Techological Advantages of Mobile IPv6

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Outline of Presentation

• Mobile IP in General
• What’s great about IPv6?
• Recent results from Mobile IPv6
• Context Transfer and Seamless Handover
• Challenges for the future
Earth with 2 Billion Mobile devices

- One billion is a large number; we’ll be there this year or next
- It’s never been done before!
- In the beginning, most of them will not be Internet enabled, but they will come online rapidly
- If IPv4 can do it at all, it will be at a tremendous (unimaginable, even) cost in complexity
- Only IPv6 offers enough addresses; the Internet is still young!
- IPv6 also offers the features needed for mobile networking
- Only Mobile IPv6 takes advantage of the IPv6 features to offer seamless roaming.
- Network-layer roaming also enables significant cost reductions and improved deployability
Protocol Stacks vs. Mobility

- Mobility affects every layer of the protocol stack
  - Physical layer: variable S/N ratio, directionality, etc.
  - Link-layer: error correction, hidden terminal effects, …
  - Network layer: what this talk is about!
  - Transport layer: congestion vs. errors, ?QoS?
  - Application configurability, service discovery

- Eventually, the Internet will be dominated by mobile nodes
  - but as of now the IETF effort doesn’t reflect this!

- Low level protocols attempt to provide transparency
- But application protocols sometimes need triggers
  - need for new APIs to support mobility
- Levels 8, 9, and 10 are also affected by mobility
- Profile management and adaptive network environment
Why Mobile IP?

• Both ends of a TCP session (connection) need to keep the same IP address for the life of the session.
  • This is the *home address*, used for end-to-end communication

• IP needs to change the IP address when a network node moves to a new place in the network.
  • This is the *care-of address*, used for routing

Mobile IP considers the mobility problem as a *routing* problem
• managing a *binding* – that is, a dynamic tunnel between a care-of address and a home address
• *Of course*, there is a lot more to it than that!
Mobile IP protocol overview

- Routing Prefix from local Router Advertisement
- **Seamless Roaming**: Mobile Node appears “always on” home network
- Address autoconfiguration → care-of address
- Binding Updates → home agent & correspondent nodes
  - (home address, care-of address, binding lifetime)
IPv6 & Mobile IPv6 Design Points

• Enough Addresses
• Enough Security (we thought)
• Address Autoconfiguration
• Route Optimization
• Destination Options and other extension headers
• also, reduced Soft-State, etc., not covered here
Enough Addresses

• 340 undecillion addresses
  • (340,282,366,920,938,463,463,374,607,431,768,211,456) total!

• Needed for billions of IP-addressable wireless handsets over the next 20 years

• IPv4 address space crunch driving current deployment of NAT
  • But, multi-level NAT unknown/unavailable
  • Besides, NAT not useful for always on operation

• Even more IP addresses needed for embedded wireless!

• Especially interesting for China now
  • 22 million IPv4 addresses and 130+ million handsets
Route Optimization

• Most Internet devices will be mobile, so we should design for that case for the health of the future Internet
• Binding Update SHOULD be part of every IPv6 node implementation, according to IETF specification
• Reduces network load by ~50%
  • (depending on your favorite traffic model)
• Route Optimization could double Internet performance
  • reduced latency
  • better bandwidth utilization
  • reduced vulnerability to network partition
  • eliminate any potential Home Agent bottleneck
Message Types

• Binding Cache Maintenance
  • Binding Update
  • Binding Acknowledgement
  • Binding Request

• Home Address Option

• Return Routability Tests
  • Home Address Test Initiate
  • Care-of Address Test Initiate
  • Home Address Test
  • Care-of Address Test

• Renumbering Messages
  • Mobile Prefix Solicitation
  • Mobile Prefix Advertisement

• Home Agent Discovery
Header Types

- New Routing Header for comfortable firewall administration
  - Used by correspondent nodes
  - Has no other intermediate nodes past mobile node’s care-of address (cannot be forwarded)
  - Makes firewall administrators happier

- Mobility Header
  - All Binding Cache messages
  - Return Routability messages (HoTI, CoTI, HoT, CoT)

- Destination Option Header contains Home Address Option

- Non-Final Mobility Header
  - Same messages, but can carry payload also
  - Should be a working-group document by the this time

- ICMP for Home Agent Discovery
Ingress Filtering and Home Address Option

• Ingress filtering border routers enforce topologically correct source IP address fields
• End-to-end applications want to deal with home address exclusively
• Topological correctness requires the care-of address to be in the Source IP address field
• IP traditionally passes the Source IP address field up to higher level protocol (e.g., TCP)
• Home Address Option changes this behavior, so that the option data is passed instead (i.e., the *home address*!)
• Result: topological correctness AND stable identification for higher-level protocols
Establishing a Binding Security Association

- BSA is needed specifically for authenticating Binding Updates
- Return Routability (RR) tests rely on routing infrastructure
- Mobile IPv6 RR enables mobile *authentication* not *identification*
  - Latter could require validation via *certificate authority*
  - The correspondent node only has assurance that the Binding Update comes from the same node as before
- Mobile IPv6 solution resists Denial of Service (DoS) attacks
- “First, do no harm”
  - That is, we must be as safe as communications between statically located IPv4 network nodes
  - Only nodes between correspondent node and home network can disrupt traffic
RR Protocol Overview

- Test return routability for home address (HoTI, HoT)
- Test return routability for care-of address (CoTI, CoT)
- HoT and CoT carry nonces to be combined to make $K_{bu}$
- Very few nodes see nonces in both HoT and CoT
- BSA in current specification is short-lived
- Correspondent node keeps no *per-mobile* state during HoT/CoT
- Diffie-Hellman could be another option
  - but it’s either expensive or patented
Mobile IPv6 status

- Mobile IPv6 testing event Sept 15-17, 1999
  - Bull, Ericsson, NEC, INRIA
- Return Routability for Key Establishment
- Distinguishing between renumbering and movement
  - tunneled router solicitations and advertisements
- Authentication data in options as well as in AH or ESP(?)
- Fast handover design team has issued Internet Draft
- Chairs and ADs are pushing for re-completion in May
Advantages and Features of Mobile IPv6

• Scalable approach to transparent mobility management
• Applications really can continue to work without modification
• Performance is quite acceptable, and typically should not overburden network capacity
• Uses IPv6 features with very little change
  • address autoconfiguration
  • authentication
  • requires no address-space partitioning
  • reduced implementation requirements
• Network renumbering in home domain or foreign domain without restarting mobile device
• Home Agent discovery
• Scalable approach to establishing Binding Security Associations
Smooth/Fast/Seamless Handover

- Smooth handover == low loss
- Fast handover == low delay
  - 30 ms?
  - Can router pre-empt Duplicate Address Detection??
- Seamless handover == *smooth* and *fast*
Context Features for Transfer

- Feature state established to minimize connection overhead
  - Mainly, to conserve bandwidth
- Header Compression
- Buffered Data
- Quality of Service requirements, and perhaps accounting data
- Security Association with access router, authorization tokens
- Application context transfer also needed, but not appropriate for resolution within mobile-ip, aaa, rohc, or seamoby working groups
- Care-of Address, MAC address, etc. handled via fast handover
Context Transfer Framework

• Control messages
  • HI and Hack (ICMP messages) from Mobile IPv6 fast handover design team are good candidates
  • What about scenarios besides smooth handovers?
  • Context features requested/provided as options
  • Could be another ICMP message, or SCTP, or Dest Opt, or ??

• Generic Profile types
  • Could be used with any control messages
  • Most kinds of context features will have a number of variants, each with different profile types (e.g., QoS, or [rohc])
  • Profile types would be registered with IANA, and each specification would lay out fields of suboptions
  • Presence vectors/default values for each field
Mobile-controlled handover

One scenario: mobile sends special Router Solicitation (RS)
- Previous Access Router → Proxy Router Advert. (RA)
- Previous Access Router sends Handover Initiate (HI)
- New Access Router → Handover Acknowledge (HACK)
Network Controlled Handover

- Previous access router (PAR) sends Proxy Router Advertisement on behalf of the new access router (NAR)
  - contains prefix and lifetime information, etc.
- PAR sends *Handover Initiate* message to NAR
- Mobile node *SHOULD* finalize context transfer at NAR
Challenges for Mobile IPv6

• Achieving Proposed Standard (esp. re: HAO)
• Legacy equipment and smooth transition (esp. with HLR)
• Walled Gardens (mobile access to all Internet services desired)
• Application adaptations to mobility (new APIs needed)
• Security protocol development, deployment (key distribution)
• Maintaining same level of quality as in current cellular (help from [seamoby])
• Enabling ad hoc networking (what is the business model?)
• Governmental considerations (Location)
• Harmonizing 3GPP and 3GPP2
• Video?
• QoS?
• Social awareness to restore the end-to-end application model (vs., e.g., NATs)
Summary and Conclusions

- Mobile IPv6 offers scalable, secure, and high-performance mobility management
- Mobile IPv6 is working, but there remain issues under discussion
  - We have a lot of interoperability experience, but new draft is different
  - Implementation is pretty natural under IPv6 and Ipsec
  - Still working to recover certain features
- Binding Update now has a lightweight key establishment protocol
  - “First, do no harm”
- Fast Handover has been developed for improved handover performance (goal: smooth voice handovers – and, video!)
- Context Transfer to preserve link contexts to avoid re-establishment (gaining further performance