Early Binding Updates for Mobile IPv6

Christian Vogt, chvogt@tm.uka.de
Roland Bless, bless@tm.uka.de
Mark Doll, doll@tm.uka.de
Tobias Küfner, kuefner@tm.uka.de

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Outline

- Mobile IPv6 basics
- Security and efficiency
- Proposed optimization
  - Early Binding Updates
  - Credit-Based Authorization
- Analysis
- Conclusion
Mobile IPv6 Basics

Mobile Node

Home Address

2000::/64

Correspondent Node

Internet

3000::/64

Care-of Address

Home Address = global ID above IP
Care-of Address = locator
Mobile IPv6 Basics

Home Address = global ID above IP
Care-of Address = locator

Mobile Node
Correspondent Node
Home Agent
Be Aware!

Issue 1: Impersonation

- Attacker **binds a false HoA** to some CoA
- Unauthorized use of a HoA $\Rightarrow$ connection
  - hi-jacking, eavesdropping, man-in-the-middle attacks, DoS

Issue 2: Packet Misdirection

- Attacker **redirects packets to a false CoA**
- Unauthorized use of a CoA $\Rightarrow$ flooding

Solution: **HoA/CoA-ownership proofs** (HoA/CoA tests)
What Mobile IPv6 Does About It…

Relationship btw. MN and HA

- **Long-lasting**
- Pre-configuration: Credentials, authorization records
- Mobile IPv6: **IPsec authentication**

Relationship btw. MN and CN

- Usually **without history**
- No pre-configuration
- Key exchange insufficient; HoA/CoA-ownership proof required
- Mobile IPv6: non-cryptographic **HoA/CoA tests**
What Mobile IPv6 Does About It…

Detach

Attach

Mobile Node

Home Agent

Correspondent Node

Registration with HA

Home Address Test

Care-of Address Test

Registration with CN

Binding Update to CN

〈RFC 3775〉
...And How This Performs

- Registration with HA
- Home Address Test
- Care-of Address Test
- Binding Update to CN

1 RTT

Mobile Node

Home Agent

Correspondent Node

Last packet

First packet

〈RFC 3775〉
...And How This Performs

Mobile Node

Home Agent

Correspondent Node

Detach
Attach

Last packet

First packet

〈RFC 3775〉

2 RTT

Registration with HA

Home Address Test

Care-of Address Test

Binding Update to CN

Christian Vogt, Research Institute of Telematics, University of Karlsruhe, Germany
Our Objectives

Need Optimization Which…

- significantly reduces handover latency
  across domains and without special network support

Related Work

- Local: Hierarchical Mobile IPv6, Fast Handovers
  - pro: low latency, zero packet loss
  - con: network support required, no inter-domain optimization

- End-to-end: Cryptographically Generated Addresses
  - pro: cryptographic HoA-ownership proof, eliminates HoA test
  - con: CoA test still required
Our Approach: Early Binding Updates

- Do this test before handover!
- Register early with the CN!
- Use CoA during test!

Register early with the CN!
Unverified Care-of Addresses

Issue: CoA unverified for a while

- Period of vulnerability btw. Early and standard Binding Update
- Negligible in some scenarios, usually requires additional protection

Solution: Prevent amplification

- Observation: amplification (not misdirection per se) makes redirection-based flooding attractive
- Rationale: no amplification $\Rightarrow$ redirection-based flooding unattractive
- Credit-based technique
Our Solution: Credit-Based Authorization

- **Mobile Node**: Acquires credit by sending pkts.
- **Consumes credit for being sent pkts. to unverified CoA**
- **Home Agent**
- **Correspondent Node**: Maintains credit account
Our Solution: Credit-Based Authorization
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Our Solution: Credit-Based Authorization
Our Solution: Credit-Based Authorization

- Mobile Node
- Home Agent
- Correspondent Node
Our Solution: Credit-Based Authorization
Our Solution: Credit-Based Authorization

- Mobile Node
- Home Agent
- Correspondent Node

- Detach
- Attach

CoA unverified signaling not shown
Our Solution: Credit-Based Authorization

CoA unverified

Signaling not shown

Detach

Attach

Mobile Node

Home Agent

Correspondent Node

Detach

Attach

CoA unverified

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Our Solution: Credit-Based Authorization
Our Solution: Credit-Based Authorization
Our Solution: Credit-Based Authorization

CoA unverified
Signaling not shown

Mobile Node
Home Agent
Correspondent Node

Detach
Attach

CoA unverified
Signaling not shown
Our Solution: Credit-Based Authorization

Mobile Node  Home Agent  Correspondent Node

Detach  Attach

CoA unverified signaling not shown
Our Solution: Credit-Based Authorization
Our Solution: Credit-Based Authorization

- Mobile Node
- Home Agent
- Correspondent Node

Signaling not shown

Detach
Attach

CoA unverified

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Asymmetric Traffic Patterns

Issue: Asymmetric Traffic Patterns

- Some applications feature asymmetric traffic patterns
- No sufficient credit upon handover

Solution: Credit for Packet Reception and Processing

- Feedback mechanism for CN
- Care-of Address Spot Checks (in-band extension of CoA tests)
- Not covered here
How Much Do We Benefit?

Mobile Node | Home Agent | Corresp'dnt Node
---|---|---
| | | 〈RFC 3775〉

First packet | Last packet | 1 RTT

Mobile Node | Home Agent | Corresp'dnt Node
---|---|---
| | | 〈Early Binding Updates〉

First packet | Last packet | Other

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How Much Do We Benefit?

First packet

Last packet

2 RTT

1 RTT

First packet

Last packet

〈RFC 3775〉

〈Early Binding Updates〉
Analysis of Early Binding Updates

Advantages of Early Binding Updates

- Half of standard latency, or less
- No special network support
- Applicable to inter-domain handovers

Drawbacks of Early Binding Updates

- Additional signaling for proactive HoA tests (if done periodically)
- Still 1 RTT latency
Scenario 1: TCP Throughput

RFC 3775

Early Binding Updates

3,678KB

4,363KB
One-Way Times & Bandwidths

100ms, 256kbps

50ms

100ms, 256kbps

x+5s  x+10s  x+15s  x+20s

3.5E6

2.5E6

1.5E6

0.5E6

Seqno

RFC 3775

Early Binding Updates

4,226KB

2,296KB

Preliminary Results of TCP Experimentations

Preliminary Results of TCP Experimentations
Conclusion

Current Status

- Implementation in FreeBSD 5.3, Kame-Shisa Mobile IPv6
- Ongoing work in IETF, IRTF; CBA now to be integrated into HIP

Open Issues

- Impacts on applications? Effects on TCP retransmission timers?

Future Perspectives

- Proactive registration before handover ⇒ eliminate remaining delays