Mobile IPv6 performance in 802.11 networks: handover optimizations on the link and network layer

LaTe project, Networking laboratory, TKK

Mikko Hautala
mhautala@cc.hut.fi

16.03.2006

Supervisor: Professor Jörg Ott, Networking laboratory

Instructor: Lic.Tech. Markus Peuhkuri, Networking laboratory

Presentation outline

- Introduction
  - Background
  - Research problem
  - Objectives and methods
  - 802.11 wireless access network
- Handover optimization
  - Link layer (L2) handovers of 802.11
  - Network layer (L3) handovers of Mobile IPv6
- Experimental results
  - Simulator framework
  - Handover delay measurements
  - Signaling traffic measurements
- Conclusion

Background

- LaTe project is about the feasibility of common standards based wireless networks in military use
  - IEEE 802.11 (Wi-Fi) and 802.16 (WiMAX)
- Wireless networks are a cost effective, flexible and fast to deploy alternative for fixed networks
- Tolerable against physical harming but vulnerable to jamming
- Mobile IPv6 can provide the needed wide area mobility support

Research problem

- Both the 802.11 link layer and the Mobile IPv6 network layer handovers are inefficient
- This hurts realtime applications like VoIP, but throughput sensitive applications using TCP can suffer too
- We study both the link and network layer optimization mechanisms

Objectives and methods used

Objectives

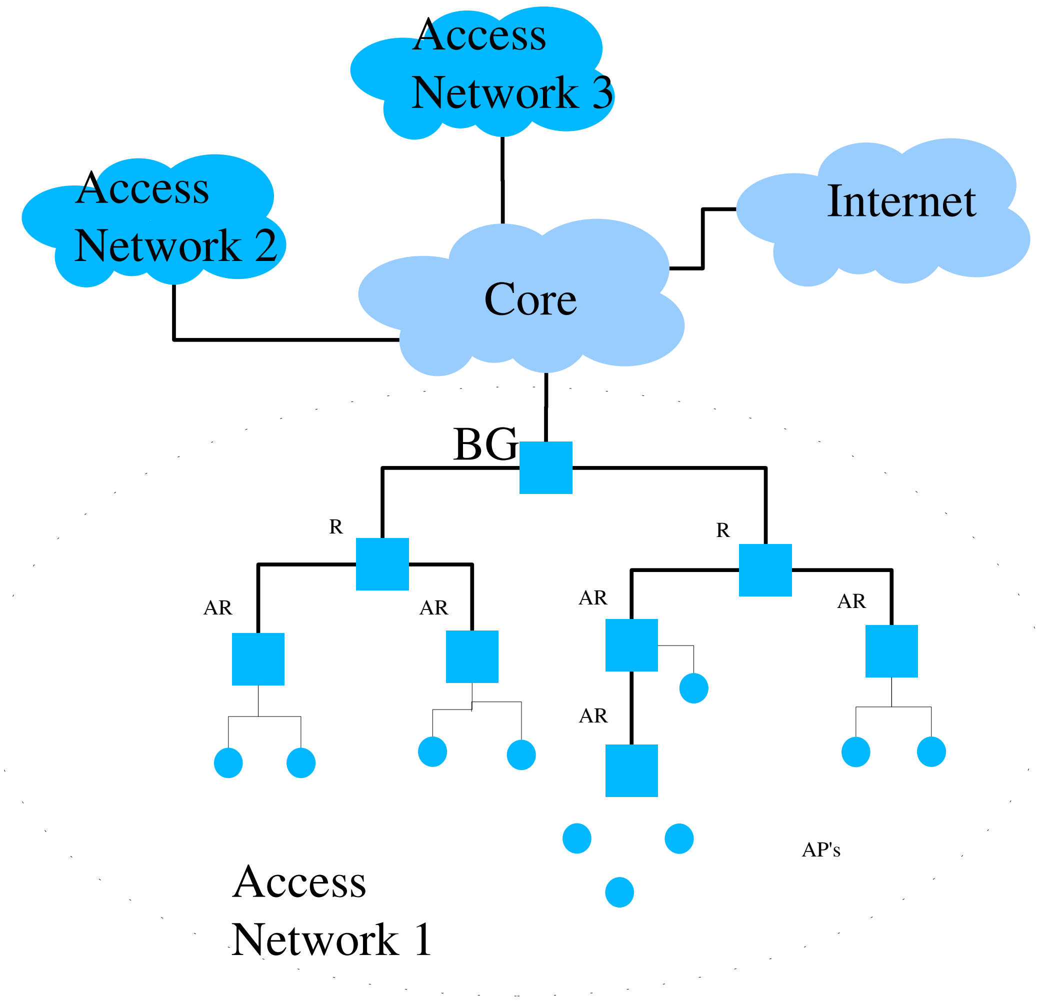
- What is the expected performance of already existing optimization mechanisms ?
- Can some of these mechanisms provide seamless handover performance ?

Methods used

- In the literature part, we conduct a survey of various optimization mechanisms
- In the experimental part, the most promising methods are studied using simulation

802.11 wireless access network

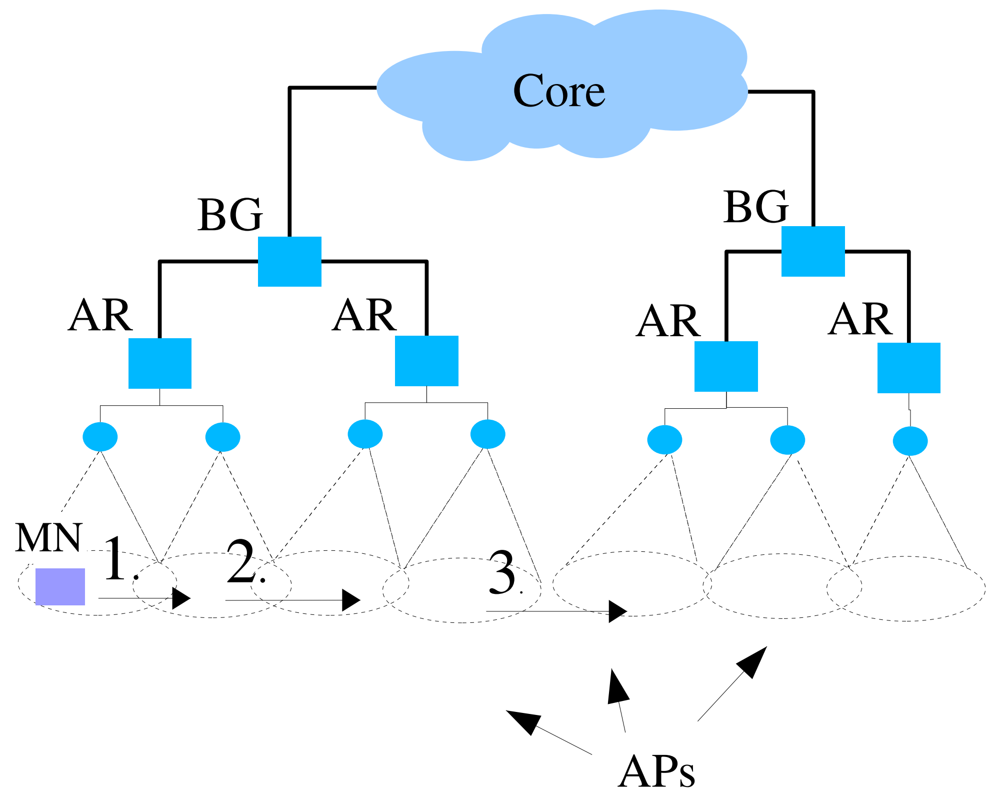
- 802.11 supports combining multiple APs
- Broadcast traffic sets bounds for the size of a single subnet
- Common IP equipment is used to combine these subnets



AR: Access Router BG: Border Gateway
AP: Access Point MN: Mobile Node

Handover scenarios in the access network

- Handover can be L2 only (1.)
- Or both L2 and L3 (2. and 3.)
- Handover between two domains (3.)



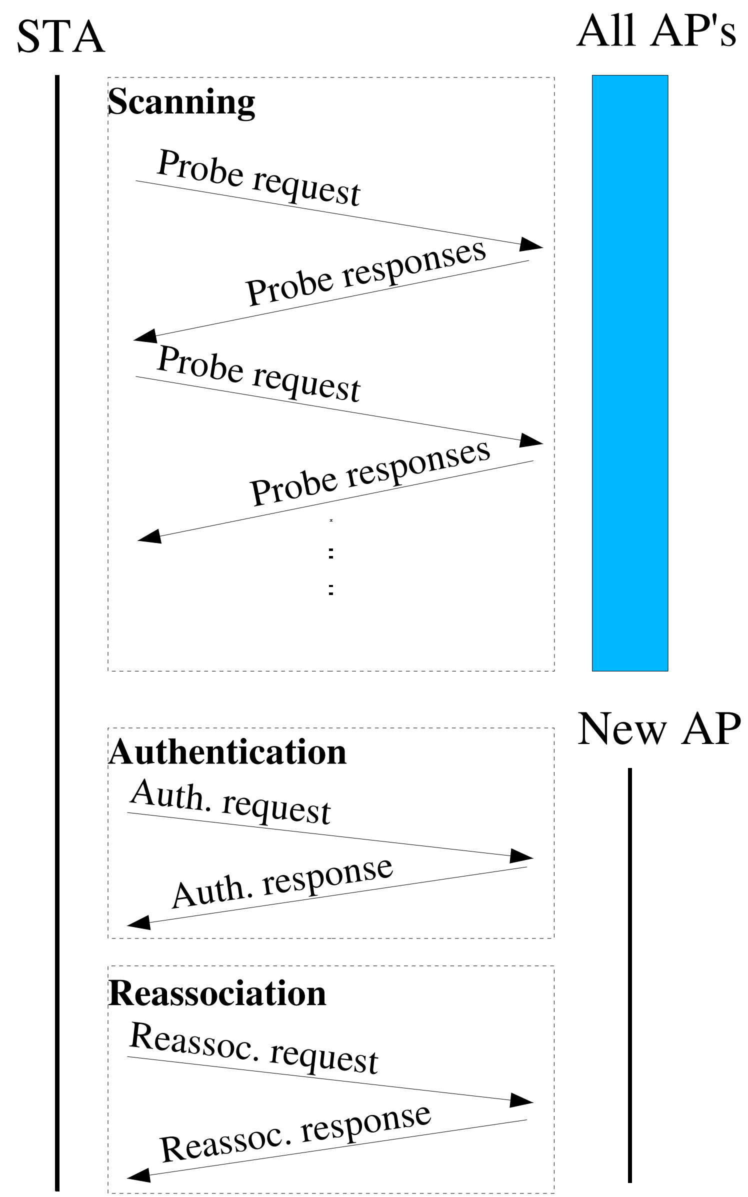
AR: Access Router BG: Border Gateway
AP: Access Point MN: Mobile Node

Presentation outline

- Introduction
  - Background
  - Research problem
  - Objectives and methods
  - 802.11 wireless access network
- Handover optimization
  - Link layer (L2) handovers of 802.11
  - Network layer (L3) handovers of Mobile IPv6
- Experimental results
  - Simulator framework
  - Handover delay measurements
  - Signaling traffic measurements
- Conclusion

Basic 802.11 link layer handover

- Scanning is dominating: 90% of the delay
- Delay ~ 50-420 ms, when there is a single station
- Could be as high as ~8 seconds, when multiple stations

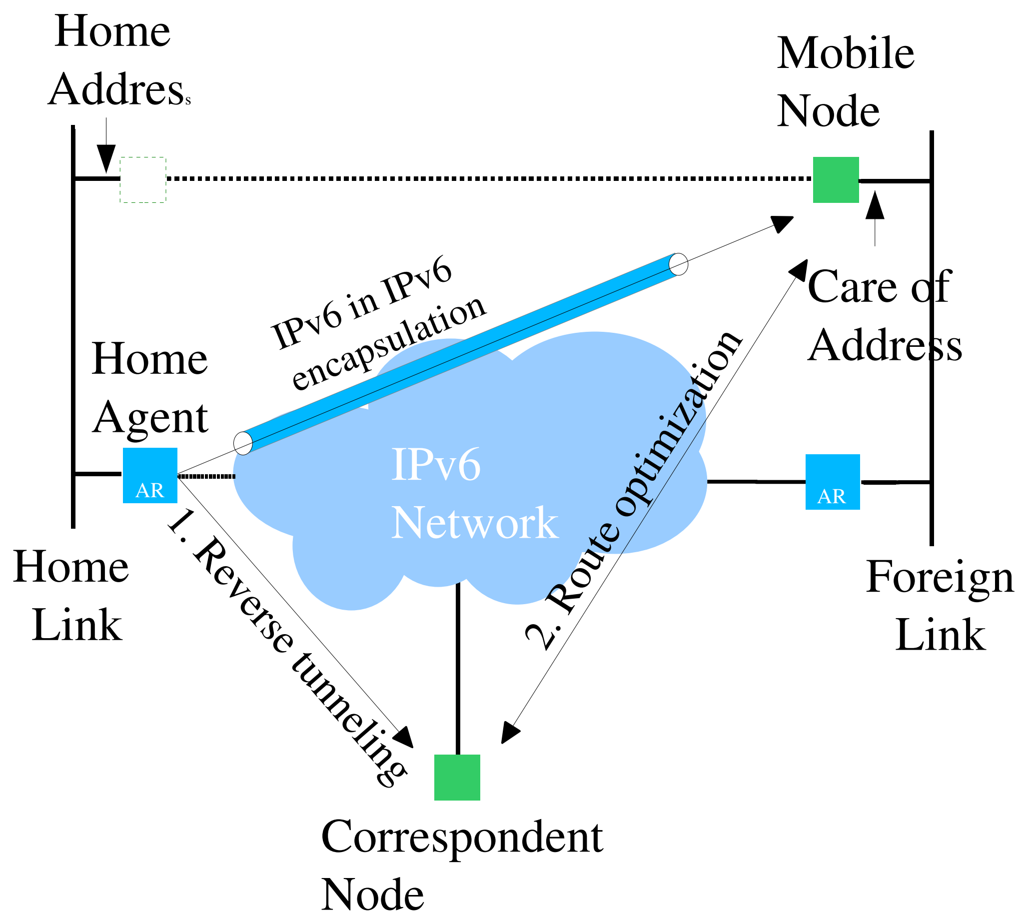


Optimizing 802.11 handover

- Focus in optimizing the scanning delay
  - Proactive scanning seems to be the best approach
- SyncScan:
  - A station switches between channels in parallel to data communications to catch the beacon frames
  - Requires synchronization of the APs and stations
- MultiScan:
  - Two radios: one for data communications and the other for constantly scanning nearby access points
  - Requires changes only to the client side

Mobile IPv6 protocol (RFC 3775)

- Mobile Node has a home address and a care-of-address
- In reverse tunneling (1.), Home Agent captures and tunnels packets for the MN
- Using route optimization (2.), packets are sent directly
- Mobile Node updates its location with binding updates to HA and to CNs



Basic Mobile IPv6 handover

- Contributions to the delay:
  1. Movement detection
  2. New care-of-address (CoA) configuration
  3. Binding update (BU)
- 1. and 2. depend on the Neighbor Discovery protocol, which has inefficiencies
- Binding update latency depends on the delay between the MN and HA
  (or MN and CN if route optimization)

Optimizing the Mobile IPv6 handover (1/3)

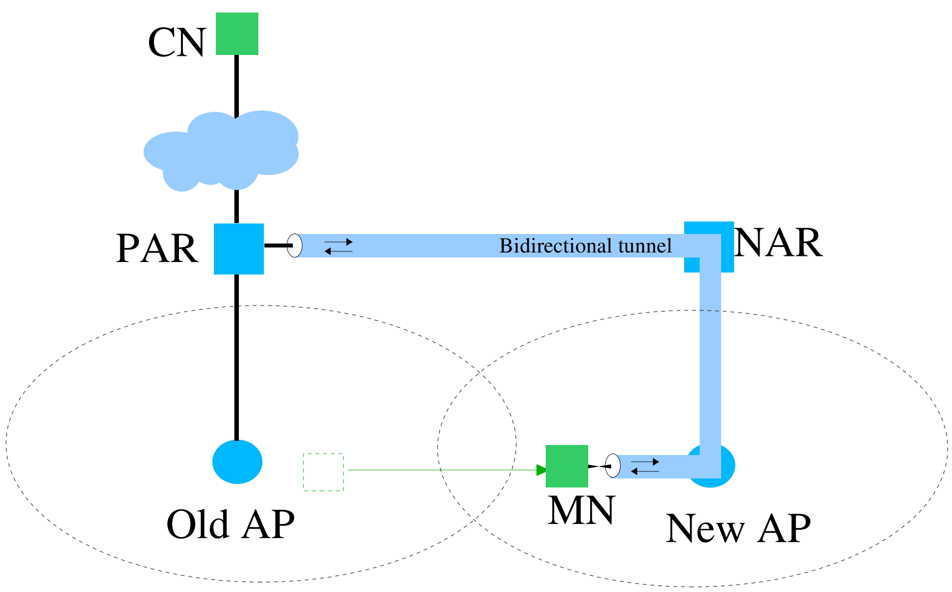
Simple mechanisms:

- LinkUP trigger from the link layer
  - Helps detecting movement (trigger to send router solicitation)
- Fast Router Advertisements (Fast RA)
  - Fast reply to a router solicitation
- Optimistic Duplicate Address Discovery (ODAD)
  - Avoids the costly DAD mechanism

Optimizing the Mobile IPv6 handover (2/3)

Fast handovers for MIPv6 (RFC 4068):

- Prefix discovery and tunneling
- Tunnel setup is either predictive or reactive
- In predictive handover, the L3 handover is nearly eliminated
- Prefix discovery requires that nearby APs are detected before handover is conducted

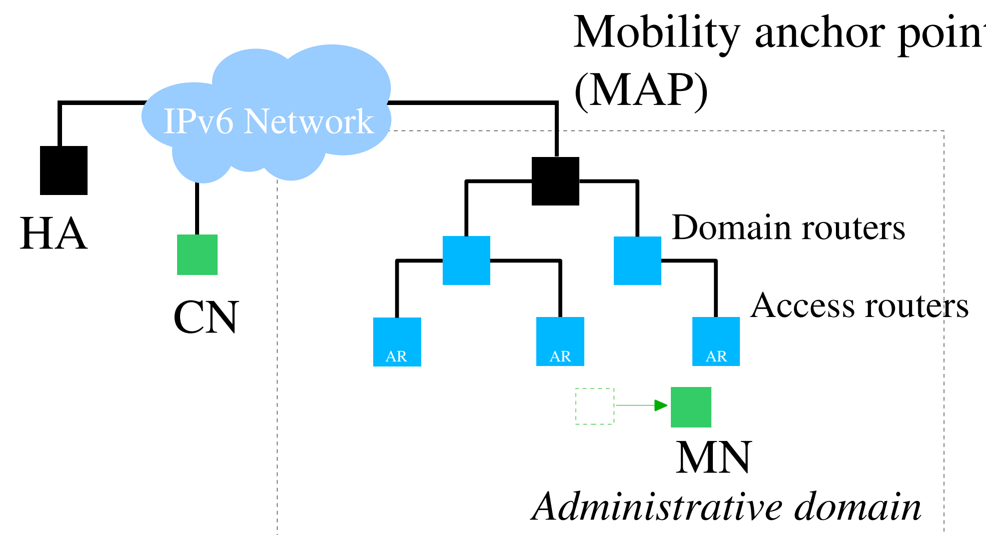


PAR: Previous Access Router
NAR: New Access Router
MN: Mobile Node
CN: Correspondent Node
AP: Access Point

Optimizing the Mobile IPv6 handover (3/3)

Hierarchical MIPv6 (RFC 4140):

- Mobility Anchor Point (MAP) is basically a local HA
- In local handovers: send binding updates only to the MAP
- Mainly reduces signaling, but the BU latency is reduced also



MAP: Mobility Anchor Point
HA: Home Agent
MN: Mobile Node
CN: Correspondent Node

Presentation outline

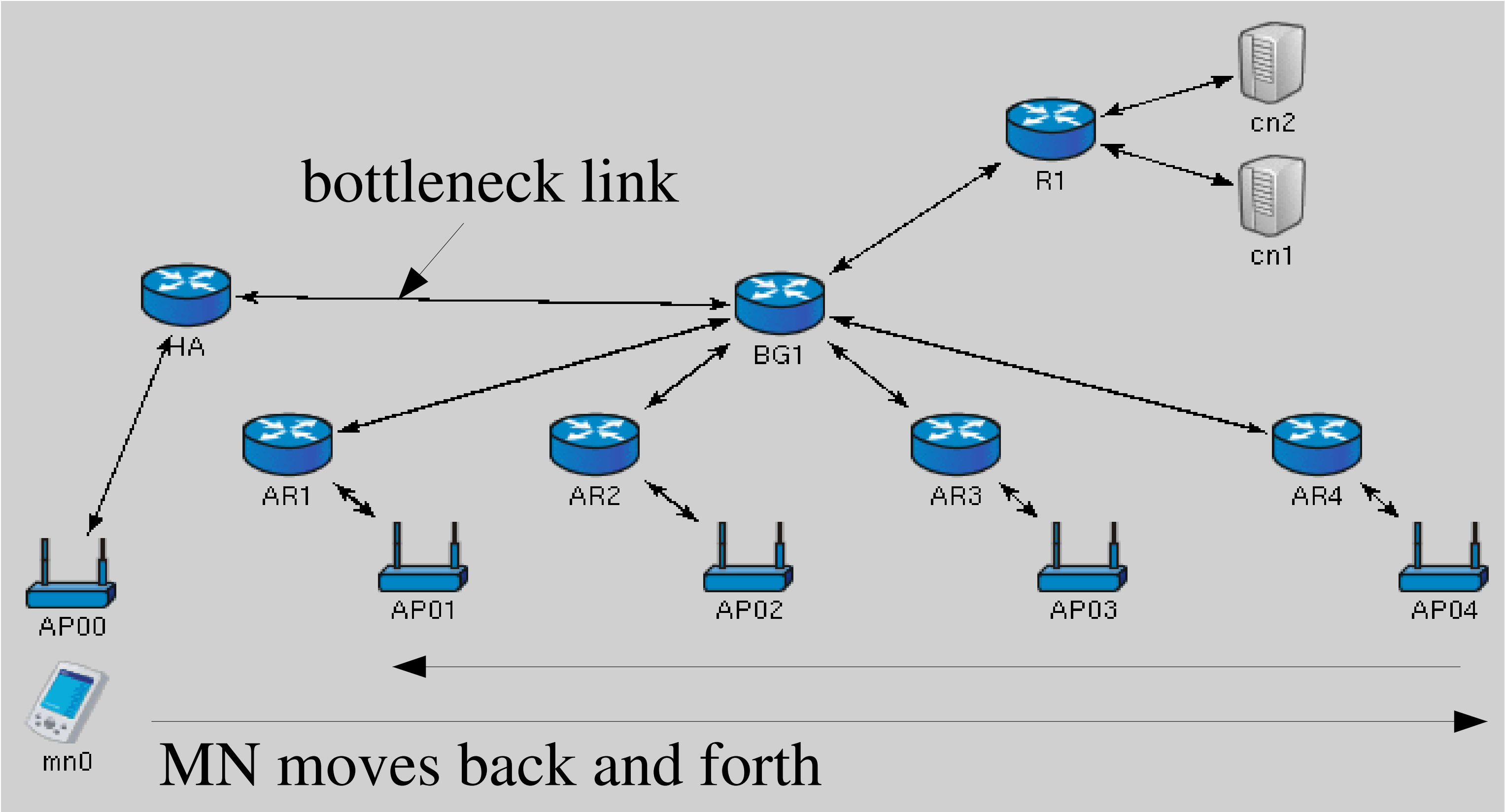
- Introduction
  - Background
  - Research problem
  - Objectives and methods
  - 802.11 wireless access network
- Handover optimization
  - Link layer (L2) handovers of 802.11
  - Network layer (L3) handovers of Mobile IPv6
- Experimental results
  - Simulator framework
  - Handover delay measurements
  - Signaling traffic measurements
- Conclusion

The simulation experiments

- OmNet++ simulator was used
- IPv6 / Mobile IPv6 support provided by the "IPv6Suite" extension
- We implemented the FMIPv6 protocol to the simulator
- We conducted measurements for handover delay and for the signaling traffic

Simulation network

- The bottleneck link: 2 Mbit/s link with a 100 ms delay
- All other links: 1 Gbit/s links with a 5 ms delay



Handover delay measurements (1/3)

- Network layer optimizations studied:
  - Basic MIPv6 and HMIPv6
  - reactive and predictive FMIPv6
  - a combination of LinkUP trigger, Fast RA and ODAD
- On the link layer, we studied the basic mechanism and the “MultiScan” optimization (two radios)
- 9 different scenarios overall
- We used different random seeds and calculated the averages and standard deviations

Handover delay measurements (2/3)

Scenarios using basic 802.11:

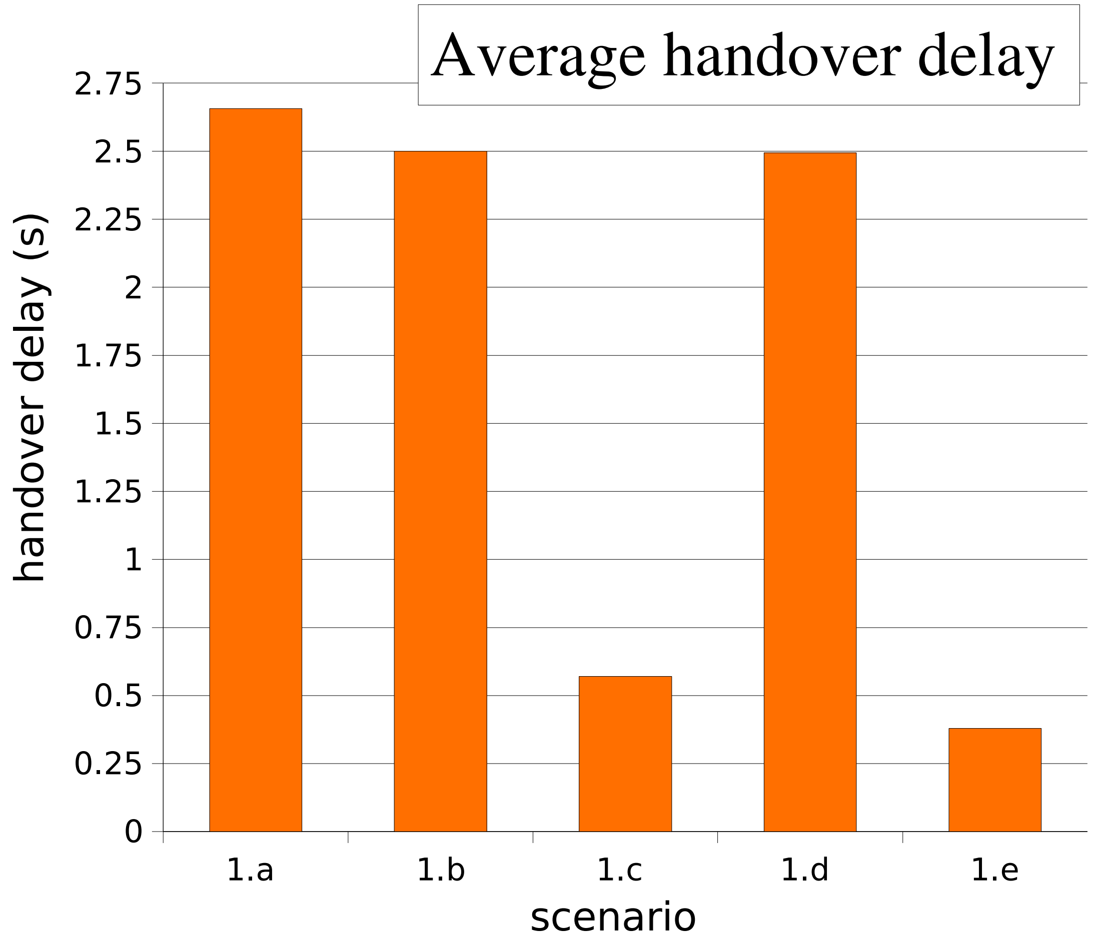
1.a) MIPv6

1.b) HMIPv6

1.c) LinkUP, Fast RA and ODAD

1.d) FMIPv6 fully reactive (only temporary tunnel)

1.e) FMIPv6 fully reactive with LinkUP, Fast RA and ODAD



Handover delay measurements (3/3)

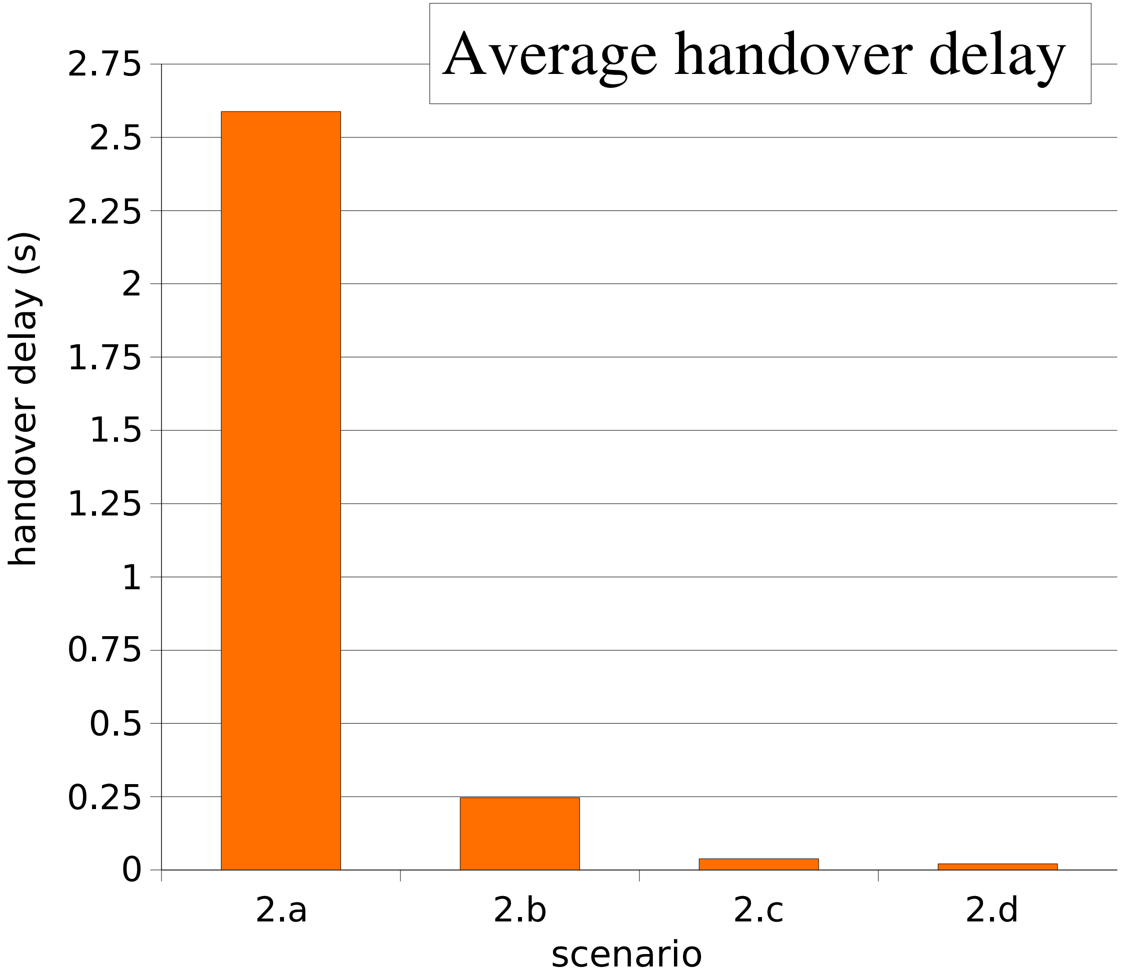
Scenarios using MultiScan:

2.a) MIPv6

2.b) LinkUP, Fast RA and ODAD

2.c) FMIPv6 reactive

2.d) FMIPv6 predictive



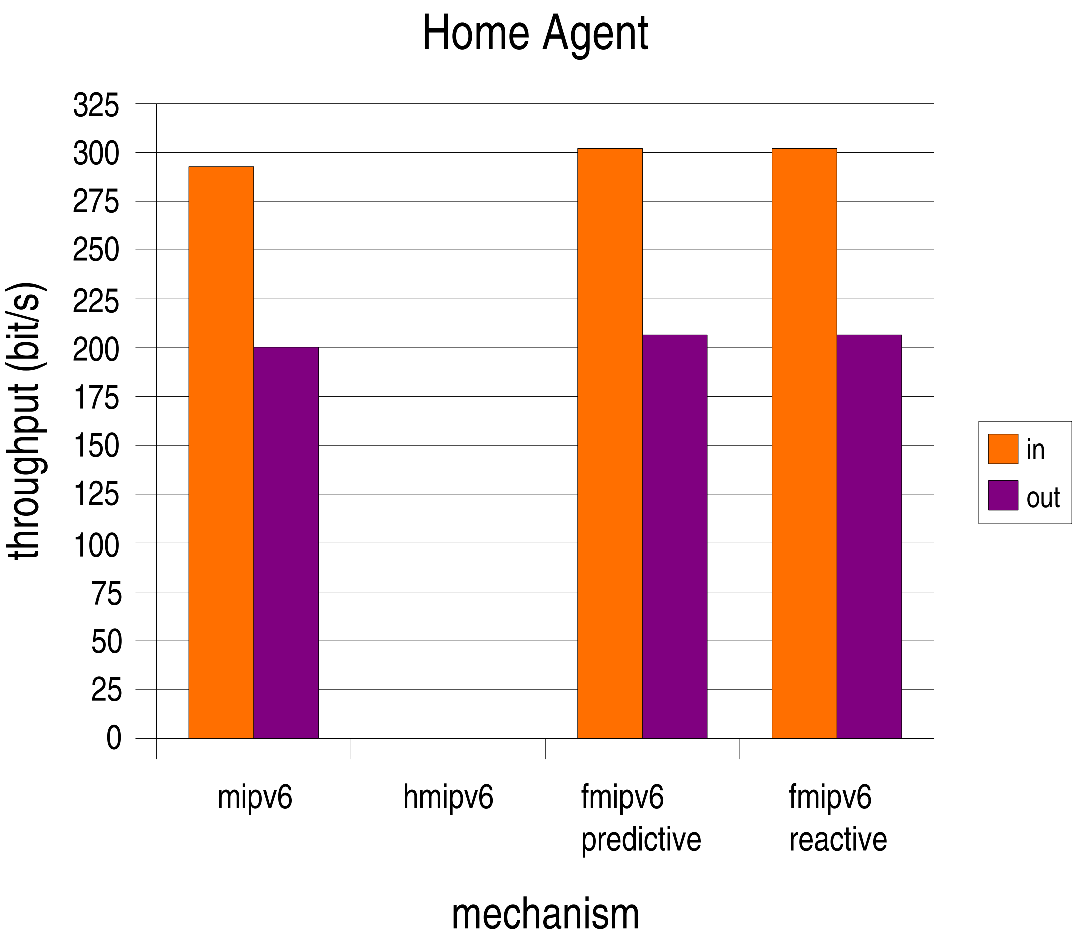
Signaling traffic measurements (1/3)

- The same network topology was used, but with 20 mobile nodes
- Similar movement pattern and speeds were used in each scenario
  - Each MN had a handover rate of ~1.9 handovers per minute
- We studied single runs of 600 seconds
  - Hence, results are only indicative
- We compared basic MIPv6 and HMIPv6 to both reactive and predictive FMIPv6 handovers

Signaling traffic measurements (2/3)

Global signaling:

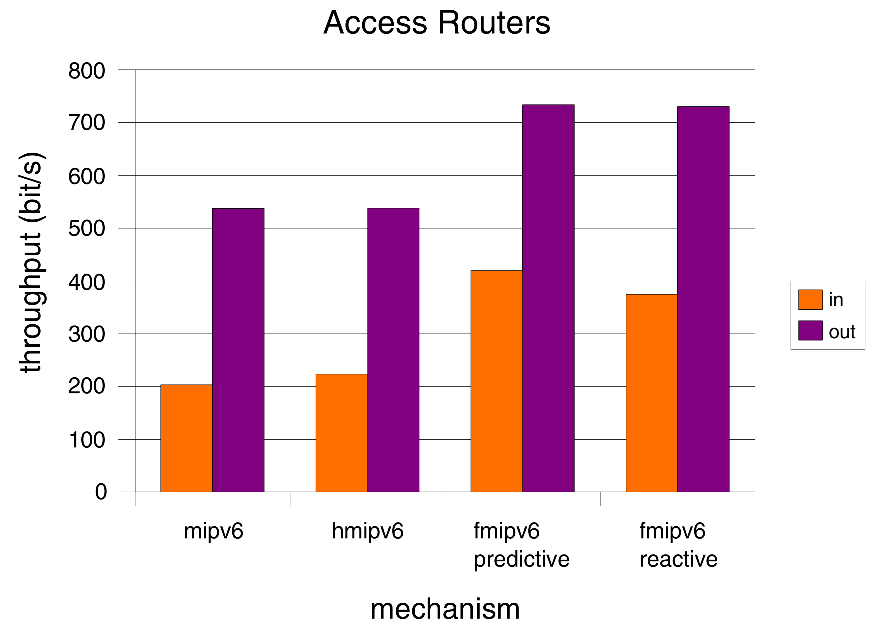
- For HMIPv6, no global signaling
- For MIPv6 and FMIPv6, quite the same loads, as excepted
- Overall, the signaling loads were quite modest (around 200 – 300 bit/s)

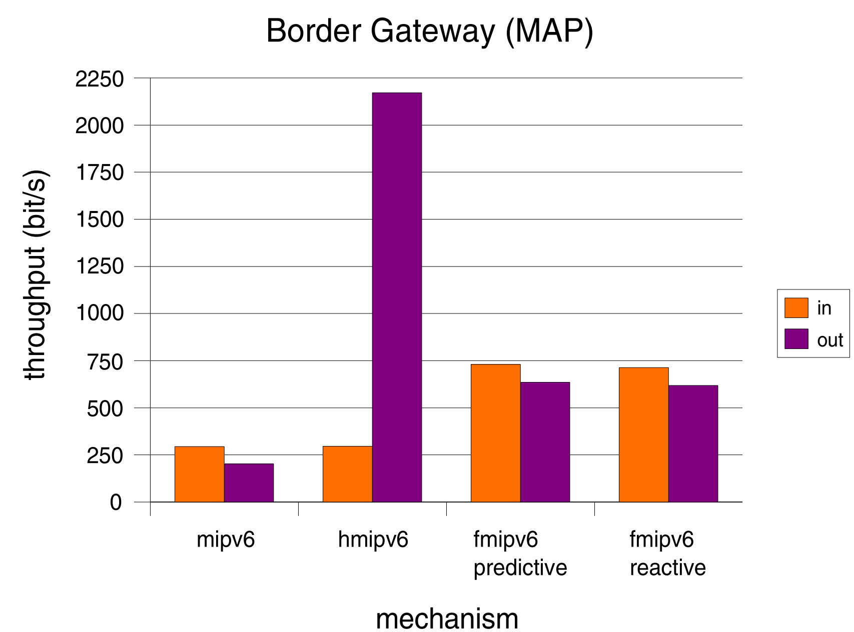


Signaling traffic measurements (3/3)

Local signaling:

- In HMIPv6, the router advertisements (MAP option) increase signaling at MAP
- FMIPv6 slightly increases local signaling
- No large differences between the reactive and predictive FMIPv6





Conclusions

- Movement detection is the most critical part in MIPv6 handovers
  - Hence, reducing the BU latency only, is not that rewarding (HMIPv6, FMIPv6 fully reactive)
- FMIPv6 can achieve seamless handovers
  - Requires a link layer optimization
- Quite good performance is gained with simple modifications only to the client side
  - LinkUP, Fast RA, ODAD
- Signaling loads of all the network layer mechanisms were quite modest

Possibilities for future work

- Develop our FMIPv6 model to support co-operation with HMIPv6
- More extensive signaling load measurements using different number of mobile nodes, different handover speeds and network topologies
- Implement FMIPv6 and the needed link layer optimization in practice
  - Mobile IPv6 for Linux (MIPL) project sources could provide a starting point

Thank you !

- Any questions / comments ?