University of Würzburg
Informatik III (Distributed Systems)
Prof. Dr. P. Tran-Gia

Supporting Vertical Handover by Using a Pastry Peer-to-Peer Overlay Network

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Mobile Peer-to-Peer Computing MP2P'06,
Pisa, Italy, March 17th 2006

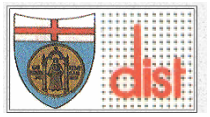
Carrier-Grade Peer-to-Peer (CaPi) Project

- from 10/2004 – 09/2005

SIEMENS

Siemens AG Com: *Frank-Uwe Andersen*

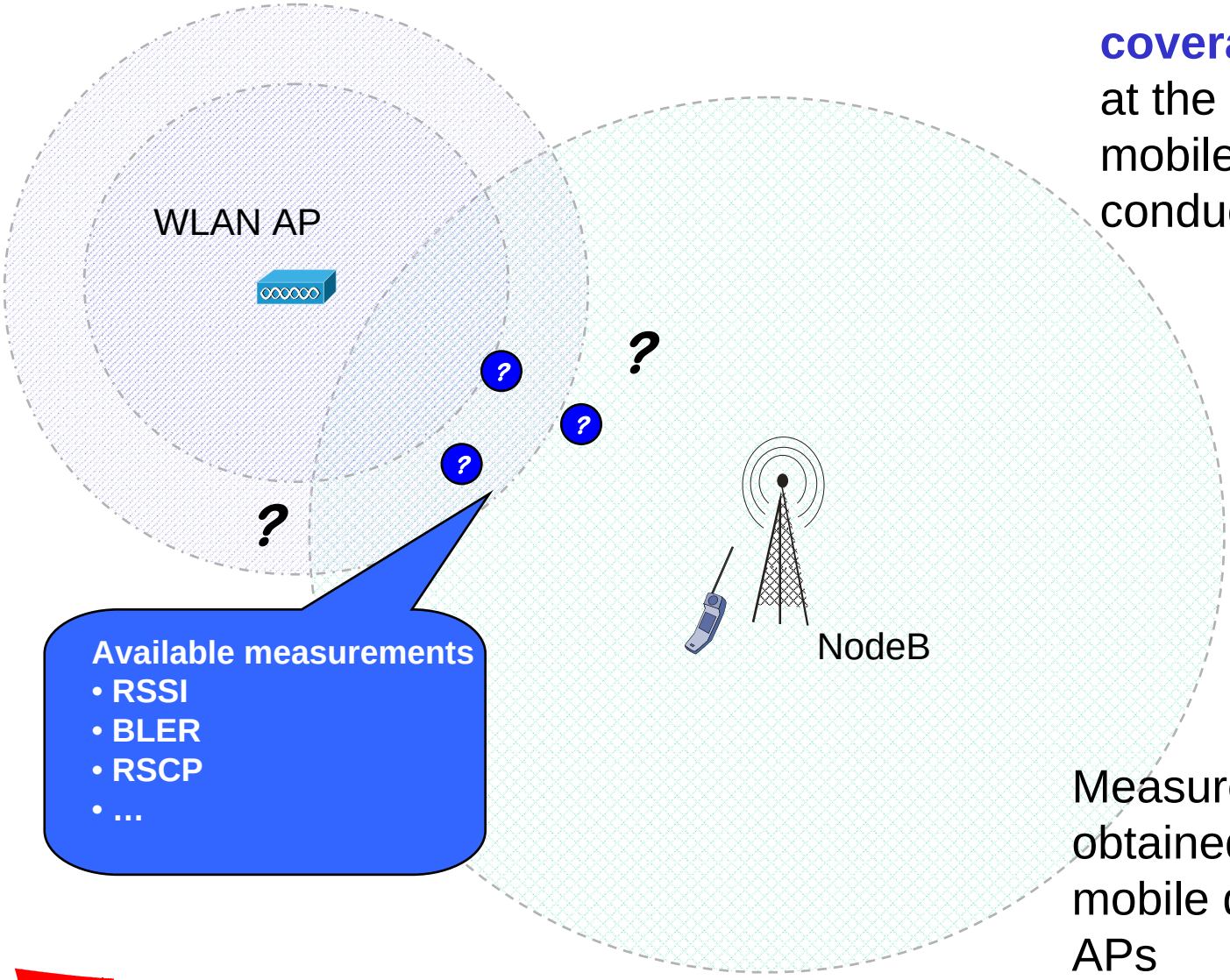
University of Würzburg, Department of Distributed Systems: *Prof. Dr. Phuoc Tran-Gia, Dr. Kurt Tutschku, Tobias Hoßfeld, Simon Oechsner*



University of Genova, D.I.S.T., Department of Communications, Computer and Systems Science: *Prof. Dr. F. Davoli, Luca Caviglione, Marco Perrando*

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

Vertical Handover



coverage information at the location of the mobile is needed to conduct VHO

Measurements are obtained by other mobile devices or APs

Problem Formulation

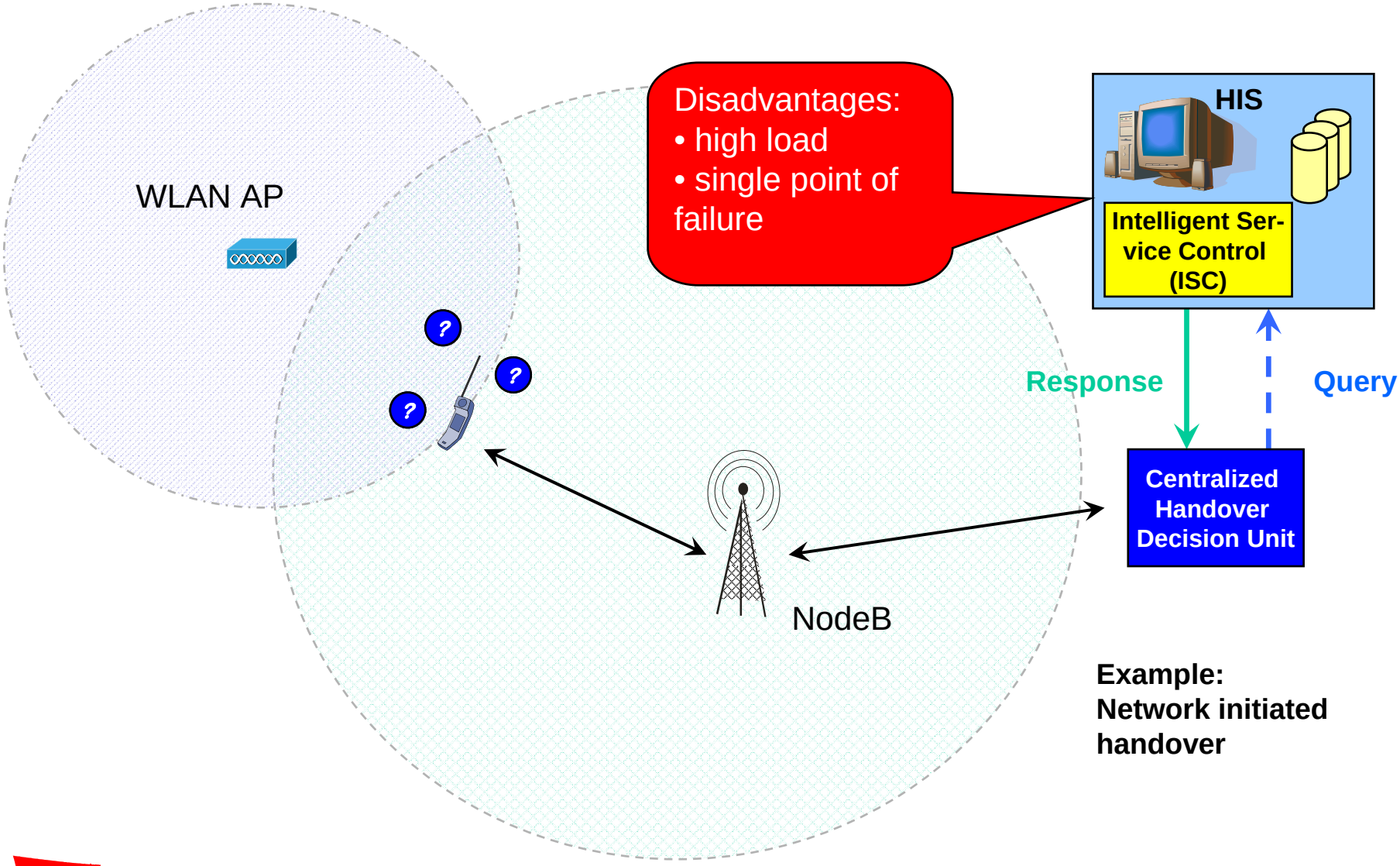
- Locality-bound measurement information has to be made available (e.g. signal strength)
- Different access technologies must be supported
- Information is time-dependent (changing network conditions)
- Large number of handover requests has to be served
- Fast response times are needed for viable handover

→ **VHO support system must be scalable and efficient**

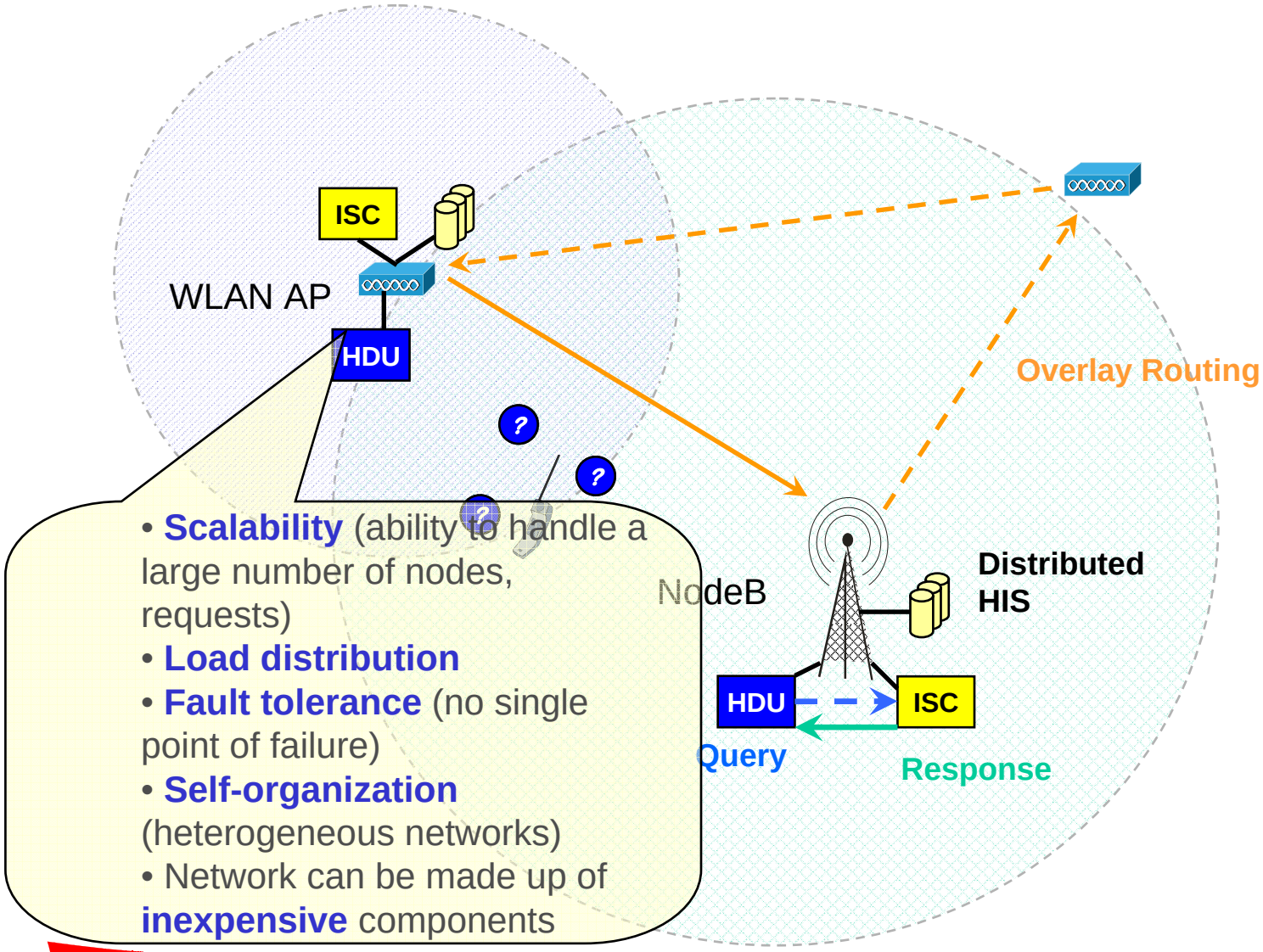
Example: HIS

- **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 making handover more secure

HIS: Querying a Database for Information



Our Approach: Distribution of Database



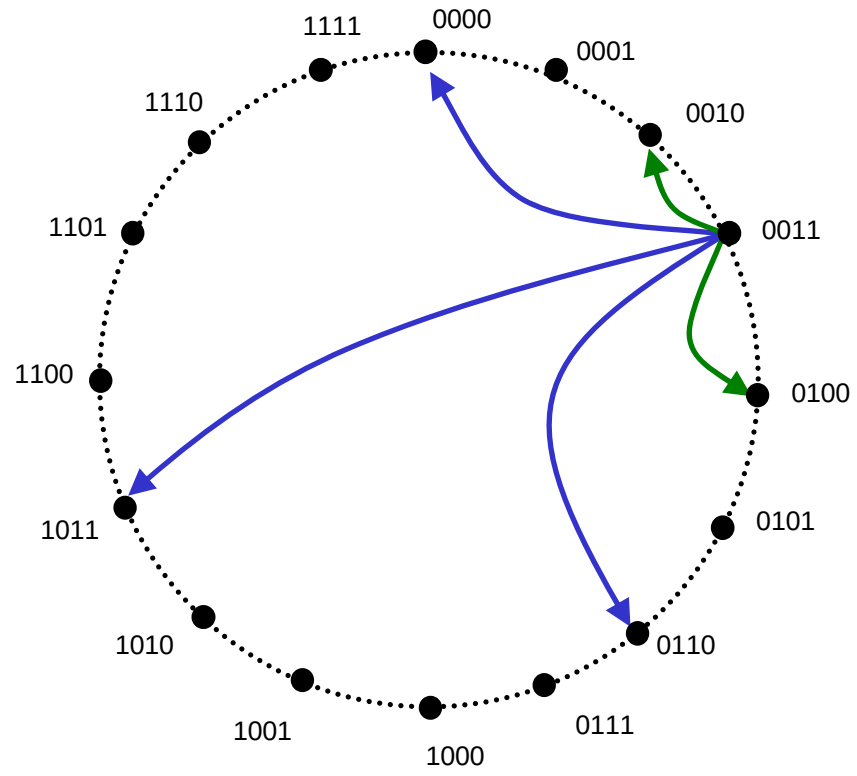
- **Scalability** (ability to handle a large number of nodes, requests)
- **Load distribution**
- **Fault tolerance** (no single point of failure)
- **Self-organization** (heterogeneous networks)
- Network can be made up of **inexpensive** components

How to distribute the database?

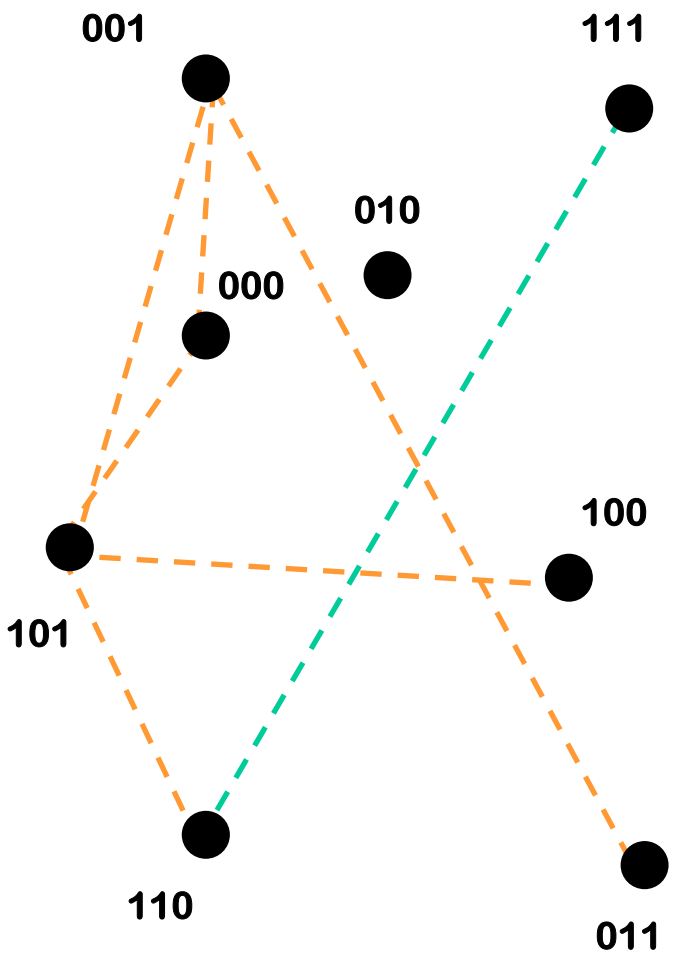
- Basic idea is to split up the database among the peers
- Each AP, i.e. NodeB and WLAN Access Point, in the access networks is a peer
- Each peer only stores a segment of the **information map**
- To interconnect all parts of the database, an overlay is used
- **Structured Peer-to-Peer** algorithms implement such an overlay
- Geographically close peers should be neighbors in the overlay
- **Symmetric location-aware overlay metric required**

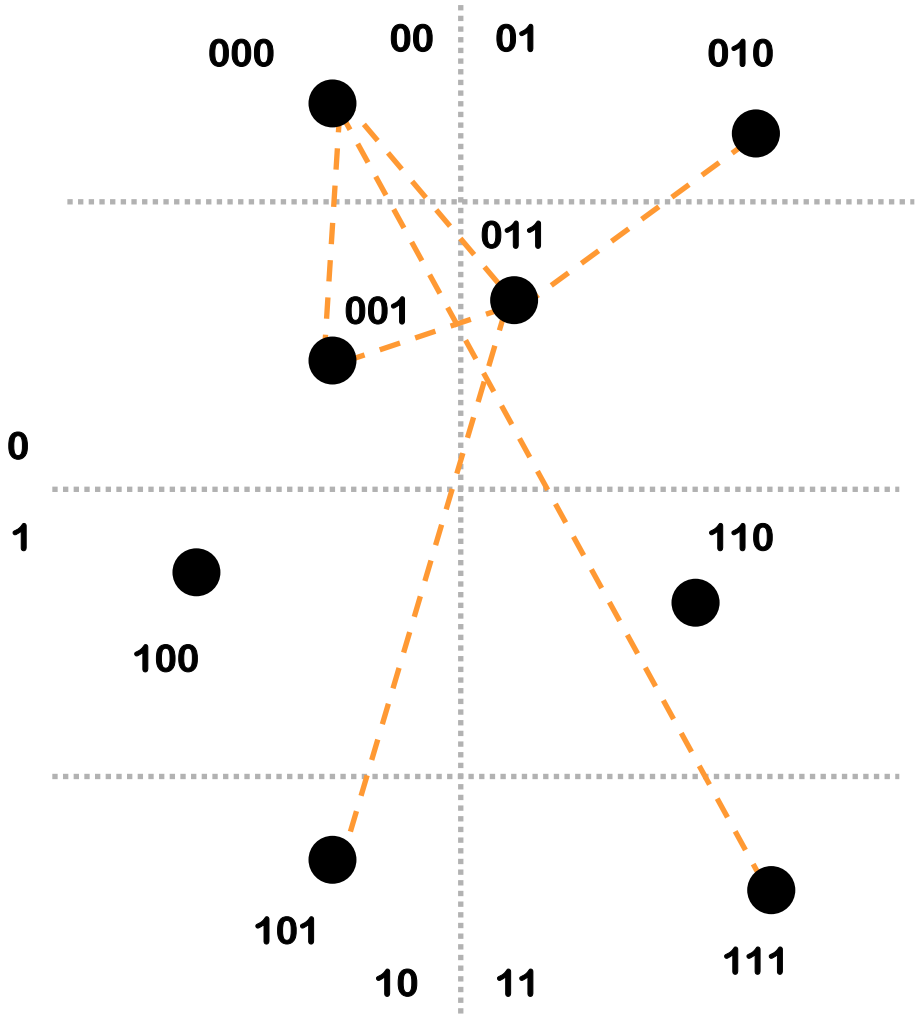
Pastry

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



Pastry and its Modifications





- Random ID: $r_1r_2r_3r_4$…
- Location-aware ID: $x_1y_1x_2y_2$…
- Pastry routing not changed

Responsibility Areas

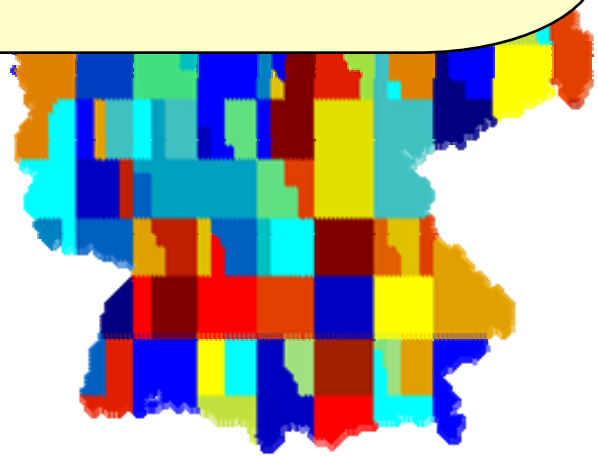
- Measurements are a
  closest peer accordi
  prefix matching
- UMTS NodeBs only
  measurements, WL
  WLAN measuremer
- Replacement of the standard Pastry ID (SHA-1 hash) by a location- and technology-aware ID: $t_1t_2x_1y_1x_2y_2$

→ overlay structure is adapted to physical network layout

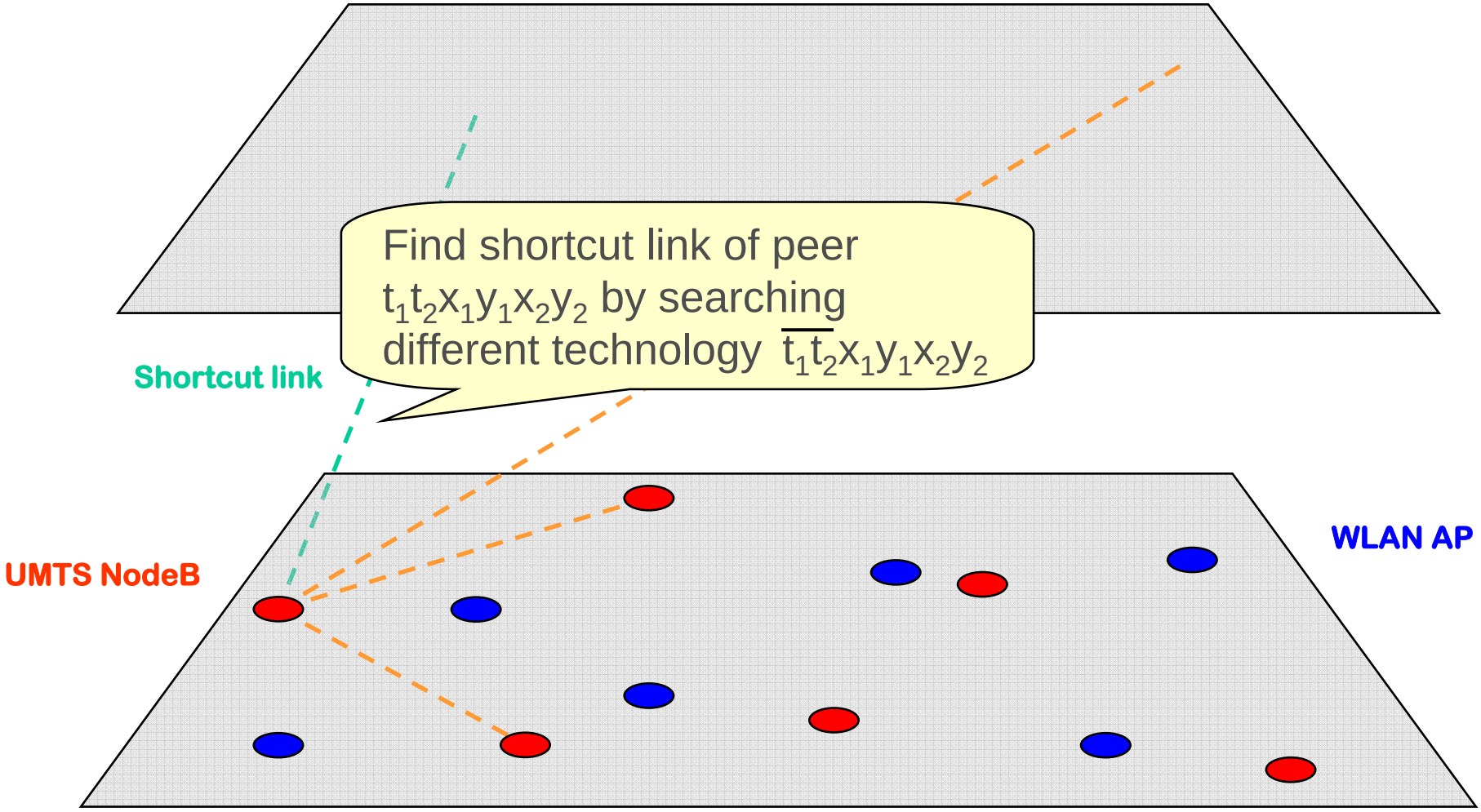
Problem: Consider UMTS to WLAN handover

• UMTS nodeB knows only some WLAN APs (with prefix 0)

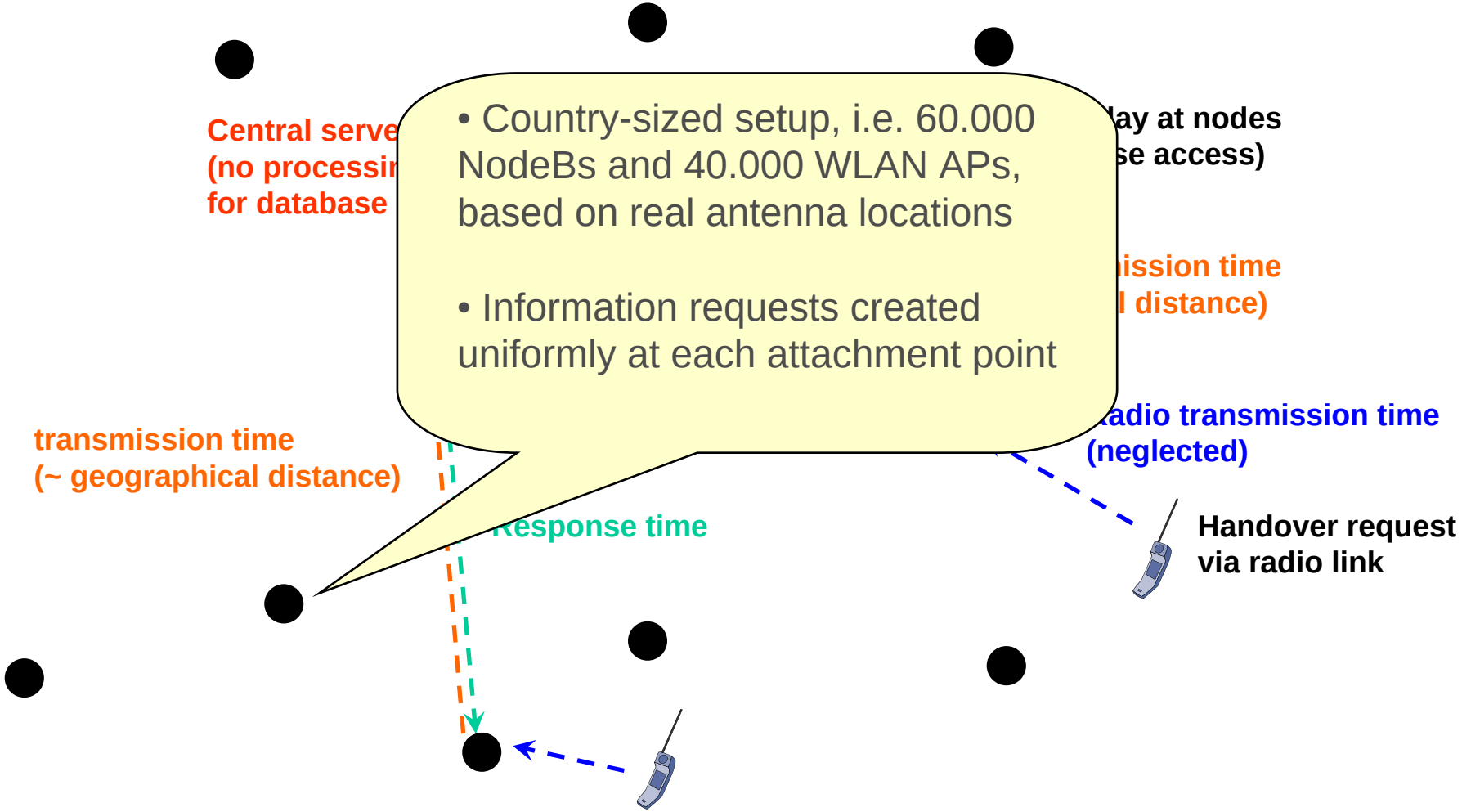
• unnecessary routing (between WLAN APS) to find a WLAN AP close to the UMTS nodeB



Shortcut Links

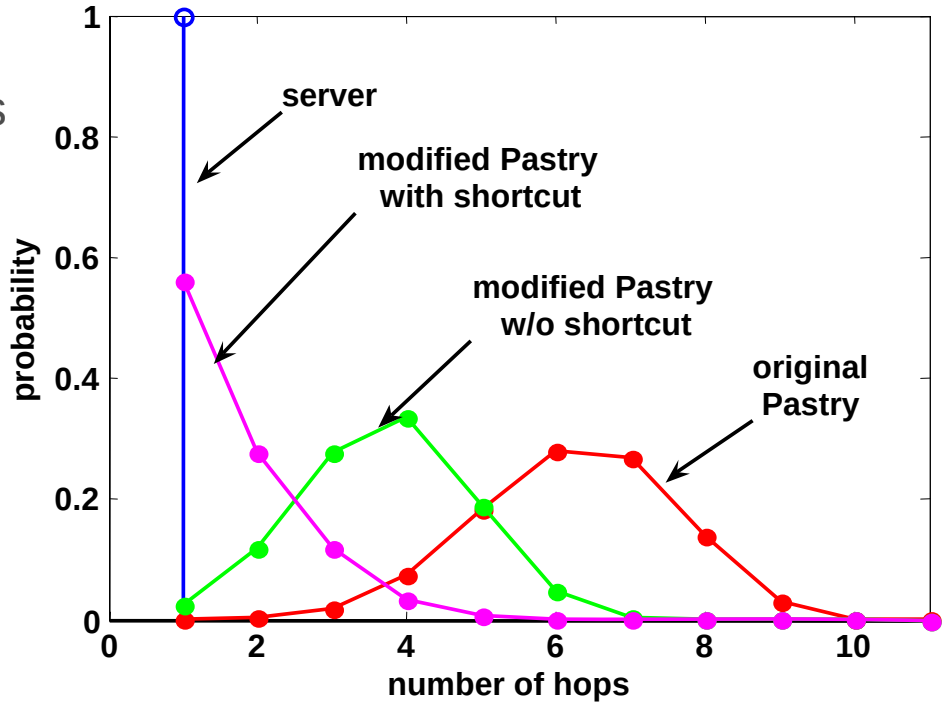


Simulation Model



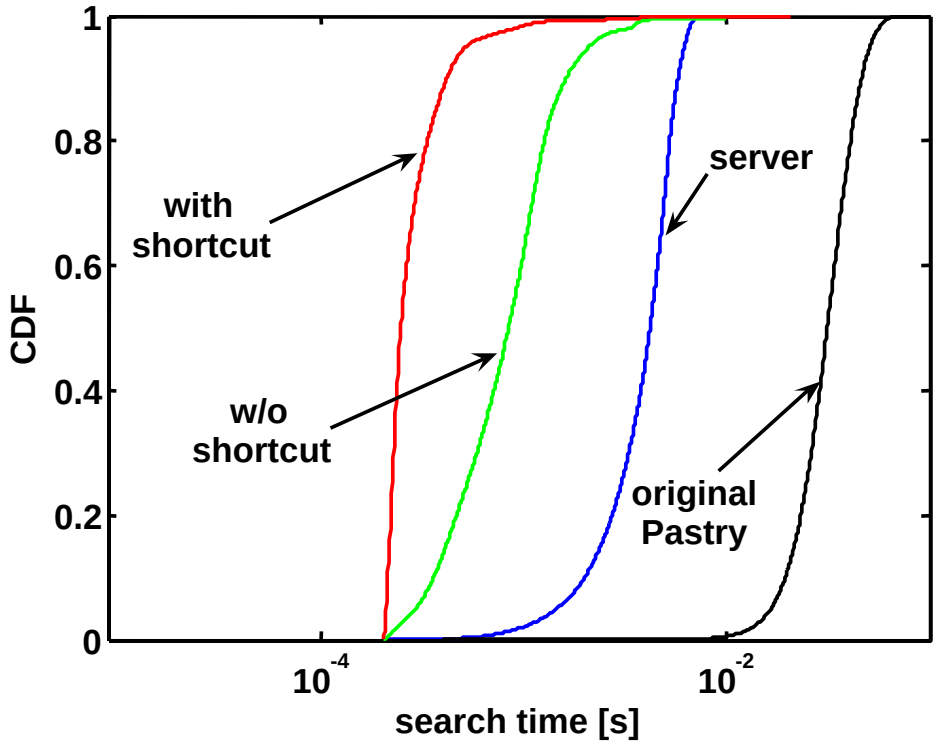
Hop distributions

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

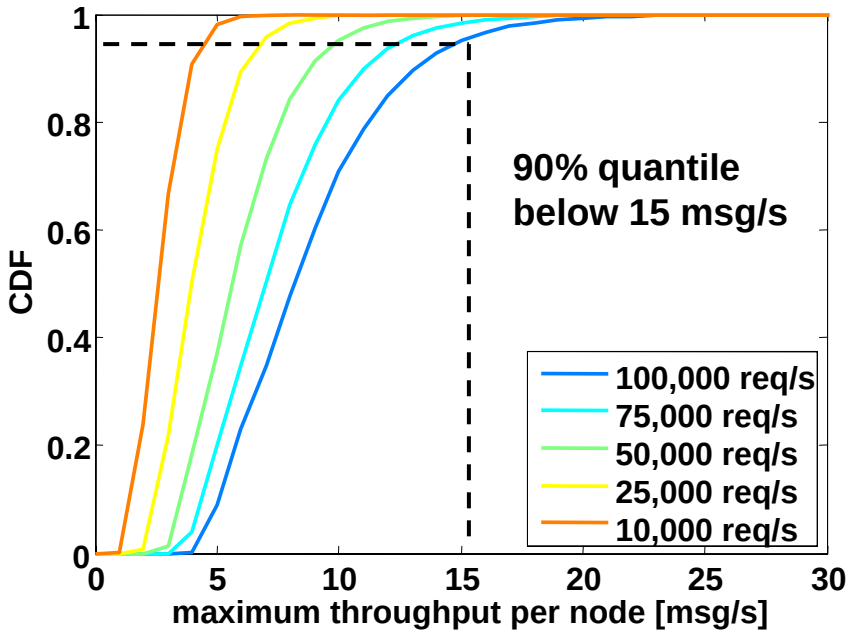


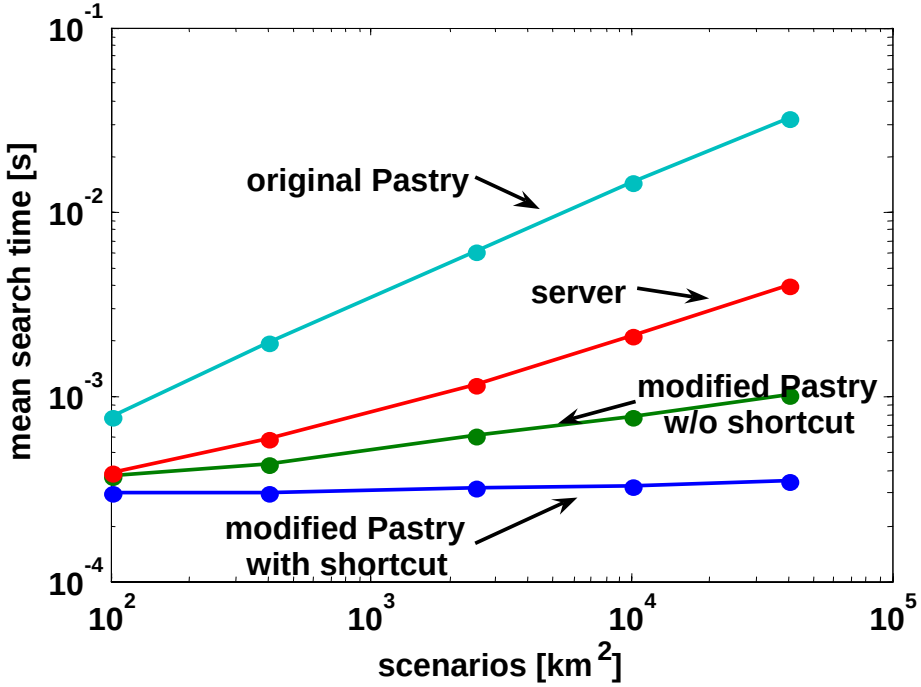
Search time distributions

- Standard Pastry performs not as good as classical client/server approach
- When improved with locality and shortcuts, search is sped up
- Modified algorithm is faster than a central server
- Modifications are necessary to get **dependable systems**
- Neglecting physical network hop processing times and time in waiting queues: **current work**



Scalability





- Message throughput each node has to handle and search time of requests were considered
- Nodes can be kept inexpensive, the **system scales well** w.r.t.
  - system load in terms of requests per seconds:
  - networks size, i.e. number of APs within a geographical area

Conclusion

- Using a peer-to-peer architecture to support VHO offers advantages like scalability and inexpensive components
- Standard algorithms have to be modified to get dependable systems, 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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Backup

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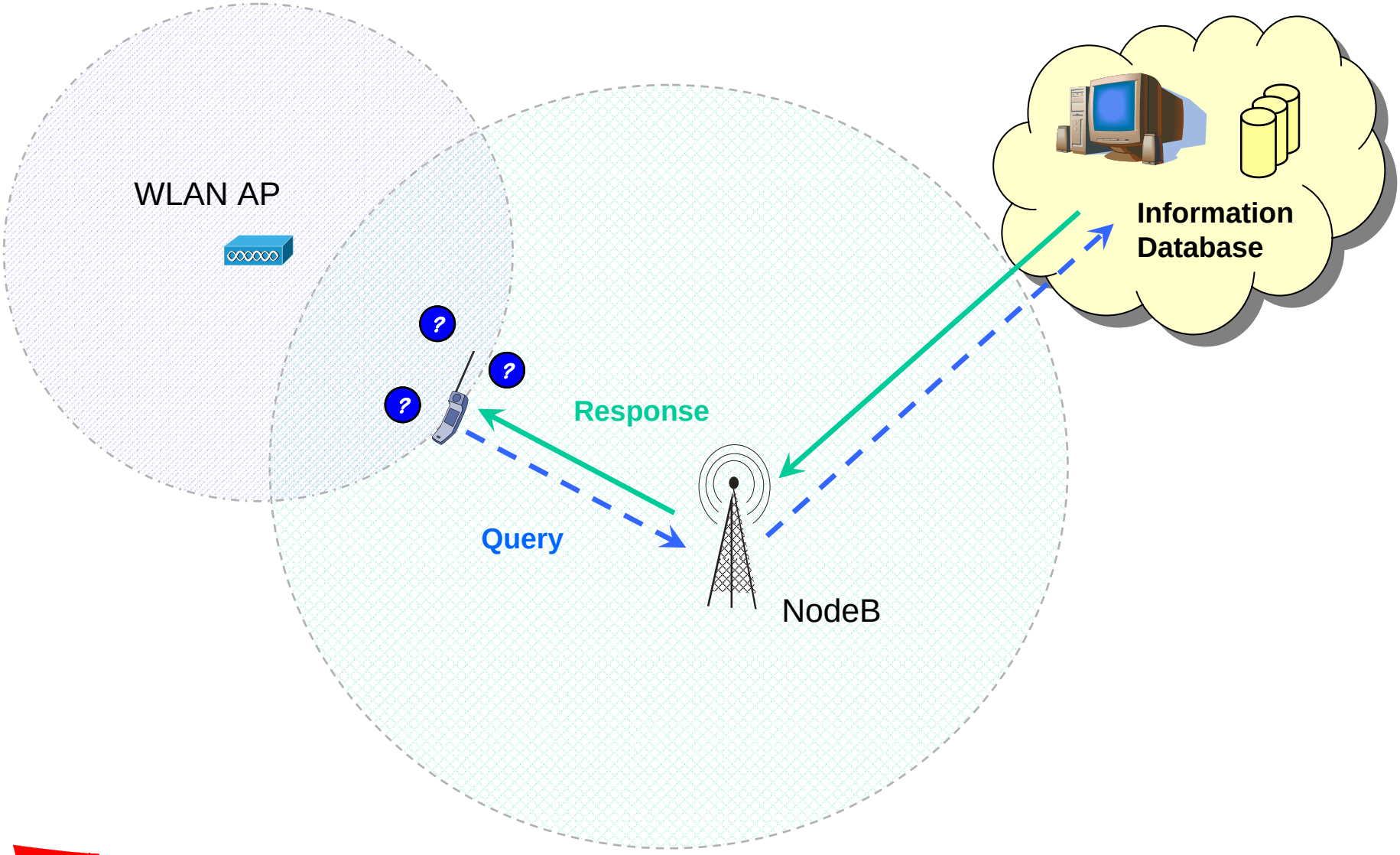
Querying a Database for Information



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- Antony Rowstron and Peter Druschel:
  Pastry: Scalable, decentralized object location and routing for large-scale peer-to-peer systems.
  Lecture Notes in Computer Science, 2218, 2001.
- Simon Schütz:
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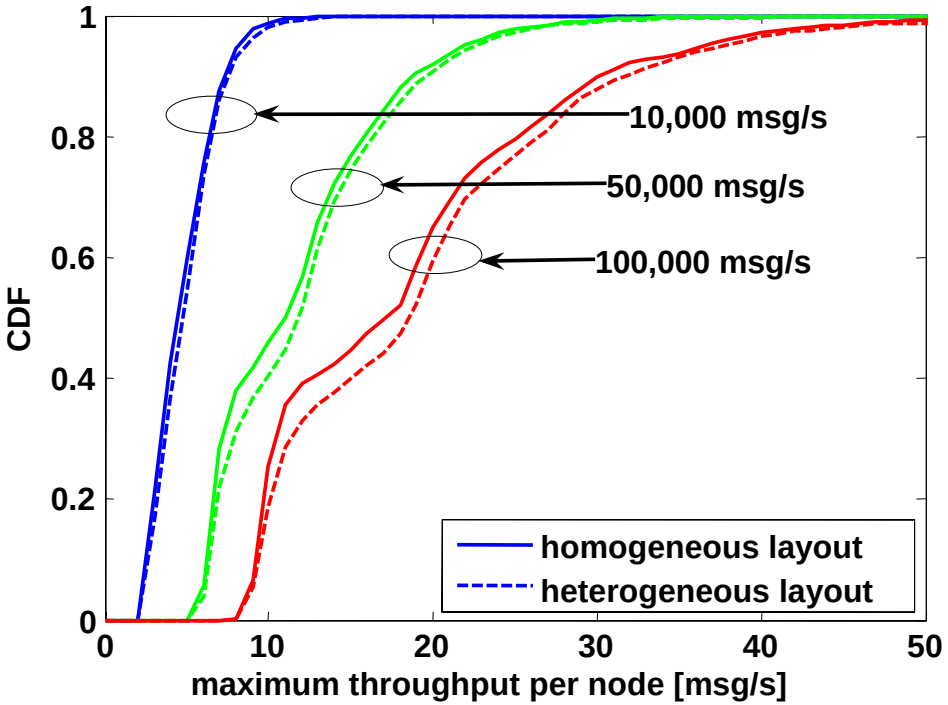
  5. Würzburger Workshop 'IP-Netzmanagement, Netzplanung und Optimierung', July 2005

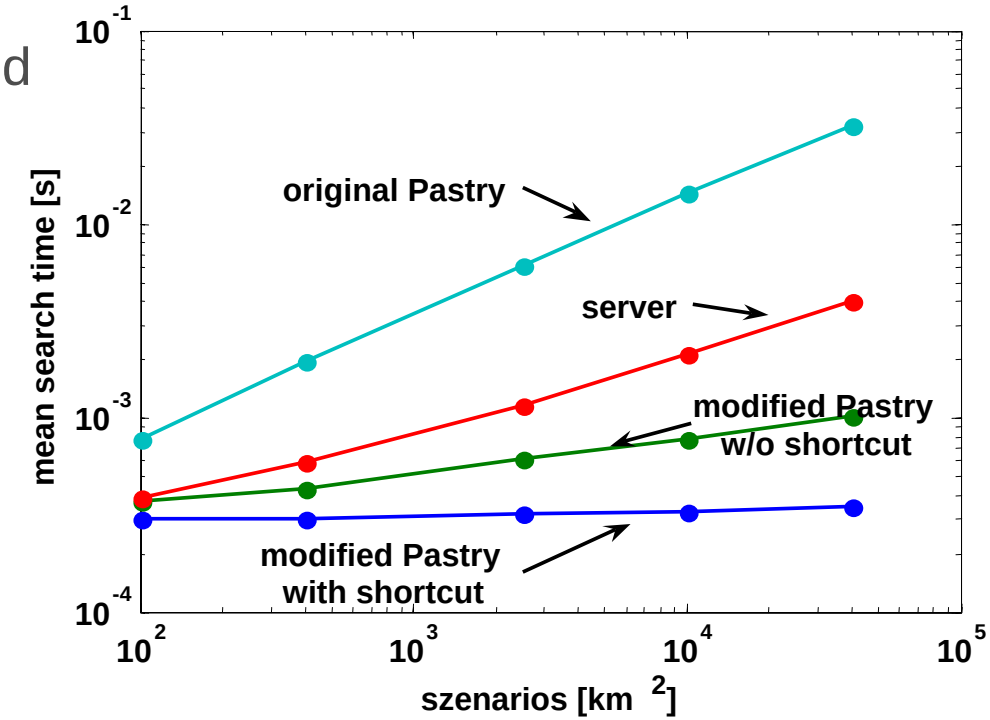
Homogeneous and heterogeneous scenarios

- 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 w.r.t. Number of APs

- 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
- System scales well



Conclusion

- P2P technology offers advantages like scalability & reliability
- Standard algorithms have to be modified, e.g., to achieve search speed
- modified Pastry algorithm with new ID structure and shortcut links is a viable solution
- Self-organizing P2P mechanisms permit new ways of OA&M
  - Attachment points can easily be added → reduced operational costs
  - Highly heterogeneous, dynamic networks supported
  - Even single attachment point providers possible?