Hierarchical Mobile IPv6

Implementation Experiences

Axel Neumann <neumann@ft.ee.tu-berlin.de>

Andreas Festag <festag@ee.tu-berlin.de>

TKN, TU-Berlin

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Overview

- **SeQoMo Project**
- **HMIPv6**
  - Motivation, Objective, Signaling
- **Implementation**
  - Selection of Environment
  - Functionalities to be Implemented
  - Implementation Design
- **Testbed Setup and Preliminary Performance Results**
- **Conclusion and Outlook**

SeQoMo Project

- Objective:
  - Investigate suitability of IP-based networks to support of host mobility
  - Advanced mobility mechanisms, security and quality of service
- Selected features:
  - Optimize handover operation (hierarchical Mobile IPv6, multicast-based mobility), utilization of link-layer triggers
  - QoS-aware handover support (conditionalized handover)
  - Authorization to control access to different service qualities according to subscription context

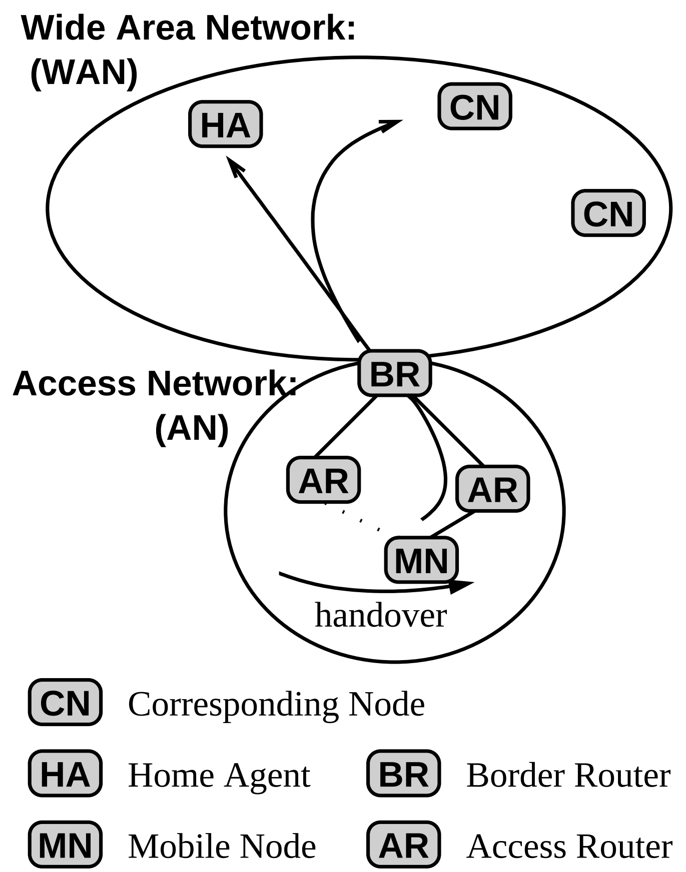
Towards a **Se**cure **Qo**S-enabled **Mo**bility architecture

HMIPv6: Motivation

- Assumptions for future all IP networks:
  - Many mobile nodes
  - Frequent handover due to smaller cell size
- Problems for MIPv6: Binding updates (BUs) are sent for every handover and traverse potentially the whole network

⇒ High signaling overhead

⇒ Long signaling latency

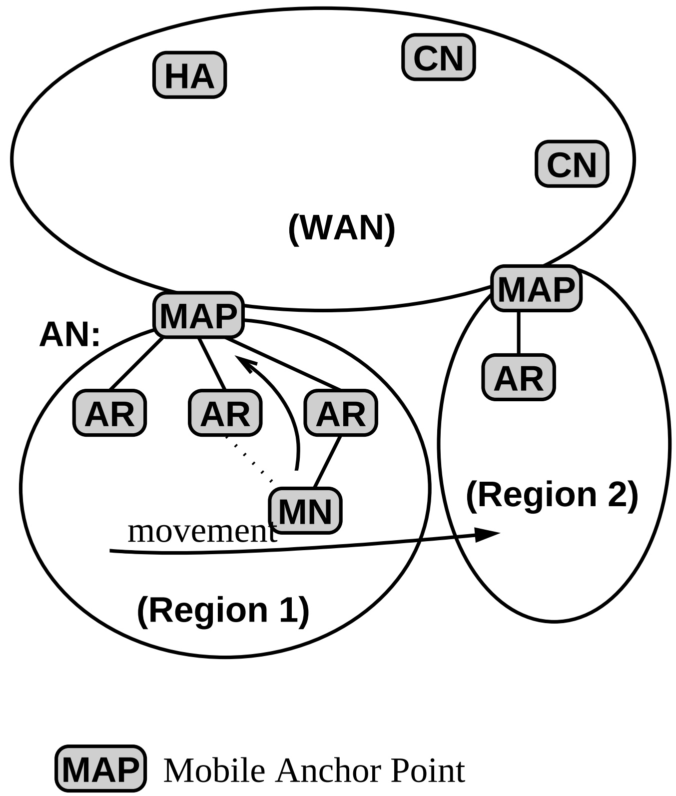


HMIPv6: Objective

- Assumption: Most movements are local
- Approach: Hierarchical concept
  - New entity: Mobile Anchor Point (MAP)
  - Logical tree structure in AN with MAP as root
  - Point of rerouting closer to MN
- Improvements: For local handover, signaling messages travel only up to MAP:

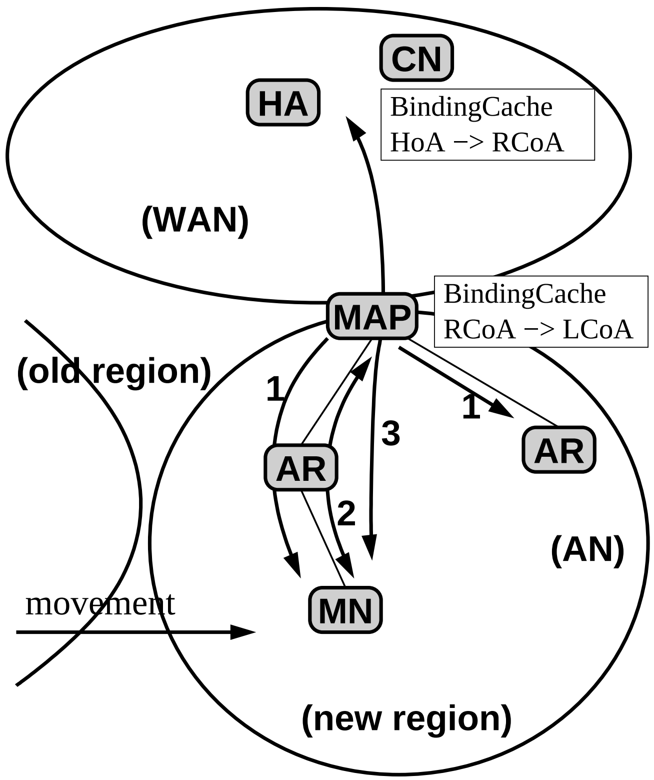
  ⇒ Less signaling latency

  ⇒ Less signaling overhead



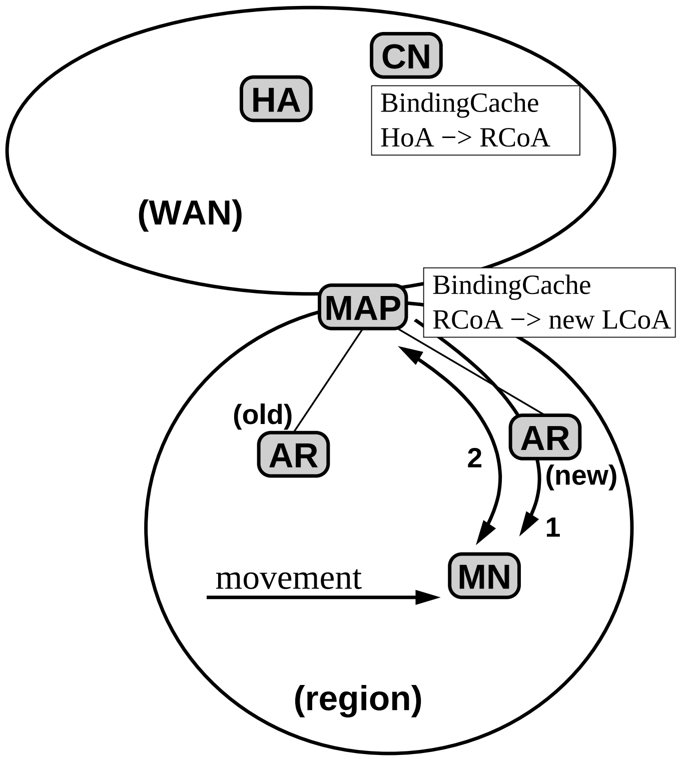
HMIPv6: Signaling (1)

- CoA splits into Regional-CoA and Local-CoA
  - RCoA identifies region (AN)
  - LCOA identifies access point
- MAP discovery:
  - MN learns the availability of new MAP by MAP options piggybacked in router advertisements (1)
- Global movement:
  - MN registers LCoA with MAP (2)
  - MN registers RCoA with HA and CNs (3)



HMIPv6: Signaling (2)

- Local movement: Requires single registration
  - MN learns the availability of the same MAP (1)
  - MN registers new LCoA with MAP (2)
  - For HA and CNs the RCoA has not changed



Implementation: Environment

- No stable released HMIPv6 implementation

Mobile IP for Linux (MIPL):

- Project from HUT Telecommunications and Multimedia Lab.
- http://www.mipl.mediapoli.com/
- Pro:
  - Open, stable and well maintained IPv6 / MIPv6 implementation
  - Very responsive mailing list
- MIPL provides MIPv6 functionalities as a loadable kernel module which can be dynamically loaded, modified and reloaded into the running system

Implementation: Functionalities (1)

- MAP:
  - Advertise and propagate MAP options in router advertisements for MAP discovery
  - Same functionalities as HA:
    - Receive, process and confirm BUs
    - Maintain binding cache
    - Intercept packets destined to MNs RCoA
    - Tunnel intercepted packets to MNs LCoA
- Intermediate routers (IR):
  - Receive and propagate MAP-options in Router-advertisements

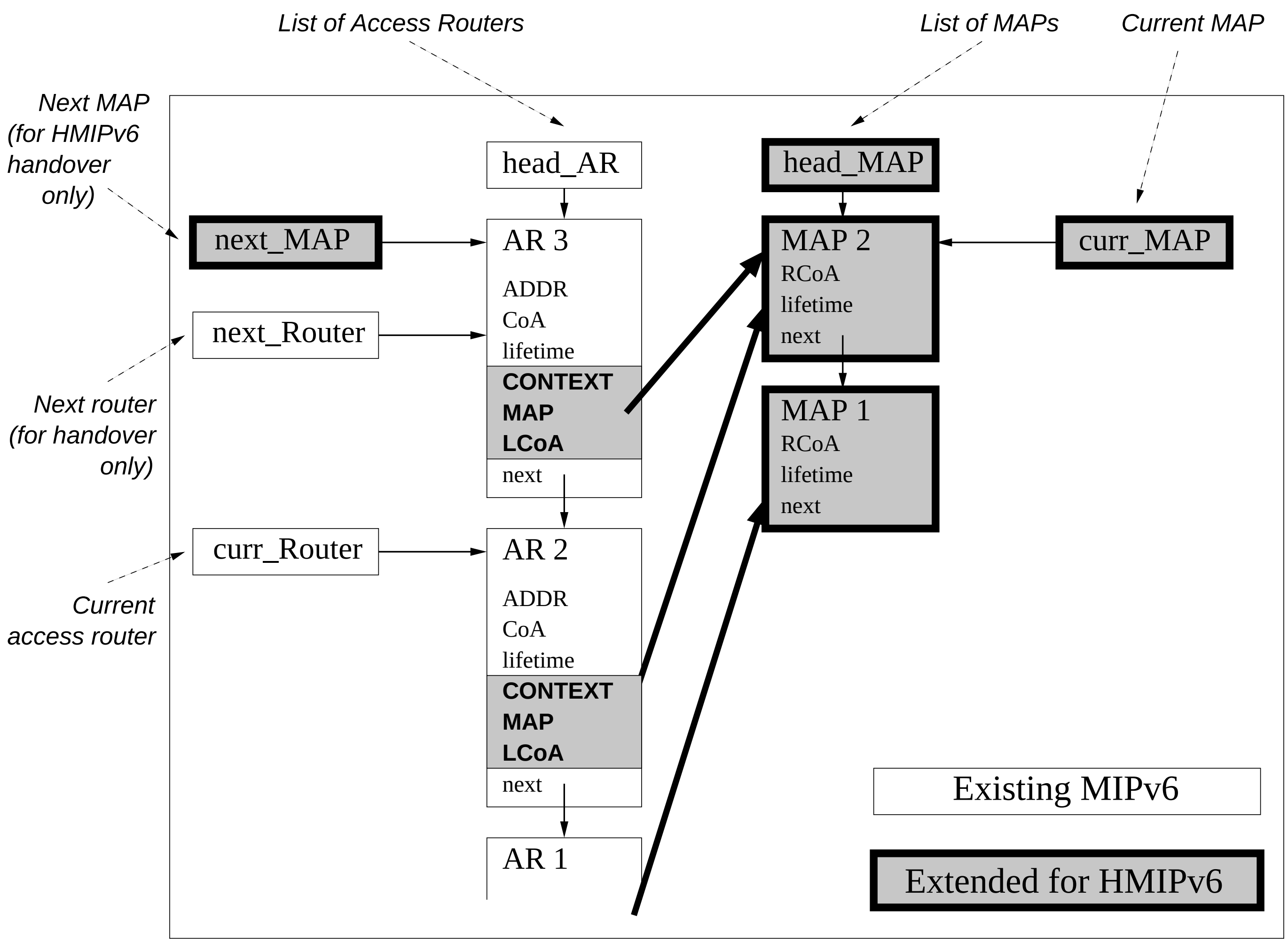
Implementation: Functionalities (2)

- MN:
  - Receive, process and maintain MAP options
  - Distinguish MIP and HMIP mode
  - If HMIP mode:
    - Distinguish local and global movement
    - Register at MAP with RCoA & LCoA
    - Register at HA and CNs with HoA & RCoA

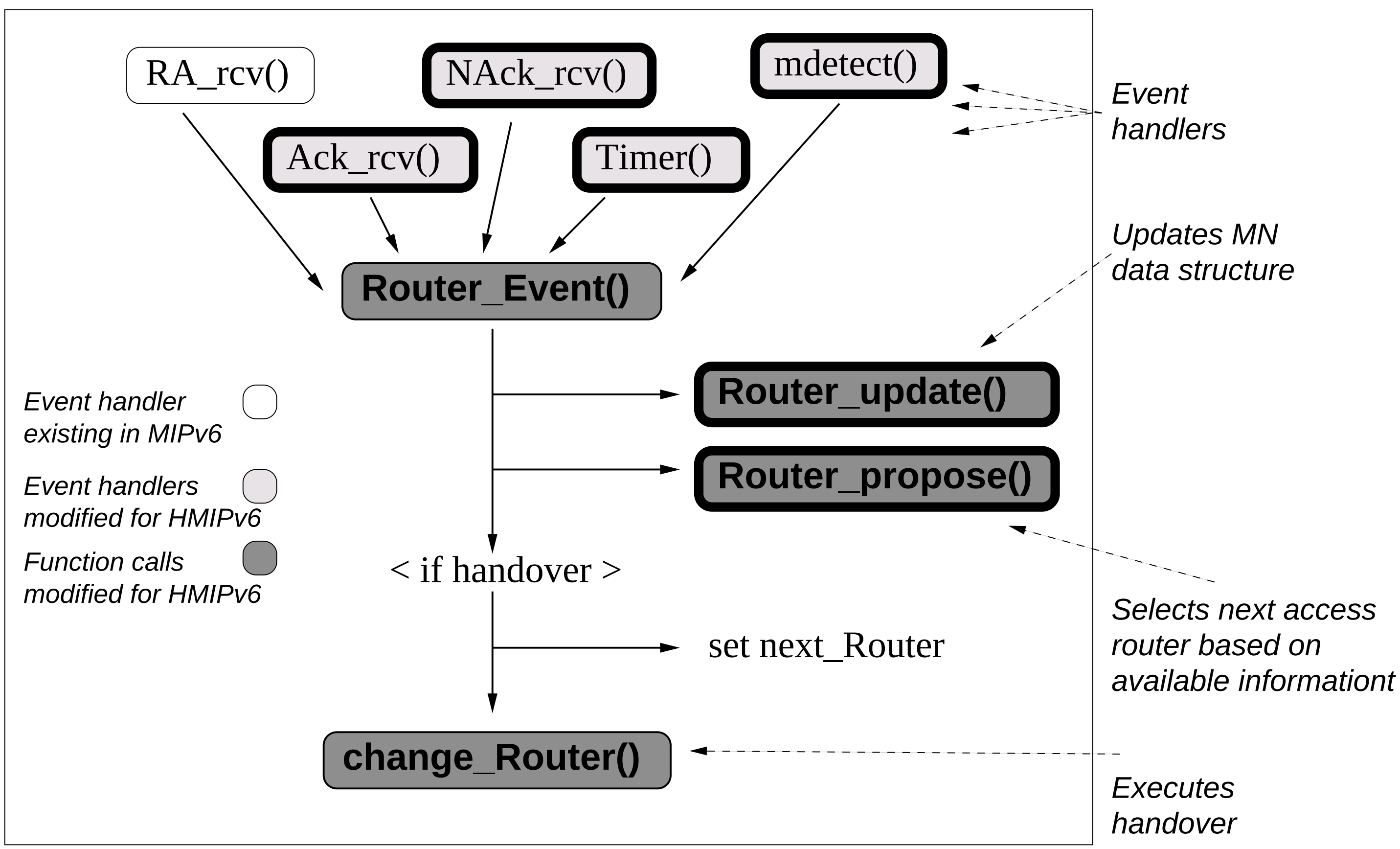
Implementation: Selected Issues of Design

- Extensions and modifications of
  - MN data structures
  - MN event handling
  - MN policy handling
  - MN handover processing

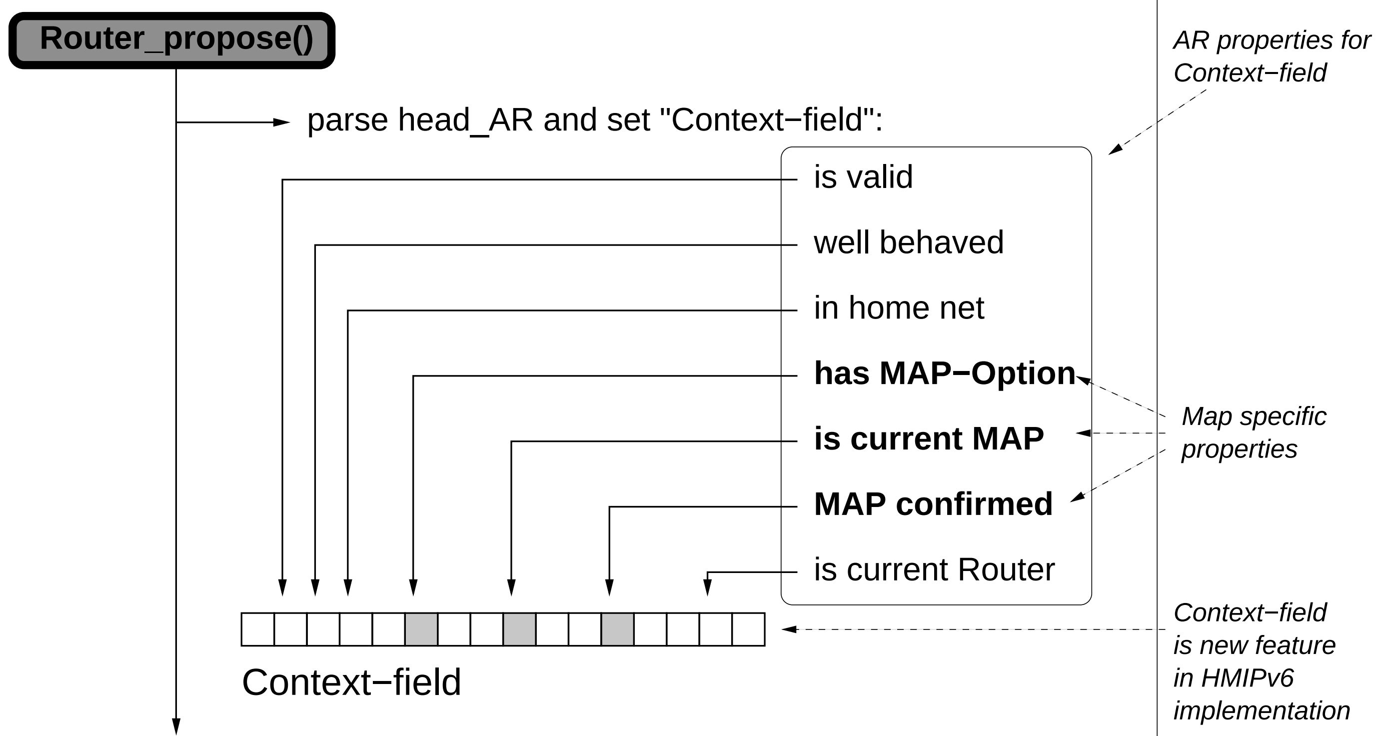
Implementation: MN Data-Structure



Implementation: MN Event-Handling

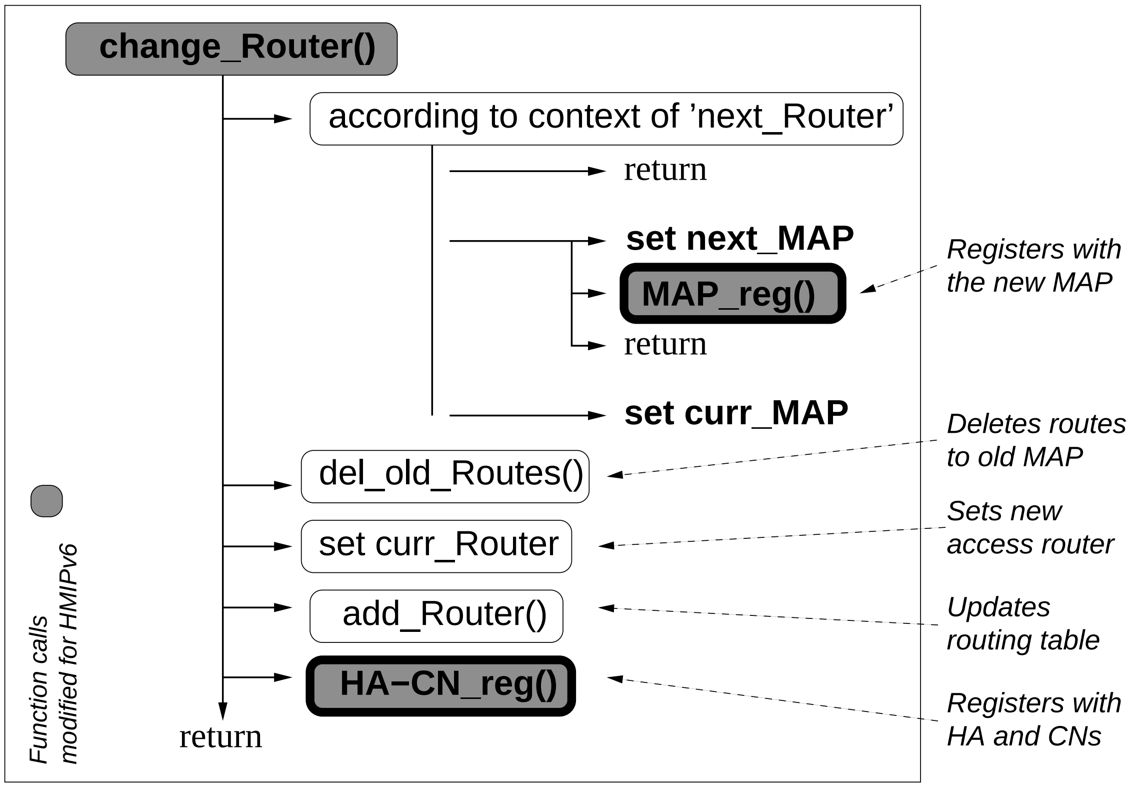


Implementation: MN Policy-Handling

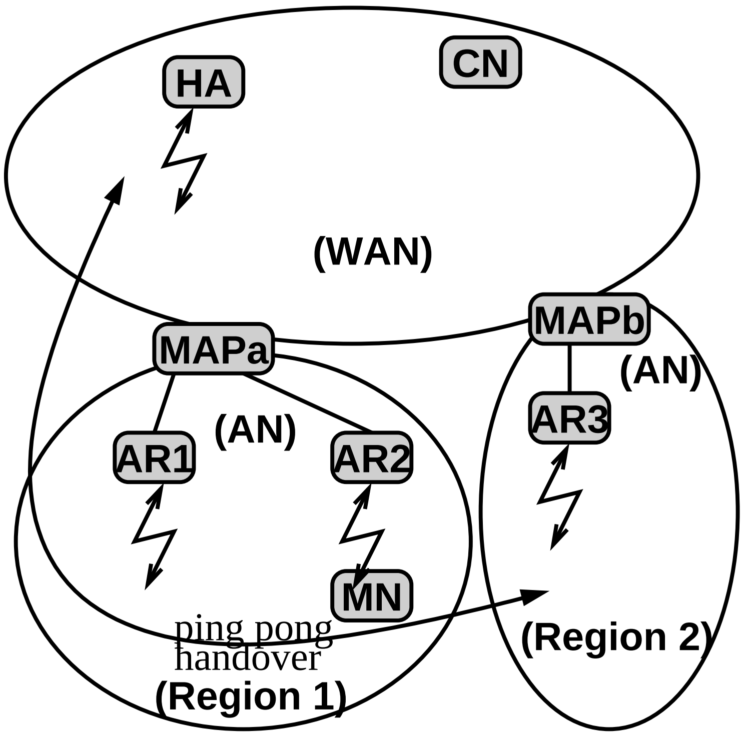


− Router with largest value of "Context−field" becomes handover target
− Ties are broken in preference of recently added routers

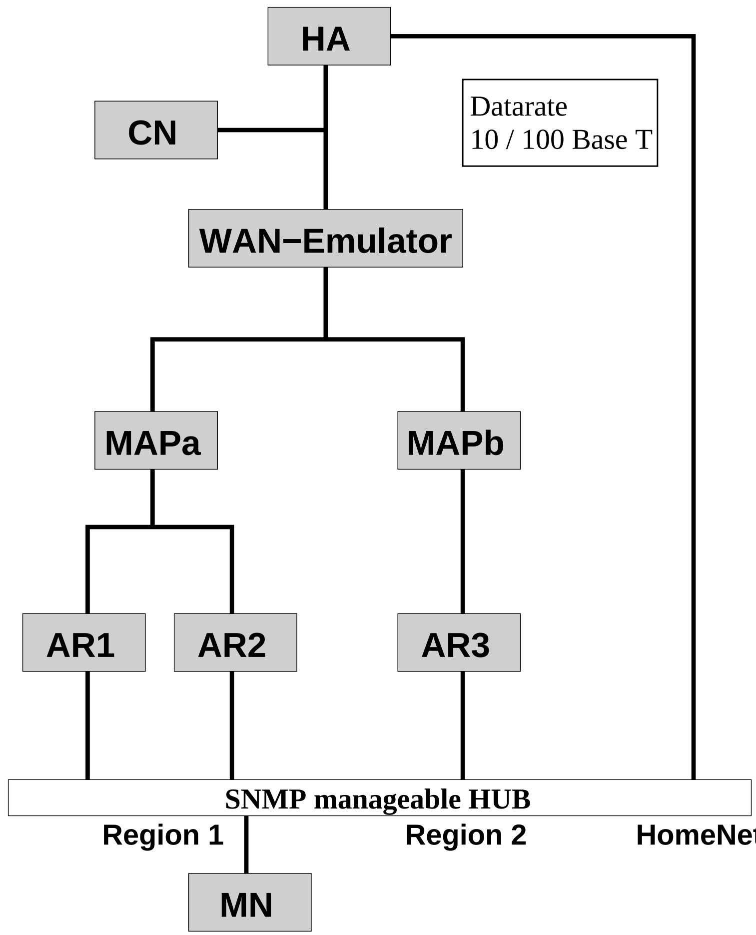
Implementation: MN Handover-Processing



Testbed: Real Scenario

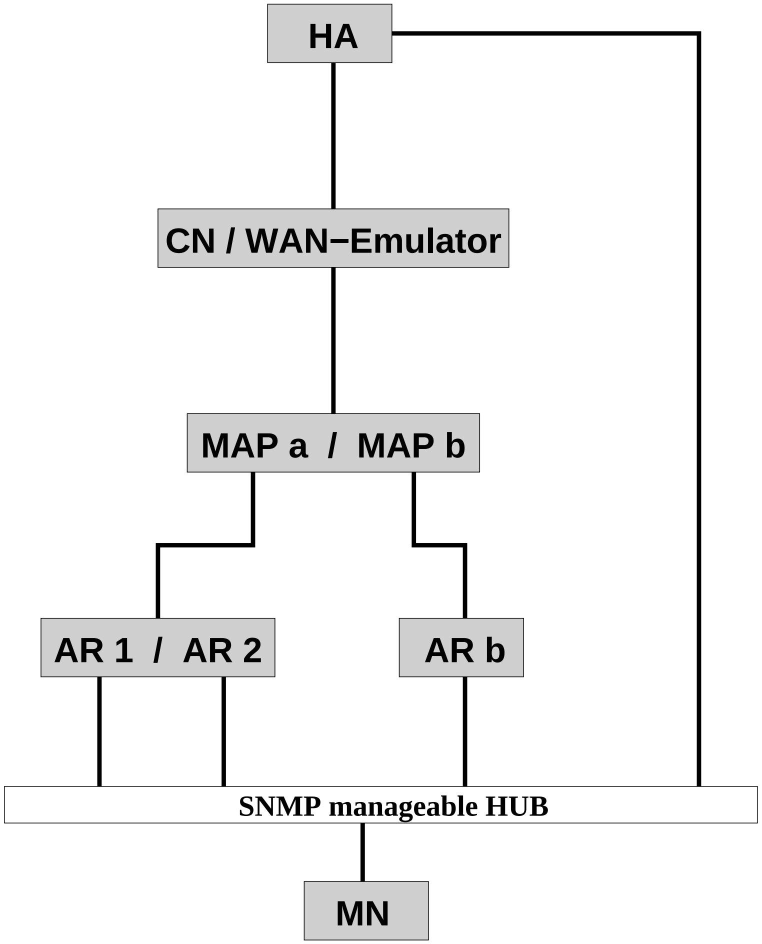


Testbed: System Model



Testbed: Tools and Setup

- WAN-emulator: SoftLink for IPv4
  - Tunnels IPv6 packets over IPv4
- Traffic generator: Ping6, SendIP6
- Network monitor: Tcpdump6
- Movement emulation:
  - Manageable SNMP hub
  - Use Netfilter to drop packets from certain AR
- Emulate link-layer trigger: LinkMonitor
  - Tool to monitor link connectivity



Testbed: Preliminary Performance Results (1)

- Experiment 1
  - Metric: Handover latency as duration of entire registration process (binding update to binding ack)
  - in case of global movement in HMIPv6 mode: duration from BU to MAP and BA from HA
  - RTT between MN and HA / CN: 90ms

	MIPv6	HMIPv6
Local Handover	91 ms	0.5 ms
Global Handover	91 ms	92 ms

Table 1: Handover latency

Testbed: Preliminary Performance Results (2)

- Experiment 2
  - Metric: Send ping6 packets from MN to CN and Count lost ping6 replies per handover
  - Constant generation interval of 10ms
  - RTT between MN and HA / CN: 90ms
  - LinkMonitor takes 20-30ms to detect movement

	MIPv6	HMIPv6
Local Handover	10	4

Table 2: Total packet loss per handover

Personal Implementation Experience

- Lack of protocol and implementation design for Linux IPv6/MIPv6 made the extensions to HMIPv6 a challenging task
- Complex structure of existing implementation
- Implementing in Linux kernel means:
  - Heavy fighting with the whole kernel, especially the:
    Network, IPv6 and MIPv6 stack
  - Hypertext cross reference tools to navigate the kernel was very helpful
  - Difficult debugging: the system tends to crash faster than any debugging message could reach the screen
- IPv6 tools for performance evaluation are hard to get

Conclusion and Outlook

- Hierarchical Mobile IPv6 conceptually improves handover latency and signaling overhead for basic Mobile IPv6
- HMIPv6 functionalities based on MIPL have been implemented
- Preliminary measurement results prove that HMIPv6:
  - Outperforms MIPv6 in local movement
  - Causes only small increase of signaling latency in global movement
- HMIPv6 Implementation serves as basis for a prototype implementation of QoS-enabled handover scheme proposed in: draft-tkn-nsis-qosbinding-mipv6
- Further measurements will be conducted