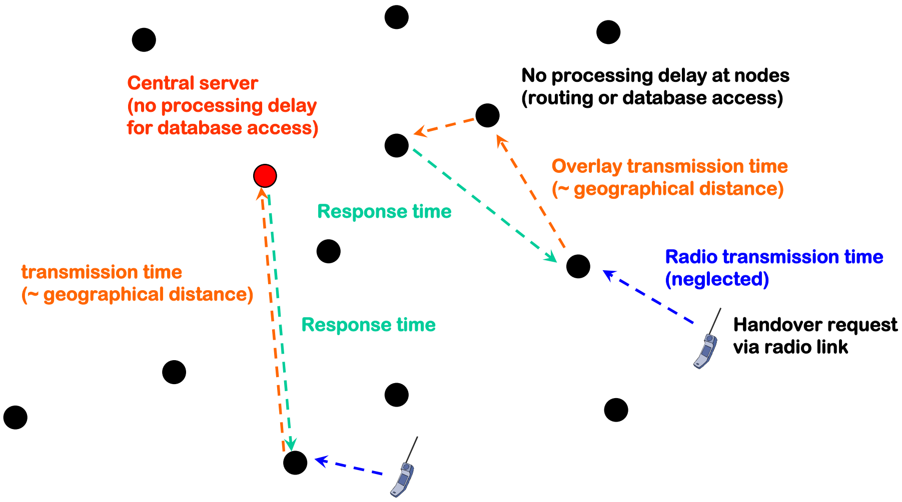
Simulation model

- Primary performance indicators:
  - Search speed
  - Scalability
- Simulation scenarios are based on real antenna locations
  - Construction of homogenous layouts with realistic densities of antennas
  - Attachment points assumed to have direct IP connectivity
- Country-sized setup, i.e. 60.000 NodeBs and 40.000 WLAN APs
- Information requests created uniformly at each attachment point

Simulation model



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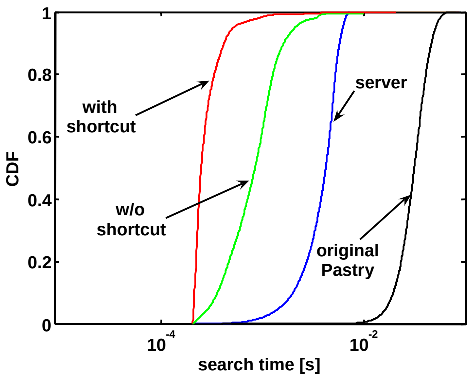
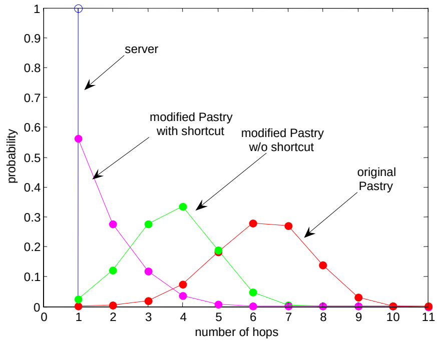
Search time distributions

- Standard Pastry performs not as good as the classical client/server approach
- When improved with locality and shortcuts, search is sped up
- Modified algorithm is faster than a central server



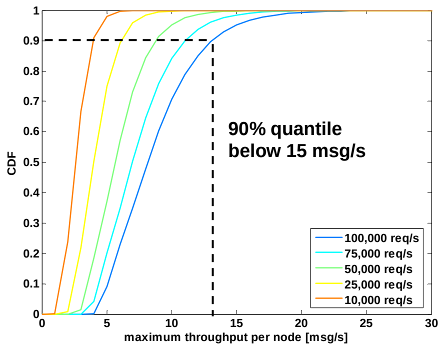
Hop distributions

- Connection to server modeled as one hop
- Normal Pastry takes log(N) hops to route messages
- Our modifications improve the routing by shortening the search path
- Shortcut improvement cuts off the most ineffective part of the search (possible due to local searches)



Scalability load

- The message load (traffic and processing time) each node has to handle was considered
- The maximum throughput is on a low level even for high load
- Nodes can be kept inexpensive, the system scales well



Conclusion

- Using a peer-to-peer architecture to support VHO offers advantages like scalability
- Standard algorithms have to be modified to fit the problem, e.g., to achieve search speed
- Our modified Pastry algorithm (with new ID structure and shortcut links) is a viable solution and performs better than a server alternative
- Self-organizing P2P mechanisms permit new ways of operating
  - Attachment points can easily be added → reduced operational costs
  - Even single attachment point providers possible
  - Highly heterogeneous networks supported

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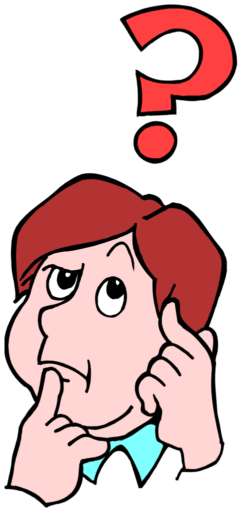
Thank You

Q&A



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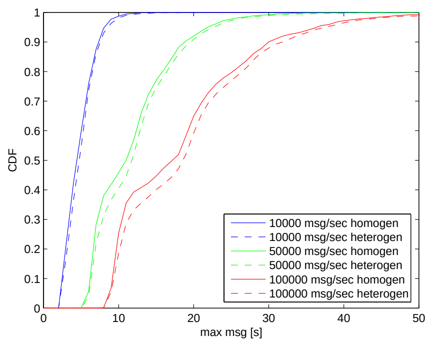
Backup

Homogeneous and heterogeneous scenarios

- Homogeneous layout (i.e., uniformly distributed attachment points) is a simplification and nor realistic
- To validate simulation results, a comparison was done between
  - a realistic setup (based on antenna locations in Frankfurt)
  - A homogeneous setup of the same size
- Results are comparable, no loss of significance



Scalability