



Hierarchical Structures in Peer-to-Peer Overlay Networks

**5. Würzburger Workshop
"IP-Netzmanagement, Netzplanung und Optimierung"
18.-19. Juli 2005**

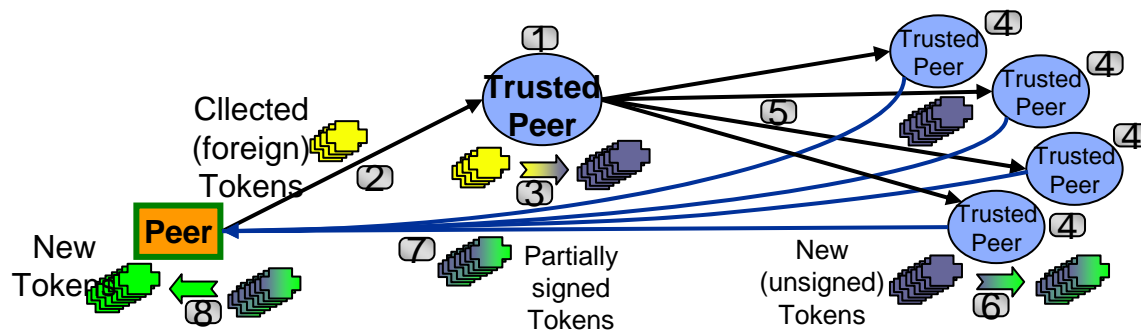
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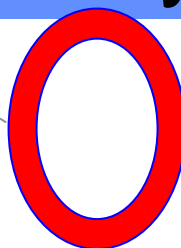
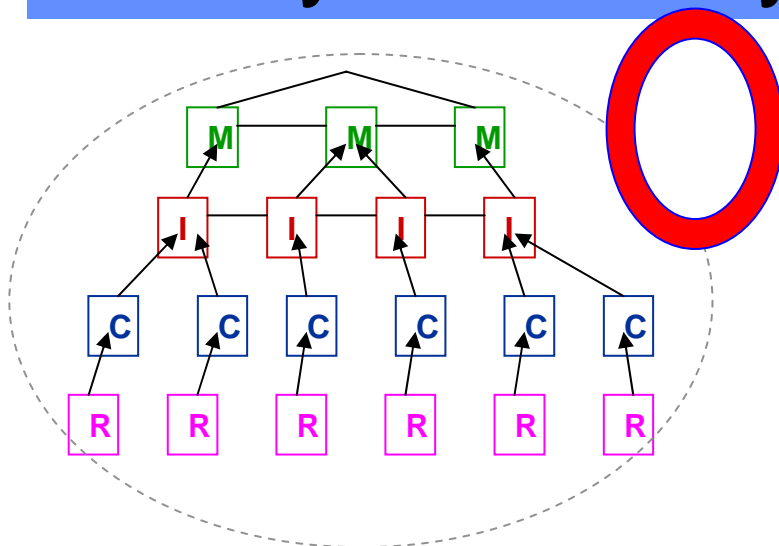
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Accounting in Autonomous Decentralized Systems



Quality in Overlay Networks



OMICON

A role based P2P protocol



Outline

I. Introduction

II. Analysis of hierarchical overlay structures

- Application Layer Simulation
- Analysis of the FastTrack Protocol
- The Multi-Layer-Overlay-Protocol

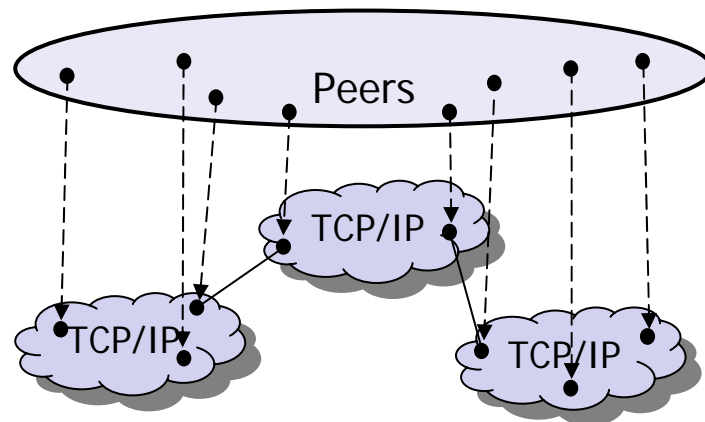
III. Summary and Conclusion



P2P Overlay Networks

Systems that are considered

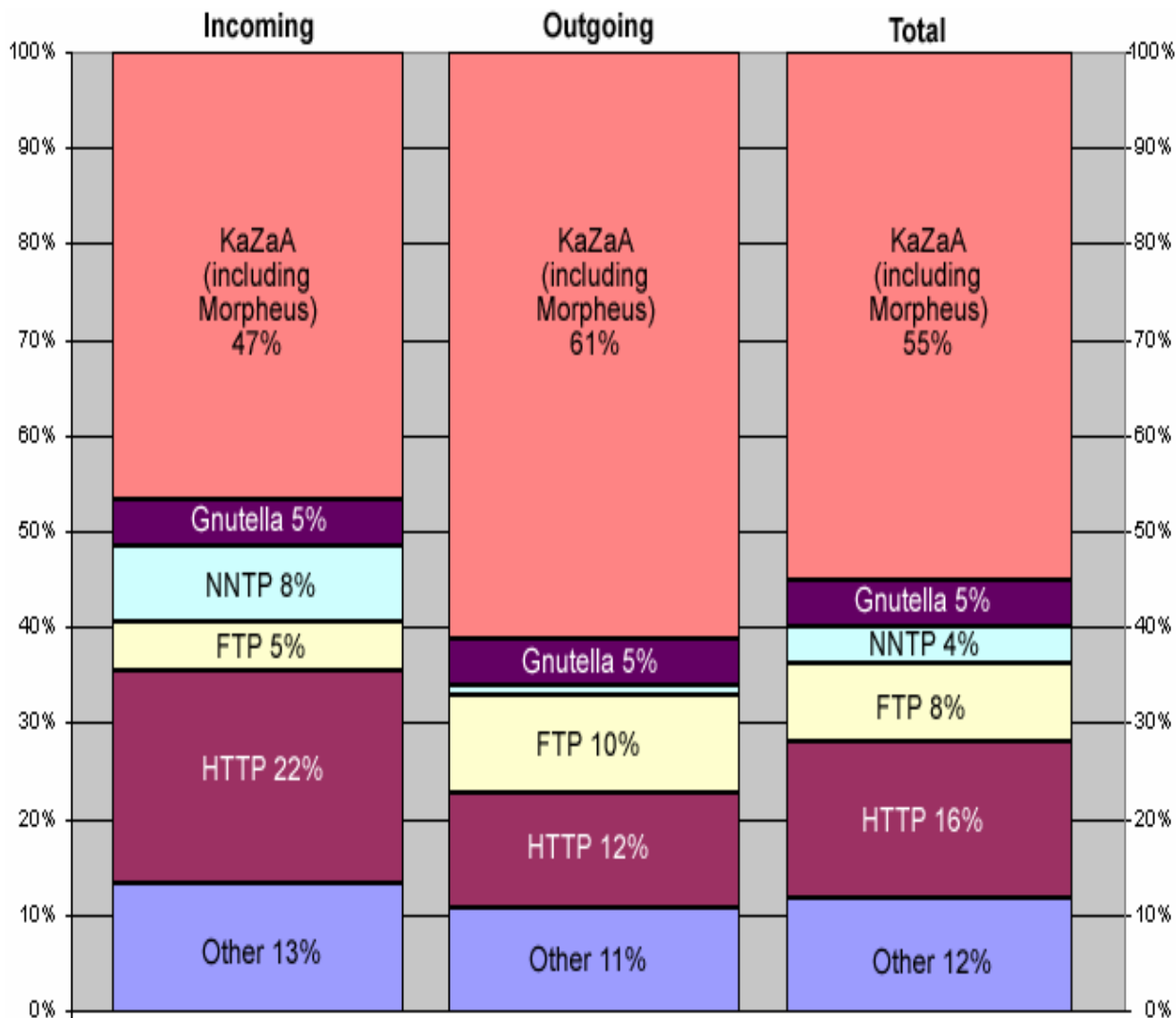
- Distributed, Autonomous, Self-organizing
 - P2P (Gnutella, KaZaA, etc.), companies' Intranets
- Assumption
 - Complete decentralization, no central control
- Advantages
 - Robust
 - Failures, Attacks, Censorship
 - Better Resource Utilization
 - Extensibility
 - light weight character
- Problems
 - Huge amount of (signaling) traffic
 - Dynamic behavior of P2P systems
 - Handle large networks





Prevalence of hybrid structures

- KaZaA
- Gnutella



Measurement traffic volume Germany 2004



Hybrid P2P Systems

Hybrid P2P systems have been used by the most popular file-sharing systems, such as KaZaA, Gnutella and Overnet.

- Largest overlay networks ever – very popular
- Cope with extremely dynamical user behavior
- Several millions users online
- Billions of files accessible
- Short search time, good hit rate.

⇒ Why are such Systems so successful?

⇒ Advantages useable for other application areas?

⇒ Concepts improvable?



Analysis of hierarchical Overlay Structures

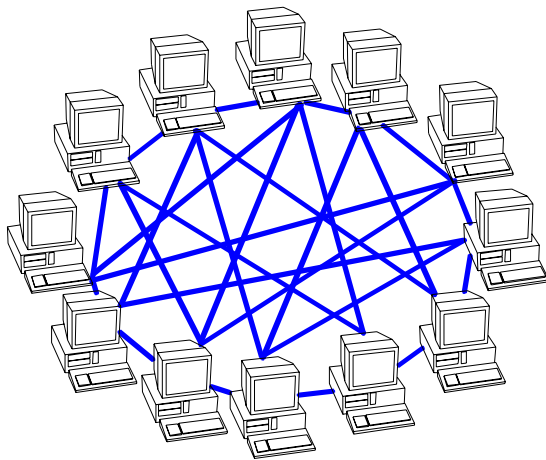
- Why were P2P systems so successful?
 - hybrid structures more effective than others?
- Advantages useable for other structures and systems?
 - Hierarchies for GRID?
 - Mixture with DHT?
- Comparisons of various hybrid structures:
 - Efficiency factor?
 - Application areas (size, user behavior)?



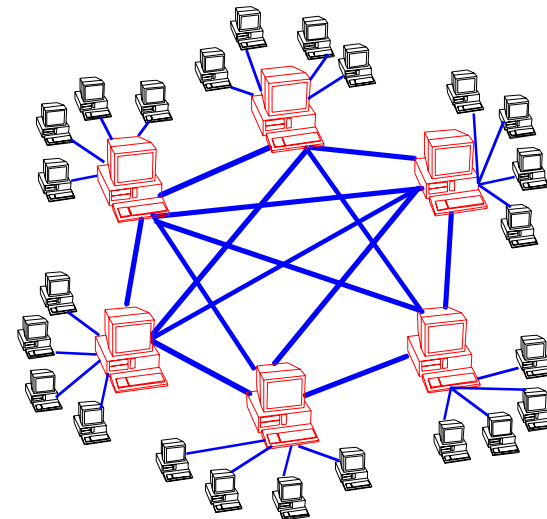
Hybrid and hierarchical Overlay Structures

KaZaA, Gnutella and Overnet:

- This hybrid P2P systems use hierarchical 2-tier structures.



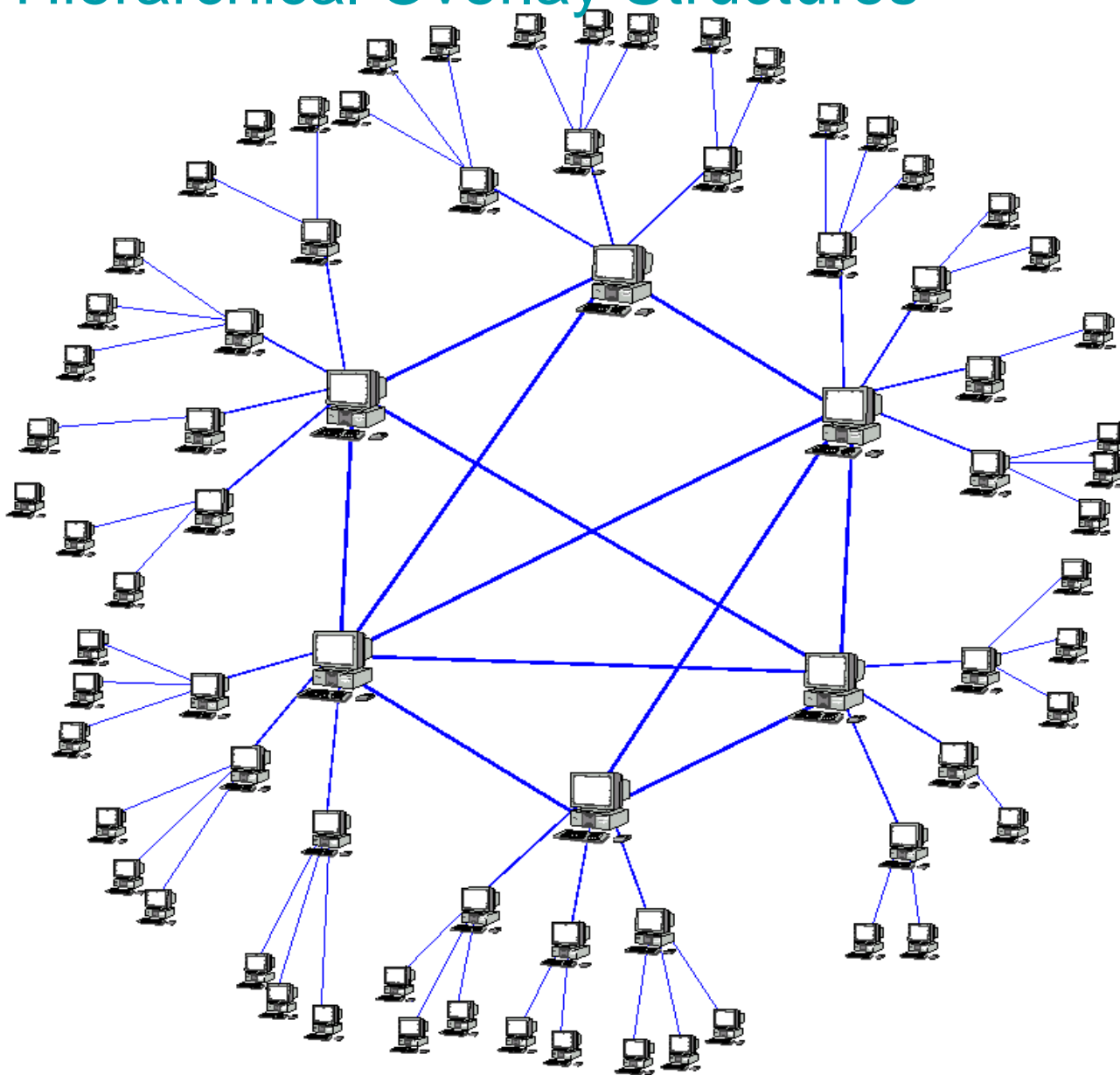
Pure P2P - No central entities



Hybrid P2P – dynamic central entities



Hierarchical Overlay Structures





A Generic Application Layer Simulation

Application Layer Simulation (ALS) Features/Properties

- High abstraction level
- Application Layer details
- Easy to learn and use
- Flexible and extensible
- Efficiency

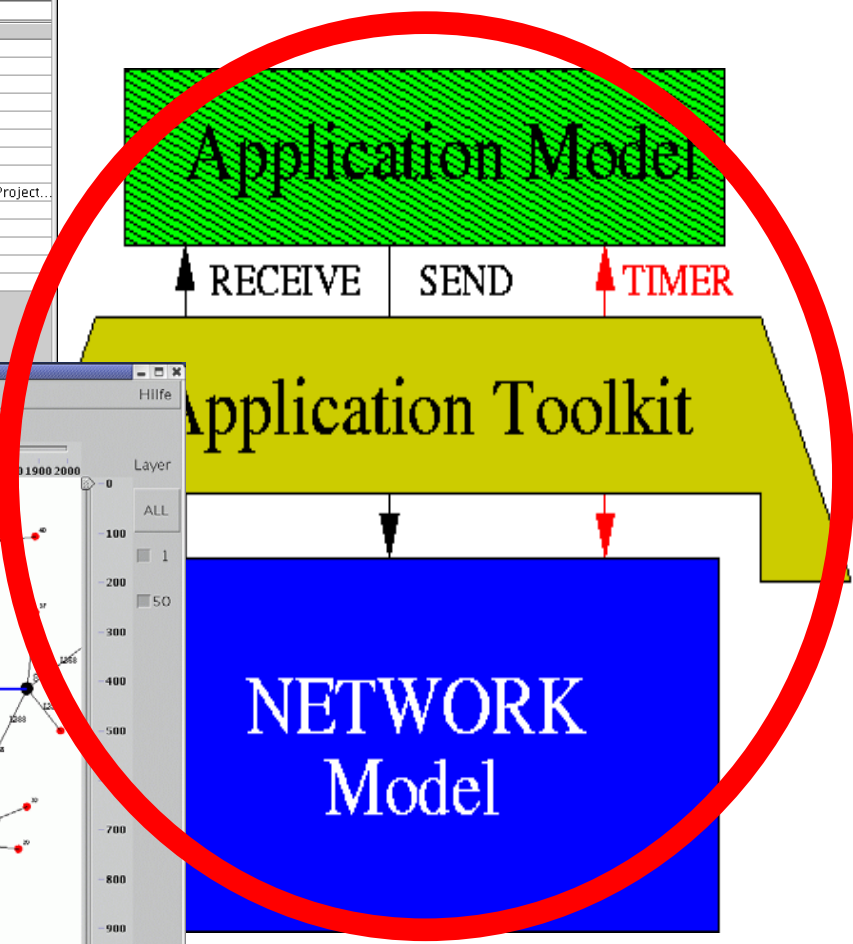
Expected analysis results

- Traffic characterization
- Traffic volume and overlay topology
- Systems dynamics
- Complete view of overlay traffic
- Proof of concept for overlay protocols



A Generic Application Layer Simulation

Architecture



Simulator MainFrame

File Config Run Help

Simulation Output

```
simp2p.cc:84 Read Parameterfile "/home/birck/src/simp2p/parameter.ini"
parameter.cc:65 ** read /home/birck/src/simp2p/parameter.ini
generator.cc:14 On-time Pareto 1,2, 18
generator.cc:22 Interarrival CNNegExp
generator.cc:33 Info - read dpf topology /home/birck/src/drawProject/net4.dpf
topology/simtopology.cc:720 ** read dpf /home/birck/src/drawProject/net4.dpf
topology/simtopology.cc:814 69 nodes
generator.cc:55 NAM-file net4.nam = 1
namoutput.cc:20 create new NAM-file "net4.nam"
namoutput.cc:33 -l- open "net4.nam"
network.cc:40 Location: 45 Type: 3
```

Config Parameter

Name	Value
keepalive	40
nopeers	200
staticpeer	5
peer	n20,
peer	bACTIVE
interarrival	0.0375
MsgSize	82
simend	1000
topofile	/home/birck/src/drawProject...
namfile	net4.nam
rankTableSize	100
maxfilesize	40000
minfilesize	1000
meanfilesize	20000

draw Project Network (C) 15.11.2002 by HEB - ALS ScenarioEditor

Datel Config Tools

The network graph shows a complex set of nodes (represented by red and black dots) connected by edges (represented by blue and red lines). The nodes are labeled with numbers, and the edges are labeled with IP addresses. The graph is displayed on a coordinate system with X and Y axes ranging from 0 to 2000.

Simulation

Analyse

quit

ok

Clear

Filter

other

X: 69 Y: 104 State: Node Zoom: 1.0 DrawLayer: 5 GridX: 010 GridY: 010

typ WAN

Welcome to the draw Project (C)



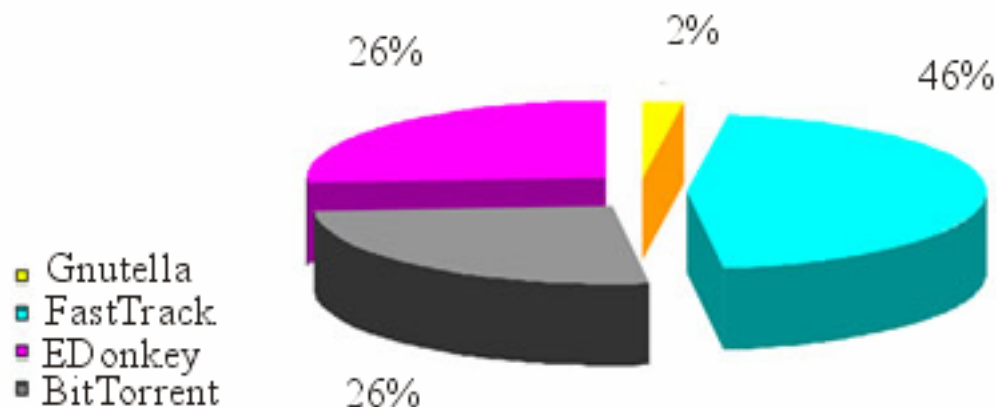
Demo



Analysis OpenFastTrack Protocol

- Other peer-to-peer protocols are already analyzed
 - Gnutella, EDonkey at the TUD
 - FastTrack is one of the last challenges
- FastTrack was the most popular file sharing protocol
 - Responsible for huge amount of network traffic
- Understand the protocol behavior for simulation purpose
 - Function
 - Timing
 - Traffic efficiency

Januar 2004

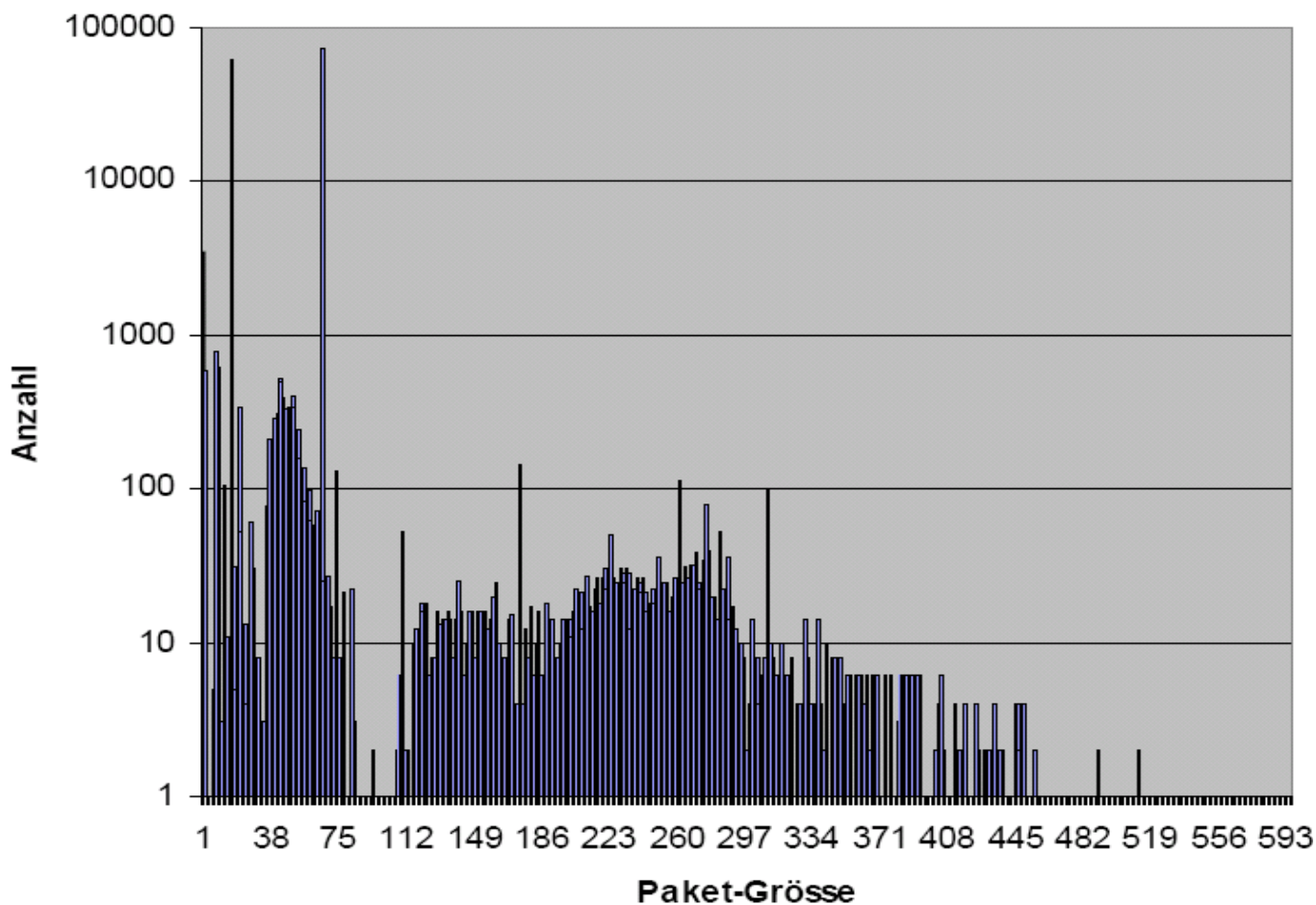




Measurements

Measurement of the traffic behavior

- Join & leave, Retrieval process
- Timing, On/Off times, packet sizes





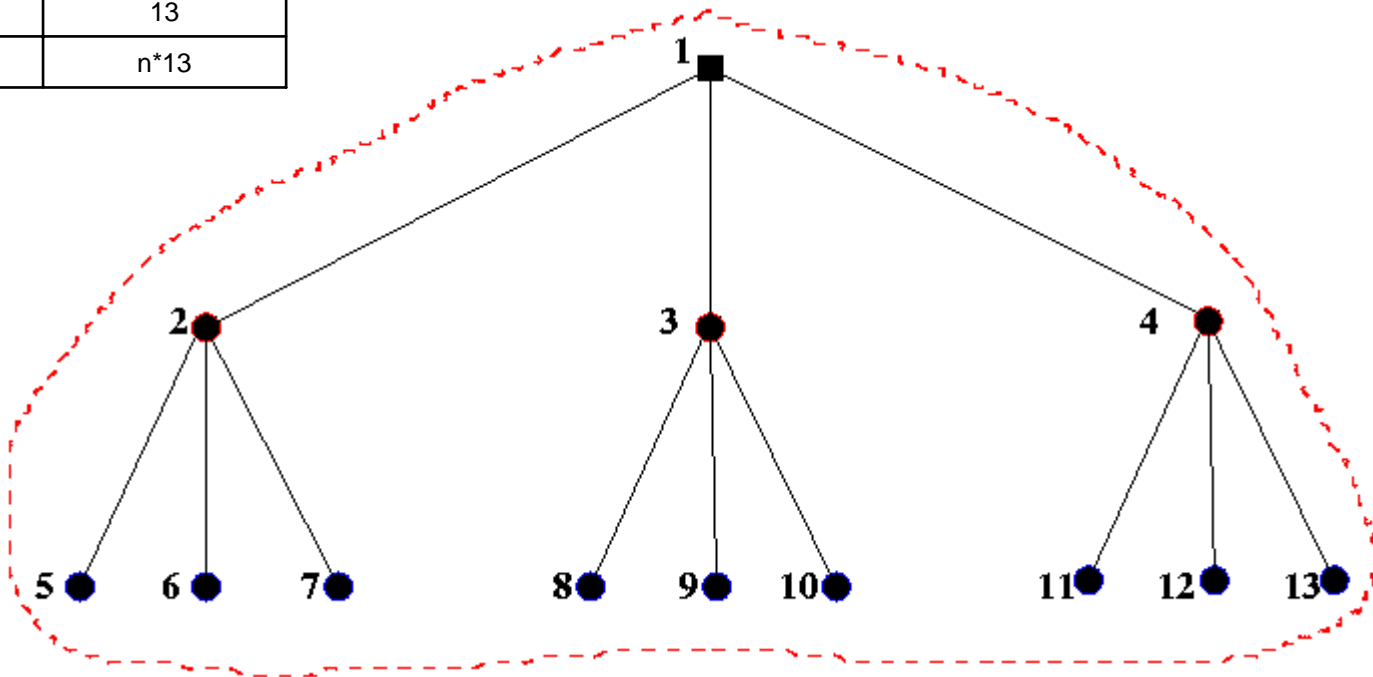
Our Approach: MLOP

- Conception and implementation of a simple *Multi-Layer-Overlay-Protocol (MLOP)* based on OpenFastTrack protocol
- P2P Overlay Network Design Mechanisms in large-scale, heterogeneous, dynamic environments
- Design goals for MLOP
 - Analysis protocol
 - Lightweight
 - Reduced signaling traffic
 - Simple routing algorithms



Searching in hierarchical structures

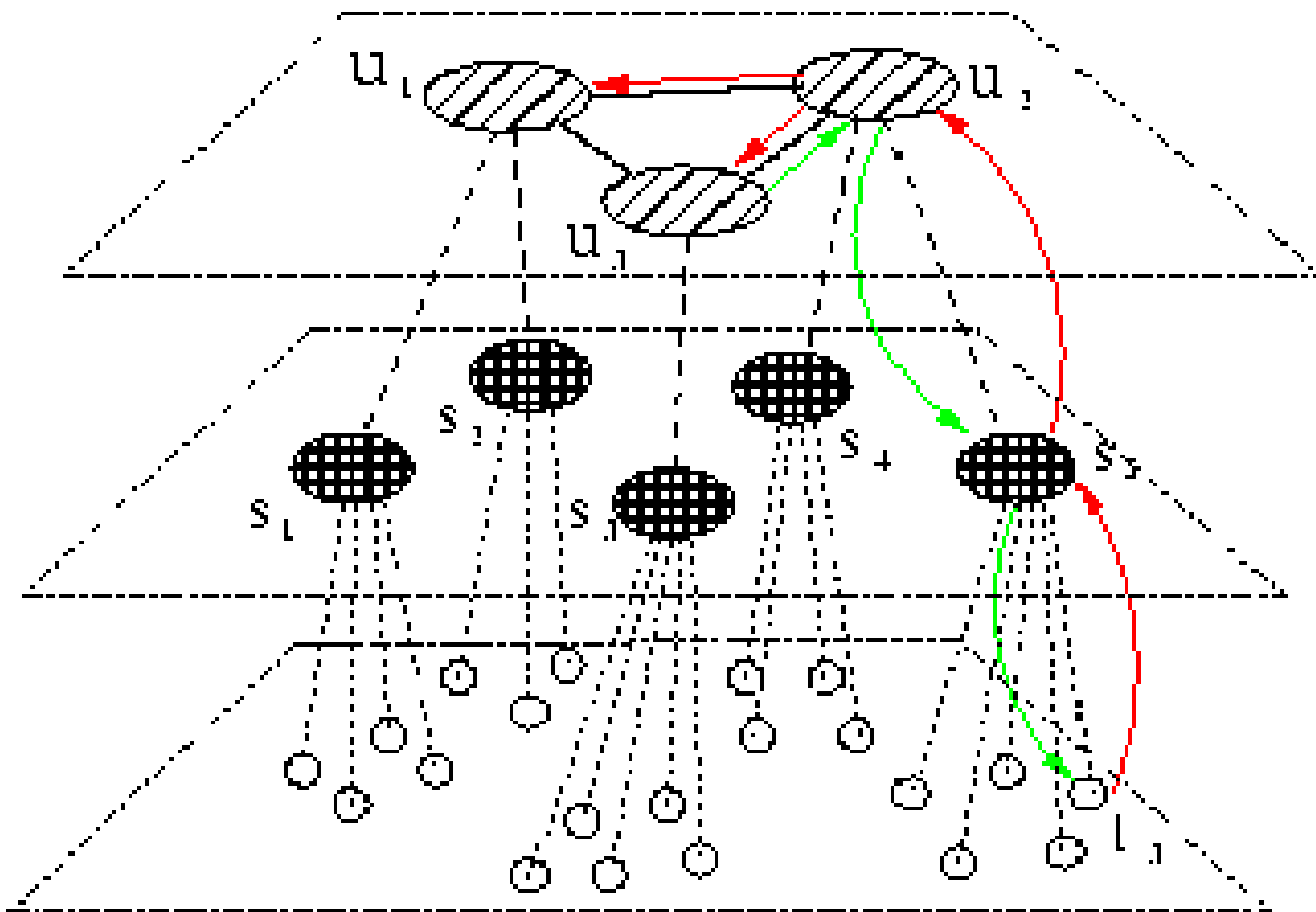
Hop	Nodes
0	1
1	4
2	13
3	$n \cdot 13$





Searching in hierarchical structures (2)

<http://www.kom.tu-darmstadt.de>





Experiments

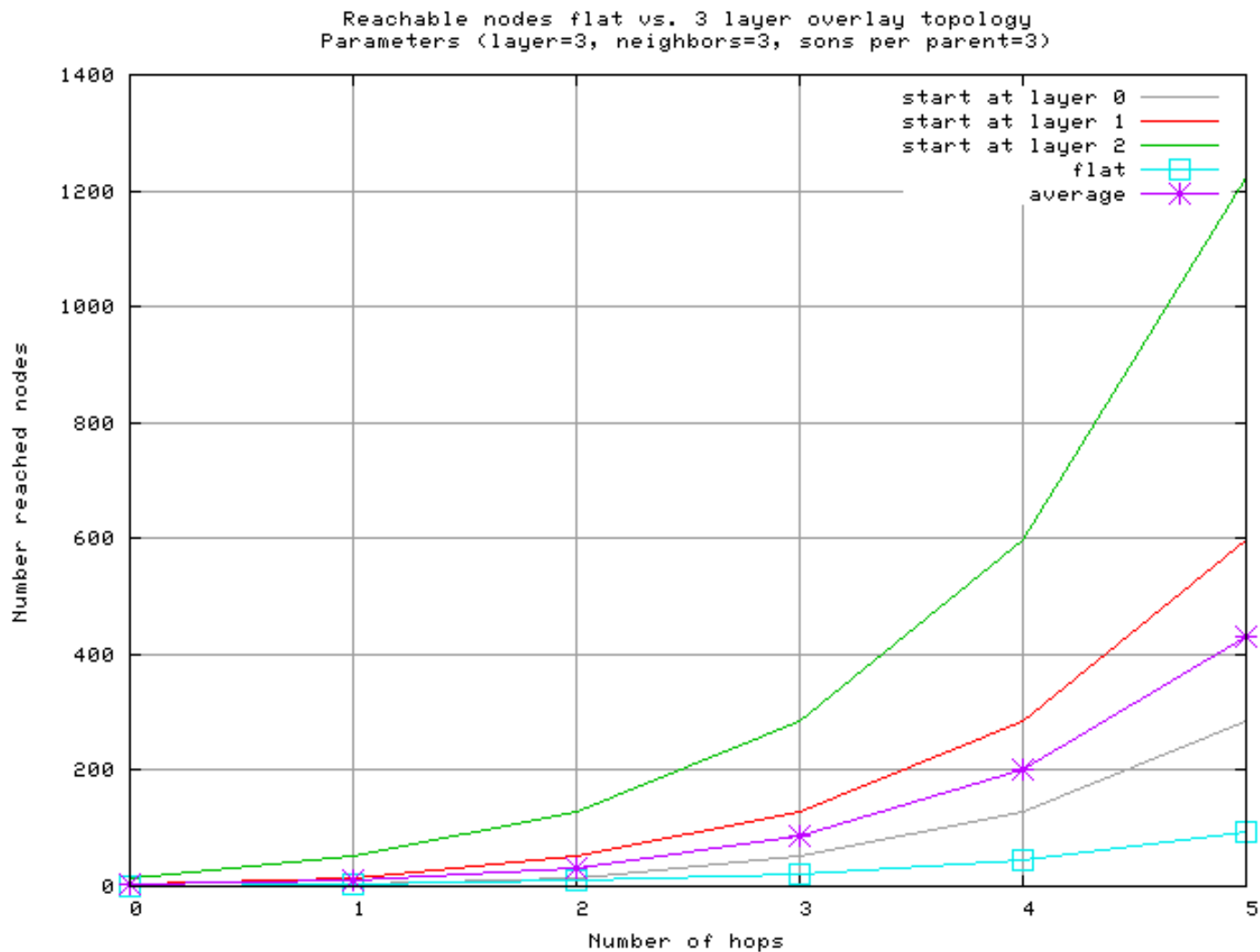
“General statement for the (dis-) advantages of hierarchical structures in dynamic overlay networks.”

- Application area
 - Performance vs. signaling traffic
 - Network size
 - Scalability
 - Topologies (clustering)
- Experiments of overlay networks with various ...
 - Dynamics (on/off, join& leave, queries)
 - Topologies (logical + physical)
 - Hierarchies (1-2-3-4 layer)



Theory of Reachable Nodes

<http://www.kom.tu-darmstadt.de>





Theory of Reachable Nodes (2)

1. Reachable nodes for flat topologies (flooding)

$$r_1 = 1 + n \frac{(n-1)^h - 1}{n-2}$$

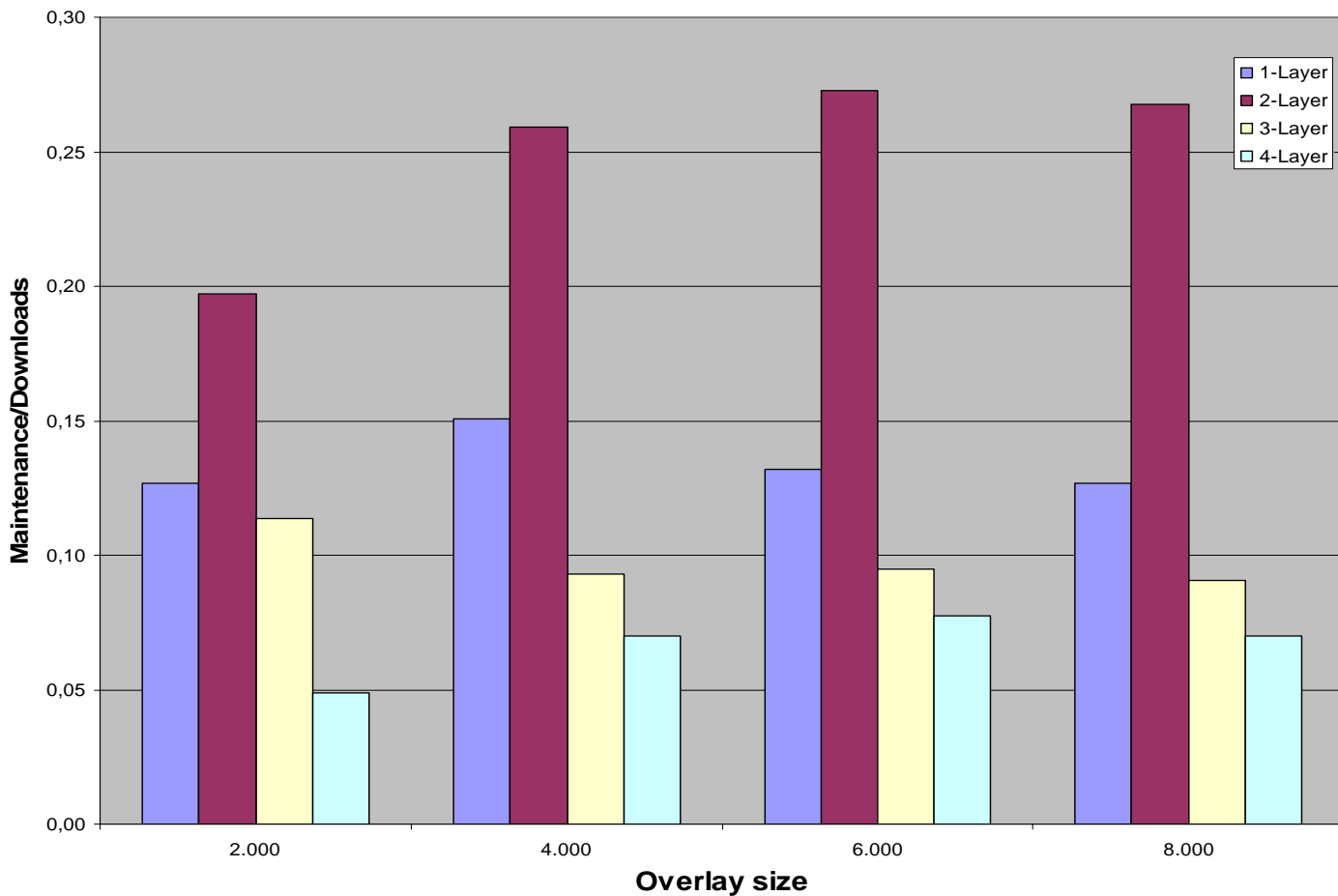
2. Reachable nodes for hierarchical topologies

$$r_l = \begin{cases} \sum_{j=0}^{l-1} s^j + \frac{n}{n-2} \sum_{j=0}^{l-1} s^j (n-1)^{h-j} - s^j & : l \geq h \\ \sum_{j=0}^h s^j + \frac{n}{n-2} s^h \sum_{j=0}^h \left(\frac{h-1}{s}\right)^j - \left(\frac{1}{s}\right)^j & : l > h \end{cases}$$



Comparison

Efficiency factor

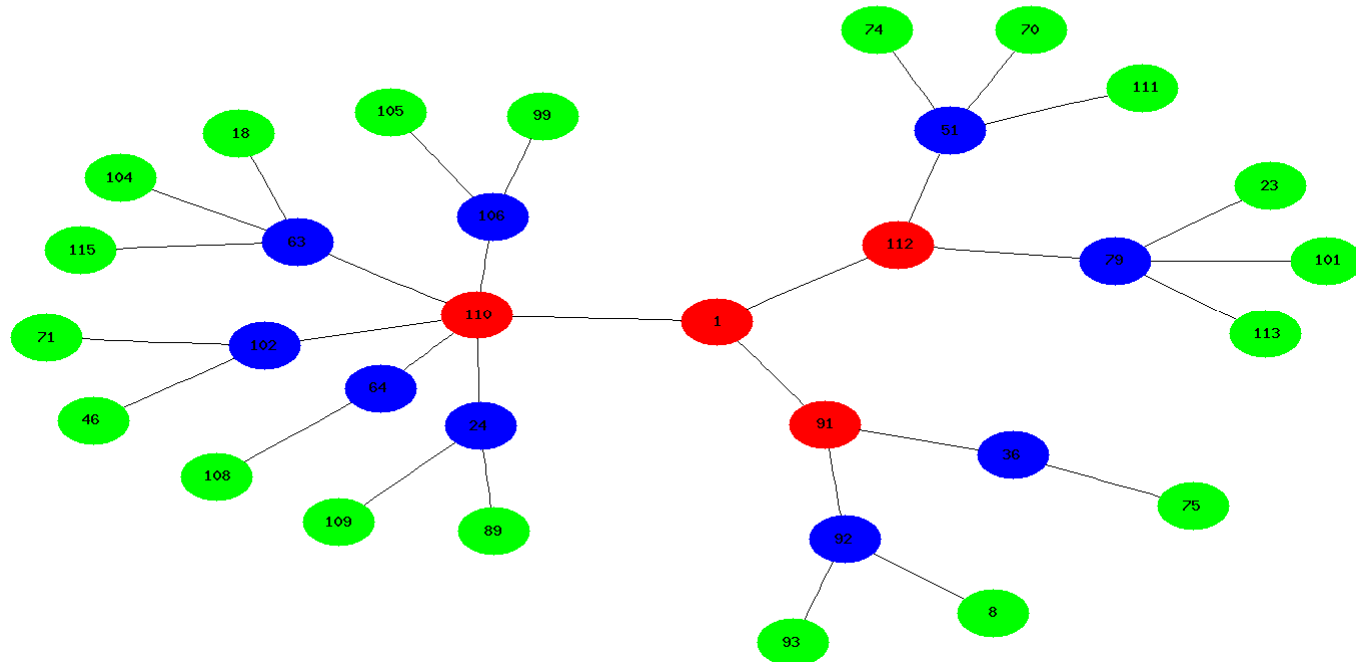


Efficiency factor:
maintenance costs/number successful download



Conclusion

Quality of achieved Network topology





Ongoing Work/Future

- Challenges
 - Clustering/Cliquish
 - Quality of graph structure
- Improvements of MLOP
 - Redundancy
 - Replication index
 - Link concept
- Future trends
 - Technology mixture (DHT + hierarchies).



Summary

- Hierarchical Overlay Structures
 - Prevalence of hybrid systems
- Analysis Framework
 - Application Layer Simulation
 - Analysis OpenFastTrack Protocol
- Multi-Layer-Overlay-Protocol
 - Lightweight protocol for analysis purpose
- Evaluation
 - Strong impact of dynamic behavior



Thank you!



- Contact:
 - Hannes Birck
 - birck@kom.tu-darmstadt.de
- Download ALS/MLOP:
 - <http://www.kom.tu-darmstadt.de/~birck>