# End-to-end IP Service Quality and Mobility
**- Lecture #7-**

Special Course in Networking Technology

S-38.215

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# Planned contents & draft schedule

1. Introduction — Jan 13th
2. Characteristics of mobile applications — Jan 20th
3. Service quality requirement characterizations — Jan 27th
4. Challenges of mobile environment — Feb 3rd
5. Mobility and QoS in GPRS — Feb 10th
6. Mobility and QoS in 3GPP systems — Feb 17th
7. **Mobility and QoS with Mobile IP** — Feb 24th
8. Mobile IP QoS enhancements — Mar 3rd
9. Edge mobility — (Mar 10th)
10. Inter-system mobility — (Mar 17th)
11. End-to-end QoS management — (Mar 31st)
12. Summary — (Apr 7th)

**Dates in parentheses to be confirmed**

# Agenda

- Design principles of Mobile IP
- User viewpoint
- Mobile IPv4
- Mobile IPv6
- Mobile IP and service quality
- Summary



# Goals of the lecture

- Understanding for what purpose MIP was designed.
  - MIPv4
  - MIPv6
- Understanding the relation of service quality support mechanisms to MIP.
- Understanding of QoS challenges in basic MIP framework.

# IP mobility problem

- Goal: support mobility, not only nomadicity.
- More precisely, support *session* mobility.
  - Case TCP: socket connection opened between (IP address, port) pairs.
    - Reachability address.
  - On the other hand, the IP address of the terminal should reflect PoA.
- Mobile IP is a scheme for managing dynamically the binding between reachability address and PoA.
  - *Home address (HA)*: reachability address from the home link.
  - *Care-of-address (CoA)*: PoA from the “visited” link.
  - *Binding:* association between HA and CoA.

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# Mobile IP design principles

- **Network layer** solution to mobility in the Internet.
  - Mobile Node (MN) and mobility servers handle mobility.
    - Intermediate servers do not need to be mobility servers.
      - Normal IP routing sufficient.
    - Corresponding hosts (Correspondent Nodes, CN) run normal IPv4 or IPv6 stacks.
      - No changes to applications required.
    - Host-specific routes not required in intermediate nodes.
  - Independent of link layer technology.
  - Can be used together with link layer mobility schemes.
- Designed for solving IP mobility, not all associated problems.
- Security with respect to endpoint location.

[Perkins: MIP]

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# End user viewpoint of MIP

- Scenario: user accesses HTTP server while changing WLAN APs so that access router changes.
  - Simple L2 mobility support assumed.
- **Without MIP** (and other session mobility schemes):
  - When PoA changes (attach to new access router), session is lost.
  - Session can be restarted in new PoA by using IP address from the new AR.
- **With MIP**:
  - Session can be maintained transparently.
  - Depending on whether enhancements to basic MIP are used or not, momentarily lower QoS during handover possible.

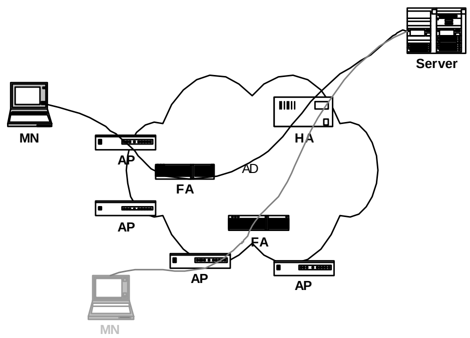


# MIPv4

- Home address resides on home link.
- If mobile node is away from home link, it registers its CoA in Home Agent (HA).
  - MN learns CoA from Foreign Agent (FA) advertisement.
  - CoA is sent to HA (registration).
    - FA-CoA: by FA.
    - Co-located CoA (CCoA): by MN or FA.
  - HA updates binding between home address and CoA.
  - HA tunnels packets to CoA.
    - Tunnelling: IP-in-IP / minimal encapsulation / GRE.
    - HA must proxy ARP requests on home link.
- MN uses it home address as source address.

## MIPv4 example (FA-CoA)

- MN acquires CoA from 1st FA.
- MN opens a socket connection to Internet server.
- MN moves to an AP under a different FA.
- New CoA acquired from 2nd FA.
- Binding updated in HA.

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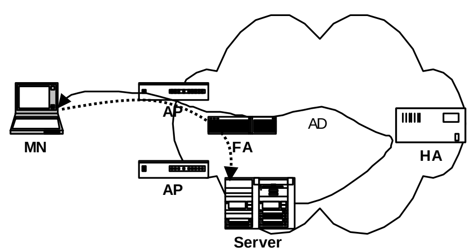
## Triangular routing in MIPv4

- Traffic **to** MN always goes through HA.
- Traffic **from** MN can be routed directly.
- "Route Optimisation" solution: MN bindings sent to CNs.
  - IPv4: extra functionality into protocol stack required.
  - IPv6: part of basic operation.

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# Reverse tunnelling

- MN needs to use its home address as the source address of transmitted packets.
- Firewalls may drop packets whose source address is not topologically correct (source address is not within the AD).
- Solution: **reverse tunnelling**.
  - Tunnel established between CoA and HA for traffic from the MN.
  - Consequence: also uplink traffic routed via HA.



# Further challenges with MIPv4

- **NATs**
  - NATs allow multiple hosts to use the same public IPv4 address, given that port number is different.
  - If multiple MNs are “sharing” a public IPv4 address, NAT can’t unambiguously translate public IPv4 address in MIPv4 tunnel header to private CoA.
  - Proposed solution: IP-in-UDP: can also convey port number.
- **Address shortage**
  - Would run out of home addresses.
- **Foreign agents**
  - Extra functionality needs to be brought into access network routers.

## Brief recap of IPv6

- IPv6 has 128-bit address space.
- Unicast IP address: 64 bit prefix + 64 bit interface ID.
- Basic header simple, extension headers:
  - Hop-by-Hop Options
  - Routing (Type 0)
  - Fragment
  - Destination Options
  - Authentication
  - Encapsulating Security Payload
- Routing header: list one or more intermediate nodes to be "visited" on the way to a packet's destination.

**[RFC2373, RFC2460]**



## MIPv6 design principles

- No FAs => only CCoAs to be used.
- Route optimisation built into MIPv6.
- No need for reverse tunnelling.
  - IPv6 header options can be used.
- Packets need not be encapsulated because of mobility.
  - IPv6 header options can be used.
- No separate control packet needed.
  - Piggyback mobility information into payload as IPv6 header options.
- Multi-homing possible.
  - Multiple IP addresses simultaneously in use.

**[Wisely: MIP]**

# MIPv6 details

- No FA, MNs create their CoAs using link-local address and address autoconfiguration.
  - Stateless: get subnet prefix from neighbour discovery messages.
  - Stateful: DHCPv6.
- *All* IPv6 hosts support binding cache.
  - Binding updates carried as destination options.
- IPv6 has options after the basic header, including routing header.
- CNs put CoA in routing headers.
- HA can tunnel those packets which it receives.



# MIPv6 example

- MN moves under a new AR.
- MN forms link local address using link-local prefix and its unique interface ID.
- MN gets AR prefix from router advertisement.
  - MN can use router solicitation to get router advertisement.
- MN sends binding update to CNs and HA.
- CNs update their binding cache.
- CNs put CoA in routing header of packets destined for MN.
- HA tunnels packets destined to MN from CNs the binding of which is not up-to-date.

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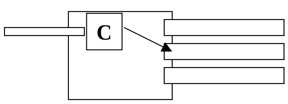
# Mobile IP and service quality

- MIP was designed to solve session mobility via routing.
- Service quality support, AAA etc. are assumed to be handled outside of the MIP framework.
- Consequences:
  - There is no single service quality model for MIP.
  - There is no single standard service quality support scheme to be used with MIP.
- Possible service quality support schemes:
  - Best Effort.
  - Reserved aggregate capacity + edge conditioning.
  - DiffServ.
  - Signalled QoS.



# Service quality state

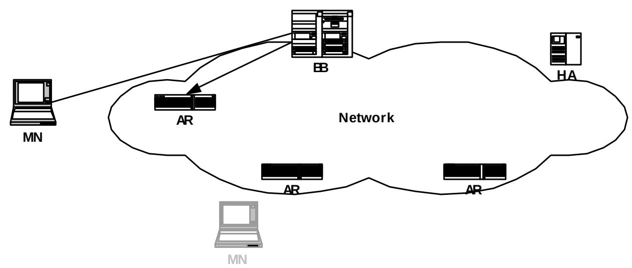
- Mobile user needs to be authenticated to access network resources.
  - Result: SLA for network access.
- Service quality support at the edge of the network:
  - Conditioning function.
  - Mapping function.
- Per-user state can be installed to network edge element.
  - By end-to-end signalling.
  - By the network.
- Alternative: aggregate treatment.




[Räisänen]

# Example: DiffServ + bandwidth broker

- MN signals with BB to instantiate service quality support.
- BB can install per-user DiffServ edge state in AR.
- When user moves to an AP under a different AR, edge state needs to be installed into the new AR.




**[Trimintzios** *et al*.**,** *A management and control architecture…*, **IEEE Comm. Mag., May 2001, p. 80 ff.]**

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# Handovers

- Mobile IP framework supports handovers between access routers.
- Handover to new AR triggered from link layer.
  - Link layer mobility under single AR possible.
- Link layer mobility issues:
  - Link layer handover trigger.
    - When to switch – "eager" vs. "lazy" AP switching.
  - Break-before-make vs. make-before-break.
- Target for real-time traffic:
  - As little delay variation as possible.
  - As little packet loss as possible.

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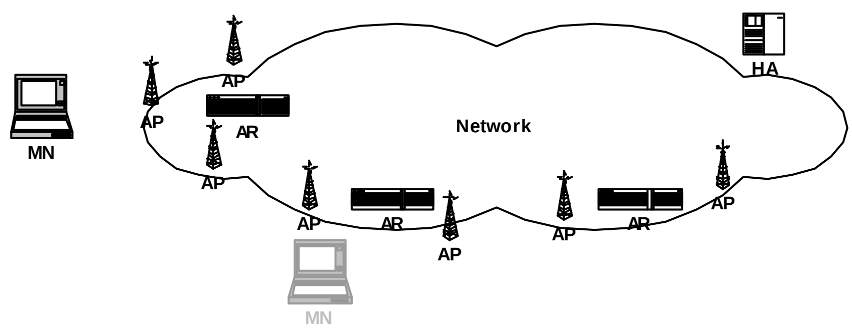
## Basic MIP handover challenges

- Basic MIP does not guarantee that packets sent to old AR are delivered after link layer connectivity between MN and old AR has been lost.
- Handovers in basic MIP may be slow if HA is far away from AR.
  - HA could be in a different country.
- Signalling overhead may be large in basic MIP.
  - Example: nationwide MIP network.
- Basic MIP does not provide for means of coupling QoS to mobility.
- **Next lecture: complementary handover techniques help in obtaining better QoS.**



## Handover example



## Summary

- MIP supports session mobility on network layer.
  - Service quality support is not an integral part of MIP.
- MIPv4: interoperates with standard IPv4 routers and CNs.
  - Requires FA.
  - No route optimisation in base MIPv4.
  - NATs and firewalls, address shortage.
- MIPv6: solves many of MIPv4's shortcomings.
- Service quality support still not part of basic MIP.
  - Handover performance.
  - Handover scalability.