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

Using Kademlia for the Configuration of B3G Radio Access Nodes

Simon Oechsner

www3.informatik.uni-wuerzburg.de

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*

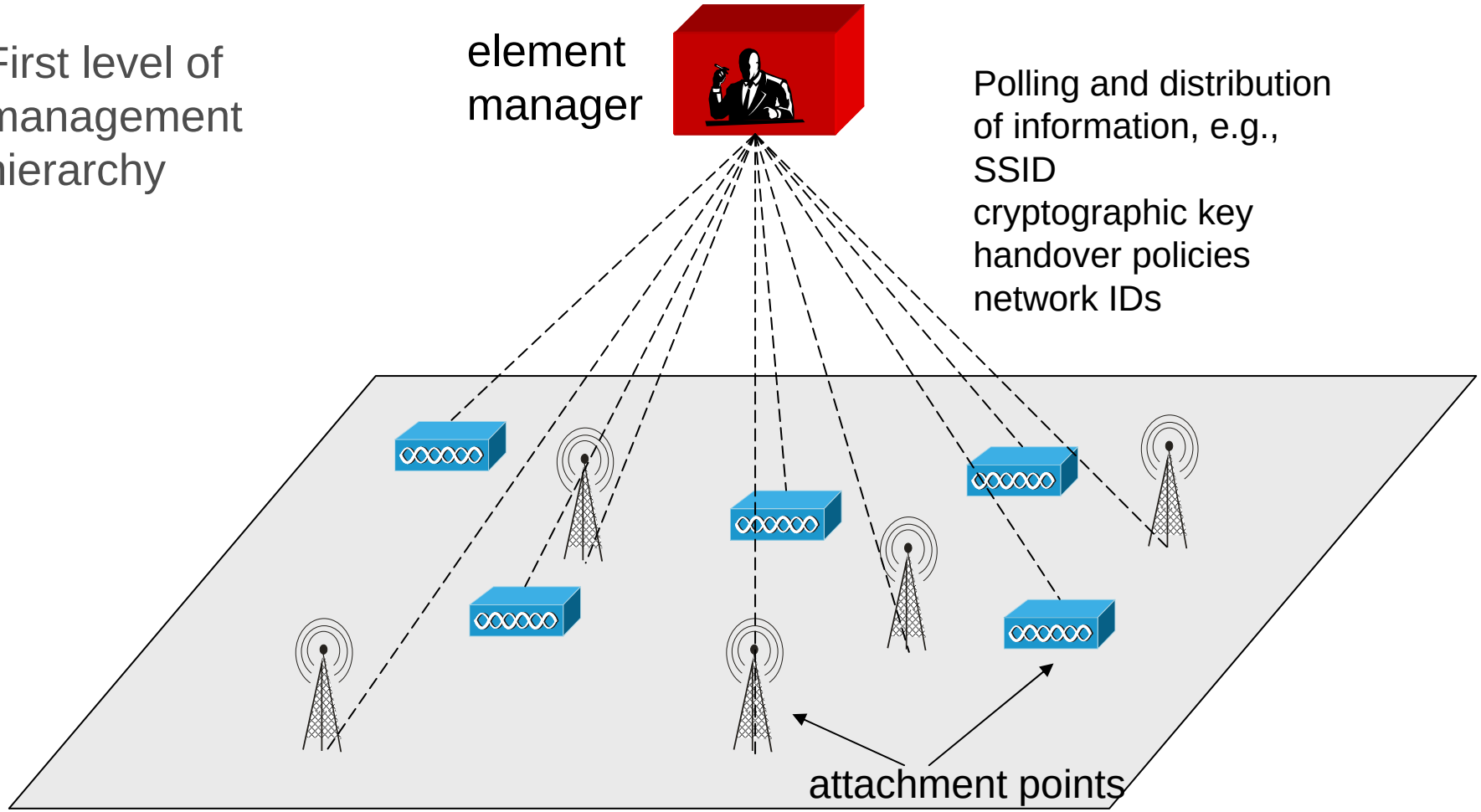
University of Genova, D.I.S.T., Department of Communications, Computer and Systems Science: *Prof. Dr. F. Davoli, Luca Caviglione, Marco Perrando*

Content

- Introduction and Problem description
- The ECAP architecture
- Simulation results
- Conclusion

Introduction: Network Management

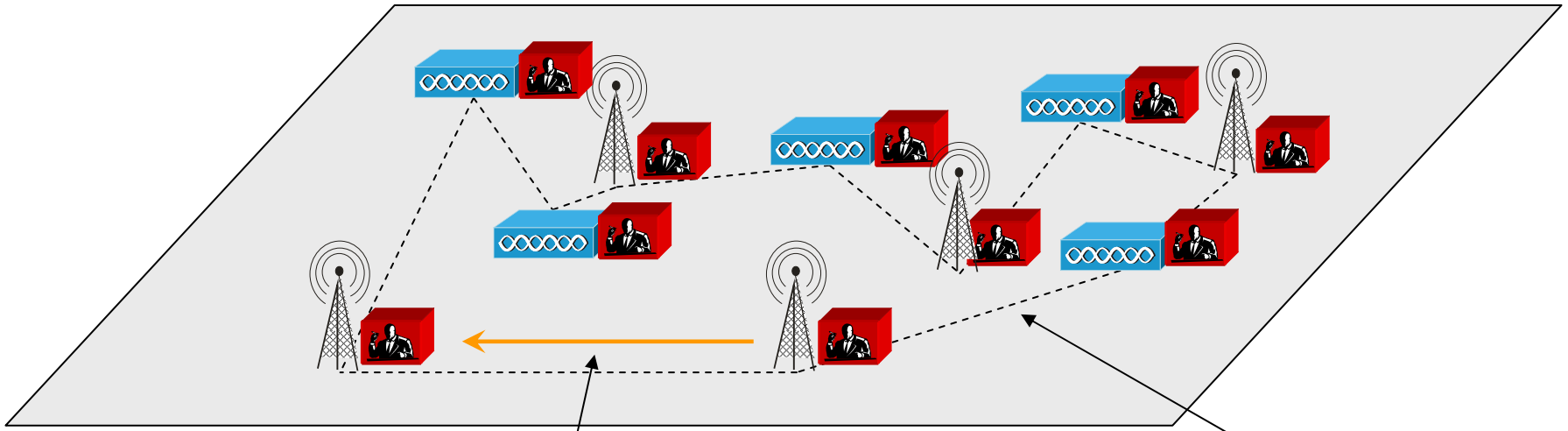
First level of management hierarchy



Problem formulation

- Configuration information has to be distributed to suitable nodes (i.e., cells that overlap the local cell)
- These neighboring cells/nodes have to be identified
- Large effort in heterogeneous networks with many small cells
- System must be flexible to react on changes in the network topology

Distribution of configuration functions



exchange of configuration information (e.g. network IDs)

neighborhood relationship (overlay connection)

Why P2P?

- Scalability
  - Access network is expected to grow
- Self-organization: new nodes/attachment points are easily adapted into the system without manual interference
  - Allows for easy expansion of the system
- Heterogeneous nodes are supported
  - Future technologies can be added
- Failure of some nodes do not impair the whole system (no central point of failure)

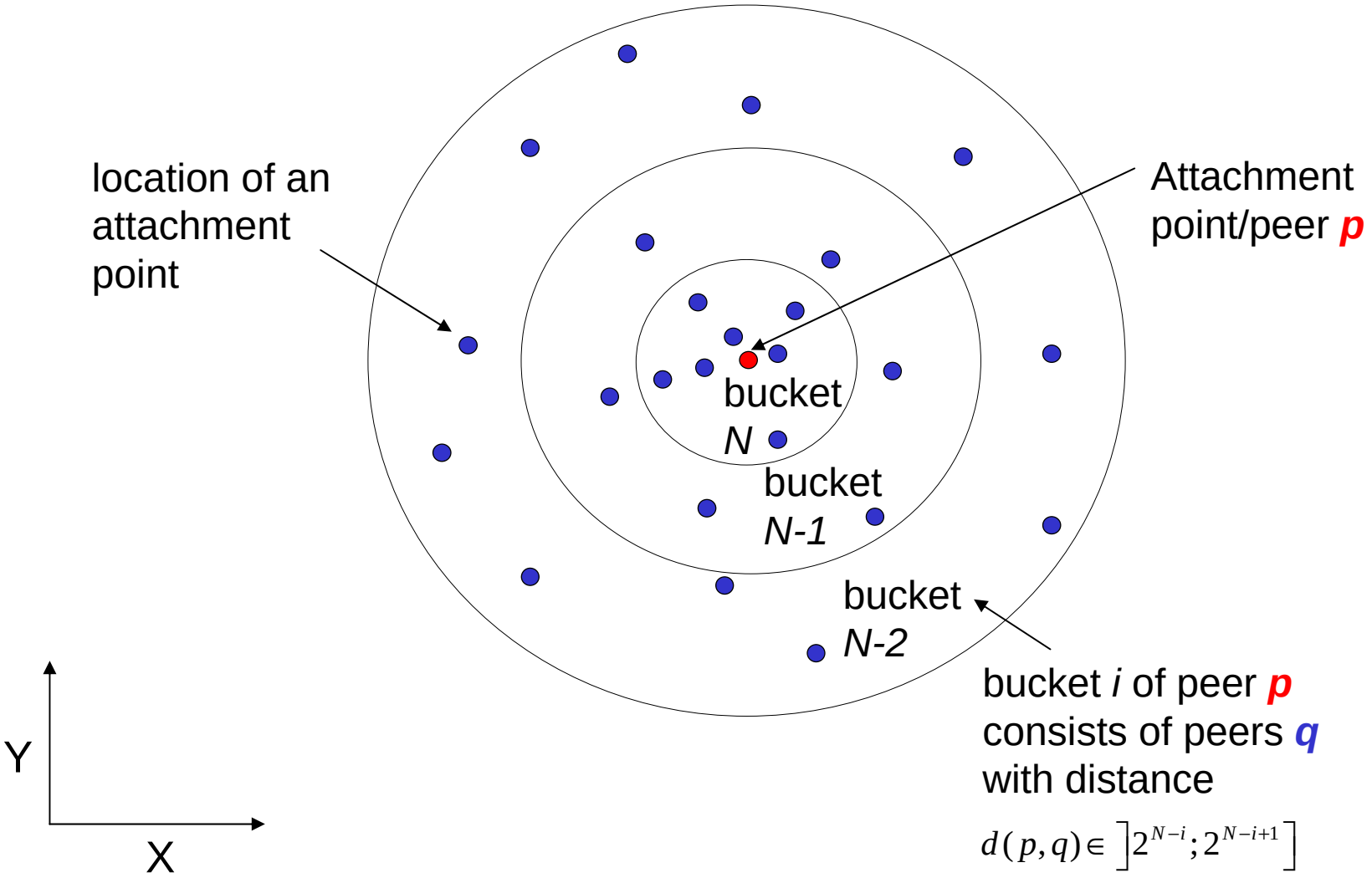
The ECAP architecture

- ECAP: easy configuration of attachment points
- Each attachment point (nodeB, WLAN AP, etc.) is a node in a peer-to-peer (P2P) overlay network
- The overlay is used by each peer to determine its physical neighbors and to enable communication
- With this infrastructure, configuration tasks like the establishment of handover connections can be automated
- Additionally, the network can be used to store network management information in a distributed fashion

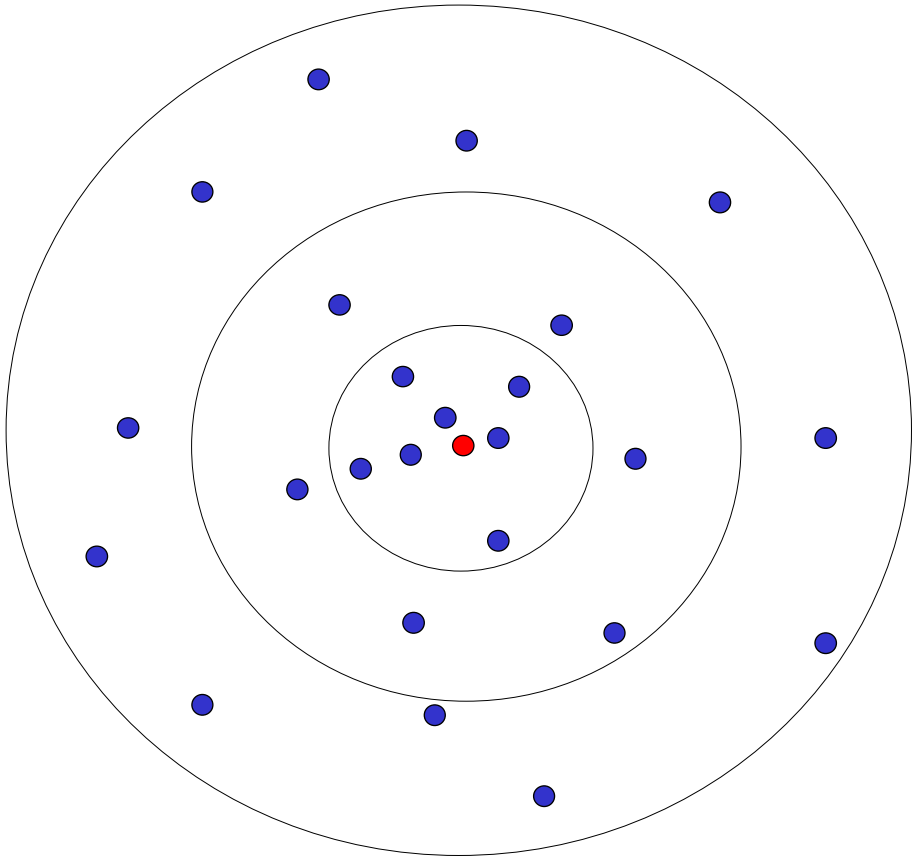
Architectural details

- Kademlia is used as a basic algorithm
- To achieve adaptation in the required sense (automatic detection of close nodes), a spatial metric is used
- Coordinates (known e.g. via GPS) are used as node IDs
- Distance in the overlay is the Euclidean distance
- Symmetry of the metric is conserved

Spatial metric



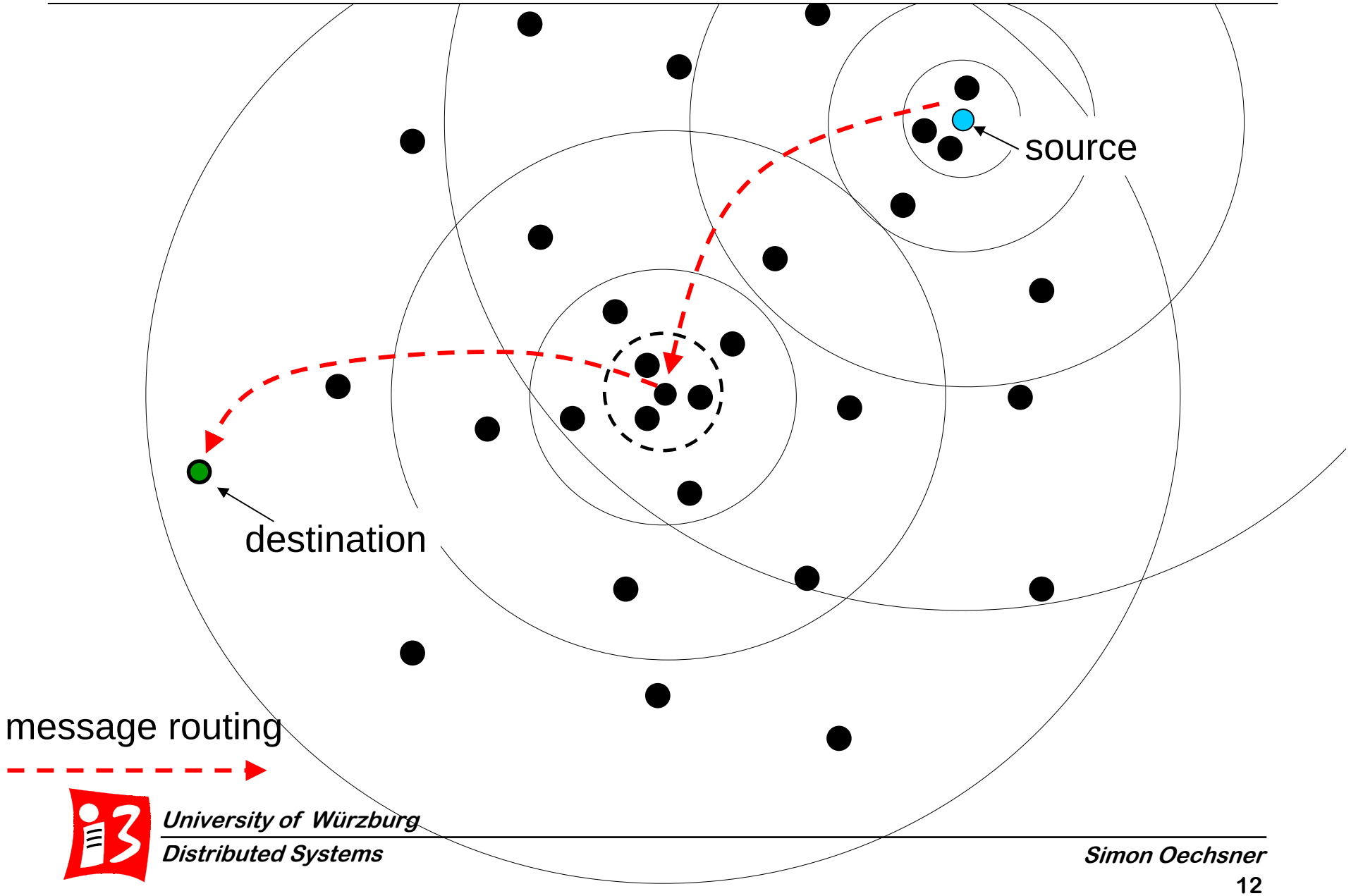
Finding neighbors



Upon join, the k closest nodes are known. These nodes are also the best candidates for neighbors.

After a longer time in the network, more distant nodes are put into the buckets. More nodes are known in closer areas than in distant ones.

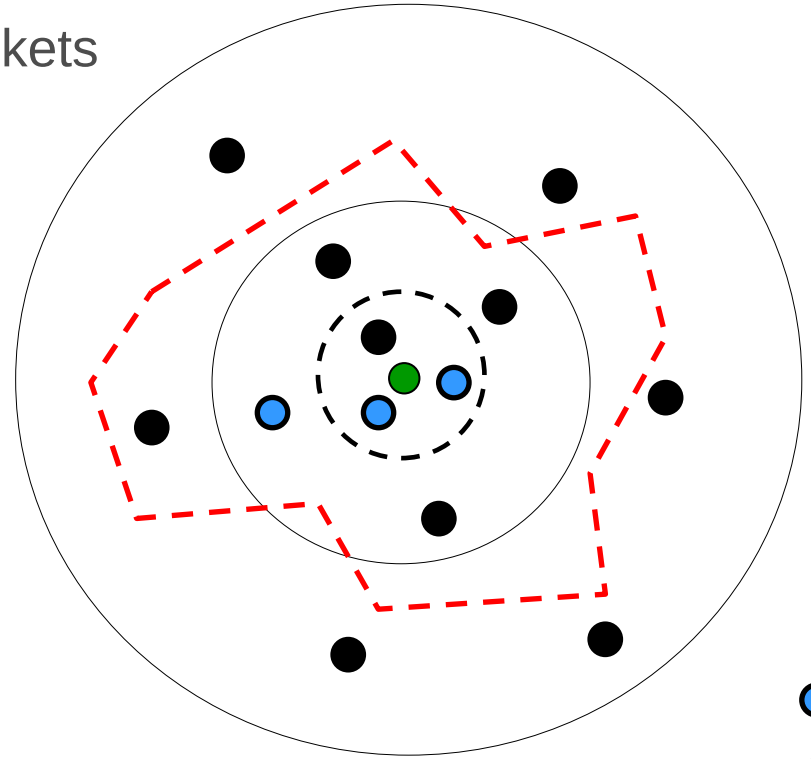
Routing



Range queries

- Aim: get all nodes in a certain area

Step 1: All nodes in buckets that lie in the specified area are asked



Step 2: All new nodes are asked until no new nodes are found

Known nodes

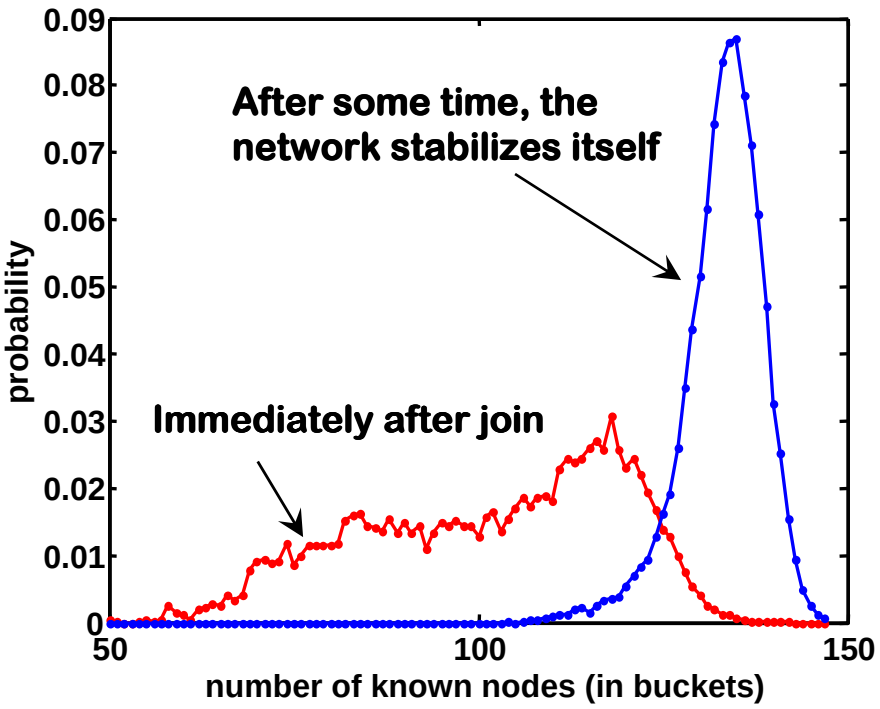
asked nodes

Document storage

- Additional to the establishment of neighbor relationships, network management documents can be stored in the network
  - P2P allows for redundant storing
- Each document also gets a two-dimensional ID, with each dimension carrying different types of information
  - e.g., IP of the responsible node and type of information
- Search for documents also accelerates information dissemination
  - Kademlia uses information contained in queries to update its buckets

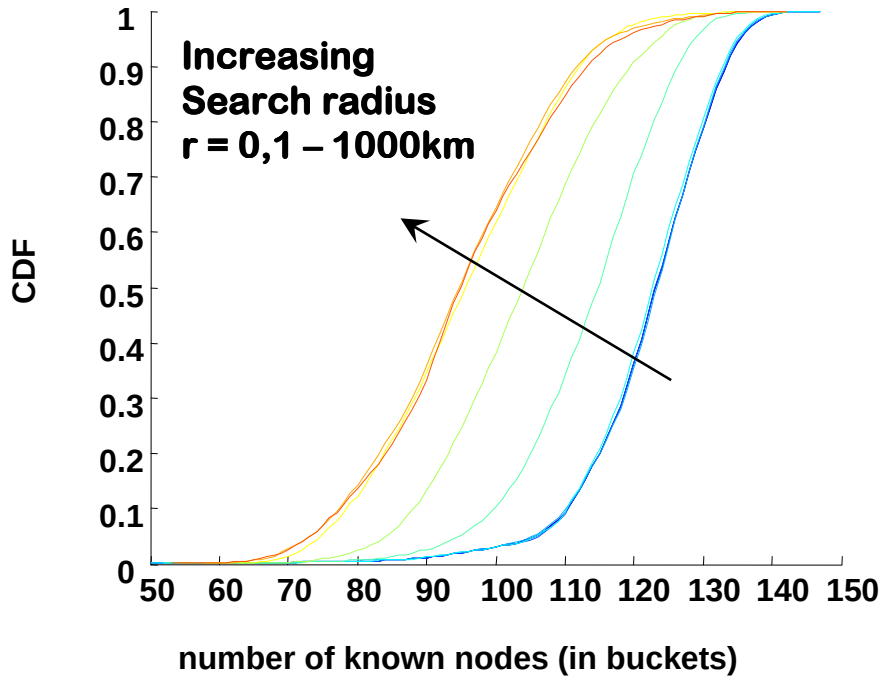
Results

- Network organizes itself
- A high number of known nodes implies a high number of known neighbors
- The exact time needed for stabilization depends on a number of parameters (e.g., network size)
- Different methods for neighborhood detection have been tested



Impact of search radius

- Manual filling of routing tables by periodic search
- Search radius below 10km and above 200km has no significant effect
- Smaller search radius leads to better knowledge, due to symmetry of the metric and a larger portion of the routing table that is reserved for closer nodes



Conclusions

- Solution for heterogeneous network management
  - It reduces configuration efforts
  - Information about the network is stored in a redundant fashion
- Highest reduction is achieved for heavily heterogeneous networks
  - Usage of P2P technology allows for incorporation of different access technologies
- Flexibility and adaptivity for changing network structures
- Outlook: churn studies, search methods, …

Thank You

Q&A