Mobility management in IP networks & Mobile IP

Lecture slides for S-38.192

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General notes on mobility

- Mobility in communications consists of various technologies and aspects
  - Wireless transmission
    - Using the frequency space
      - Multiplexing, modulation, spread spectrum, cellular systems
  - Medium access control
    - SDMA, FDMA, TDMA, CDMA
  - Communication systems
    - GSM, DECT, TETRA, UMTS, Satellite systems, Broadcast systems
- Mobility may occur on 1) Access-level(OSI 2), 2) Network-level (OSI 3) 3) Transport-level (OSI 4)

What is mobility?

- A node moving from a location to another location while preserving its original IP address
  - Horizontal handover in the IP level regradless that we (most probably) need vertical handover in layer 2.
    - Different layer 2 networks are (usually) separated by routers (or gateways)
- On the border of different layer 2 networks the change of IP address has to be notified
  - For instance when moving from WLAN to GPRS
  - This would be YAP (Yet Another Protocol) ☹
    - and most probably it would also break up TCP connection state

Types of mobility

- Global mobility
  - (interdomain) movement across different domains
- Macro mobility
  - (intradomain) movement across different subnets within domain
- Micro mobility
  - (intrasubnet) movement within subnet

What moves? Services or users

- Service mobility
  - User moves and connects to his home network with arbitrary devices
    - VPNs, secure connections, WWW-mail services, etc.
- User mobility
  - User and the device moves and connects to his home network
    - Use of all home network services
    - Appearing to be in the home network

Why mobility in IP?

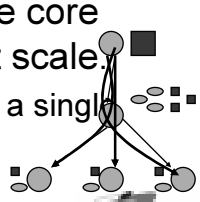
- Need to change physical media without breaking (TCP) connections
- People want Wireless Network Access
  - Ease and economy of operation
- Continuous connectivity
- Home network addressable from the entire Internet

Host routes – the easy solution?!

- Spread knowledge on the movements to all Internet routers
  - Assign a new address to the mobile node as it moves
  - This solution does not scale, overload of networks with location information
- We need to restrict the circulation of location and IP address information to a minimum!

Network scalability

- All technical solutions in the Internet should be scalable!
  - IETF requirement, code of practise
- Scalability in networks
  - If the number of information elements grows faster or at equal speed in the core of the network the solution does not scale.
    - No sense in distributing information on a single user to all nodes in the network



Mobility design guidelines

- No modifications to (other) host operating systems
- Internet-wide mobility calls for a scalable solution
  - and preferably infrastructure independency
- Application transparency, seamless transitions
- No modifications to Internet routing
  - mobility solution needs to have location/mobility mgmnt
- Compatibility with Internet Addressing

Mobility management

- Location management
  - registration and location updates
  - to enable a network to discover the current location of a mobile node (MN)
- Handoff management
  - to enable a network to maintain a connection while MN moves its location in the network

Mobility protocols in the Internet

Mobility	Protocol
Global mobillity	Mobile IP (MIP)
	TR45.6 (WIPNA)
	Mobile IPv6
Global/macro mobility	HMIP
	HMIPv6
	TeleMIP
	DMA
Macro	HAWAII
Micro	TIMIP
	CIP

Global/macro mobility

- Mobile IP, Mobile IPv6
  - more details later
- Hierarchical MIP, HMIPv6
  - introduces hierarchy in FAs, establishes a tunnel from the MN to a gateway FA. Packet to MN travel thru this tunnel
  - MAP (mobility anchor point) acts as a local HA for a certain domain
    - MAP receives packets for the MN and forwards them to the link CoA
    - As long as MN is within the MAP influence the global CoA stays the same
- HAWAII (Handoff-Aware Wireless Access Internet Infrastructure)
  - Mixes the concepts of co-located CoA and FA CoA, no private address support
  - Local handovers by sending registration to base stations (FA)

Macro/Micromobility

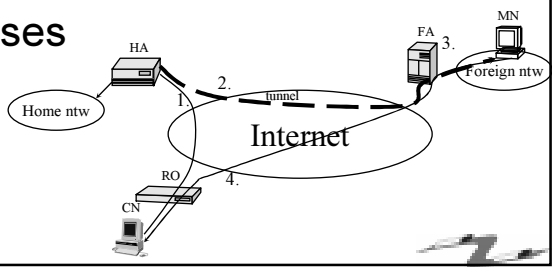
- Cellular IP, CIP
  - Local handovers without renewed registration with CIP gateway
    - Requires changes into Mobile IP protocols
    - Not transparent to existing systems
    - Easy to manage, self-configuring
    - Packets forwarded via multiple paths, routing tables changed by mobile nodes -> not secure
- TIMIP (Terminal Independent Mobile IP)
  - Combination of CIP, HAWAII and MIP

Mobile IP standards

- Mobile IP is an IETF effort
  - dealt with in several workgroups
- Mobile IP is defined in IETF standards
  - RFC 2002, 2003, 2004, 2006
  - See also, RFC 1701 (GRE) and RFC 1321.
- Standards define
  - Agent discovery
  - Registration procedure
  - Tunneling

Mobile IP components

- Mobile and correspondent nodes
- Foreign Agents (IPv4 only)
- Home Agents
- Tunnels - - - - - →
- Care-of- addresses



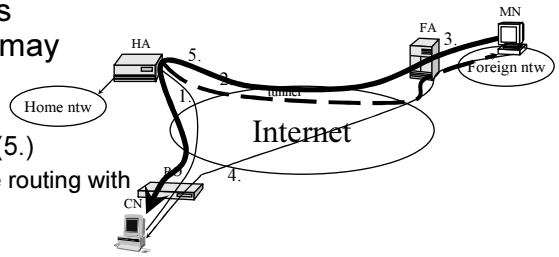
Mobile IP basic features

- Only the Home Agent knows where you are
  - This solution scales better
- With tunneling one is able
  - to forward packets from HomeAgent to MobileNode
    - And back, if necessary
  - to appear to be in one's home network
- Security is required but not restricted
  - The four building blocks
    - Confidentiality, Authentication, Integrity, Non-repudiation

Mobile IP transforms the mobility problem into a routing problem!

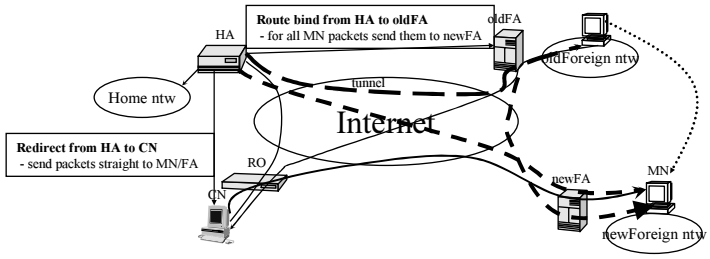
Triangle routing and reverse tunneling

- CN sends to MN and traffic flows via HA (1., 2. and 3.)
- MN to CN
  - traffic may take the shortest path (4.)
  - If ingress filtering is in effect the traffic may be dropped
    - Solution: Reverse tunneling(5.)
      - Result: triangele routing with CN, HA and MN



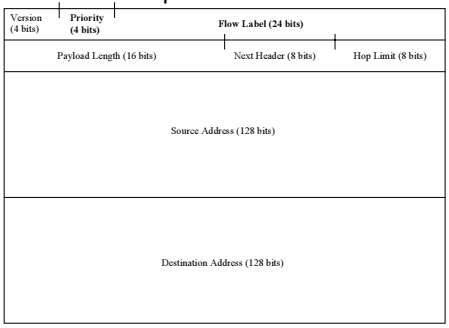
New route advertisements

- Home agent knows the true location of the MN
  - HA sends redirects to correspondent nodes (avoid triangle routes)
  - HA sends newFAinfo to oldFA and make oldFA redirect packets



IPv6 fundamentals

- New header
- Addressing space increased from 32 bits to 128 bits
  - by some estimates IPv4 addresses are depleted by 2005-2015
  - IPv6 addresses, realistically applied, can cover at least 1564 addresses/m^2 (oceans included), optimistic calculations give up to 3911873538269506102 addresses/m^2



IPv6 - reprecussions

- Simpler, though longer header
  - Arbitrary amount of option headers that are not examined in all routers
    - routing
    - fragmentation (only at the source)
    - authentication (for data integrity)
    - security (for data confidentiality)
    - hop-by-hop (to be examined at every hop)
    - destination (to be examined by the destination router)
      - there will be difficulties of keeping up with new headers
      - GOLDEN RULE for LARGE SCALE NETWORKS: Extended would be better than extensible
- TCP has to be updated
  - checksum counted with IP address fields

Mobile IPv6

- MN creates its own CoA with automatic address configuration
  - Stateful: DHCPv6
  - Stateless: Local subnet prefix as in Neighbor Discovery (RFC 2461, IPv6 ARP)+own hardware address
- MN may notify its correspondents when it moves (no more triangular routing)
- Correspondents put CoA in routing headers
- HA encapsulates packets if it gets them
- Binding updates carried in Destination Option

IPv4 vs. IPv6 and mobility

IPv4

1. MN, HA
2. MN home address
3. Foreign Agent
4. FA CoA/CoCoA
5. Address from
   1. Agent discovery
   2. DHCP
   3. Manually
6. Agent discovery
7. Tunneling
8. Routes optimized by a separate protocol

IPv6

1. MN, HA
2. Global home address and link-local address
3. Plain IPv6 router
4. All colocated CoAs
5. Address from
   1. Auto-configuration
   2. DHCPv6
   3. Manually
6. Router discovery (ICMPv6)
7. Source routing (option) or tunneling
8. Integrated route optimization

Mobile IP design objectives

- Limit the size and frequency of route updates
  - preserve host address regardless of location
- Simple implementation
- Simple and straightforward use of address space without resorting to assumptions on address availability

Home agent

- Router for the home network
- Mobility service providing agent
  - access to the home address of the mobile node without mobile node's presence.
- Advertise routing info on demand
  - to home network, and to other nodes
- Tunnels packets to mobile node (or foreign agent)

Foreign agent (IPv4 only)

- Delivers packets to a mobile node
- Mobility service provider in the foreign network
  - Inform the home agent on FA care-of-address
  - Provide CoA and detunneling for the MN
- Act as the default router for the mobile node in the foreign network

Care of address

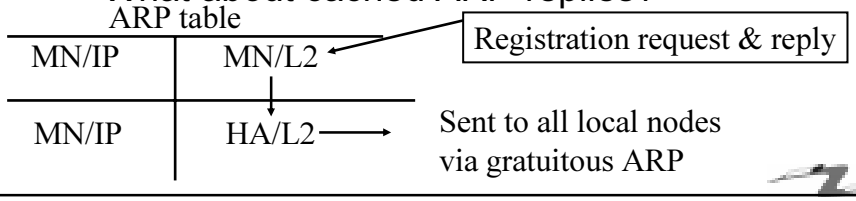
- Foreign Agent CoA and Co-located CoA
- CoA is the mobile nodes point of attachment
  - changes when the network changes
  - stored together with the permanent (home) IP address
  - not used as the the IP source or destination by the other nodes (use the home IP address)
- CoA is the exit point from the tunnel
  - either the Foreign Agent (FA CoA) or
  - mobile node (co-located CoA)

Traffic forwarding – Internet

- Home Agent intercepts packets sent to the Mobile Node and sends the packets tunneled to the MN
- ARP requests outside of the home network are answered with HA L2 address
  - proxyARP aka Gratuitous ARP

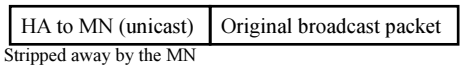
Traffic forwarding – home network

- Home Agent intercepts packets sent to the Mobile Node and sends the packets tunneled to the MN
- How about home network ARP requests?
  - What about cached ARP-replies?

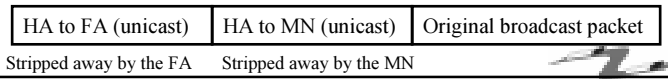


Receiving home network broadcast in foreign network

- Co-located address
  - Broadcast packets encapsulated and tunneled to the Mobile Node (tunnel exit point)

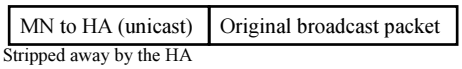


- Foreign Agent address
  - Tunneled to the FA (tunnel exit point)
    - If link level broadcast, then packets have to be recursively encapsulated otherwise broadcasted in the foreign network ->Requires (de)tunneling capability from the MN



Sending broadcasts

- Directed broadcasts sent as such
  - If allowed by the Home Agent
- Link layer broadcasts tunneled to the HA



Multicast

- Multicasts are sent to the
  - Multicast router
    - No encapsulation/tunneling needed
  - HA that should have multicast routing capability
    - encapsulated and tunneled to the HA

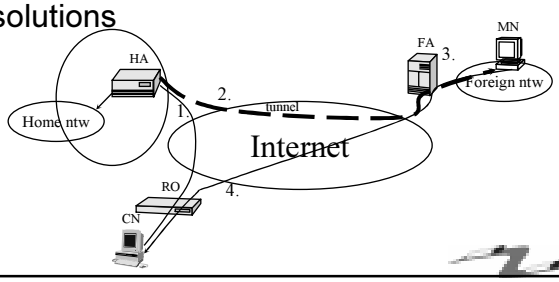
MN to HA (unicast)	Original multicast packet

Stripped away by the HA/MC router

  - Multicast is received
    - normally as a group member (co-located address)
    - via HA as encapsulated/tunneled packets
      - may require recursive encapsulation

Home agent at home network edge

- Client based VPNs
- Direct connection to home (organization) network
- Requires Home Agent management resources from the organization
  - Flexible security solutions



Home agent at ISP network edge

- Requires less network experts in home network
- Outsources the HA management
  - Dependence on ISP choices on security etc.