Early Binding Updates and Credit-Based Authorization – A Status Update

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Why Do We Need Enhancement?

- Mobile IPv6 Route Optimization uses return-routability procedure to authorize binding between...
  - Home address == Who I am
  - C/o address == Where I am

- Idea: Verify MN's reachability at
  - home address for authentication
  - c/o address for binding authorization

- Handoff delays btw. 3 and 4 RTT
  - depends on degree of parallelism that implementation use

- Reduce this!
Enhancement Approaches

Early Binding Updates
- Modification to Mobile IPv6 binding-update procedure
  - Proactivity
  - Concurrency
  - Higher degree of parallelism
- Reduces handoff latency
  - to 1 RTT for reactive handoffs
  - to 0~1 RTT for proactive handoffs

Credit-Based Authorization
- Strategy followed by CN
- Determines data that CN can securely send to MN before MN's reachability at new c/o address verified
Standard Mobile IPv6

- Link-layer handoff
- Home registration
- Care-of Test Init
- Home Test Init
- Home Test
- Care-of Test
- Binding Update
- Binding Ack

Authenticated w/both tokens

Include tokens

Return-routing procedure
Standard Mobile IPv6

3 RTT

Mobile Node

Home Agent

Correspondent Node

- link-layer handoff
- optimistic approach

- Binding Update
- Binding Ack

- Home Test Init
- Care-of Test Init
- Home Test Init
- Home Test
- Care-of Test

- Binding Update
- Binding Ack

switch to new c/o address

return-routing procedure

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Mobile IPv6 + Early Binding Updates

Home Test (Init) exchange **prior to handoff**

Home and correspondent registration **simultaneously**

Tentative registration of new c/o address without c/o test

Deferred full registration of new c/o address

Care-of Test (Init) exchange **in parallel with data**
Mobile IPv6 + Early Binding Updates

Mobile Node                  Home Agent                  Correspondent Node

proactive home-address test:
  Home Test Init
  Home Test
  Home Test Init

link-layer handoff
  Binding Update
  Early Binding Update
  Care-of Test Init
  Binding Ack
  Early Binding Ack
  Care-of Test
  Binding Ack

concurrent care-of-address test:
  Binding Update
  Binding Update

switch to new c/o address

1 RTT
However…

CN sends packets to unverified location
period of vulnerability
requires additional protection

care-of-address unverified
Why This Is An Issue

Attacker could…

- establish a higher-layer connection (e.g., download)
- redirect packets to victim
- spoof TCP acknowledgments

Amplification!

- CN generates large data packets
- Attacker sends small ACKs

Without amplification…

- Flooding no more effective than direct flooding
- Direct flooding always possible
...and How It Can Be Solved

Idea
- Limit packets sent to unverified c/o address so as to not cause amplification

Solution
- Count the bytes received from MN/attacker
- Send no more bytes to unverified c/o address

Credit-Based Authorization
- Byte counter == "Credit account"
Credit-Based Authorization

Mobile Node

- Acquires credit by sending pkts.
- Consumes credit for being sent pkts. to unverified addr.

Correspondent Node

- Maintains credit account
Credit-Based Authorization

Mobile Node → Correspondent Node

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Credit-Based Authorization

Mobile Node

Correspondent Node
Credit-Based Authorization

Mobile Node

Correspondent Node
Credit-Based Authorization

Mobile Node

Correspondent Node

[Diagram showing the interaction between a Mobile Node and a Correspondent Node]
Credit-Based Authorization

Mobile Node

Correspondent Node

Diagram showing credit-based authorization between a mobile node and a correspondent node.
Credit-Based Authorization

Mobile Node

Correspondent Node

[Diagram showing interactions between a mobile node and a correspondent node]
Credit-Based Authorization

Diagram showing the interaction between a Mobile Node and a Correspondent Node. The diagram illustrates the process of attachment and detachment, with arrows indicating the flow of data. The diagram also includes annotations such as "c/o address unverified" and "Attach Detach."
Credit-Based Authorization
Credit-Based Authorization

Mobile Node

Correspondent Node

c/o address unverified

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Mobile Node
c/o address unverified

Correspondent Node

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Credit-Based Authorization

Mobile Node

c/o address unverified

Correspondent Node

Unauthenticated
Credit-Based Authorization

Mobile Node

c/o address
unverified

Correspondent Node

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Credit-Based Authorization

Mobile Node

Correspondent Node

c/o address unverified
Credit-Based Authorization

C/o address unverified
Credit account allows an attacker to...

- accumulate credit over a long time
- at a slow rate, and
- use this credit all at once

Facilitates large burst of packets from attackers with low-bandwidth Internet access

Credit aging prevents this
Credit Aging

- **Credit Aging**
- **CN learns new c/o address**
- **New c/o address becomes verified**
- **New c/o address becomes unverified**
- **Exponential aging**
Experimental Evaluation

- Handoff delays w/IP telephony
- Handoff delays w/TCP file transfers
- Throughput of TCP file transfers
- Analysis of TCP benefits
IP Telephony: Parameters

Application
- 64 kbps payload
- 10ms chunks
- 164B per packet (IPv6, extensions, UDP, RTP)
- bidirectional

Network
- 200ms round-trip time

Mobility protocols
- standard (conservative) Mobile IPv6
- optimistic Mobile IPv6
- w/Early Binding Updates and Credit-Based Authorization

Confidence
- 500 handoffs per mobility protocol
Handoff Delay w/IP Telephony

\[ \text{RTT} = 200 \text{ ms} \]

![Graph showing handoff latency distribution with RTT delays]

- **ebb/cba**: 1 RTT + \( \epsilon \)
- **optim**: 3 RTT + \( \epsilon \)
- **conserv**: 4 RTT + \( \epsilon \)

Handoff latency (s)
TCP File Downloads: Parameters

Application
- 60s download (chargen-generated data)
- 1024 kbps bandwidth
- unidirektional
- TCP Reno

Network
- 40ms to 200ms round-trip time

Mobility protocols
- standard (conservative) Mobile IPv6
- optimistic Mobile IPv6
- w/Early Binding Updates and Credit-Based Authorization

Confidence
- 20 experiments per mobility protocol per round-trip time
- 5 handoffs per experiment
Handoff Delay w/TCP File Transfers

- conserv
- optim
- ebu/cba

handoff latency (s)

round-trip time (ms)

40 80 120 160 200
Throughput w/TCP File Transfers

Why does TCP benefit so much?
Why TCP Benefits So Much

1st timeout → new c/o address

1st timeout → old c/o address
2nd timeout → new c/o address
Why TCP Benefits So Much (2)

TCP behavior after 1st timeout
- set cwnd = 1
- set ssthresh = flightsize
- do Slow Start until cwnd > ssthresh

TCP behavior after 2nd timeout
- set cwnd = 1
- set ssthresh = 2 (minimum)
- effectively skip Slow Start
New Drafts

draft-vogt-mobopts-simple-ebu-00.txt
  - includes diff's to RFC 3775
  - specifies support for proactive handoffs
  - no IANA requirements

draft-vogt-mobopts-simple-cba-00.txt
  - transparent to MN
  - no signaling
  - no IANA requirements
No IANA Requirements

- Early BU == BU where
  - Kbm == SHA1(home keygen token)
  - Care-of Nonce Index == 0
- Early BA accordingly
- CN w/EBU support
  - checks Nonce Indices option
    - Care-of Nonce Index == 0 ? ⇒ early Binding Update
    - Care-of Nonce Index != 0 ? ⇒ standard Binding Update
- CN w/o EBU support
  - sends BA w/status 137, "Expired care-of nonce index" or
  - sends no BA due to Authentication failure
- MN sets Acknowledge flag in early BU
Conclusion

Advantages of EBU/CBA
- Reduce handoff delays to 0~1 RTT (L3 only)
- Better accommodate TCP's retransmission algorithm
- No special network support required
- Applicable to inter-domain handovers

Drawbacks of EBU
- Additional signaling, especially for proactive home-address tests if done periodically
- Still 1 RTT latency for reactive handoffs
- Still 0~1 RTT latency for proactive handoffs
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