

# Edge Handovers for Mobile IPv6

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*... an interoperable enhancement to Mobile IPv6 to reduce handover latency for movement within an edge network, and to reduce handover signalling outside the edge network.*

## Converged Services

- Modern mobile networks carry different types of traffic:
  - ◇ “Real-time services” – Voice, Video, Games
  - ◇ “Packet services” – Web, Email, More Games
- Any given device or applications may need to use *both* kinds of traffic
- “Converged Services” – both kinds of traffic use same routing (etc) infrastructure.
- Can use packet traffic over voice channel but it’s inefficient, inflexible.

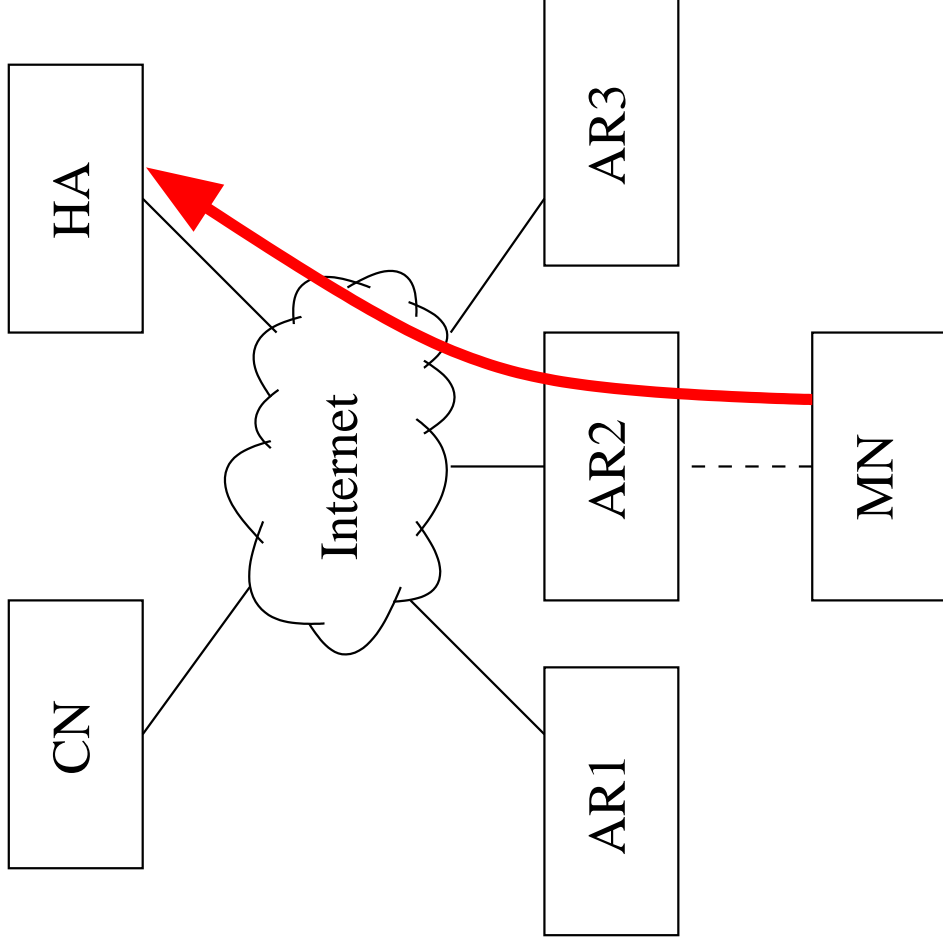
## Real-time Services over IPv6

- Session initiation with SIP
- Bandwidth allocation with RTP / QoS
- Lots of audio & video codecs

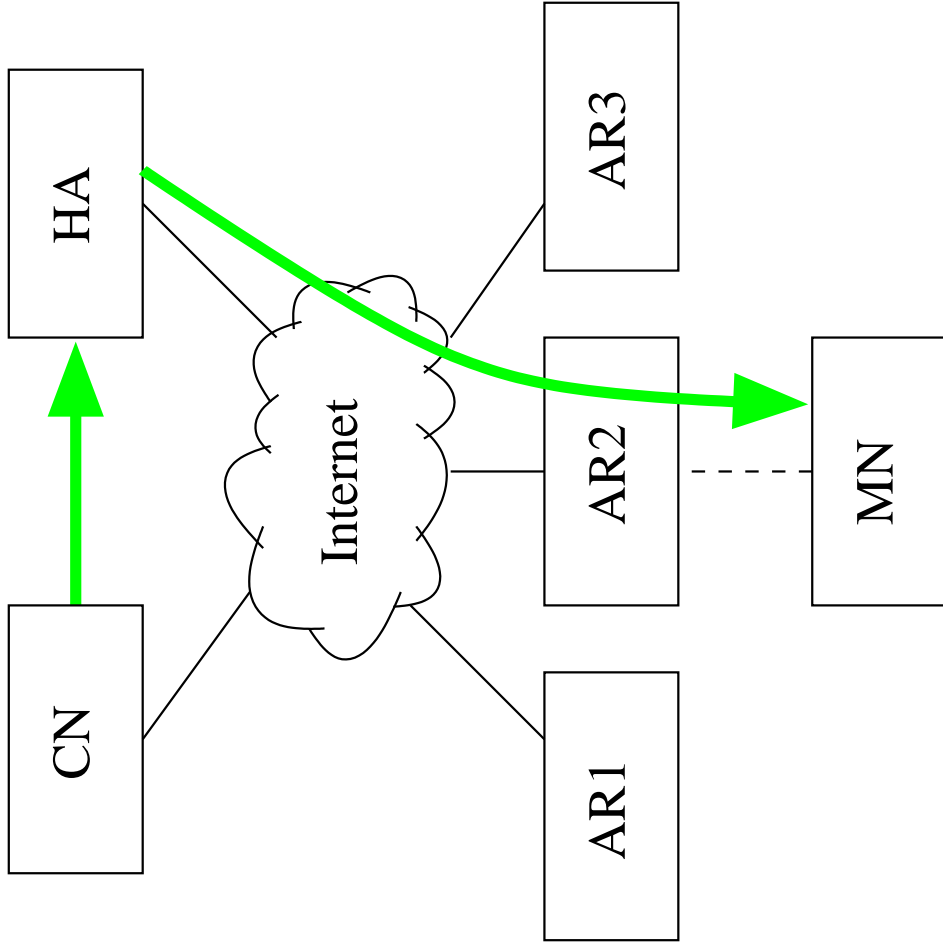
What about *mobility*?

## Mobile IPv6

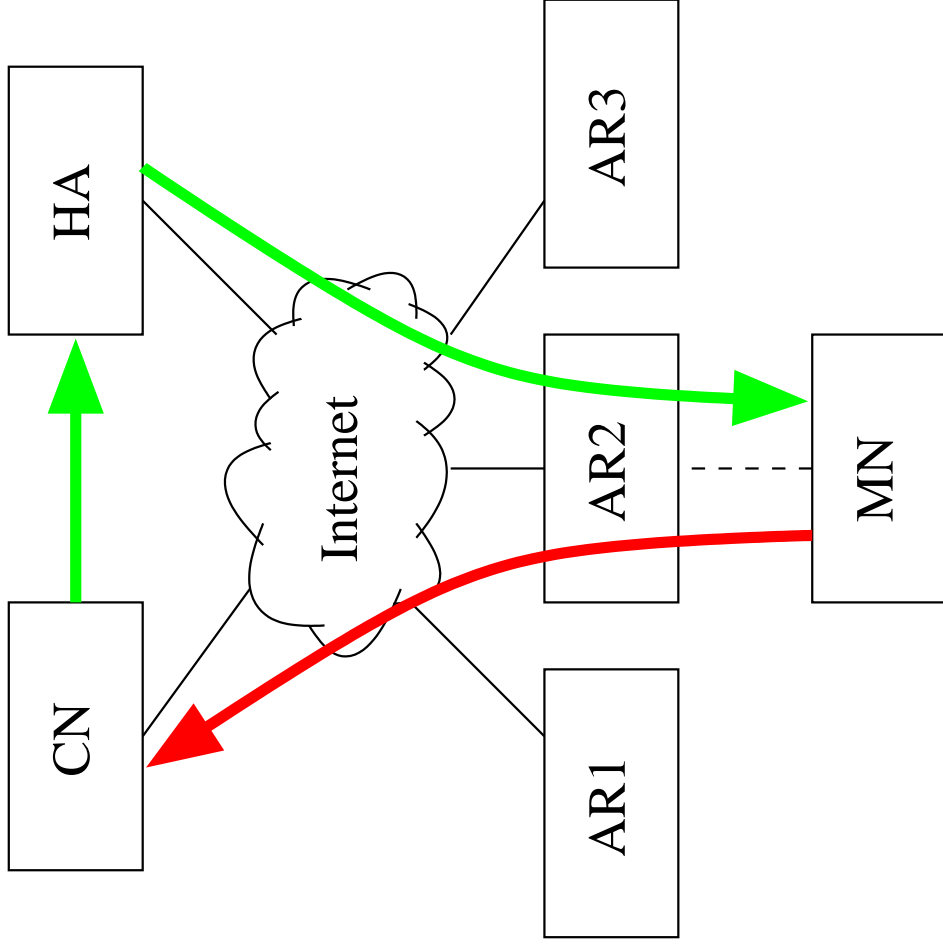
- IPv6 routing is designed for a static Internet.
- MIPv6 provides ‘overlay routing’ for mobile devices.
- Uses a Home Agent to redirect traffic to a Mobile Node.



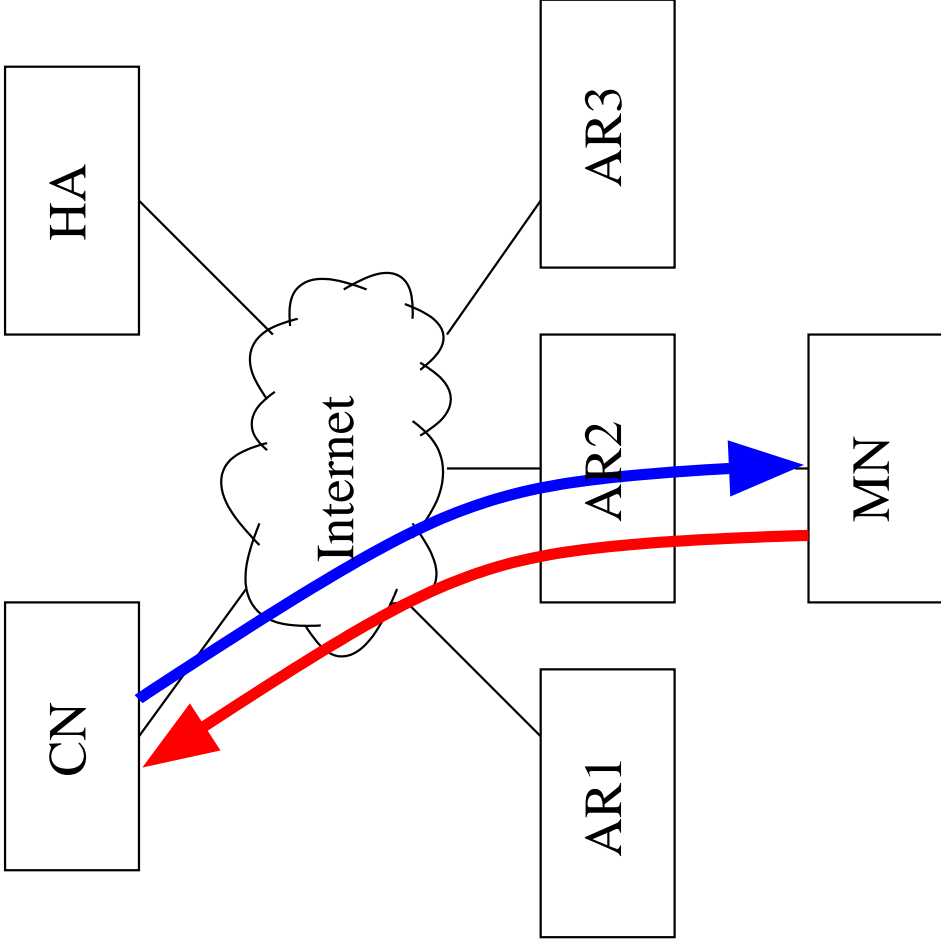
- Mobile Node (MN) moves between Access Routers (ARs).
- MN sends Binding Updates (BUs) to Home Agent (HA).



- HA forwards traffic to MN.
- no Foreign Agent needed.

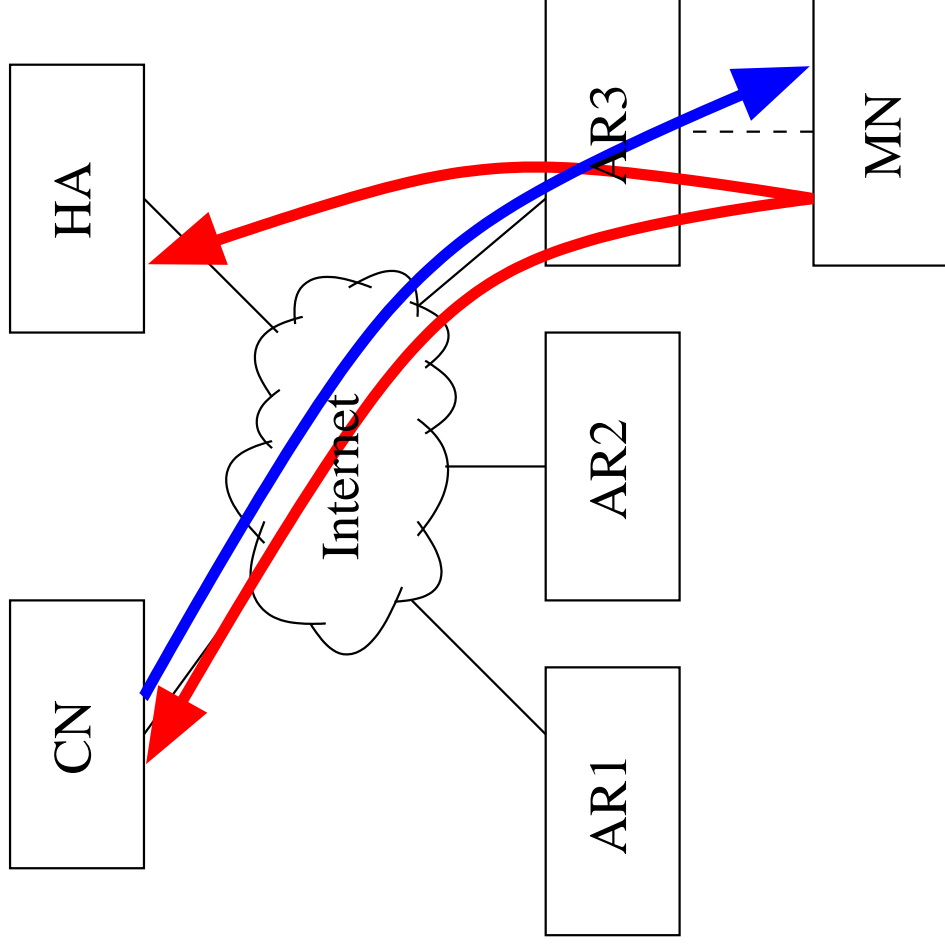


- MN sends data and BU direct to CN.



- CN and MN can now correspond directly.





- If MN moves, it sends BU to HA, CN.
- CN starts sending data to new location.
- HA sends new connections to new location.

## Fast Handovers

- IPv6 handovers are not sufficiently fast for real-time services – over 3000ms avg. if fully compliant.
- Handover latency is due to the time taken for the MN to establish itself on the foreign network.
- If we can predict where our new location will be, we can prepare the way and thus establish more quickly.
- Difficult at best.
- RFC4068: Fast Handovers for Mobile IPv6

*R. Koodli, Ed.*

## Four Delays

Handover delay can be broken down into four parts:

<i>Movement Detection Delay</i>	...	“Are we there yet?”
<i>Router Advertisement Delay</i>	...	“Where am I?”
<i>Address Configuration Delay</i>	...	“Is this number free?”
<i>Binding Update RTT</i>	...	“Dear Home Agent ...”

## Four Delays: Solutions

Rather than trying to solve whole problem at once, address the causes of delay individually:

<i>Movement Detection Delay</i>	↔	DNA WG; L2 Triggers
<i>Router Advertisement Delay</i>	↔	Fast RA; FRD
<i>Address Configuration Delay</i>	↔	Optimistic DAD
<i>Binding Update RTT</i>	↔	HMIPv6; Edge Handovers

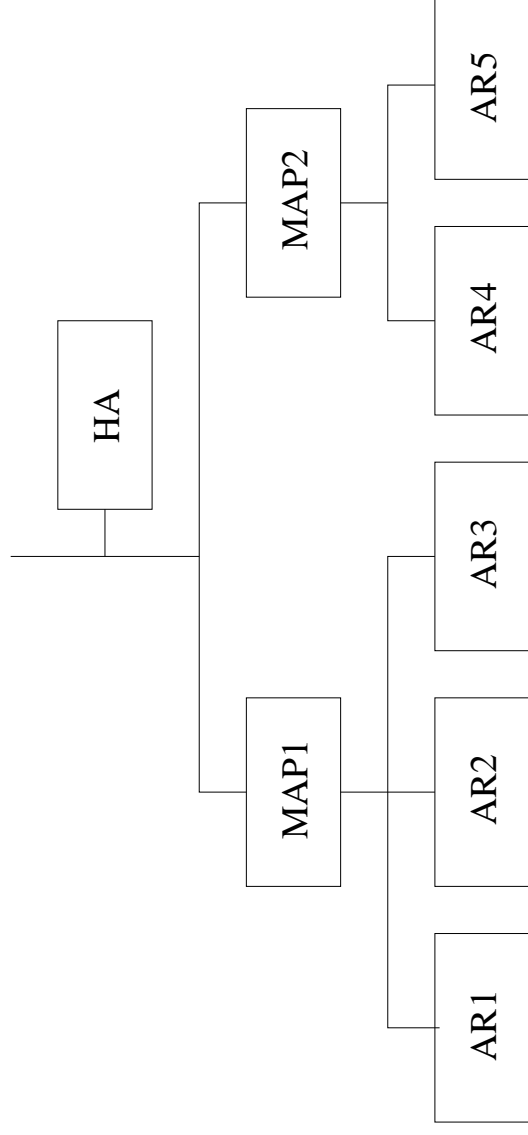
## Localized Mobility Management

We're making some assumptions about the characteristics of the Edge Network compared to the Internet:

- High bandwidth
- Low latency
- Low Cost

Localized Mobility Management spends Edge Network resources to save Internet resources.

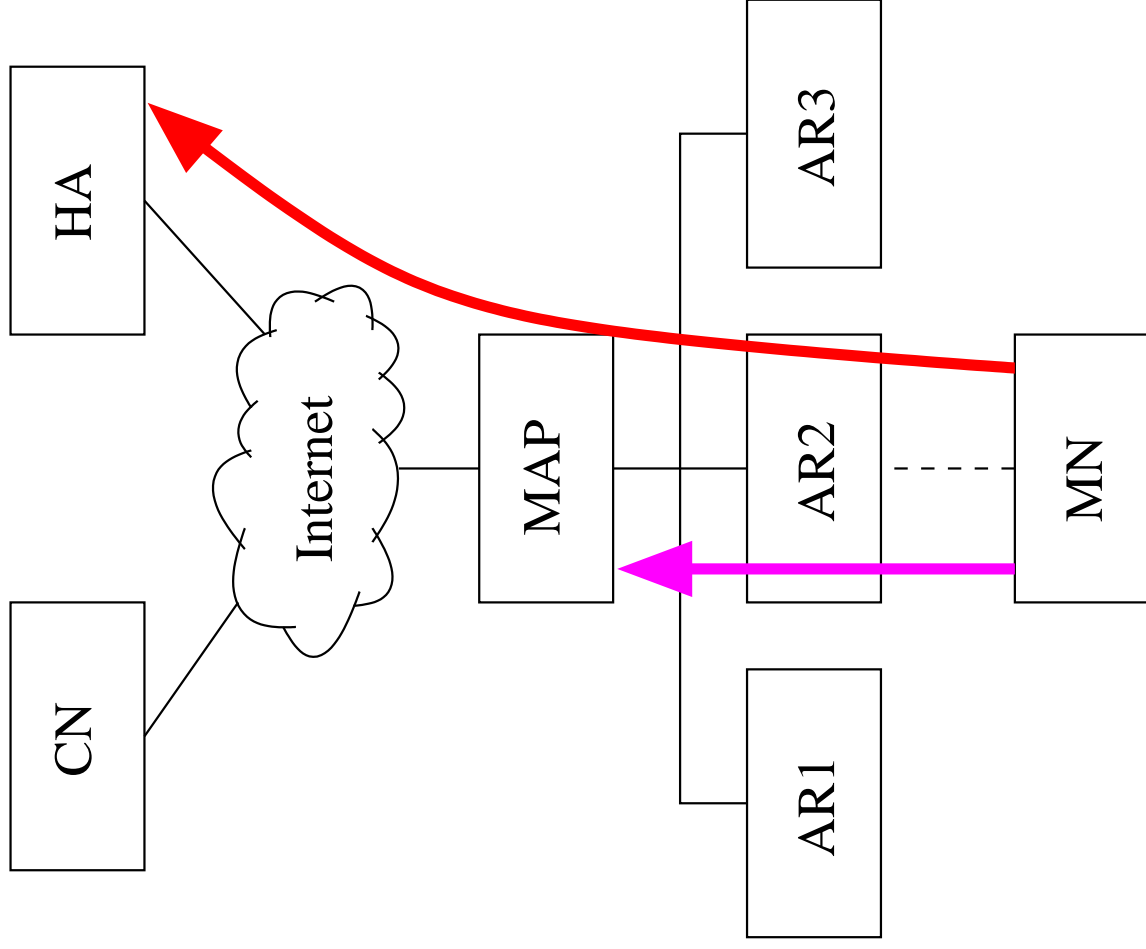
# HMIPv6



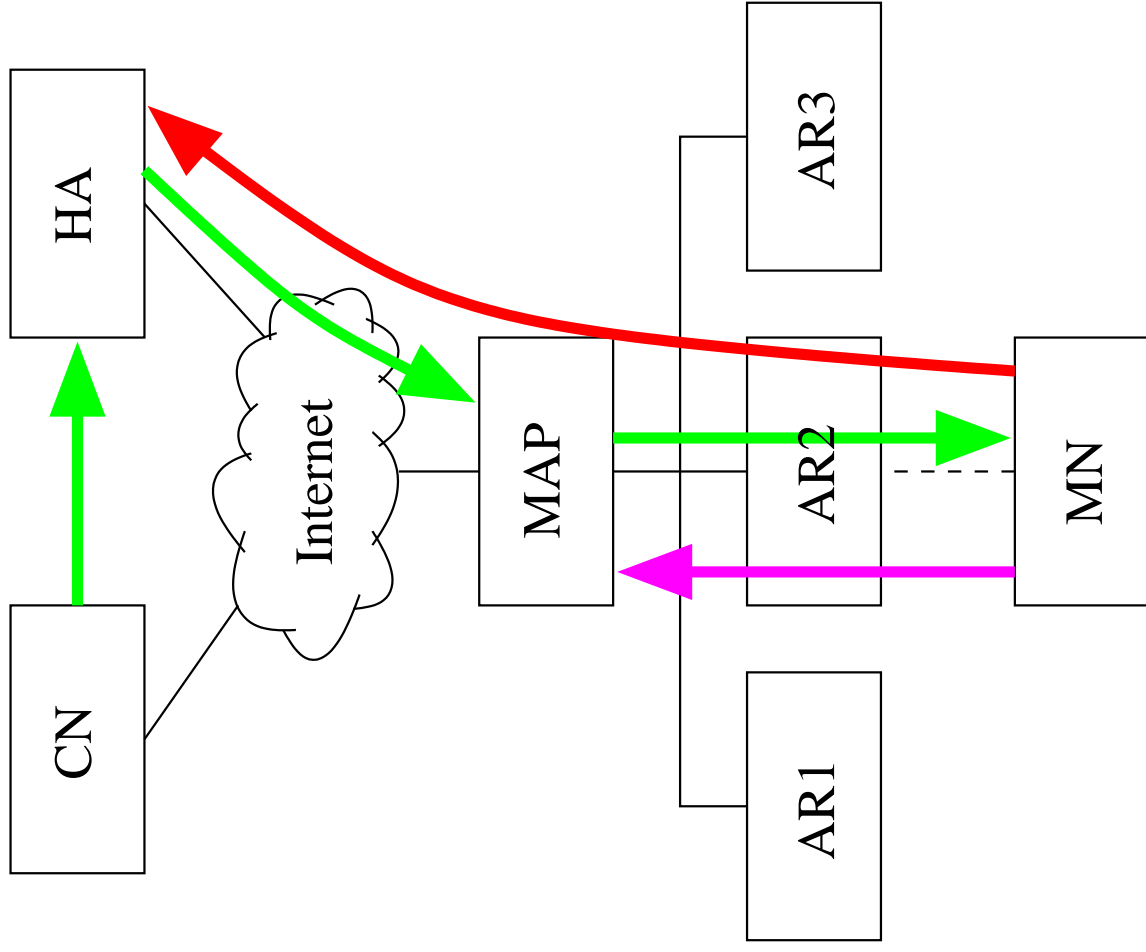
- RFC4140: Hierarchical Mobile IPv6 Mobility Management

*H. Soliman, C. Castelluccia, K. El Malki, L. Bellier*

- *Mobility Anchor Point (MAP) between HA and MN.*
- Signalling to HA only required when MN leaves coverage area of its MAP.
- Establishes *Bindings* from a *Regional Care-of Address (RCoA)* to a *Local Care-of Address (LCoA)*.

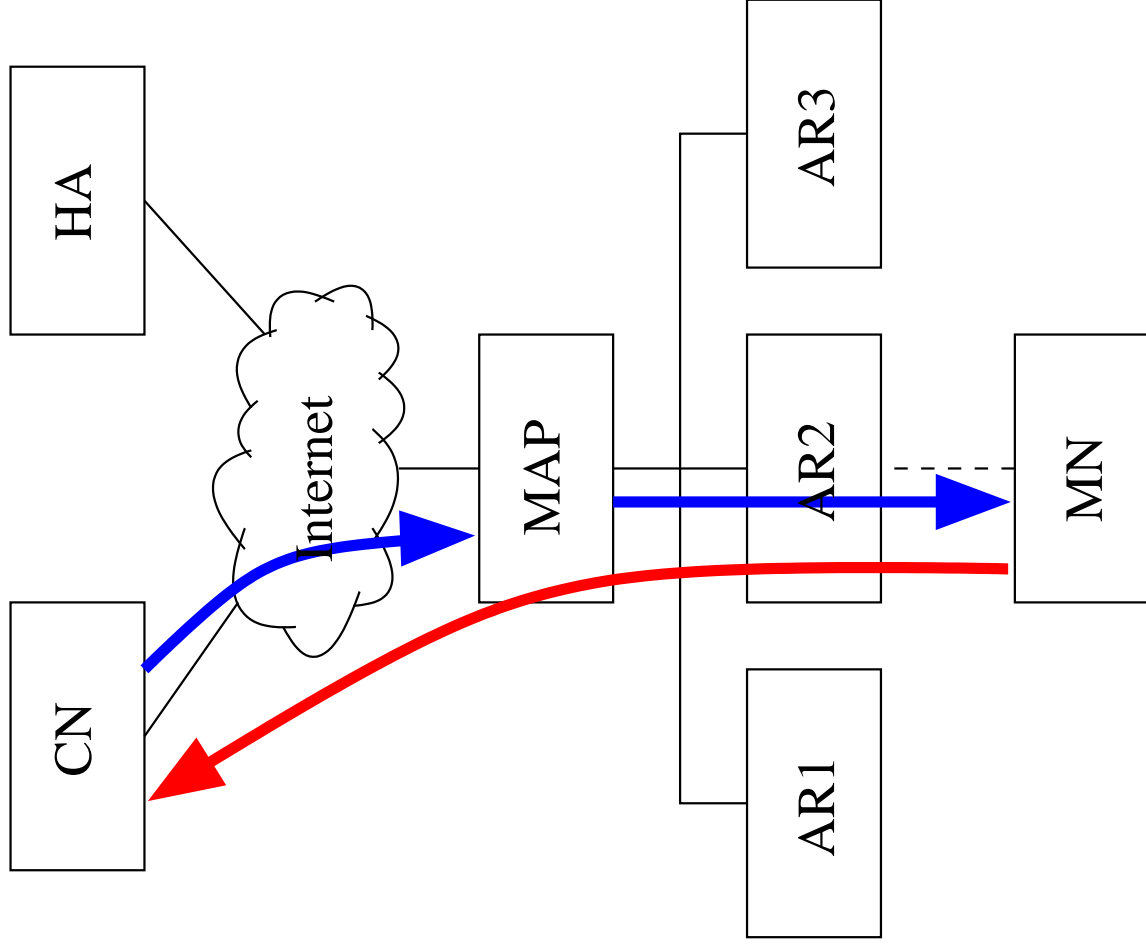


- MN tells MAP its location (LBU).
- MN tells HA location of MAP (BU).

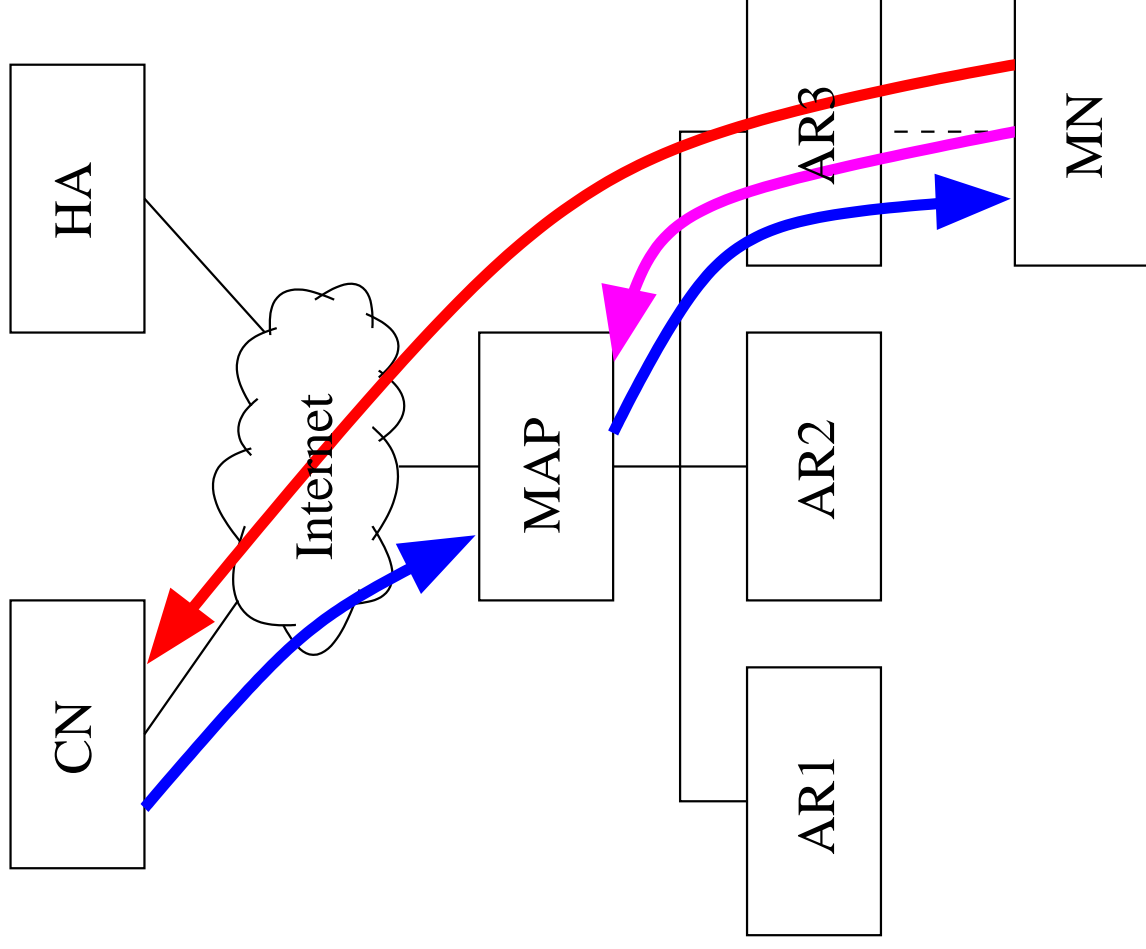


- HA forwards traffic via MAP.





- MN tells CN its address on the MAP
- Route is optimized.

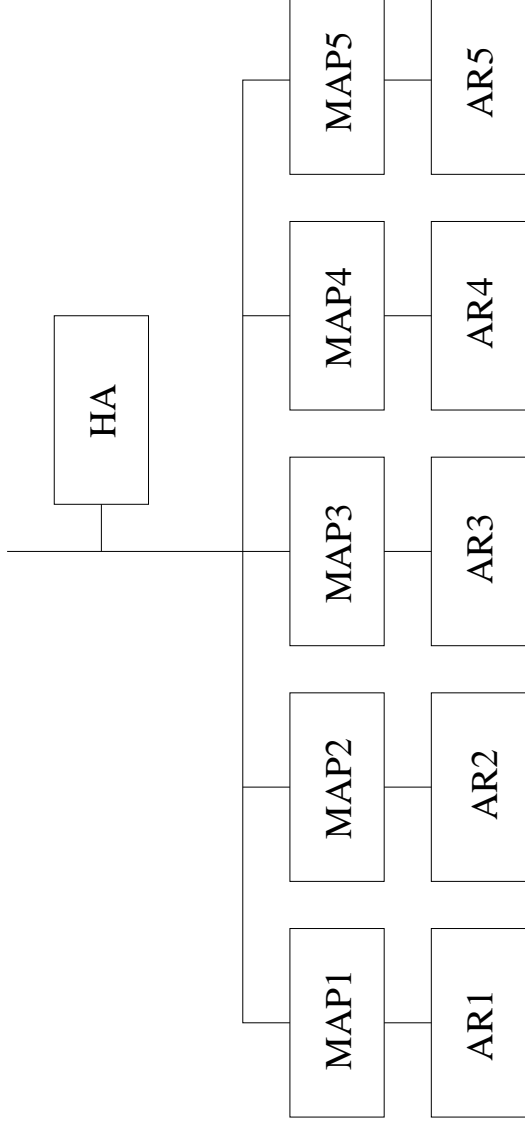


- Now when the MN moves it need only tell the MAP.
- The MAP is much closer to the ARs than the HA was, so less latency.

## Problems with HMIP

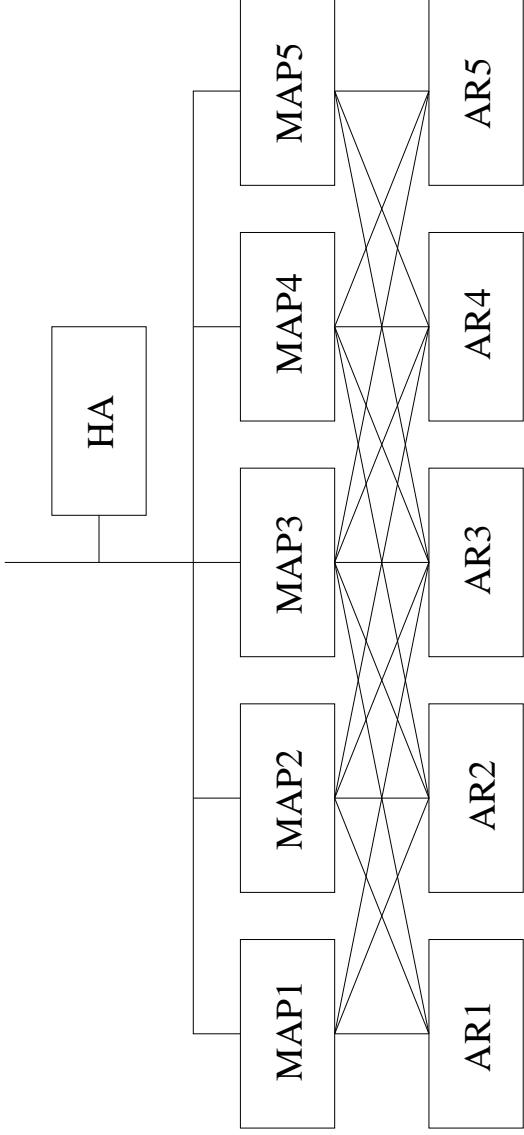
- Trend is towards ‘stupid network’ with intelligence at edge – MAP is not at edge.
- Where should the MAP be?
  - ◊ Close to the edge: lower latency for faster handovers.
  - ◊ Far from the edge: larger coverage area thus less MAP-to-MAP handovers.
- MAP is single point of failure.

## HMIPv6 at the Edge



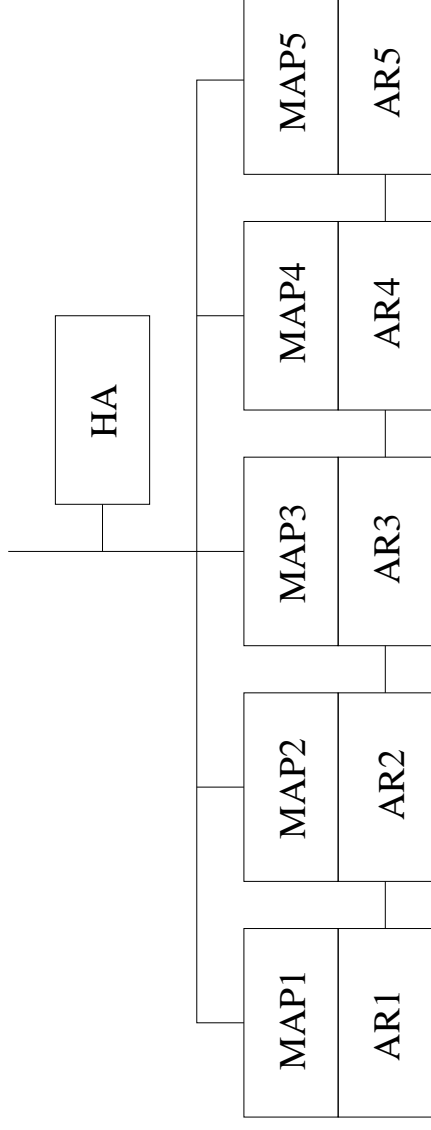
- Migrate MAPs down to access routers.
- Described in section 10.2 of the HMIPv6 draft.
- Degenerate case of HMIPv6? (1-hop tunnels, RCoA and LCoA)
- **To be useful, improved MAP-to-MAP handovers are needed.**

# Edge Mesh



- If MAP1 could continue to provide service to the MN for some time after it moves to AR2, the signalling required for the handover to MAP2 would be removed from the critical path of the handover.
- If MAP1 could continue providing service for the MN when it moves from AR2 to AR3, the handover to MAP2 need not be performed, eliminating that MAP-to-MAP handover entirely.

## Edge Network



- MAP functionality can be integrated into the AR for a simplified network.
- A single physical device can easily perform both MAP and AR functions at each location.

## Edge Handovers

- `draft-moore-mobopts-edge-handovers-01`  
*N. Moore, JH. Choi, B. Pentland*
- `draft-moore-mobopts-tunnel-buffering-00`  
*N. Moore, JH. Choi, B. Pentland*

## Forwarding

One very simple thing we can do to improve handovers is to forward traffic bound for the old address to the new address instead:

MN: LBU(ORCoA, NLCoA)  $\rightarrow$  OAR

- Described in section 8 of the HMIPv6 draft.
- We've extended this behaviour.



## Buffering

If we don't know where we're going, request the old MAP/AR to buffer traffic for us by sending an update to 'nowhere'.

MN: LBU(ORCoA, ::) → OAR

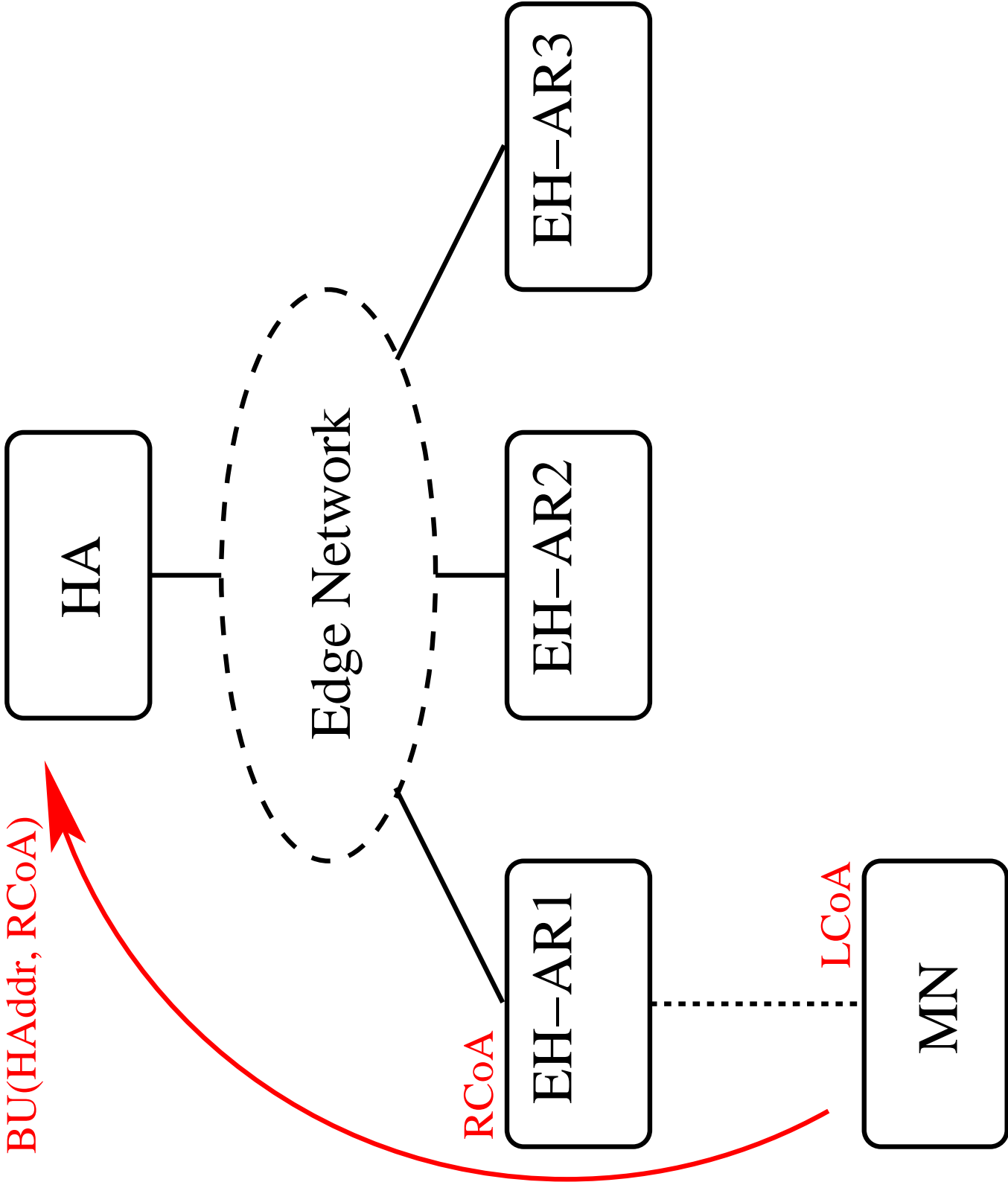
This could easily be introduced into HMIPv6, too.

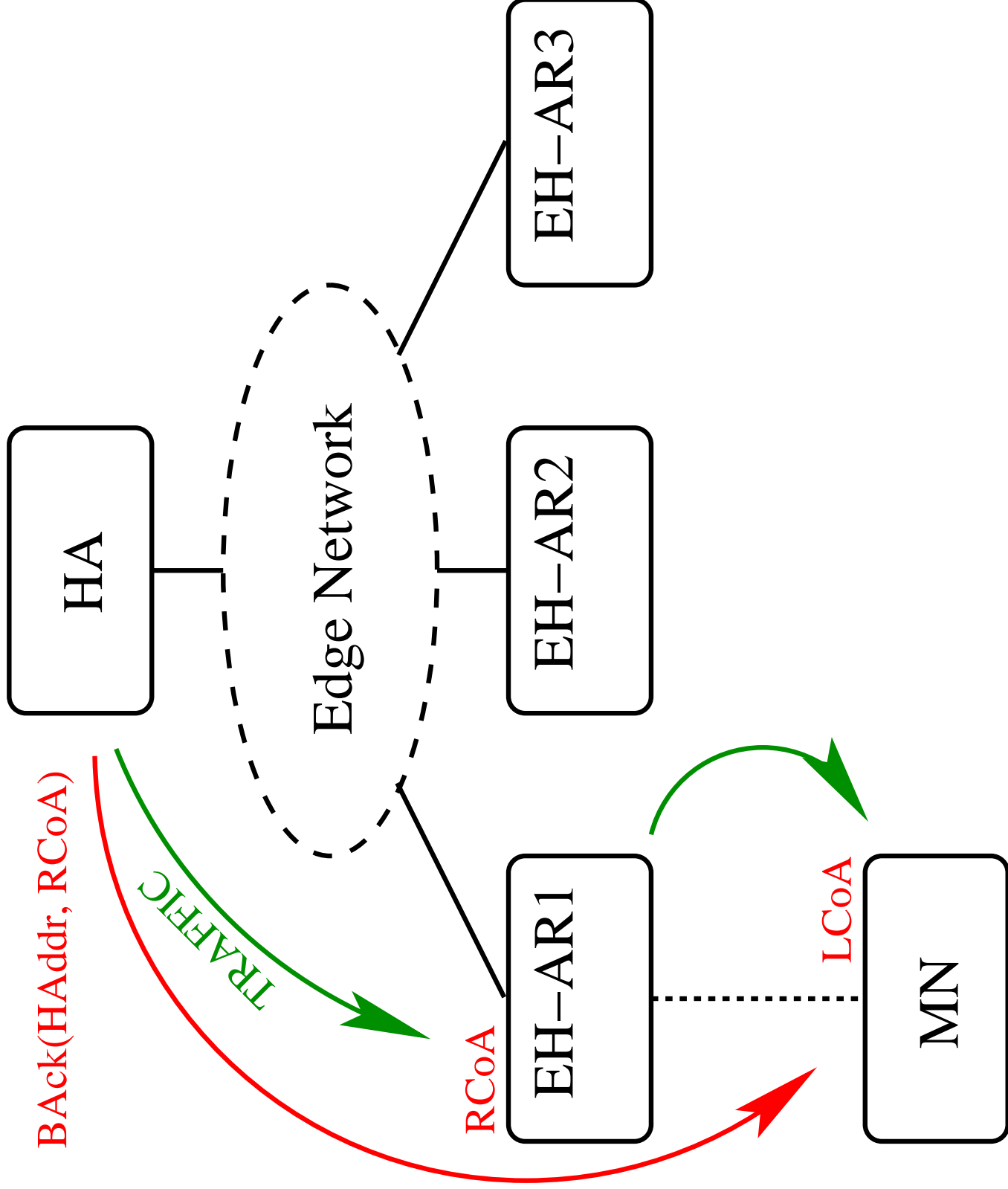
Precedent:

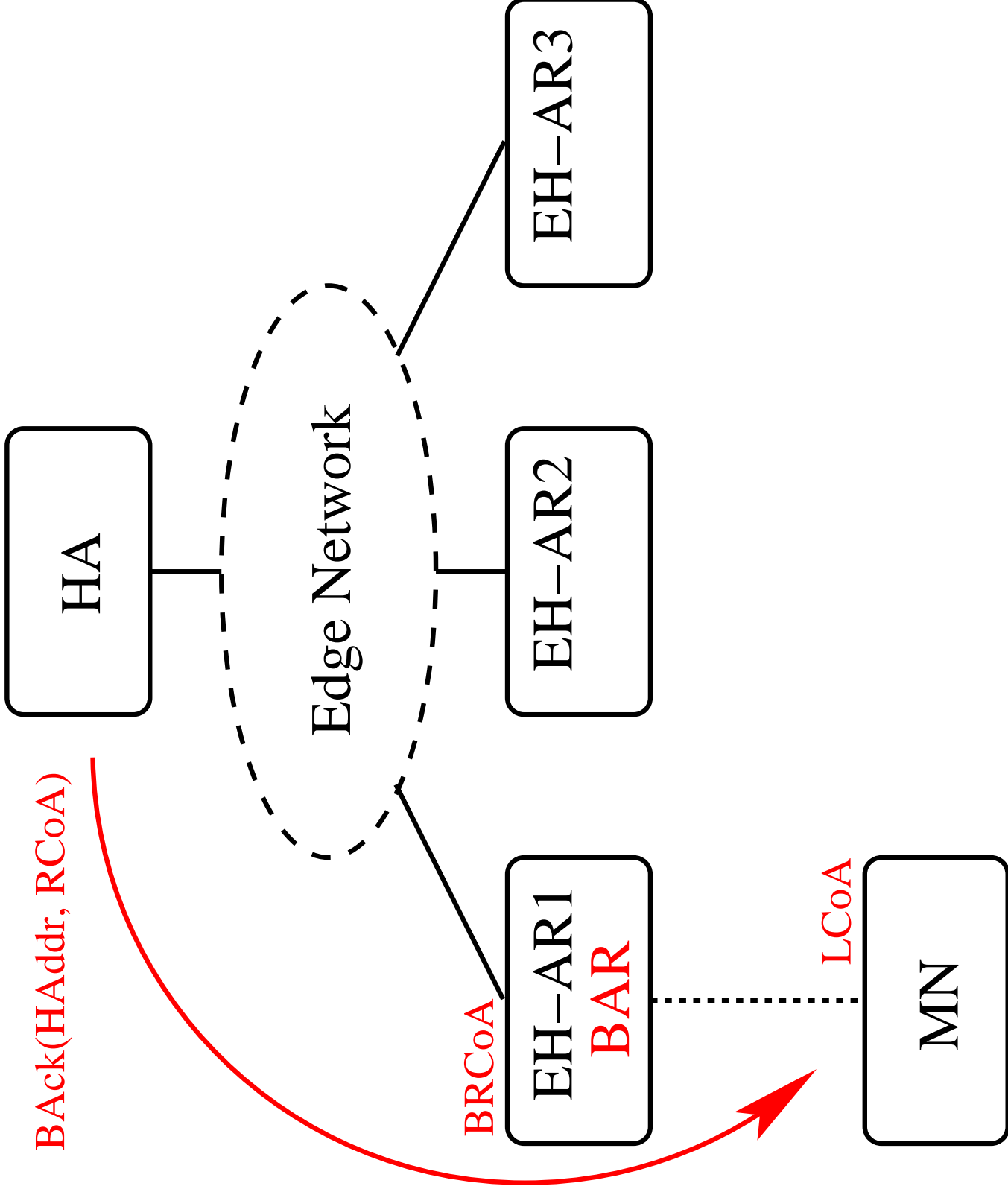
- Suggested to us by Richard Nelson (Waikato)
- [draft-krishnamurthi-mobileip-buffer6-01](#)

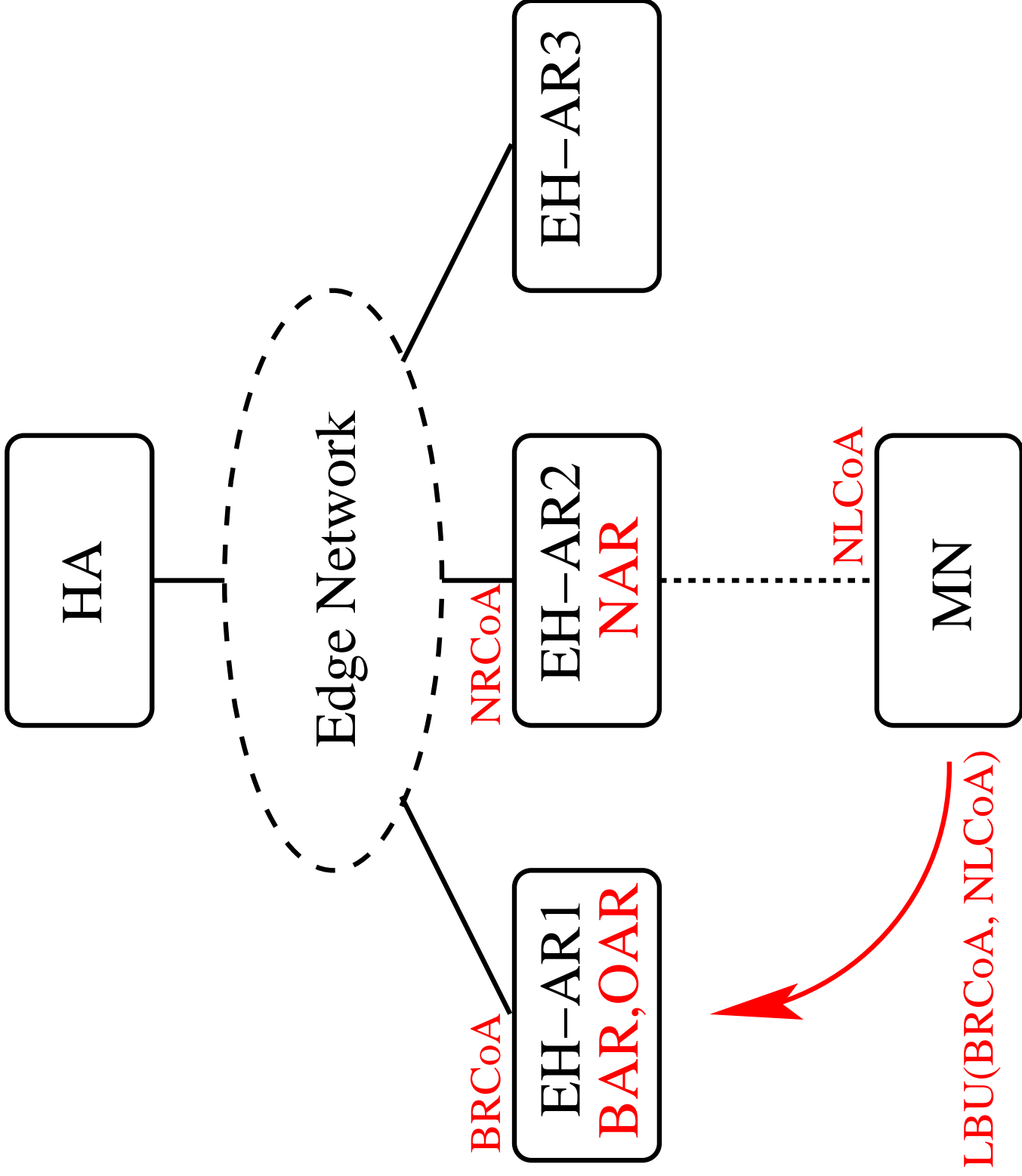
## MAP-to-MAP-to-MAP handovers

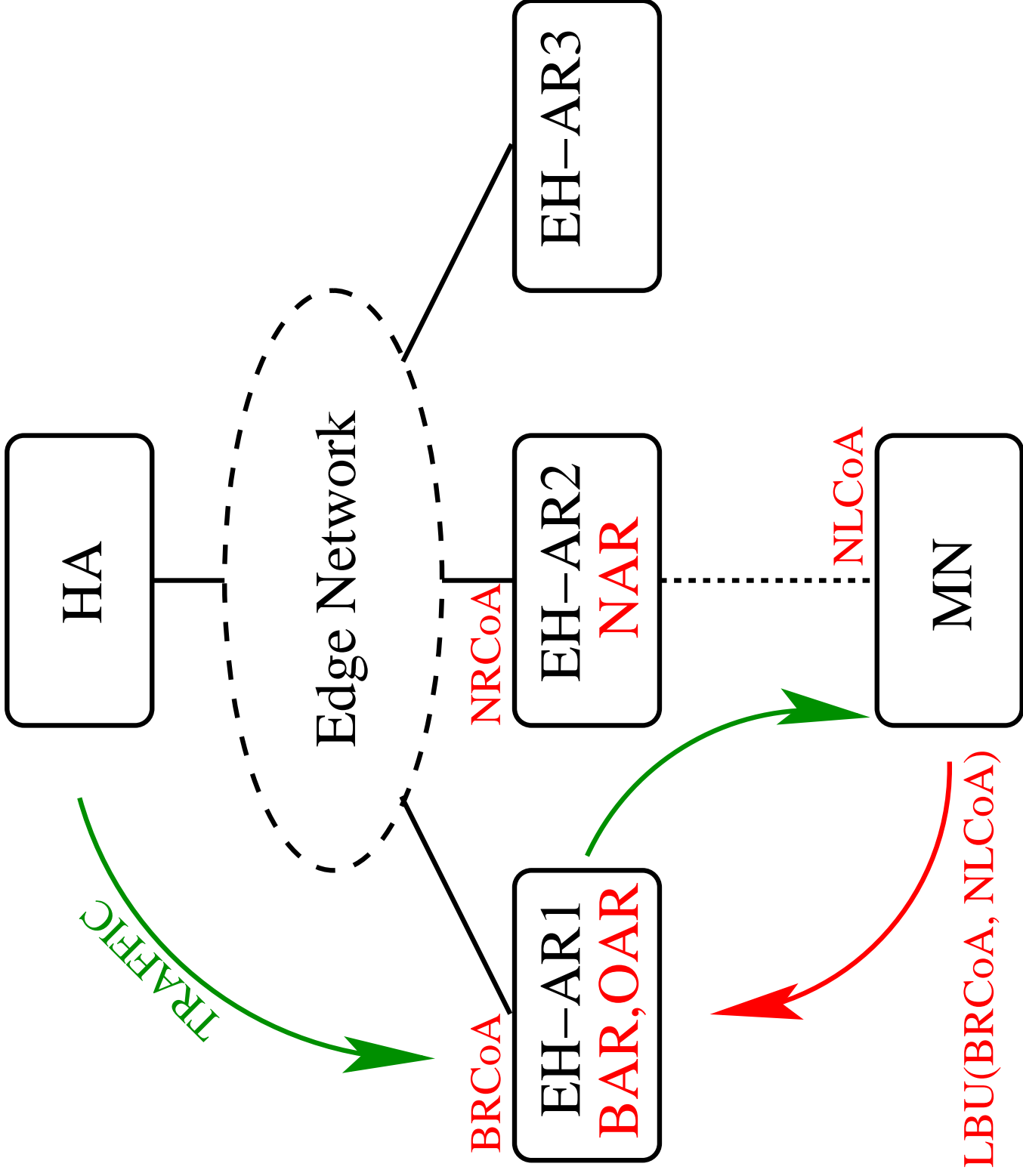
- The *Bound Regional Care-of Address* (BRCoA) is the RCoA for which you most recently received a BAcK from your HA.
- The *Bound Access Router* (BAR) is the AR which provided you with the BRCoA. It is the AR which is acting as your MAP.

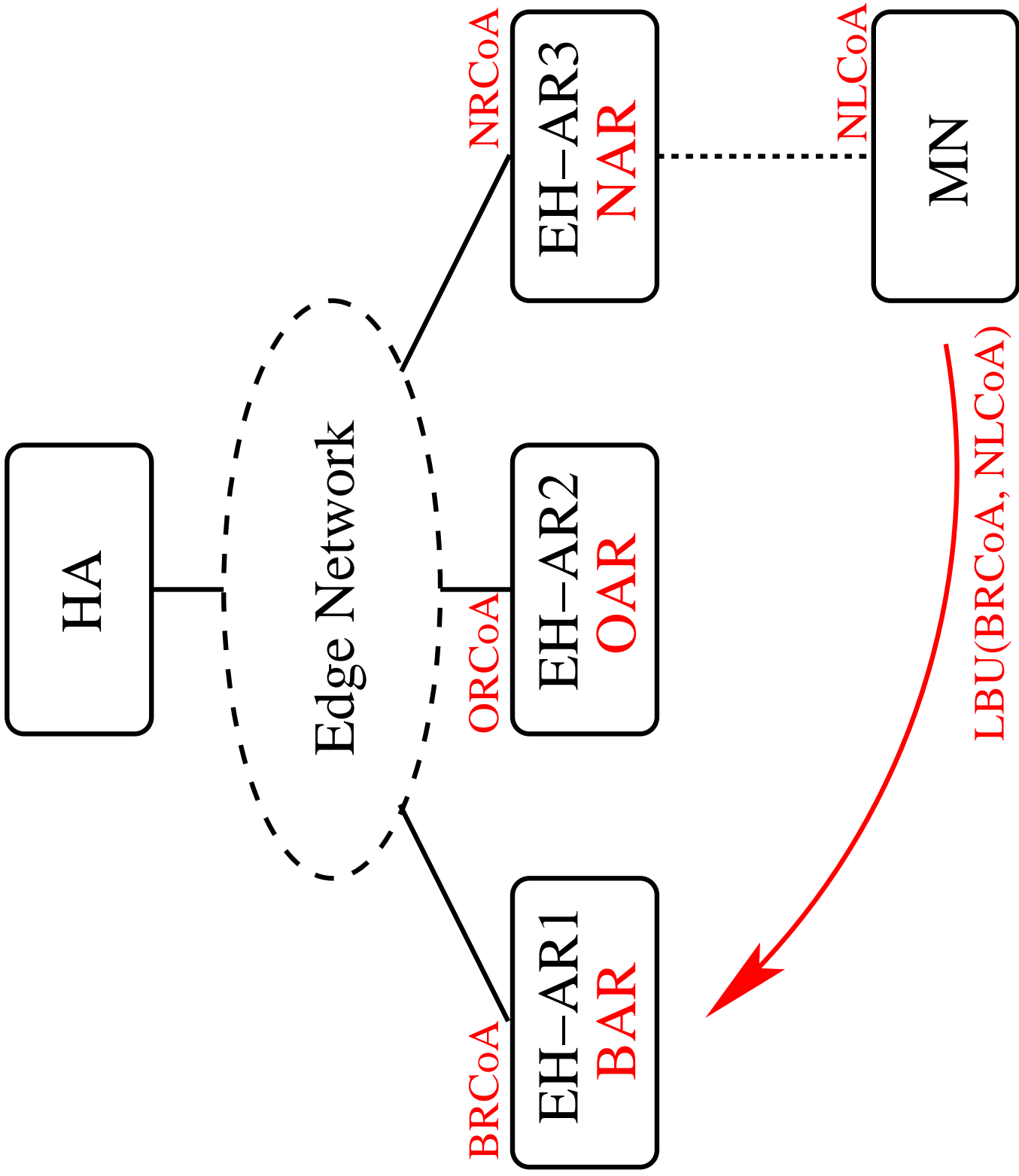




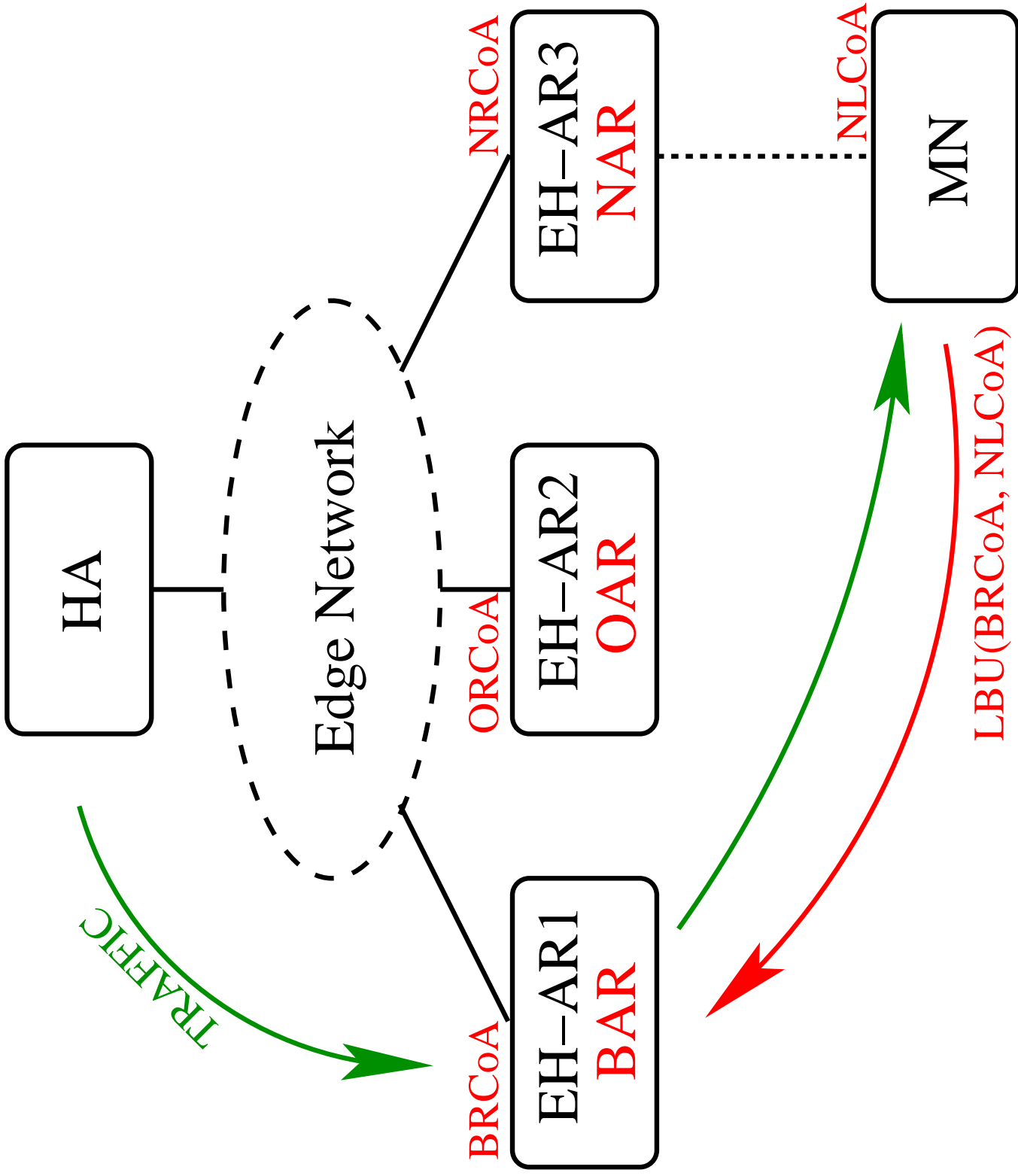


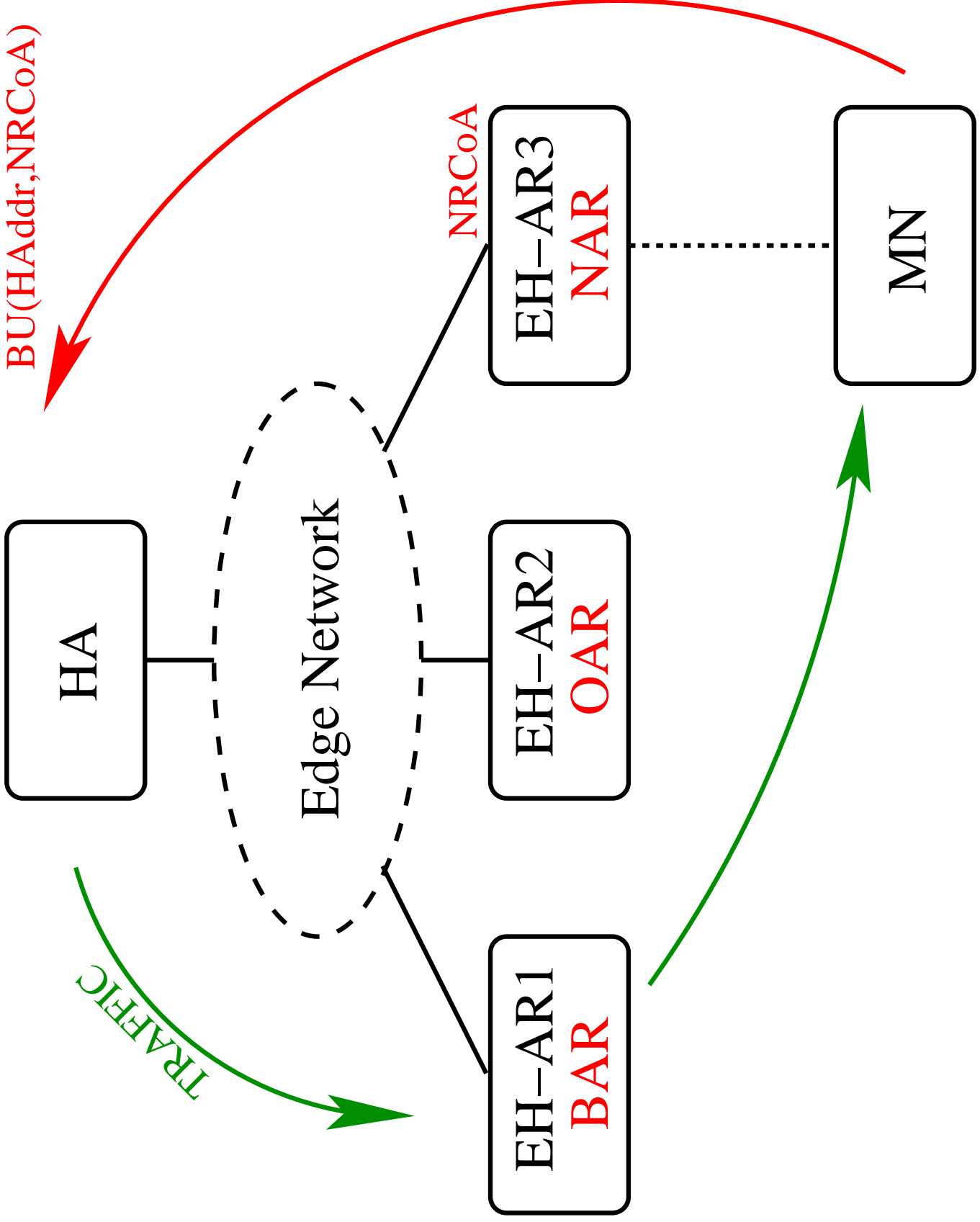


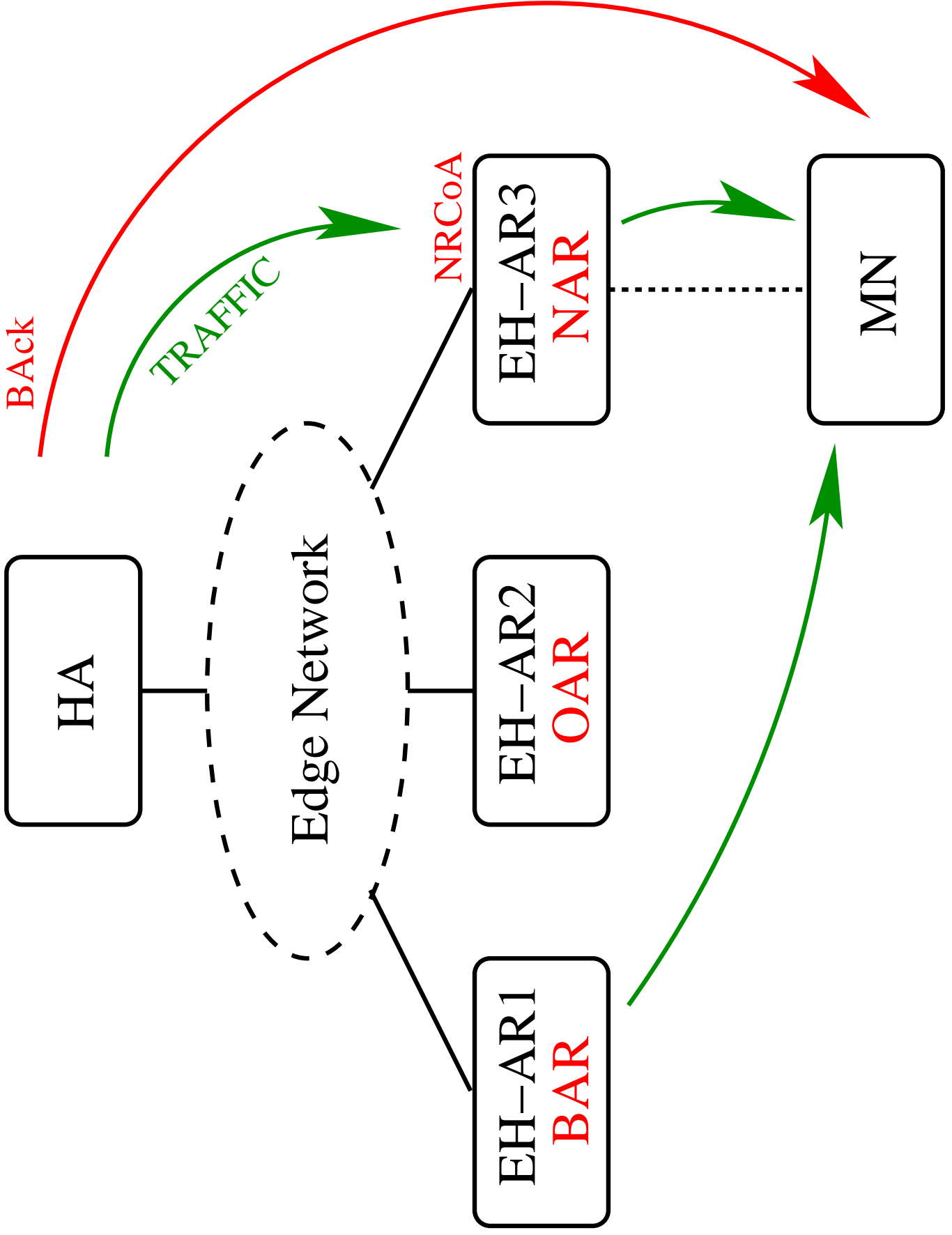


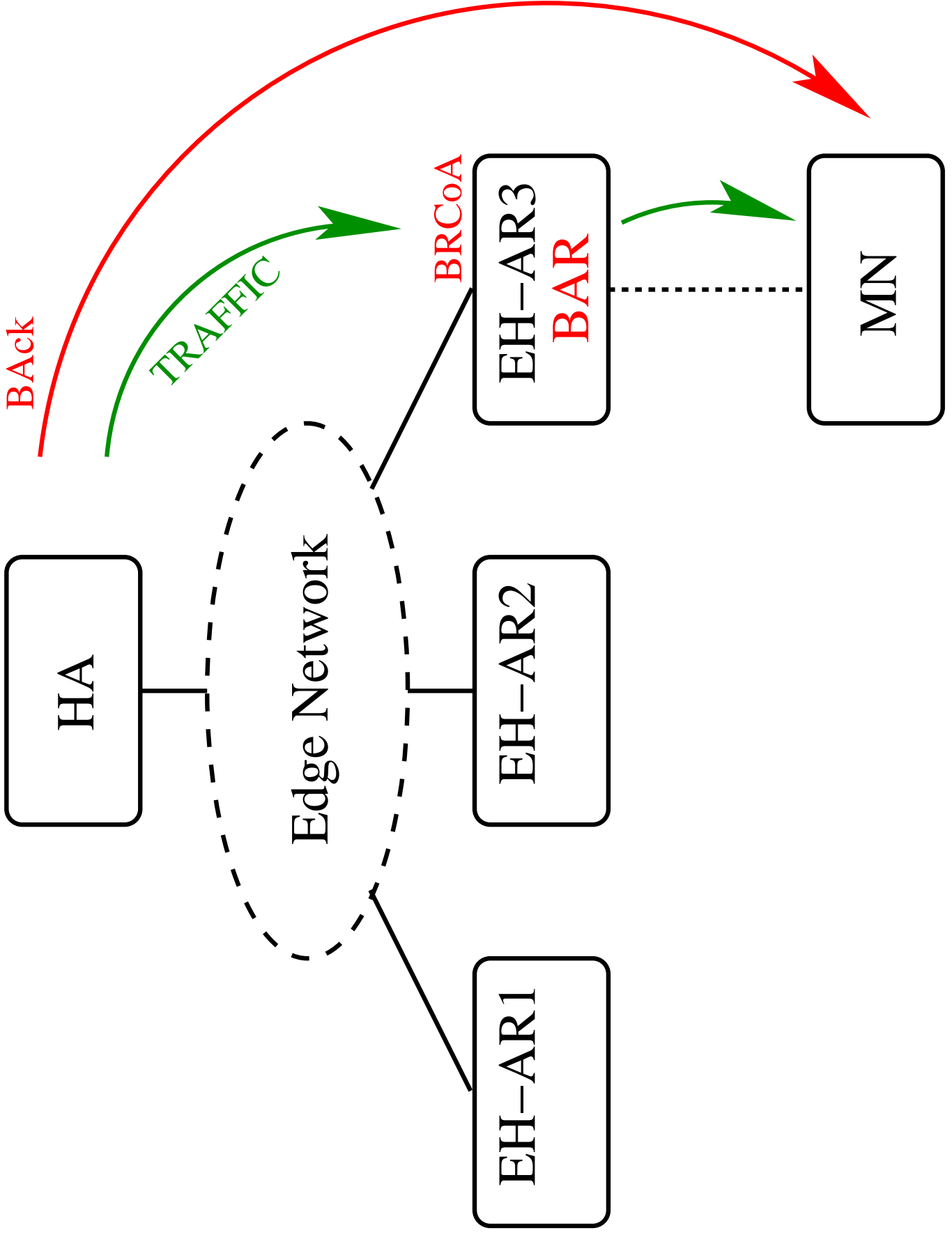












## Handover Heuristic

The MN must choose when to update its Home Agent and thus change its BAR.

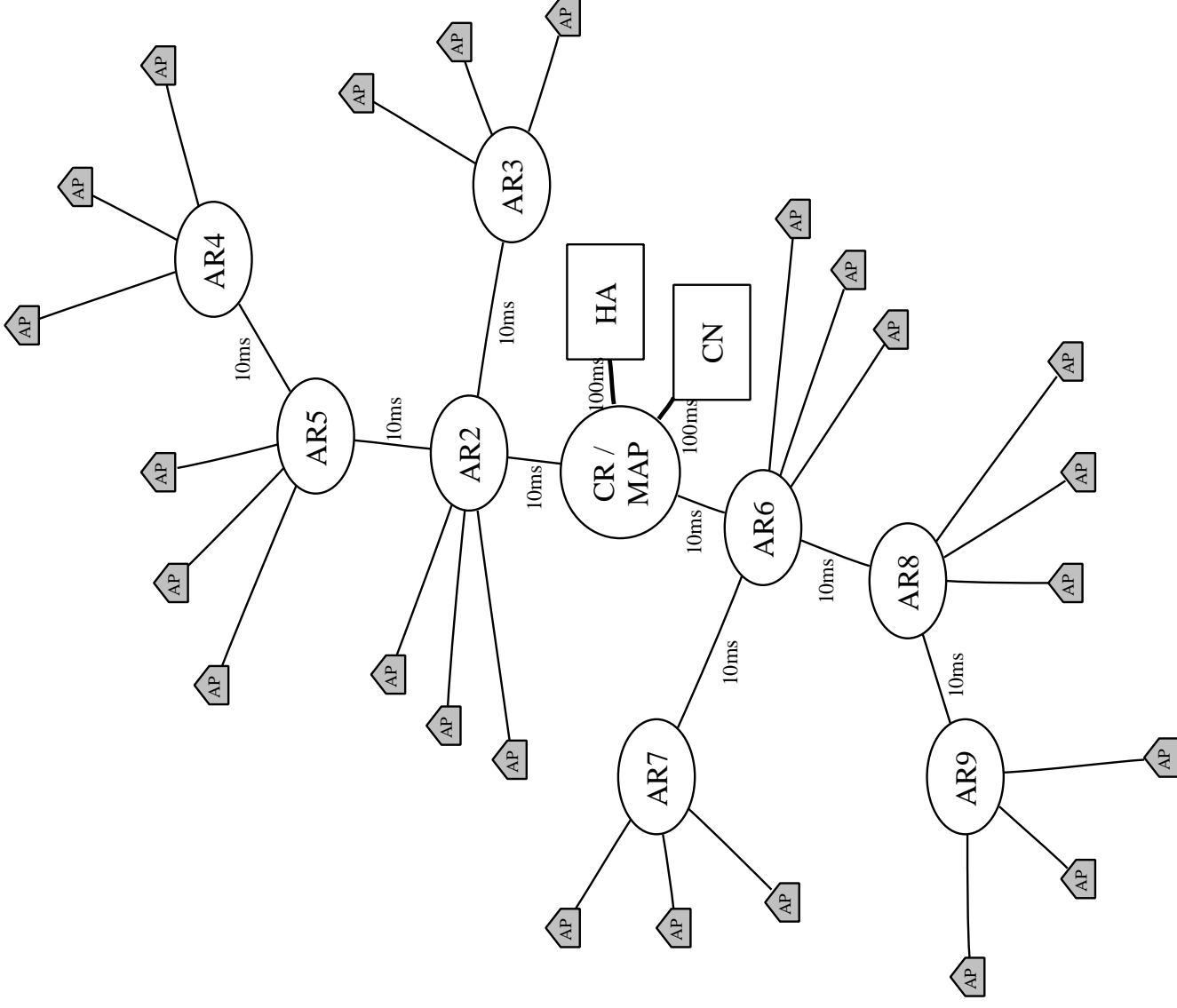
- as soon as the critical path of the handover is complete.
- every  $N$  seconds.
- every  $N$  handovers.
- once the MN has been on the same AR for  $N$  seconds.
- if a handover has crossed an administrative domain.
- The LBAck has taken  $> N$  routing hops.
- ???

# Simulation

- OMNeT++
- IPv6Suite

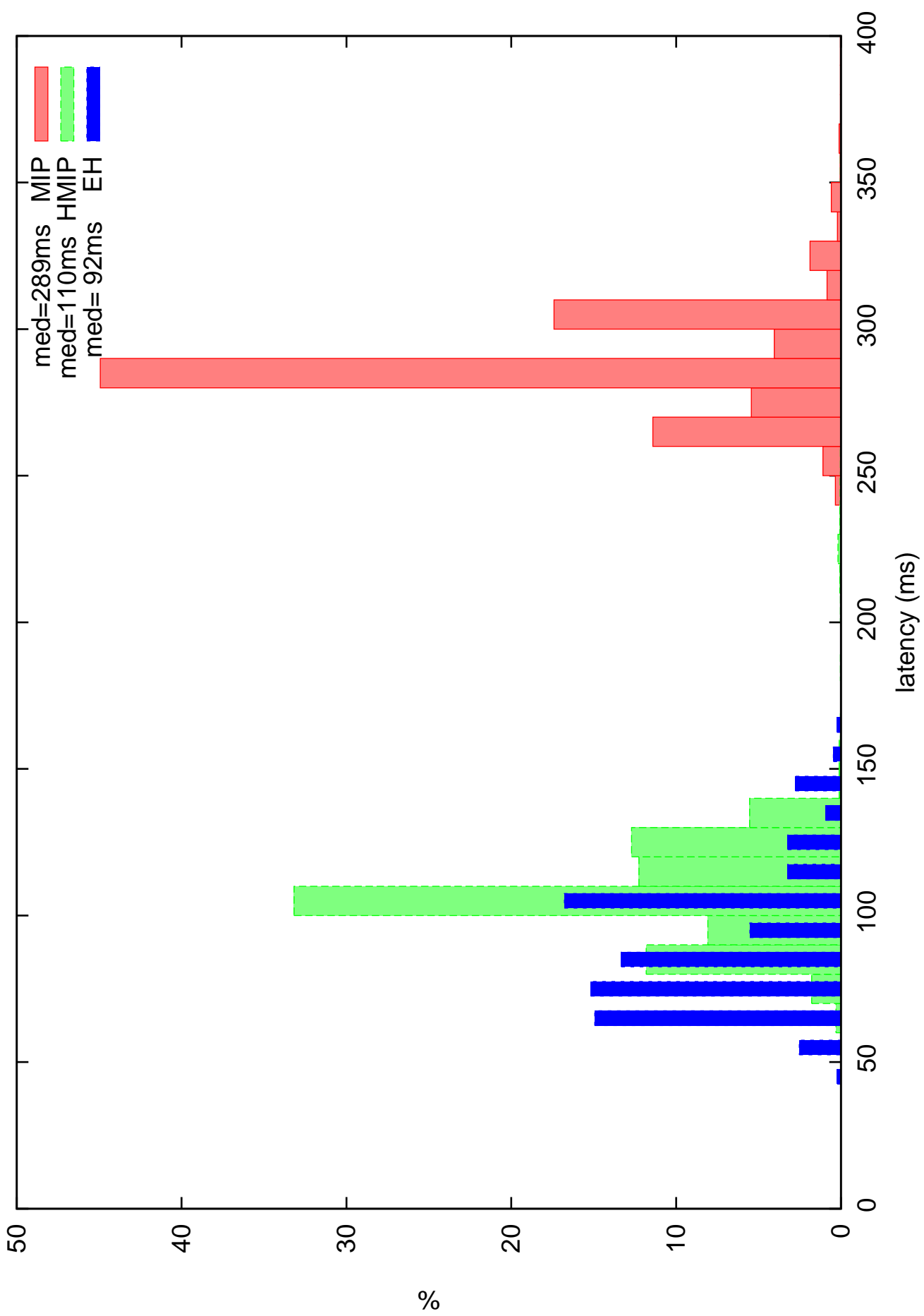
# Campus Network

- 24 Access Points
- 8 Access Routers
- 1 Core Router / MAP
- 1 Home Agent
- 1 Correspondant Node
- 50 Mobile Nodes

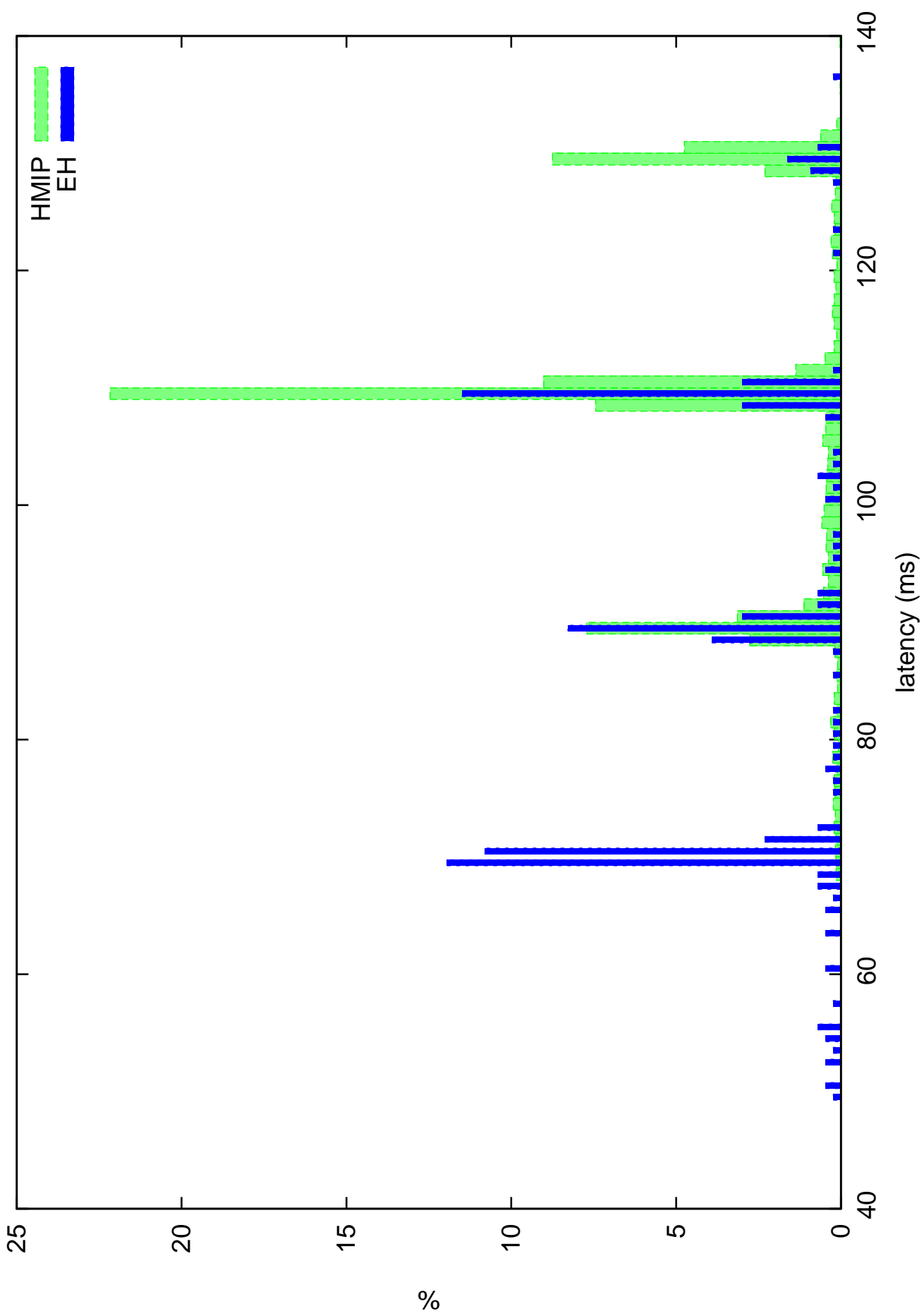


## Results

- HMIP: CR is the MAP
- EH: All ARs are EH capable.
- Handover Heuristic: change BAR every 10 seconds
- Measured time between L2 Up signal and the next ...
  - ◇ MIP: BBack from HA.
  - ◇ HMIP: LBack from MAP.
  - ◇ EH: LBack from BAR.







## Ongoing Work

- Larger Scenarios.
- Mesh Scenarios.
- More investigation of Handover Heuristic.
- Release of Linux implementation.
- IETF standardization.
- JinHyeock Choi and Brett Pentland, my co-authors.
- Johnny Lai for writing the simulation code and running experiments.
- Ahmet Şekerciöğlü for getting this project underway.
- Samsung SAIT for funding this research via ATCRC.

## Acknowledgements