Lecture 9 (Jan 17, 2004)

Outline
IP Mobility

Portable Networking Technology

- Cellular systems
  - Cellular Digital Packet Data (CDPD)
  - 3G
- Bluetooth
  - Low cost, short range radio links between mobile devices
- Wireless Ethernet (802.11)
  - Widely used wireless MAC layer technology

Mobility and Standard IP Routing

- IP assumes end hosts are in fixed physical locations
  - What happens if we move a host between networks?
- IP addresses enable IP routing algorithms to get packets to the correct network
  - Each IP address has network part and host part
  - This keeps host specific information out of routers
  - DHCP is used to get packets to end hosts in networks
  - This still assumes a fixed end host
- What if a user wants to roam between networks?
  - Mobile users don’t want to know that they are moving between networks
  - Why can’t mobile users change IP when running an application?

Mobile IP

- Mobile IP was developed as a means for transparently dealing with problems of mobile users
  - Enables hosts to stay connected to the Internet regardless of their location
  - Enables hosts to be tracked without needing to change their IP address
  - Requires no changes to software of non-mobile hosts/routers
  - Requires addition of some infrastructure
  - Has no geographical limitations
  - Requires no modifications to IP addresses or IP address format
  - Supports security
    - Could be even more important than physically connected routing
- IETF standardization process is still underway

Mobile IP Entities

- Mobile Node (MN)
  - The entity that may change its point of attachment from network to network in the Internet
    - Detected as it moves and registers with “best” FA
    - Assigned a permanent IP called its home address to which other hosts send packets regardless of MN’s location
    - Since this IP doesn’t change it can be used by long-lived applications as MN’s location changes
- Home Agent (HA)
  - This is router with additional functionality
  - Located on home network of MN
  - Does mobility binding of MN’s IP with its COA
  - Forwards packets to appropriate network when MN is away
    - Does this through encapsulation

Mobile IP Entities contd.

- Foreign Agent (FA)
  - Another router with enhanced functionality
  - If MN is away from HA the it uses an FA to send/receive data to/from HA
  - Advertises itself periodically
  - Forward’s MN’s registration request
  - Decapsulates messages for delivery to MN
- Care-of-address (COA)
  - Address which identifies MN’s current location
  - Sent by FA to HA when MN attaches
  - Usually the IP address of the FA
- Correspondent Node (CN)
  - End host to which MN is corresponding (e.g. a web server)
Mobile IP Support Services

- Agent Discovery
  - HA’s and FA’s broadcast their presence on each network to which they are attached
  - Beacon messages via ICMP Router Discovery Protocol (RDP)
- MN’s listen for advertisement and then initiate registration
- Registration
  - When MN is away, it registers its COA with its HA
  - Typically through the FA with strongest signal
  - Registration control messages are sent via UDP to well known port
- Encapsulation – just like standard IP only with COA
- Decapsulation – again, just like standard IP

Mobile IP Operation

- A MN listens for agent advertisement and then initiates registration
  - If responding agent is the HA, then mobile IP is not necessary
- After receiving the registration request from a MN, the HA acknowledges and registration is complete
  - Registration happens as often as MN changes networks
- HA intercepts all packets destined for MN
  - This is simple unless sending application is on or near the same network as the MN
  - HA masquerades as MN
  - There is a specific lifetime for service before a MN must re-register
  - There is also a de-registration process with HA if an MN returns home

Registration Process

- Mobility Binding Table
  - Maintained on HA of MN
  - Maps MN’s home address with its current COA
- Visitor List
  - Maintained on FA serving an MN
  - Maps MN’s home address to its MAC address and HA address

Mobile IP Operation contd.

- HA then encapsulates all packets addressed to MN and forwards them to FA
  - IP tunneling
- FA decapsulates all packets addressed to MN and forwards them via hardware address (learned as part of registration process)
- NOTE that the MN can perform FA functions if it acquires an IP address eg. via DHCP
- Bidirectional communications require tunneling in each direction

Tables maintained on routers

<table>
<thead>
<tr>
<th>Route Address</th>
<th>Home Address</th>
<th>Interface</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0.0.0/16</td>
<td>10.0.0.1</td>
<td>Ethernet</td>
<td>5000</td>
</tr>
<tr>
<td>10.0.0.1/32</td>
<td>10.0.0.2</td>
<td>Ethernet</td>
<td>5000</td>
</tr>
<tr>
<td>10.0.0.0/16</td>
<td>10.0.0.3</td>
<td>Ethernet</td>
<td>5000</td>
</tr>
</tbody>
</table>

Mobile IP Tunneling

- Original IP Packet
- Encapsulated IP Packet
- Tunnel (FA)
- Encapsulated Packet
- Decapsulated Packet
- Destination

Across Internet
Security in Mobile IP

- Authentication can be performed by all parties
  - Only authentication between MN and HA is required
  - Keyed MD5 is the default
- Replay protection
  - Timestamps are mandatory
  - Random numbers on request reply packets are optional
- HA and FA do not have to share any security information.

Problems with Mobile IP

- Suboptimal “triangle” routing
  - What if MN is in same subnetwork as the node to which it is communicating and HA is on the other side of the world?
    - It would be nice if we could directly route packets
  - Solution: Let the CN know the COA of MN
    - Then the CN can create its own tunnel to MN
    - CN must be equipped with software to enable it to learn the COA
  - Initiated by HA who notifies CN via ‘binding update’
  - Binding table can become stale

Other Mobile IP Problems

- Single HA model is fragile
  - Possible solution – have multiple HA
- Frequent reports to HA if MN is moving
  - Possible solution – support of FA clustering
- Security
  - Connection hijacking, snooping…
- Many open research questions