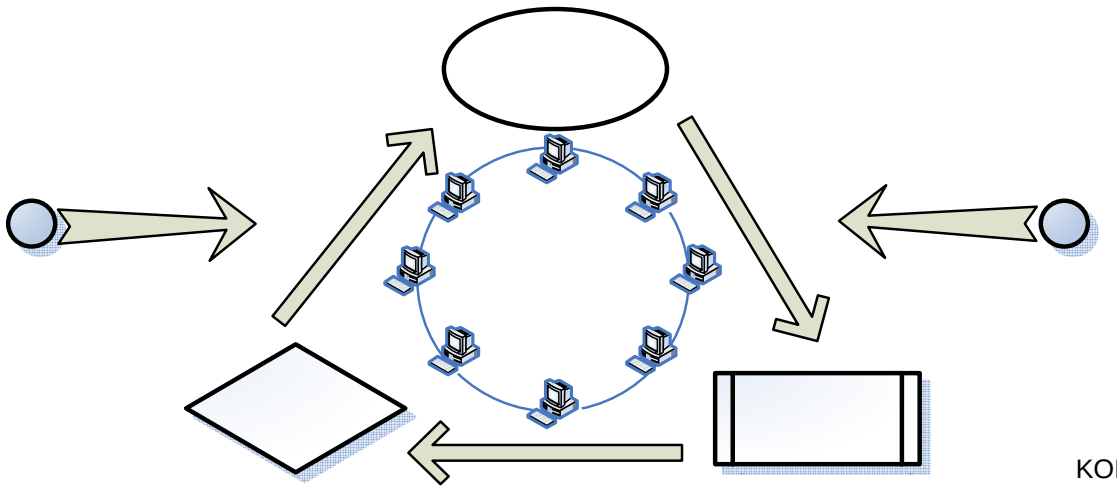
Monitoring and Management of P2P Overlays

How to coordinate millions of autonomous peers to provide controlled quality of service?

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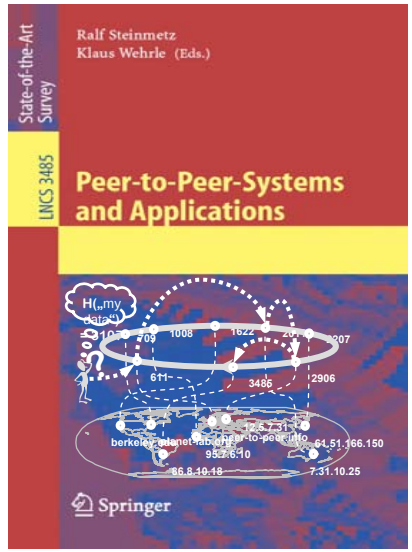
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The Peer-to-Peer Paradigm

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Peer-to-peer systems

- Users build infrastructure
- Service is provided from users to users
- Peer-to-peer overlays
  - Connecting all peers, providing new functionality
  - E.g. Distributed Hash Tables, keyword-based search



Evolution of applications / QoS demands

- File sharing
  - No Quality of Service (QoS) requirements
- Voice over IP
  - Real-time requirements
- Video-on-demand
  - Real-time and bandwidth requirements
- Online community platforms
  - Potential for high user interaction



→ See: K. Graffi, AsKo, et al. “Peer-to-Peer Forschung - Überblick und Herausforderungen”
In: it - Information Technology (Methods and Applications of Informatics and Information Technology), vol. 46, no. 5, p. 272-279, July 2007

Dynamics in P2P System

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Various scenarios

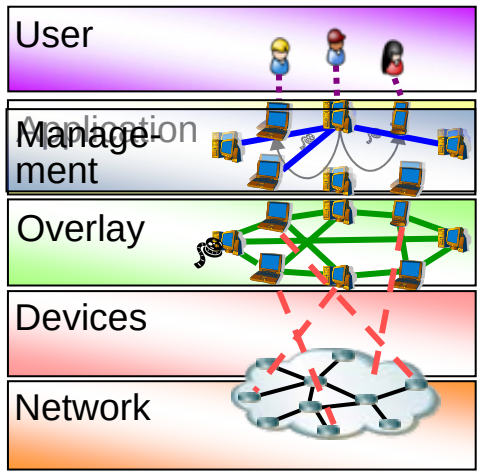
- Distributed storage
- Content delivery
- Discovery and contacting of users

Dynamics over time

- Network size
- Churn

Peer heterogeneity

- Peer capacities
- Connectivity



Create a new overlay for every case?

→No, automated reconfiguring of established overlays!

→Management of P2P overlays

Problem Statement: Self-X and Automated Reconfiguration

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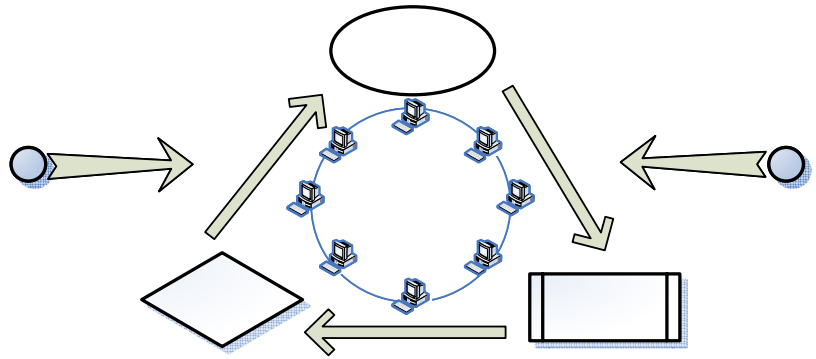
System goals are predefined

- Application and scenario specific

→e.g. Metric intervals

Examples

- Goal interval for hop count: [7,10]
- Standard deviation of peer load: max 500%



Goal

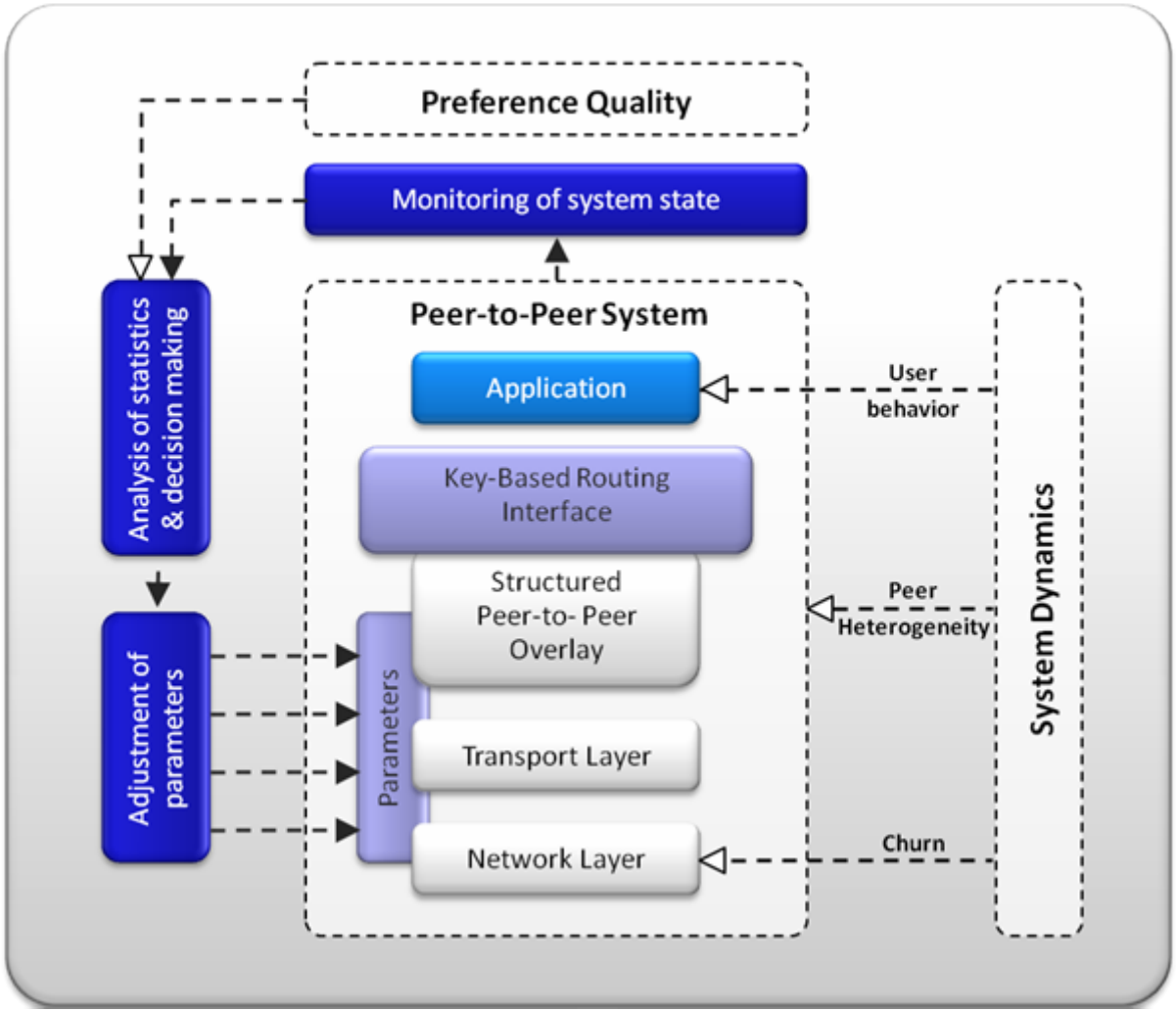
- Configuration should adapt to system goals
- Automated meeting of predefined metric intervals

Step 1: Monitor current system state

Step 2: Analysis state, plan new parameters

Step 3: Distribute and adopt new parameters on all peers

Self-Configuration Cycle in P2P Systems



Monitoring: SkyEye.KOM

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Monitoring system state

- Applicable on all (KBR) struct. overlays
- Global view on system metrics
- Statistical representation

Quality requirements

- Performance: precise, fresh, robust
- Costs: lightweight, minimal costs

General Metrics	Monitoring and Overlay
number of online-peers	monitoring: in-/out-traffic
average online-time	overlay: in-/out-traffic
complete in-/out-traffic	average bandwidth-consumption
average lookup-time in seconds	succeeded and failed operations
in-/out-traffic of lookup-messages	traffic of ping- and pong-msgs
number of join- and leave-messages	

Function	Description
MIN(metric)	Calculates the minimal value of a metric
MAX(metric)	Calculates the maximal value of a metric
SUM(metric)	Sums the values of a metric
SUMOFSQ(metric)	Sums the squares of the values of a metric
COUNT(metric)	Counts the number of metric values
AVG(metric)	Calculates the average of a metric
STANDARDDEV(metric)	Calculates the standard deviation of a metric

→ K. Graffi et al. “SkyEye.KOM: An Information Management Over-Overlay for Getting the Oracle View on Structured P2P Systems” IEEE ICPADS 2008

SkyEye.KOM – Architecture Design Decisions

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Integrated vs. new layer

- New layer allows wider applicability

Reactive vs. proactive

- System state information is continuously interesting for all users

Monitoring topology: bus, ring, star, mesh, tree

- Tree structure alleviate information aggregation

Support for peer heterogeneity: heterogeneous vs. equal roles

- Load similar for all peers in all positions, no further roles needed

Position assignment: dynamic vs. deterministic

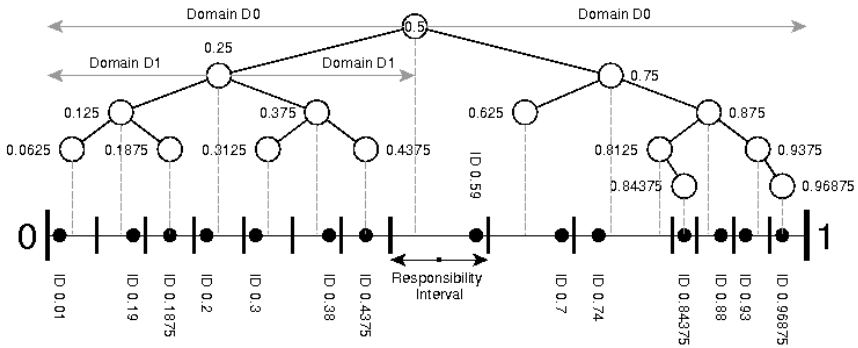
- Deterministic IDs used in topology, dynamically resolved with DHT

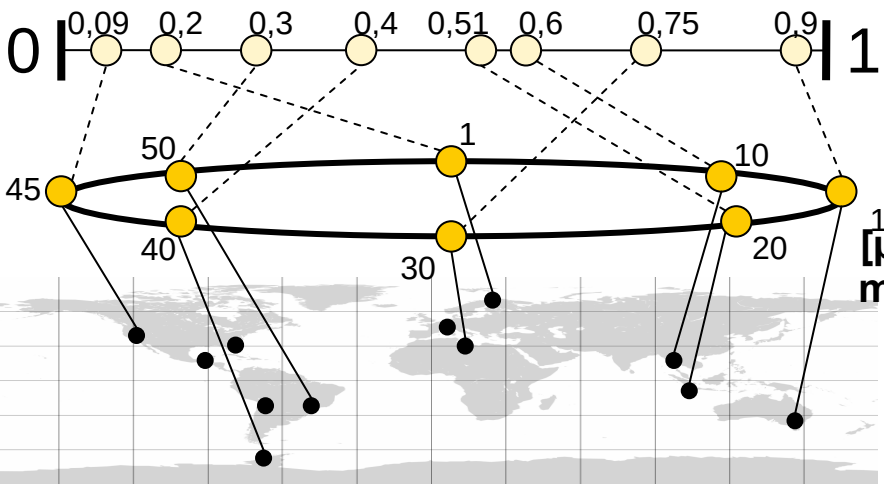
Overview on SkyEye.KOM

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Topology

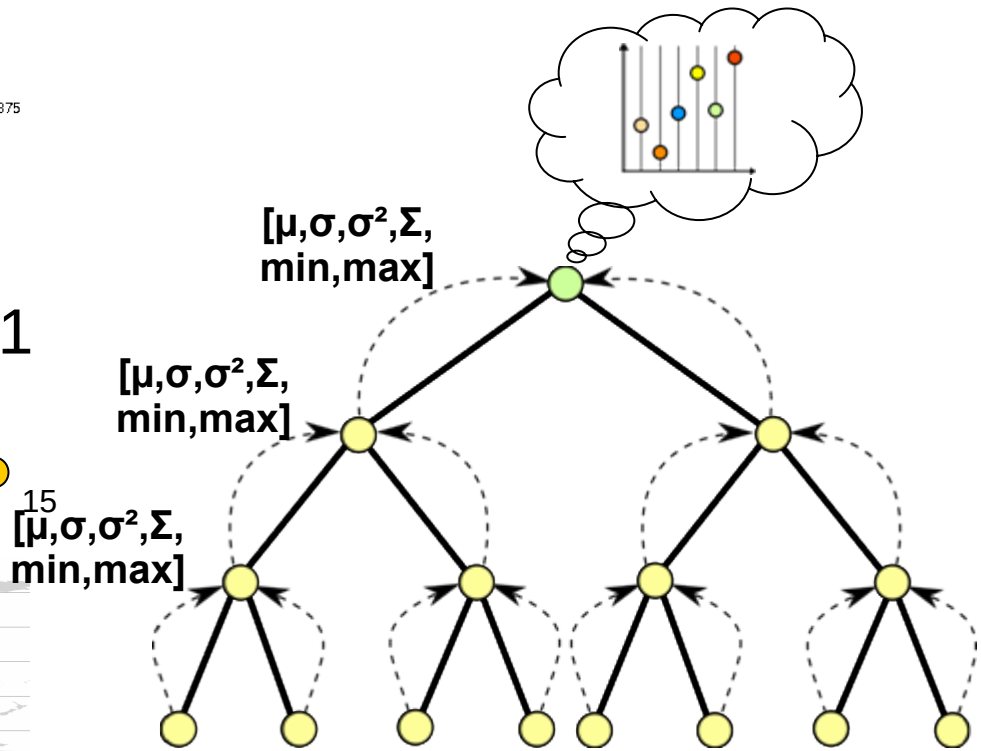
- Tree based information architecture
- Uses p2p overlay functionality





Statistic updates

- Periodically sent to parent peer
- Aggregated in each node (→ same size)

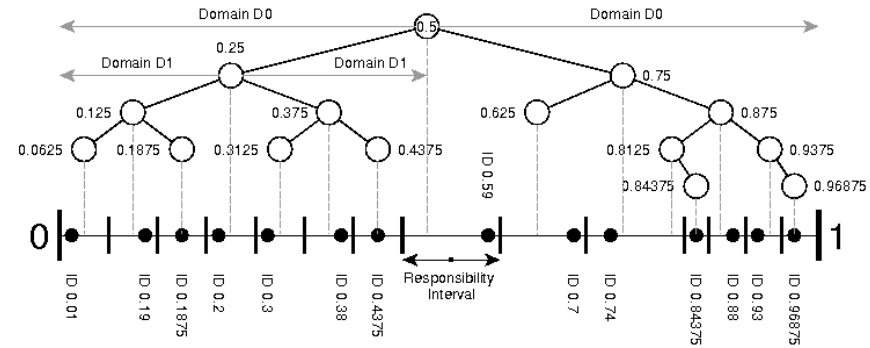


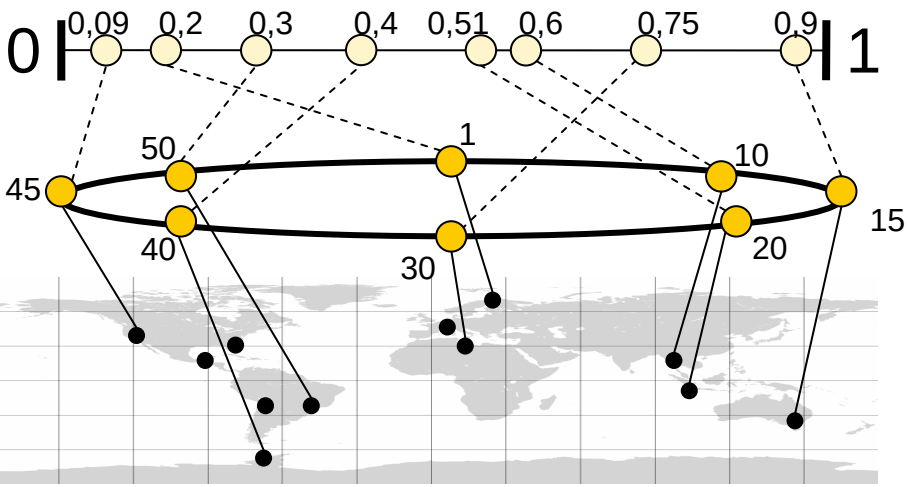
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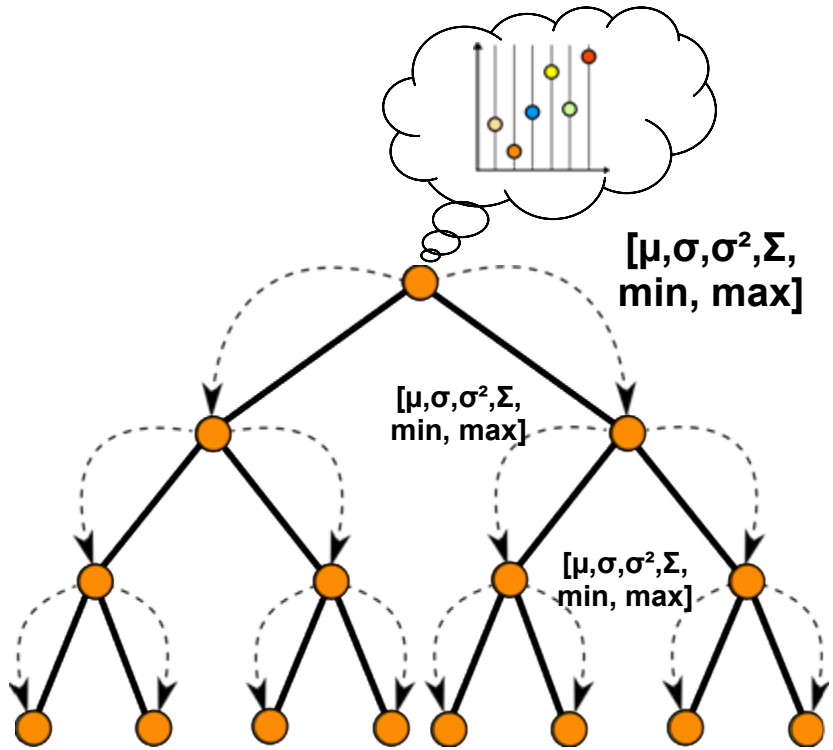
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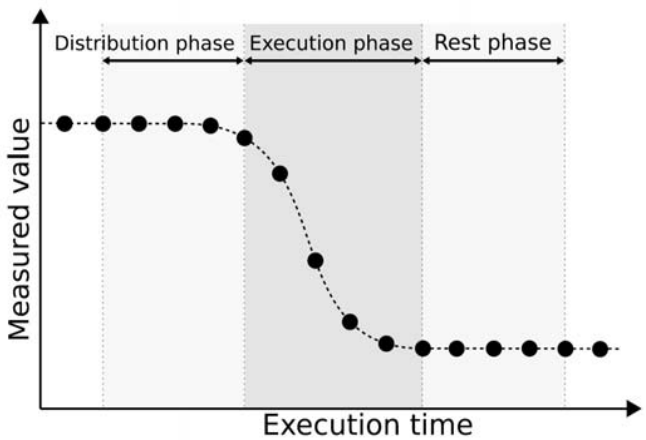


Deriving a new Configuration

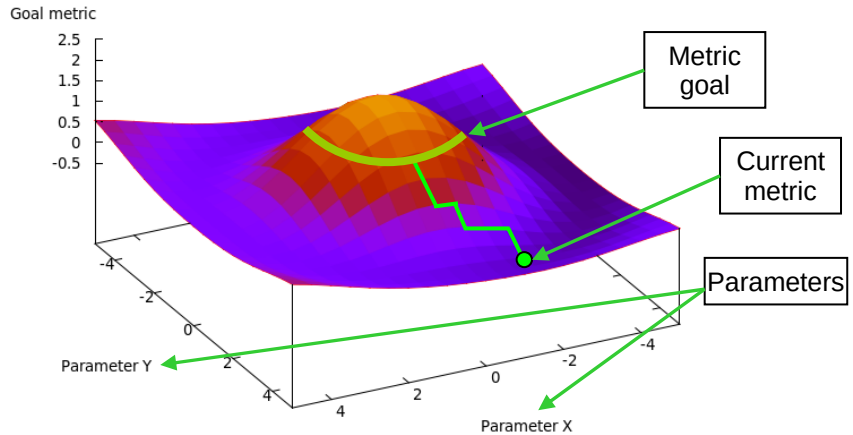
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Root is deciding component

- P2P overlay parameterizable
- Monitoring reveals current system state
- Predefined quality goals given
- Detects missed quality intervals
- Plans new configuration
- Spreads new configuration to all peers using SkyEye.KOM
- Peers adopt locally the new rules







Prevent configuration oscillation

- Give time for changes to take effect
- Introduce execution delay
- Analyze slope of value history
- Act only if small, i.e. changes settled

Analysis Point and Configuration Distribution

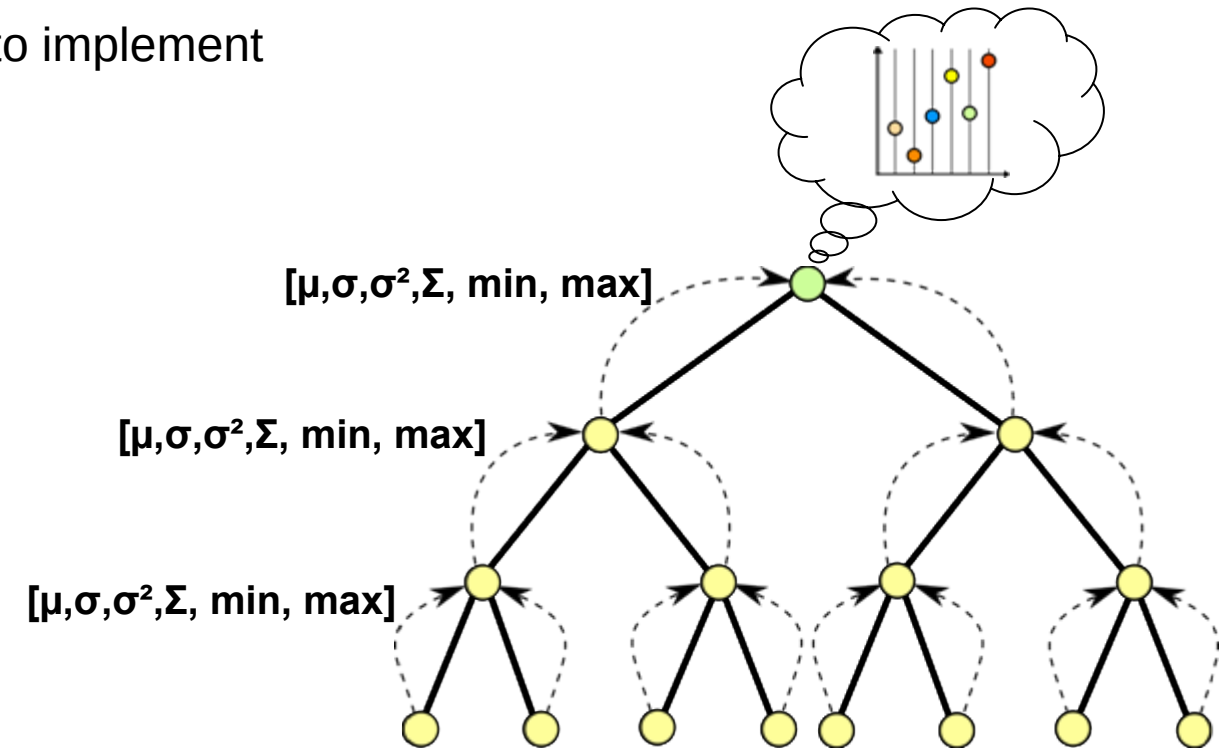
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SkyEye.KOM topology

- SkyEye.KOM aggregates system statistics up the tree
- Every update message is acknowledged
  - Global view from above
  - Policy of new actions to implement

Root has global view and can reach all leafs

→ Root analyzes and pushes new configuration down



Analysis Point and Configuration Distribution

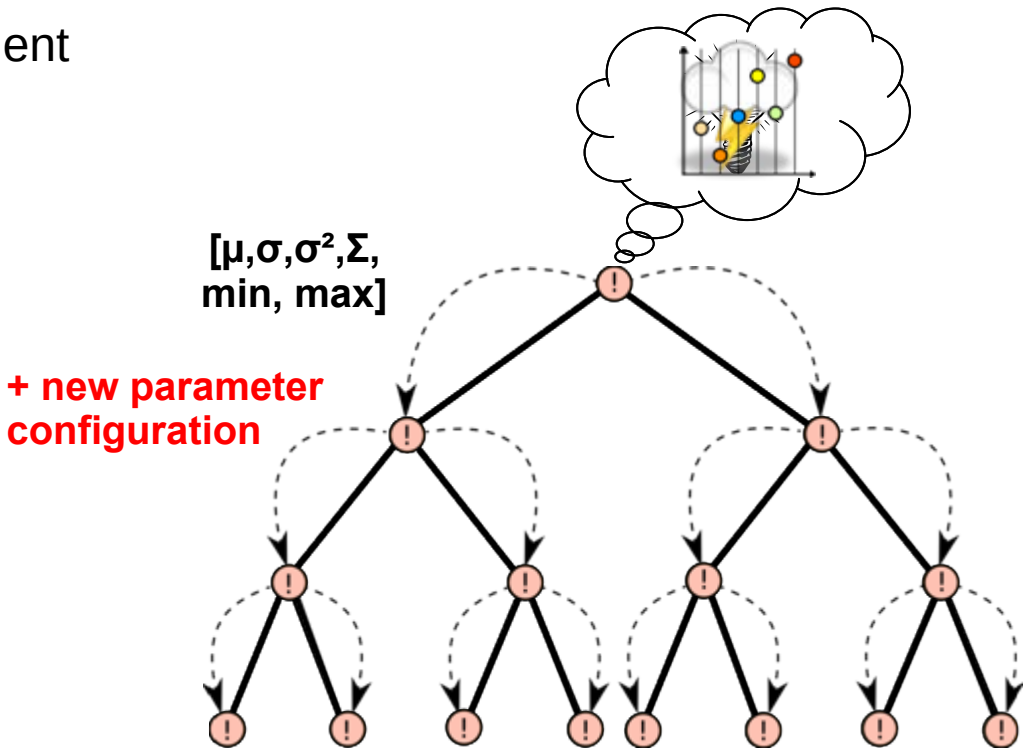
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Simulation Setup

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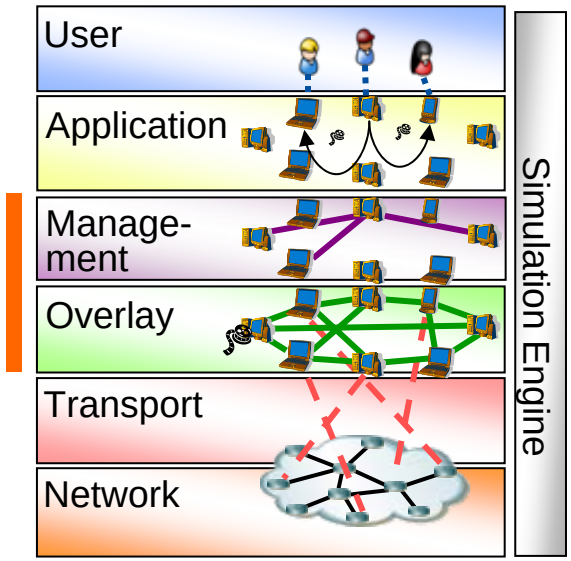
Evaluated in PeerfactSim.KOM

Simulation Setup

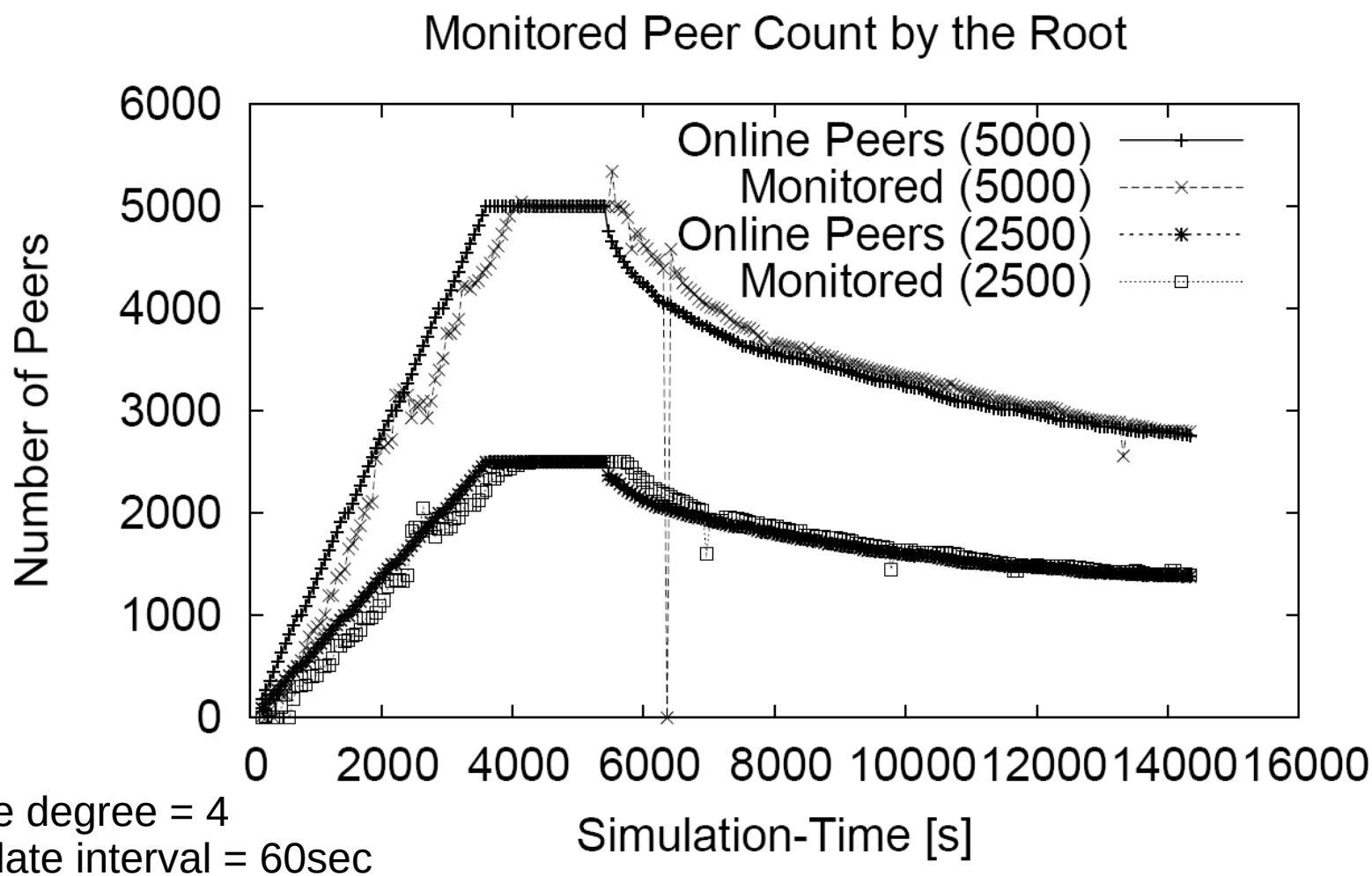
- IdealDHT: Dispatches messages to responsible peer
- 5000 Nodes
- Delay model: global network positioning
- Churn model: based on KAD measurements (Steiner et al.)

Metrics

- Monitored and real metrics
- Relative monitoring error
- Monitoring age
- Traffic overhead



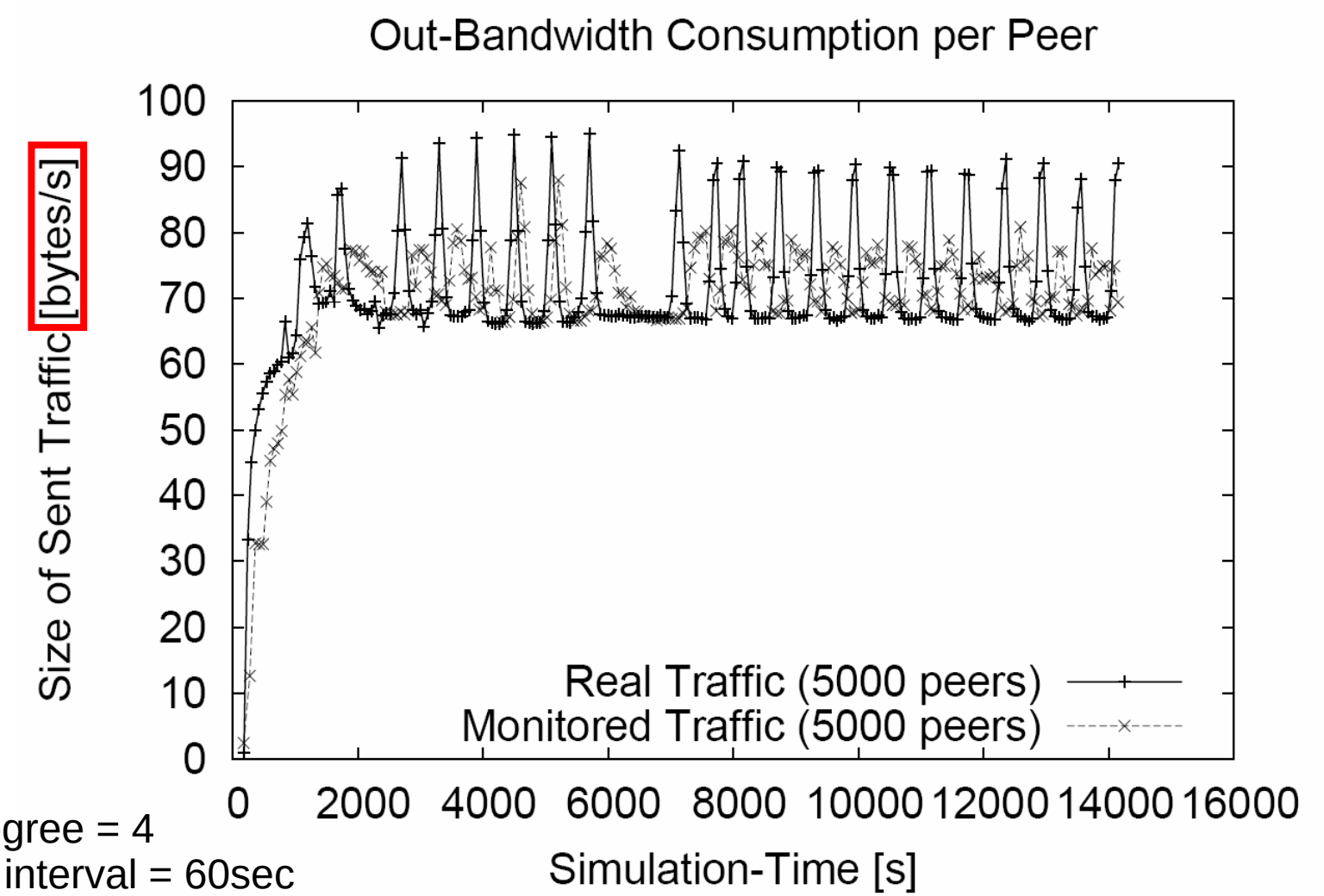
Monitoring Performance



Tree degree = 4
Update interval = 60sec

→ K. Graffi, D. Stingl et al. “Monitoring and Management of Structured P2P Systems” submitted to IEEE P2P 2009

Monitoring Costs



Tree degree = 4
Update interval = 60sec

→ K. Graffi, D. Stingl et al. "Monitoring and Management of Structured P2P Systems" submitted to IEEE P2P 2009

Case: Chord, Hop Count, Routing Table Size

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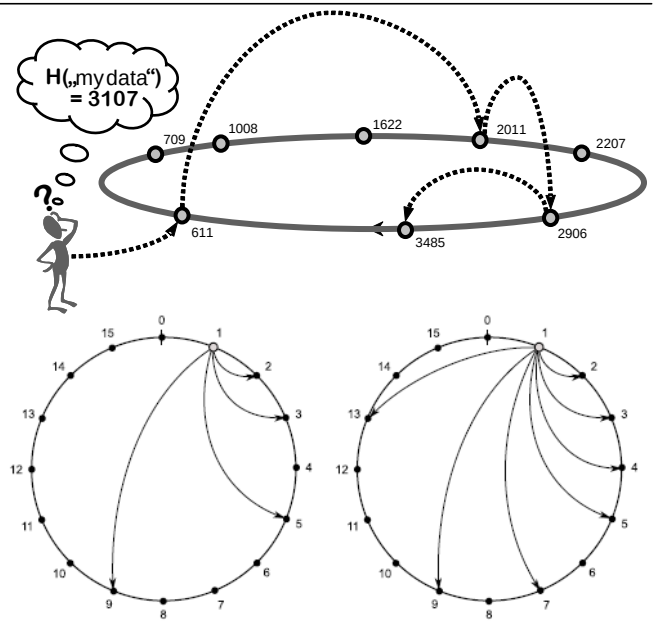
Chord

- Classic DHT, provides req. functionality
- Adapted to consider new configuration

Parameter: Finger table (FT) size

Metric: Hop count (HC)

Analysis: Hop count interval [7,10]



Plan:

- Hop count large → FT +100%
- Hop count small → FT -10%

General		Monitoring	
Simulation time:	900min	Update-Interval	300s
Number of nodes:	1000	Tree degree	2
Chord		**Management**	
FixFinger-Interval	10s	Goal Hop Count	[7,10]
Stabilize-Interval	10s	History size	10
CheckPredecessor-Interval	30s	Maximum Slope	0.2

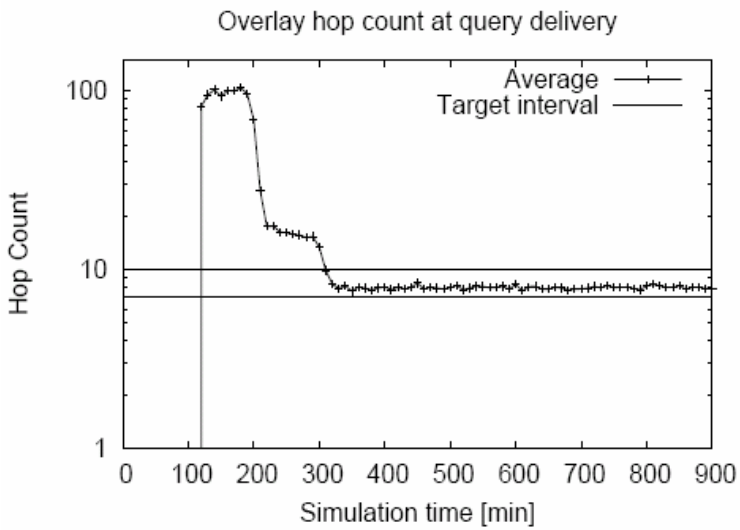
Starting with High Hop Count

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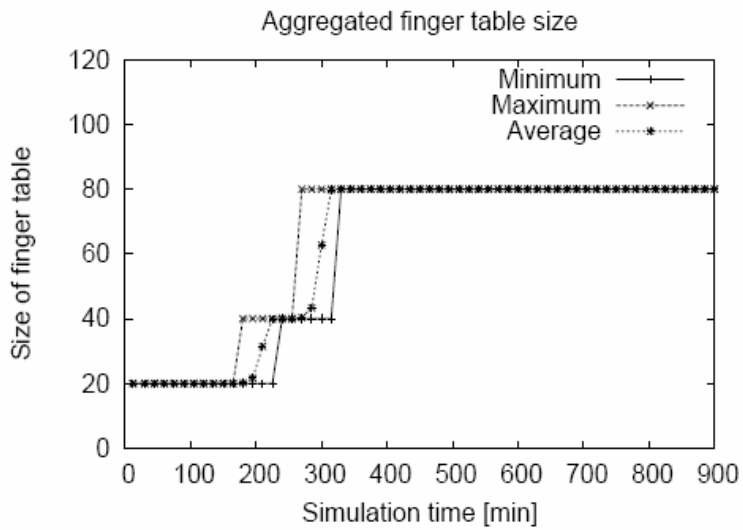
Quick convergence towards preset quality interval

Analysis:

- Too large hop count is detected
- → Finger table size: increase by 100%
- Initial FT size: 20, at end 80
- Quality goal is reached and kept



(Hop Count



Routing Table Size

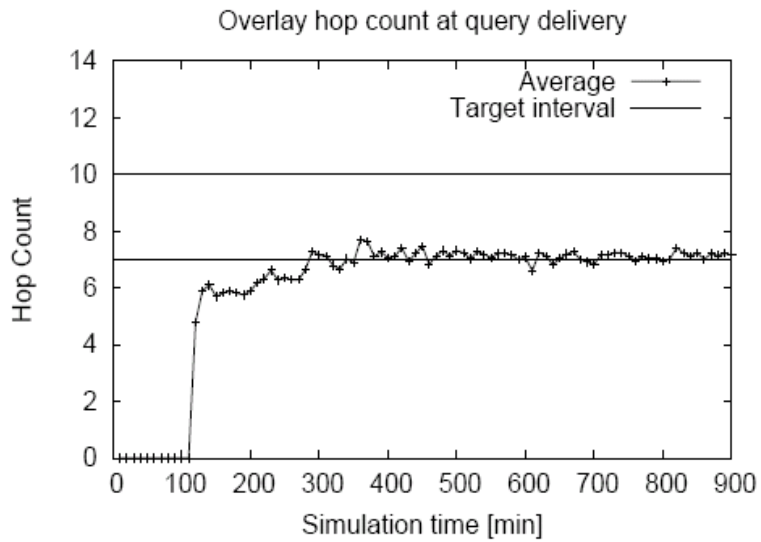
Starting with Low Hop Count

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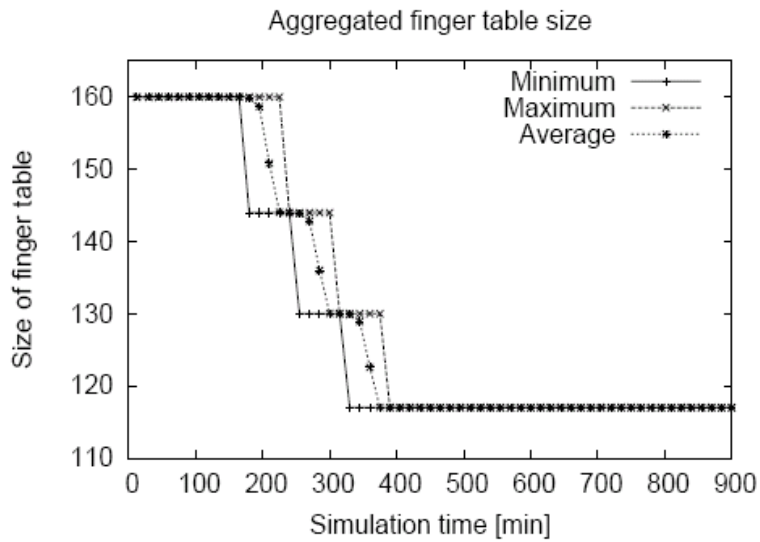
Quick convergence towards preset quality interval

Analysis:

- Too small hop count is detected
- → Finger table size: decrease by 10%
- Initial FT size: 160, at end 116
- Quality goal is reached and kept



Hop Count

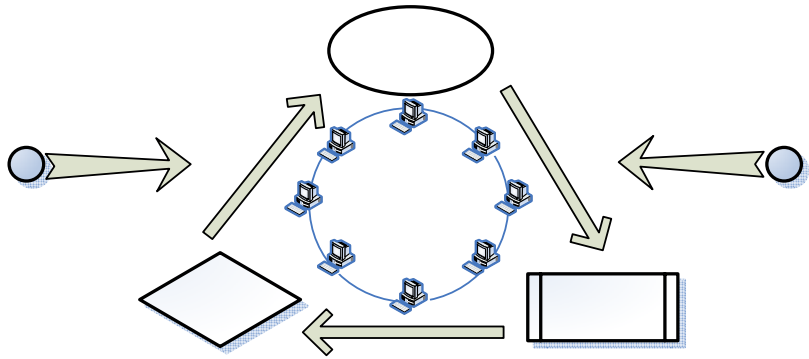


Routing Table Size

Summary

Management of P2P overlays

- Reach and hold preset quality intervals
- Through system management cycle

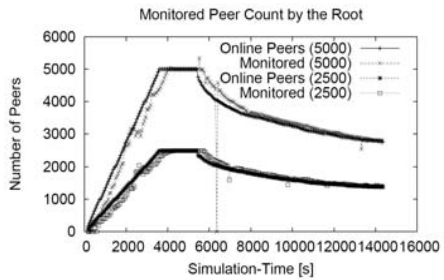


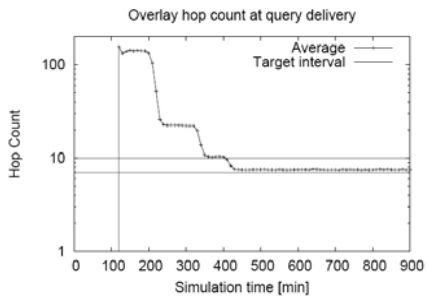
Coordinated resource usage

- Through reconfiguration
- Tunable optimization goals

Monitoring: SkyEye.KOM

- Global view on statistics of running system: avg./std./min./max on all metrics
- Precise yet cost effective monitoring





Analysis / Plan / Execute in Chord

- Automated rule application
- Preset quality intervals are reached/hold

Outlook

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Future work

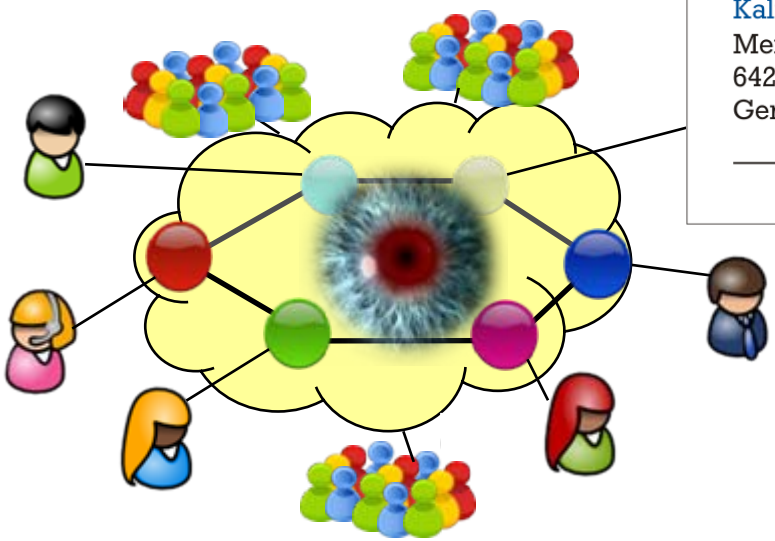
- Evaluate cycle in Kademlia
- Automatically detect rules
  - Parameter-metric correlation
  - Using machine learning and genetic algorithms

Implications

- Allows the usage of P2P overlays “off the shelf”
  - For various scenarios / environments
- Monitoring and quality control
  - P2P as mature IT architecture
  - Interesting for industry
- Self-configuration framework can include and consider other functional layers

Questions?

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and Information Technology
Multimedia Communications Lab - KOM

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