18-452/18-750
Wireless Networks and Applications
Lecture 17: Wireless and the Internet

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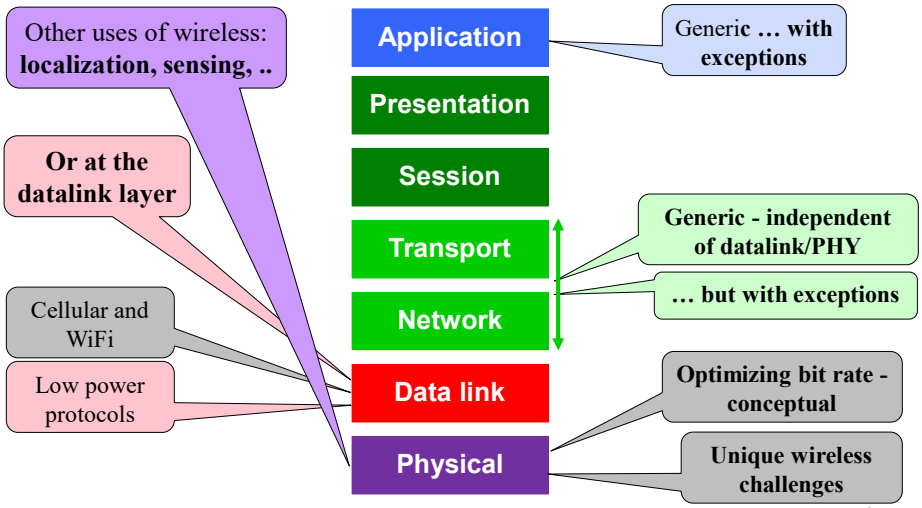
http://www.cs.cmu.edu/~prs/wirelessF24/

Outline

- **Wireless and the Internet**
- **Mobility: Mobile IP**
- **TCP and wireless**
- **Applications and wireless**

Course Overview



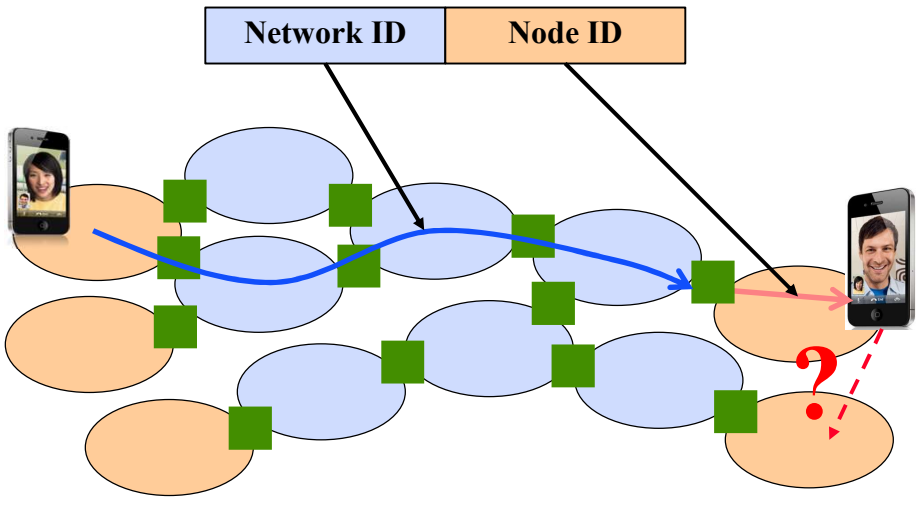
Wireless and the Internet Challenges

- IP addresses are used both to forward packets to a host and to identify the host
  - » Active session break when a host moves
- TCP congestion control interprets packet losses as a sign of congestion
  - » Assumes links are reliable, so packet loss = full queue
- TCP is also very sensitive to latency!
  - » Wireless networks tend to have higher latencies
- Applications can no longer assume they are always connected to the Internet
  - » Mobile apps must support "disconnected" operations!
- We focus on using the internet with WiFi
  - » Cellular is discussed later

IP Address Structure

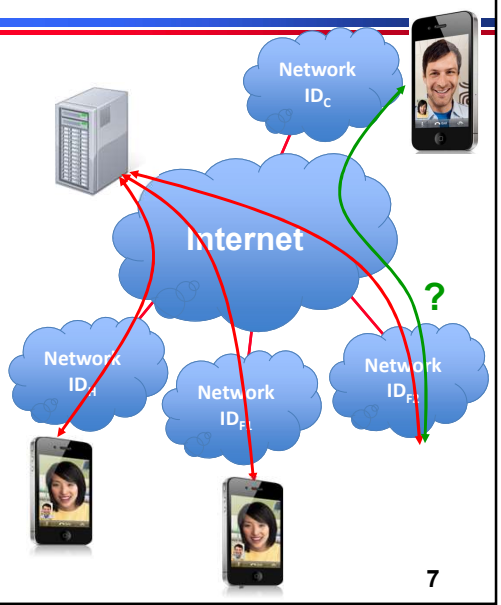
- Network ID identifies the network
  - » CMU = 128.2
- Node ID identifies node within a network
  - » Node IDs can be reused in different networks
  - » Can be assigned independently by local administrator
- Size of Network and Node IDs are variable
  - » Originally Network IDs came in three sizes only
  - » Variable sized Network IDs are often called a prefix
- Great, but what does this have to do with mobility?

Routing and Forwarding in the Internet



Mobility Challenges

- When a host moves to a new network, assume it gets a new IP address
- How do other hosts connect to it?
  - » They have old IP address!
- How do peers know you are the same host?
  - » IP address identifies host
- Or maybe they should keep their "home" IP address?
  - » Packets are forwarded to the wrong network!



Types of Mobility

- Nomadic users use their device in different locations, but not while moving between locations
  - » Example: using a laptop at home, CMU, coffee shop, ..
- Mobile users use their device while moving
  - » Example: use cell phone while browsing
- We focus on using the internet with WiFi
  - » WiFi is mostly used by nomadic users
  - » Cellular is more flexible

Finding Mobile Hosts: Two Simple Solutions

- Routing: mobile nodes keep "home" IP address and advertise route to mobile address as /32 in BGP
  - » Leverages LPM semantics - should work!!
  - » Bad idea: scalability
- DNS: mobile nodes get "local" IP address and update name-address binding in DNS
  - » This assumes DNS allows clients to update their address on the DNS servers of the address
- This should work but it is a terrible idea
  - » It results in a lot of write traffic to DNS
    - – Increases the load on the DNS servers
    - – Raises security concerns
  - » DNS relies heavily on caching of name-address pair
    - – Frequent updates reduce efficiency of caching

Solution #1: Mobile IP (1996) Requirements

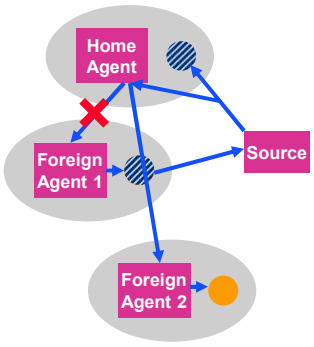
- Communicate with mobile hosts using their "home" IP address
  - » This made sense at the time
  - » Assignment of IP addresses to laptop was done manually!
- Mobility should be transparent to applications and high level protocols
  - » No need to modify the software
- Minimize changes to host and router software
  - » No changes to "communicating host", the host communicating with the mobile devices
- Security should not get worse

Finding Mobile Hosts: Mobile IP

- Any host can contact mobile host using its usual "home" IP address
  - » Target is "nomadic" devices
- Home network has a "home agent" that is responsible for intercepting packets and forwarding them to the host when it is mobile
  - » E.g., router at the edge of the home network
  - » Forwarding is done using tunneling
- Remote network has a foreign agent that manages communication with mobile hosts
  - » Module that runs on mobile and the point of contact for the mobile host
- Binding ties home IP address of mobile host to a "care of" address in the foreign network.
  - » binding = (home IP address, foreign IP addess)

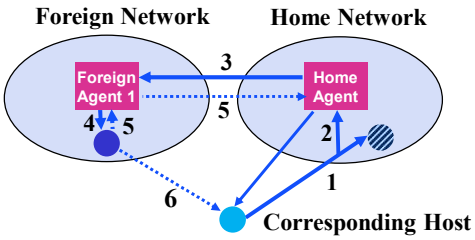
Mobile IP Operation

- Registration process: mobile host registers with home agent.
  - » Home agents needs to know that it should intercept packet and forward them
- In foreign network, foreign agent gets local "care of" address and notifies home agent
  - » Home agent knows where to forward packets
- Tunneling
  - » Home agent forward packets to foreign agent
  - » Return packets are tunneled in the reverse direction
- Supporting mobility
  - » Update binding in home and foreign agents.



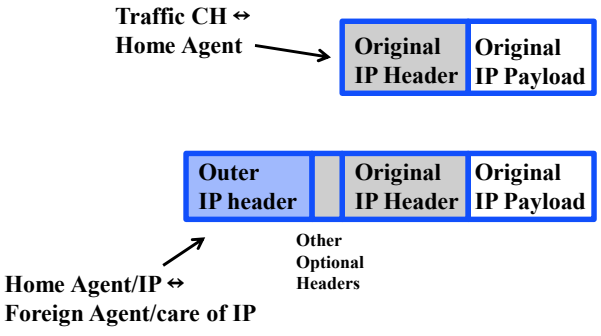
Mobile IP Operation

- Mobile Host registers with the Home Agent and with the Foreign Agent
  - » It receives a local "care of" address
  - » Foreign agent notifies Home Agent so it knows who to contact if needed

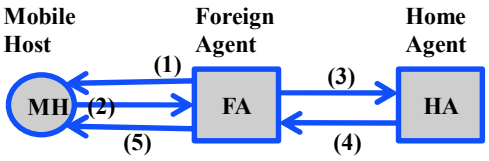


- Corresponding Host sends packet to host (1) but it is intercepted by the Home Agent (2)
- The packet is forwarded to the Foreign Agent (3) which forwards it to the mobile host (4)
- The Mobile Host's response is sent to the Foreign Agent, then to the Home Agent, and finally the Corresponding Host (3, 4, 5)
- Alternatively: Mobile Host responds directly to Corresponding Host (6)
- But how are packets forwarded between the Foreign and Home Agents and the Mobile Host?
  - » Tunneling

Tunneling
IP-in-IP Encapsulation

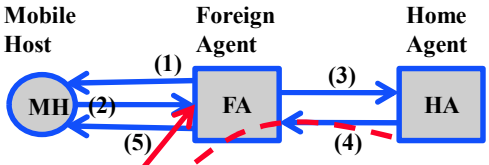


Registration via Foreign Agent



1. FA advertizes service
2. MH requests service
3. FA relays request to HA
4. HA accepts (or denies) request and replies
5. FA relays reply to MH

Authentication



Darth Vader will receive all the traffic destined to the mobile host

Solution: Registration messages between a mobile host and its home agent must be authenticated

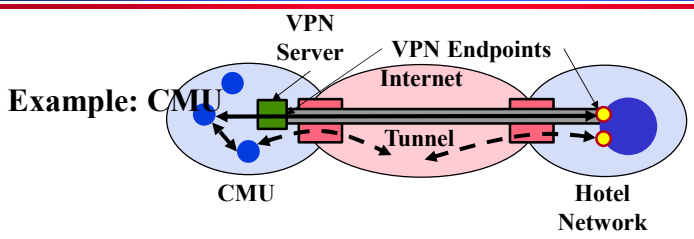
Mobile IP Discussion

- Mobile IP not used in practice
- Mobile devices are typically clients, not servers, i.e., they only initiate connections
  - » The problem that Mobile IP solves rare in practice
- Mobile IP is not designed for truly mobile users
  - » Designed for nomadic users, e.g. visitors to a remote site
- IETF defined several solutions that are more efficient
  - » Also more heavy weight: creates overlay with tunnels and special "routers", but they rely on "relays" similar to mobile IP
- Reality: maintaining your "home" address while being mobile is not particularly useful
- Practical solution: when you connect to new network, you obtain a "local" IP address and use that for communication

More Practical Way to Support Mobility

- Host gets new IP address in new "foreign" network
  - » Simple: they use Dynamic Host Configuration (DHCP) to get a local address
    - – Will require authentication, e.g., as "guest"
  - » They simply use this address for any communication
- But this introduces problems at higher layers in the stack!
  1. Some devices may need to contact the host
     - – E.g., servers with notifications, e-mail, ..
  2. How to maintain a TCP session while mobile
  3. Clients needs a home address to contact services in home network

Using A Virtual Private Network (VPN)



- To access sensitive services, clients often need a "local" IP address
  - » You are effectively on the CMU network
- The idea is to create a "tunnel" between you remote network and the CMU network
  - » All packets are encapsulated
- VPN server de-encapsulates incoming packets and encapsulates outgoing packets

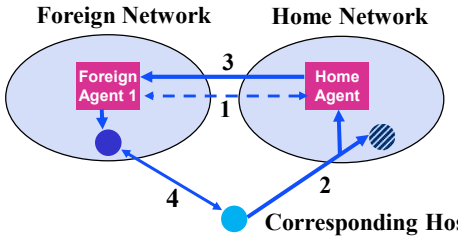
Types of VPNs

- Full VPN: all packets are tunneled to the CMU campus network before being delivered to their destination
  - » Benefit: the destination network does not know you are not on campus
  - » Drawback: longer latencies, e.g., making a dinner reservation while in Europe
- Campus VPN: only packets to on-campus destinations are tunneled to the campu network
  - » Other packets are sent directly to the destination
  - » Benefit: faster!

Cellular Networks

- **Supporting mobile and nomadic users has always been a requirement for cellular**
  - » **Cellular was originally designed for mobile phones**
  - » **Wifi: portable laptops (nomadic use)**
- **We must consider three cases:**
  - » **Mobility between basestations in a single network**
    - – **E.g., driving around in a city**
    - – **Explicitly supported by control protocols**
  - » **Mobility between networks of a single cellular provider**
    - – **E.g., networks on the east and west coast**
  - » **Mobility between cellular providers**
    - – **E.g., travel to Europe and your US provider has an agreement with a European provider**

Mobility between Networks of Single Provider



- **High level design of Mobility IP similar to that of inter-network mobility in cellular**
- **The design for third case is similar**