Efficient End-to-End Mobility Support in IPv6

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What makes Route Optimization slow
How we make it better
Analysis
Implementation and ongoing work
Involvement in IETF, IRTF

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Securing Route Optimization: Be Aware!

Issue 1: Impersonation
- Connection hi-jacking
- Eavesdropping
- Man-in-the-middle attacks
- DoS

Issue 2: Packet misdirection
- Flooding

But: Peers don't share credentials!
What Mobile IPv6 Does About This…

- **Mobile Node**
  - Test home address
  - Test new care-of address
  - Register new care-of address

- **Home Agent**

- **Correspondent Node**
  - Return Routability

(RFC 3775)
...And How This Performs

![Diagram showing the sequence of events involving a Mobile Node, Home Agent, and Correspondent Node, with arrows indicating the flow of packets and the timing of detach and attach events.](image)
...And How This Performs

- **Home Agent**
- **Mobile Node**
- **Correspondent Node**

Detach
Attach

First packet
Last packet

3 RTT

⟨RFC 3775⟩
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 verification of home-address, no reachability test
  - con: care-of-address test still required
Our Approach: Early Binding Updates

- Test home address proactively
- Register new care-of address early
- Test new care-of address concurrently
- Confirm new care-of address
- Confirm new care-of address
- New care-of address unverified (period of vulnerability)

(The diagram illustrates the interactions between Mobile Node, Home Agent, and Correspondent Node for early binding updates.)
Unverified Care-of Addresses

Observation

- Amplification makes redirection-based flooding attractive

Idea

- Make amplification impossible
- $\Rightarrow$ Make flooding unattractive

Our Solution

- Weigh data sent to unverified care-of address against data sent by mobile node
Our Solution: Credit-Based Authorization

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

Diagram:
- Mobile Node
- Home Agent
- Correspondent Node

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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

care-of address
unverified

Signaling not shown
Our Solution: Credit-Based Authorization

Mobile Node

Home Agent

Correspondent Node

Detach

Attach

Signaling not shown

care-of address
unverified
Our Solution: Credit-Based Authorization

- Mobile Node
- Home Agent
- Correspondent Node

Detach
Attach

care-of address
unverified

Signaling not shown
Our Solution: Credit-Based Authorization

- Mobile Node
- Home Agent
- Correspondent Node

Detach - Attach

Signaling not shown

care-of address unverified
Our Solution: Credit-Based Authorization

- Mobile Node
- Home Agent
- Correspondent Node

Signaling not shown

Detach
Attach
care-of address
unverified
Our Solution: Credit-Based Authorization
Our Solution: Credit-Based Authorization

Mobile Node       Home Agent     Correspondent Node

Detach            Attach

Signaling not shown

care-of address unverified
How Much Do We Benefit?

Mobile Node  Home Agent  Correspondent Node

Last packet  First packet

2 RTT

RFC 3775

Mobile Node  Home Agent  Correspondent Node

Last packet  First packet  Other

Early Binding Updates

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How Much Do We Benefit?

- **First packet**
- **Last packet**
- **3 RTT**
- **1 RTT**
- **Corresp'dnt Node**
- **Mobile Node**
- **Home Agent**

**RFC 3775**

**Early Binding Updates**

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Conclusion

Ongoing work in IETF, IRTF

- EBU and CBA, related mobility work
  draft-vogt-mobopts-early-binding-updates-00.txt
  draft-vogt-mobopts-credit-based-authorization-00.txt
  draft-irtf-mobopts-ro-enhancements-01.txt
  draft-vogt-dna-relocation-01.txt
  draft-arkko-mipv6-binding-lifetime-extension-00.txt

- CBA now integrated into HIP
  draft-ietf-hip-mm-02.txt

- CBA integrated with CGA-based MIPv6
  draft-arkko-mipshop-cga-cba-01.txt

Still on the agenda

- Impacts on TCP and applications?
- Proactive registration before handover

Implementation

- FreeBSD 5.3
- Kame-Shisa Mobile IPv6