A Testbed-based Analysis of the Incorrect Lookup Routing Attack on the Pastry DHT

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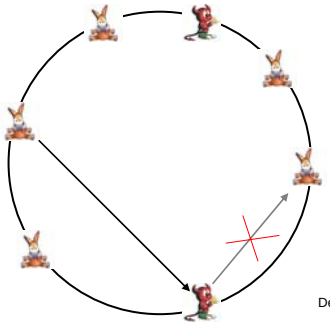

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Peer-to-Peer Networks

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Several applications

- File sharing, (voice) chat, file storage, video streaming …
- About 40 % of internet traffic caused by P2P

Distributed hash tables (DHT)

- Scales well to the network size
- Decentralized and self-organized

BUT:

- Nodes have to rely on other nodes

THUS:

- Low effort but high impact attacks easily possible

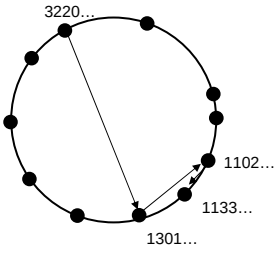

Image source: skype.com ateranetworks.com joost.com emule-board.de

Outline

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Motivation

Attacking DHTs
- Classification of Node Behavior
- Incorrect Lookup Routing

Evaluation
- Testbed-based Evaluation
- Analysis of results

Conclusions

Classification of Node Behavior

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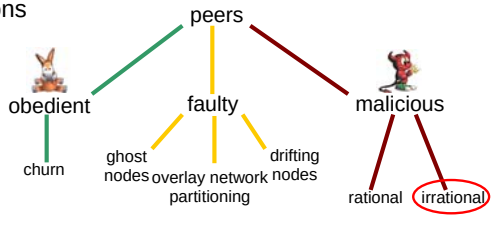
Peers can be categorized into
- 'Obedient' peers
  - Behavior according to protocol specifications
  - But also here: Churn (peers joining and leaving the system)
- Faulty peers
  - Effects of implementation errors
  - Effects of unexpected disconnections
- Malicious peers
  - Rational:
    Goal is maximizing own benefit
  - Irrational:
    Tamper with network services



Our Focus: Irrational behavior

Incorrect Lookup Routing

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Incorrect Lookup Routing

- Forward or redirect packets
  - Denial of service
- May be combined with …
  - Sybil or Incorrect Routing Update attack
  - To increase impact

Attack depends theoretically on

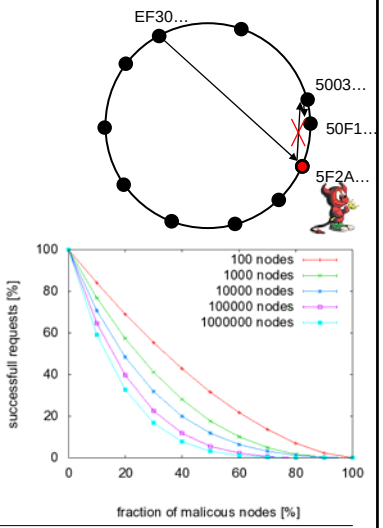
- Fraction of malicious nodes f
- Number of overall nodes N
- Pastrys configuration parameter b
  - Influences the routing table size

Formula [4]:

$$\sigma = (1 - f)^h$$

With h as the average number of hops [5]:

$$h_{Pastry} = \log_{2^b}(N)$$



How to Evaluate P2P Networks?

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Analyzing P2P networks

- Analytic — Large systems, high abstraction
- Simulation — Medium systems, medium abstraction
- Testbed — Small systems, low to no abstraction

PlanetLab

- Nodes distributed around the world
  - 1068 nodes at 494 sites
- Heterogeneous hardware
  - Strong / weak nodes
- Heavy load

G-Lab

- Nodes distributed around Germany
  - 153 nodes at 6 sites
- Homogeneous hardware
  - Every node is equal
- Low load

Image Source: planet-lab.org german-lab.de

Testbed-based Evaluation

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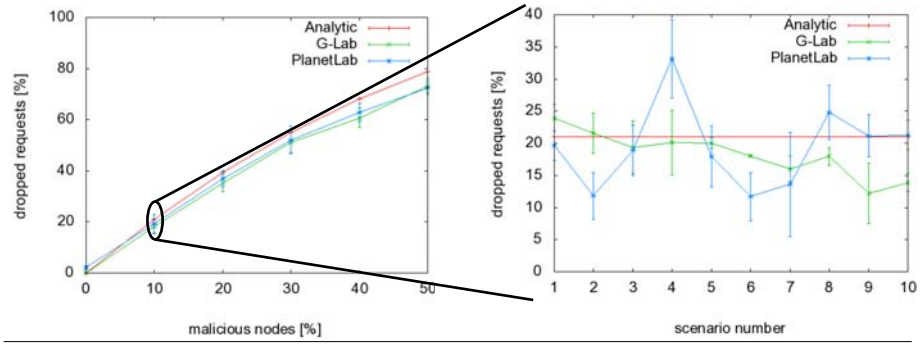
Homogeneous G-Lab

- Nodes which are online longest have strong impact

Heterogeneous PlanetLab

- Nodes with good link quality have strong impact



Analysis of results

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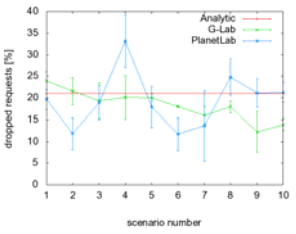
Observation: Differences between testbeds

- Result of Pastry's proximity metric
- Other metrics may provide better robustness



Chord metric

- Node IDs are distributed equally in the ID-space
- Routing table stores links to nodes
  - With an ID closest to a specific ID
- Malicious nodes can not misuse this metric

Kademlia metric

- Nodes that are online for the longest time are preferred
- Can be misused by malicious nodes
  - BUT: Efficient when a countermeasure excludes malicious nodes

Security metric?

- A metric based on route reliability may increase the security

Conclusions

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Important factors not yet covered by analytical model

- Metric of the DHT
- Structure of the network

Increasing robustness and availability of DHTs required

- Adapt the metrics to include security schemes
- Consider the field of application
  - Different network characteristics should not influence network robustness

Future Work

- Analyze known countermeasures
  - Reveal unconsidered influences
- Improve the robustness of the DHT against routing attacks

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Thank you for your attention.
Any questions?

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