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

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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

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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.

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]
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.

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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.

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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.

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.
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.

[MFC2373, 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.

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**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.
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.

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.
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.

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