Mobility
(and philosophical questions about names and identity)

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CMU CS 15-744

The problem

- How to “support” mobile users
- What do we mean by support?
- Make it easy and convenient to effectively use the network while moving from location to location

The Solution Space

- Where can we address this problem?
  - Physical layer? (sure; very limited)
  - Link layer
  - Transport layer
  - "Something higher" (often called session)
  - Application layer

The questions

- *What components are affected?*
  - E.g., what needs to explicitly support mobility?
  - Is it incrementally deployable?
- *What timescales does it support?*
- *What geographic/logical bounds does it place on mobility?*
- *What overhead does it impose?*
- *How does it affect or interact with other aspects of the architecture?*
- *How does it scale?*

Who are we supporting?

- What kinds of mobility scenarios should we support?
  - Talking on a VoIP phone while walking down the street?
  - Navigating with a laptop in a car?
  - Using a laptop in an airplane?
  - Taking laptop from home to work?
  - Walking around lab or campus?
  - Something we haven't thought of yet??

Try #1: No Network Support (Applications are on their own)

- Let them disconnect and reconnect when they arrive at a new location.
  - Network support needed: None / DHCP
  - Your SSH sessions die. ☹ Your streaming media probably gets interrupted.
  - Some applications have already worked around this:
    - Your Web browser doesn't care
    - Your IMAP mail reader probably doesn't care

Dealing with disconnection

- Possible to code many applications to deal with disconnection
  - It's all about trying to resume and managing state (we'll come back to this)
  - But should the burden be placed on every application developer?

So – Application?

- *What components are affected?*
  - Any application that wants to work
- *What timescales does it support?*
  - End-to-end application communication. Seconds?
- *What geographic/logical bounds does it place on mobility?*
  - *None*
- *What overhead does it impose?*
  - Lots of programmer overhead
- *How does it affect or interact with other aspects of the architecture?*
  - *Nothing's changed*

Try #2: Link-layer mobility

- Have the link layer mask mobility
  - E.g., the campus 802.11 wireless. You can move anywhere and keep the same MAC and IP address
- Completely transparent. No OS/App support needed. Brilliant!
- Fast & Local: Only switches near moving client must be updated.
- But – only local! Can't move out of your subnet.

So – Link?

- *What components are affected?*
  - The local switching infrastructure
- *What timescales does it support?*
  - Pretty durned fast
- *What geographic/logical bounds does it place on mobility?*
  - Can only move within local subnet
- *What overhead does it impose?*
  - Little
- *How does it affect or interact with other aspects of the architecture?*
  - Could encourage ideas like making all of CMU a single broadcast domain. Oops, too late. ☺

IP Layer Mobility

- Allow hosts to take their "home" IP address with them wherever they go.
- Advantages:
  - Potentially global mobility scope (not limited to subnet like link layer)
  - Transparent to applications and layers above IP
- How can we do it?
  - (Many ways, each with own costs)

Brute Force: IP routing

- If node leaves home, send out (global?) routing announcement pointing to new location
  - In theory, "just works"
  - Example: Boeing's "Connexion" announced a /24 into BGP for every supported airplane and moved the announcement to the gateway the plane was closest to
  - Why? Latency concerns over really long flights (start in SF, end in London)
  - Already have high latency from using satellites. Ow.

Brute force 2

- May be feasible for Boeing
- But wouldn't scale for single IP addresses
  - Every AS in world would have routing entry for every mobile user in the world? Ouch!
- Problem: Having the whole world maintain state for every user
- Alternative: Keep state local, by…

Mobile IP (& others):

- Same as other problems in Computer Science
  - Add a level of indirection
- Keep some part of the network informed about current location
  - Need technique to route packets through this location (interception)
- Need to forward packets from this location to mobile host (delivery)

Interception

- Somewhere along normal forwarding path
  - At source
  - Any router along path
  - Router to home network
  - ****Machine on home network** (masquerading as mobile host)

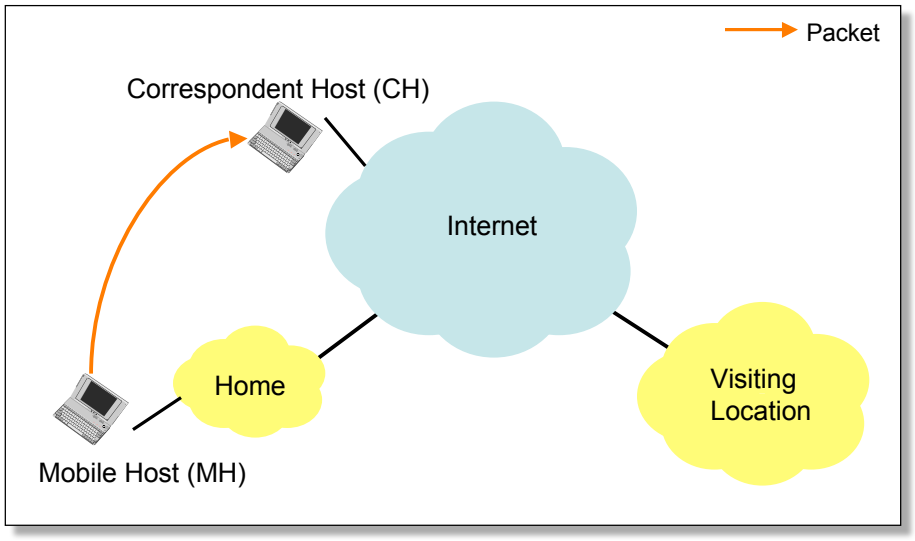
Delivery

- Get packet to mobile's current location
- **Tunnels**
  - Tunnel endpoint = current location
  - Tunnel contents = original packets
- Source routing?
  - Loose source route through mobile current location (not widely supported)
- Network address translation (NAT)
  - What about packets from the mobile host?

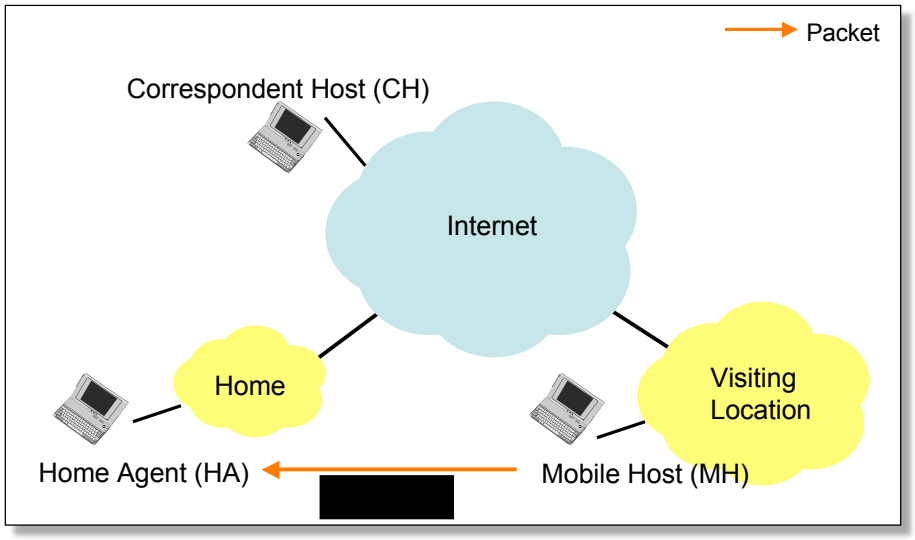
Mobile IP (RFC 2290)

- Interception
  - Typically home agent – hosts on home network
- Delivery
  - Typically IP-in-IP tunneling
  - Endpoint – either temporary mobile address or foreign agent
- Terminology
  - Mobile host (MH), correspondent host (CH), home agent (HA), foreign agent (FA)
  - Care-of-address, home address

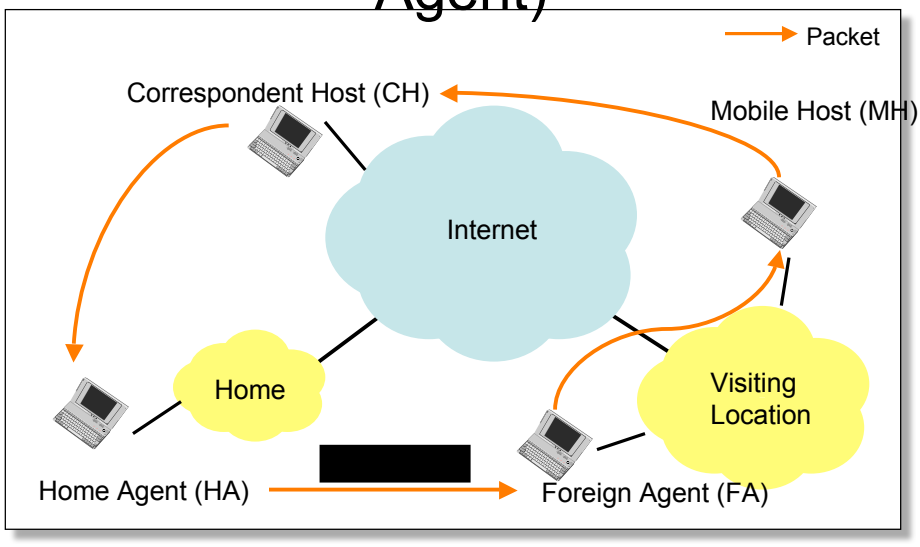
Mobile IP (MH at Home)



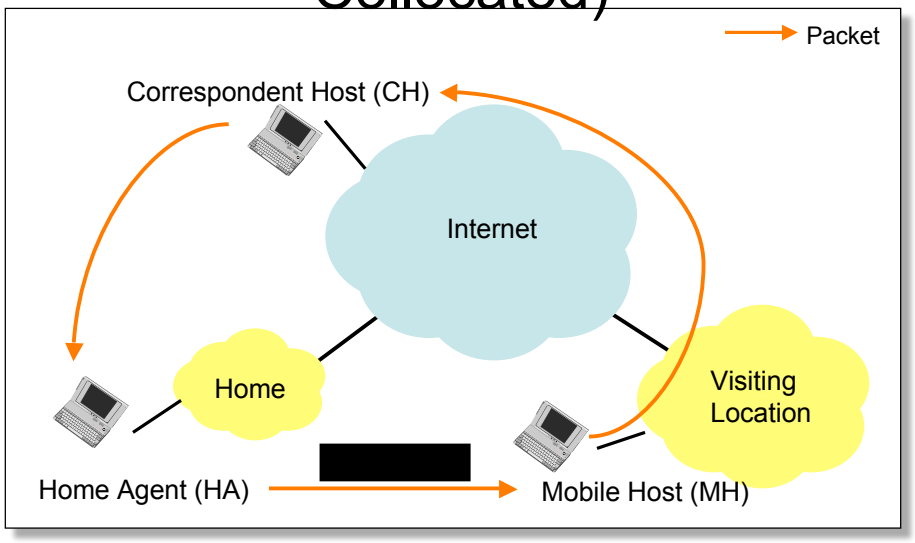
Mobile IP (MH Moving)



Mobile IP (MH Away – Foreign Agent)



Mobile IP (MH Away - Collocated)



Other Mobile IP Issues

- Route optimality
  - Triangle routing
  - Can be improved with route optimization
    - Unsolicited binding cache update to sender
- Authentication
  - Registration messages
  - Binding cache updates
- Must send updates across network
  - Handoffs can be slow
- Problems with basic solution
  - Reverse path check for security
  - Do we really need it?

TCP Migrate

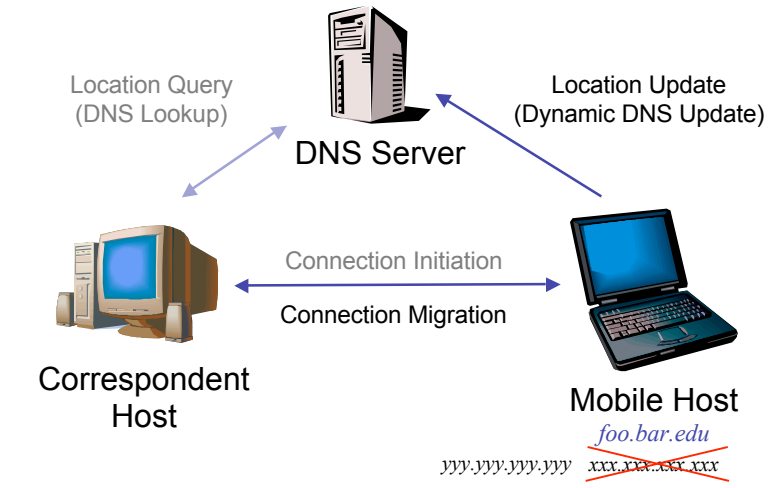
- Transport-layer solution
- Idea: No IP support; just have transport layer dynamically re-bind endpoints

The Migrate Approach

- Locate hosts through existing DNS
  - Secure, dynamic DNS is currently deployed and widely available (*RFC 2137*)
  - Maintains standard IP addressing model
    - IP address are topological addresses, not Ids
    - Fundamental to Internet scaling properties
- Ensure seamless connectivity through connection migration
  - Notify only the current set of correspondent hosts
  - Follows from the end-to-end argument

Slide Credit: Alex Snoeren

Migrate Architecture



Slide Credit: Alex Snoeren

Migrate

- Advantages:
  - (Mostly) transparent to applications
    - Unless they know their IP address and use it, e.g., peer-to-peer apps.
  - Keeps state and modifications *entirely* at endpoints
  - No triangle routing! All communication is direct
- But:
  - Requires TCP support / only works for TCP
    - Not true in general: "Host ID Protocol" – HIP – can work with both, but requires more invasive IP stack changes
  - Slower timescales than link-layer migration (several RTTs)

Complexities of e2e mobility

- Simultaneous movement
  - If only one host moves, easy
  - If both move, must be able to reconnect
  - Snoeren approch uses DNS with dynamic DNS updates – re-point your old name to your new IP when you move
- Security
  - How to prevent connection hijacking?

Mobility & Security

- Migrate principle: Equivalent security to TCP
  - TCP connections hard to hijack remotely if you can't sniff because you must guess a 32-bit sequence # space. (mostly; we'll talk about this more later)
  - Migrate approach: Establish a pretty secure session key on connection establishment
    - Resists snooping but not man-in-the-middle
    - But neither does normal TCP!
- Other options: HIP uses cryptographic host identification
  - Better idea
  - Less incrementally deployable

Names & Addresses & Bears, Oh My!

- Mobility raises good question:
  - *What is the identity of a host?*
    - MAC address? IP address? DNS name? Something else?
- Consider:
  - Hosts can have multiple MAC & IP addresses
  - IP address is a *topological* identifier – it points to a place in the local IP space and is awkward to move, as we've seen
  - DNS names? Maybe, but the binding between DNS/IP/hosts isn't very strict

Host Identity

- Considerable recent work: Give each *host* a unique identity
  - Simplifies mobility
  - Also simplifies multi-homing! (Many related issues)
  - Me? I think it's a great idea. Will it ever take off? ☺

What mobility do we need?

- Consider our scenarios and our techniques – what do we really need?
- Link layer mobility can deal with small-scale motion
- E2E mobility does a good job on “big”, less frequent movement
  - But if only a few apps matter, so does re-coding those apps to deal
  - Requires bilateral deployment! Boooo.
- Mobile IP (or VPNs, which is basically what mobile IP is) can be unilaterally deployed, but has triangle routing problems
  - But require more infrastructure
- Do most people care enough? Or would we have entire new classes of applications *if* mobility was easier?