Performance Evaluation of Mobile IP

Investigating the Concept of Hierarchical Foreign Agents

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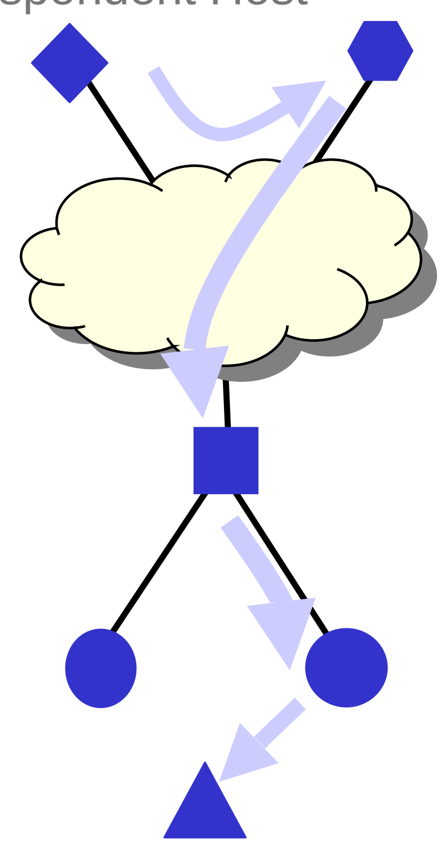
Outline

- Mobile IP with Hierarchical Foreign Agents
  - Main Idea and Advantages
- Goals of Experimental Investigations
- Testbed Setup
  - System and Workload Parameters, Factors, Metrics
- Results of Performance Evaluation
- Conclusions

MIP w/ HFA: Main Idea

- Foreign agents (FAs) arranged in a hierarchy
- Handover: FA in same hierarchy branch as both old and new FA becomes Switching FA (SFA)
- Handover messages relayed only up to SFA but not to Home Agent (HA)



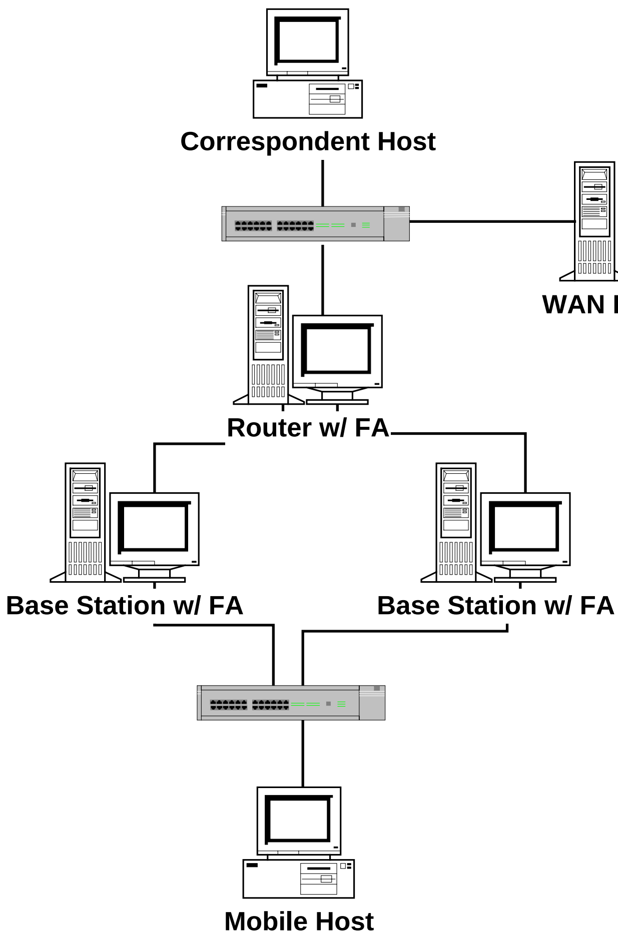
Advantages of MIP w/ HFA

- Use of hierarchical Foreign Agents reduces
  - Handover latency
  - Packet loss during handovers
  - Signaling load

Goals of Experimental Investigations

- Evaluation of mobility-related performance parameters
- Comparison of Mobile IP w/ HFA with standard Mobile IP
- Impact of handover on transport layer performance
- Evaluation of strategies to shorten the handover trigger latency
- Identification of bottlenecks & potential areas for improvement

Testbed Setup I



- Wireless link replaced by standard Ethernet to emulates „good“ wireless channel
- Handover is controlled by manageable hub (SNMP)

Testbed Setup II

- Software components
  - OS: Linux 2.2.18 on base stations, routers, and end systems
  - Dynamics Mobile IP w/ HFA implementation version 0.6 http://www.cs.hut.fi/Research/Dynamics
  - WAN emulation: *softlink* (TKN, TU Berlin)
  - Measurement: *netperf, tcpdump, tcptrace*
- Hardware components
  - Standard desktop PCs (Pentium x)
  - Networking: 10BaseT, Ethernet hub (manageable)

System and Workload Parameters

Input parameter	Value
Offered Load	UDP: 1024Byte/10ms=1MBps
Socket buffer size	32kByte
Handover model	Exponentially distributed cell-dwell time (CDT)
Mean value for CDT	10sec, offset 5sec
Overlap of cells	-1, 0, 1sec
Latency (WAN emulation) [ms]	0, 200, 400
Advertisement frequency [N/sec]	10
Handover trigger policies	3 x Advertisement interval
Tunnel lifetime	600sec
Tunneling Type	Reverse Tunneling
Test length	3600sec

Experimental Factors and Metrics

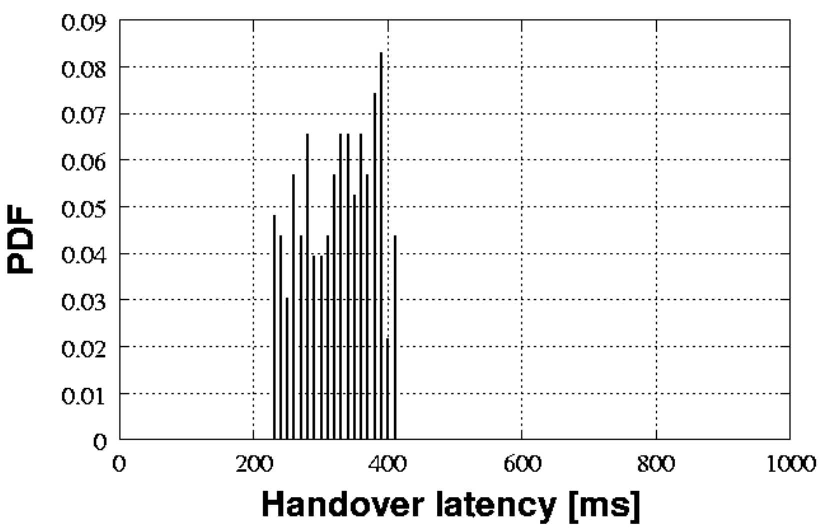
- Factors
  - Number of hierarchies
  - Traffic type
  - Direction of data flow
  - Delay
- Metrics
  - Handover latency
  - Throughput
  - Signaling overhead

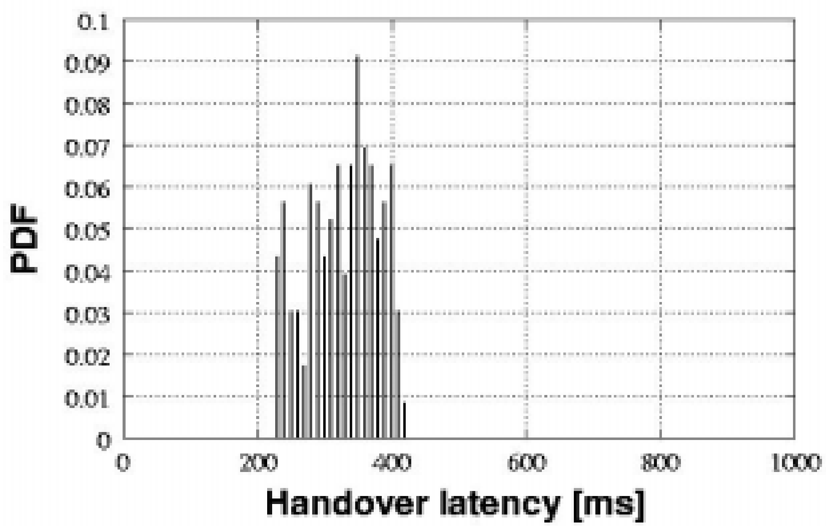
Results of Performance Evaluation

- Handover latency
- Mean throughput for UDP and TCP traffic
- Signaling overhead

Results: PDF of Handover Latency MIP w/ HFA Uplink vs. Downlink

- FA-HA delay = 100ms,
- Mean Cell-dwell time λ=10s + 5s offset
- Handover initiation policy: 3 x Adv. interval





- Uplink traffic

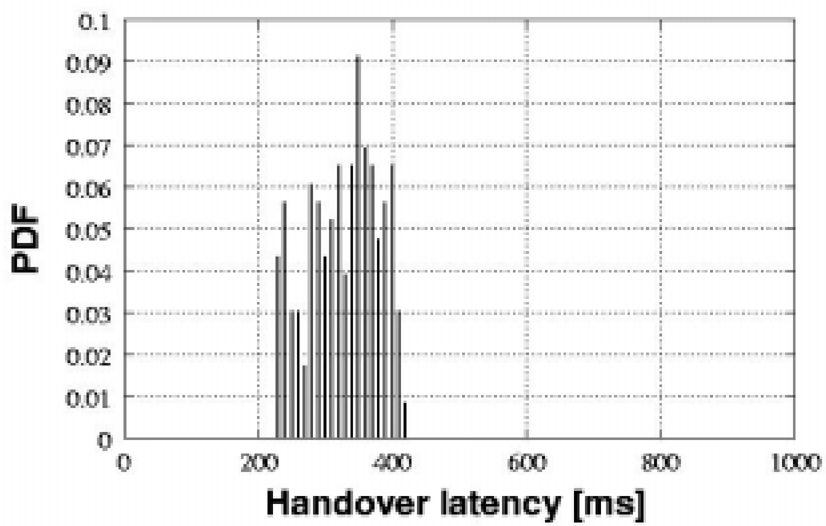
Mean=328 StdDev=88

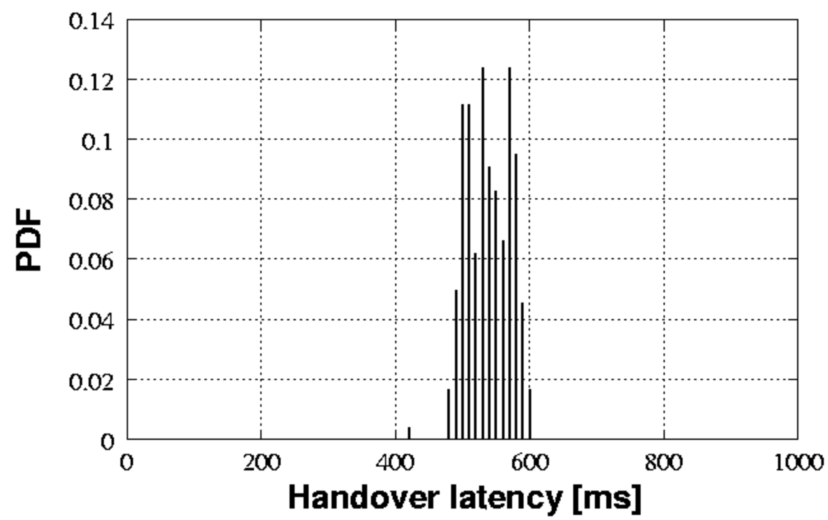
- Downlink traffic

Mean=325, StdDev=84

Results: Handover Latency MIP w/ HFA vs. Standard MIP

- FA-HA delay = 100ms,
- Mean cell-dwell time λ=10s + 5s offset
- Handover initiation policy: 3 x Adv. interval





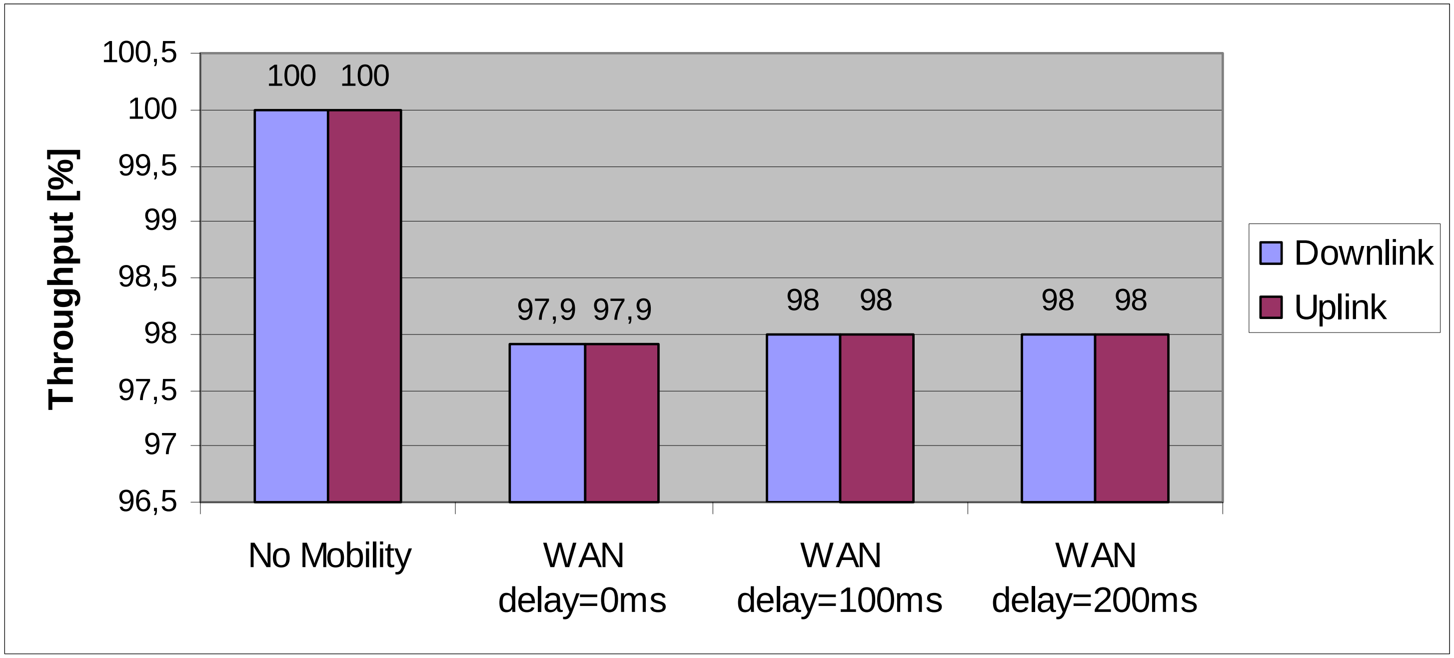
- W/ HFA

Mean=328 StdDev=88

- Standard Mobile IP

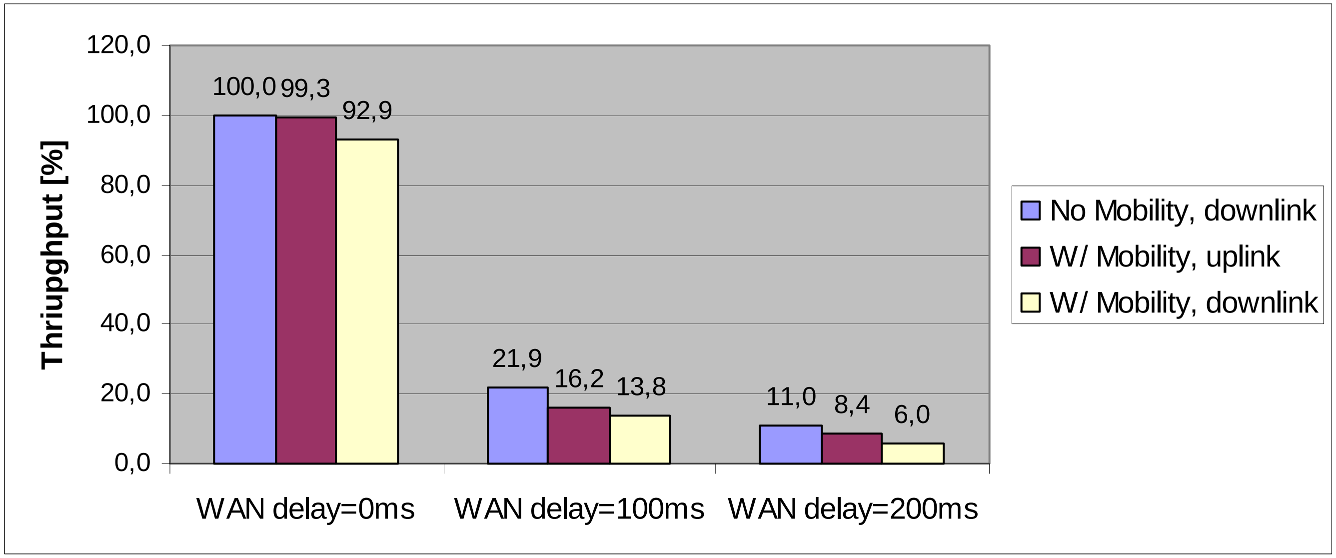
Mean=562, StdDev=73

Results: Mean UDP Throughput MIP w/ HFA, Uplink vs. Downlink



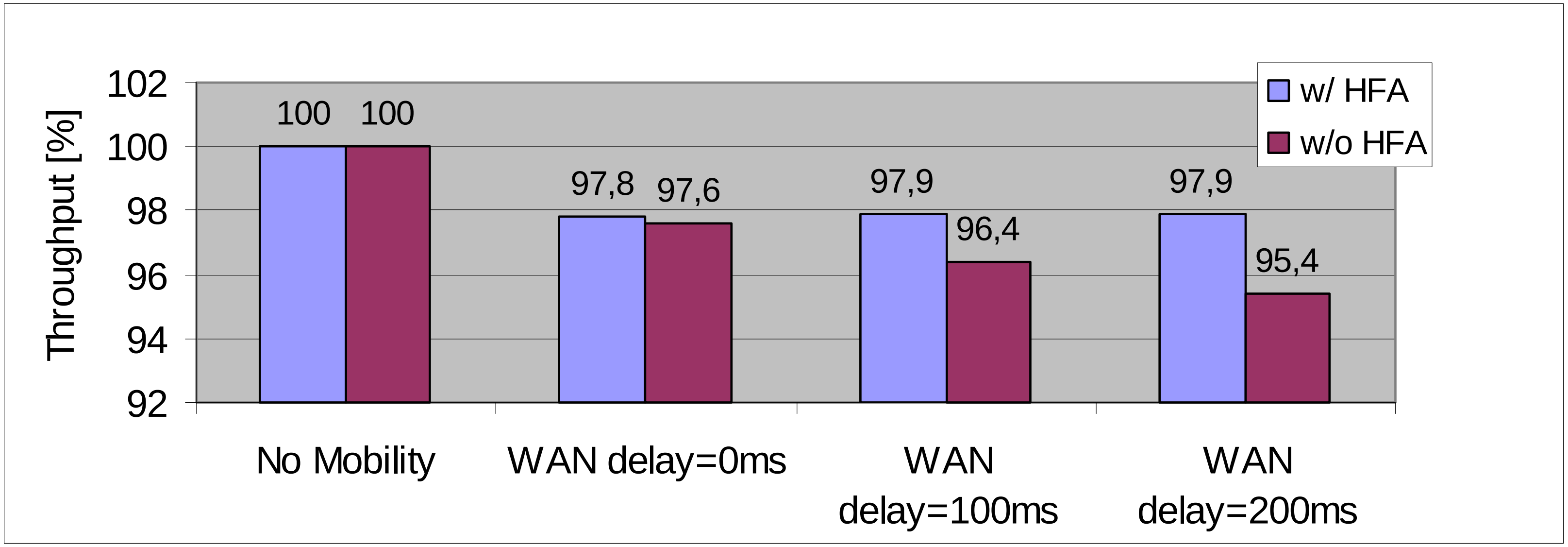
- Downlink UDP bulk transfer 1kB/10ms
- Loss ~ Service Interruption

Results: Mean TCP Throughput MIP w/ HFA, Uplink vs. Downlink



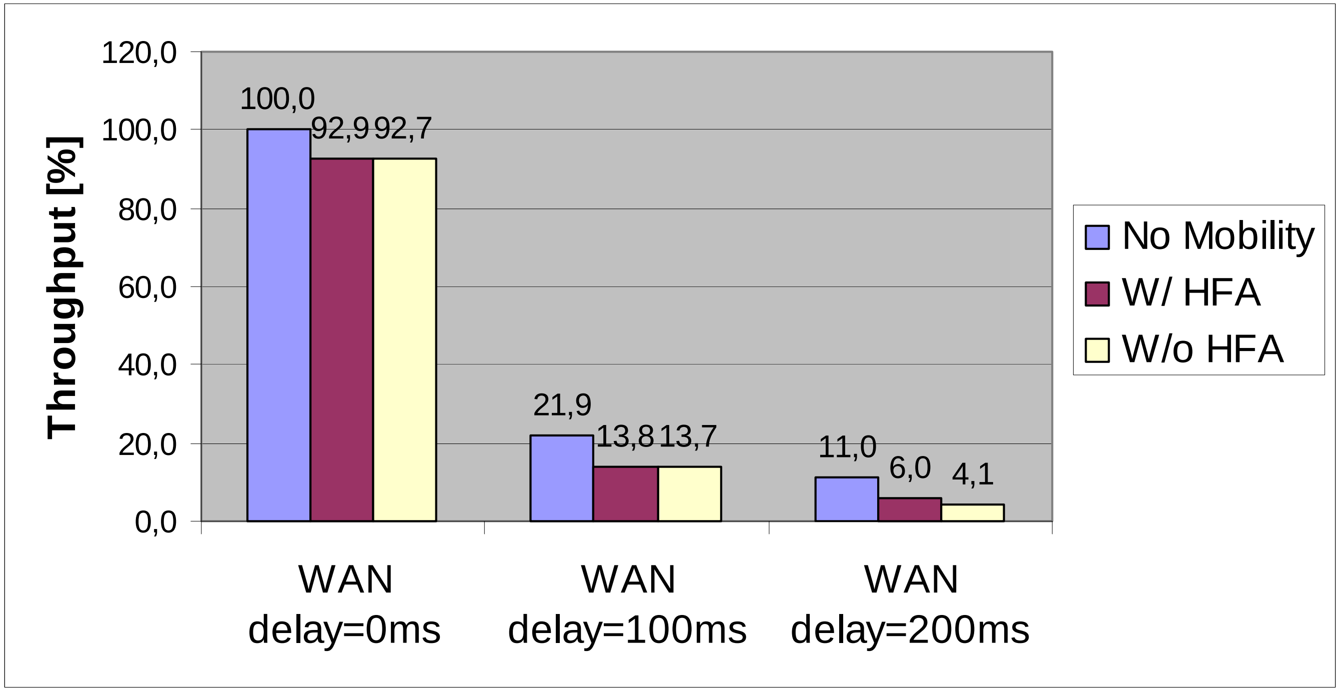
- Downlink TCP bulk transfer
- Mean Throughput [%]
- Delay varied ~0ms, 100ms, 400ms

Results: Mean UDP Throughput MIP w/ HFA vs. Standard MIP



- Similar throughput for Mobile IP w/ HFA and standard Mobile IP

Results: Mean TCP Throughput MIP w/ HFA vs. Standard MIP

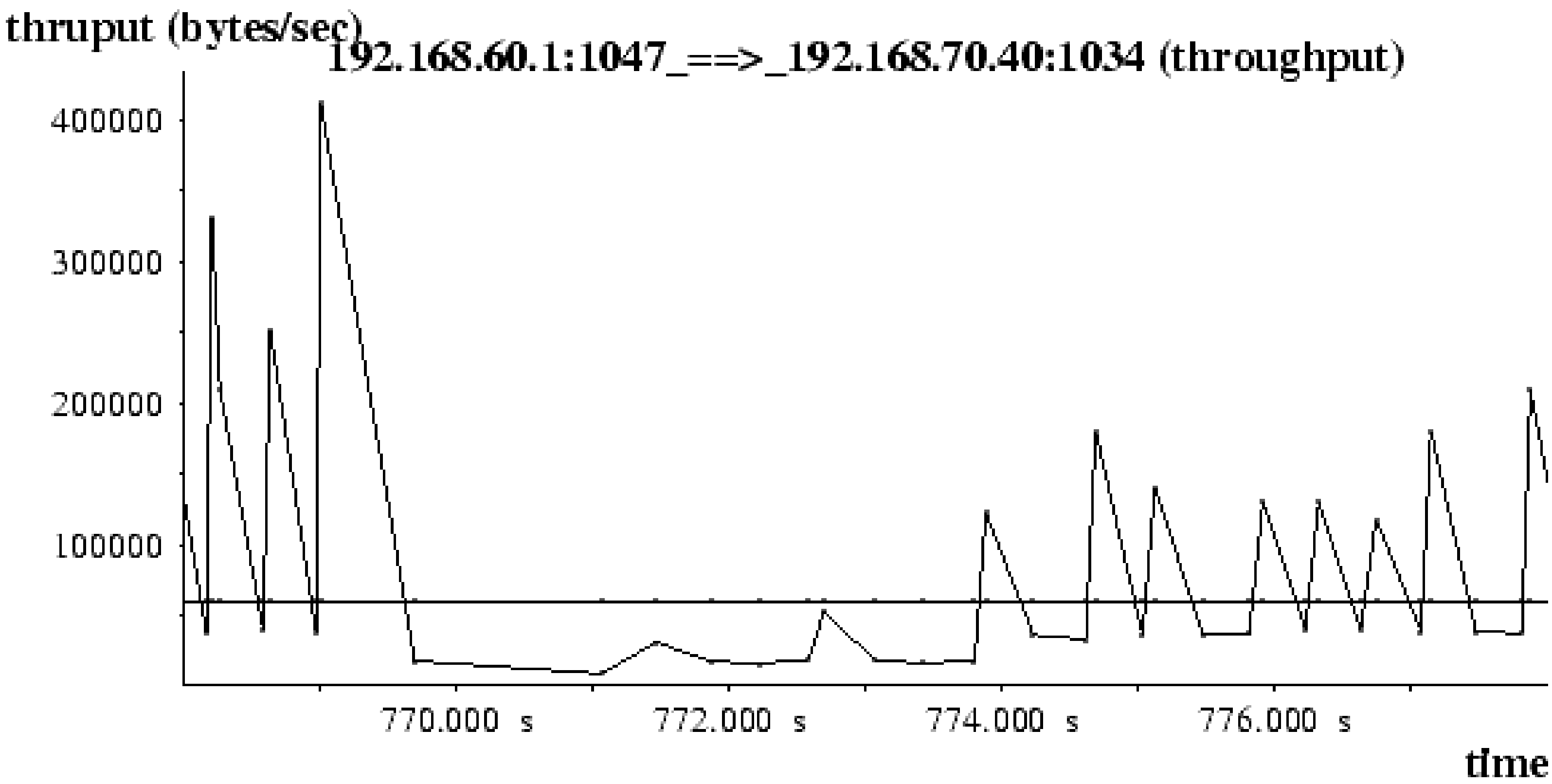


- For high delays between FA and HA Mobile IP w/ HFA improves throughput

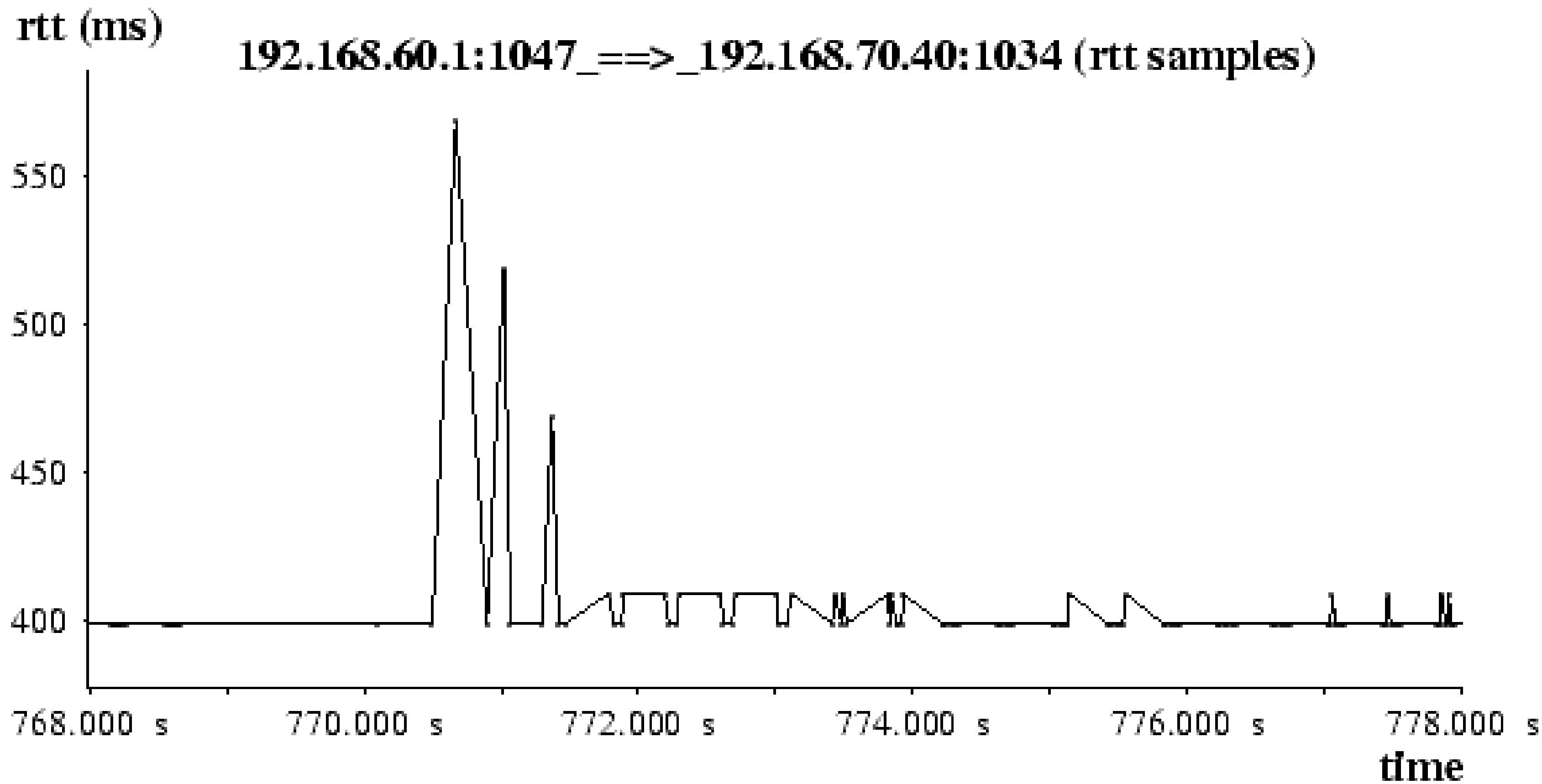
Impact of Handover on TCP Performance

- Scenario: Mobile IP w/ HFA
- Latency=100+100ms
- Snapshots of 10sec for typical TCP measures
  - Throughput
  - Round trip time (RTT)
  - Sequence numbers
  - Congestion window

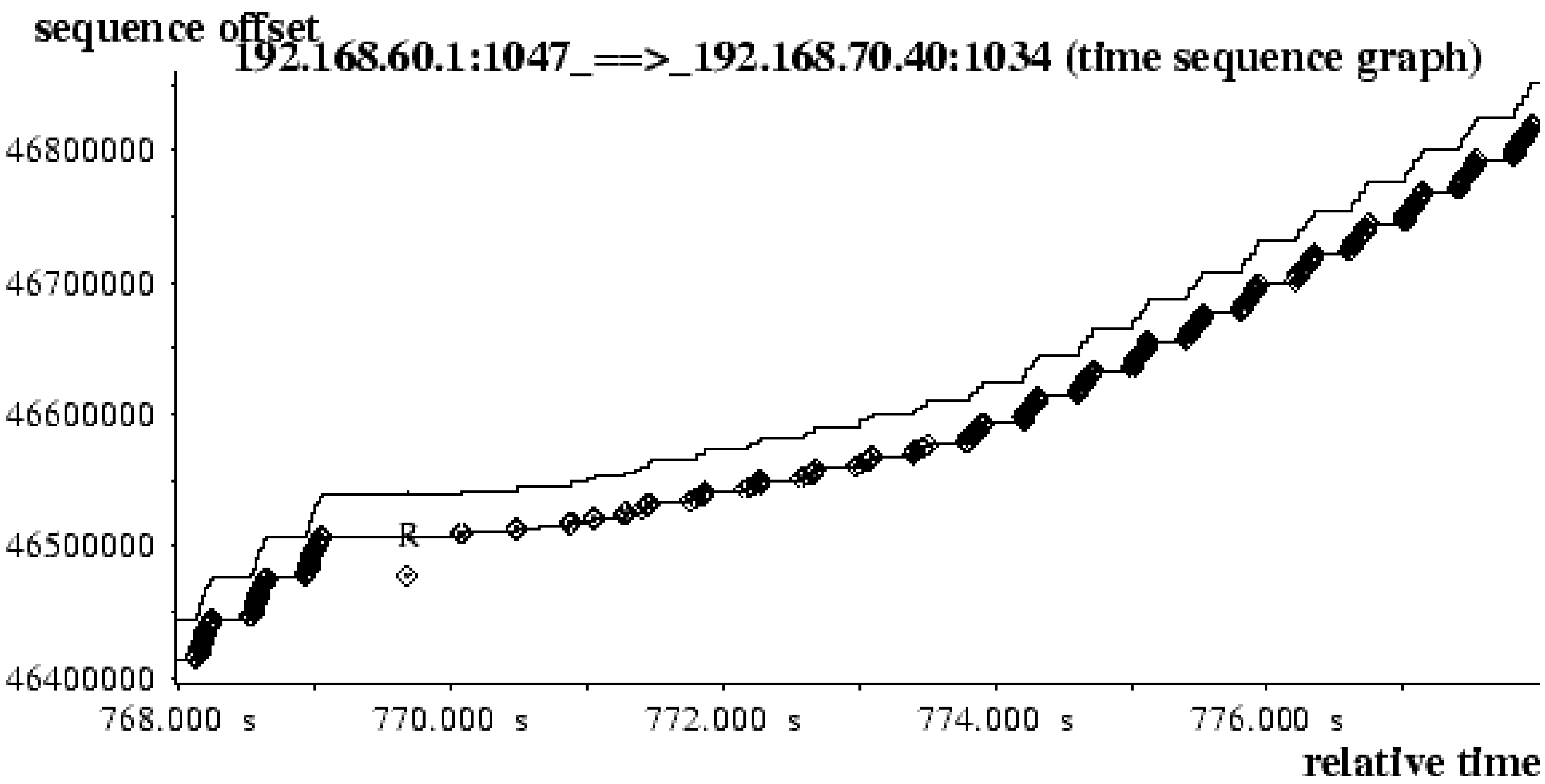
Impact of Handover on TCP Performance
Throughput Graph



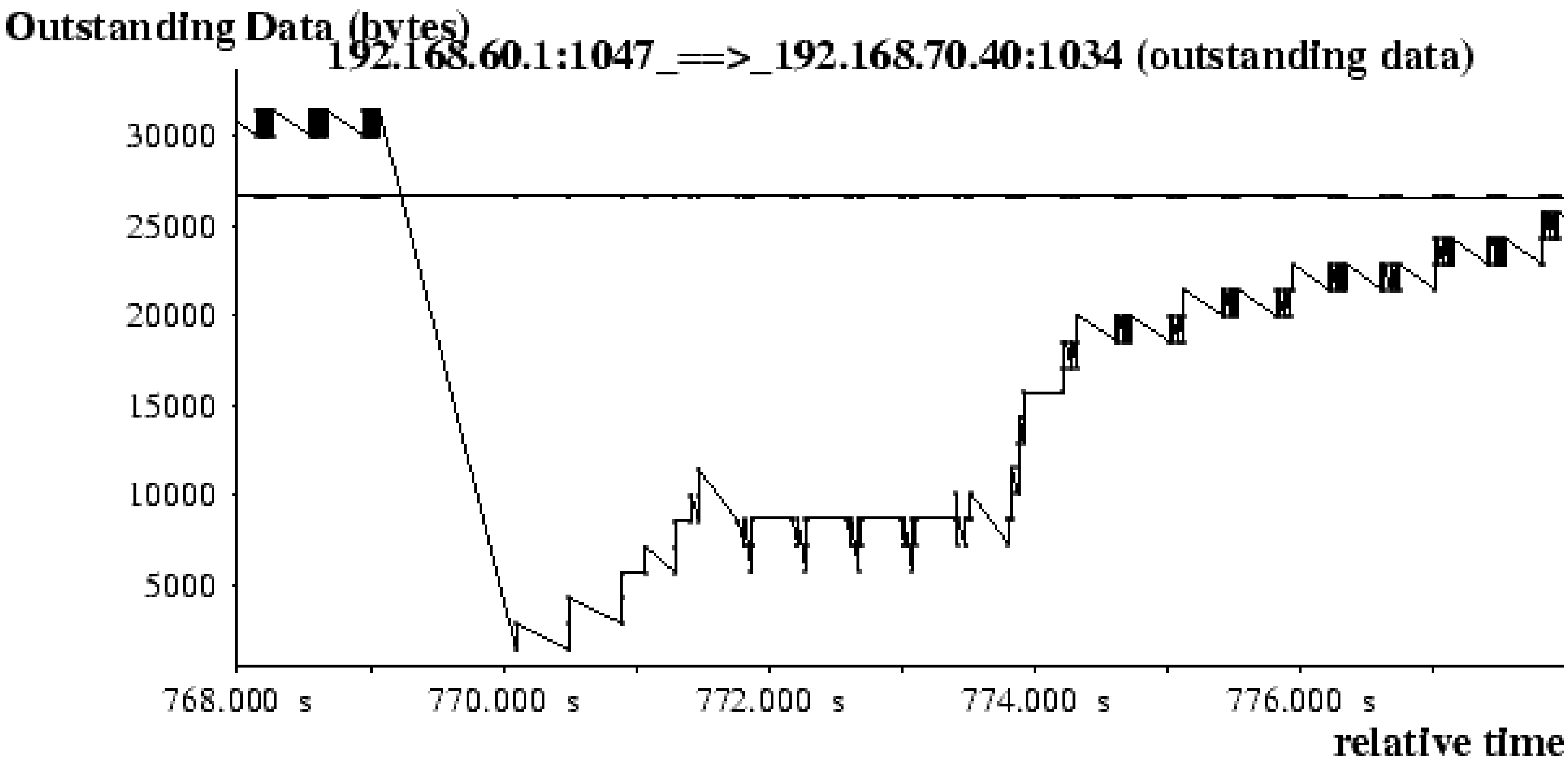
Impact of Handover on TCP Performance
RTT Graph



Impact of Handover on TCP Performance
Time Sequence Graph



Impact of Handover on TCP Performance
Congestion Window Graph



Utilization of Handover Initiation Policies

- Time to detect the need for handover is major part of the overall handover latency
- Increasing the advertisement frequency reduces latency, but signaling overhead grows
- Policies:
  - Reduced aging interval for FA advertisements
    - Handover is initiated after 2 x advertisement interval
  - Newest Foreign Agent
    - Foreign Agent with newest advertisement is used
  - Usage of link-layer trigger

Results: Signaling Overhead (w/o Advertisements)

Mobile Host – Foreign Agent

w/o hierarchy

	91 bytes	(MN → FA)
+	92 bytes	(FA → MN)
	183 bytes	total per handover

w/ hierarchy

	91 bytes	(MN → FA)
+	20 bytes	(FA → MN)
	111 bytes	total per handover

Highest Foreign Agent – Home Agent

w/o hierarchy

	165 bytes	(new FA → HA)
+	31 bytes	(HA → old FA)
+	199 bytes	(HA → new FA)
	395 bytes	**total per handover**

w/ hierarchy

~0

Conclusions

- Mobile IP w/ HFA reduces the signaling delay as part of the overall handover latency
- Time to detect the need for handover is major part of the overall handover latency in ALL scenarios
- To reduce handover latency considerably, the time to detect the need for handover must be also reduced
- Mobile IP w/ HFA does not supersedes TCP-enhancing approaches

Outlook

- Common handover trigger mechanisms for interfaces of different technology
- Comparison of Multicast-based handover (MOMBASA) and MIP w/ HFA
- Performance-enhancing proxies for TCP (ReSoA) required to improve TCP performance