HELSINKI UNIVERSITY OF TECHNOLOGY

Mobility management in IP networks & Mobile IP

Lecture slides for S-38.3192

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Learning goals in Mobility Management & Mobile IP

- After this lecture you will know
  - Reasons why mobility and its management are not straightforward tasks in the Internet
  - What are the mobility problems, mobility design guidelines and mobility management tasks
  - How Mobile IP works and what enhancements have been proposed (and what additional functionality they introduce)
  - How different traffic types are forwarded in Mobile IP –environment
- After reading the article ”An Evaluation of Current QoS solutions for Mobile IP networks” by Agarwal et al. you will be able to
  - List and briefly explain the challenges that QoS solutions face in the Mobile IP environment
  - List and briefly explain the shortcomings of using standard RSVP-protocol in Mobile IP environment
  - List and briefly explain the advantages and disadvantages of using advance resource reservation –solutions in Mobile IP -environment

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 L2 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)
  - The problem: IP address identifies 1) (to a large degree) the host identity and 2) the host location.
- 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

Mobility challenges

1. Locating the mobile host or service
   - address discovery (location)
2. Preserving connectivity
   - although location may change (tracking)
3. Controlled disconnectivity
   - file systems can do this
4. Controlled stand-by
5. Quick resume of communications
   - without unnecessary data lost

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 exchange
- We need to restrict the circulation of location and IP address information to a minimum!
  - Location independent identifier

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, host routes are not an option in the Internet
- Compatibility with Internet Addressing
- No additional vulnerabilities should be introduced
- Independence of layers (do not assume that L3 and L2 addresses are related).
- Handle disconnections properly
- Support mobility at the edge devices
  - Do not assume proxies exist

Mobility management

- Location management
  - registration and location updates
  - to enable a network to discover the current location of a mobile node (MN)
  - Location-independent identifier (IP address, hostname, some other host id)
- Handoff management
  - to enable a network to maintain a connection while MN moves its location in the network

Mobile IP standards

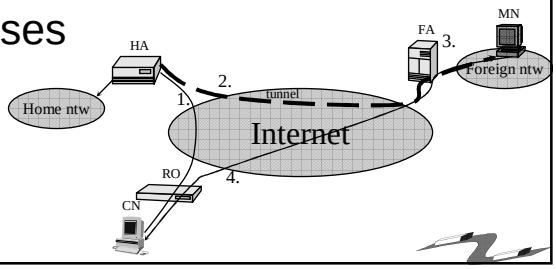
- Mobile IP is an IETF effort
  - dealt with in several workgroups
- Mobile IP is defined in IETF standards
  - RFC 2002, 2003, 2004, 2006
  - See also, RFC 1701 (GRE) and RFC 1321.
- Standards define
  - Agent discovery
  - Registration procedure
  - Tunneling
- Mobile IP is not widely used because of DHCP and VPNs provide email and web-access and NAT and firewalls block the Mobile IP functionality

Movement detection

- MN detects Home/Foreign Agent-advertisements (modified RFC 1256)
  - or solicits for a H/FA presence (unmodified RFC 1256)
    - H/FA advertisement = extended ICMP
    - Sequence numbers used to detect need for re-registration
- If no advertisements/solicitations answered
  - send ICMP to home router (check TTL!)
  - assume foreign network and try to obtain an address using DHCP or configure IP address manually
  - then register with Home Agent

Mobile IP components

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



Tunneling

- Tunnel is a path followed by packet that is encapsulated within another packet('s payload)
  - Put (IP) packets inside IP packets
    - avoid standard unicast routing
    - use other protocols in the Internet
  - Tunnels are defined manually
  - Tunnels reduce the MTU
  - Tunnel faults are hard to detect
- Tunneling techniques are several
  - IPinIP (RFC 2003, default), MinIP (RFC 2004), GRE (RFC 1701 & 1702) etc.

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)

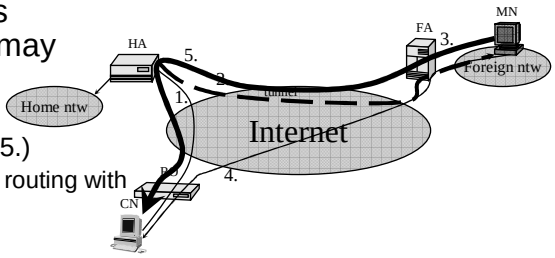
Mobile IP basic features

- 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!

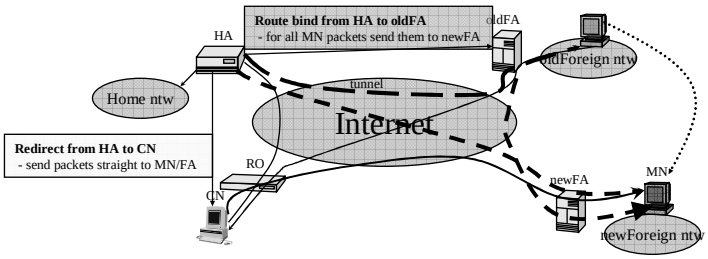
Triangle routing and reverse tunneling

- 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



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?

ARP table

MN/IP	MN/L2
MN/IP	HA/L2

Registration request & reply

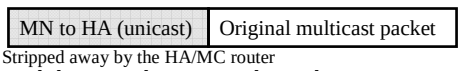
Sent to all local nodes via gratuitous ARP

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

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



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

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

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 earlier
- 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

IP & Mobility summary

- True mobility is not built-in in the Internet
  - Mobile IP handles the task somehow, and other protocols support.
- Implicit solution: Applications have developed to a direction where true mobility is not needed.
- Waiting for the killer app…