Mobile Adventure

Operator-driven Peer-to-Peer Service Platform for Mobile Environments

Joint work with
Zoran Despotovic, Maximilian Michel, Jörg Widmer, Qing Wei (DoCoMo EU-Labs),
Norihiro Ishikawa, Takeshi Kato, Tomoyoki Osano (NTT DoCoMo)
Jörg Eberspächer, Stefan Zöls and Quirin Hofstätter (TU Munich),
Jae Woo Lee, Henning Schulzrinne (Columbia Univ.),
Wojciech Galuba, K. Aberer (EPFL)
funded by NTT DoCoMo

Wolfgang Kellerer
DoCoMo Euro-Labs, Germany

DoCoMo Communications Europe GmbH
Landsberger Str. 312
80687 Munich Germany

Motivation

- **Peer-to-Peer (P2P)** systems and applications …

… **challenging** traditional fixed and mobile operators

- Is this **lost ground** or can we make use of P2P technologies in a favorable way?
- Does P2P **open a new opportunity** for service provisioning? A new service platform paradigm?
- **Are current technologies applicable** for *mobile environments*?

Outline

- Operator driven P2P service platform
  - Benefits
  - *Mobile environments?*
  - Requirements
- Platform architecture
- Development of individual components
  - Core P2P services
  - Application specific P2P services
- Testbed and P2P applications

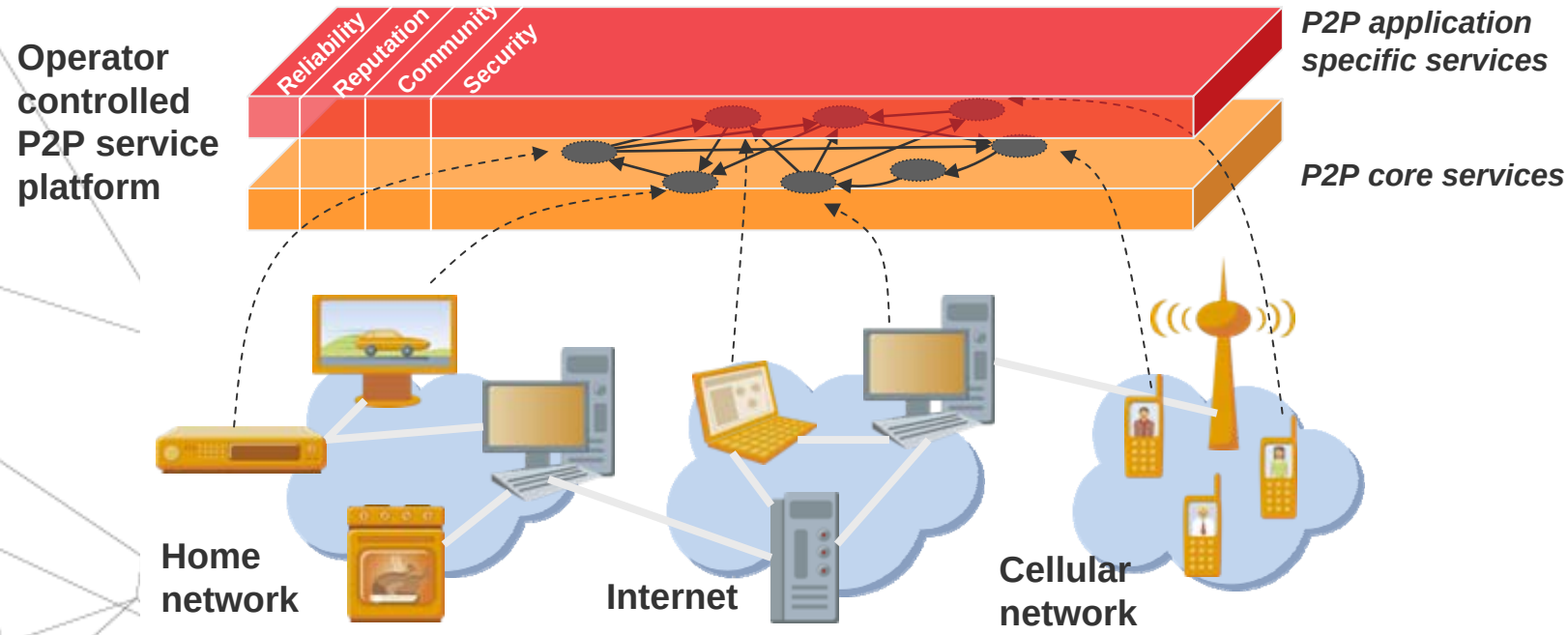
P2P - potential benefits

- Infrastructure cost saving
  - through relying on existing infrastructure (e.g., the equipment of users)
  - with high availability and scalability
    - Example: Subscriber management (VoP2P)

- New business opportunities and extended service portfolio
  - Extension of the service coverage to ubiquitous environments (independent overlay)
    - Example: Controlling home appliances
  - Services provided by users
    - Example: Blogging, info sharing
  - Spontaneous emergence of a service overlay
    - Example: Community services

Objective:
Operator-driven P2P service platform

- Develop building blocks for an operator-grade service platform based on P2P technology for low cost and rapid service provisioning



- and for any kind of user access incl. mobile

P2P - definitions

- Peer-to-Peer (P2P) networks are
  - self-organizing, distributed systems
  - realized as application layer overlay networks
  - objective: lookup and sharing of resources
- **Mobile** Peer-to-Peer systems involve mobile communication systems (at least one hop wireless): GSM, GPRS, 3G, HSDPA, Bluetooth, phone, laptop, PDA, and also DSL, PC,...

➔ Mobile P2P (here) = **P2P in heterogeneous environments**

- BUT: P2P was not designed for heterogeneity

[Kellerer, etal. in Steinmetz, Wehrle (Hrsg.), LNCS 3485]

P2P platform requirements (1)

Mobility, heterogeneity →

- Reduce the P2P lookup traffic overhead as much as possible, in order to overcome low transmission data rates of mobile devices
- Address high churn rates (causing maintenance traffic) due to frequent joins and leaves of nodes
- Considering limited resources of mobile devices addressing the heterogeneity of nodes and their distinct device capabilities

[Kellerer, A.D. Joseph, Dagstuhl 2006]

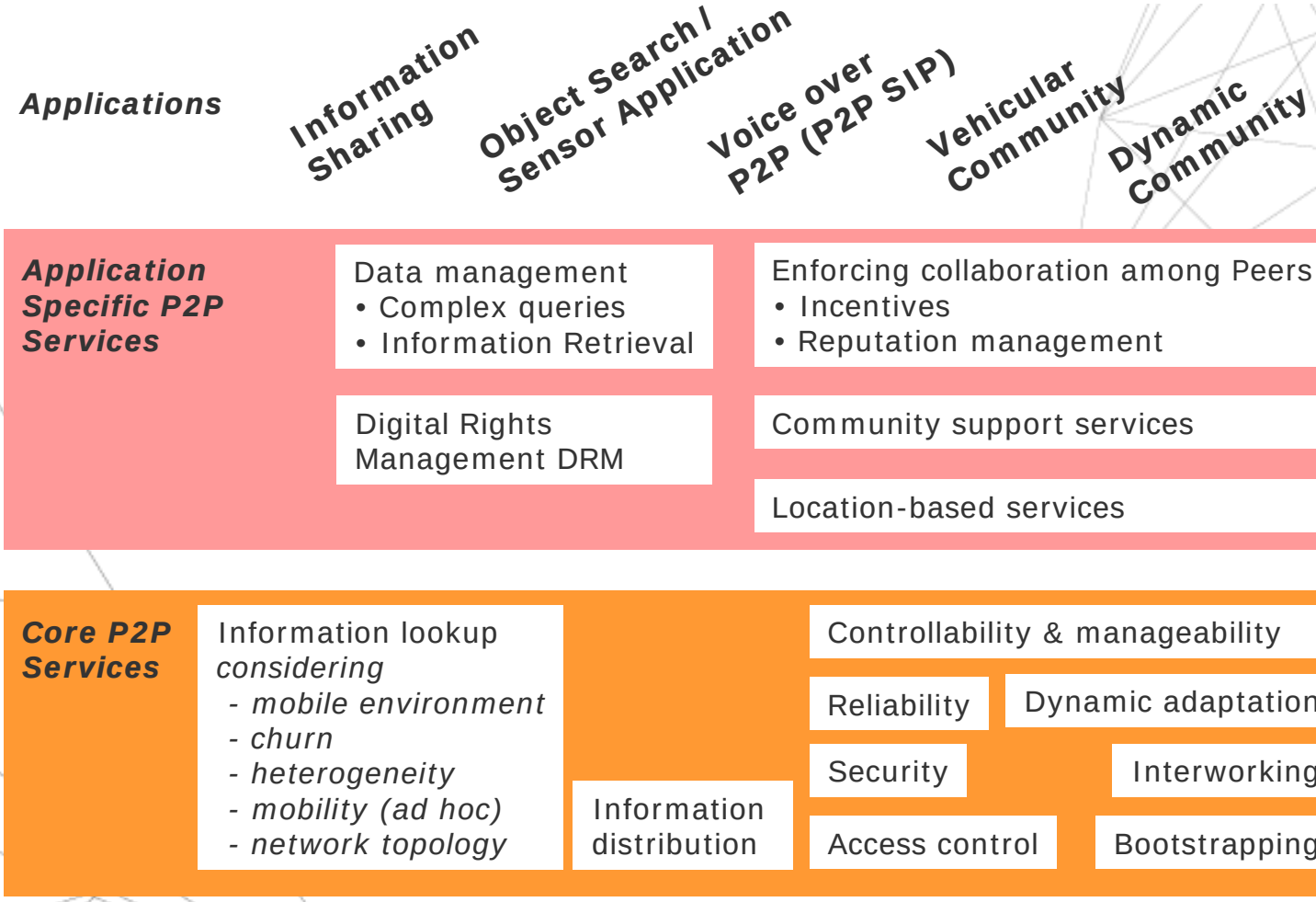
P2P platform requirements (2)

Operator driven →

- Guarantee reliability
  - E.g., "99.999%" availability
- Support system management/controllability
  - Monitoring the network operation and collecting (assessing) all relevant parameters: Network size, session times, etc.
  - Tune appropriate parameters to provide satisfactory application operation
- Provide trust and incentive models to support users' willingness to comply to protocol
- Security, interoperability, access control, …

[Kellerer, etal., IEEE SPMS/SAINT 2007]

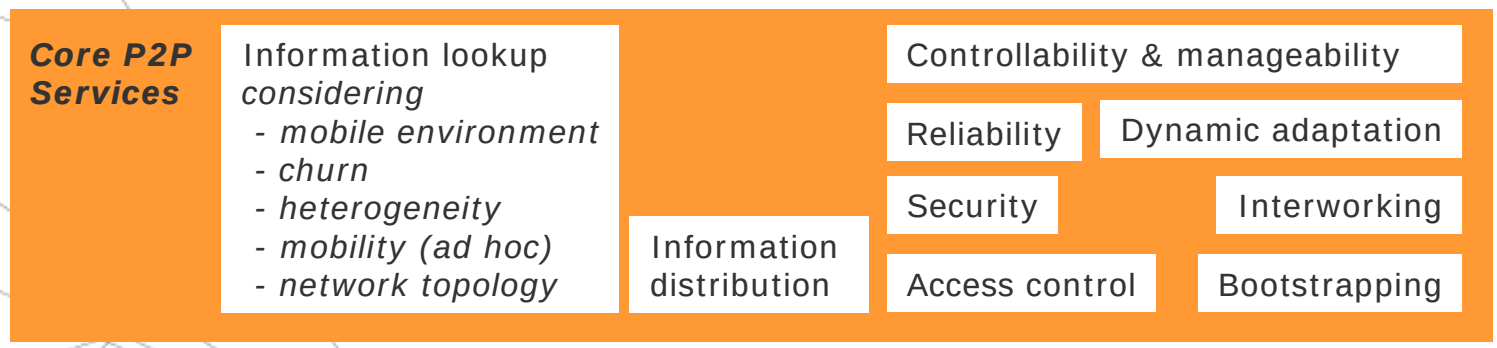
P2P service platform architecture



[Kellerer, etal., IEEE SPMS/SAINT 2007]

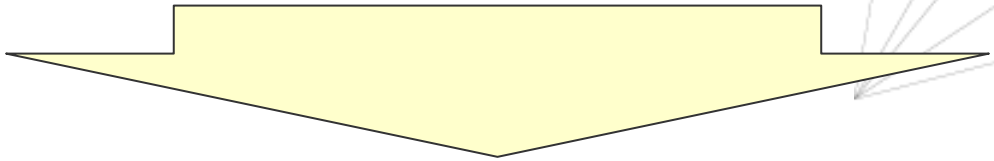
Core P2P Services

- Efficient lookup in heterogeneous (mobile) environments:
  Chordella hierachical P2P Overlay
- Controllability
- Bootstrapping



Hierarchical P2P

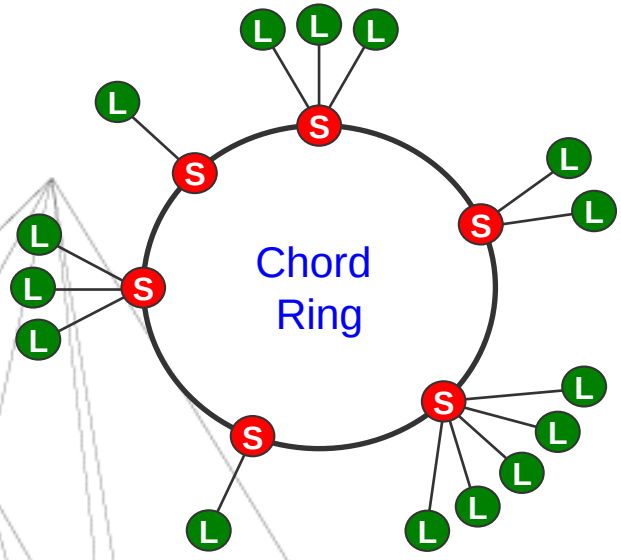
- Objective: efficient lookup of resources in heterogeneous networks and through diverse devices



- Basic concept: structured P2P
  → reduced lookup traffic
- Heterogeneity: hierarchical architecture

[Kellerer, etal., Elsevier AEÜ 2006]

Our solution: Chordella



Chordella

S: Superpeer

L: Leafpeer

- Hierarchical P2P Overlay
  - Superpeers
    - Structured P2P (we use Chord)
    - Routing of all lookup requests
  - Leafpeers
    - Devices with limuted resources interfacinf to a superpeer
    - No routing
- [Ganesan, ICDS04]: hierarchical Chord adapting to network topology
- [Garces-Erice, Biersack, Euro-Par03]: reducing the lookup path length
- Chordella:
  Total cost optimized design

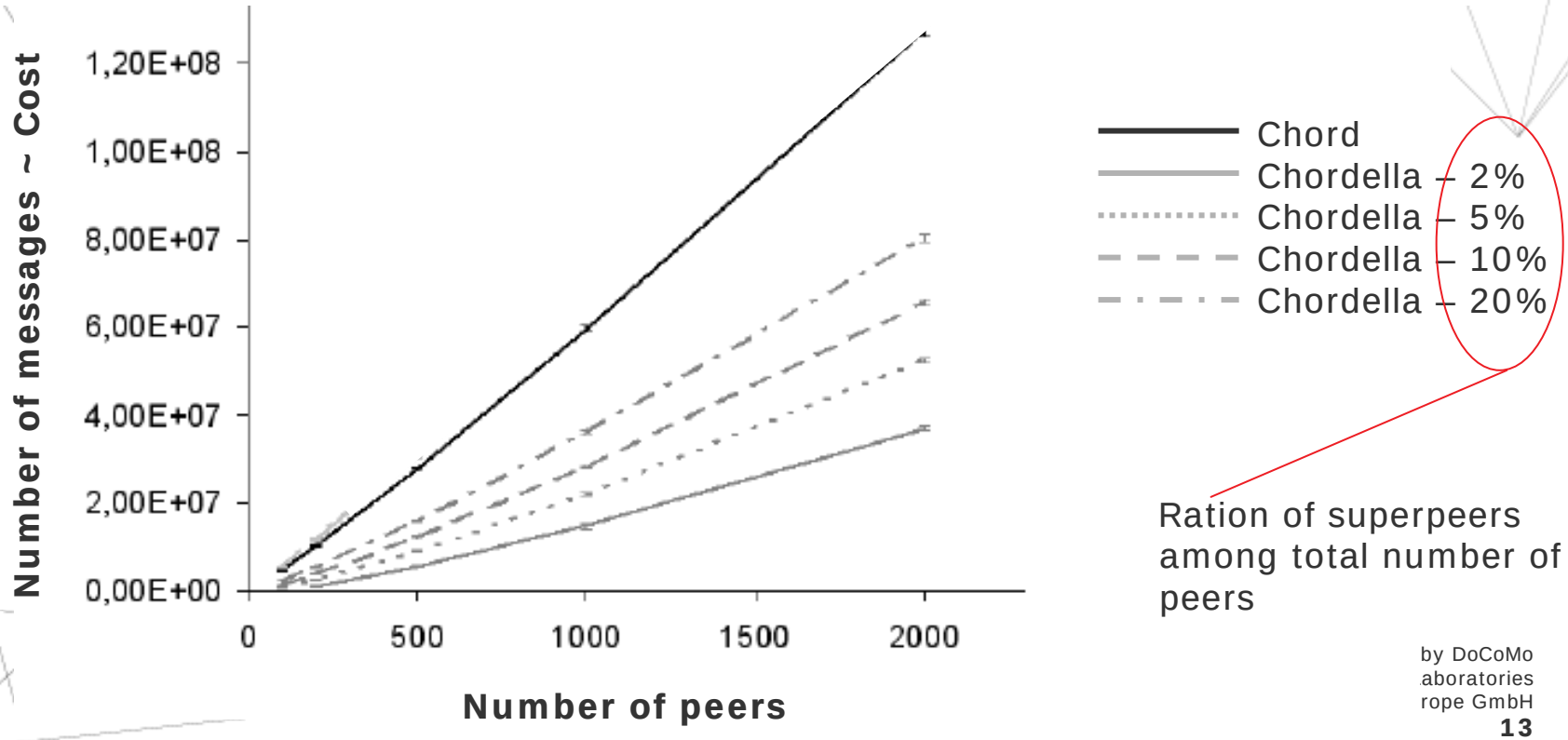
[Zöls, Kellerer, Despotovic, IEEE P2P 2006]

Evaluation

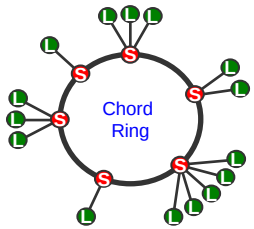
5 peer classes with different data rates, stability, shared objects,...

→ Improved cost compared to Chord

→Variation with the number of superpeers



Looking for optimal design
Cost-based analysis of Chordella

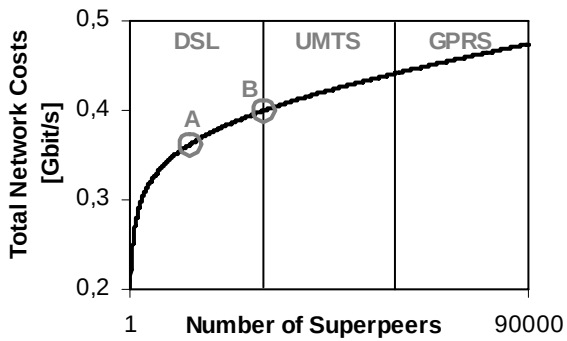


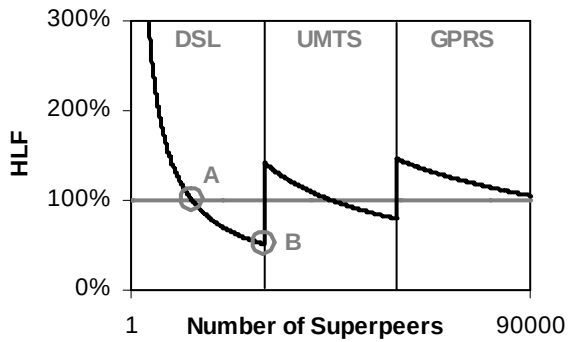
Determine the optimal superpeer ratio

- **Total cost**: (Cost= number of messages)
  C_T = {$Lookup_S$, $Lookup_L$, Ping, Stabilize, Fixfingers, Republish}
  as a function of timers, number of peers, objects,...
- **Cost per superpeer:**
  C_{Si} = {$Lookup_{Si}$, $Ping_{Si}$, $Stabilize_{Si}$, $Fixfingers_{Si}$, $Republish_{Si}$}
- Definition:
  Highest Load Factor (HLF): max{C_{Si}}/Limit{C_{Si}}

Example:

	DSL	UMTS	GPRS
Suchrate	1 / 60s	1 / 30s	1 / 30s
Objekte	500	100	50
Upstream [kbit/s]	256	92	50



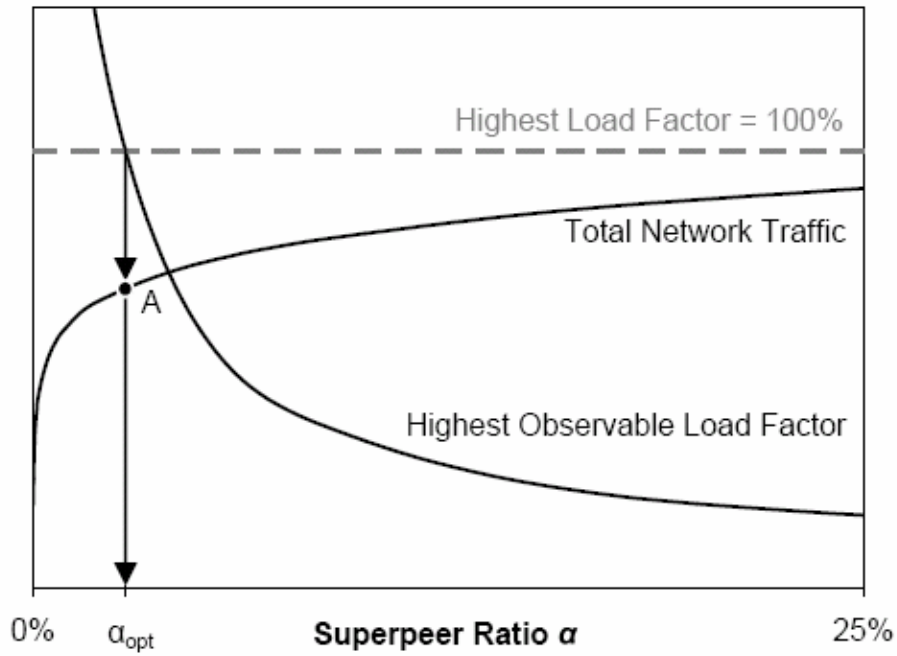


Configuration of hierarchical P2P: Determine the optimal ratio α

- α : Super Peer Ratio

$$\alpha = \frac{\#\ \text{superpeers}}{\#\ \text{peers}}$$

- α_{OPT} : optimal ratio
  Superpeer ratio α with minimum cost, while no superpeer is overloaded (HLF $\leq$ 100%)

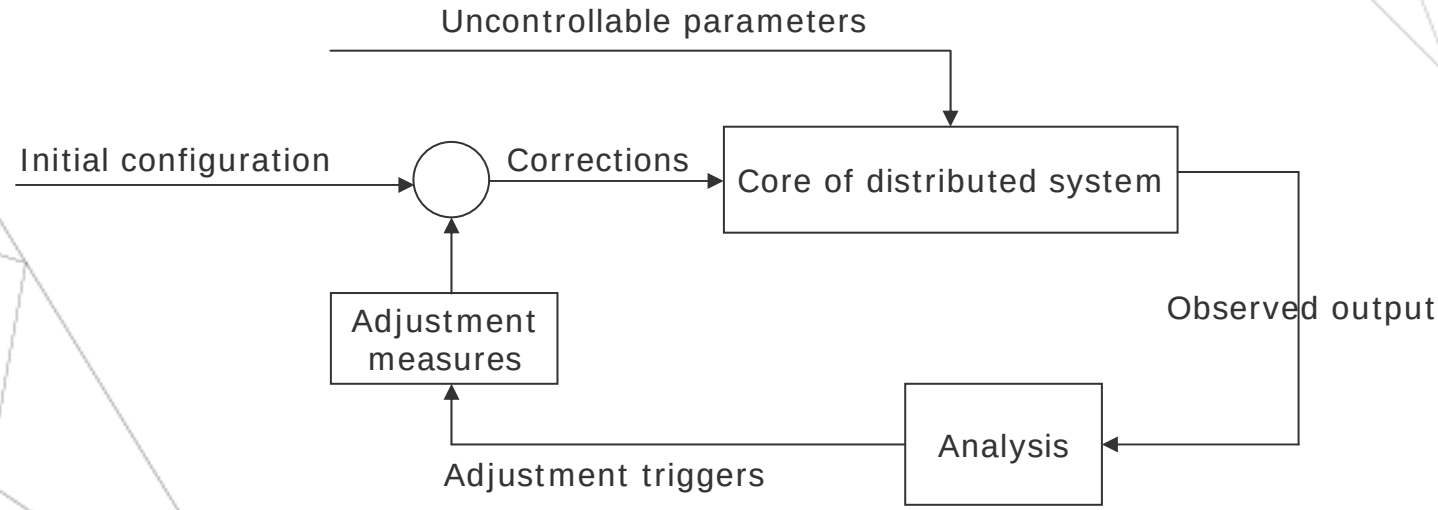


$$\alpha_{OPT} = \underset{\alpha \in [\alpha_{min};1]}{\text{argmin}}\ C_T(\alpha)$$

$$\alpha_{min} = \min\left(\alpha \in (0;1] \mid \max\left(HLF_{Si}(\alpha)\right) \leq 100\%\right)$$

Controllable P2P system

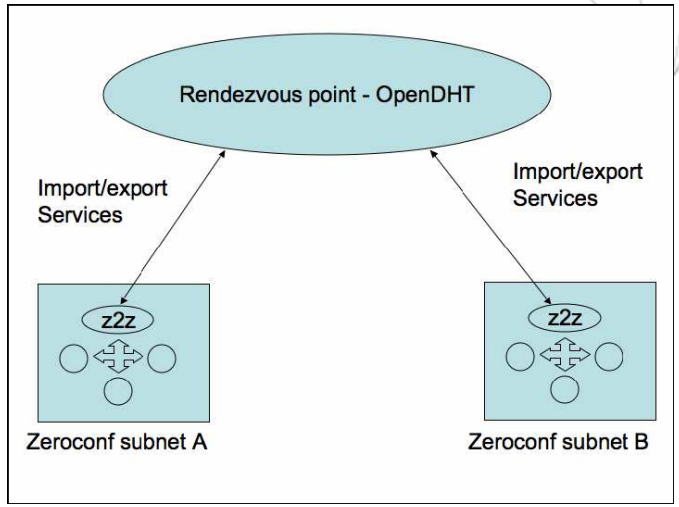
- **Monitor** the state of the network and take appropriate actions to prevent undesirable changes by **tuning** appropriate parameters
- Distributed feedback control loop mechanism



- Example: optimal selection of the superpeers ratio

Bootstrapping

- Services in networks convened for short time periods and then disbanded again
  - large-scale events, disaster recovery, during meetings …
- Initial problem: discovery of other potential peers
- Solution: z2z - Zeroconf-to-Zeroconf gateway
  - Based on Apple's imple-mentation of Zeroconf [RFC3924]
  - Discovers peers on the local link
  - z2z bridges multiple separate Zeroconf networks using OpenDHT



[Lee, Schulzrinne, Kellerer, Despotovic, 2006]

Application specific P2P services

Example:

- Reputation Management

Application Specific P2P Services	Data management • Complex queries • Information Retrieval	Enforcing collaboration among Peers • Incentives • Reputation management
	Digital Rights Management DRM	Community support services
		Location-based services

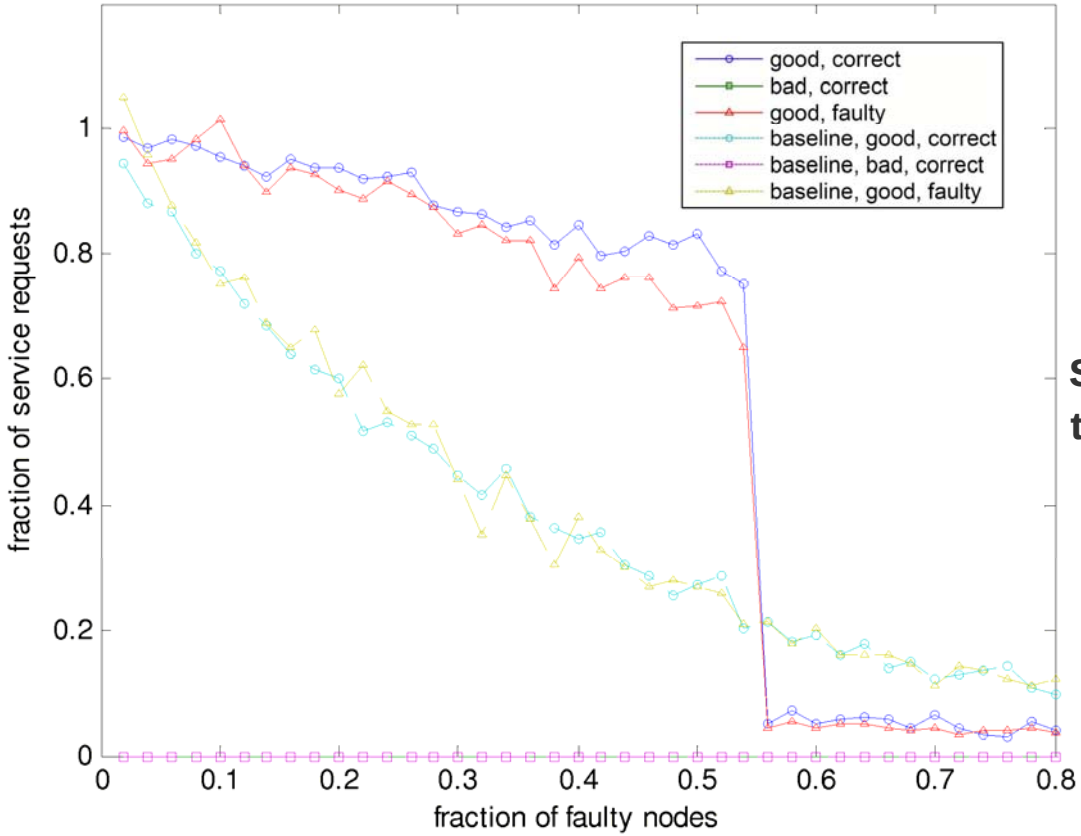
P2P reputation management

- Users can be:
  - Selfish – being clients but not servers
    - Problem of **cooperation**
  - Malicious – trying to subvert the network
    - **P2P protocol security** problem
  - Peers can also fail independently of user actions
    - **Fault tolerance** problem
- We handle all these problems in a single framework:
  - Take an existing system with recursively routed service requests and add feedback messages → reputation
  - Failures are reported to the failure predictor
  - The predictions of the failure predictor are used to avoid faulty routes
  - Reciprocation is used to punish free riders and other defectors

[Aberer, Despotovic, Galuba, Kellerer, 2006]

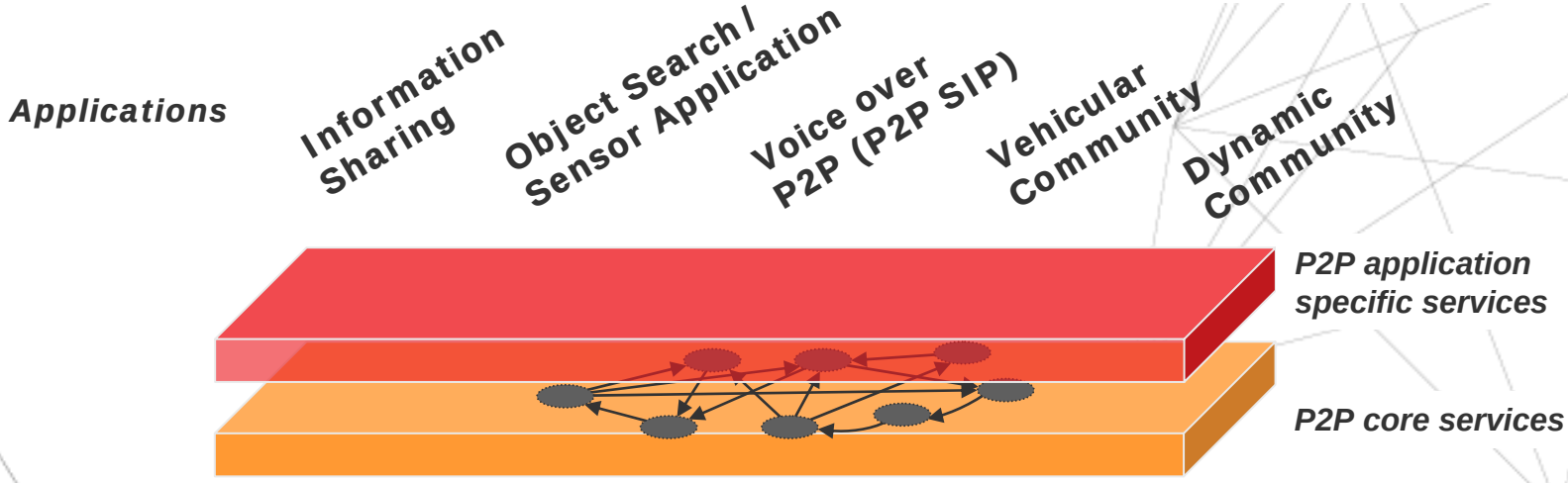
Simulations sample

- DEFECTOR nodes:
  - Always provide a bad service
  - Do not reciprocate
  - Learn to choose next hops that don't reciprocate



Services replicated to 4 nodes on average

Applications

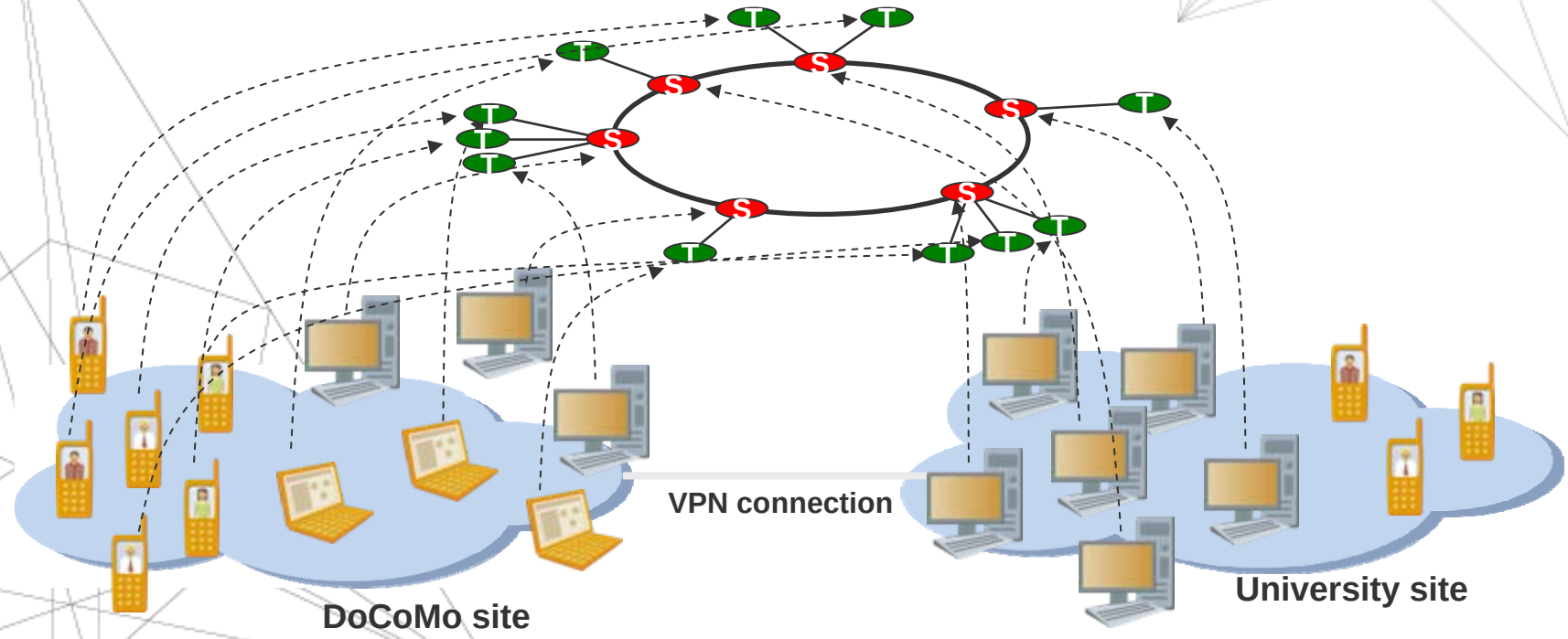


Current implementations

- Info sharing
- Sensor network data management
  → person tracking
- Dynamic services

Chordella testbed

- Current layout
  - 6 Linux PCs and Laptops (Debian)
  - 6 *cerfcube* (Embedded Linux)
  - 8 Nokia Mobile Phones (Symbian Series 60)

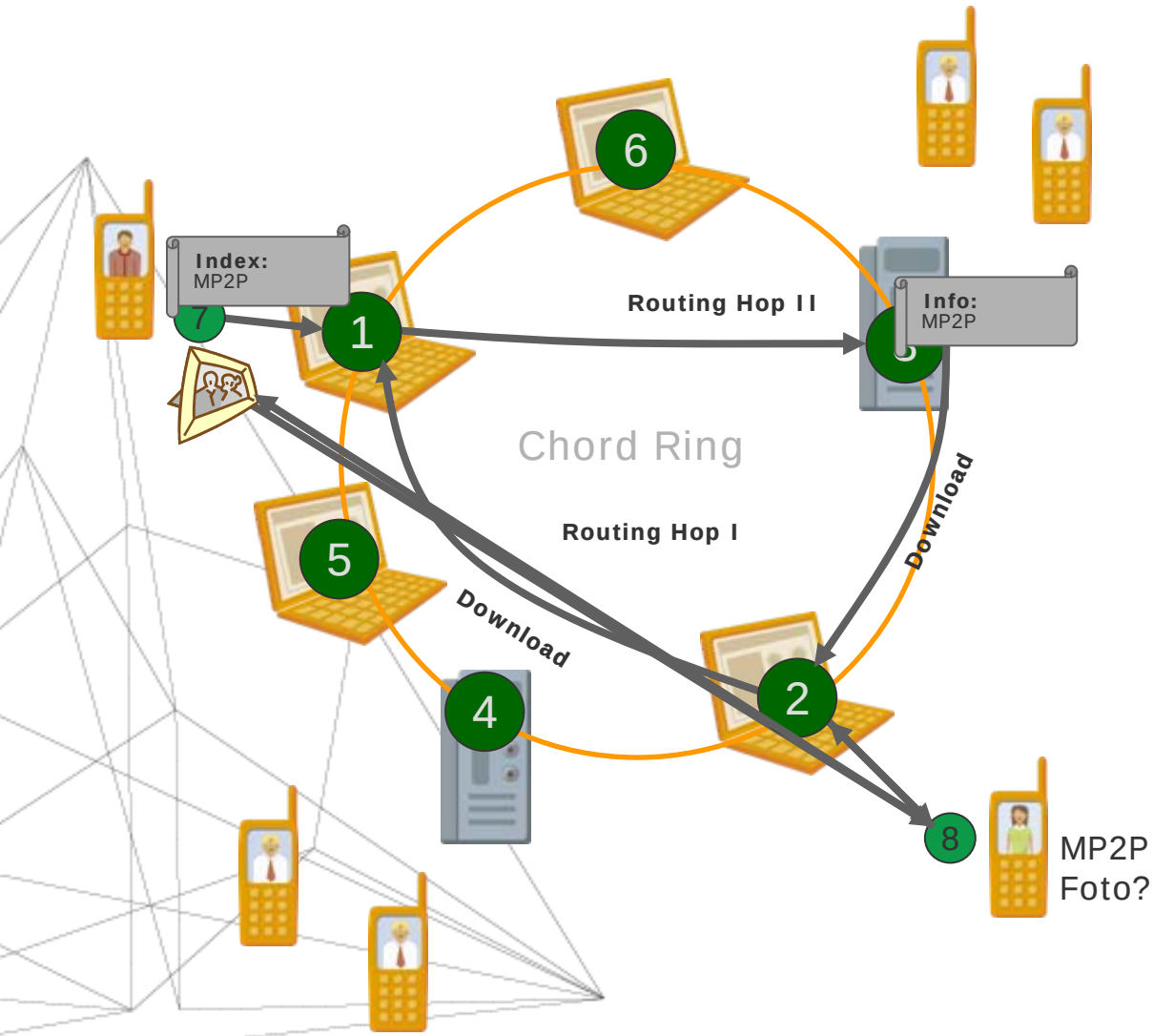


Mobile P2P Information Sharing

- Users create content on their mobile phones (Blog, photos, v-cards, address book,...)
- Users share this information without central server
- Dynamic scalability to avoid uploading not demanded content and replicate demanded content

- Examples
  - Pictures of local attraction
  - Info in discussion group
  - Address book info among corporate users
  - Lecture schedule among students on a campus
  - Social network service: share info among community without infrastructure setup
  - Private diary-like web page

Example: Information sharing



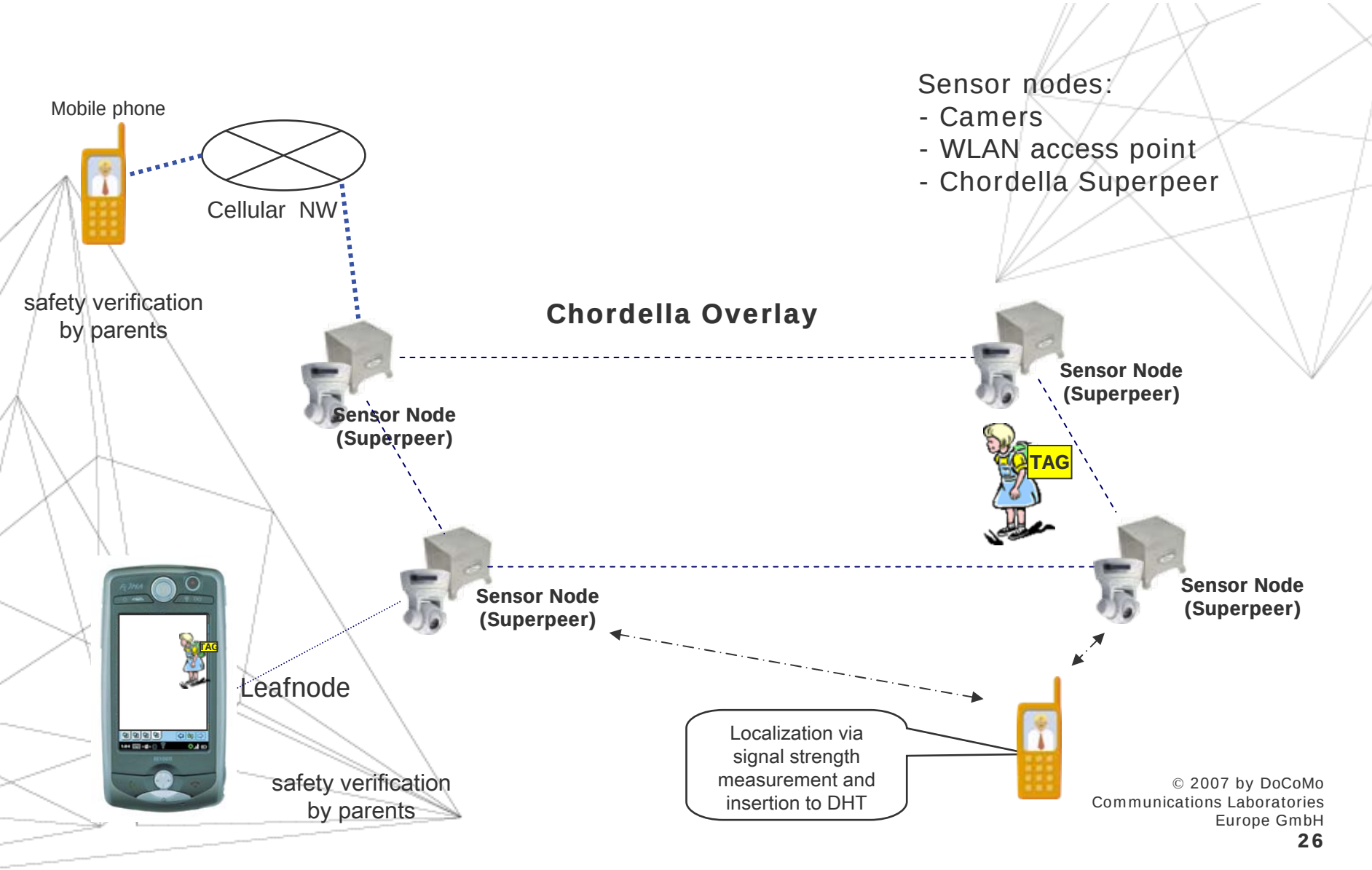
Example: P2P and sensor networks: person tracking

- Determine the location of a person
- Retrieve her/his image from a camera
- Retrieve the movement history

- High dynamicity in request and update rate are not favorable for centralized or flooding based concepts

- Solution:
  - Sensor nodes run a Chordella overlay
  - Mobile phones (leaf peers) act as
    - Clients for monitoring
    - Localization sources

Consistent interplay of localization, sensor data management and queries



Summary

P2P Service Platform

- Architecture to enable quick and easy application development
- Component based architecture
- Core Service: Chordella for heterogeneous environments

- Operator driven
  - Controllability
  - Dynamic tuning of the components
  - Reputation management

Thank You!

Dr.-Ing.

Wolfgang Kellerer

Senior Manager
Ubiquitous Services Platform Group
Future Networking Lab
DoCoMo Euro-Labs

Lecturer
Technische Universität München (TUM)

http://www.wolfgangkellerer.de

DoCoMo Communications Laboratories Europe GmbH
Landsberger Str. 312
80687 München
Tel: +49-89-56824-222
Fax: +49-89-56824-300
Email: kellerer@docomolab-euro.com
http://www.docomoeurolabs.de

References

- W. Kellerer, G. Kunzmann, R. Schollmeier, S. Zöls. *Structured Peer-to-Peer Systems for Telecommunications and Mobile Environments*. International Journal of Electronics and Communications, Elsevier, Vol. 60, Issue 1, January 2006, pp. 25-29.
- W. Kellerer, Z. Despotovic, M. Michel, S. Zoels, Q. Hofstaetter. *Towards a Mobile Peer-to-Peer Service Platform*. 3rd IEEE SPMS workshop in conjunction with IEEE SAINT 2007, Hiroshima, Japan, Jan. 15-19, 2007.
- S. Zoels, Z. Despotovic, W. Kellerer. *Cost-Based Analysis of Hierarchical DHT Design*. In proc. 6th IEEE Intl. Conference on P2P Computing (IEEE P2P 2006), Sept. 6-8, Cambridge, UK.
- S. Zoels, S. Schubert, W. Kellerer, Z. Despotovic. *Content Availability and Signaling Overhead in DHT Systems for Mobile Environments*. PODC 2006, July, 23-26, 2006, Denver, Colorado, US (Poster).
- K. Aberer, Z. Despotovic, W. Galuba, W. Kellerer. *The Complex Facets of Reputation and Trust*. Invited Paper. Intl. Conf. on Computational Intelligence, Dortmund, Germany, Sept. 18-20, 2006.
- S. Zöls, S. Schubert, W. Kellerer, Z. Despotovic. *Hybrid DHT Design for Mobile Environments*. AP2P workshop at AAMAS 2006, Hakodate, Japan, May 9-12, 2006.
- W. Kellerer and A.D. Joseph. *Mobile Peer-to-Peer*. Dagstuhl Seminar Peer-to-Peer Systems and Applications, teamwork on mobile P2P, Dagstuhl, Germany, March 26-29, 2006.
- S. Zöls, M. Eichhorn, A. Tarlano, W. Kellerer. *Content-based Hierarchies in DHT-based Peer-to-Peer Systems*. 2nd IEEE/IPSJ SAINT 2006 workshop SPMS2006, Phoenix, Arizona, USA, Jan. 23-27, 2006.
- W. Kellerer, R. Schollmeier. *Proactive Search Routing for Mobile Peer-to-Peer Networks: Zone-based P2P*. ASWN 2005, Paris, France, June 29 – July 1, 2005.
- S. Zöls, R. Schollmeier, Q. Hofstätter, A. Tarlano, W. Kellerer. *The Impact of Content Distribution on Structured P2P Networks in Mobile Scenarios*. EUNICE 2005, Colmenarejo, Spain, July 6-8, 2005.
- S. Zöls, R. Schollmeier, A. Tarlano, W. Kellerer. *The Hybrid Chord Protocol: A Peer-to-peer Lookup Service for Context-Aware Mobile Applications*. IEEE ICN, Reunion Island, April 2005. LNCS 3421.
- I. Gruber, R. Schollmeier, W. Kellerer. *Performance Evaluation of the Mobile Peer-to-Peer Protocol*. ACM/IEEE Intl. Workshop on Global Peer-to-Peer Computing, Chicago, US, April 19-22, 2004.