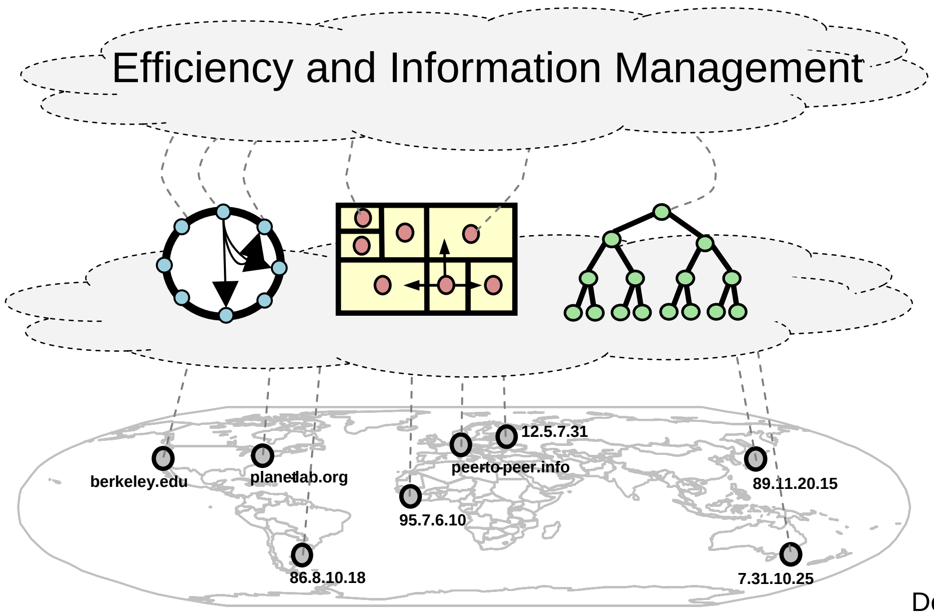
Efficiency and Information Management in Peer-to-Peer Systems

Invited Talk by the EU Initiative EMANICS @
1st EMANICS Workshop on Peer-to-Peer Management
University of Zürich, Switzerland, 3. March 2008



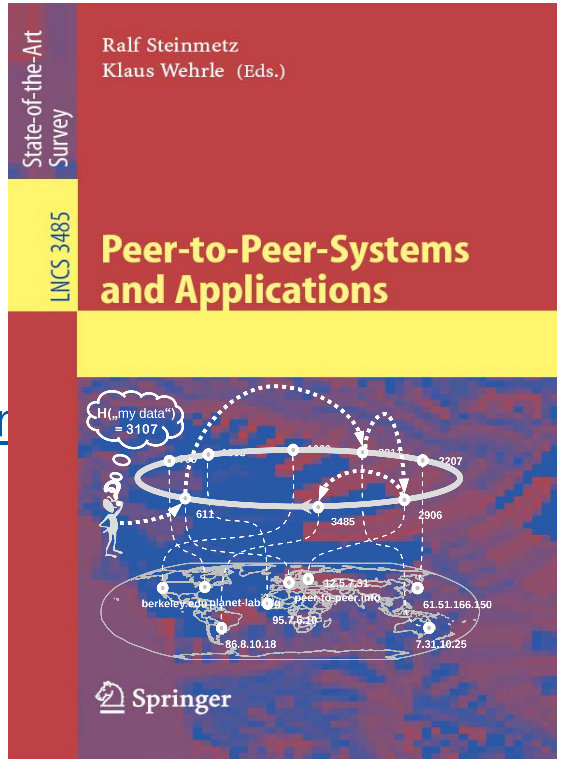
Dipl.-Math. Dipl.-Inform. Kalman Graffi
Prof. Dr.-Ing. **Ralf Steinmetz**

Ralf.Steinmetz@KOM.tu-darmstadt.de

httc –
Hessian Telemedia Technology
Competence-Center e.V - www.httc.de

KOM - Multimedia Communications Lab
Prof. Dr.-Ing. Ralf Steinmetz (director)
Dept. of Electrical Engineering and Information Technology
Dept. of Computer Science (adjunct professor)
TUD – Technische Universität Darmstadt
Merckstr. 25, D-64283 Darmstadt, Germany
Tel.+49 6151 166150, Fax. +49 6151 166152
www.KOM.tu-darmstadt.de

Overview



State-of-the-Art Survey
LNCS 3485
Ralf Steinmetz
Klaus Wehrle (Eds.)
Peer-to-Peer-Systems and Applications
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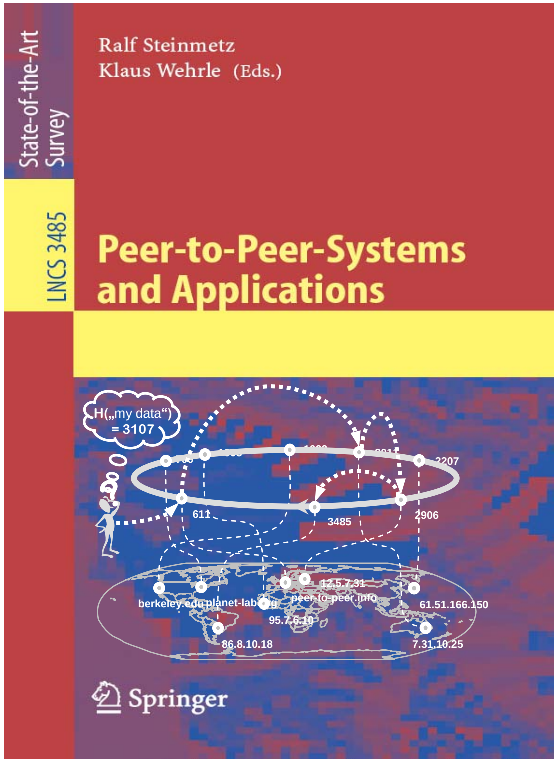
Springer

Overview

http://www.p2p08.org/



1 The Peer-to-Peer Paradigm

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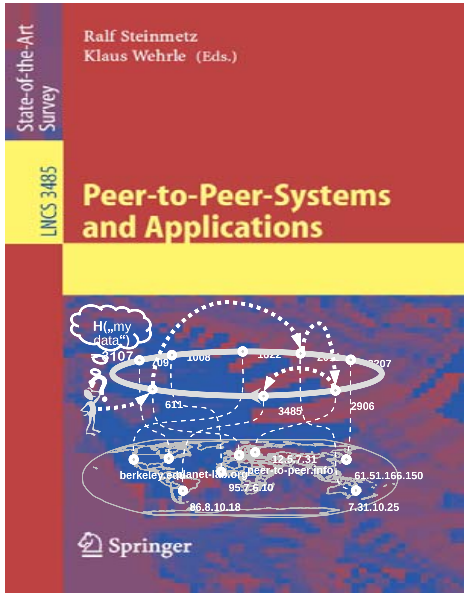
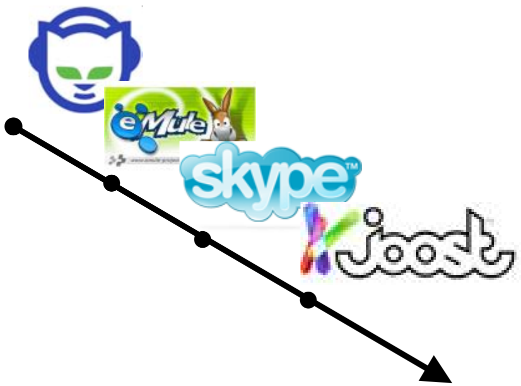
Peer-to-Peer Systems:

- Users of a system provide the infrastructure of the system
- Service is provided from users/peers to users/peers
- Peer-to-Peer overlays:
  - virtual networks, providing new functionality
  - E.g. Distributed Hash Tables, Keyword-based Search



Evolution of applications

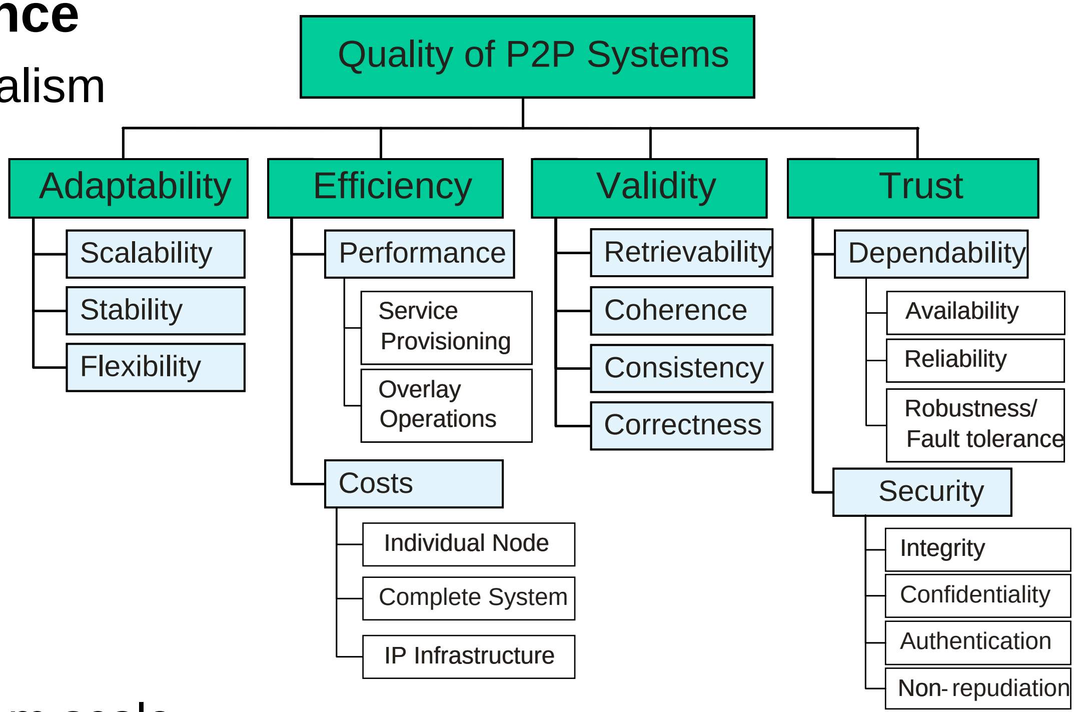
- File sharing:
  - No Quality of Service (QoS) requirements
- Voice over IP
  - Real-time requirements
- Video-on-demand
  - Real-time and bandwidth requirements



1.1 Trends in Peer-to-Peer Research

Quality aspects gain importance

- Reliability: expected professionalism
- Ease of Use:
  Multimedia and interactivity



Critical success factor for

- complex P2P applications
- modular P2P applications

Quality aspects:

- Adaptability – to scenario, system scale
- Validity – of stored data
- Trust – of users and mechanisms
- Efficiency – ratio between performance and costs

1.2 Quality in Peer-to-Peer Systems

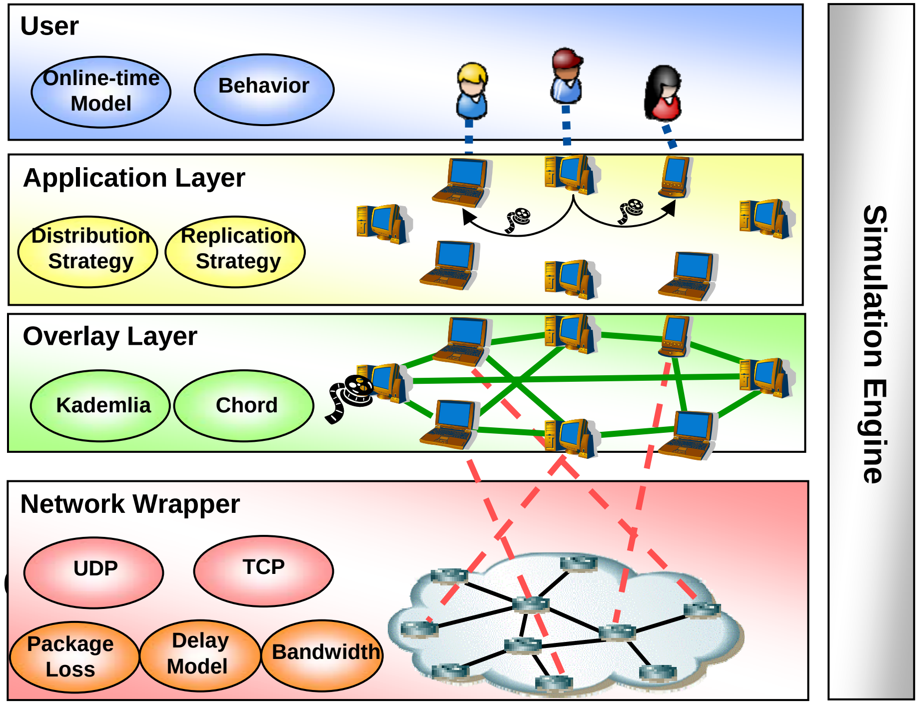
DFG Research Group FOR 733 @ TU Darmstadt

QuaP2P

- “Verbesserung der Qualität von Peer-to-Peer-Systemen durch die systematische Erforschung von Qualitätsmerkmalen und deren wechselseitigen Abhängigkeiten“

Approach

- Evaluation using simulation and prototypes
  - PeerfactSim.KOM → → → → → → →
- Proof-of-Concept of investigated mechanisms using 2 scenarios



Please visit

- www.quap2p.tu-darmstadt.de or www.
- www.peerfactsim.com

→ Visit PeerfactSim.KOM at CeBIT 2008, hall 9, stand C22

1.3 Serious Future Peer-to-Peer Applications

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Future Peer-to-Peer based applications

- Modular, component based composition
  - E.g. FreePastry and/with PAST, Scribe,
  - E.g. POST, SplitStream
- A module has to
  - be highly efficient
  - provide Quality of Service

Application Areas

- To exploit self-organization abilities of P2P

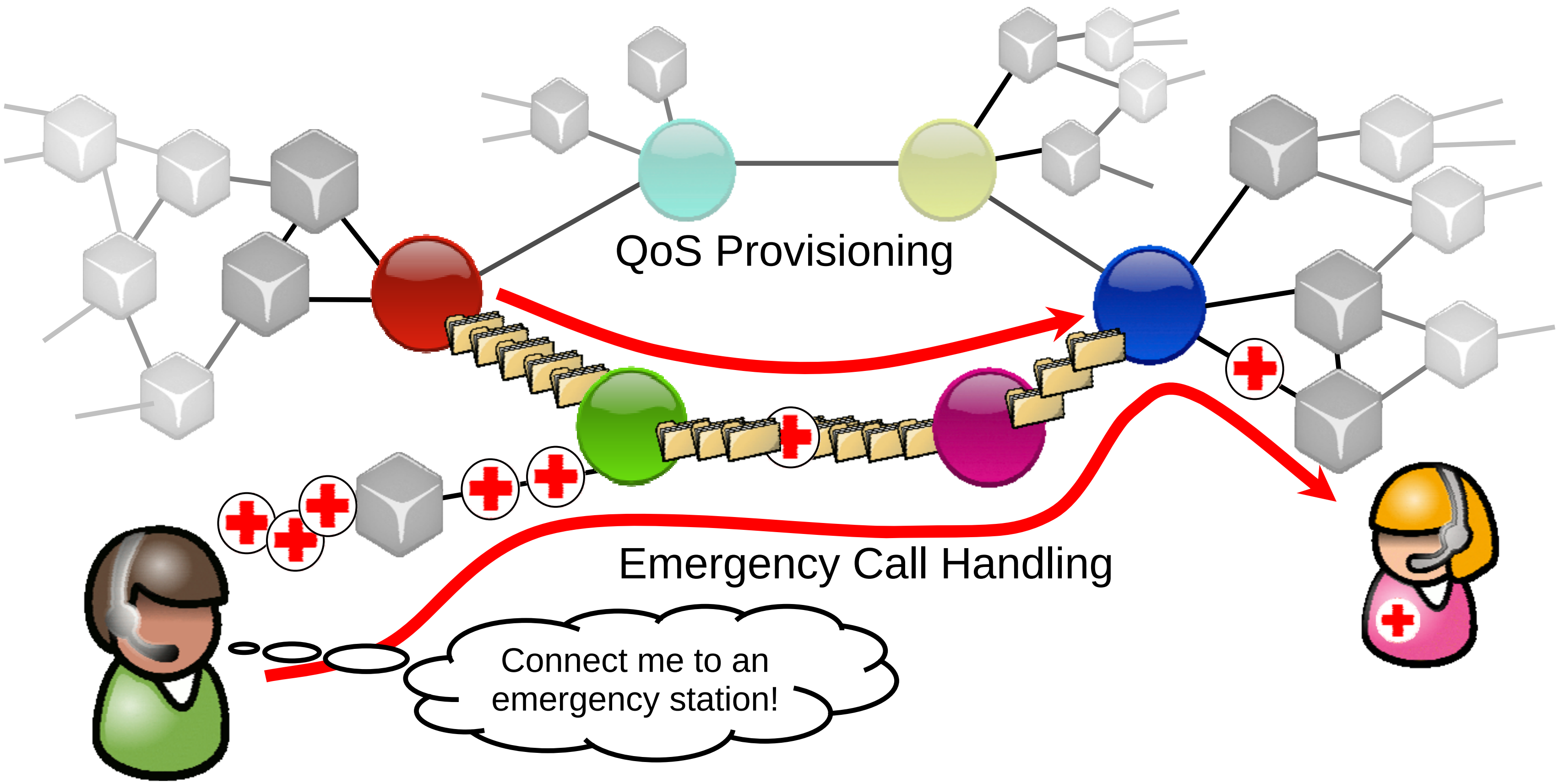
→**Catastrophe scenarios**

  - require robust mechanisms
  - E.g. coping with churn

→Example: Emergency Call Handling

- Hard QoS requirements
- Peer-to-peer mechanisms provide failure-tolerance (and QoS)

2 Towards QoS & Emergency Call Handling



2.1 Serious Application: Emergency Call Handling

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Emergency Call Handling is not supported in VoIP (Skype)

- 2009: mandatory for VoIP providers
- P2P fits: all-IP, scalable,
  - but Quality of Service?

Requirements

1. Location critical service:

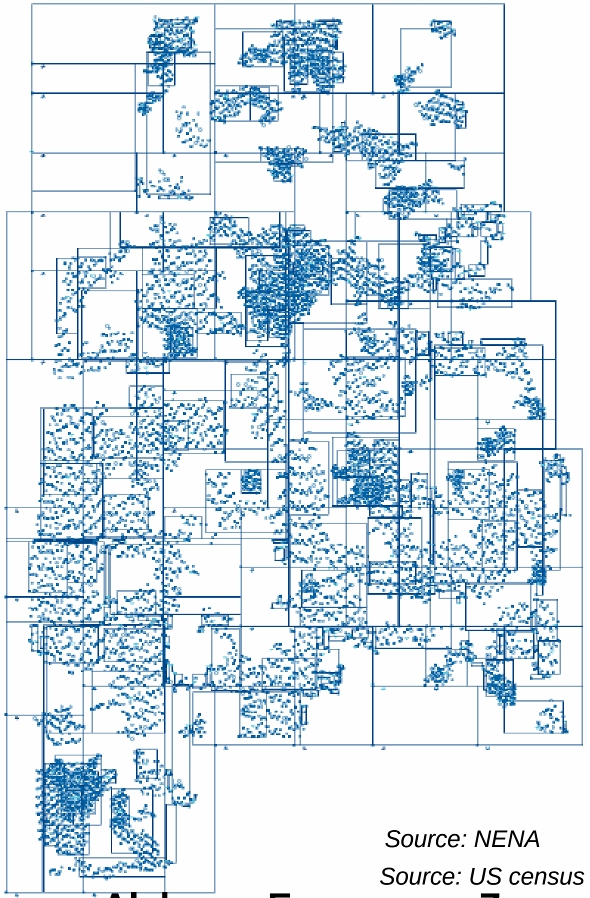
- Find closest/responsible Emergency Station

2. Quality of Service for P2P flows needed

- QoS policy: low delay, low loss
  - contact Emergency Station as soon as possible
  - without message loss

→Goal:

- How to solve problem locally ? OR
  do we need system wide management?



Source: NENA

Source: US census

Alabama Emergency Zones

Population density in Alabama

Snapshot of the simulated scenarios

→ **Paper at: K. Graffi et al., "ECHoP2P…", Int. Workshop on P2P-NVE, Nov. 2007**

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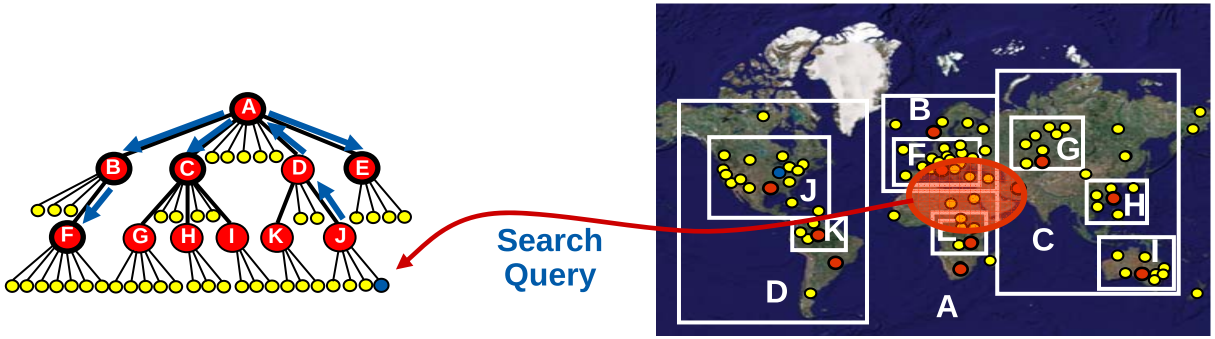
Challenge 1: Location-based search requirements

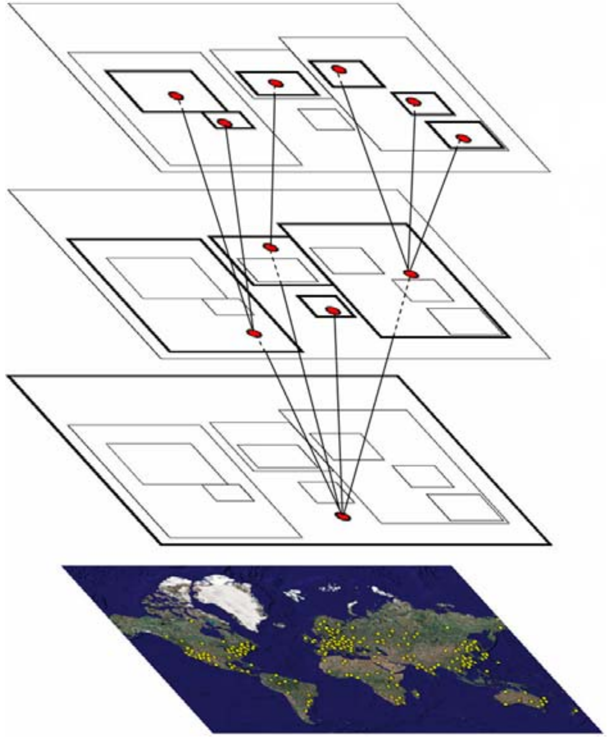
Approach: Globase.KOM - Geographical LOcation BAsed SEarch

- Engineered for requirements of location based services
- A logical neighbor is a geographical neighbor (like in CAN)
- Tree structure enables search/lookup in O(log N)

Extended with following search mechanisms:

- Closest peer (Emergency Station)
- Peer fulfilling a specific criteria (responsibility)





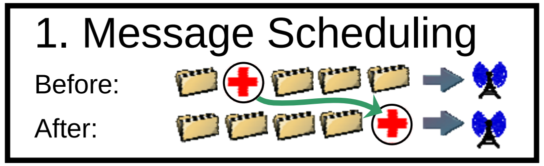
→ Paper at: A. Kovacevic et al., "Location Awareness…", Special Issue of the Proc. of the IEEE on Adv. In Distr. Multim. Comm., Jan. 2008

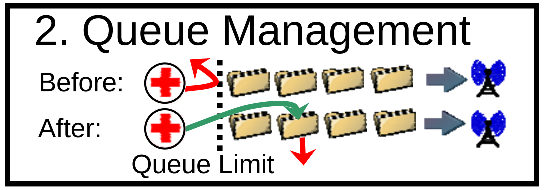
2.3 Quality of Service for Overlay Traffic

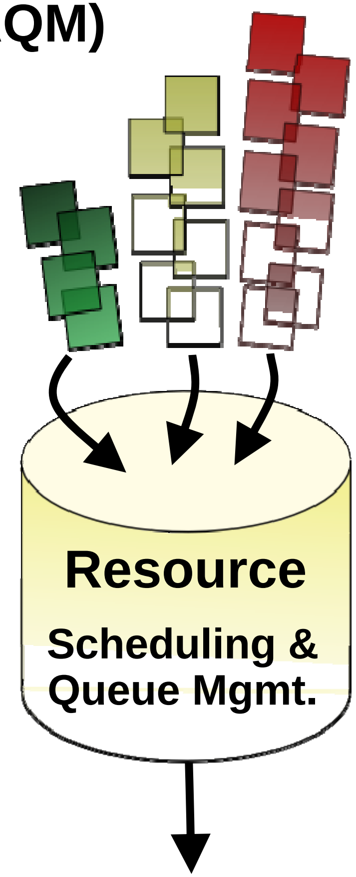
Challenge 2: Providing Quality of Service for Overlay Traffic

Approach: Scheduling and Active Queue Management (AQM)

- Scheduling: Reordering of packets
- AQM: to decide which message to drop at congestion







Observation:

Classical flows do not exist in P2P overlays

- Many small bursts, rarely from the same peers
- Requires a stateless solution

→Existing solutions mainly focus on classical flows

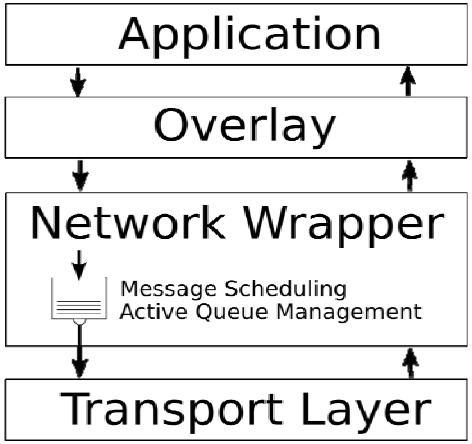
→Need for approaches for Peer-to-Peer systems

→ See: K. Graffi et al., “Taxonomy on Scheduling/AQM Strategies…” Technical Report, KOM-TR-2007-1,2, TU Darmstadt

Overlay Bandwidth Management

Novel substrate "Network Wrapper"

- Between overlay and transport layer:
  - Queues messages
  - Applies Scheduling and AQM solution: HiPNOS.KOM



HiPNOS.KOM: Highest Priority First, No Starvation

- Introduce message priorities for Loss and Delay
- AQM: at congestion, drop message with lowest loss-prio.
- Scheduling: at free bandwidth, send message with highest delay-prio.
- Avoid starvation: Periodically increase delay-prio. of queued messages

Properties of HiPNOS.KOM

- Focus on QoS for overlay flows
- Easy to apply on existing overlays

→ Paper at: K. Graffi et al., "Overlay Bandwidth Management …" in Proc. of IEEE Local Computer Networks, Oct. 2007

Overlay Bandwidth Management Results

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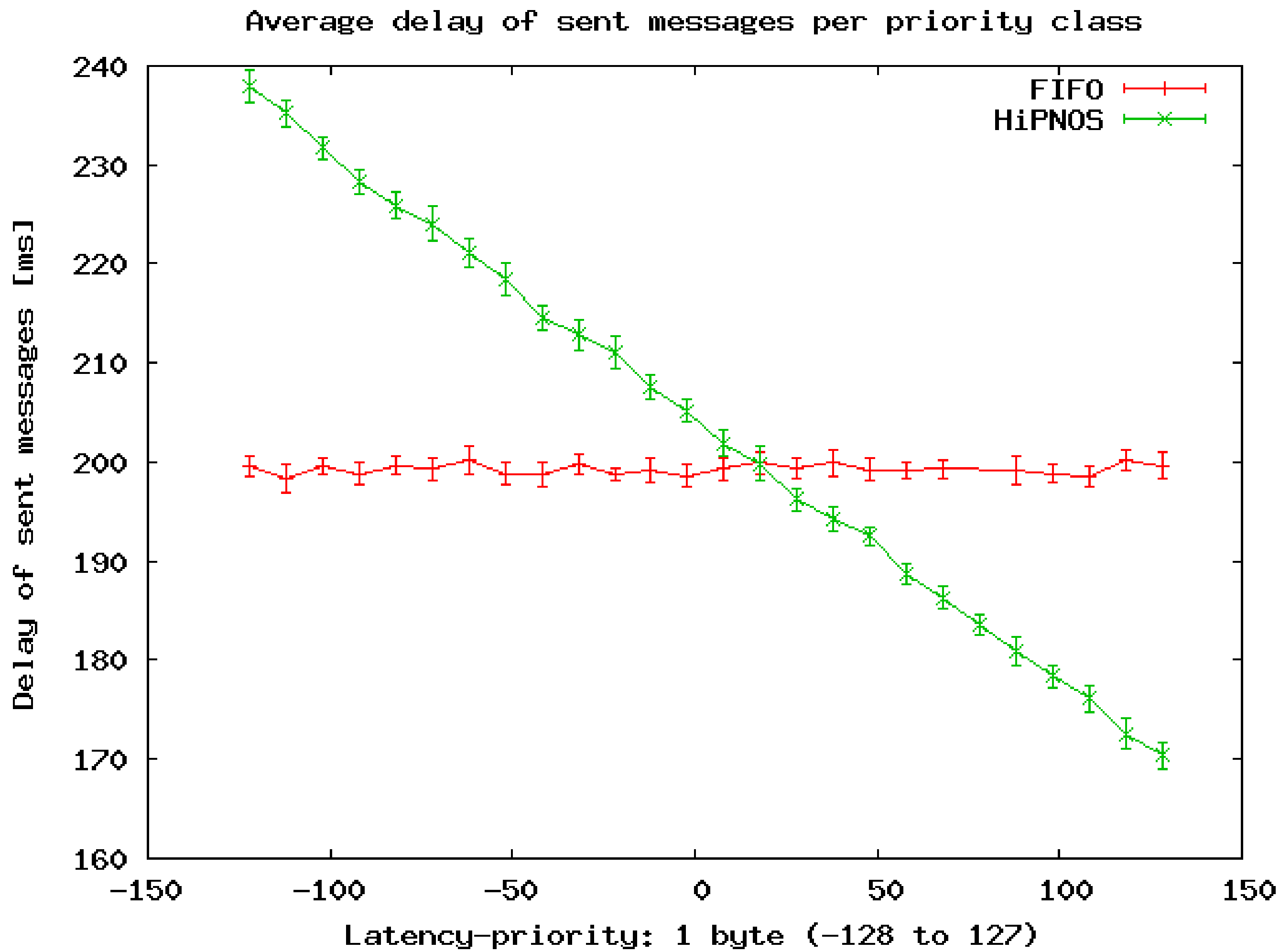
Observation:

Proportional relations:
- Delay to
- delay-priority



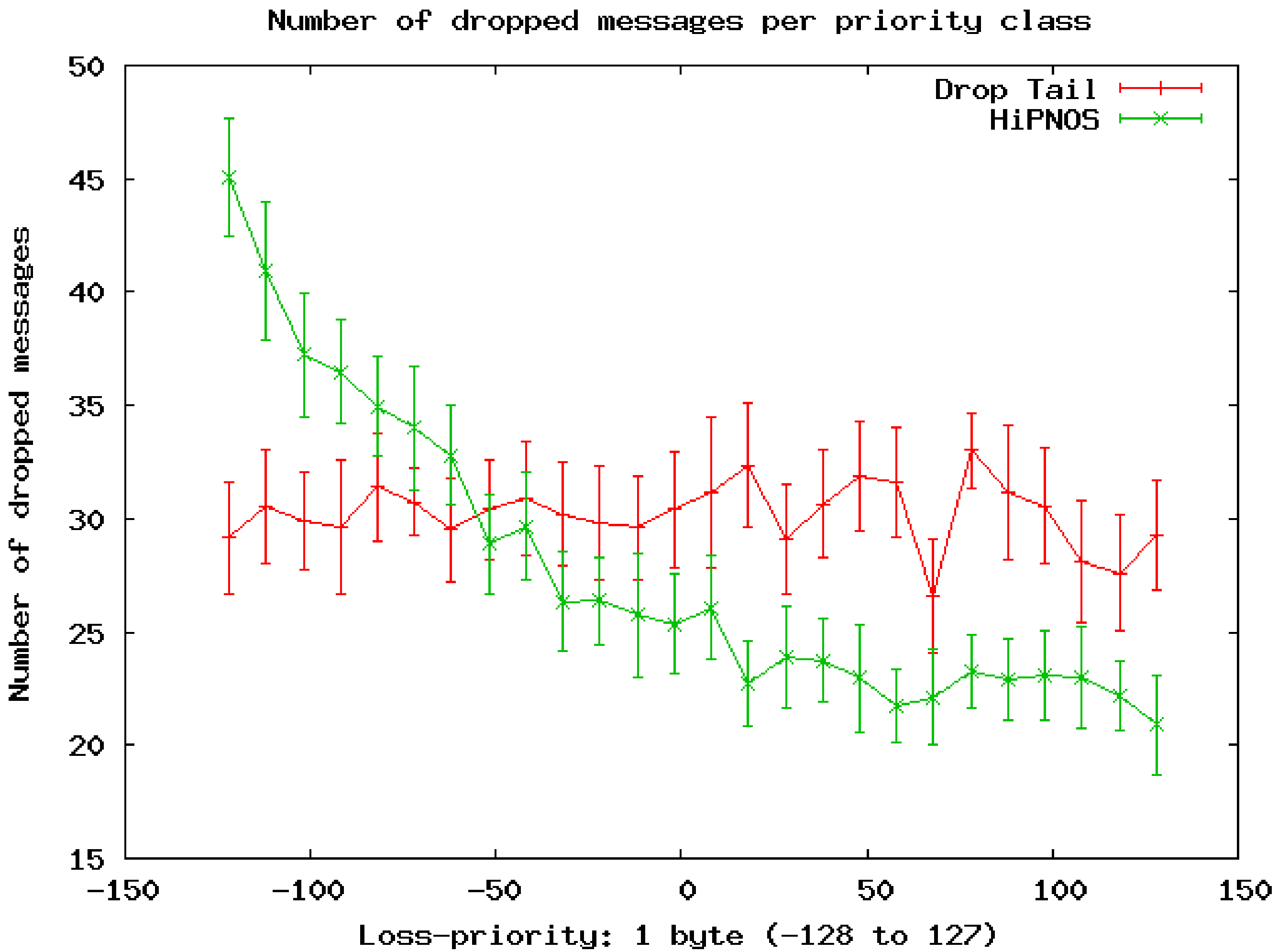
→ Paper at: K. Graffi et al., "Overlay Bandwidth Management …" in Proc. of IEEE Local Computer Networks, Oct. 2007

Overlay Bandwidth Management Results

Observation:

Proportional relations:

- Loss
- to
- loss-priority



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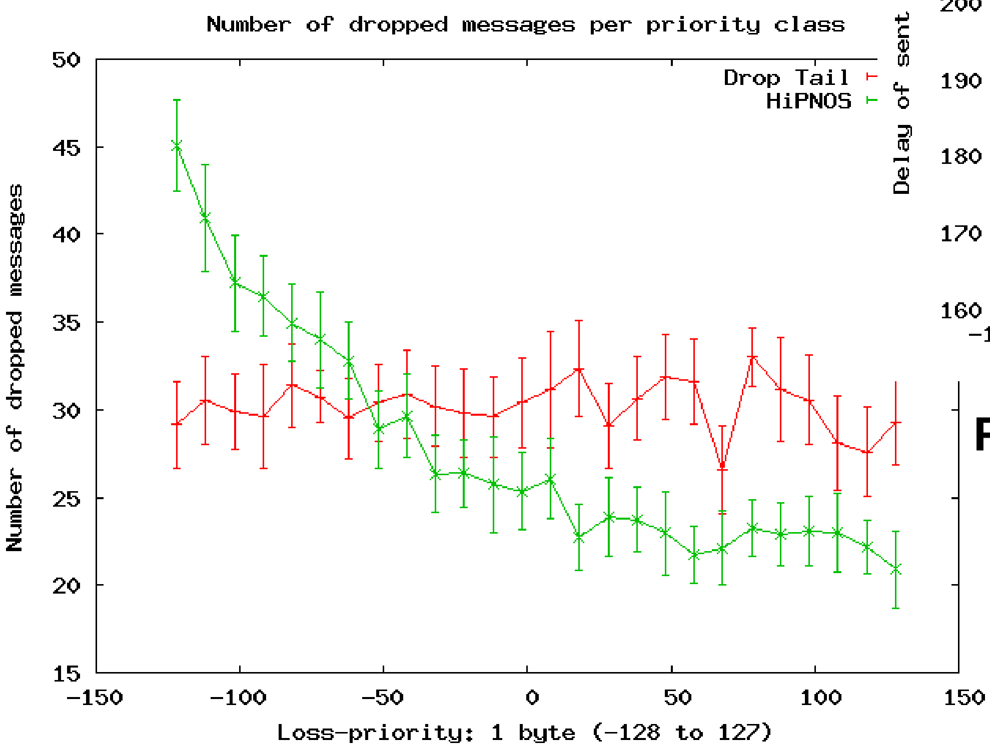
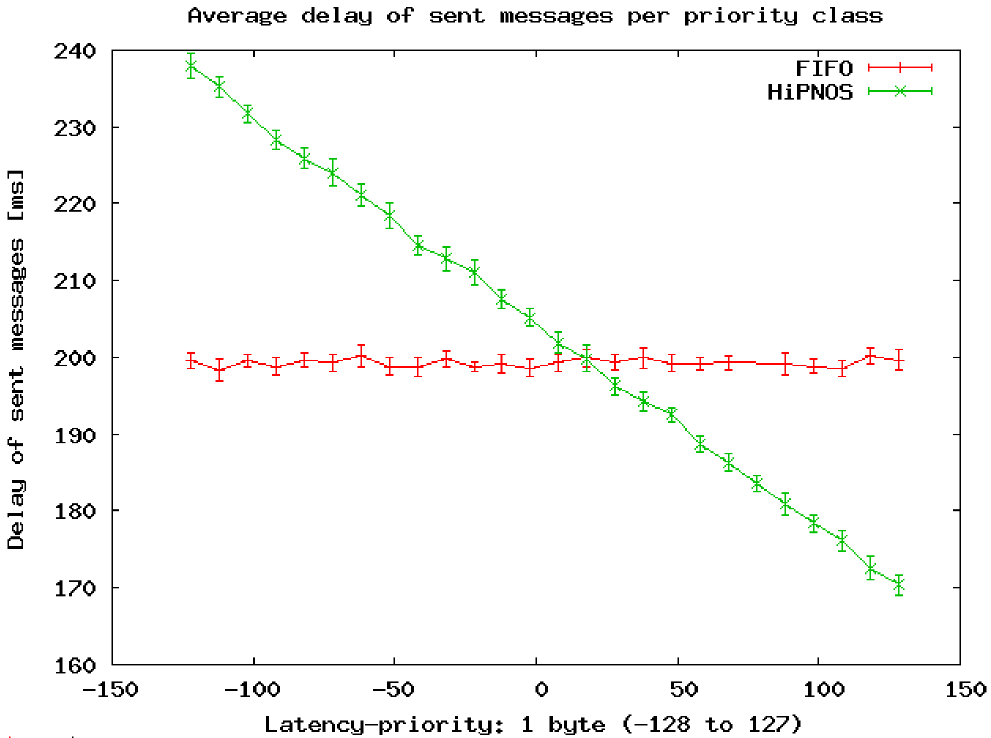
Overlay Bandwidth Management Results

Observation:

- Proportional relations:
  - Delay to delay-priority
  - Loss to loss-priority





Results:

- HiPNOS.KOM provides QoS
  - Regarding delay and loss
  - According to chosen priorities

→ Paper at: K. Graffi et al., "Overlay Bandwidth Management …" in Proc. of IEEE Local Computer Networks, Oct. 2007

3 Lessons Learned for QoS in P2P Systems

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Results for Scheduling and AQM

- Delay and delay-priority, loss and loss-priority are proportional
- Emergency Calls have always highest priority
- All other messages have lower priority
- Quality of service can be provided

Lessons learned:

IF … known:

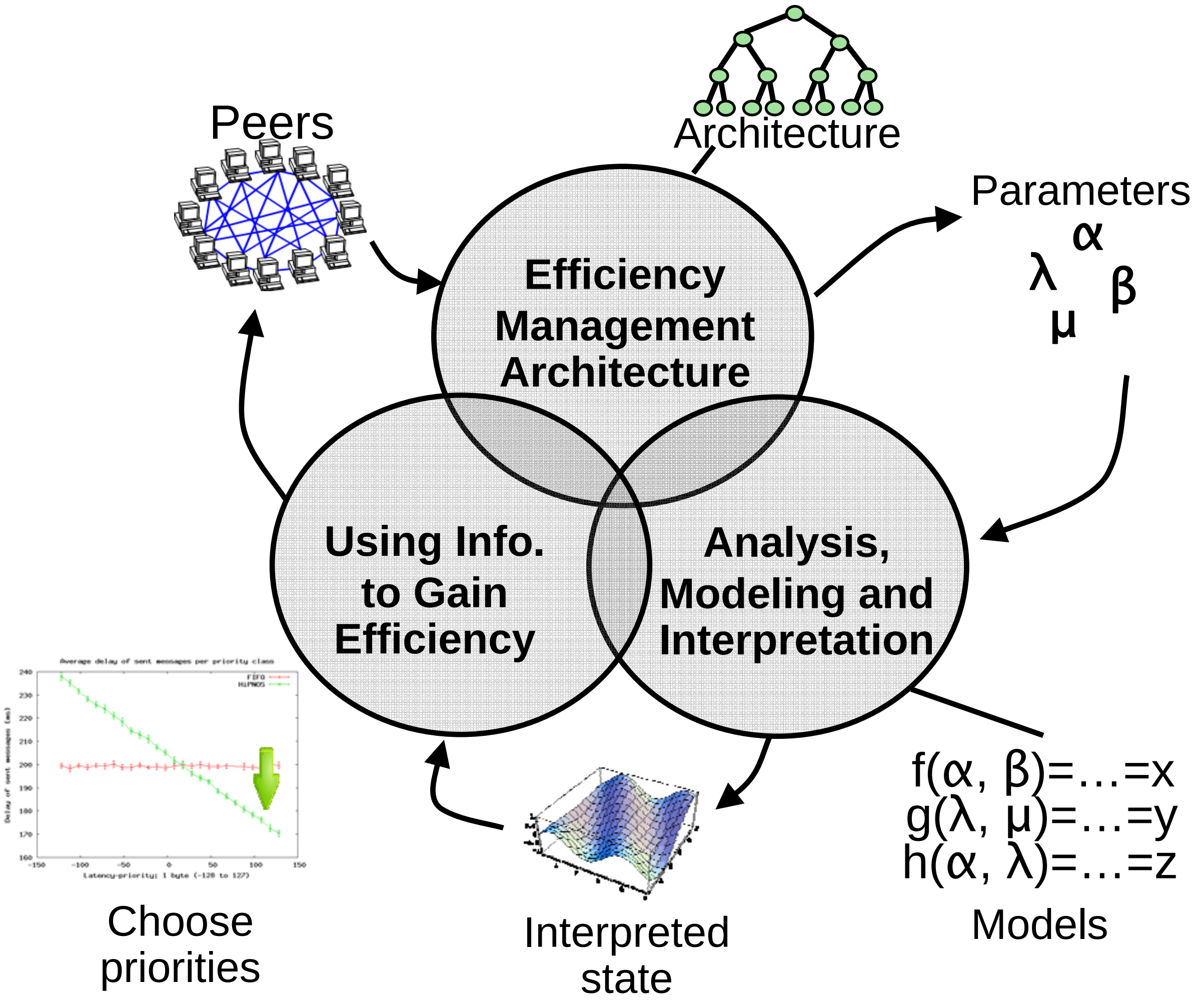
- Optimization criteria
- Set of all alternatives

THEN mechanisms for Quality of Service are easy to adopt

→ Required Information

- Necessary for efficient decisions in distributed systems
- Often missing in Peer-to-Peer systems

4 Towards a Kind of „Efficiency Management"

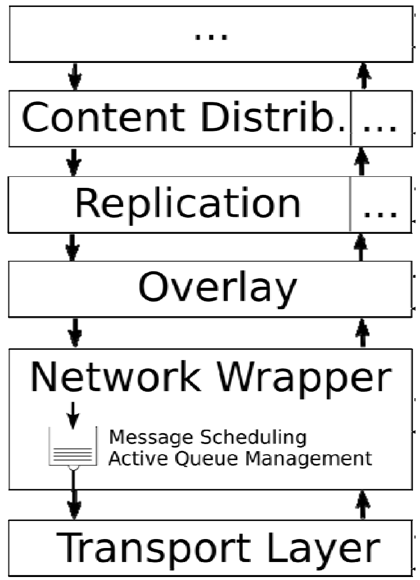


4.1 Current State of Efficiency Management

Each functional layer has its own information/analysis architecture

- To gather, analyze layer specific information
- Examples
  - BitTorrent: for Tit-for-tat peer selection
  - Replication: which data, on which peers
  - Skype: for Superpeer selection
  - Network wrapper: underlay awareness

PAST



Common basic functionality can be "abstracted", i.e. "extracted"

- To gather layer specific information
- To analyze information, (derive optimization goals)
- To apply results for better decisions

→ Separate Information/Efficiency Management Layer for this task

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Efficiency Management System:

To engineer & to build architectu

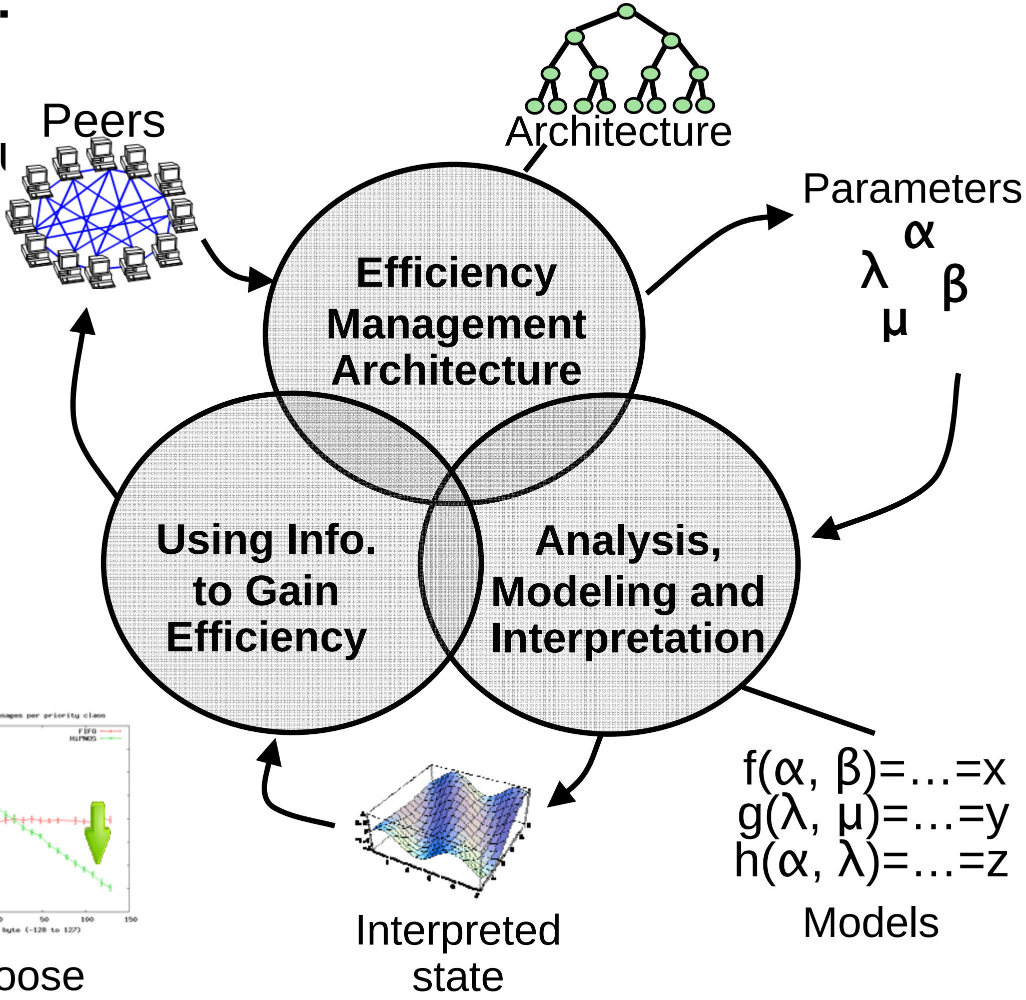
- To gather information from peers
- To retrieve system parameters

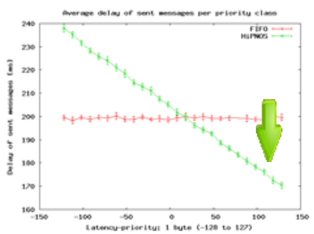
To analyze component

- To use system model
- To prepare statistics
- To interpret system state

With application Component

- To Provide QoS
  - Based on above issues





4.3 Over-Overlay: Efficiency Management System

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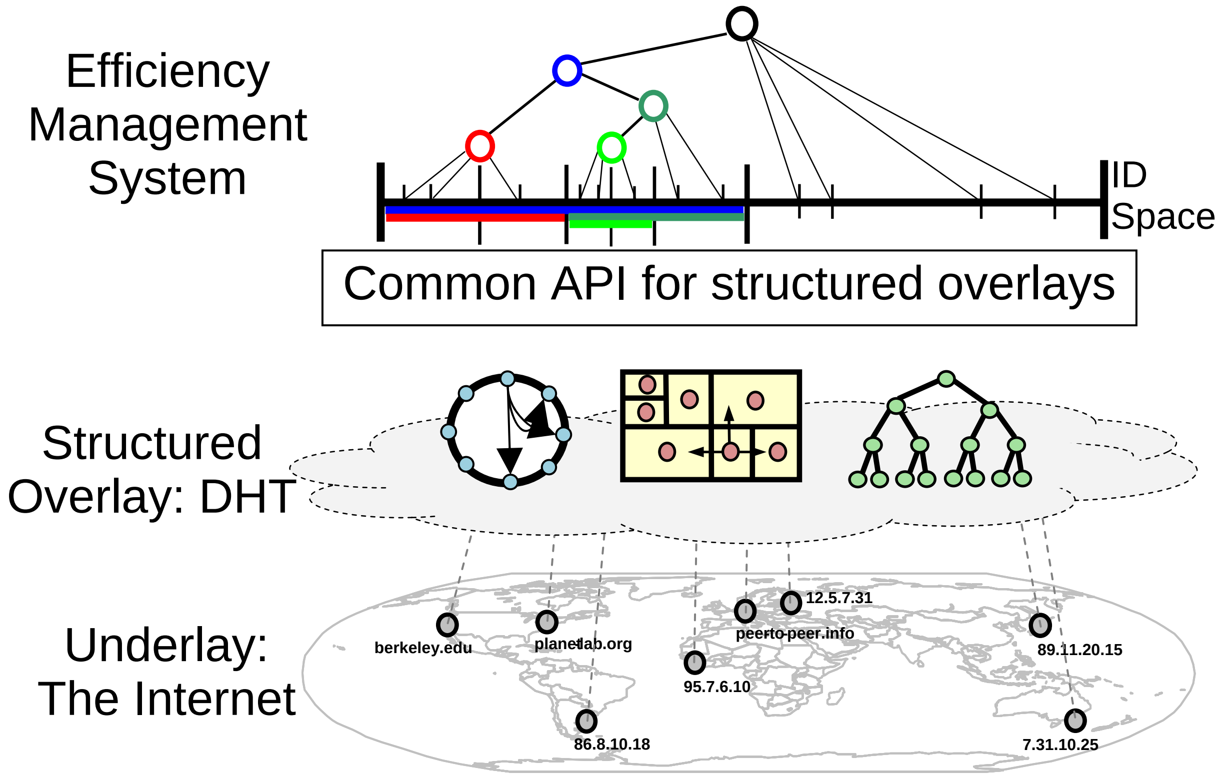
For all structured P2P overlays

- Covered by common API
- Usable by all functional layers in a P2P system

Enables query for:

- M peers with
- specific characteristics



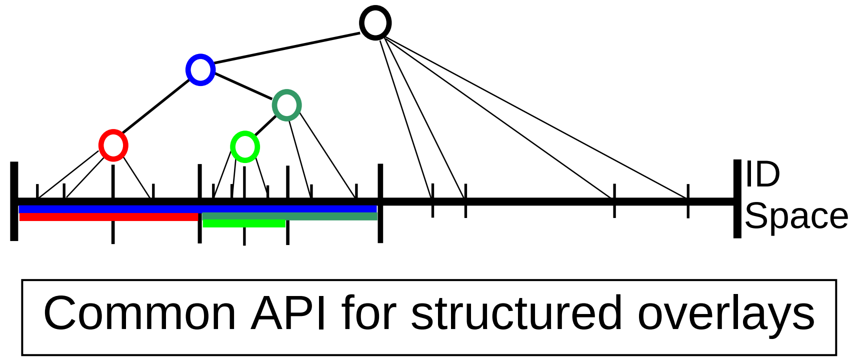
Application Examples:

- Super-peer choosing
  - 3 peer
  - Storage space > 20Mb
  - Bandwidth > 100kb/s

Efficiency Management Architecture

Efficiency Management Architecture

- Built on underlying structured overlay
- Communicates via common API
  - Route to PeerID
- Just an add-on, easy to deploy



Principle

- Each node publishes information updates in the architecture
- Update-tree is established
- Each node knows where to send updates to
- Queries are processed bottom up

→ See: K. Graffi et al., "Towards an Information and Efficiency Management Architecture…" Technical Report, KOM-TR-2008-2, TU Darmstadt

Efficiency Management Architecture Details

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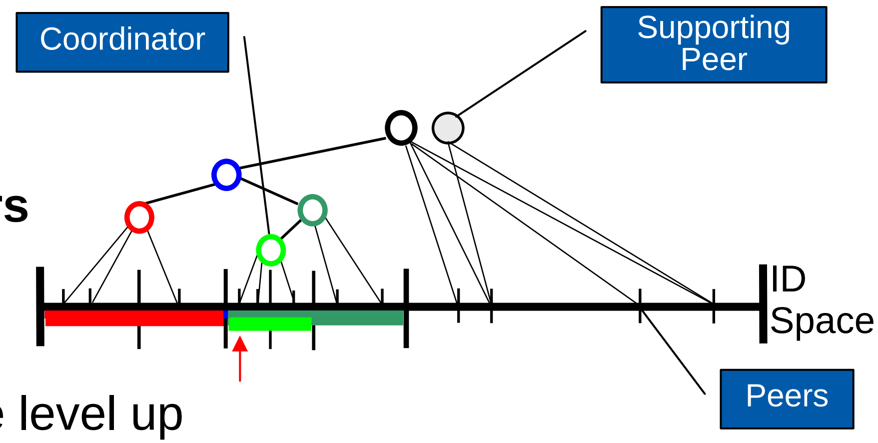
Over-overlay:

- ID space separated in intervals (domains)
- Peer responsible for a specific ID (e.g. middle) is responsible for ID domain
- Peers in the domain send updates to this **Coordinator**
- Updates propagated upwards the tree



Supporting Peers for Load Balancing

- Coordinator may chose **Supporting Peers**
- Good peers chosen by 50/50 ratio
  - Pick e.g. 20 best peers in the domain
  - Best 10 peers in domain advertised one level up
  - Second best 10 peers can be used as support
- Workload can be delegated to supporting peers
- Tree depth / peer load adjustable

4.4 Queries in the Efficiency Management System

Query Type:

- Give me M peers
- Fulfilling specific requirements on
  - Bandwidth, storage space, computational capabilities,
  - Online time, peer load, reputation
  - … (wide set of requirements definable)

Query processing

- First sent to coordinator of lowest domain
- Query traverses bottom-up, until M matching peers found
- Result is sent then to requesting peer
- Tradeoff:
  - Upper peers in tree know more
  - Load should be kept on lower levels of the tree

Structure of the Efficiency Management Arch.

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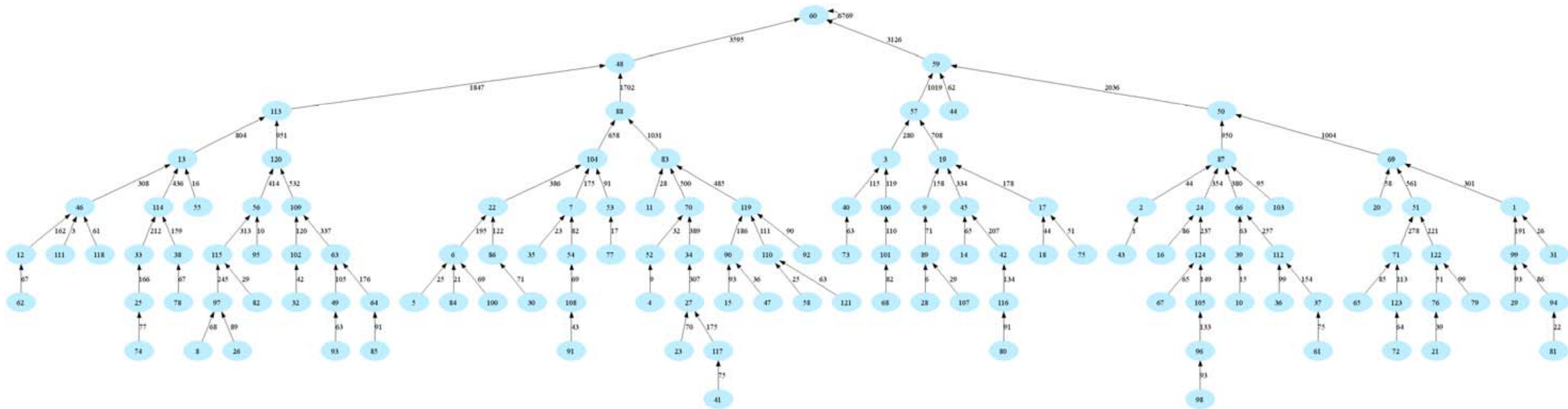

Query Performance: O(log N) hops

Scalability:

- Tree-structure of coordinators form information architecture
- Supporting peers: Strong peers can take the load

Robustness:

- No additional maintenance needed (done by structured overlay)
- Any peer can fail, no unwanted effects

4.5 Example Application: Replication Layer

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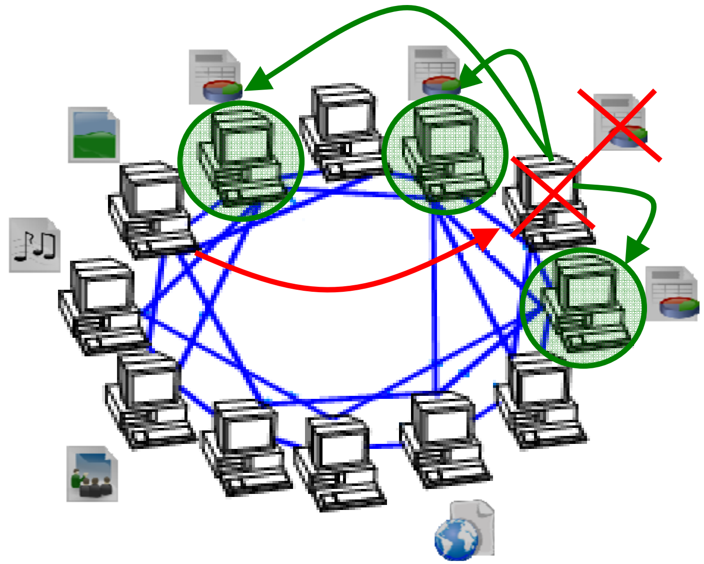
Content storage in P2P systems

- Churn is a problem
  - Data may get lost

→**Replication is a solution**



Challenges

- Which files to replicate?
  - Most requested, rarest?
- At which peers?
  - Most reliable? Highest bandwidth?
- How many replicas?
  - Depends on requirements on availability
- By which peers?

→ Efficiency Management System allows for answers

Information Management is just ONE part of the Efficiency Management Lifecycle

Next steps:

- To build information analyzing quorum
- To process and analyze gathered system parameters
- Status determination and prediction
- QoS policy determination based on identified QoS requirements

Long-term vision:

- P2P network regulates itself
  - According to QoS constraints towards efficiency
- From self-organization of the peers to self-consciousness of the system

Upcoming Applications:

- P2P-based Grid: Share resources, negotiate service in return with the system
- Modularized, layer-interactive, complex applications

Fragen ? – Any Questions ?

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Prof. Dr.-Ing. Ralf Steinmetz
Dept. of Electrical Engineering and Information Technology
Dept. of Computer Science (adjunct professor)

Ralf.Steinmetz@KOM.tu-darmstadt.de
Merckstr. 25
64283 Darmstadt
Germany

Phone +49 (0) 6151/166150
Fax +49 (0) 6151/166152
www.kom.tu-darmstadt.de

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