Mobility

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Overview

- Problem statement
- Global IP mobility
  - Mobile IP: MIPv4, MIPv6
- Local IP mobility
  - Cellular IP, HAWAII
- Session mobility
  - MIGRATE
  - TCP over wireless
- Application mobility
  - SIP Mobile

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Issues in mobility

- Terminal mobility
  - horizontal hand-off (same network)
  - vertical hand-off (different networks)
- Personal mobility
  - same person at different places/terminals
- Network mobility
  - whole network moves (car, plane, train)
  - constrained movement (set of cars)
- Session mobility
  - move an X session seamlessly

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Mobility in the Internet

- IP address
  - used as a forwarding directive
    - packets are forwarded to a destination
  - used as an end-point identifier
    - with which host we are communicating
- TCP and UDP depend on IP addresses
  - pseudo-header: end-point identifier
- TCP transport session connection id:
  - 4-tuple: <src addr, src port, dest addr, dest port>

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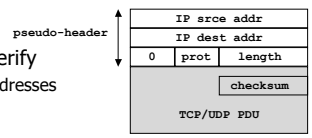
TCP/UDP on top of IP



- A checksum is used to verify
  - source and destination addresses
  - port numbers
  - the data
- optional with IPv4, mandatory with IPv6
- based on pseudo-header method:
  - checksum is computed over: TCP/UDP PDU + *pseudo header*
  - checksum is put into TCP/UDP header; pseudo header is not transmitted

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Mobile host

- Host moves - two approaches
  - address as a routing directive - get a new address at the new place
    - for new connections: use the new address
    - for existing connections: translate addresses
  - address as an end-point identifier - keep its address
    - for new connections and existing connections: use the same address
    - the address appears at the new place - may be not topologically correct
    - requires the modification of routing tables - not a scalable solution

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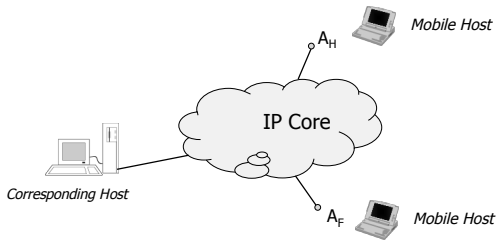
Get a new address



- Corresponding Host is sending packets to A_H (home place)
  - how to send packets to A_F (foreign place)?
  - requires address translation

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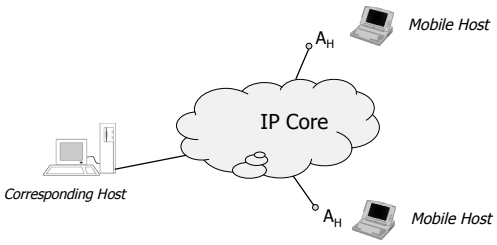
Keep the address



- Corresponding Host is sending packets to A_H
  - how to send packets to A_H at the new place?
  - requires the modification of the routing tables

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Global mobility

- Requirements
  - scalable
  - keep existing TCP connections
    - Corresponding Hosts should see the same destination address
  - different proposals for Mobile IP
- However
  - when would you like to keep existing connections alive?
  - only when moving on short distances!
  - if you go from Paris to New York, just use the nomadic approach - get a new address at the destination

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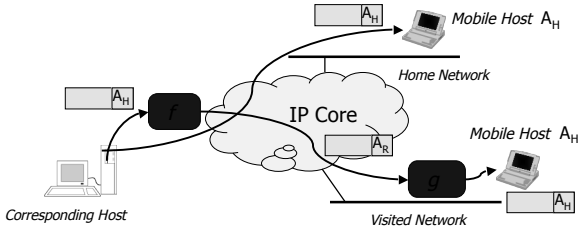
Principle of global mobility



f : home address A_H → forwarding address A_R
g : forwarding address A_R → home address A_H

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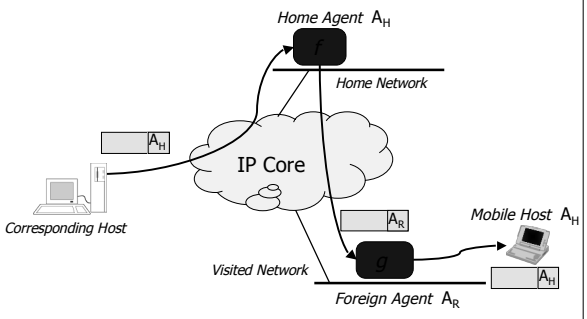
Mobile IPv4



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Mobile IPv4 - elements

- Home Agent (HA) - router on Home subnet
  - at home, intercepts packets for MH and forwards them to the new address using an IP tunnel
  - keeps a list of Mobility Associations
- Foreign Agent (FA) - router on Visited subnet
  - new address acquisition for MH
  - register with the home agent
  - receives packets and delivers them to MH
  - keeps a list of Visiting MH
- Care of address (care-of-@)
  - new address acquired by MH; reflects the current point of attachment

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Mobile IPv4 - agent discovery

- MH discovers agents
  - ICMP Router Advertisement
    - periodic message broadcast by an Agent; lifetime
    - bit H - HA, bit F - FA
  - ICMP Router Discovery
    - used by MH to find an agent
- Movement detection
  - ICMP Router Advertisement lifetime
    - expiration means lost contact with an agent
  - ICMP Router Advertisement prefix option
    - if different, MH has moved

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Mobile IPv4 - address acquisition

- Acquisition of care-of-@
  - from FA: ICMP Router Advertisement
    - care-of-@
  - by DHCP
- Default gateway
  - FA
  - given by DHCP
- HA
  - send gratuitous ARP for MH @
  - replies to ARP request for MH @

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Mobile IPv4 - registration

- MH registers at HA
  - care-of-@ from FA, FA registers
  - care-of-@ from DHCP, MH registers itself
- Messages - UDP packets, port 434
  - Registration Request (from MH to FA to HA)
  - Registration Reply (from HA to FA to MH)
- FA stores
  - MAC @ of MH, IP @ of MH, lifetime, security info
- HA stores
  - care-of-@ of MH, lifetime, security info

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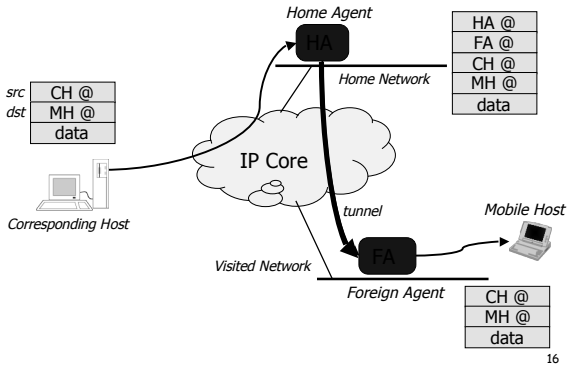
Encapsulation - FA @



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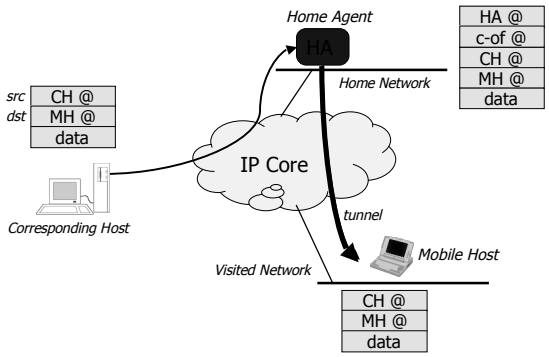
Encapsulation - collocated @



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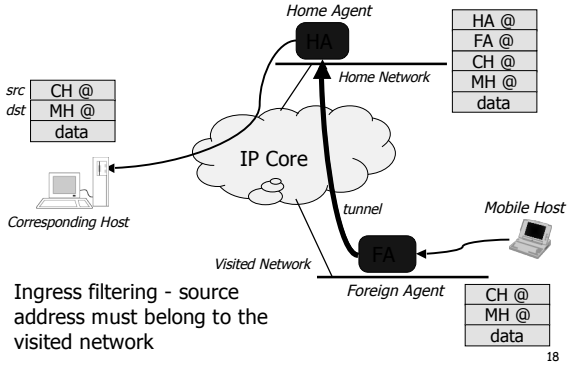
Inverse tunnel



- Ingress filtering - source address must belong to the visited network

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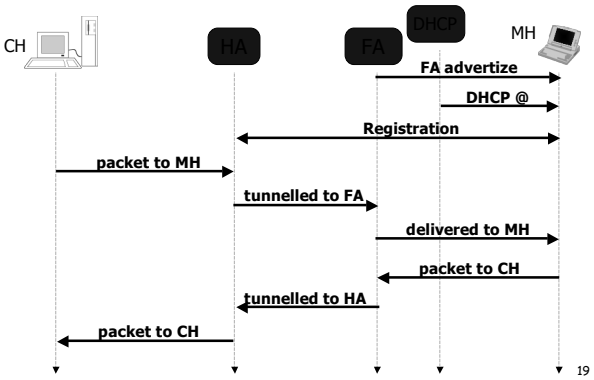
MIPv4 summary



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Mobile IP characteristics

- Routing
  - triangular in IPv4
- Address translation and tunneling
  - tunnel overhead in IPv4
    - adds 20 bytes to a 60 byte RTP packet
- Slow movement detection
- Global solution
  - keep open TCP connections when moving
  - treats all forms of mobility uniformly
    - short move - high overhead
    - large move - don't need to keep open connections

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Mobile IP characteristics

- If QoS support required
  - establish new QoS bindings after handoff
- No paging support
  - passive connectivity: when in idle state, host does not transmit
  - how to find the idle host: *paging*
  - keeping approximate location information
    - less signaling
    - lower load over the air interface
  - saves energy

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Performance

- High signaling overhead
- Tunnel overhead
- Hand-off delay
  - discover movement (periodic Agent advertisements)
  - get a new address (FA or DHCP)
  - register at Home Agent

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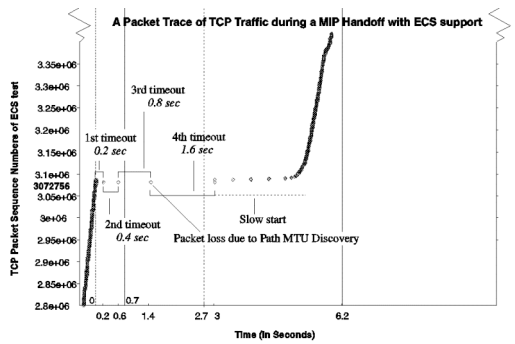
Mobile IPv4
Agent advertisement each 1 s



Fikouras *et al.* 2001

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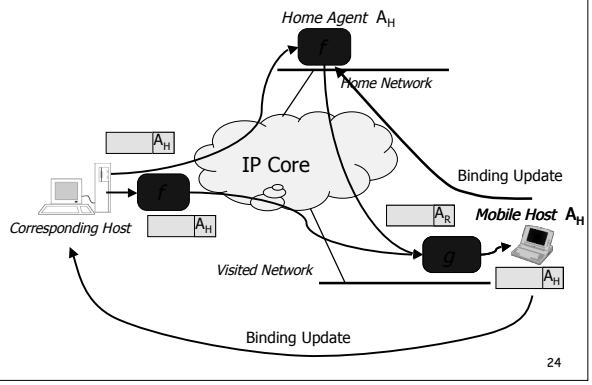
Mobile IPv6



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Mobile IPv6

- IPv6 autoconfiguration of addresses
  - stateless or statefull (DHCPv6)
  - no need for FA
- IPv6 Neighbor Discovery (ND6)
  - to discover HA at home network
- IPv6 header extensions
  - extra headers linked to the first header
  - no need for UDP messages

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Mobile IPv6

- MIPv6 uses
  - Destination Options Header: Binding Update, Binding ACK, Home Address options
  - Routing Header: to forward packets to the new destination
- MH sends a BU to a CH
  - at each movement
  - maintains a list of CH to which it has sent a BU
  - the address sent to HA - principal temporary address

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MIPv6

- CH sends a packet to home network
- HA tunnels it to MH
- MH gets the packet
  - sends Binding Update to CH
- CH sends a packet to the new destination
  - Routing Header: Care-of-@ is the only destination specified in the Routing Header
  - packets are sent directly to the destination
- When MH wants to send a packet
  - determines a router using Neighbor Discovery

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Binding Update

- MH sends a BU to a CH
  - at each movement
  - maintains a list of CH to which it has sent a BU
  - the address sent to HA - principal temporary address

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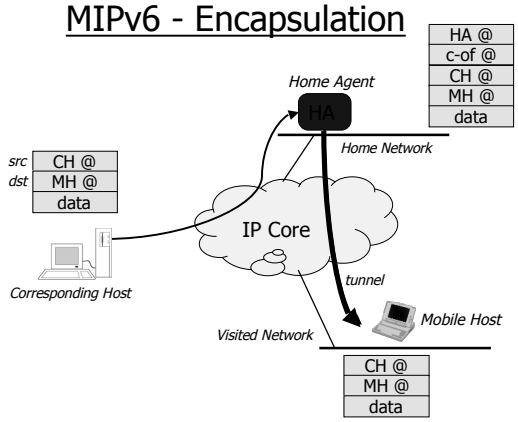
MIPv6 - Encapsulation



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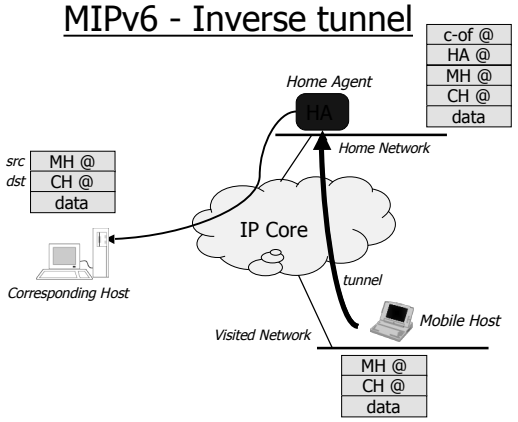
MIPv6 - Inverse tunnel



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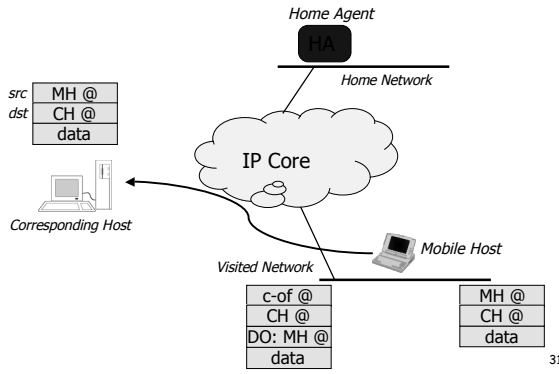
MIPv6 - After Binding Update



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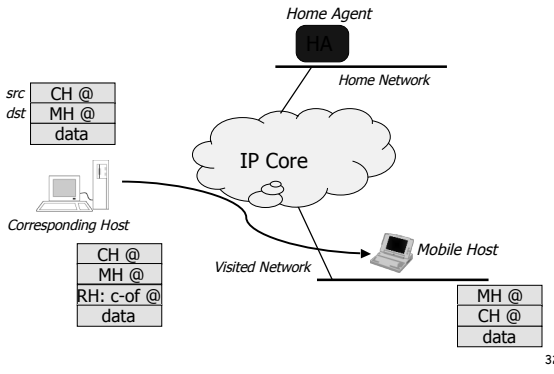
MIPv6 - After Binding Update



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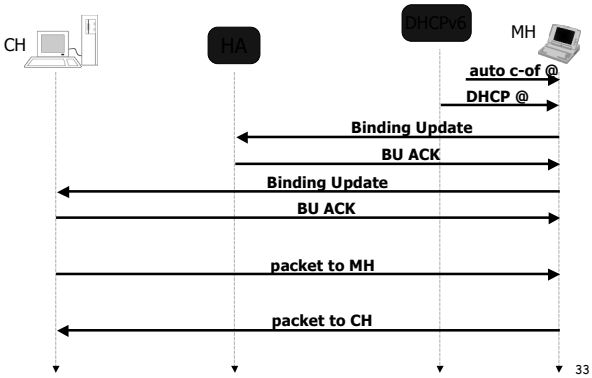
MIPv6 summary



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MIPv6 vs. MIPv4

- Integrated routing optimization
- Supports ingress filtering
- No Foreign Agent
- Signaling integrated with data
  - header extensions
- Movement detection by ND6
- Home Agent intercepts packets for MH by using ND6

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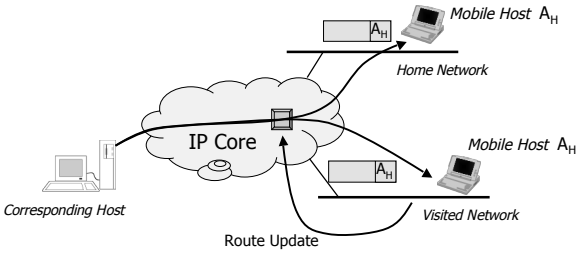
Local mobility - micro-mobility



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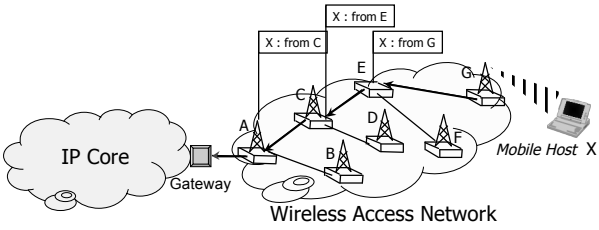
Cellular IP - create a route



- Beacons sent by gateway and flooded
- Cache at Cellular IP Routers
  - routing information (route update packets)
  - paging information (paging update packets)

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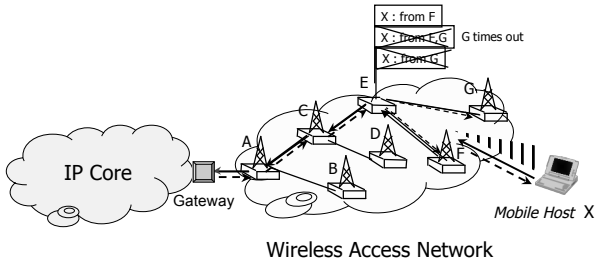
Cellular IP - handoff



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Cellular IP characteristics

- Cellular IP routers in the wireless access network
  - paging and routing update messages
  - mobile host that actively receive data must send route-update packets periodically
- Fast handoff
  - update route dynamically
- Local solution
  - routing entry per mobile host
  - gateway processes all updates for all hosts
- Efficient QoS support possible

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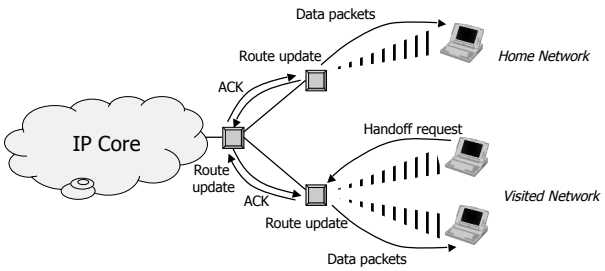
HAWAII



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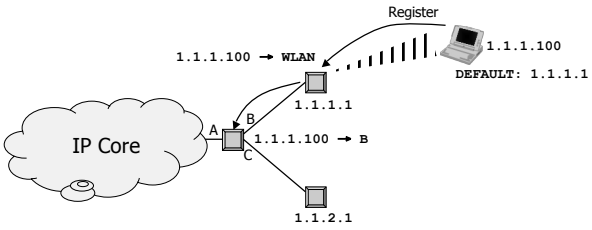
HAWAII - registration



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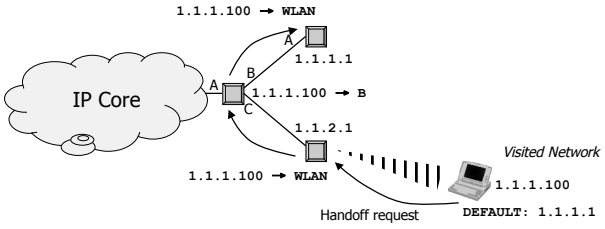
HAWAII - handoff



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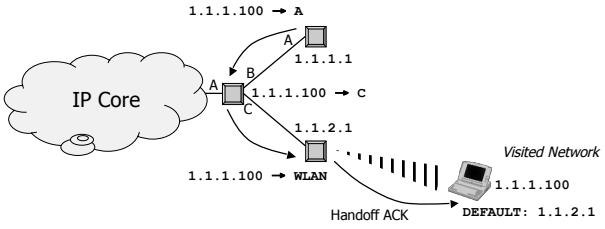
HAWAII - handoff



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HAWAII characteristics

- Standard IP infrastructure in the wireless access network
  - HAWAII daemon on routers
  - dynamic route update - host routes
  - optimal routing
  - supports paging
- Fast handoff
  - RTT of the handoff request
- Local solution
  - routing entry per mobile host
- Efficient QoS support possible

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Mobility integrated with QoS

- Current proposals, no QoS support
  - Cellular IP
  - HAWAII
    - sends hand-off request to the new Access Router
- Integration with QoS
  - hand-off initiated upon: SNR, load, QoS policy
  - hand-off request sent to the new Access Router via the old one
    - allocate resources in the new cell

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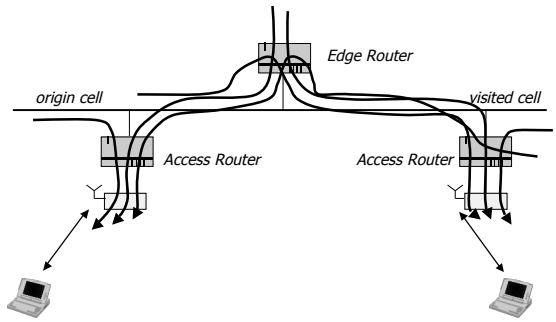
Micro-mobility



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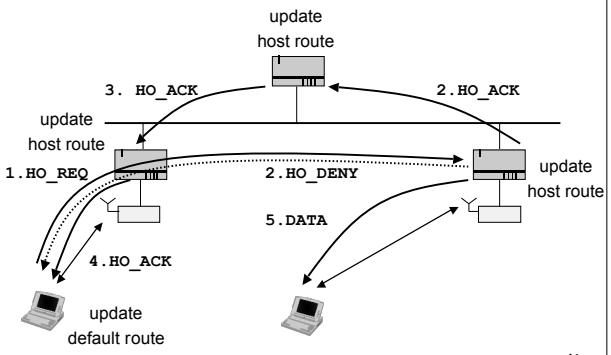
Hand-off



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Session mobility - MIGRATE

- Model of mobility
  - hosts change attachment point
  - move from home, to office, to another place
  - use multiple physical technologies
- Mobility events are rare
  - when compared with packet RTTs
- Long running applications
  - SSH tunnels
  - streaming applications

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MIGRATE - services required

- Locate the mobile host or service
- Preserve communication
  - support changes in network attachment
- Expect and support disconnection
  - gracefully detect lack of connectivity
  - conserve resources during disconnection
  - reconnect quickly and efficiently

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MIGRATE Approach

- Locate hosts through existing DNS
  - secure, dynamic DNS is currently deployed and widely available (RFC 2137)
  - maintains standard IP addressing model
    - IP address are topological addresses, not Ids
    - Fundamental to Internet scaling properties
- Ensure seamless connectivity through connection migration
  - notify only the current set of correspondent hosts
  - follows from the end-to-end argument

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Migrate applied to TCP

- Provide special TCP option - MIGRATE
  - sent with SYN packets of new connection
  - indicates that new connection can be migrated
- Use previous sequence space
  - works with SACK, Snoop…
- Preserve three-way SYN handshake
  - works with statefull firewalls

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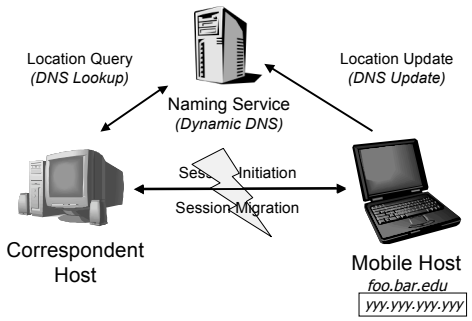
Session mobility: MIGRATE



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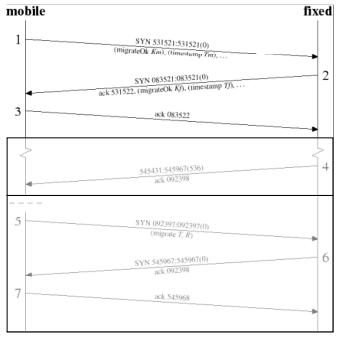

TCP Connection Migration

1. **Initial SYN**
2. **SYN/ACK**
3. **ACK (with data)**
4. Normal data transfer
5. Migrate SYN
6. Migrate SYN/ACK
7. ACK (with data)

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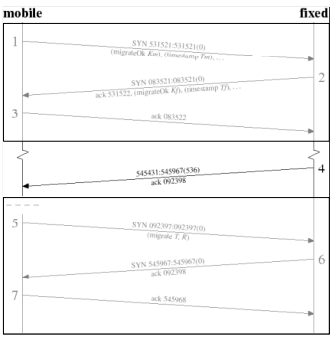

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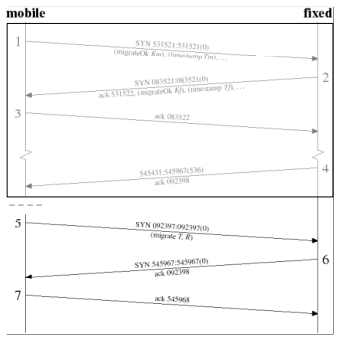

TCP Connection Migration

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4. Normal data transfer
5. **Migrate SYN**
6. **Migrate SYN/ACK**
7. **ACK (with data)**

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TCP over wireless

- Wireless links have high error rate
  - principle source of lost packets
  - congestion always possible
- Mobility may result in lost packets
  - handoff, route update
- Lost packets do not mean congestion
  - contrary to TCP assumptions
  - results in throughput decrease

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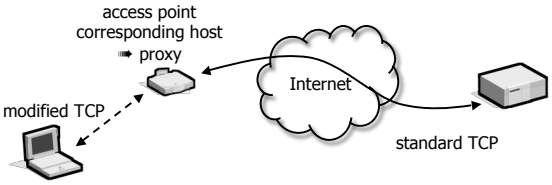
I-TCP: Indirect TCP

- Impossible to change TCP in the wired part
- Change it in the wireless part
  - modified TCP: losses do not turn on congestion control mechanisms



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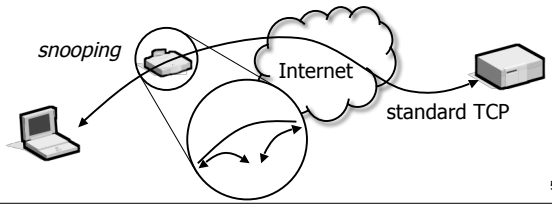
Snooping TCP

- Filtering agent
  - stores packets sent to wireless
  - analyzes packets sent to wired
- Fast retransmission on wireless
- Filtering of duplicated ACKs



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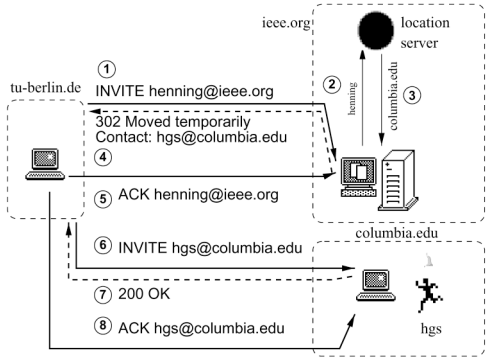
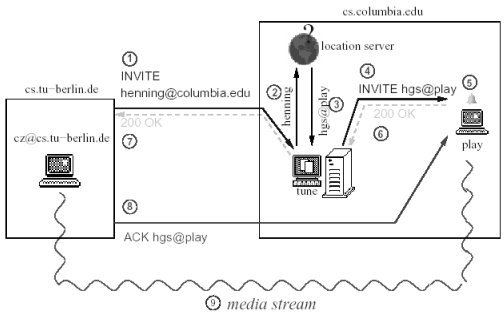
Application mobility: SIP



SIP



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Mobile SIP

- Pre-call mobility
  - SIP proxy, redirect
- Mid-call mobility
  - SIP re-INVITE, RTP
- Recovery from disconnection

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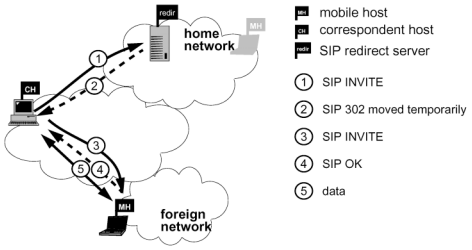
Mobile SIP: pre-call



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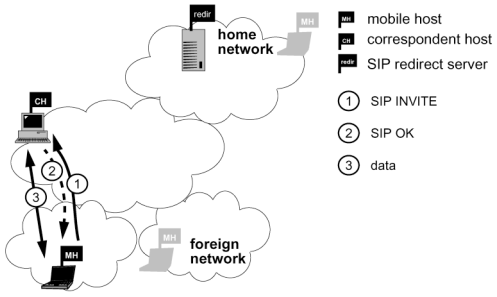
Mobile SIP: mid-call



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Wrap-up

- Mobile IP
  - global solution, performance and security problems
- Micro-mobility
  - fast local handoffs
- Upper layers
  - combine the best features
- Our experience
  - extending *DiffServ* to wireless LANs
  - efficient micro-mobility protocol

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