GeoNet WP2
IPv6 – C2C NET

Geographic addressing and routing for vehicular communications

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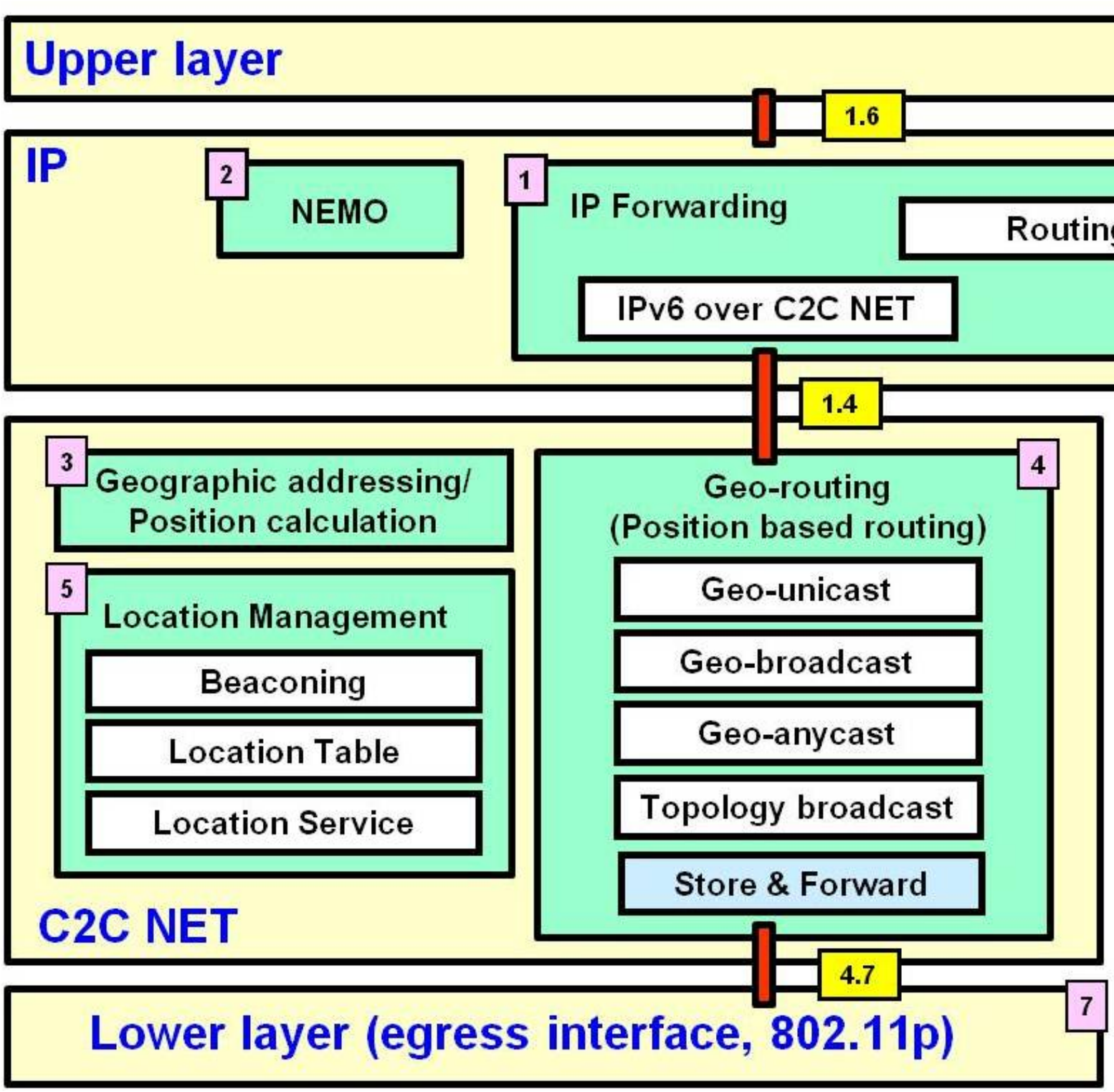
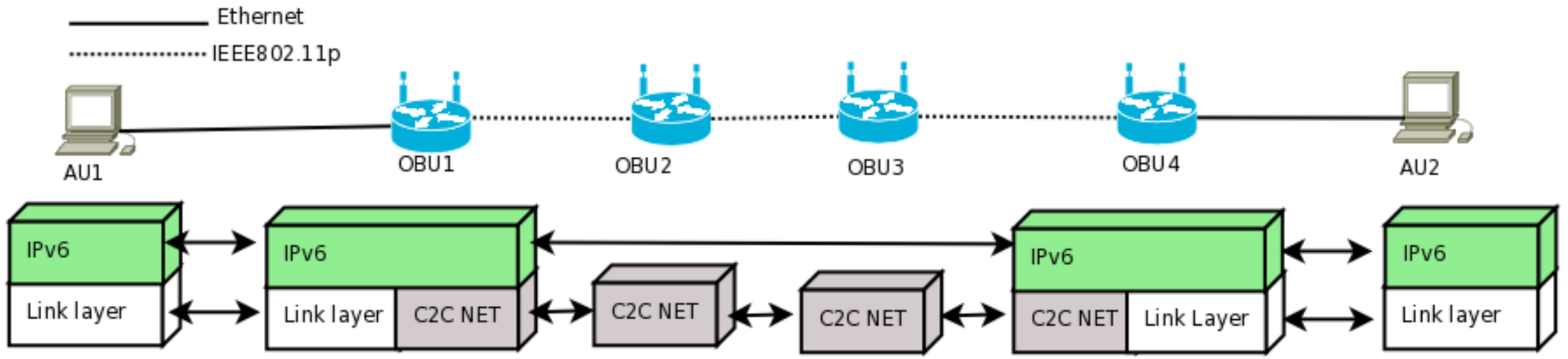
Outline

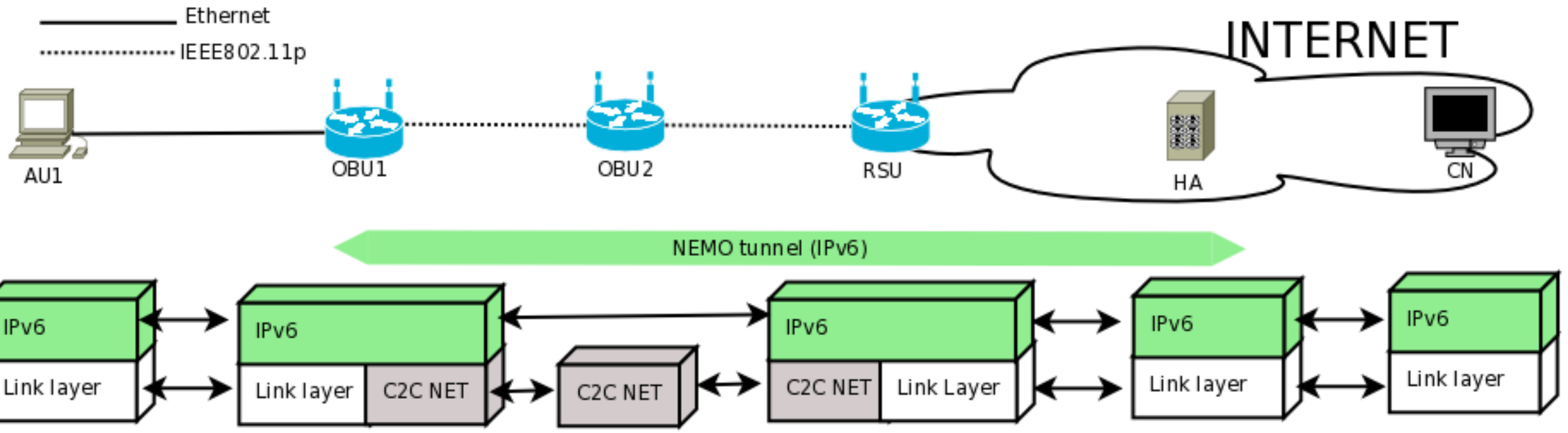
- Overview of IPv6 over C2C NET
- Missing features
  - Next hop determination
- Design of IPv6 over C2C NET
  - Unicast using Geo-unicast
  - Multicast using Geo-broadcast
  - Multicast using Topo-broadcast
  - Anycast using Geo-anycast
- Interface management and IP forwarding
  - IPv6-C2C NET interface
  - Routing
  - Pre-experiment
- Conclusion

Architecture



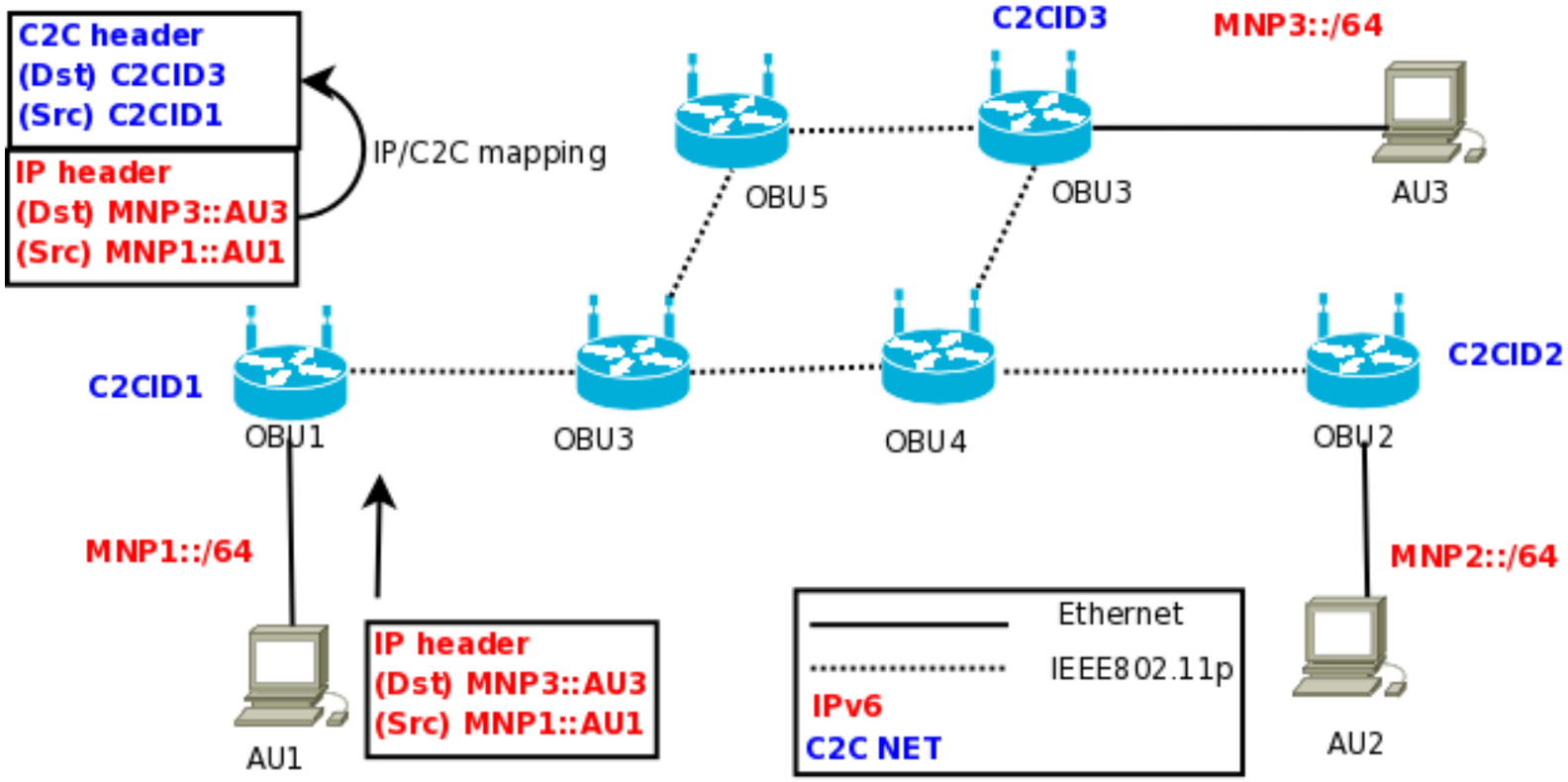
IPv6 over C2C NET





Next hop determination

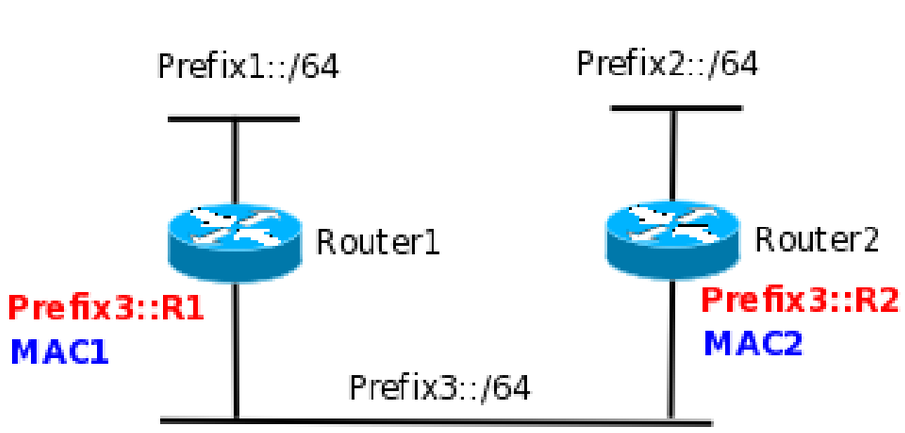
- Finding OBU3 from destination IPv6 address



- Five Propositions
  - Routing and Address Resolution like Ethernet
    - (1) Static routing
    - (2) Dynamic routing
  - (3) Host Network Association (HNA) like OLSR
  - (4) NDP extension
  - (5) DNS like solution

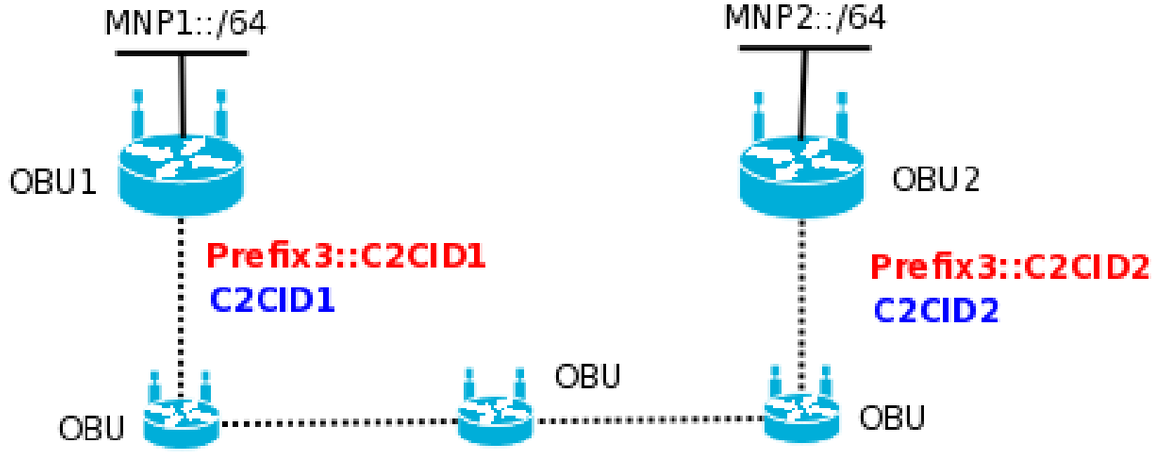
(1)(2)Address Resolution over Ethernet

- Routing (L3)
  - (1) Static: `# route -A inet6 add MNP2::/64 gw Prefix3::R2 dev eth2`
  - (2) Dynamic : OSPF, RIP, etc.
- Address resolution (L2-3)
  - Address Resolution Protocol (ARP) IPv4
  - Neighbor Discovery Protocol (NDP) IPv6



IP Routing table on Router1
[Prefix2::/64 --> Prefix3::R2]
Neighbor Cache on Router1 (ARP table in IPv4)
[Prefix3::R2 --> MAC2]

Ethernet



IP Routing table on OBU1
[MNP2::/64 --> Prefix3::C2CID2]
Neighbor Cache on OBU1 (ARP table in IPv4)
[Prefix3::C2CID2 --> C2CID2]

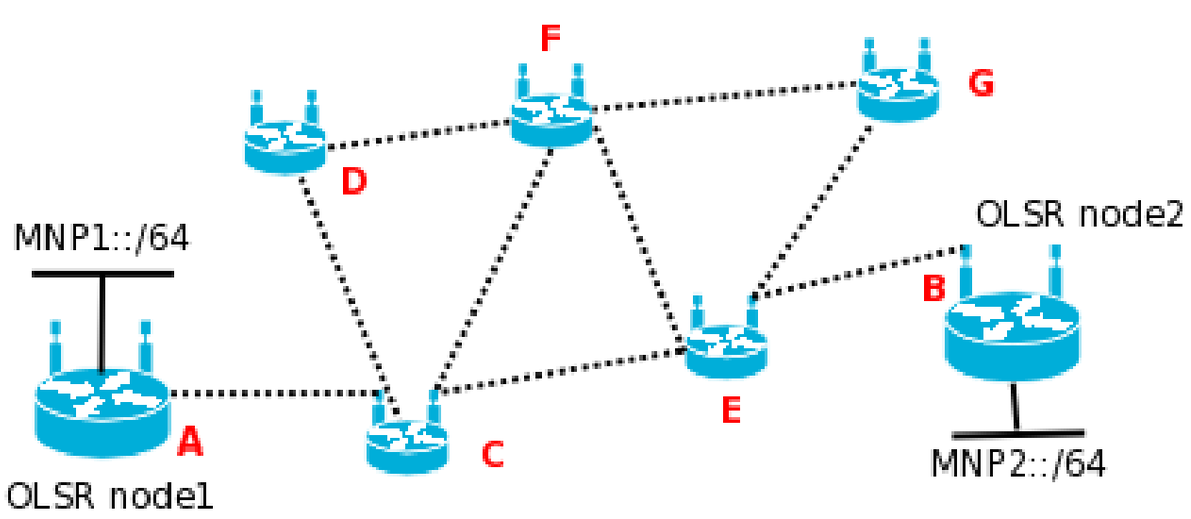
(Alternative)

Bland-new mapping table
[MNP2::/64 --> C2CID2]

C2C NET

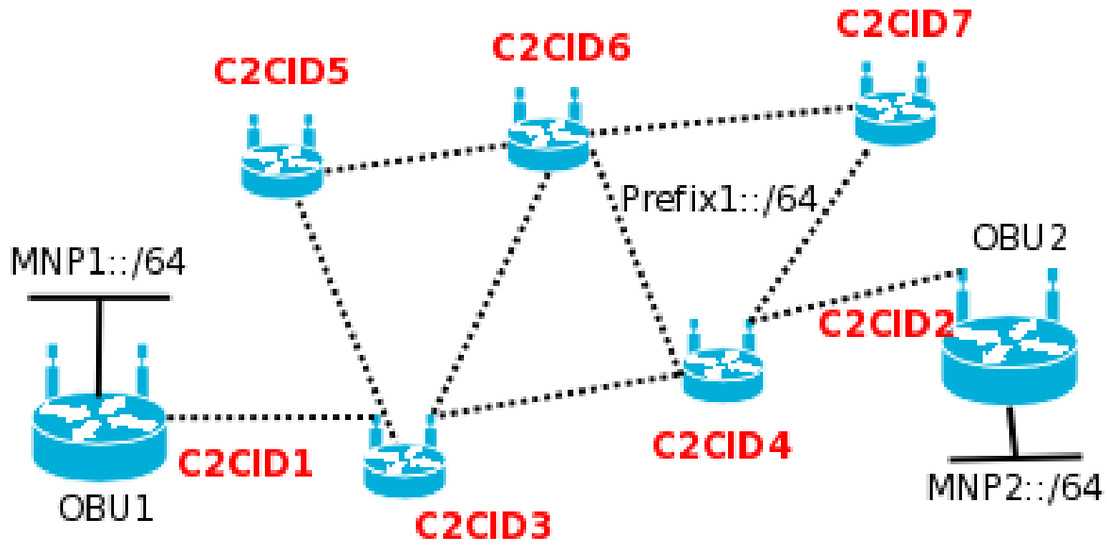
(3) Host and Network Association in OLSR

- Host and Network Association (HNA)
  - To find network behind **OLSR** nodes which connect to non-**OLSR** interface
- For us
  - To find network behind C2C NET nodes which connect to non-C2C NET interface



IP Routing table on OLSR node1
[MNP2::/64--> B]

OLSR

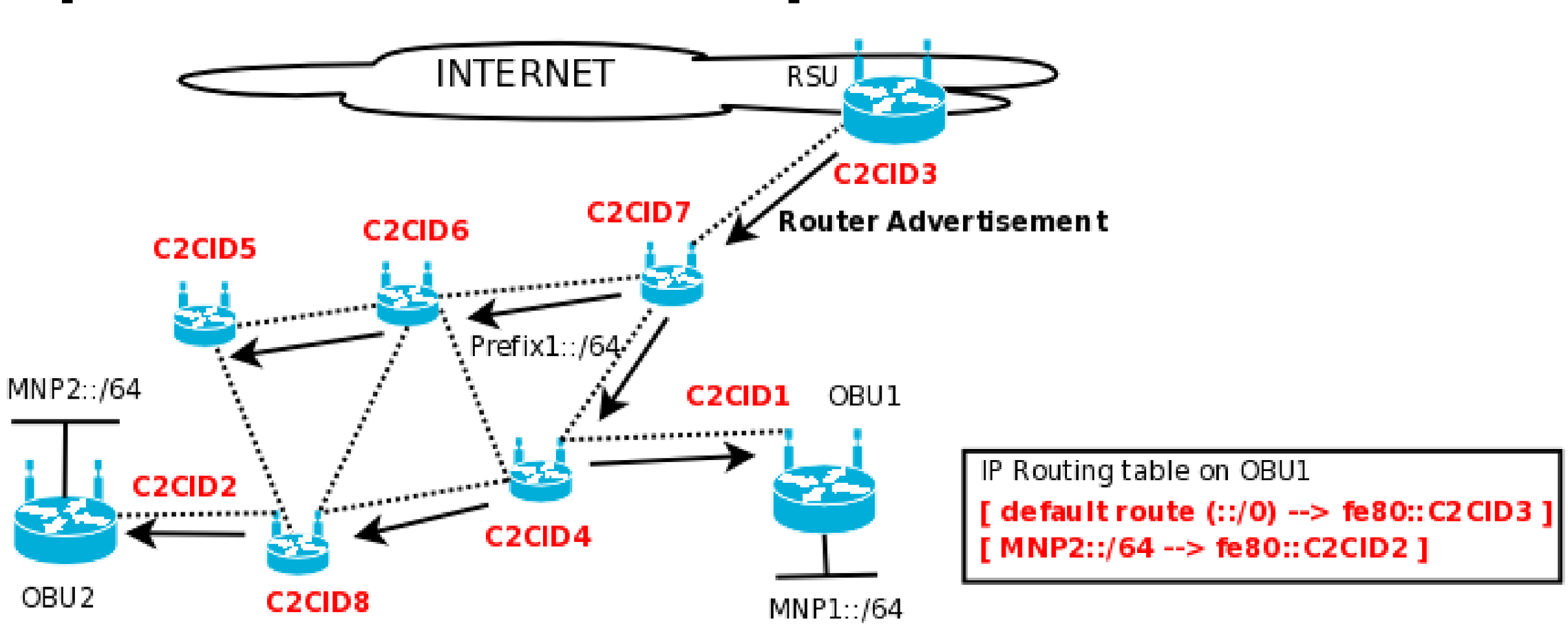


IP Routing table on OBU1
[MNP2::/64--> Prefix1::C2CID2]

C2C NET

(4) NDP extension

- Router Advertisement in NDP (Neighbor Discovery Protocol)
  - To provide on-link information
  - Also default gateway information
- For us
  - To provide prefix information
  - [MNP2::/64 → fe80::C2CID2]



Approaches Analysis

- Matching between In-vehicle network and C2C NET ID
  - Difficulty: implementation work needed (impact on architecture?)
  - Scalability: To support large scale network
  - Signaling overhead: Number of packets distributed in C2C NET
  - Delay: Wait time to resolve C2C NET ID from in-vehicle network
- Best solutions
  I. (3) HNA like extension → need specification in C2C NET
  II. (1) Static route configuration → Only for demo
  III. (2) Dynamic routing protocol → Easy solution

Vote to the Solutions

Approach comparison

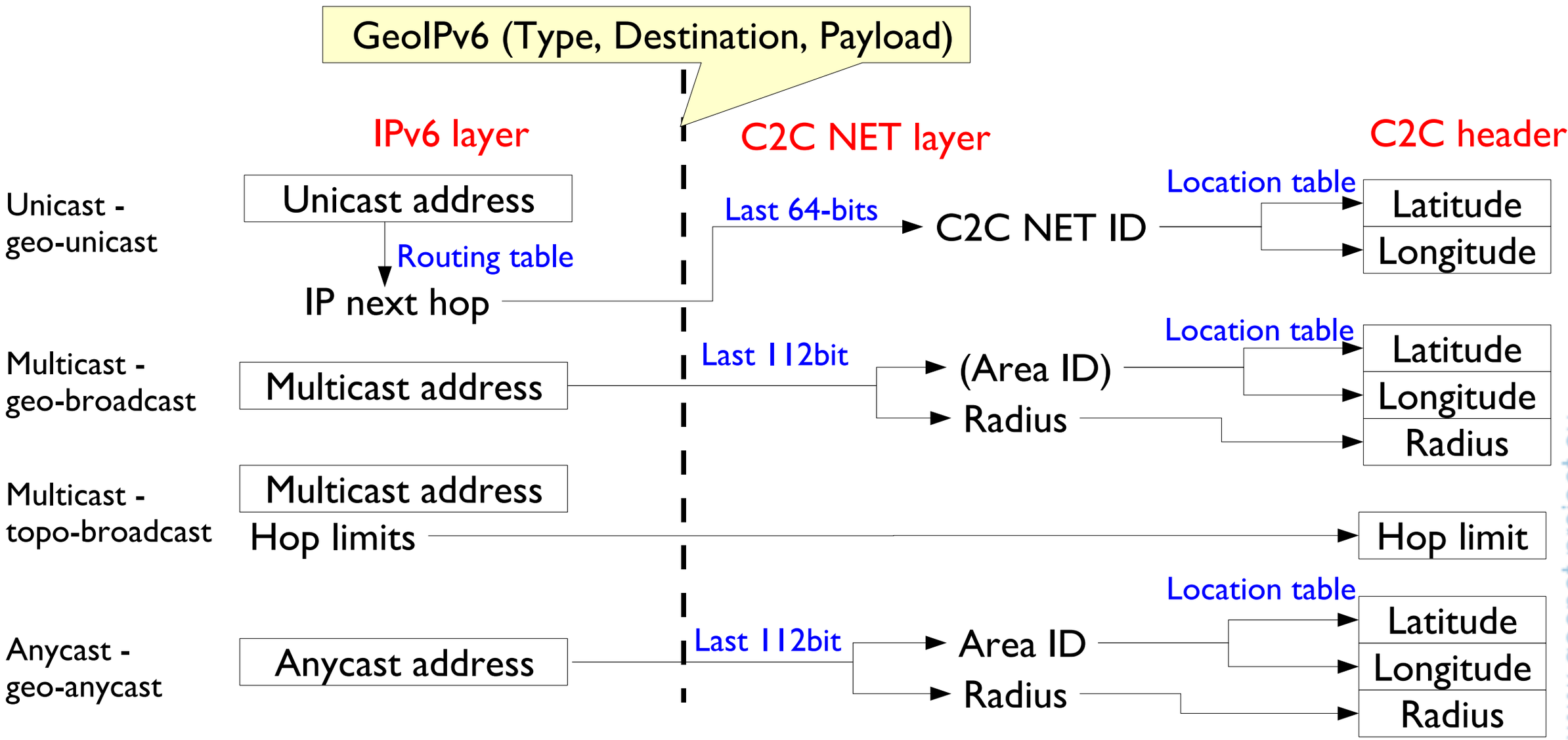
Approach	Difficulty	Scalability	Signaling overhead	Delay
(1) Static route configuration	Easy	no	No overhead	No delay
(2) Dynamic routing protocol	Easy	yes	Periodic signaling	Depend on frequency and RTT
(3) HNA like extension	Difficult	yes	Optimized signaling	Depend on frequency and RTT
(4) RA extension	Difficult	yes	Periodic signaling	Depend on frequency and RTT
(5) DNS like discovery	Difficult	yes	Once for each OBU	RTT between server and client

SAP 1.4 (IPv6 - C2C)

- Classification by destinations

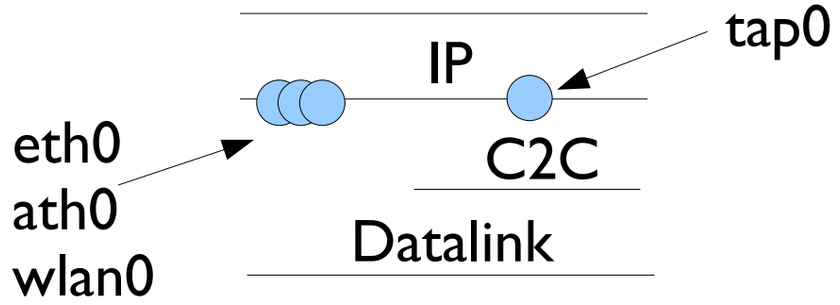
Destination	IPv6 layer	C2C NET layer
A node in a specific vehicle	unicast	geo-unicast
Nodes in vehicles in area	multicast	geo-broadcast
Nodes in vehicles x hops away	multicast	topo-broadcast
A node in a certain vehicle in area	anycast	geo-anycast

Area ID is an C2C NET ID that allocated to a static point



IPv6-C2C NET Interface

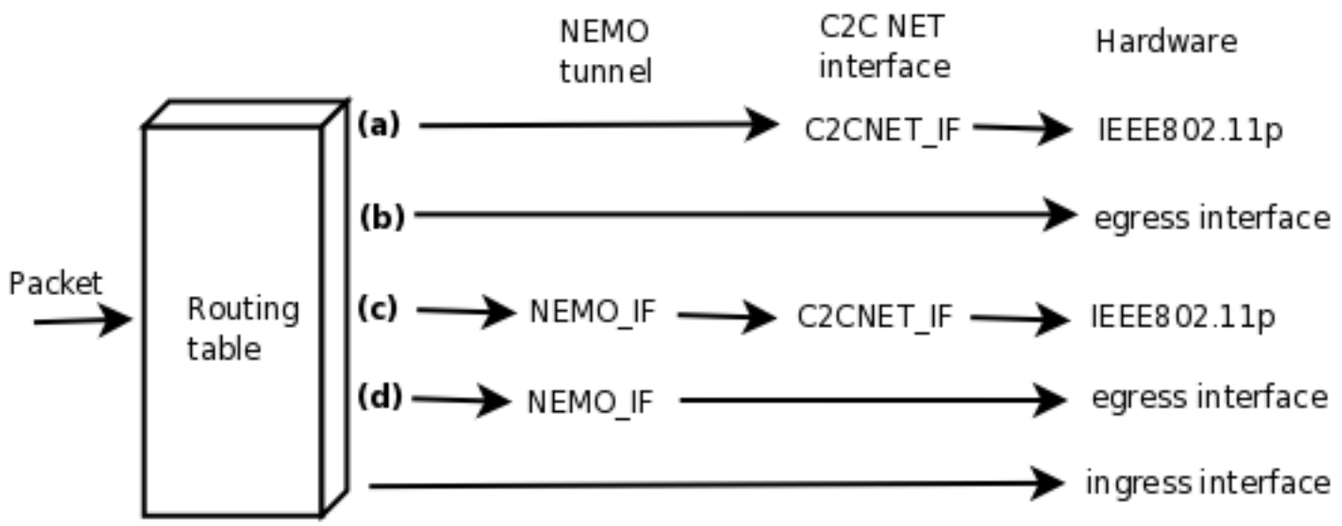
- Use tap0 (tunnel interface)
  - C2C NET layer is between IPv6 and datalink layer
  - C2C NET is implemented in userland



- Packet forwarding decision is taken in IP layer

(a) tap: C2C NET interface
(b) ath: Normal egress interface
(c) ip6tnl: NEMO tunnel over normal interface
(d) ip6tnl: NEMO tunnel over C2C NET interface

Name of interface in Linux

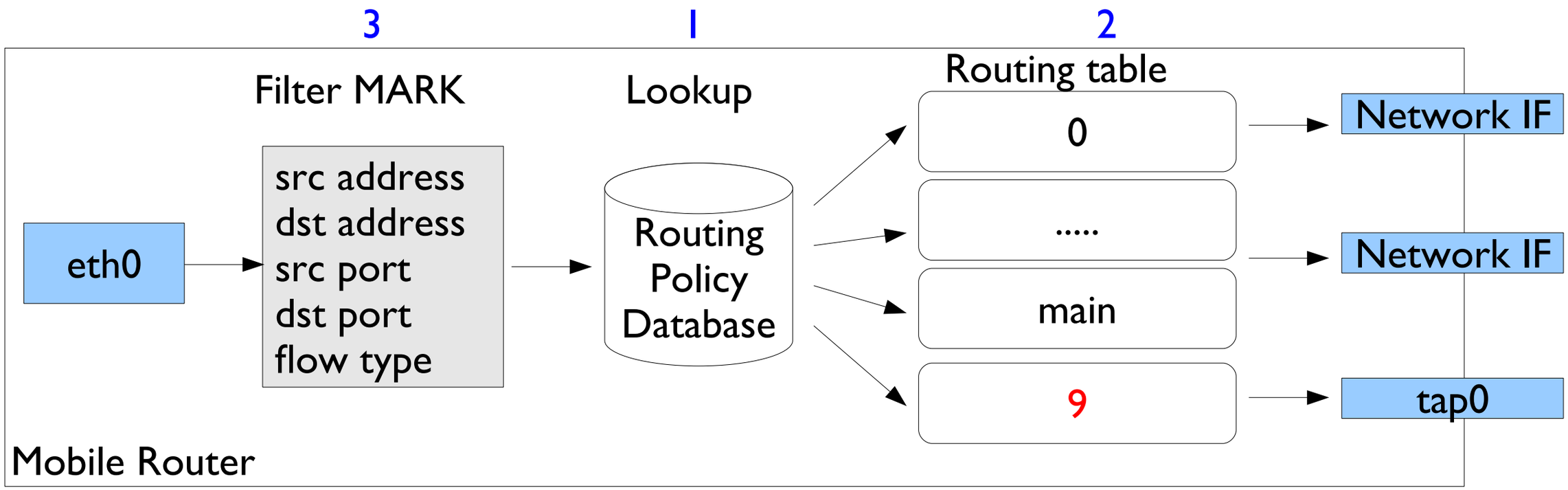


Routing

1. Add rule to the policy that the packet from MNP to routing table "9"
   ip -6 rule add from 2001:1000:2000:3000::/64 fwmark 0x9 lookup 9 prio 301

2. Add routing entry to table "9" for forwarding to tap0
   ip -6 route add default from 2001:1000:2000:3000::/64 dev tap0
   table 9 metric 10 proto 16

3. Activate routing table "9" (Mark pakcet as "9")
   ip6tables -t mangle -F PREROUTING
   ip6tables -A PREROUTING -t mangle -j MARK --set-mark 9



Pre-experiment

- We tested tap0 interface
  - Packet from MNN to AP go through to tap0 interface
  - See the document for detail

```
# ip -6 rule add from 2001:1000:2000:3000::/64 fwmark 0x9 lookup 9 prio 301
# ip -6 route add default from 2001:1000:2000:3000::/64 dev tap0 table 9 metric 10 proto 16
# ip6tables -t mangle -F PREROUTING
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```
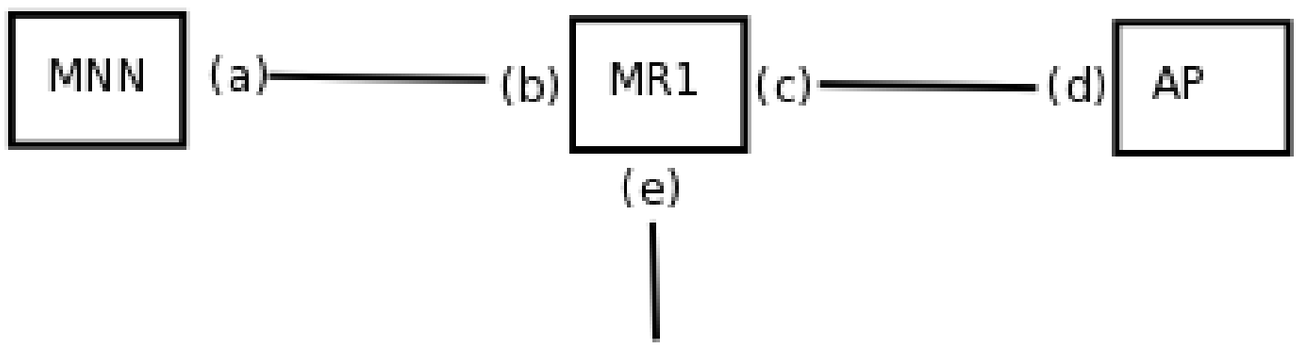
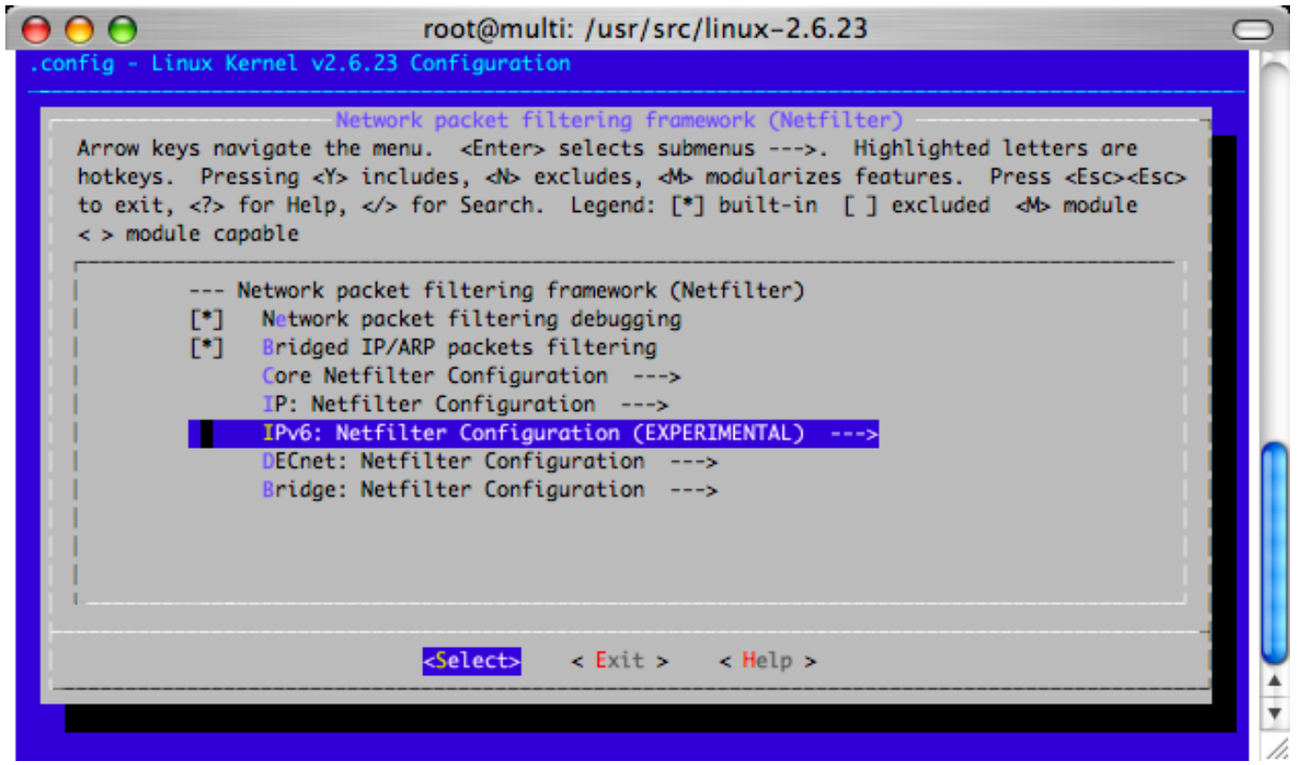



(a): eth0 2001:1000:2000:3000::2
(b): eth0 2001:1000:2000:3000::1
(c): eth1 2001:1000:2000:3001::1
(d): wlan0 2001:1000:1000:3001::2
(e): tap0 Virtual interface between IPv6 and C2C

System requirements

- CVIS package Release 7
- UMIP version 0.4??
- Ubuntu version 8.1
- Kernel version 2.6.??



- Netfilter

Networking
–> Networking options
–> Network packet filtering framework (Netfilter) [CONFIG_NETFILTER]
–> Core Netfilter Configuration
–> Netfilter Xtables support (required for ip_tables) [CONFIG_NETFILTER_XTABLES]
–> "MARK" target support [CONFIG_NETFILTER_XT_TARGET_MARK]
–> "mark" match support [CONFIG_NETFILTER_XT_MATCH_MARK]
–> IPv6: Netfilter Configuration (EXPERIMENTAL)
–> IP6 tables support (required for filtering) [CONFIG_IP6_NF_IPTABLES]
–> Packet mangling [CONFIG_IP6_NF_MANGLE]

Conclusion

- Overview of IPv6 over C2C NET
- Missing features
  - Next hop determination
- Design of IPv6 over C2C NET
  - Unicast using Geo-unicast
  - Multicast using Geo-broadcast
  - Multicast using Topo-broadcast
  - Anycast using Geo-anycast
- Interface management and IP forwarding
  - IPv6-C2C NET interface
  - Routing
  - Pre-experiment

- Thanks for your attention

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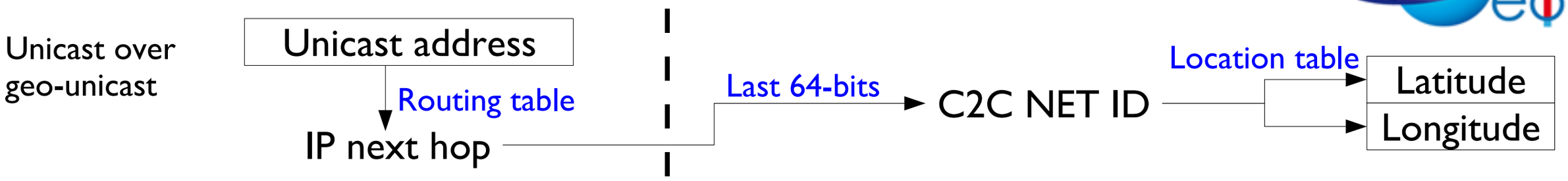
- Yacine Khaled <yacine.khaled@inria.fr>
- Thierry Ernst <thierry.ernst@inria.fr>

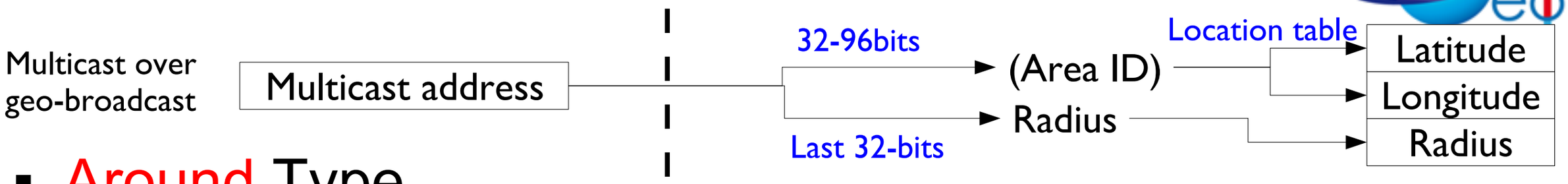
Multicast in C2C NET

IP Unicast - Geo-unicast



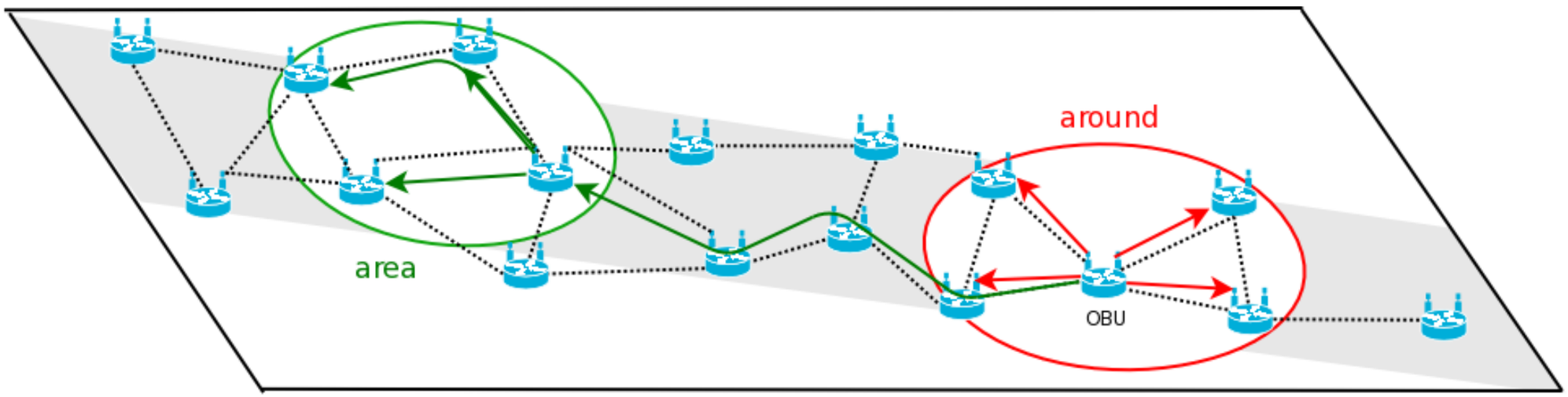
- In a C2C NET → IP next hop is OBU
  - The routing entry comes from In vehicle network discovery
- Via the Internet → IP next hop is RSU
  - The routing entry comes from Router Advertisement (RA)

Multicast - Geo-Broadcast



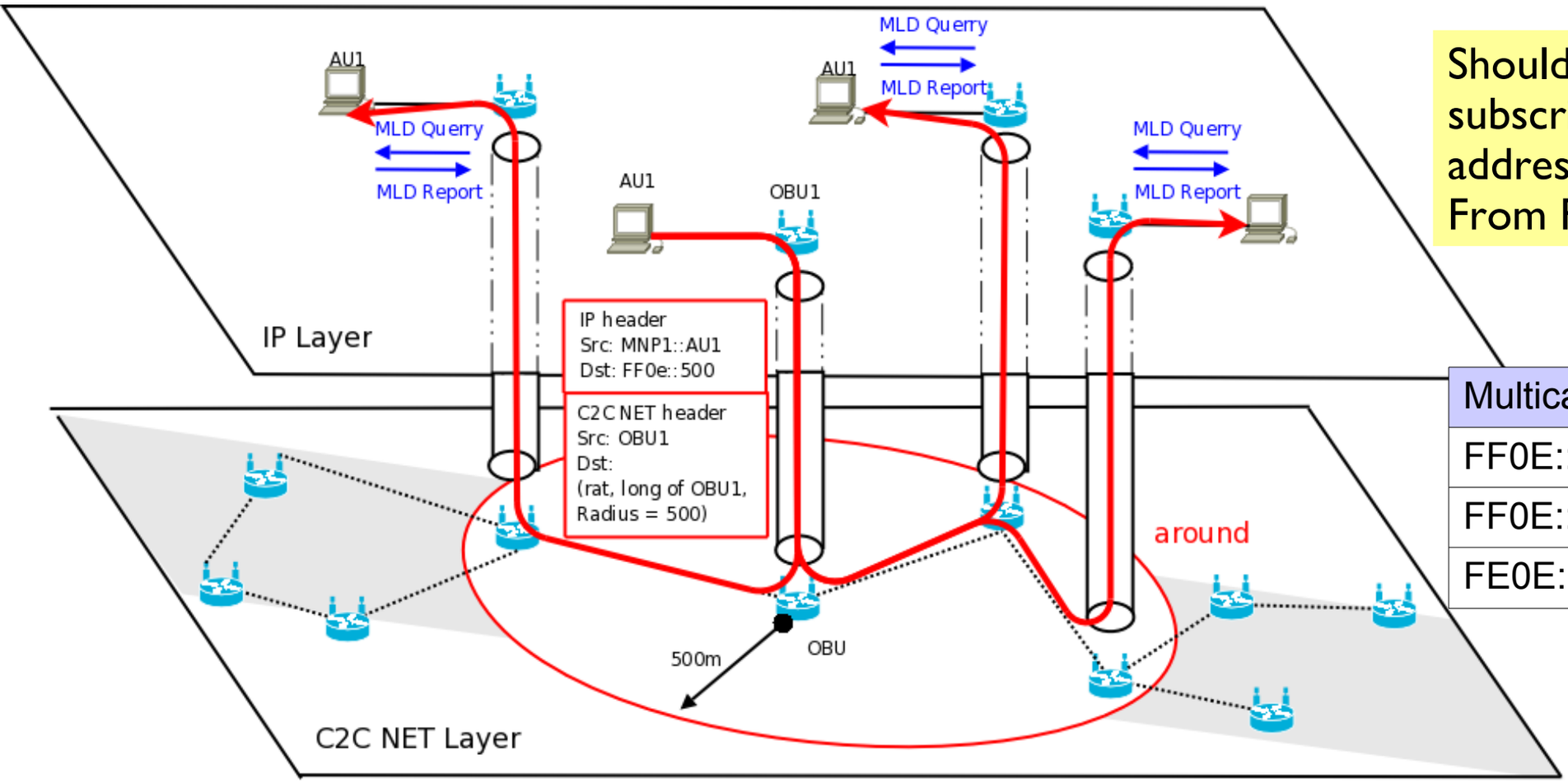
- Around Type
  - Multicast packet is delivered within some distance from the Source
  - Only radius is specified by IPv6 layer
- Area type
  - Multicast packet is delivered to an area
  - Area ID and radius is specified in IPv6 layer

RFC 3306	8 11111111	4 flags	4 scope	8 reserved	8 plen	64 Network prefix	32 Group ID
Around	11111111	flags	scope	reserved	plen	::	Radius
Area	11111111	flags	scope	reserved	plen	Area ID	Radius



Multicast over Geo-Broadcast

- Around type Geo-Broadcast
  - Radius is specified in multicast address
  - Latitude and longitude of C2C NET header is source's position
  - Receivers should subscribe to the multicast address with MLDv2 (RFC3810)
  - Router Advertisement is performed Around type by specifying the multicast address instead of all node multicast address



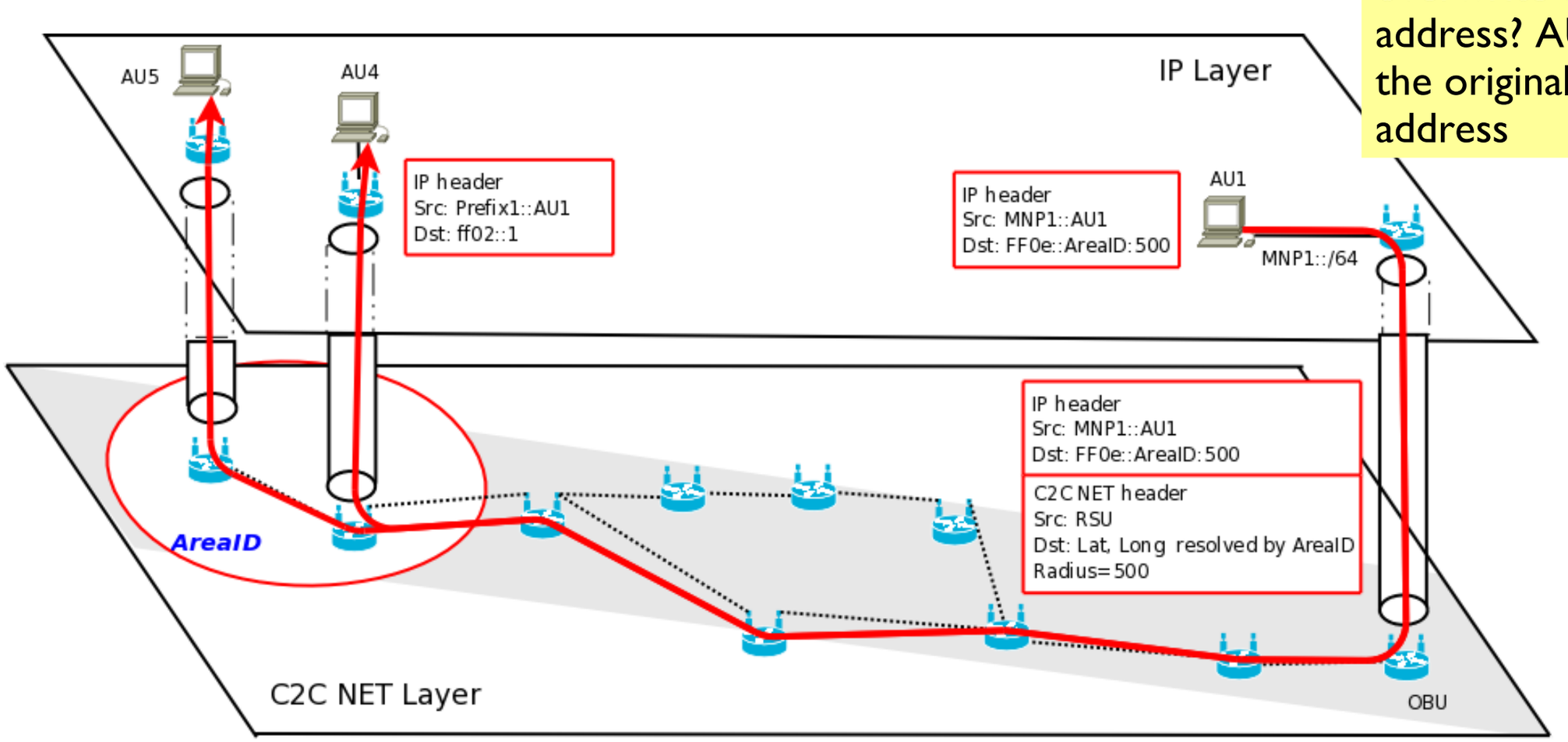
Should Listener AUs subscribe all the multicast address such as :
From FF0E::1 to FF0E::500 ?

Multicast address	Radius
FF0E::500	500 m
FF0E::1000	1000 m
FE0E::1500	1500 m

Multicast over Geo-Broadcast

- Multicast Listener cannot subscribe the multicast address ahead of packet arrival
  - FF0E::AreaID:Radius
- Receiver side OBU overwrite destination address by ff02::1 (link-local all node multicast) for the issue

Can we allow that OBUs overwrite the destination address? AUs cannot know the original destination address



Anycast and Topo-Broadcast

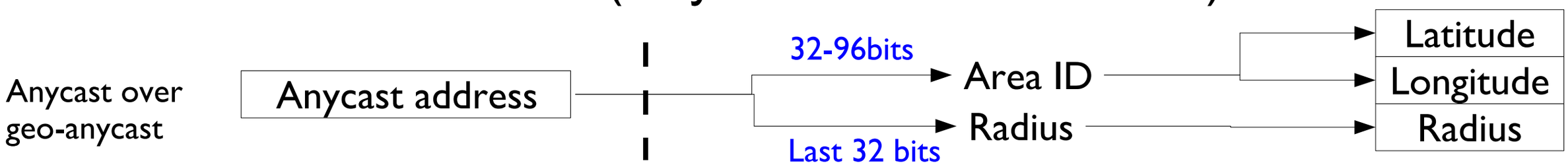
- Multicast over topo-broadcast
  - Define special multicast address for topo-broadcast
  - Hop limit of IPv6 header transmitted to C2C NET header

- Anycast Over Geo-Anycast
  - Reserved IPv6 subnet anycast address (RFC 2526) cannot apply for C2C NET
    - MNP::/64 means a certain vehicle
    - There are no place to put position and radius value

64 bits	57bits	7 bits
Subnet prefix	fdff:ffff:fff...	Anycast ID

  - Propose IPv6 Anycast address for C2C NET
    - fdff:ffff:ffff:Area-ID:Radius
    - Around mode omits Area-ID
    - AUs cannot configure the address ahead in Area mode
    - Receiver side OBU overwrite destination address by MNP::fdff:ffff:ffff:fffc (Anycast address in MNP)

Anycast over Geo-unicast is simpler



End

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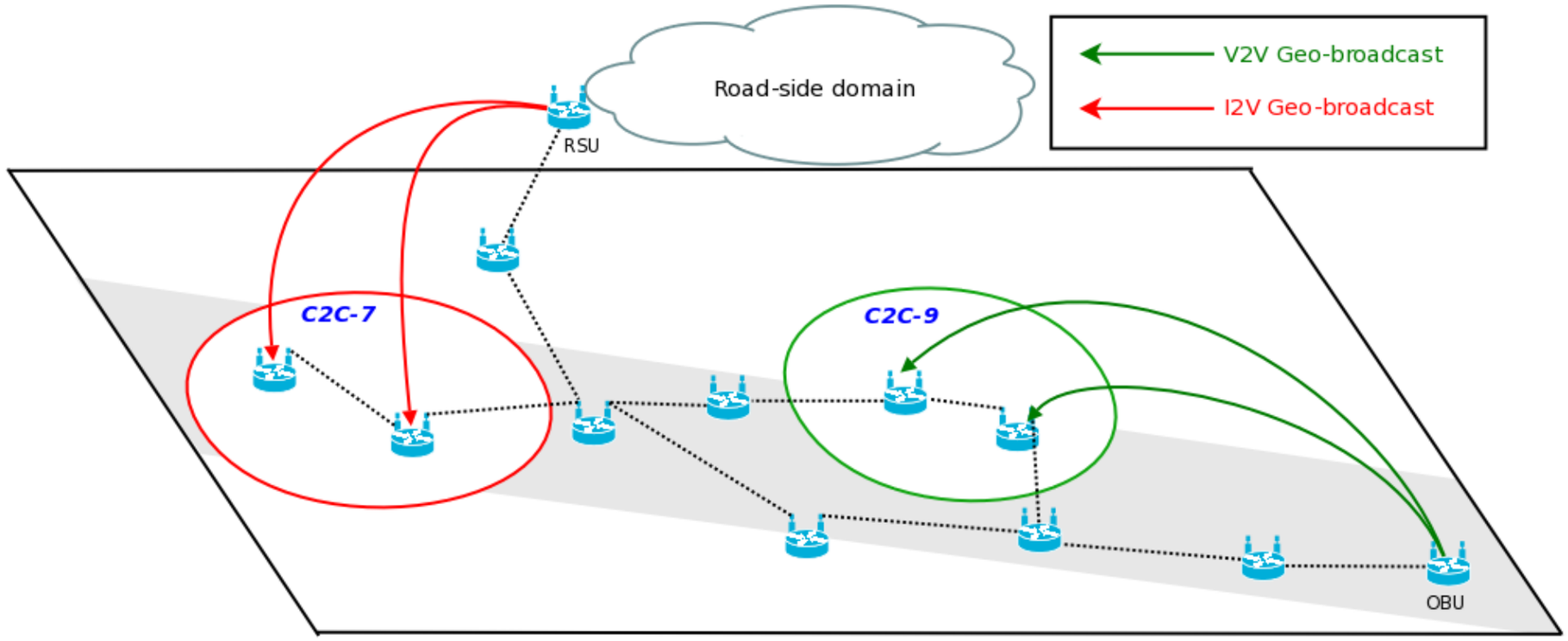
  - Thierry Ernst <thierry.ernst@inria.fr>

Multicast over Geo-Broadcast

- Notion of Area ID
  - C2C NET ID allocated to an area
  - The set of (Latitude, longitude) can be resolve by Area ID



- Destination multicast address
  - Example: FF0E::C2C-7, FF0E::C2C-9
- Issue for multicast grouping
  - Receiver AUs cannot subscribe the multicast address ahead