Mobility in IP networks
Mobile IP

Lecture slides for S-38.191

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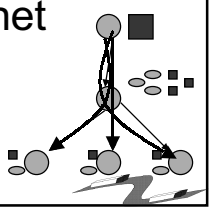
Network scalability

- 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
- All technical solutions in the Internet should be scalable!



What is mobility?

- A node moving from a location to another location while preserving its original IP address
  - Possibly also changing the layer 2 environment
  - 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)☹

Different users – different mobility

- Service mobility
  - User moves and connects to his home network with arbitrary devices
    - VPNs, secure connections, WWW-mail services
- 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

Host routes – the easy solution?!

- Why not spread knowledge on the movements to all Internet routers?
  - Solution does not scale, overload of networks with locality information
- We need to restrict the circulation of location and IP address information to a minimum

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Mobile IP design objectives

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

Mobile IP standards

- Mobile IP is an IETF working group
- 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

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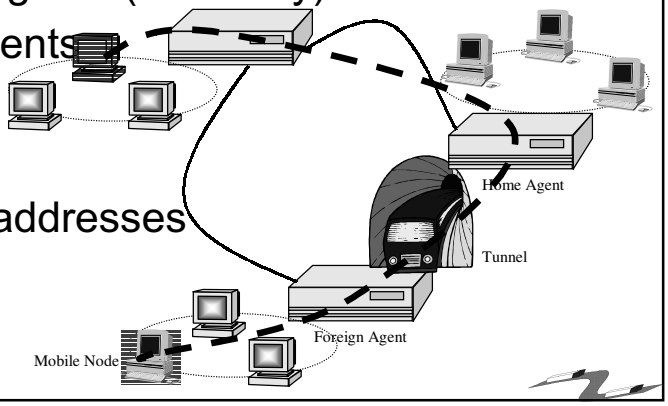
Mobile IP basic features

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

Mobile IP components

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



Home agent

- 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, or to other nodes
- Tunnels packets towards mobile node

Foreign agent

- 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

Tunneling

- Tunnel is a path followed by packet that is encapsulated within an 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, MinIP, GRE etc.

Care of address

- Foreign Agent CoA
- 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)

Movement detection

- MN detects Home/Foreign Agent-advertisements
  - or solicits for a H/FA presence
    - 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

Registration

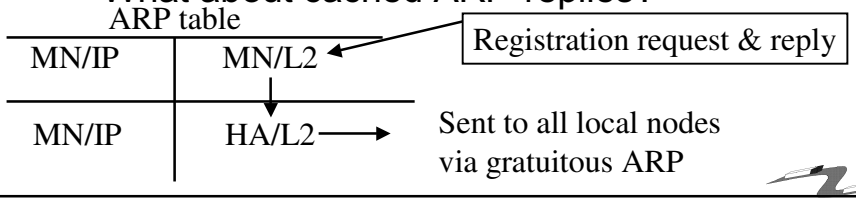
- Request help in routing from the FA
- Inform HA current location of MN
- Re-registrate
- Notify HA when returned to home network
- Registration done over UDP
  - Registration request
  - Registration reply

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

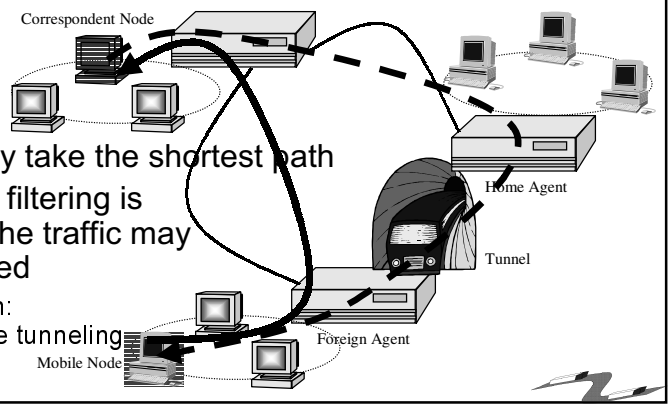
Traffic forwarding – home network

- 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?



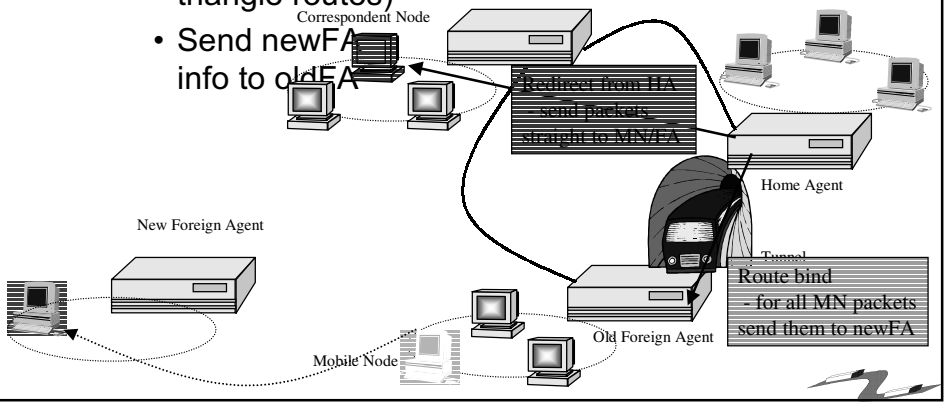
Triangle routing and reverse tunneling

- CN sends to MN
  - Traffic flows via HA
- MN to CN
  - traffic may take the shortest path
  - If ingress filtering is in effect the traffic may be dropped
    - Solution: Reverse tunneling



New route advertisements

– Home agent knows the true location of the MN
  - Send redirects to correspondent nodes (avoid triangle routes)
  - Send newFA info to oldFA



Receiving home network broadcast in foreign network

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

HA to MN (unicast)	Original broadcast packet

Stripped away by the MN

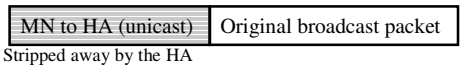
- Foreign Agent address
  – Tunneled to the FA (tunnel exit point)
    - If link level broadcast then packets have to be recursively encapsulated otherwise broadcasted in the foreign network – Requires (de)tunneling capability from the MN

HA to FA (unicast)	HA to MN (unicast)	Original broadcast packet

Stripped away by the FA Stripped away by the MN

Sending broadcasts

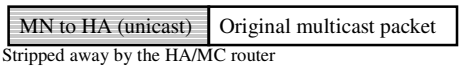
- Directed broadcasts sent as such
  - If allowed by the Home Agent
- Link layer broadcasts tunneled to the HA



Stripped away by the HA

Multicast

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

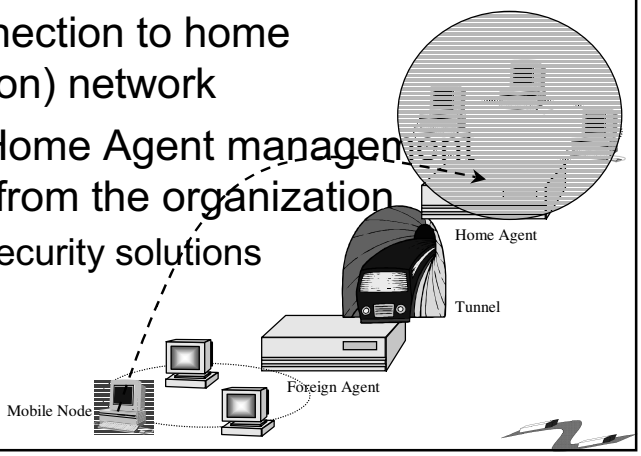


Stripped away by the HA/MC router

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

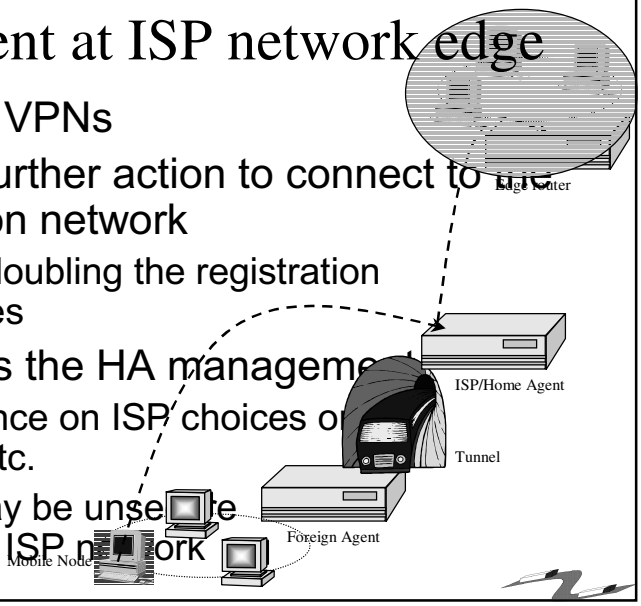
Home agent at home network edge

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



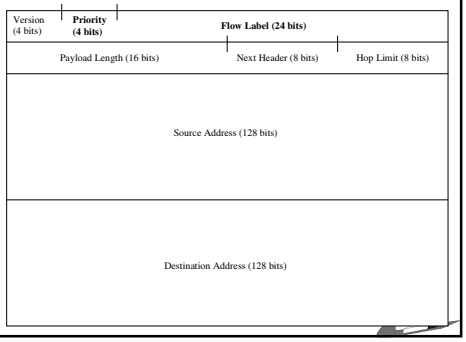
Home agent at ISP network edge

- ISP based VPNs
- Requires further action to connect to the organization network
  - possibly doubling the registration procedures
- Outsources the HA management
  - Dependence on ISP choices on security etc.
  - Traffic may be unsecure within the ISP network



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 – new features

- New anycast –sending mode added to broadcast, multicast and unicast
  - same address for several nodes
  - packet is sent to nearest node having the anycast address
- Multicast sendings controlled with scope – field
- Flow labels to cache forwarding information
- Priority field to support QoS
- Stateless autoconfiguration
  - no more DHCP or BOOTP

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

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IPv6 vs. IPv4 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 summary

- Method to ensure packet forwarding to the mobile node
  - Home Agent, Mobile node, encapsulation and tunneling
    - possibly also Foreign Agent
- Requires registration (although not covered in these slides)
- Useful also in IPv6