Unified L2 Abstractions for L3-Driven Fast Handover

- Media Independent L2 Triggers from the Perspective of IP Layer -

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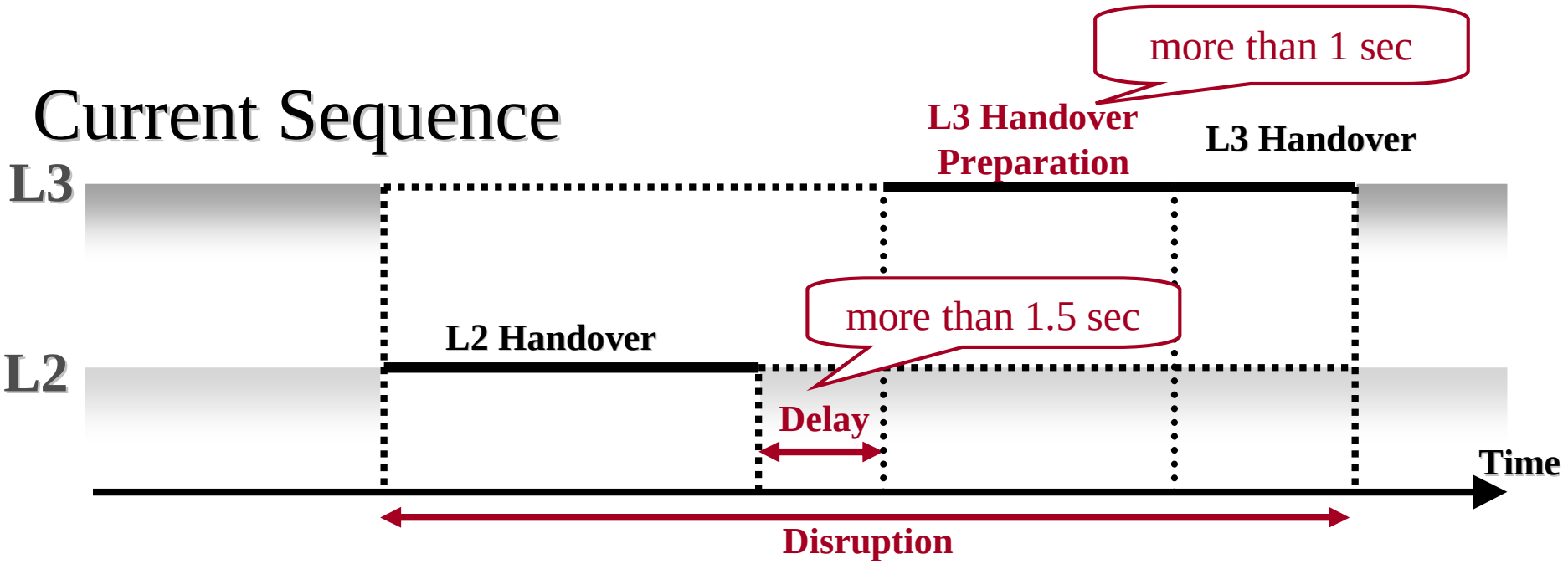
Outline

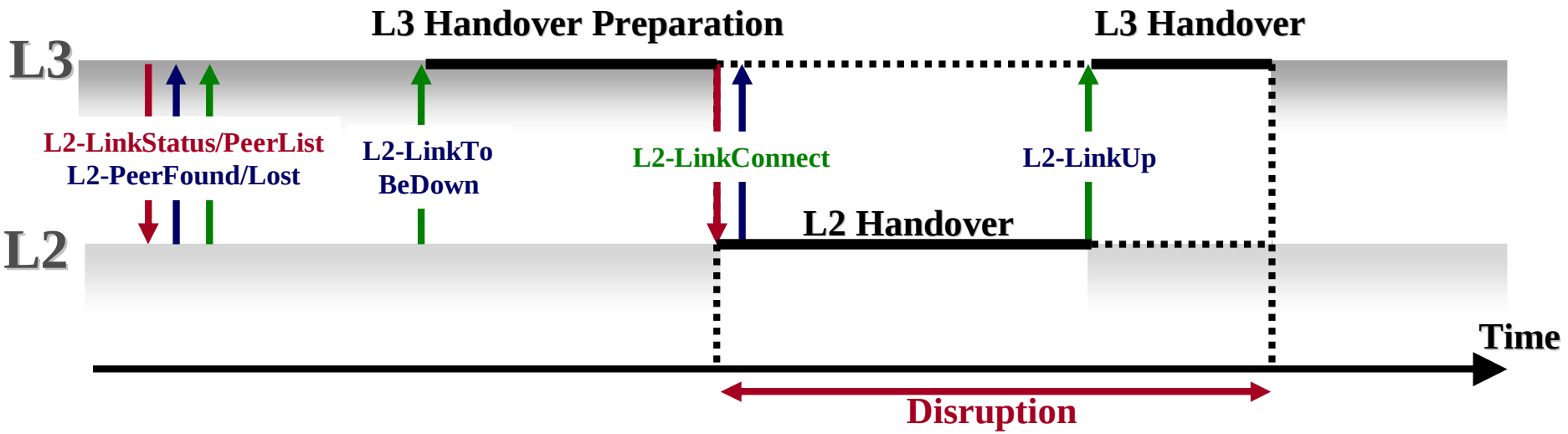
- L2 Abstractions for L3-driven Fast Handover
  - Goals of L3-driven fast handover
  - Architecture for control information exchange
  - L2 Primitives for L3-driven fast handover
- Details
  - Mapping of Primitives and Wireless LAN Parameters
- Evaluation
  - L3-Driven Fast Handover on FMIPv6
- Demonstration
  - L3-Driven Fast Handover on Predictive-LIN6

Goal A: L3-Driven Fast Handover

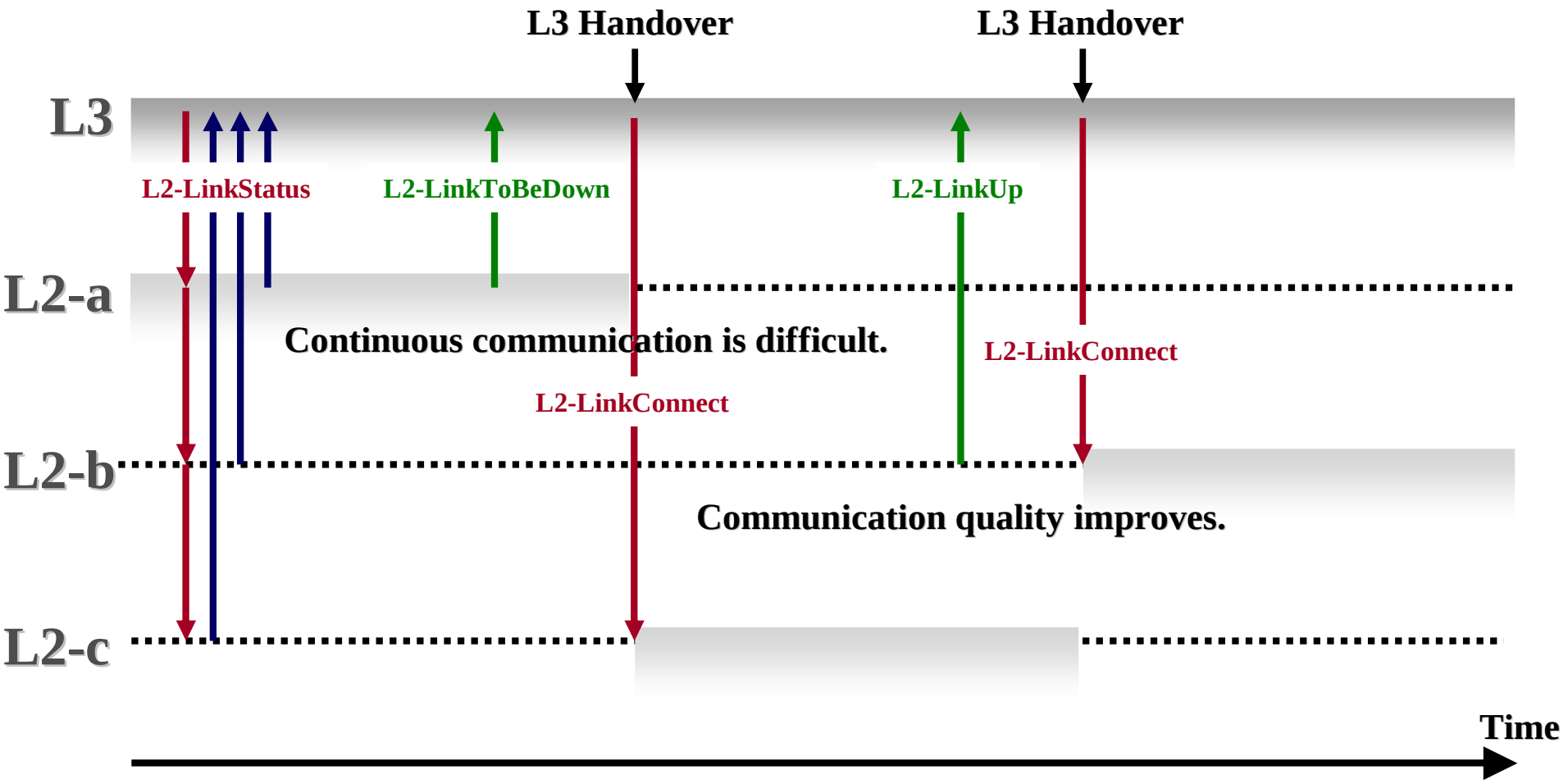
- Current Sequence



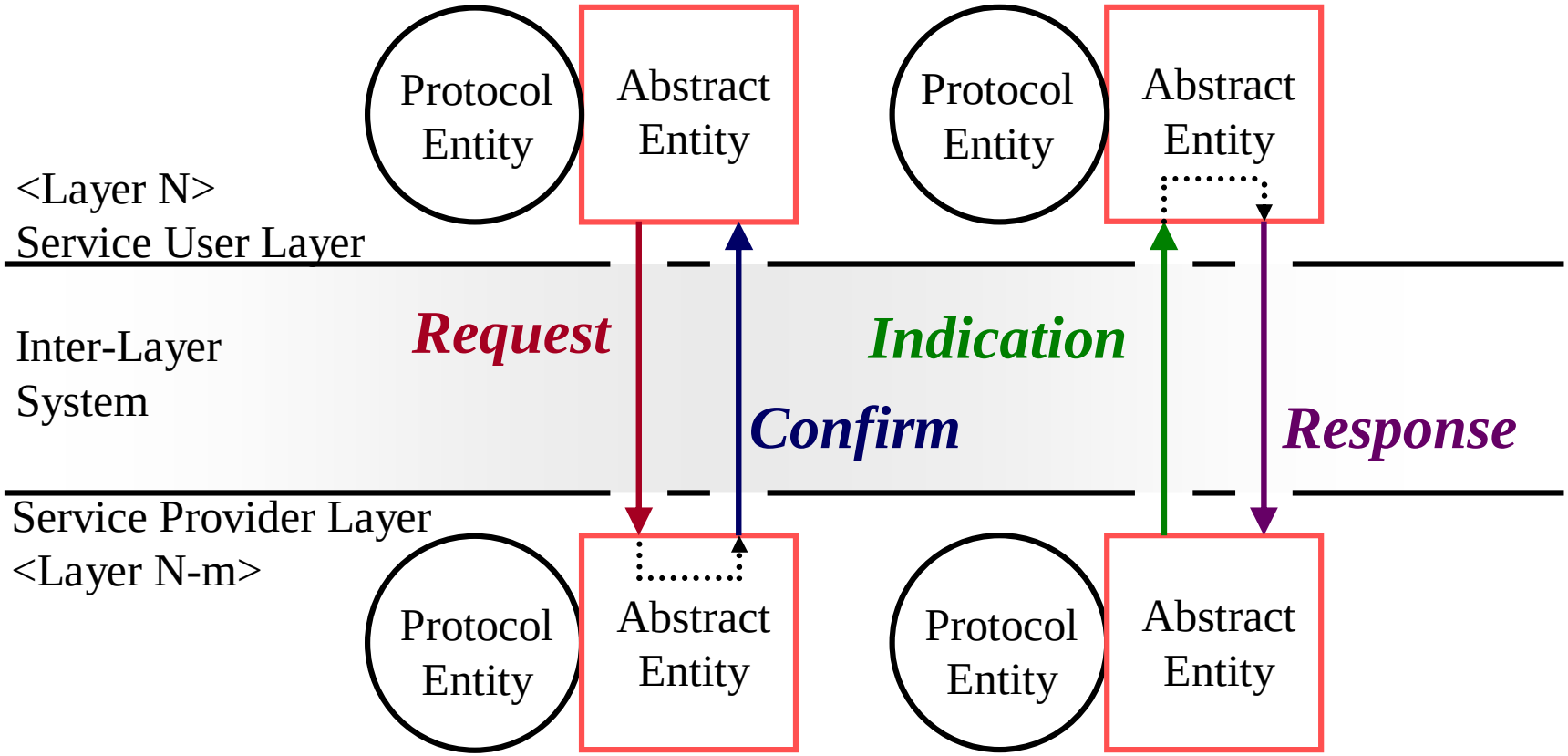
- L3-Driven Fast Handover



Goal B: L3-Driven Vertical Handover



Architecture for Control Information Exchange



Request is the acquisition request of the lower layer information or a registration of conditions for ***Indication***.
In response, ***Confirm*** returns.

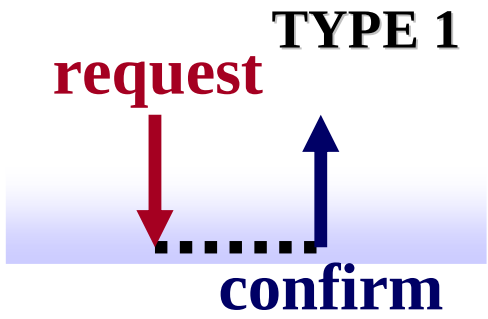
Indication is asynchronously delivered to an upper layer when an event which needs to be notified occurs.
In response, ***Response*** returns.

Usage Types of Primitives

Type 1. Provide L2 information to upper layers

request: Acquisition request

confirm: L2 information

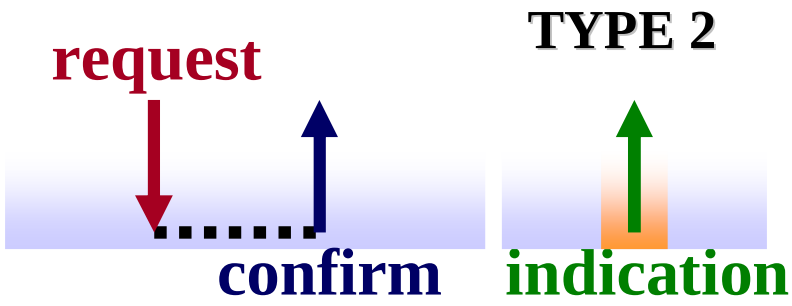


Type 2. Notify upper layers of L2 events

request: Registration for notification

confirm: Valid or invalid

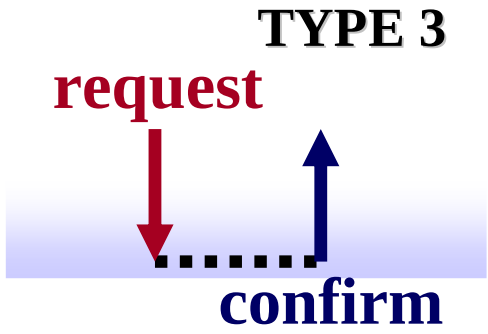
indication: Asynchronous notification



Type 3. Control L2 actions from upper layers

request: Control

confirm: Ack or nack



L2 Primitives for L3-driven Fast Handover

TYPE 1
TYPE 2
TYPE 3

- **L2-LinkStatus**
  - Acquisition request for the current link status.
- **L2-PeerList**
  - Acquisition request for the list of possible access points.
- **L2-PeerFound / L2-PeerLost**
  - Indication of discovery/missing of candidate access points.
- **L2-LinkUp / L2-LinkDown**
  - Notification that a new link is brought up / an existing link is brought down.
- **L2-LinkToBeDown**
  - Notification that the existing link is bringing down.
- **L2-LinkConnect / L2-LinkDisconnect**
  - Request for connection/disconnection of the specific link.

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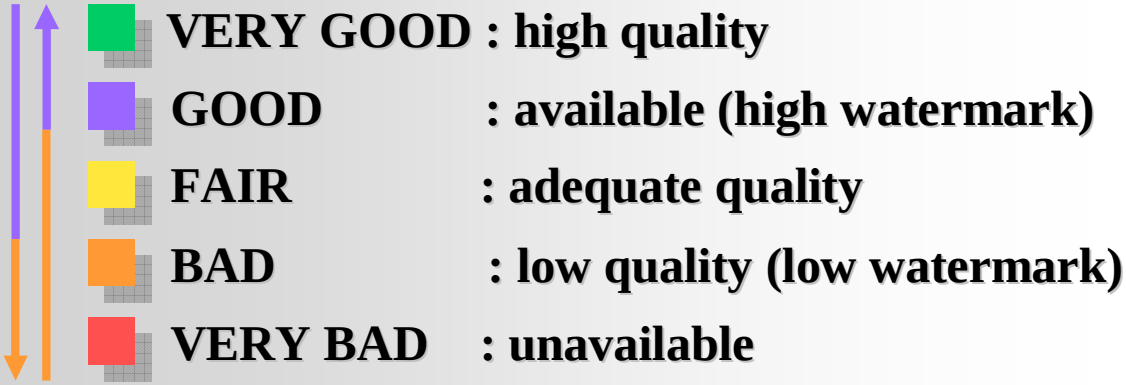
L2 Primitives for Link Status

- L2-LinkStatus
  - Network Interface ID
  - Peer
    - MAC Address
  - Condition
    - Bandwidth
    - Link Quality Level

L2-LinkStatus
i/f id: ath0
peer {
MACaddr: 01:23:45:67:89:ab
}
condition {
bw: 2Mbps
quality: GOOD
}

Link Quality Level



L2 Primitives for AP Discovery

- L2-PeerList
  - Network Interface ID
  - Peer List
    - One or more [Peer*, Condition*] tuples
- L2-PeerFound / L2-PeerLost
  - Network Interface ID
  - Peer List
    - One or more [Peer*, Condition*] tuples

L2-PeerList
i/f id: ath0
[Peer1, Condition1]
[Peer2, Condition2]
[Peer3, Condition3]
[Peer4, Condition4]

L2-PeerFound
i/f id: ath0
[Peer5, Condition5]

L2-PeerLost
i/f id: ath0
[Peer5, Condition5]

* Each ***Peer*** and ***Condition*** parameter consists of one or more sub-parameters, as described in the next slide.

L2 Primitives for L3 Handover

- L2-LinkUp
  - Network Interface ID
  - Peer
    - MAC Address
- L2-LinkDown
  - Network Interface ID
  - Peer
    - MAC Address

```
L2-LinkUp
  i/f id: ath0
  peer {
    MACaddr:  01:23:45:67:89:ab
  }
```

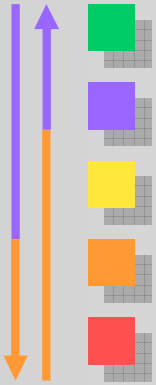
```
L2-LinkDown
  i/f id: ath0
  peer {
    MACaddr:  01:23:45:67:89:ab
  }
```

L2 Primitives for Preparing L3 Handover

- L2-LinkToBeDown
  - Network Interface ID
  - Peer
    - MAC Address
  - Condition
    - Bandwidth
    - Link Quality Level

L2-LinkToBeDown
i/f id: ath0
peer {
MACaddr: 01:23:45:67:89:ab
}
condition {
bw: 2Mbps
quality: BAD
}

Link Quality Level



VERY GOOD : high quality
GOOD : available (high watermark)
FAIR : adequate quality
BAD : low quality (low watermark)
VERY BAD : unavailable

L2 Primitives for L3-Driven Handover

- L2-LinkConnect
  - Network Interface ID
  - Peer
    - MAC Address
- L2-LinkDisconnect
  - Network Interface ID
  - Peer
    - MAC Address

```
L2-LinkConnect
  i/f id: ath0
  peer {
    MACaddr:  01:23:45:67:89:ab
  }
```

```
L2-LinkDisconnect
  i/f id: ath0
  peer {
    MACaddr:  01:23:45:67:89:ab
  }
```

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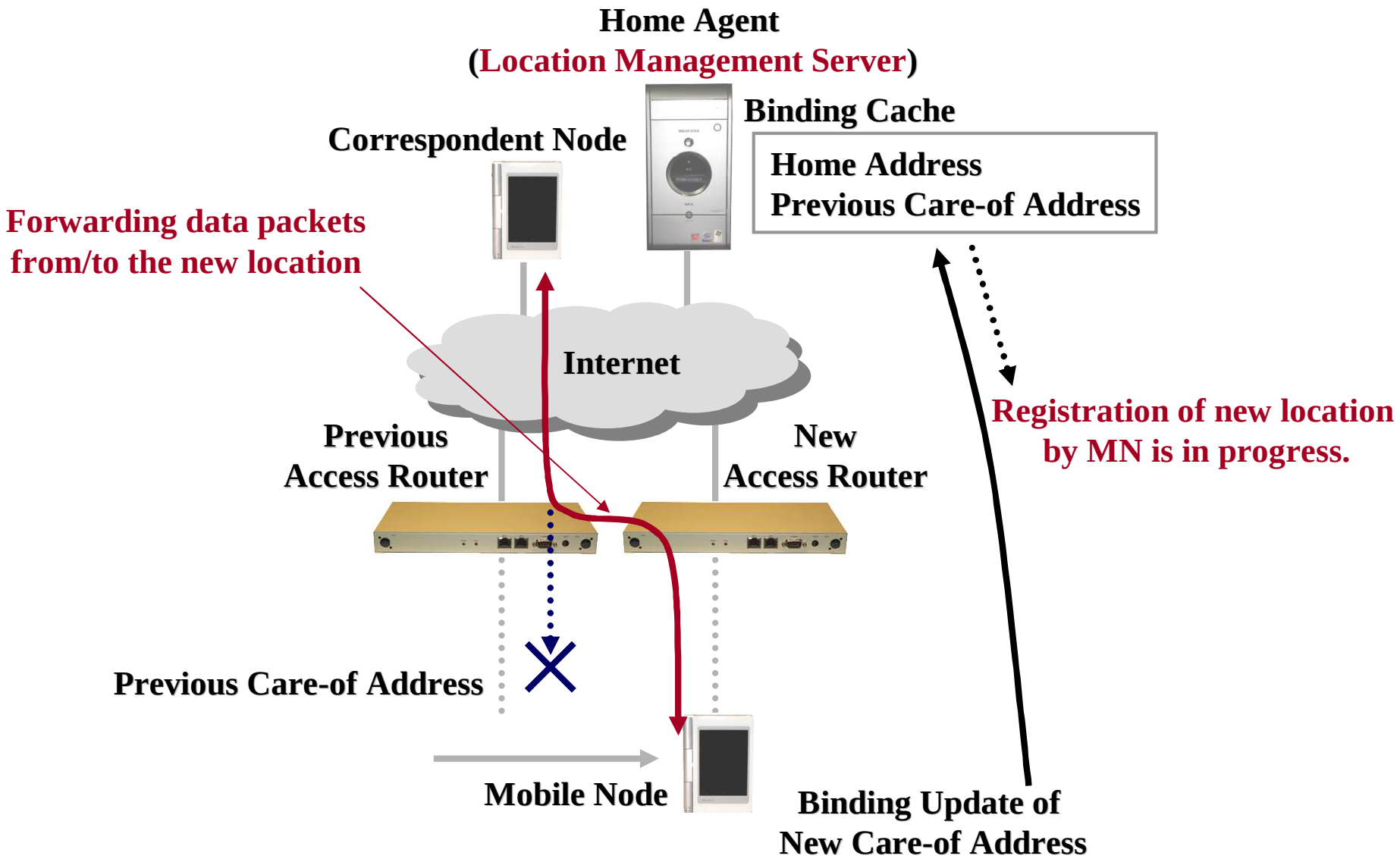
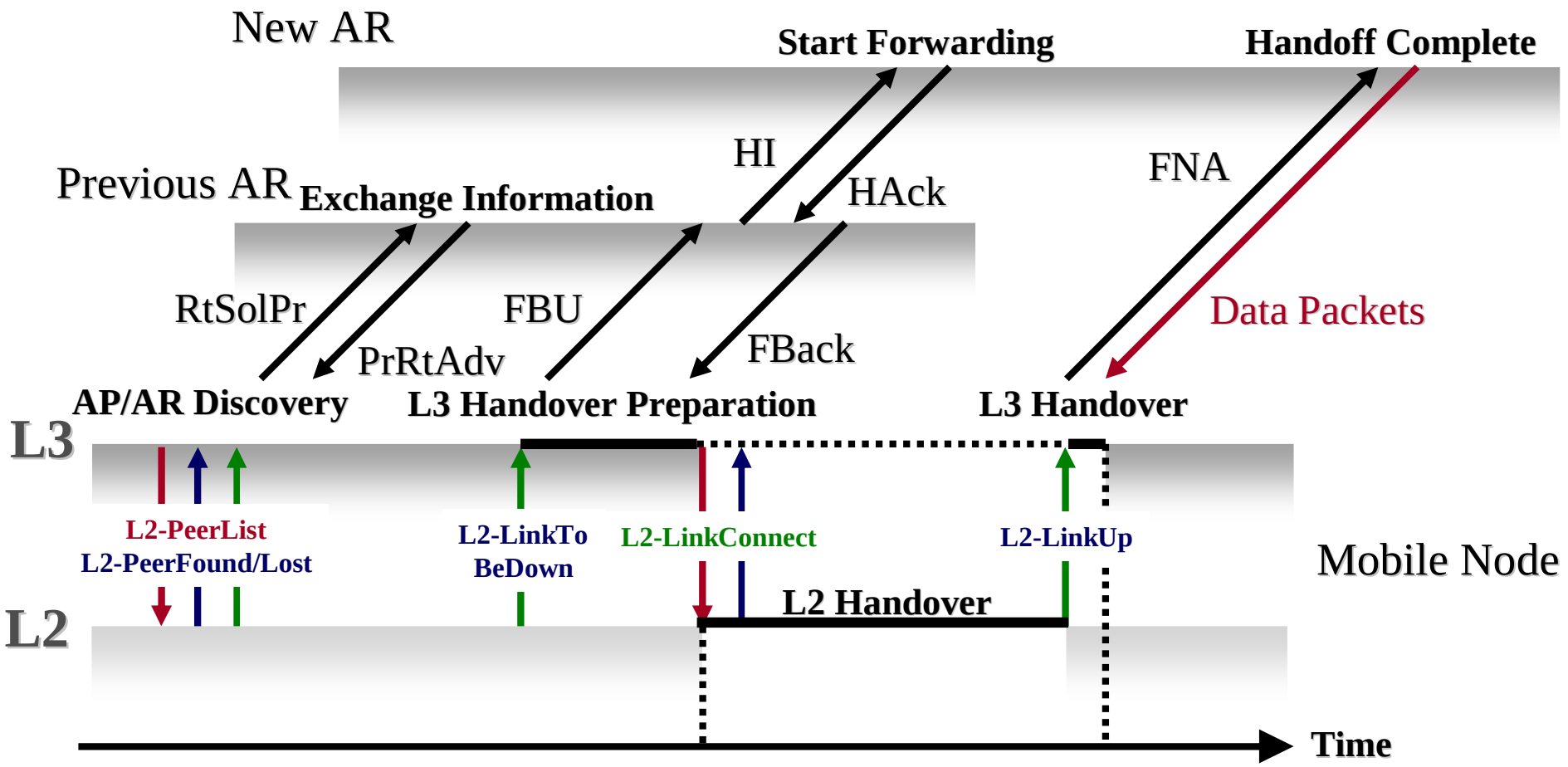
What is FMIPv6?

- L3 Fast Handover Protocol based on Mobile IPv6
  - AR forwards data packets to the new location during L3 handover



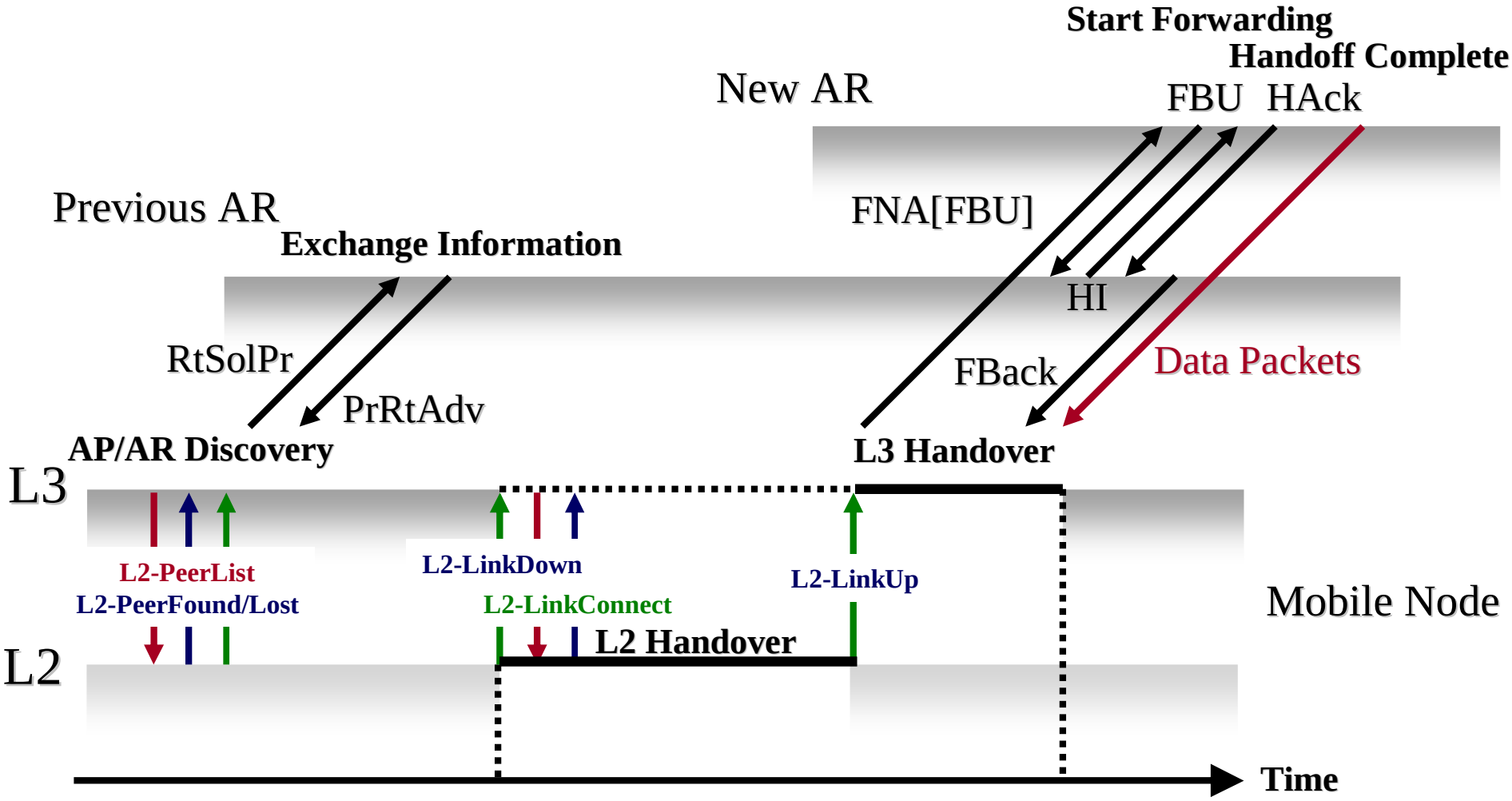
L3-Driven Fast Handover on FMIPv6

- L3-Driven + FMIPv6 Predictive Mode



L3-Driven Fast Handover on FMIPv6

- FMIPv6 Reactive mode
  - The case that handover prediction failed.

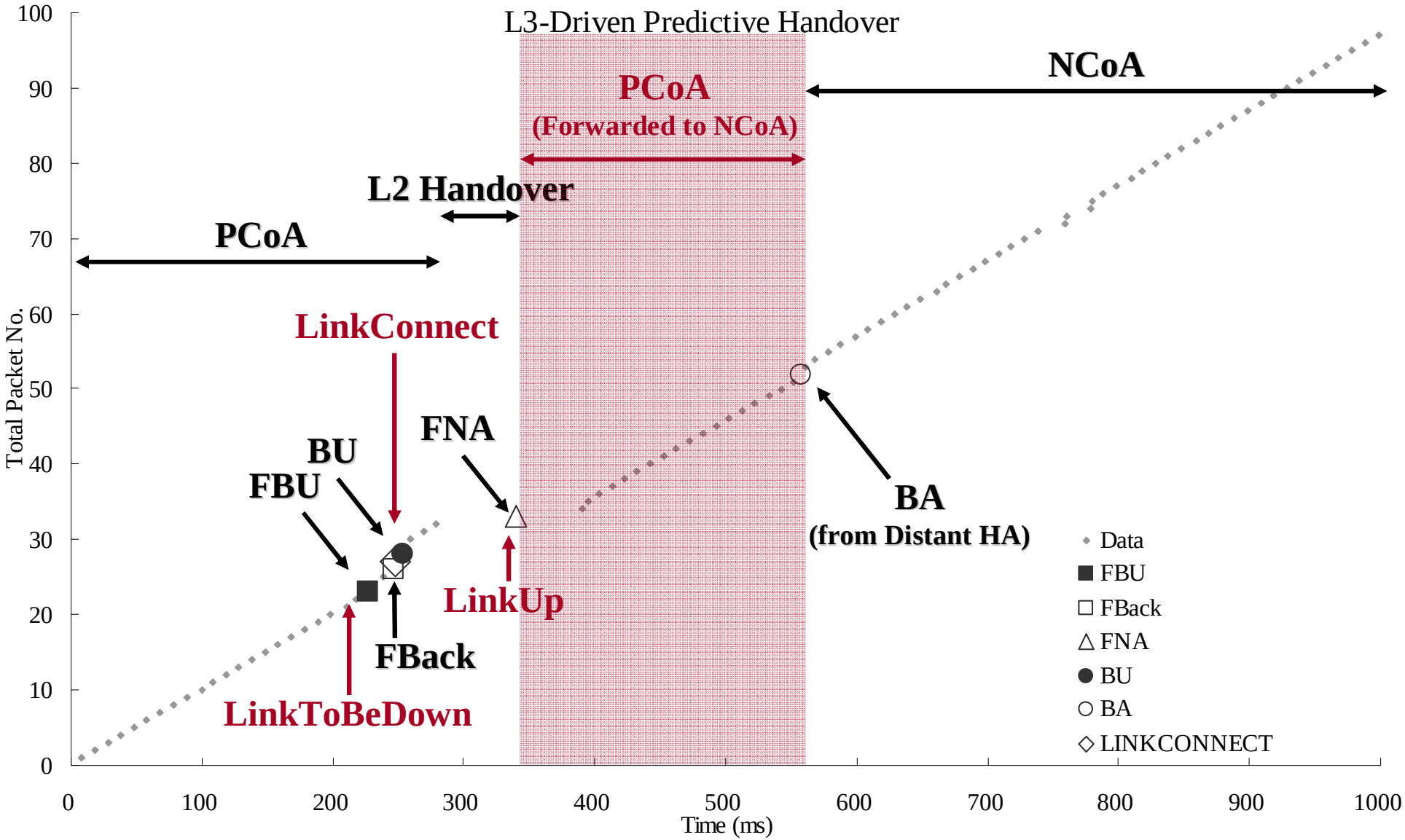


FMIPv6 Implementation for BSD: **TARZAN**

- By Nautilus6 Project
  - http://www.nautilus6.org/
    http://www.ietf.org/internet-drafts/draft-ietf-mipshop-fast-mipv6-03.txt
- Based on SHISA
  - Mobile IPv6 and NEMO implementation for KAME (*BSD)
  - http://www.kame.net/
- Support both MN and AR
- **L2 trigger by LIES**
  - Inter-Layer Control Information Exchange Architecture
  - **L2 Abstraction:**
    http://www.ietf.org/internet-drafts/draft-koki-mobopts-l2-abstractions-02.txt
- Manual CAR (Candidate Access Router) installation
  - car_info.conf
- Buffering is not supported yet.

Evaluation of L3-Driven Predictive FMIPv6

(without Buffering)



Total Disruption Time: 60ms(L2) + 50ms(L3) = 110ms / L2: Wireless Environment Emulator

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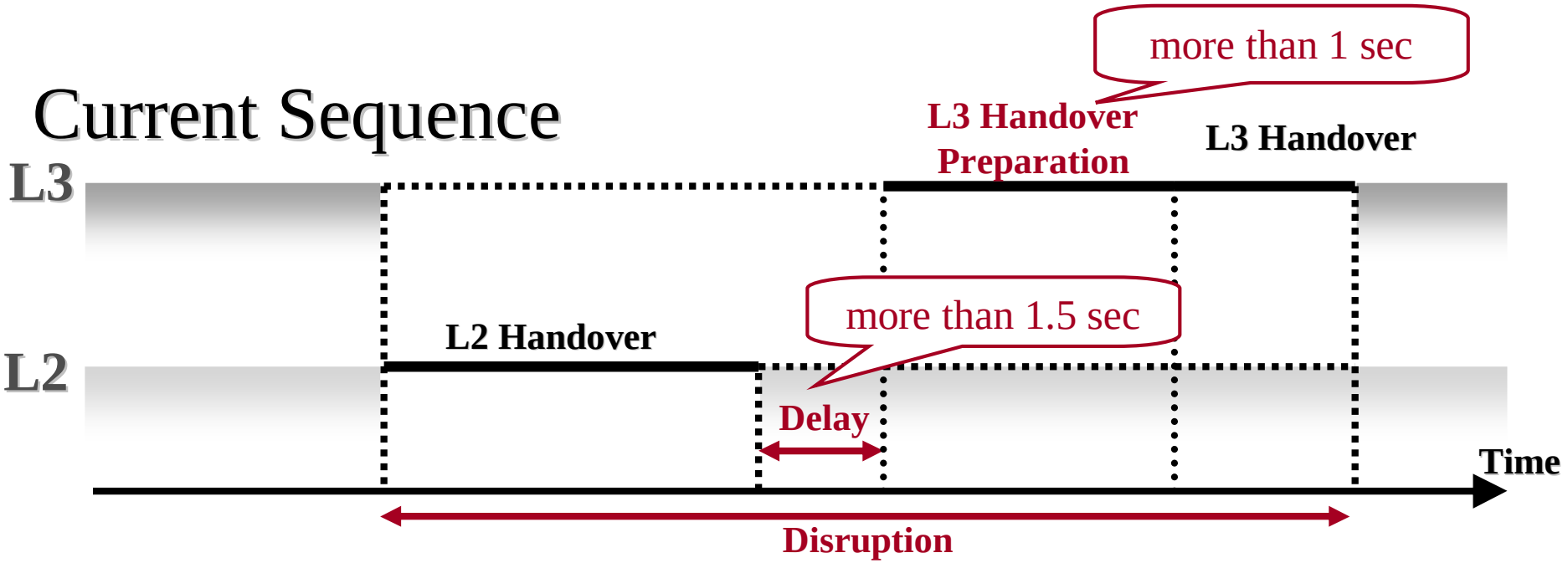
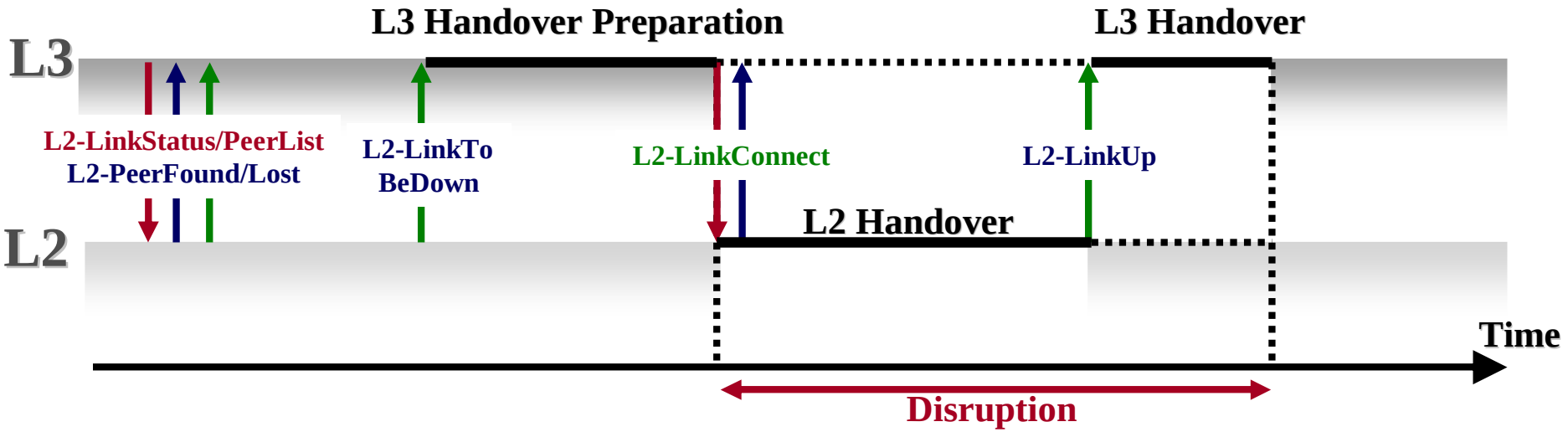
L3-Driven Fast Handover on Predictive-LIN6

- Current Sequence



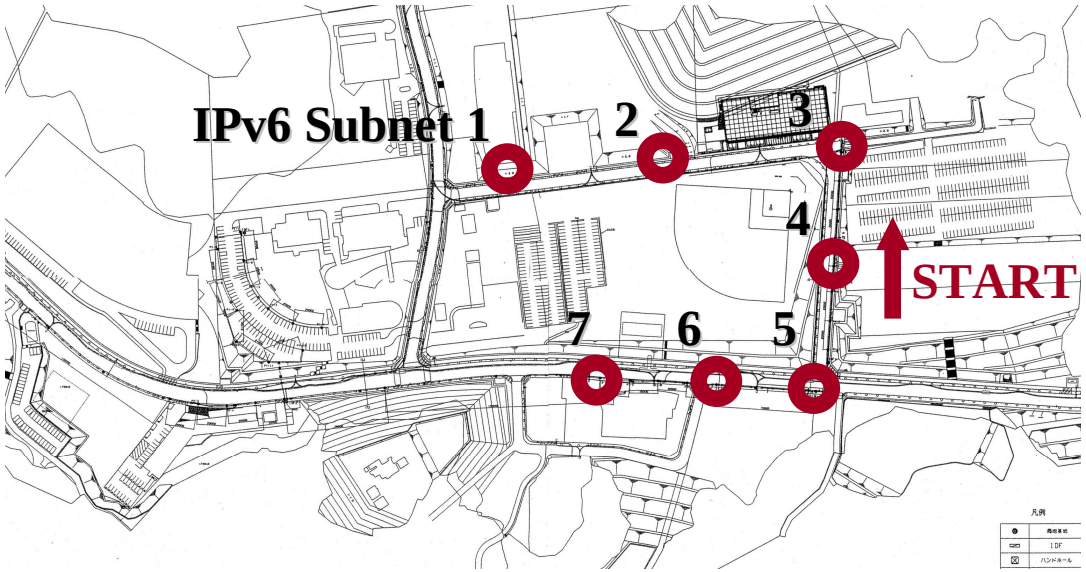
- L3-Driven Fast Handover



Demonstration of L3-Driven Fast Handover on Predictive-LIN6

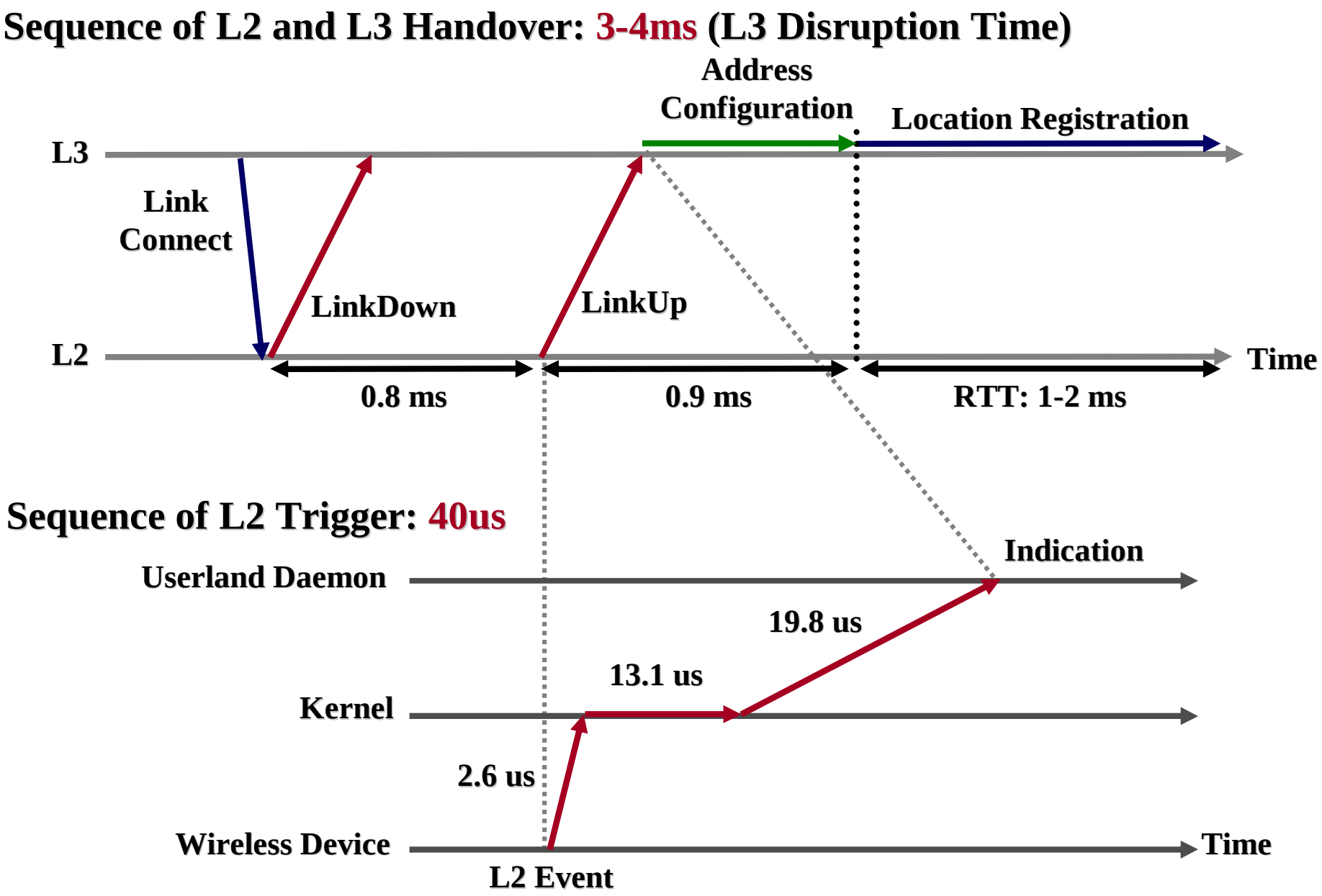
- Application: DVTS (15Mbps)
  - Digital Video Stream on IEEE1394 Encapsulated into IP
  - Sender: MN in a car
- L3 Mobility Protocol: Predictive-LIN6 (No Forwarding, No Buffering)
  - **Prediction of LinkDown and Candidate AP/AR by L2 Triggers**
  - DAD is performed before L2 handover
- L2: IEEE802.11a (5GHz, 54Mbps)
  - All APs are same channel
  - All APs have different SSID
- Project: SIMPLE
  - Smart Internet Mobile Project with Layered Effects

Handover: L2 (1-2ms) + L3 (RTT 1-2ms)
LinkToBeDown (Prepare L3 Handover)
→ LinkConnect (L2 switch to a specified AP)
→ LinkUp (Finish L3 Handover)



Receiver (CN) **Sender (MN car)**

Sequence of L3-Driven Fast Handover on Predictive-LIN6



Summary

- Designed L2 abstractions as primitives.
  - L2-PeerList / L2-PeerFound / L2-PeerLost
  - L2-LinkStatus / L2-LinkUp / L2-LinkDown / L2-LinkToBeDown
  - L2-LinkConnect / L2-LinkDisconnect
- L3-driven fast handover on FMIPv6 was evaluated.
- L3-driven fast handover on Predictive-LIN6 demonstration.

IETF Document:

http://www.ietf.org/internet-drafts/draft-koki-mobopts-l2-abstractions-02.txt

Teraoka Lab. Keio Univ. http://www.tera.ics.keio.ac.jp/

Nautilus6 Project http://www.nautilus6.org/

SIMPLE Project