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Technological Advantages of Mobile IPv6

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Outline of Presentation

- Mobile IP in General
- What's great for mobility about IPv6?
- Recent results from Mobile IPv6
- Context Transfer and Seamless Handover
- Challenges for the future

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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

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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

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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!

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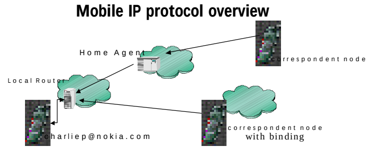
Mobile IP protocol overview



- 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)

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IPv6 features used for Mobile IPv6

- Enough Addresses
- Enough Security (we thought)
- Address Autoconfiguration for getting care-of addresses
- Destination Options (and, now, Mobility) extension headers
- also, reduced Soft-State, etc., not covered here

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Features added

- Binding Cache management in new Mobility Header
  - (a lot like the existing Destination Options header)
- Route optimization using new Route Header
  - (Almost exactly like the existing Route Header was used)
- New ICMP messages
  - For Home Agent discovery
- New Router Advertisement extension
  - For renumbering
  - Binding Request message type

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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

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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

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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

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Header Types

- Mobility Header
  - All Binding Cache messages
  - Return Routability messages (HoTI, CoTI, HoT, CoT)
- New Routing Header for comfortable firewall administration
  - Used by correspondent nodes
  - Has intermediate node == mobile node's care-of address (cannot be forwarded)
  - Presmably makes firewall administrators happier
- Destination Option Header contains Home Address Option
- IPv6 in IPv6 encapsulation
- *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

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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

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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

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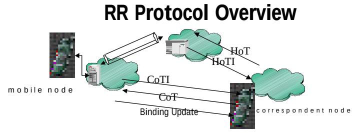
RR Protocol Overview



- 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

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Mobile IPv6 status

- Mobile IPv6 testing event Sept 15-17, 1999
  - Bull, Ericsson, NEC, INRIA
- ETSI bake-offs, 2000 & 2001 – success!
- Connectathon March 2000, 2001, 2002 – success!
- Return Routability for Key Establishment
- Distinguishing between renumbering and movement
  - tunneled router solicitations and advertisements
- Authentication data in option, as well as in AH or ESP(?)
- Fast handover design team has issued Internet Draft
- Chairs and ADs are pushing for re-completion
  - Draft ...-17.txt issued on Monday, may go to Last Call
  - Draft ...-18.txt is quite likely to be needed early June

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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 rarely should burden network capacity
- Uses IPv6 features with very little change
  - address autoconfiguration
  - authentication
  - requires no address-space partitioning
  - reduced implementation requirements
- Scalable approach to establishing Binding Security Associations
- Network renumbering in home domain or foreign domain without restarting mobile device
- Home Agent discovery

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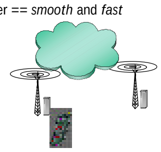
Smooth/Fast/Seamless Handover

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



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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*

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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

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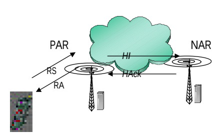
Mobile-controlled handover



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)

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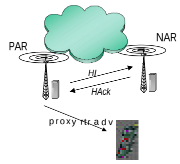
Network Controlled Handover



- 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

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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)

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Summary and Conclusions

- Mobile IPv6 offers *scalable*, *secure*, and *high-performance* mobility management
- Mobile IPv6 is working, and new issues are resolved
  - There's lots of interoperability experience, but new draft is different
  - Implementation is natural under IPv6 and IPsec
- 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 improvements)