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Impact of Route Caching on Route Discovery Delay in Ad Hoc Network

5. Würzburger Workshop
„IP-Netzmanagement, Netzplanung und Optimierung“

Würzburg, 19.07.2005

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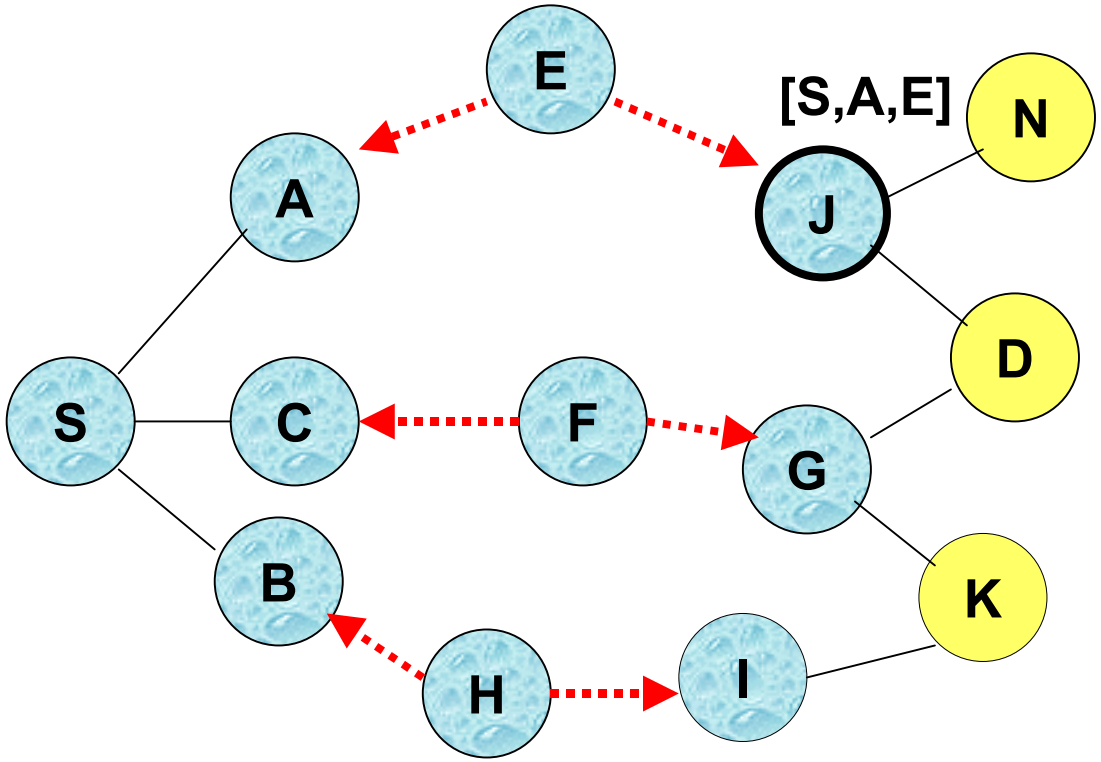
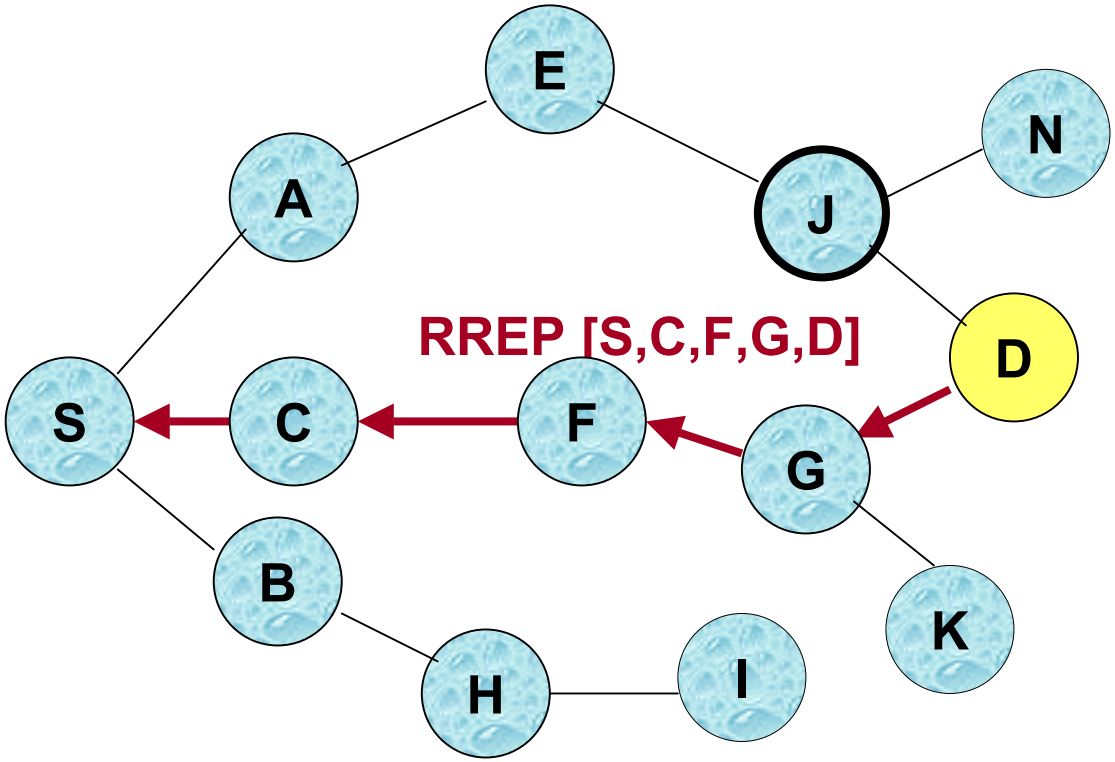
Route Discovery



J receives Route Request [S,A,E],
node J caches route [J,E,A,S] to node S

Route Request

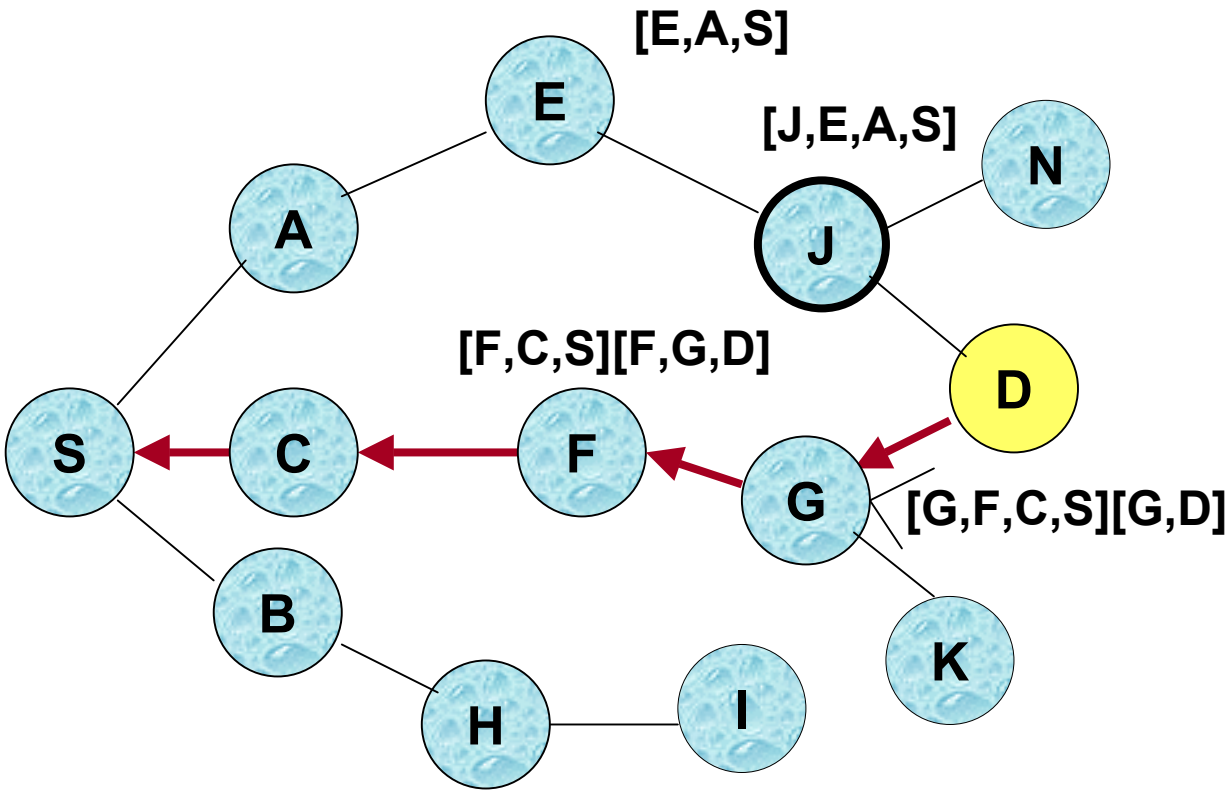
Route Reply



When node F forwards Route Reply RREP [S,C,F,G,D], node F caches route [F,G,D] to node D

← Route Reply

Use of Route Caching



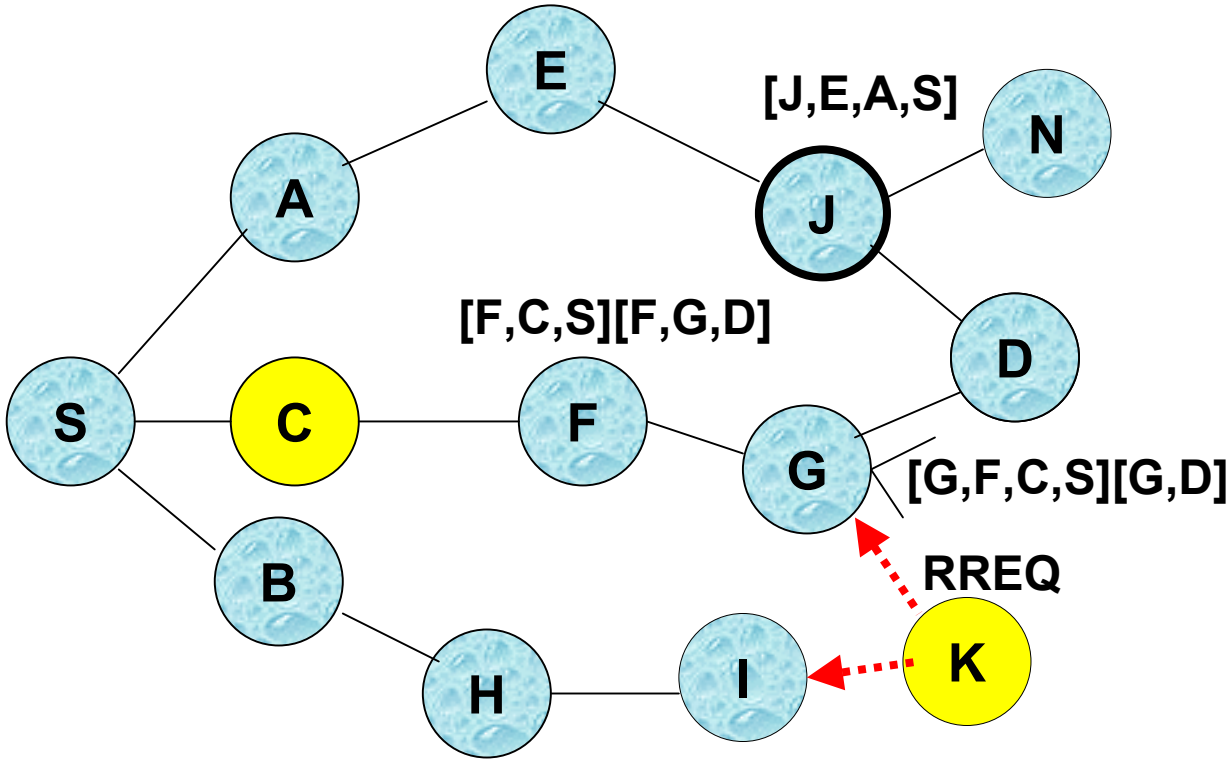
Not all cache entries are shown

[E,A,S] Represents cached route at a node

← Represents RREP control message

Use of Route Caching

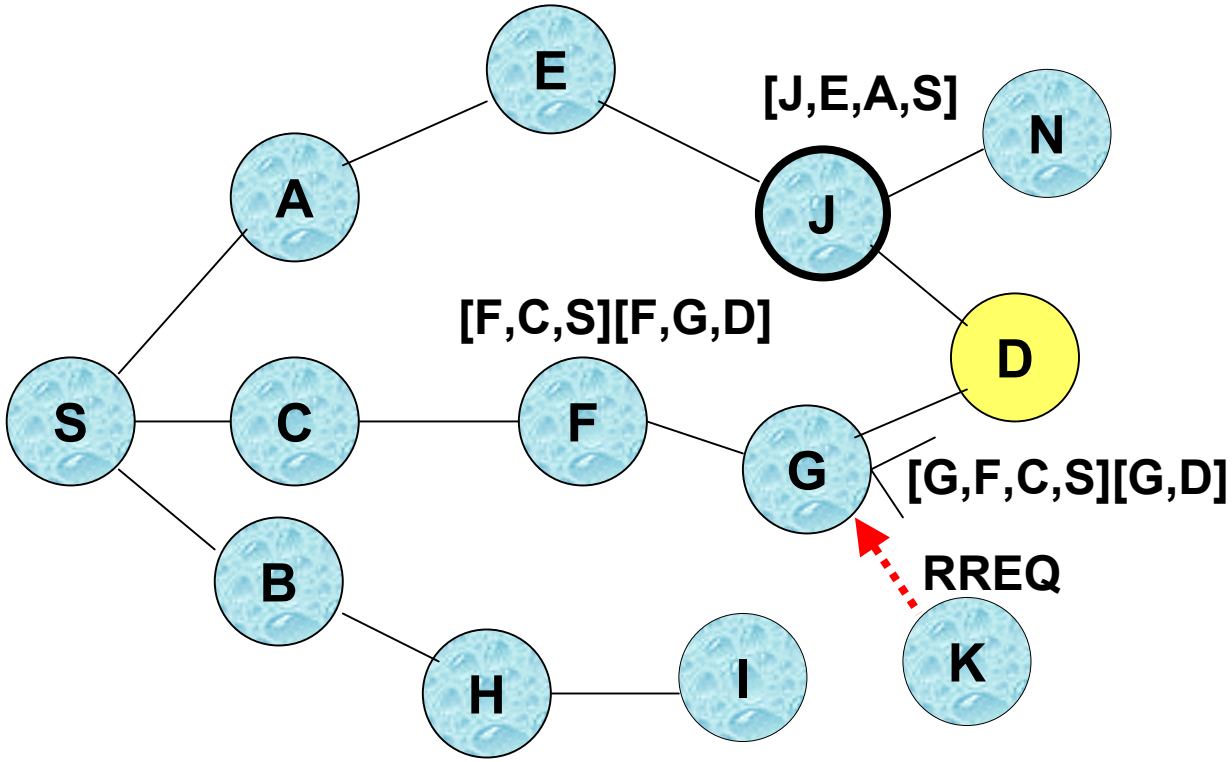
speed up route discovery



When node K sends a Route Request for node C, node G sends back a route reply [K,G,F,C] to node K using a locally cached route

Use of Route Caching

reduce propagation of route requests



Route Reply (RREP) from node G limits flooding of RREQ.

Use of Route Caching

- Route caching as a mechanism to reduce route discovery overhead
- When a route is detected as broken, nodes may:
  - Use another cached route from local cache, or
  - Obtain a new route using cached route at another nodes
- Each node may cache one or more routes to a given destination

Analysis of Route Discovery Delay

expected number L of hops from the source to the intermediate node which can answer with a route from its cache

$$L = (1-P_0)P_1 \cdot 1 + (1-P_0)(1-P_1) \cdot P_2 \cdot 2 + \ldots + (1-P_0)\ldots(1-P_{H-1})^{H-1} \cdot P_H \cdot H =$$

$$= \sum_{i=1}^{H} \left[\prod_{k=1}^{i} (1-P_{k-1}) \right] \cdot P_i \cdot i$$

P_i probability that route is found in route cache of nodes that are i hops away from the source

H average number of hops to the destination

Analysis of Route Discovery Delay

probability that route is found in route cache of nodes

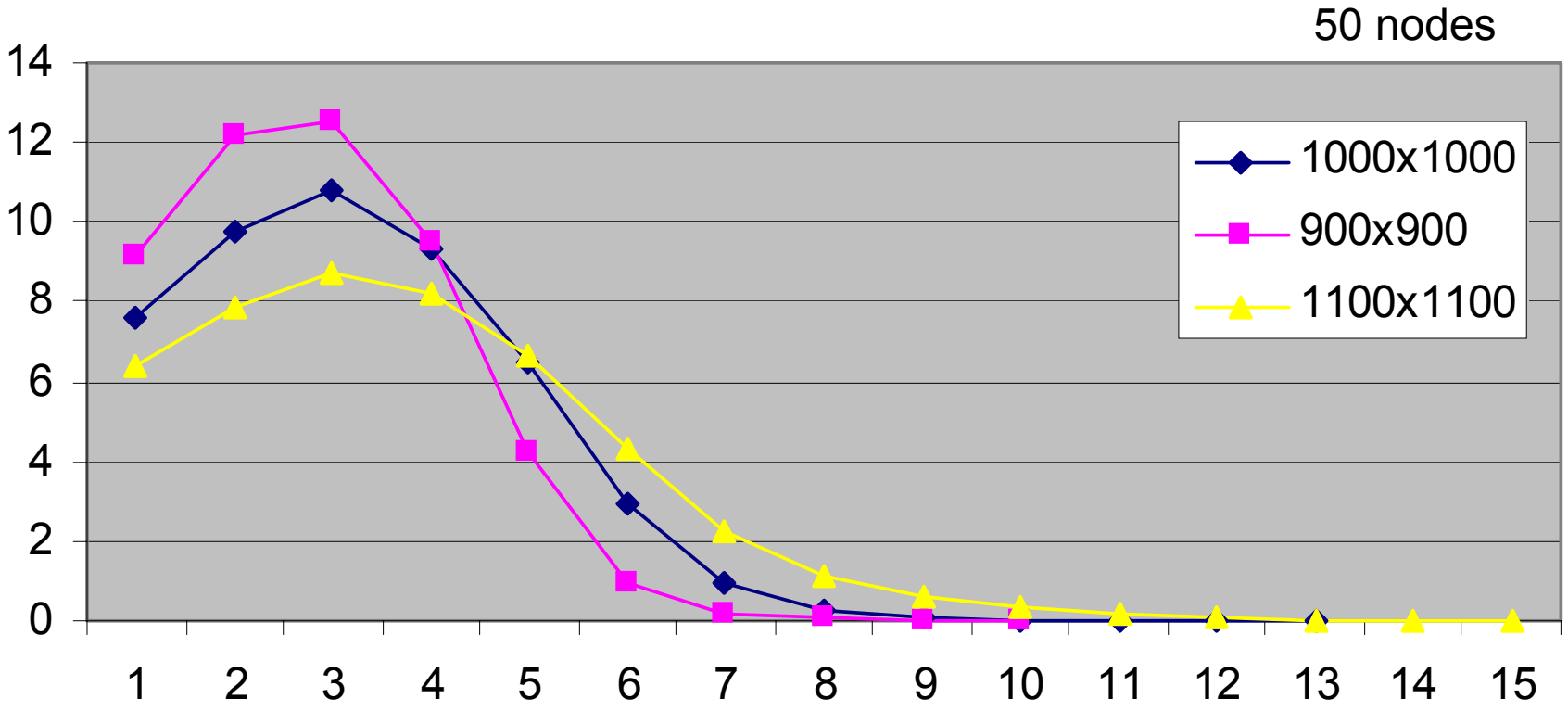
that are i hops away from the source

$$P_i = 1 - (1 - P)^{q_i}$$

q_i number of nodes i hops away from the source,

P overall cache hit rate:
probability that the reply with a requested route exists in the route cache

Number n-hop neighbours



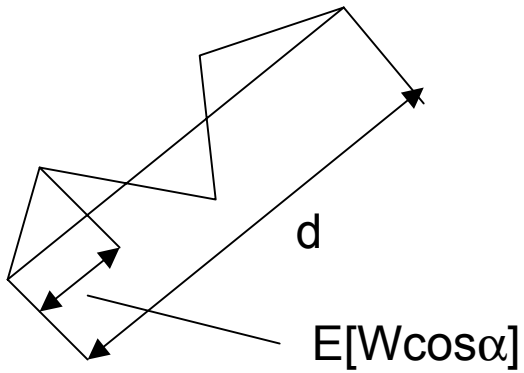
Average Number of Hops

$$H \sim \frac{\ln(N)}{\ln(k_{ave})}$$

$$H \approx \frac{d}{E[W\cos\alpha]},$$

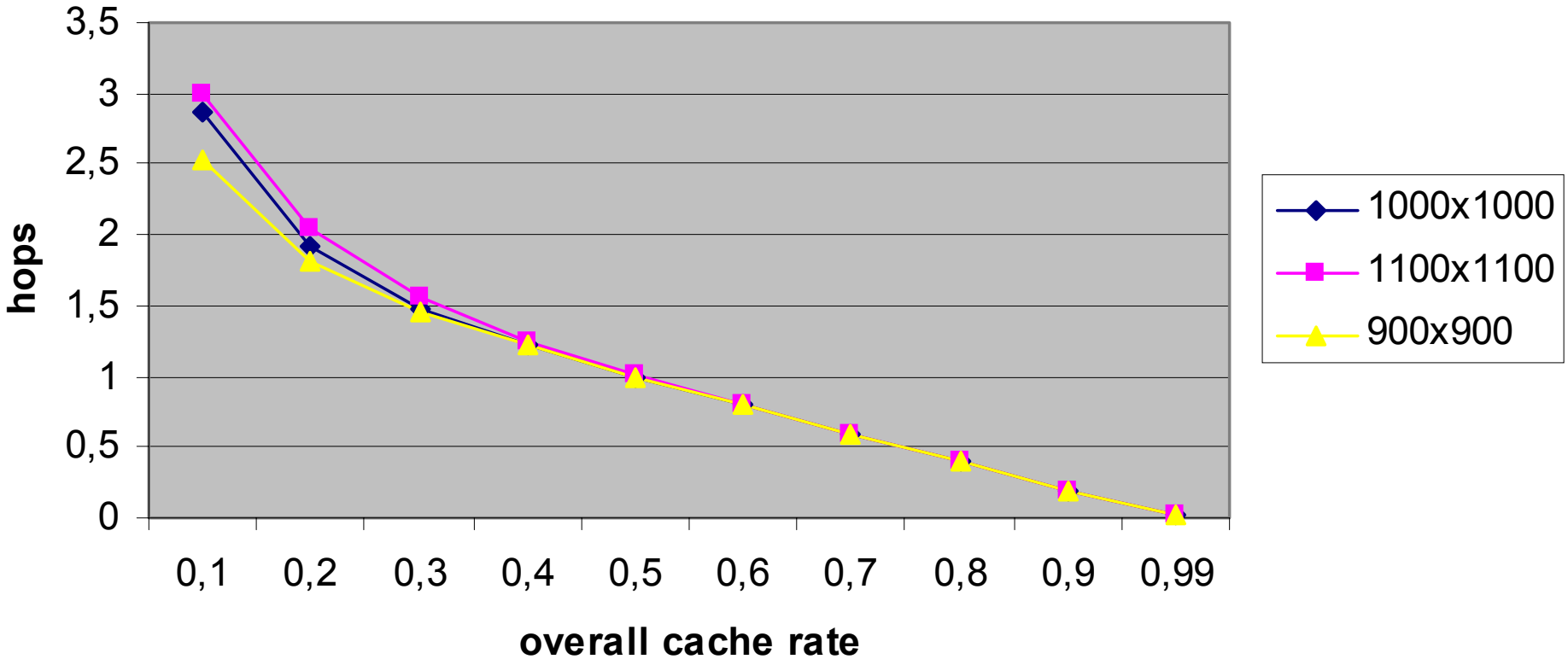
$$E[W\cos\alpha] = E[W]E[\cos\alpha]$$

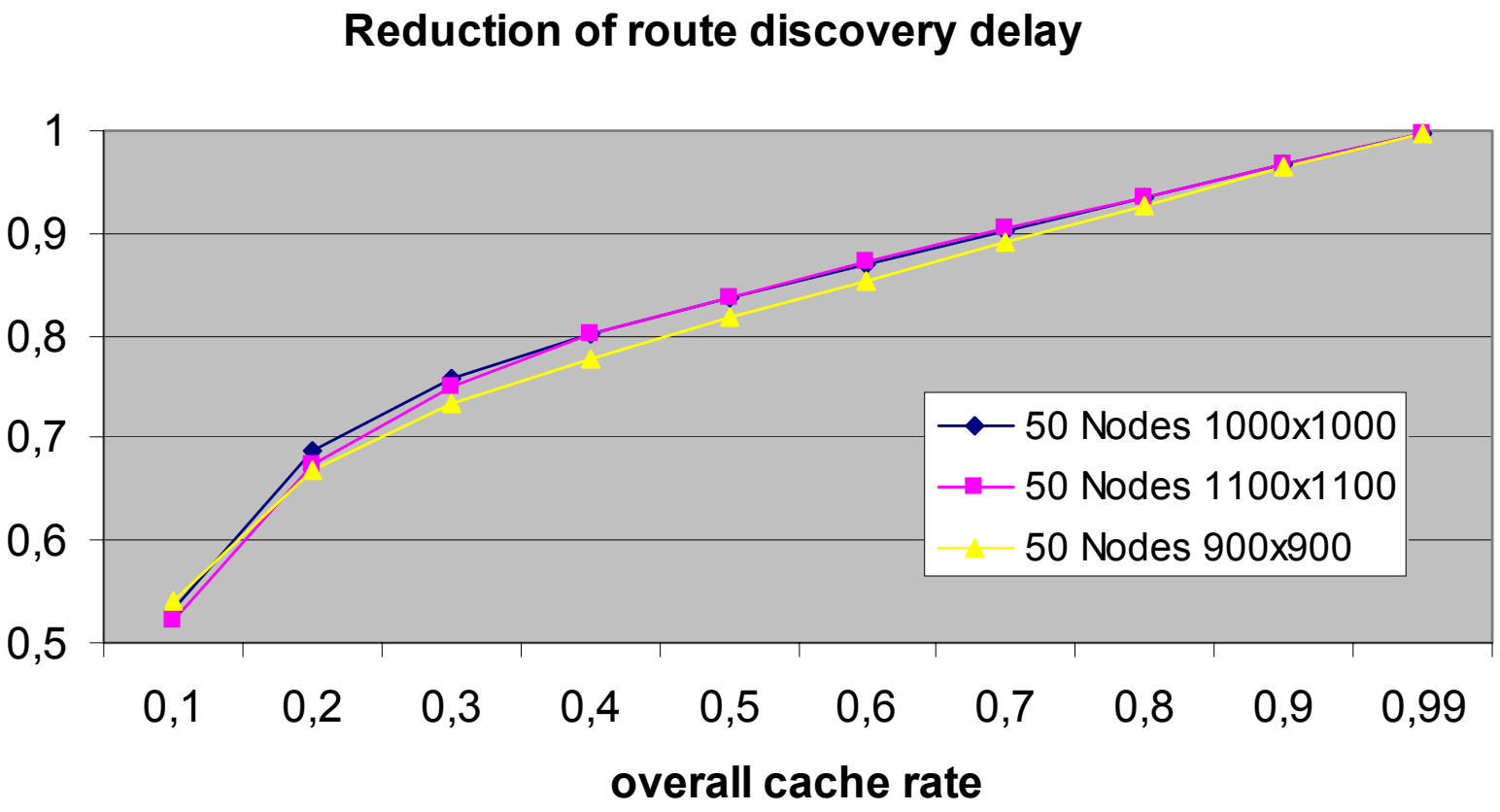
$$E[\cos\alpha] = \frac{2}{\alpha}\sin\frac{\alpha}{2}$$



α deviation from reference path
uniformly distributed in $[-\alpha/2, \alpha/2]$

Average number of hops to find a cached route




Reduction of route discovery delay
1
0,9
0,8
0,7
0,6
0,5
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
0,99
overall cache rate
50 Nodes 1000x1000
50 Nodes 1100x1100
50 Nodes 900x900

Invalid Caching Entries

- Caching can result in faster route discovery
- Faster does not necessarily mean correct
- Due to mobility cached routes may become invalid
- Extension of model with cache miss rate

$M=(4L+2H)P_m+ 2L(1-P_m)$

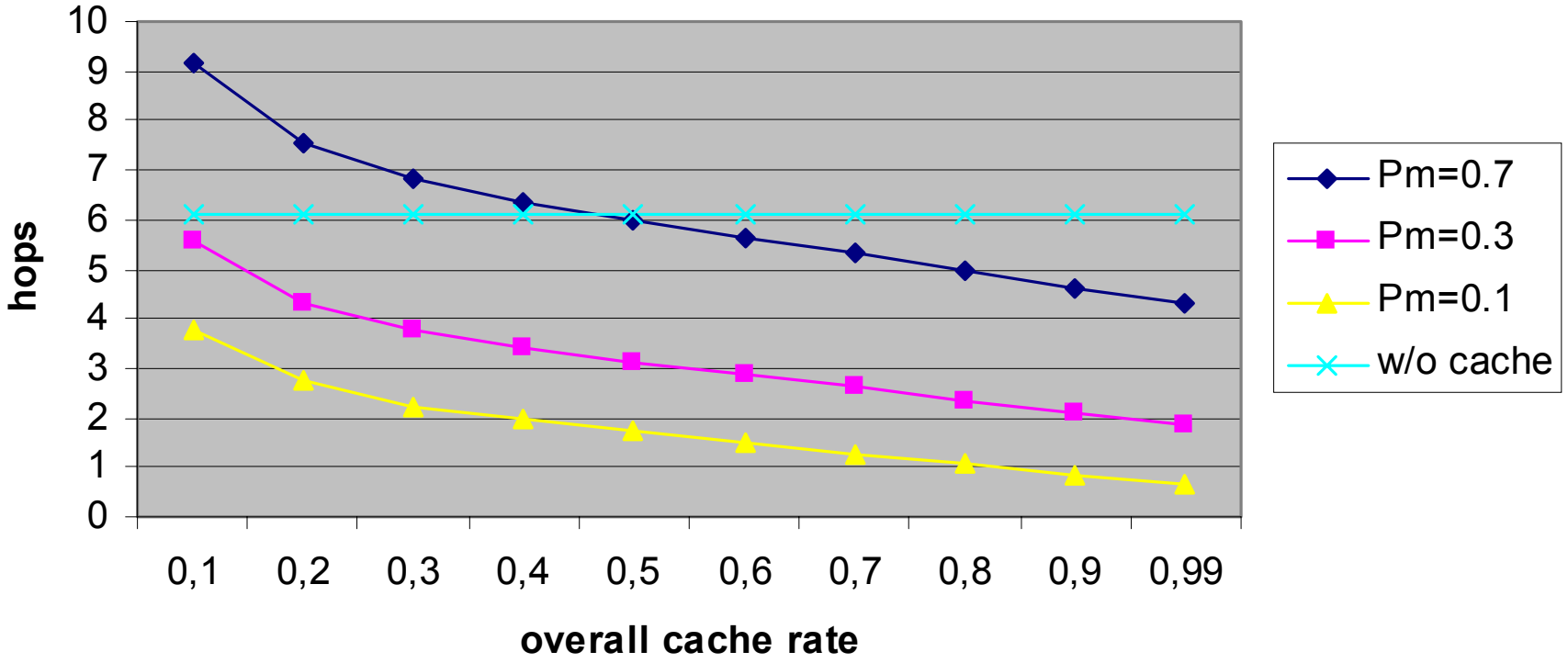
M – average delay (in hops) to find a route

P_m – cache miss rate

L - hops that to the intermediate node with a route from its cache

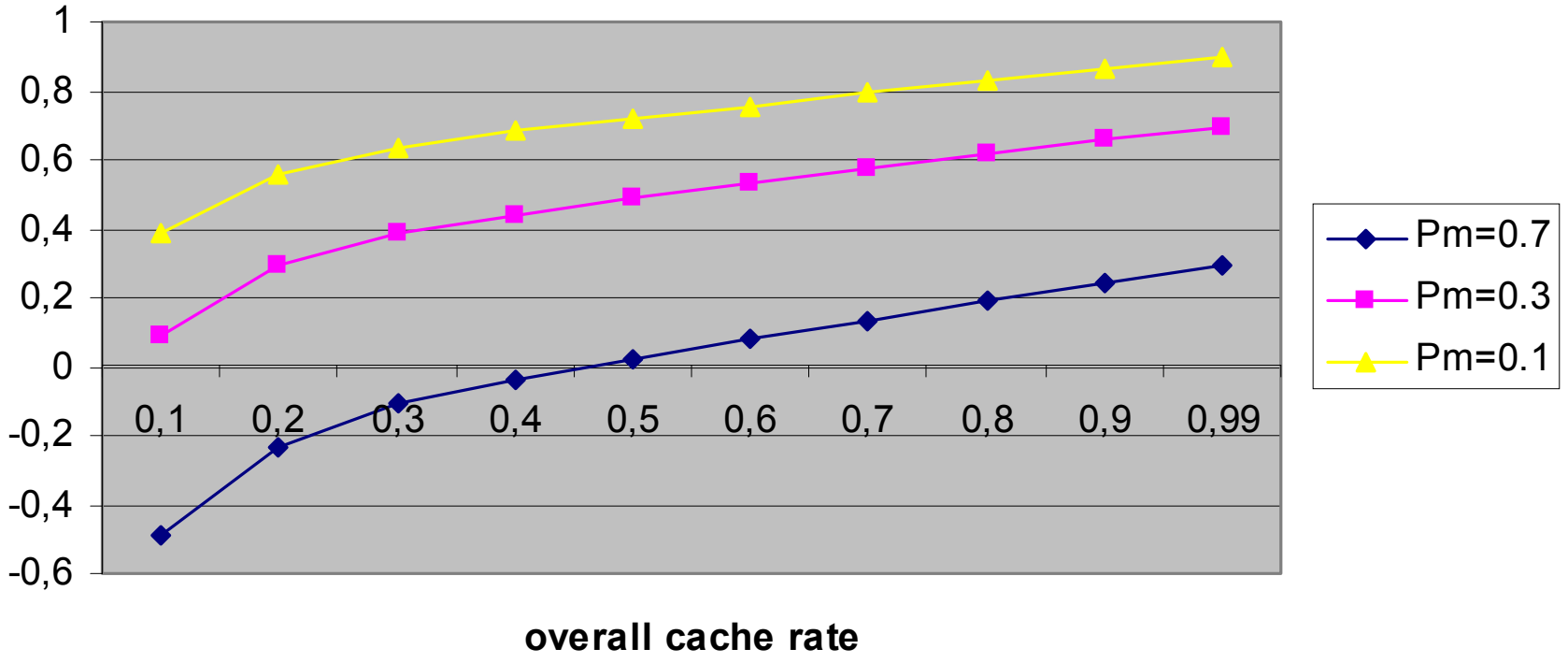
H – average number of hops from source to destination

Discovery Delay



50 nodes 1000x1000

Reduction of Discovery Delay



50 nodes 1000x1000

Conclusions

- Route discovery delay in ad hoc network is important
- Route caching as a mechanism to reduce
  - route discovery delay
  - routing overhead
- Analysis of Route discovery delay proposed
- Cache entries can be incorrect
- Model extended to take into account invalid cache entries
- Model assumption:
  - traffic uniform distributed

Future work

- dependence cache miss rate from mobility