CSE 222
Graduate Networking

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Lecture 12: Mobile Routing

Geoffrey M. Voelker

Overview

- We've covered standard unicast IP routing
  - Distance vector, link state
- Then we detoured
  - DNS: How do we name hosts in the Internet?
  - Internet Measurement: How do we find out what's happening?
- Now we're going to look at new routing problems
  - Mobile routing: What happens when end points move?
    - » Mobile IP (Network approach)
    - » E2E Mobility (DNS + Transport migration)
  - Multicast: What if you have multiple recipients?

The Mobility Problem

- The IP architecture has an implicit assumption that hosts are stationary
  - IP addresses are names that include location information
  - IP routing interprets names to decide how to forward packets
  - Aside: What other names are like this?
- However, in our brave new world, IP-addressed devices move yet want to remain connected
  - Laptops, handhelds, phones, cars, etc.
  - Local movement: one subnet (access point) to another in the same building, on the same campus
  - Global movement: into a “foreign” network in another admin domain, another city

The Mobility Problem (2)

- Why is this a problem?
  - If you change locations, you have to change IP addresses
  - Open connections will break as a result
  - Packets sent to the old IP address get dropped or sent to the wrong host
  - If you do not have any open connections when you change locations (IP addresses), is mobile routing necessary?
    - » Does Web browsing require mobile routing?
    - » How does DNS play a role in this?

Mobile IP: Johnson96

- Mobile IP is the current IETF proposed standard for supporting mobility in the Internet
  - Dates back to research in the early 90s
- Approach
  - Network layer solution
  - Only requires changes to mobile hosts
  - Stationary hosts oblivious to mobility

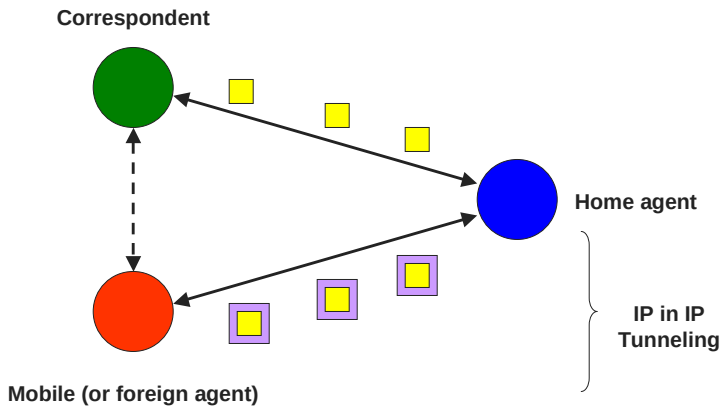
Mobile IP Approach

- Mobile hosts have two IP addresses
  - Home address
  - Care-of address
- Home address
  - Never changes, uniquely identifies the host
  - In “home network”
  - Correspondents address all packets to the home address
- Care-of address
  - Will change, perhaps frequently
  - In “foreign network”
  - Related to current location (IP routing gets it to the right place)

Home and Foreign Agents

- Home agent acts as a level of indirection between the mobile host and correspondents
  - Home agent accepts traffic sent to home address
  - Tunnels the traffic to the mobile host (using care-of address)
  - Mobile host responds by tunneling traffic back to home agent
  - Home agent forwards it on to the correspondent
  - Correspondent none the wiser
- Foreign agent represents mobile in foreign network
  - Foreign agent can be care-of address
    - » Mobile host does not need its own address in foreign network

Mobile IP Routing



Mobile IP Issues

- To make all this happen, a number of issues have to be addressed
  - Discovering agents
  - Registering addresses with agents (establishing bindings)
  - Authentication
  - Tunneling
  - Performance (!)

Agent Discovery

- Agent discovery enables a mobile host
  - To notice when it changes networks
  - To notice when it is home again
    - » When home, take down the tunnel
  - To find a foreign agent to register with
- Agents multicast agent advertisements
  - Beacons that tell the mobile who it can hear
  - Start in network A, move to network B
  - Lack of A's beacons and presence of B's tells mobile it has switched networks
- Mobile can also multicast an agent solicitation

Registration

- Mobiles must register care-of addresses with their home agents
  - So that the home agent knows where to tunnel packets
  - Registration needs to be updated when location changes
- Multiple steps
  - Registration requests first go to foreign agent, then to home agent, which replies to foreign agent, which forwards back to the mobile
- Lifetimes
  - Registrations have TTLs
  - Used to garbage collect addresses (why necessary?)

Registration Authentication

- Registration requests can be used by attackers to hijack tunnels from home agent
  - Hey, send all the mobile's traffic to me now
- Need to authenticate that a registration
  - Came from mobile host
  - Has not been altered
  - Is not a replay attack
- Mechanisms
  - Shared keys (mobile and home are from same admin domain)
  - MD5 digests

Tunneling

- Home agent and mobile communicate using a tunnel
  - IP in IP encapsulation
- Original packet
  - Correspondent address (src) → mobile home address (dest)
  - Gets sent to home agent, reversed used by mobile
- Tunnel packet
  - Encapsulates original packet
  - Home agent (src) → care-of address (dest)
  - Gets sent to foreign agent (or mobile, depending on care-of)
- Asides
  - Very easy protocol to implement
  - Bit of overhead (20 byte header for every packet…poor telnet)

Performance

- The good: No overhead in local operation
  - Home agent out of picture, no longer intercepts packets
  - The common case?
- The bad: Significant overhead in remote operation
  - Triangle routing: Packets between two hosts separated by inches can travel 1000s of miles
  - Wide-area effects determine “local” connection performance
  - The uncommon case? Even so, a steep price to pay
- Hence: Route optimization

Route Optimization

- Route optimization shortcuts the triangle
  - Correspondents can learn and use mobile care-of addresses
  - Tunnel packets directly to care-of address, skip home agent
  - Requires changes to correspondents
    - » Or to routers: How likely do you think this is?
- Issues
  - Binding cache updates (consistency)
  - Binding update authentication (more trust)
  - Yet more complexity
  - Necessary for scalability?

E2E Host Mobility: Snoeren00

- E2E Host Mobility: Same goals
  - Do not disrupt connections when network address changes
- Different approach
  - Combination of DNS and connection migration
  - Naming + transport (vs. network-layer w/ Mobile IP)
  - Based upon observation of how connections are made from mobile
- Three components
  - Addressing
  - Locating mobile hosts
  - Connection migration

Addressing

- Mobiles obtain an network-local IP address
  - No home agent, no home address
  - No foreign agent
  - No tunneling
  - Communication between correspondent and mobile uses addresses directly
- Problem: How does the correspondent learn the mobile's address?
  - Note that if the mobile initiates the connection, the mobile tells the correspondent its address with the SYN packet

Locating Mobiles

- Observation: Whenever connections are established, a DNS lookup is performed
- Idea: Use the DNS lookup to return latest mobile address to correspondent
  - In Mobile IP, home address is used to unique identify mobile
  - In E2E, DNS name is used for this purpose
  - Force lookups by setting DNS response TTL to 0
    - » What are the performance implications?
  - When mobile moves and obtains a new IP address, it updates its DNS entry (using secure DNS)
    - » Opportunity for a race condition
    - » Proposed solution: Application-level retries

Connection Migration

- Problem: Works for establishing new connections, but what about when the mobile moves and connections remain open?
- Solution: TCP Connection Migration
  - New IP Option: Migrate
  - Negotiated with Migrate-Permitted option in SYN
    - » Same structure as SACK
  - Requires modification to TCP stacks at both ends
  - A solution for TCP – what about other transports?

Basic Idea

- We have an open connection between correspondent (src) and mobile (dest)
  - Doesn't matter who initiated the connection (cf. locating)
  - Connection represented by
    - » <src IP, src port, dest IP, dest port>
  - Mobile moves
    - » Now has new <dest IP*, dest port*>
  - Want to change connection to
    - » <src IP, src port, dest IP*, dest port*>
  - Mobile creates a new connection to the correspondent, forces correspondent to migrate old connection to new one

Issues

- Connection Migration: Devil in the details
  - Migrate-Permitted option: Negotiate migratability
  - Migrate option: Initiate migration
  - MIGRATE_WAIT state: Handle dangling pointers
  - Security: DoS, hijacking (cf. Mobile IP), keys, IPsec
  - Performance: Why use 19.2Kb/s clients?
  - Deployment: Have to change all hosts!
  - Other transport protocols: Can easily generalize?

Discussion

- Which approach did you prefer? Is Mobile IP too wasteful? Is TCP Connection Migration just a hack?
  - But why would any organization will have foreign agents. I mean they have to spend some resources over it.
  - Reading the existing infrastructure, one point that struck me was, if the user of a PDA is driving in a car, his care-of-address continually changes and he has to continually keep binding to his home agent - will that not be a lot of overhead on the network traffic?
  - I believe that while the attempt to provide and E2E solution to mobile IP is admirable there are some problems with the approach presented. The major problem is the requirement of changes to TCP on both hosts to allow TCP migration…

Discussion

- Final project idea (1)
  - Extend mobile routing to handle disconnectivity
  - For which protocols/applications is this a problem?
- Final project idea (2)
  - Extend E2E Host Mobility to other transport protocols

For Next Time…

- Midterm project due Sunday 2/18 at midnight
- Email project group info!