FP7 GeoNet Architecture (D1.2) & Specification (D2.2)

Geographic addressing and routing for vehicular communications

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GeoNet Fact Sheet

- Starting date: 1st Feb. 2008
- Duration: 24 months
- Budget: 3 M€
- Funding: 1.9 M€
- 7 partners
  - 2 Research Institutes (INRIA and IMDEA)
  - 1 SME (Broadbit)
  - 4 industrial partners (EFKON, Hitachi, NEC and Lesswire)

- Web: http://www.geonet-project.eu

- Objective: Design the concepts linking geographic addressing and routing with IPv6 mobility mechanisms (IPv6 geonetworking)

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GeoNetworking

IPv6 geonetworking will ensure convergence between both IPv6 and non-IPv6 communications

In addition to decreasing road fatalities and injuries in accidents, it will improve traffic efficiencies and create new business markets.

The GeoNet Project

- The GeoNet's 3 main axes:

  - **Knowledge**: to elaborate a unified GeoNetworking solution compliant with best practices in vehicular communications;

  - **Standards**: to produce a reference GeoNetworking specification and push it in standardization organizations (particularly IETF, ISO and ETSI);

  - **Software**: to produce two prototype implementations and disseminate it to existing consortia (particularly SafeSpot, CVIS, COOPERS and C2C-CC).
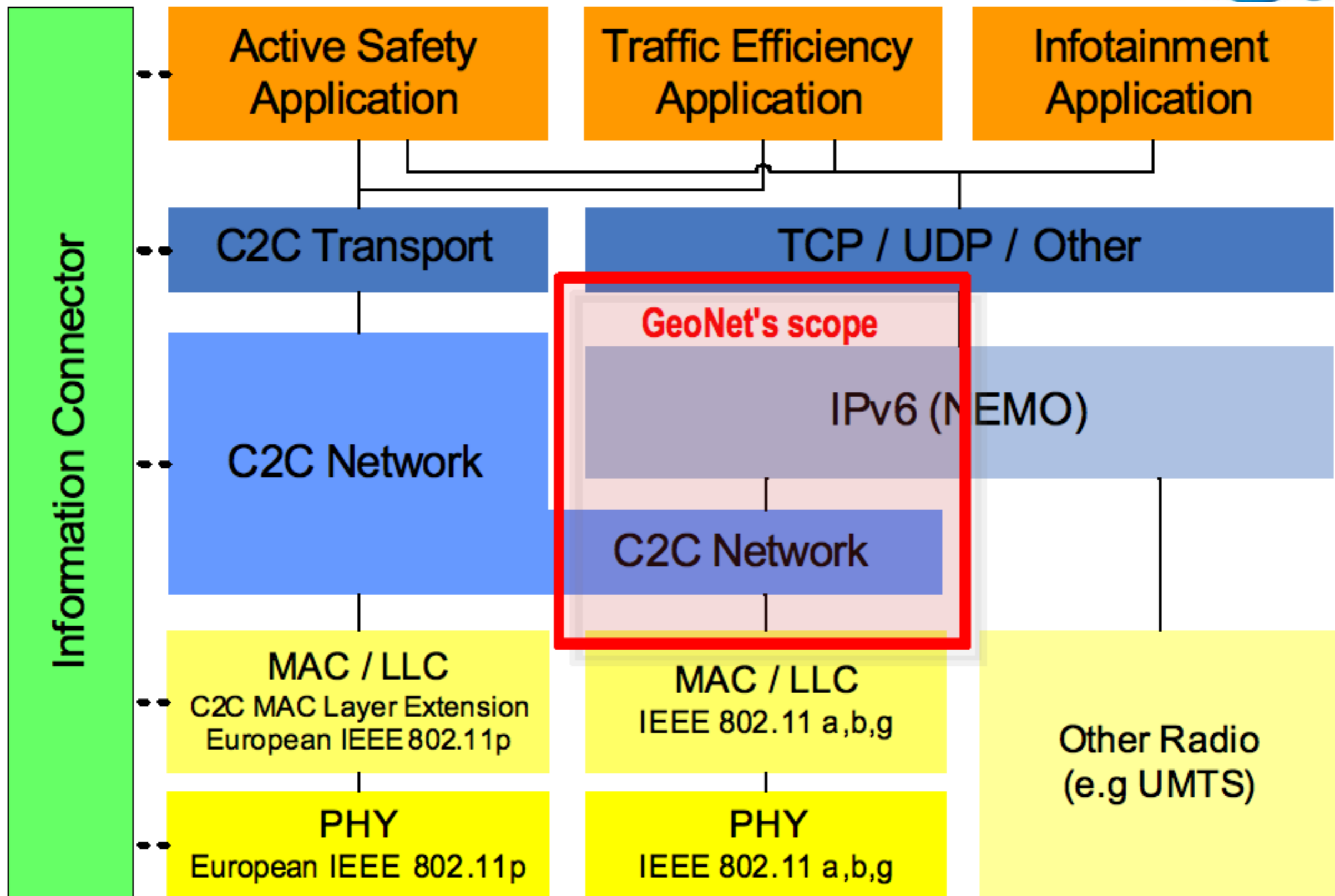
GeoNet Work Packages

- WP0: Management (INRIA)

- WP1: Architecture (INRIA)

- WP2: Specification (Efkon - Broadbit)

- WP3: Implementation (NEC)

- WP4: Conformance testing (Broadbit)

- WP5: Emulation Environment Development (Hitachi)

- WP6: Integration & Porting (Lesswire)

- WP7: Experimental validation (INRIA)

- WP8: Dissemination & use (INRIA)

GeoNet Relationships
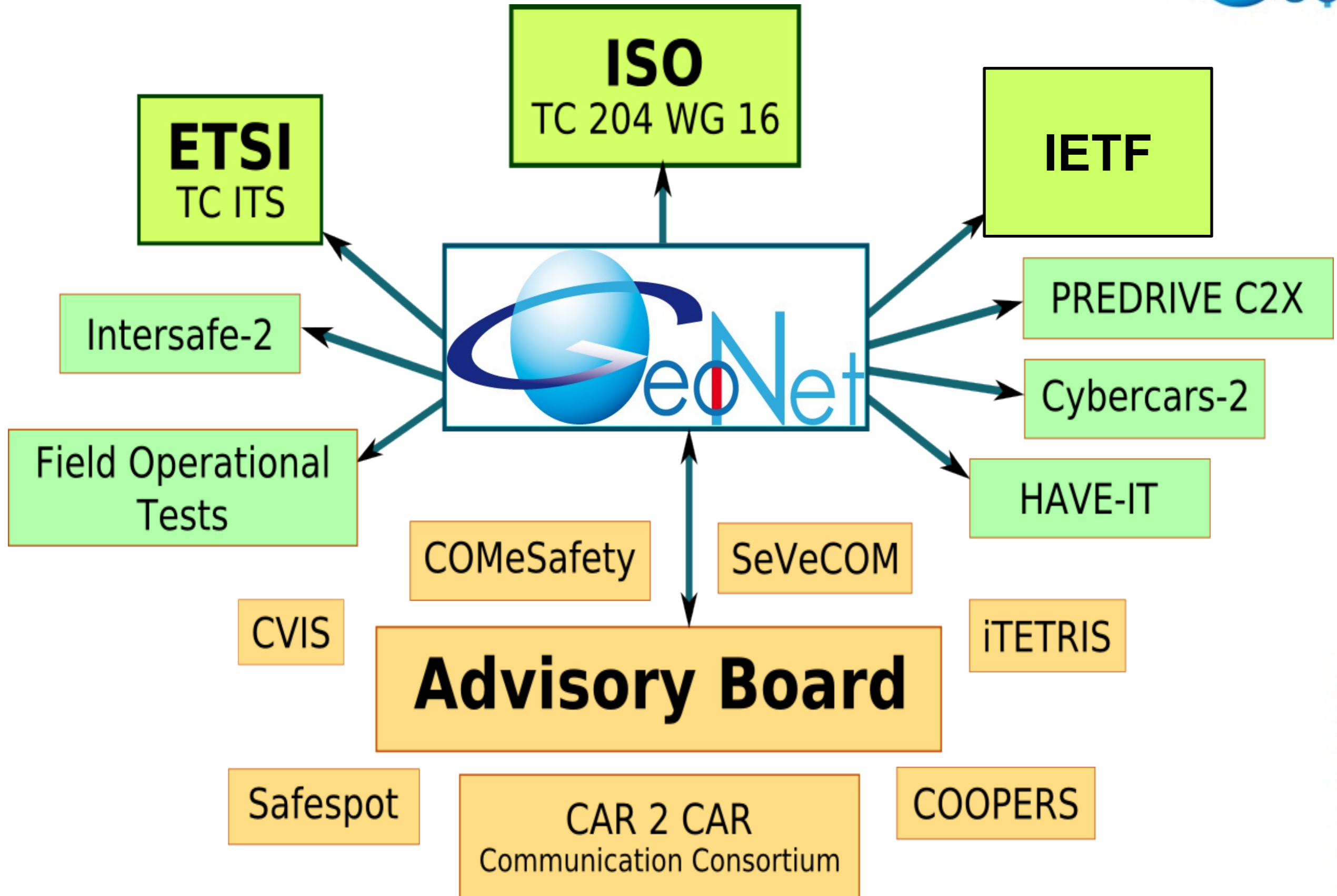
GeoNet Scope

GeoNet Scenarios

- GeoNet: scenarios requiring both IPv6 and geonetworking

- Scenario Type 1: sender is in the Internet
  - Packets are transmitted in IPv6 until the RSUs serving the geographic area where they are GeoRouted through intermediate vehicles to the final destination(s).

- Scenario type 2: receiver is in the Internet
  - Packets are GeoRouted through intermediate vehicles (using GeoUnicast) until a RSU where they are transmitted in IPv6 to the final destination.

- Scenario type 3: sender and receiver(s) are only reachable through the Internet
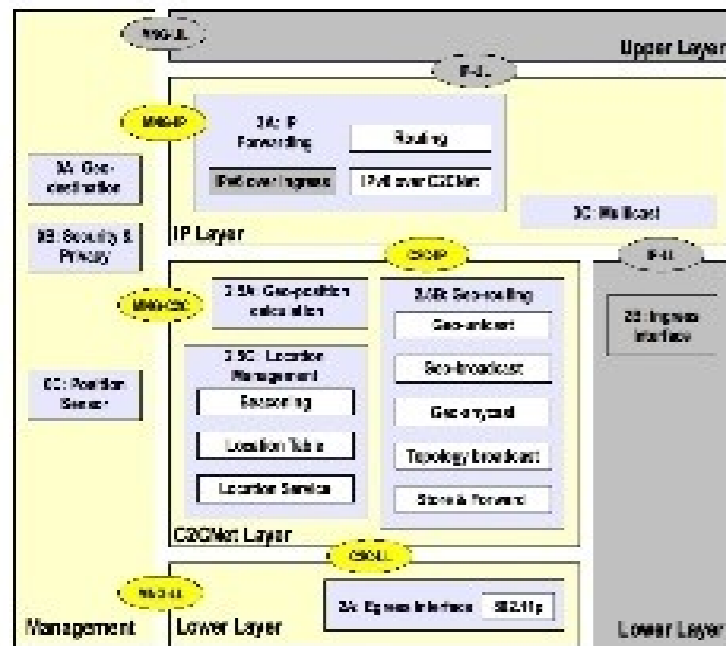 - Combination of Scenarios Type 1 & 2 where source and destination(s) are out of multihop wireless range

GeoNet Scenarios
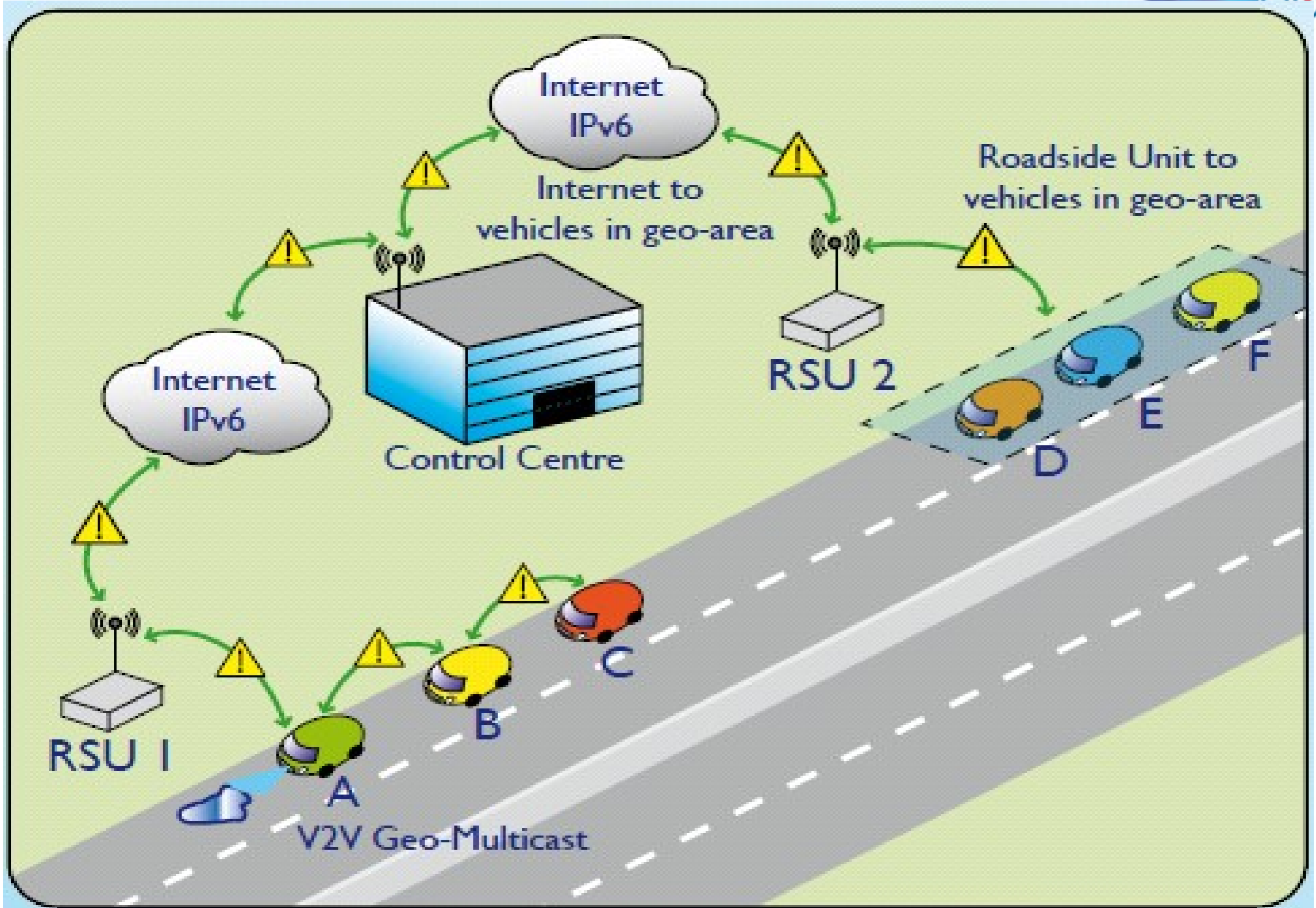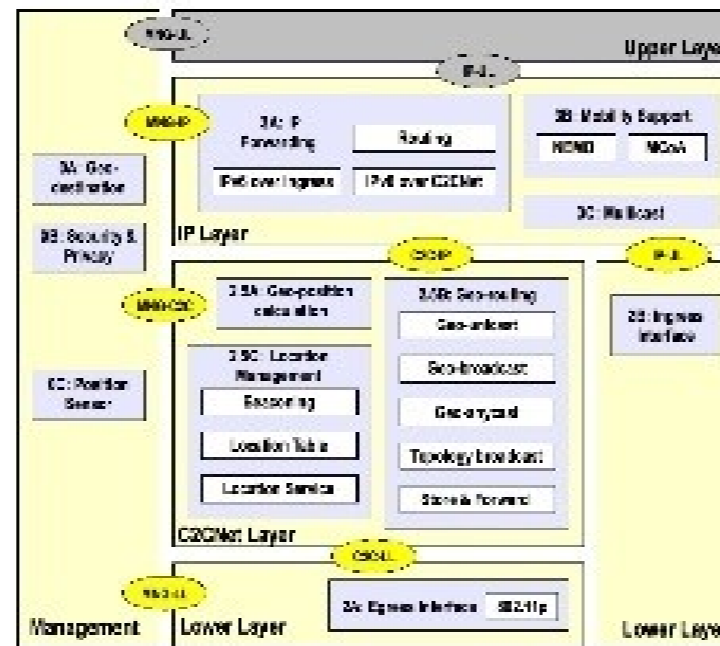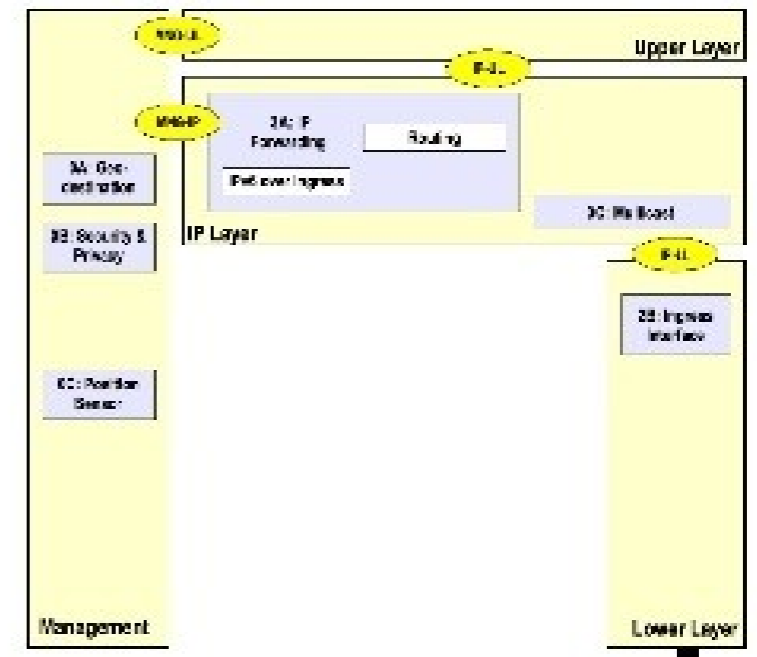
GeoNet In-Vehicle Network

AR (GeoNet RSU)   MR (GeoNet OBU)   MNN (AU)

802.11p

Ethernet

In-vehicle IPv6 network

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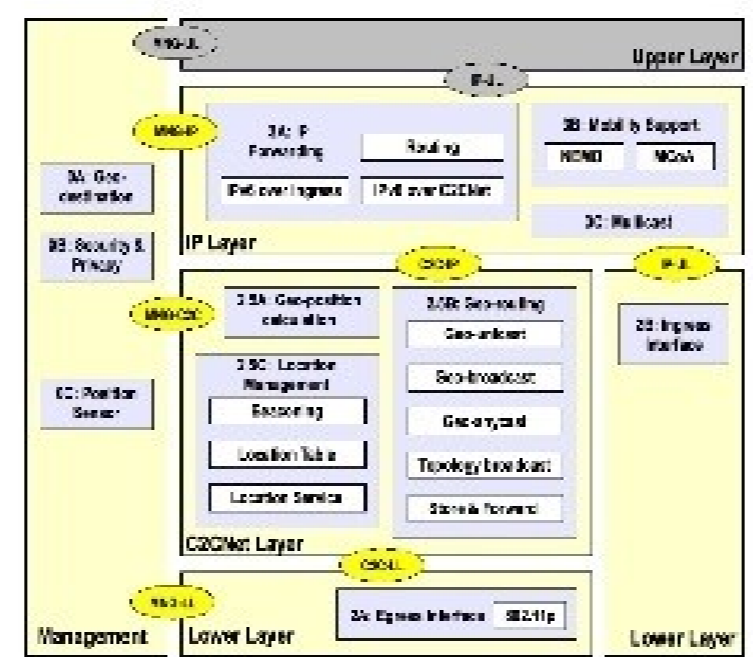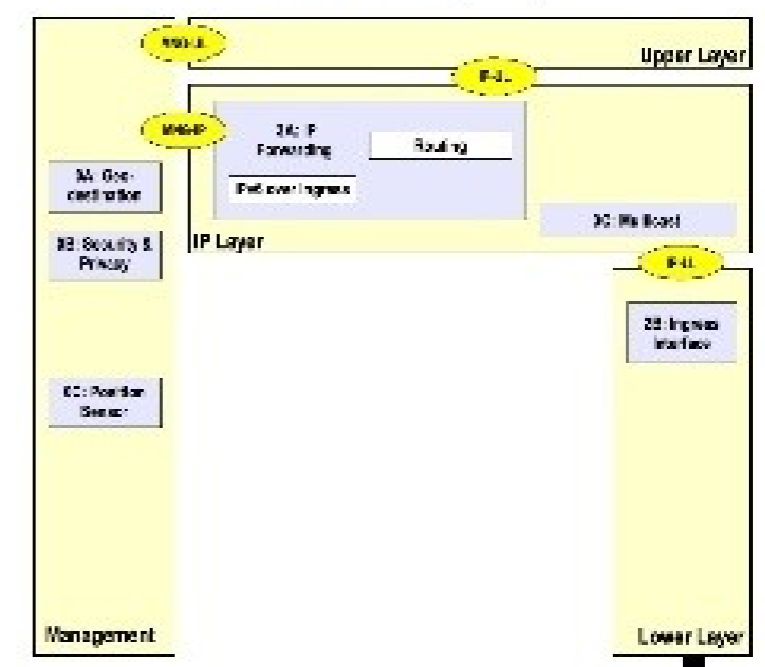# GeoNet C2CNet Link

AR (GeoNet RSU)
MR (GeoNet OBU)
MNN (AU)

802.11p

**C2CNet IPv6 link
(defined according to radius or
number of C2CNet hops)**

Ethernet

GeoNet domain

AR (GeoNet RSU)   MR1 (GeoNet OBU)   MNN (AU)

C2Net link (multi-hop 802.11p)

Ethernet link

MR2 (GeoNet OBU)

GeoNet domain
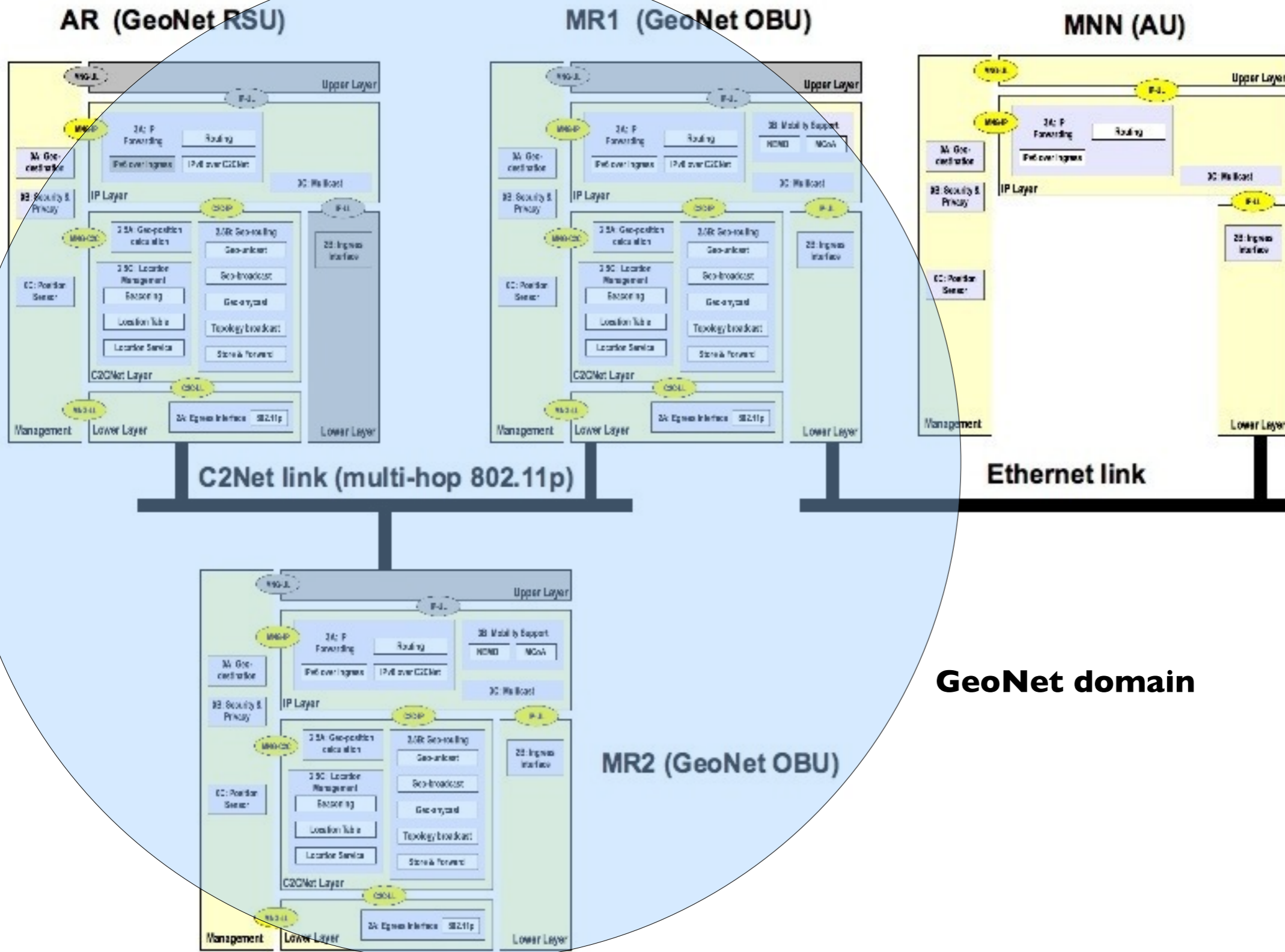
GeoNet Functional Modules

Upper Layer

MNG-UL

IP-UL

MNG-IP

3A: IP Forwarding | Routing

IPv6 over Ingress | IPv6 over C2CNet

3B: Mobility Support

NEMO | MCoA

3C: Multicast

0A: Geo-destination

0B: Security & Privacy

IP Layer

C2C-IP

IP-LL

MNG-C2C

2.5A: Geo-position calculation

2.5B: Geo-routing

Geo-unicast

Geo-broadcast

Geo-anycast

Topology broadcast

Store & Forward

2.5C: Location Management

Beaconing

Location Table

Location Service

2B: Ingress Interface

0C: Position Sensor

C2CNet Layer

C2C-LL

MNG-LL

2A: Egress Interface | 802.11p

Management

Lower Layer

Lower Layer

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GeoNet: Management Layer

Management

- MNG-UL
- MNG-IP
- MNG-C2C
- MNG-LL

0A: Geo-destination

0B: Security & Privacy

0C: Position Sensor

Upper Layer

IP-UL

IP Layer

3A: IP Forwarding — Routing

IPv6 over Ingress — IPv6 over C2CNet

3B: Mobility Support
- NEMO
- MCoA

3C: Multicast

C2C-IP

IP-LL

C2CNet Layer

2.5A: Geo-position calculation

2.5C: Location Management
- Beaconing
- Location Table
- Location Service

2.5B: Geo-routing
- Geo-unicast
- Geo-broadcast
- Geo-anycast
- Topology broadcast
- Store & Forward

2B: Ingress Interface

Lower Layer

C2C-LL

2A: Egress Interface — 802.11p

Lower Layer

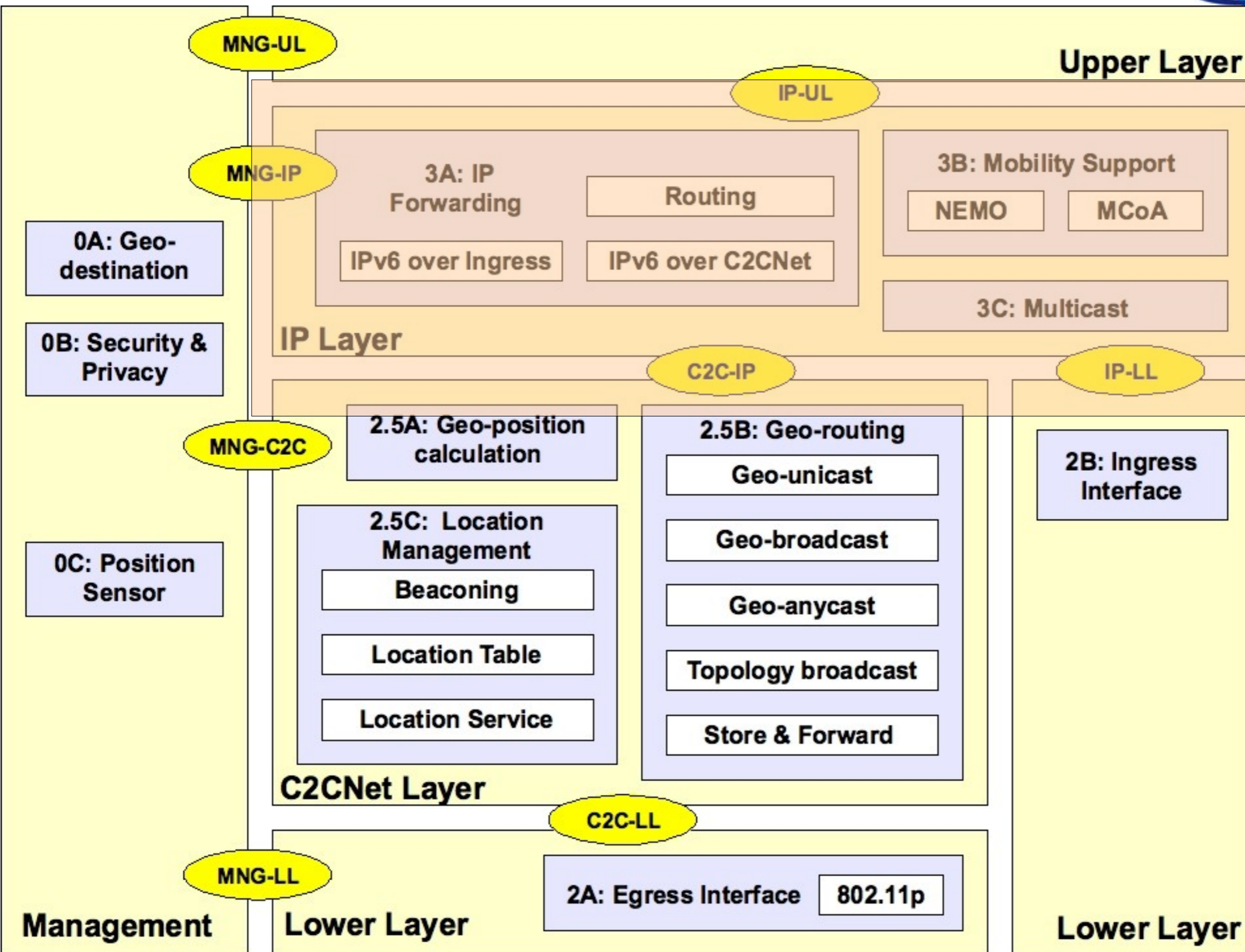www.geonet-project.eu

GeoDestination encoding in IPv6

- **GeoDestination**
  - Transmitted from the application to GeoNetworking layer
  - Several encoding approaches

- **Concept:**
  - Multicast: only one copy of a message is transmitted on any given iff there is a group member
 - Geocast: flooding in a bounded geographic area

8 bits	4 bits	4 bits	112 bits
0XFF	0 flgs	E scope	group ID = C2C ID
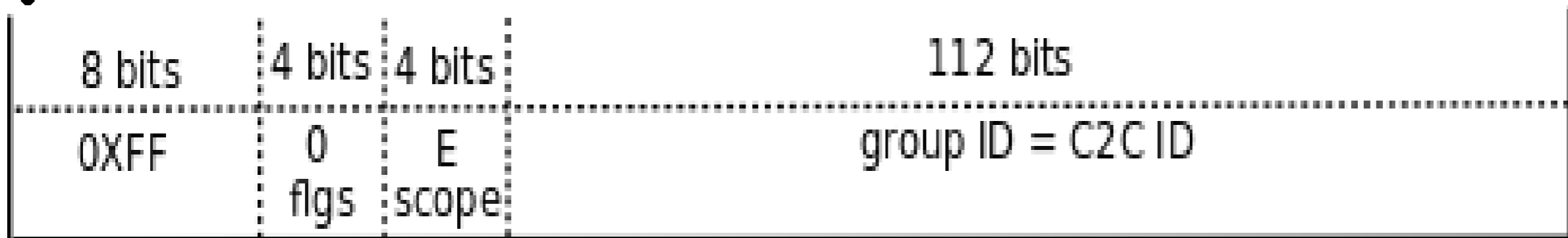
- **GeoNet simplified implementation**
  - Application provides GeoDestination ID
  - IPv6 multicast address encodes GeoDestination ID
 - C2CNet retrieves GeoDestination mapped to ID

GeoNet: IP Layer

Upper Layer

MNG-UL

IP-UL

MNG-IP

3A: IP Forwarding | Routing

IPv6 over Ingress | IPv6 over C2CNet

3B: Mobility Support
NEMO | MCoA

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IP Layer

C2C-IP

IP-LL

MNG-C2C

2.5A: Geo-position calculation

2.5B: Geo-routing
Geo-unicast
Geo-broadcast
Geo-anycast
Topology broadcast
Store & Forward

2.5C: Location Management
Beaconing
Location Table
Location Service

2B: Ingress Interface

0C: Position Sensor

C2CNet Layer

C2C-LL

MNG-LL

2A: Egress Interface | 802.11p

Management

Lower Layer

Lower Layer

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IP Forwarding (V2X)

Module 3A: Dynamic IPv6 routing table updating is based on Neighbor Discovery extension (MNPP)
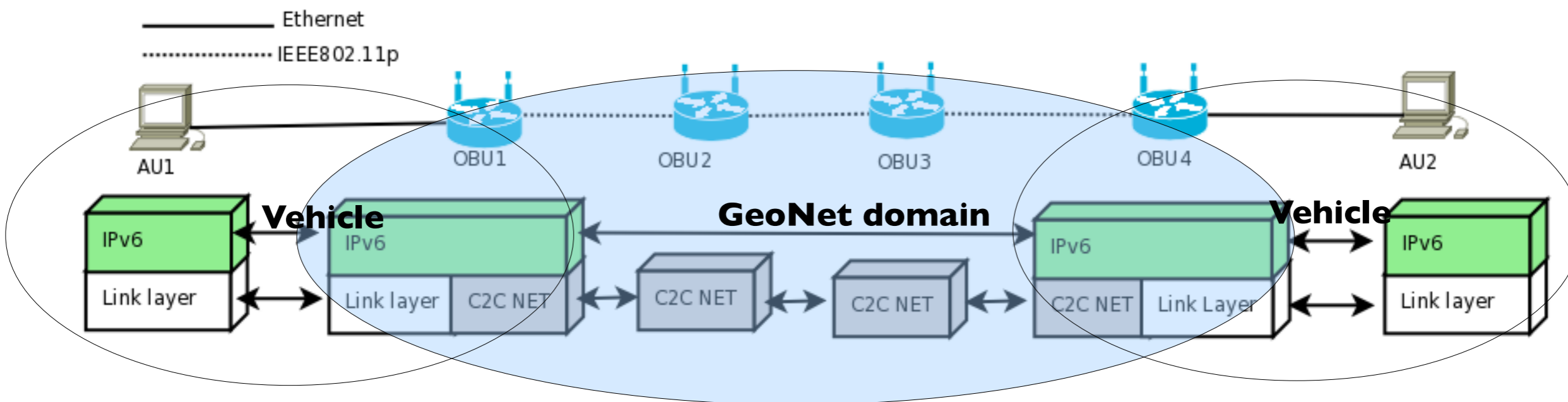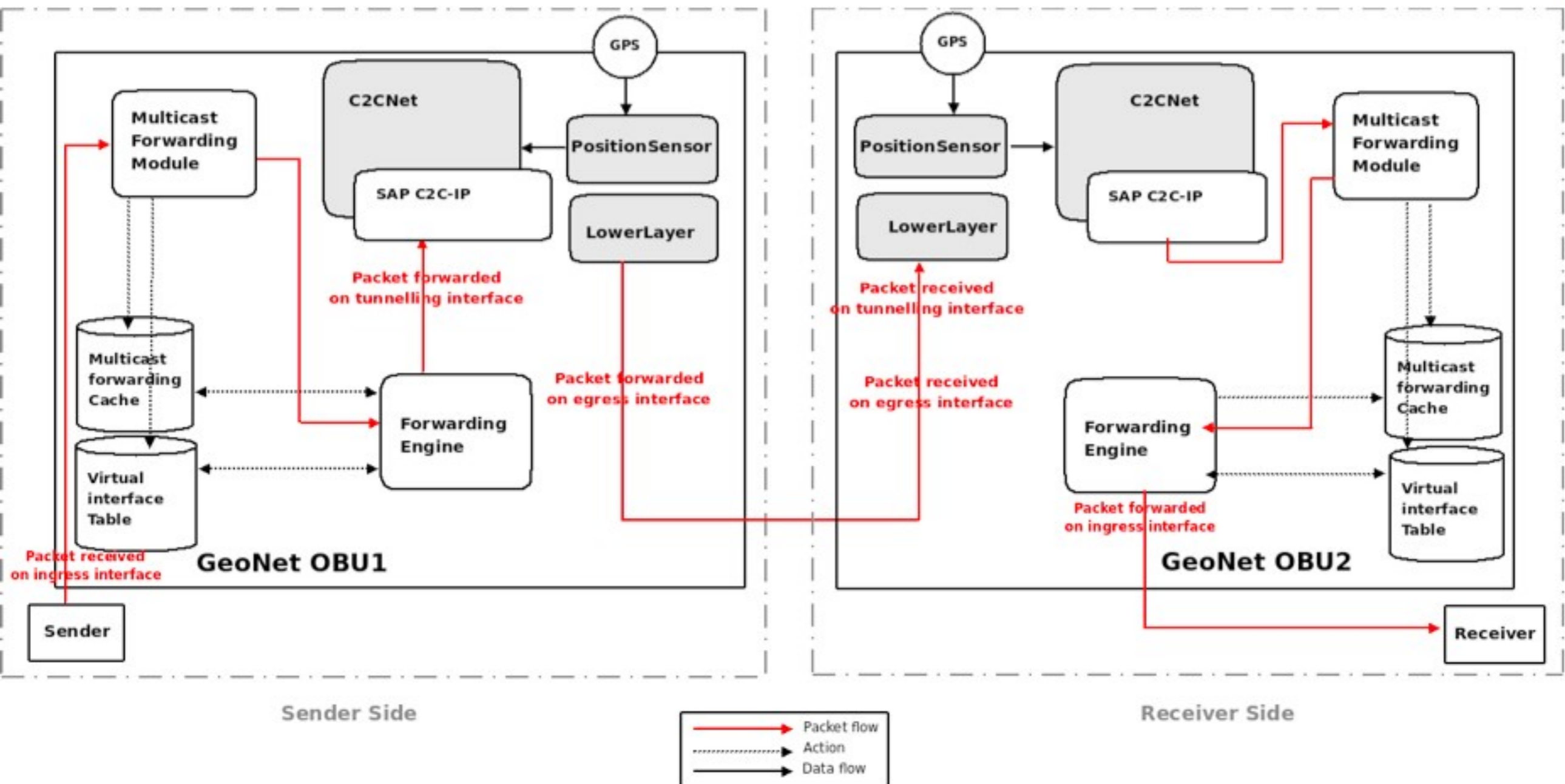

Module 3B: Network mobility support using NEMO
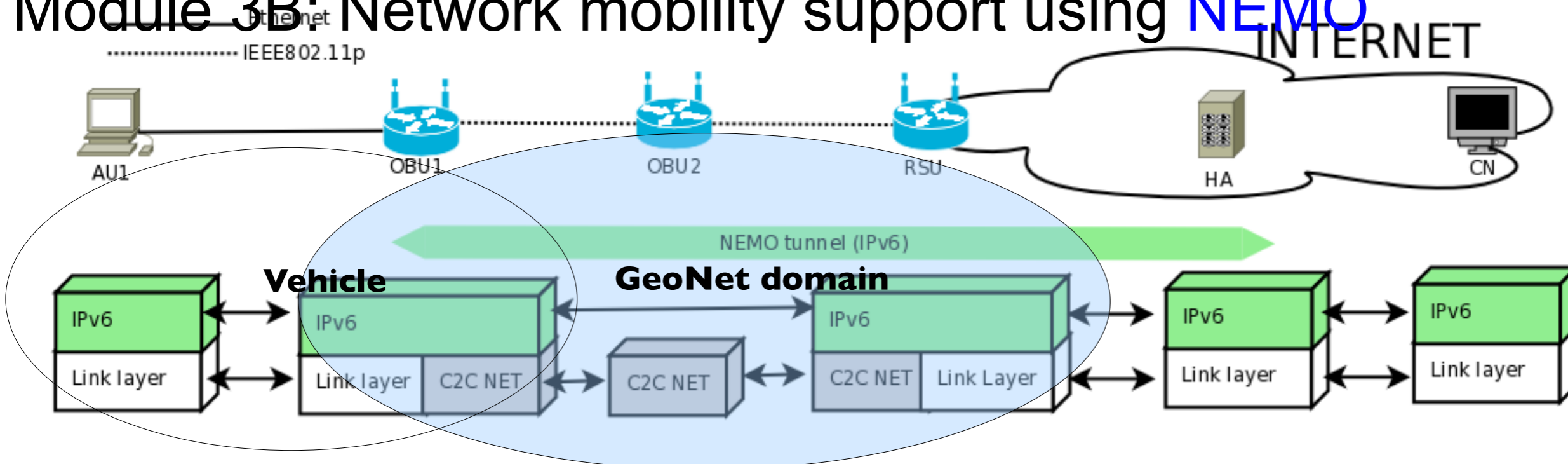
GeoNet: Multicast support

- Multicast management is based on MLDv2 mechanism
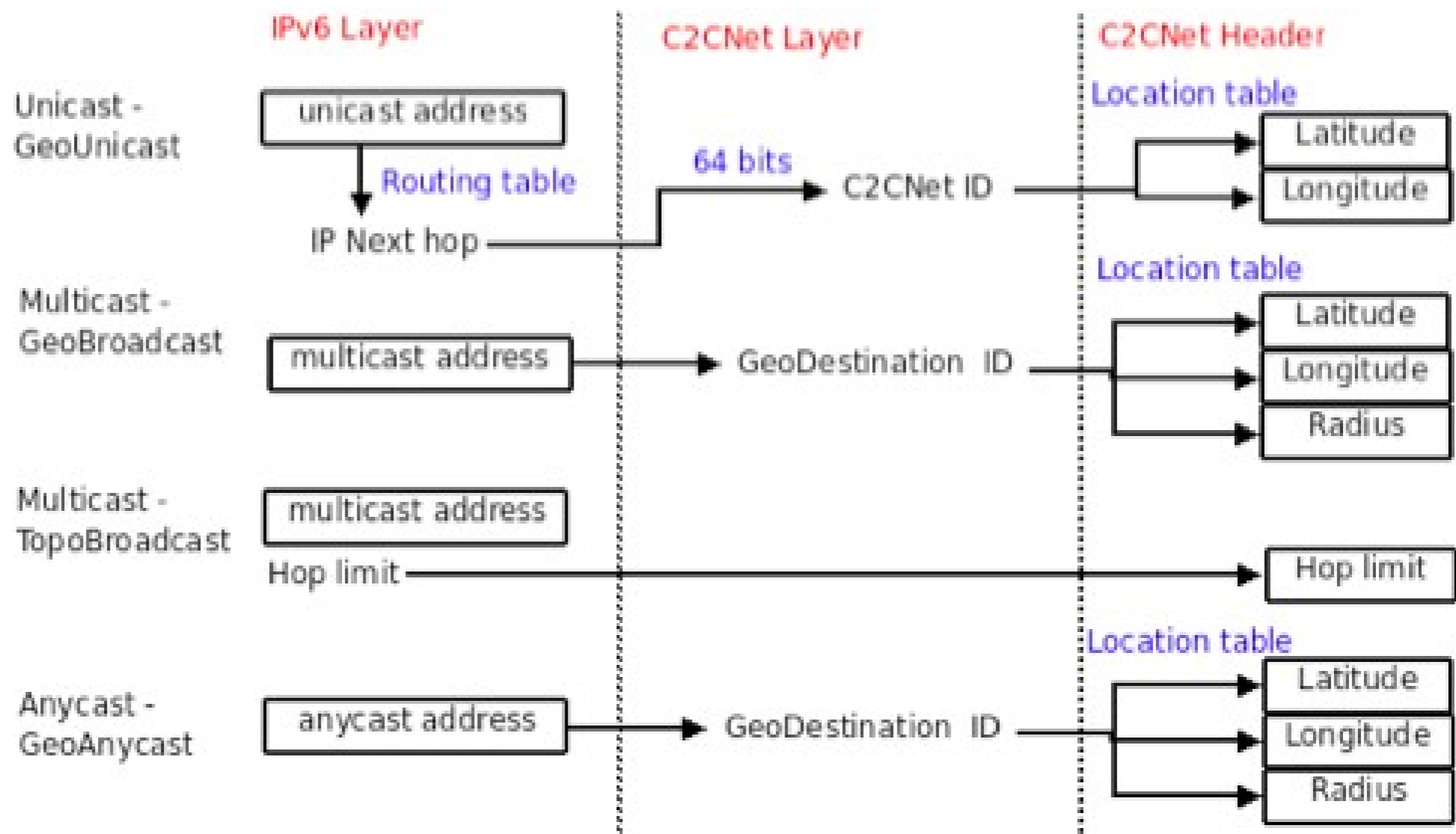- Multicast handling is fully integrated with C2CNet layer

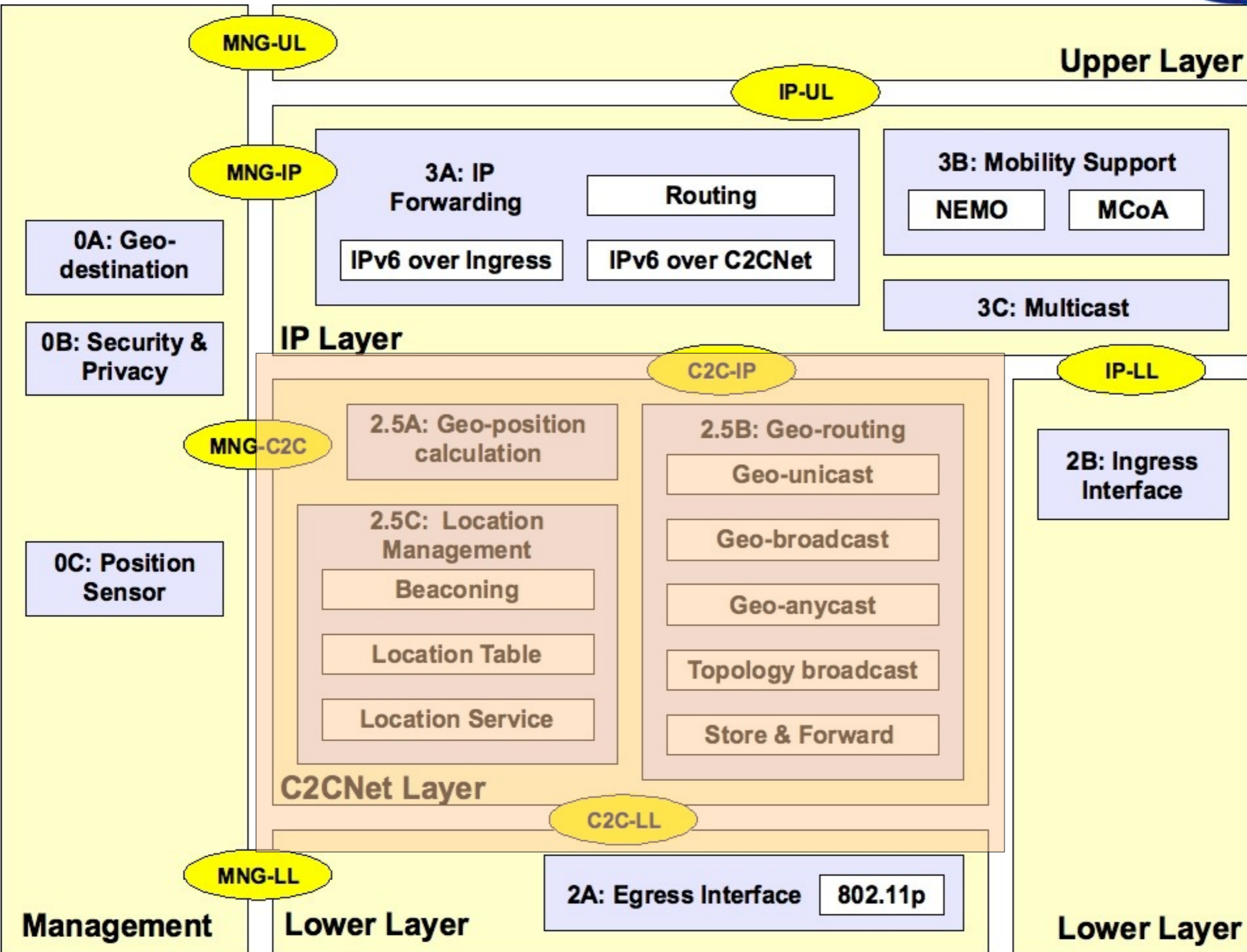# C2C-IP SAP between C2CNet & IP

- Defines the integration of IPv6 forwarding on top of C2CNet layer

Note: five alternative mechanisms have been subscribed for encoding of multicast GeoDestination → ETSI WG3 should select the most suitable one(s) for the geonetworking standard.
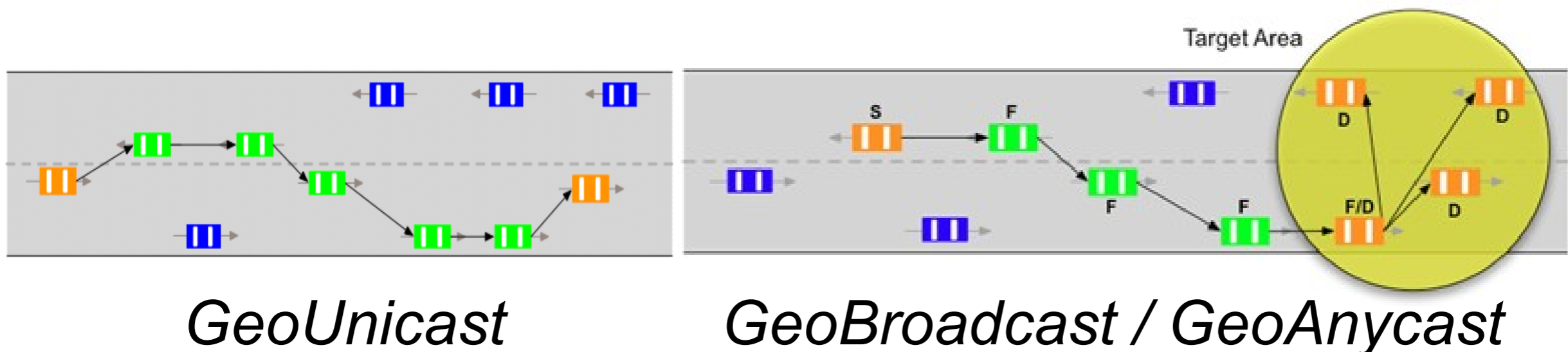
GeoNet: C2CNet Layer

MNG-UL

IP-UL

Upper Layer

MNG-IP

3A: IP Forwarding | Routing

IPv6 over Ingress | IPv6 over C2CNet

3B: Mobility Support
NEMO | MCoA

3C: Multicast

0A: Geo-destination

0B: Security & Privacy

IP Layer

C2C-IP

IP-LL

MNG-C2C

2.5A: Geo-position calculation

2.5B: Geo-routing

Geo-unicast

2B: Ingress Interface

2.5C: Location Management

Beaconing

Location Table

Location Service

Geo-broadcast

Geo-anycast

Topology broadcast

Store & Forward

0C: Position Sensor

C2CNet Layer

C2C-LL

MNG-LL

2A: Egress Interface | 802.11p

Management | **Lower Layer** | **Lower Layer**

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C2CNet: Specification

- GeoNet has completely specified the GeoNetworked packet forwarding / distribution functionality:
  - GeoUnicast
  - GeoAnycast
  - GeoBroadcast
  - TopoBroadcast
  - Message buffering (with GeoNetwork triggered re-evaluation)
- GeoNet has completely specified the GeoNetworked location management functionality:
  - Beaconing (periodic single-hop broadcast)
  - Location Table
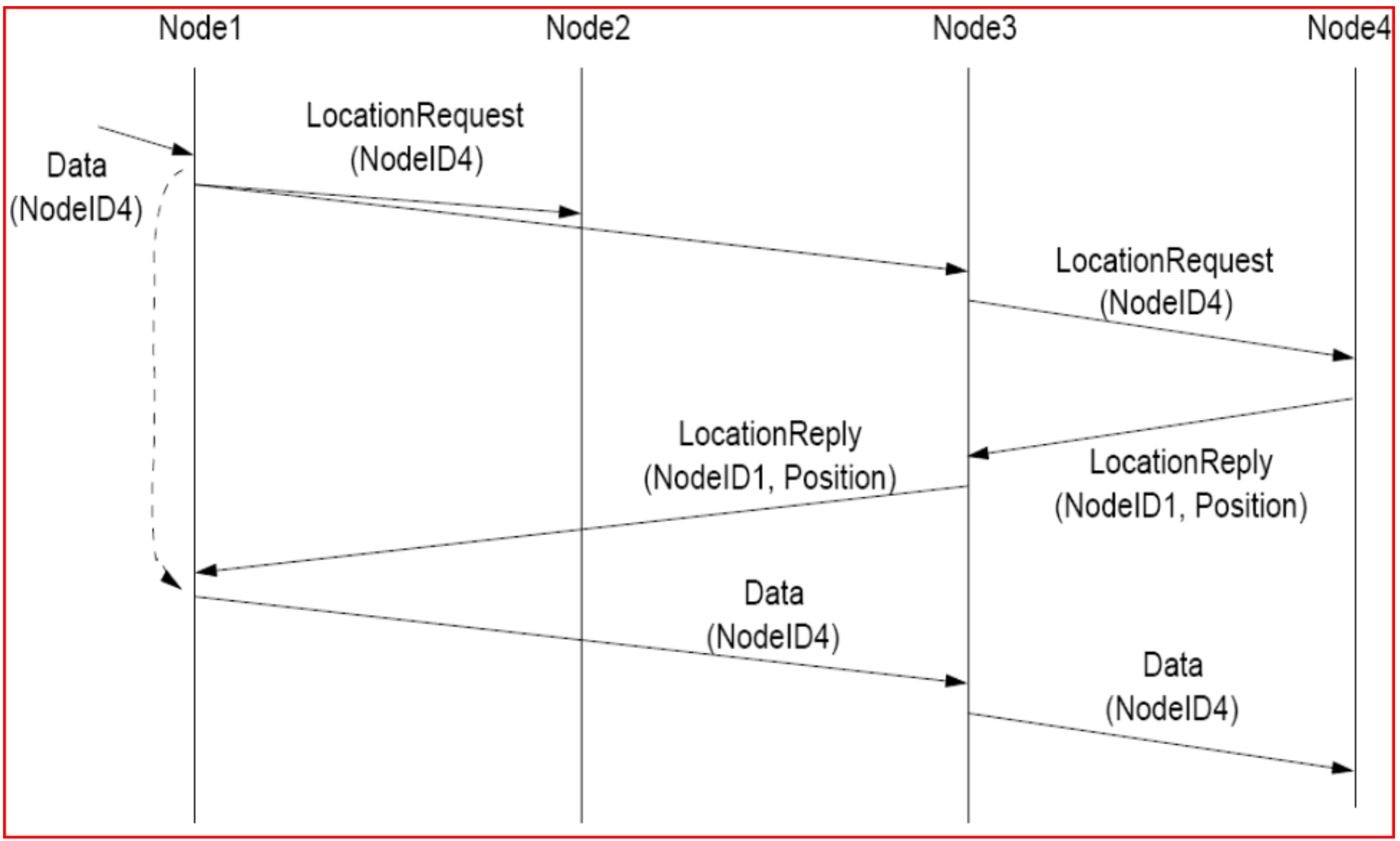 - Location Service (lookup of unknown destinations)

GeoUnicast

GeoBroadcast / GeoAnycast

C2CNet: Functionalities (1)

- **Location management**
  - Beacon
  - Location table
  - Location service
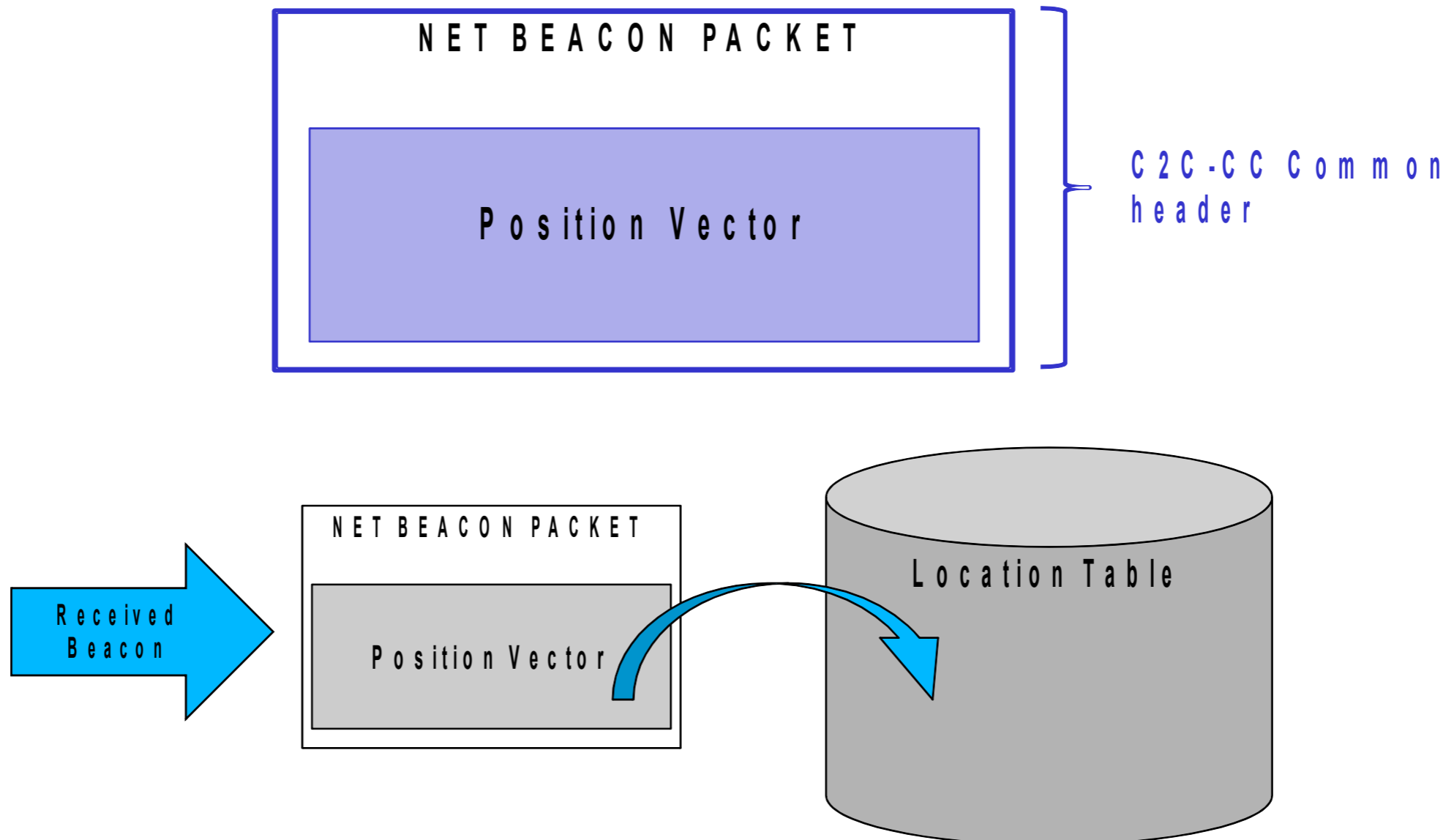
C2CNet: Functionalities (2)

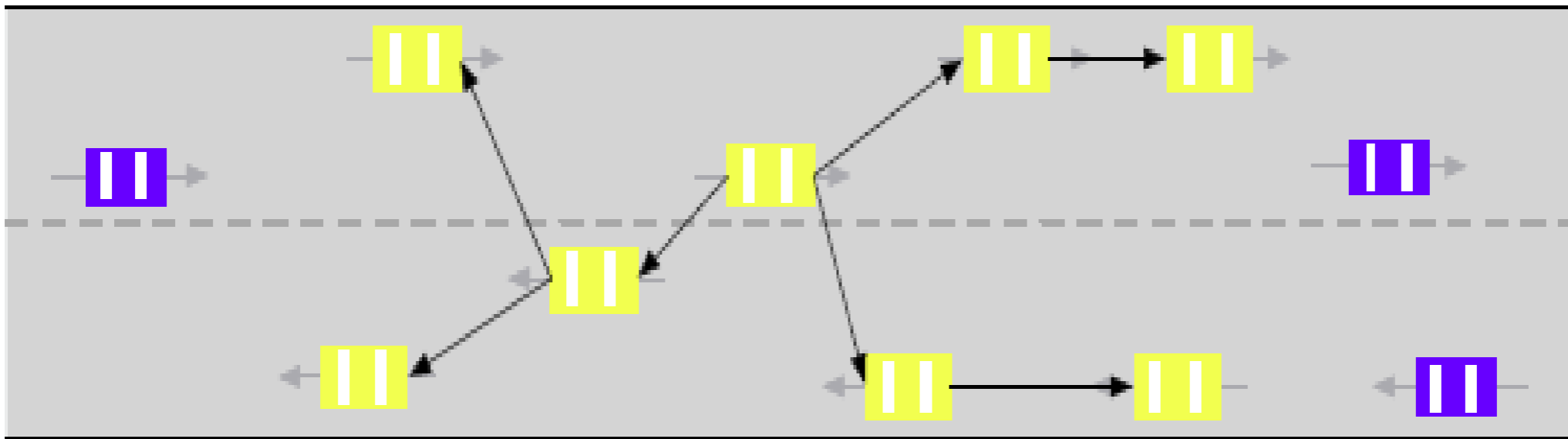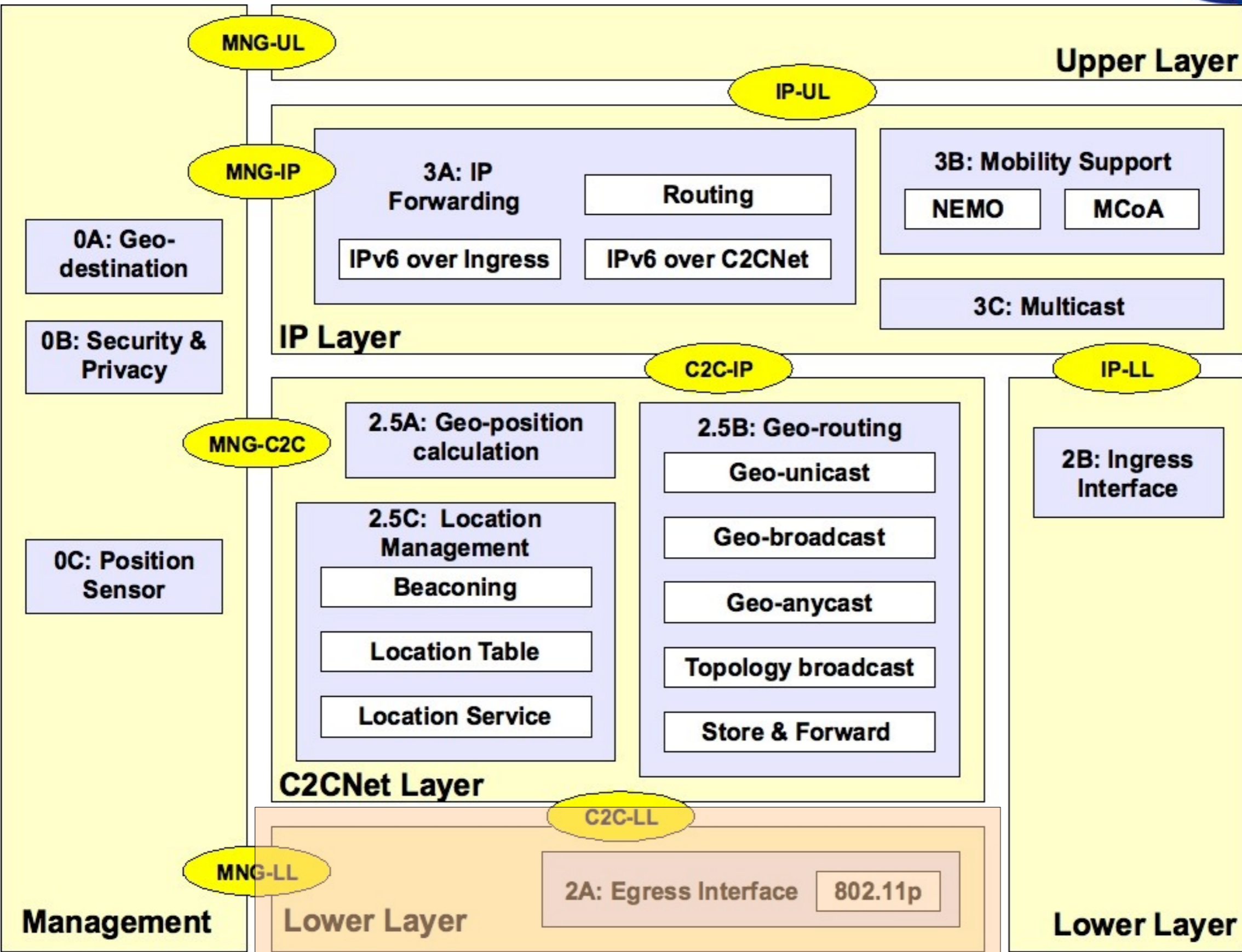- Location service

- Georouting
  - TopoBroadcast

C2CNet: Packet Format suffit



```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
:                   Common header                               :
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
:               Source node position vector                     :
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
|                   Destination node ID                         |
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   Destination node Latitude                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   Destination node Longitude                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
:                        Payload                                :
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
:                      Common header                            :
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
:                 Source node position vector                  :
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          Reserved            |             Radius             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Destination node Latitude                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Destination node Longitude                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
:                          Payload                              :
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

GeoNet: C2CNet Layer

Upper Layer

MNG-UL

IP-UL

IP Layer

MNG-IP

0A: Geo-destination

0B: Security & Privacy

3A: IP Forwarding — Routing

IPv6 over Ingress — IPv6 over C2CNet

3B: Mobility Support — NEMO — MCoA

3C: Multicast

C2C-IP

IP-LL

MNG-C2C

0C: Position Sensor

2.5A: Geo-position calculation

2.5C: Location Management
- Beaconing
- Location Table
- Location Service

2.5B: Geo-routing
- Geo-unicast
- Geo-broadcast
- Geo-anycast
- Topology broadcast
- Store & Forward

2B: Ingress Interface

C2CNet Layer

C2C-LL

MNG-LL

Management

Lower Layer

2A: Egress Interface — 802.11p

Lower Layer

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C2CNet: Lower Layer

- A lower layer adaptation module has been defined to support multiple underlying MAC/LLC types
- Two lower layer packet types are supported in current GeoNet implementation:
  - C2C Demo packet format
  - CVIS packet format
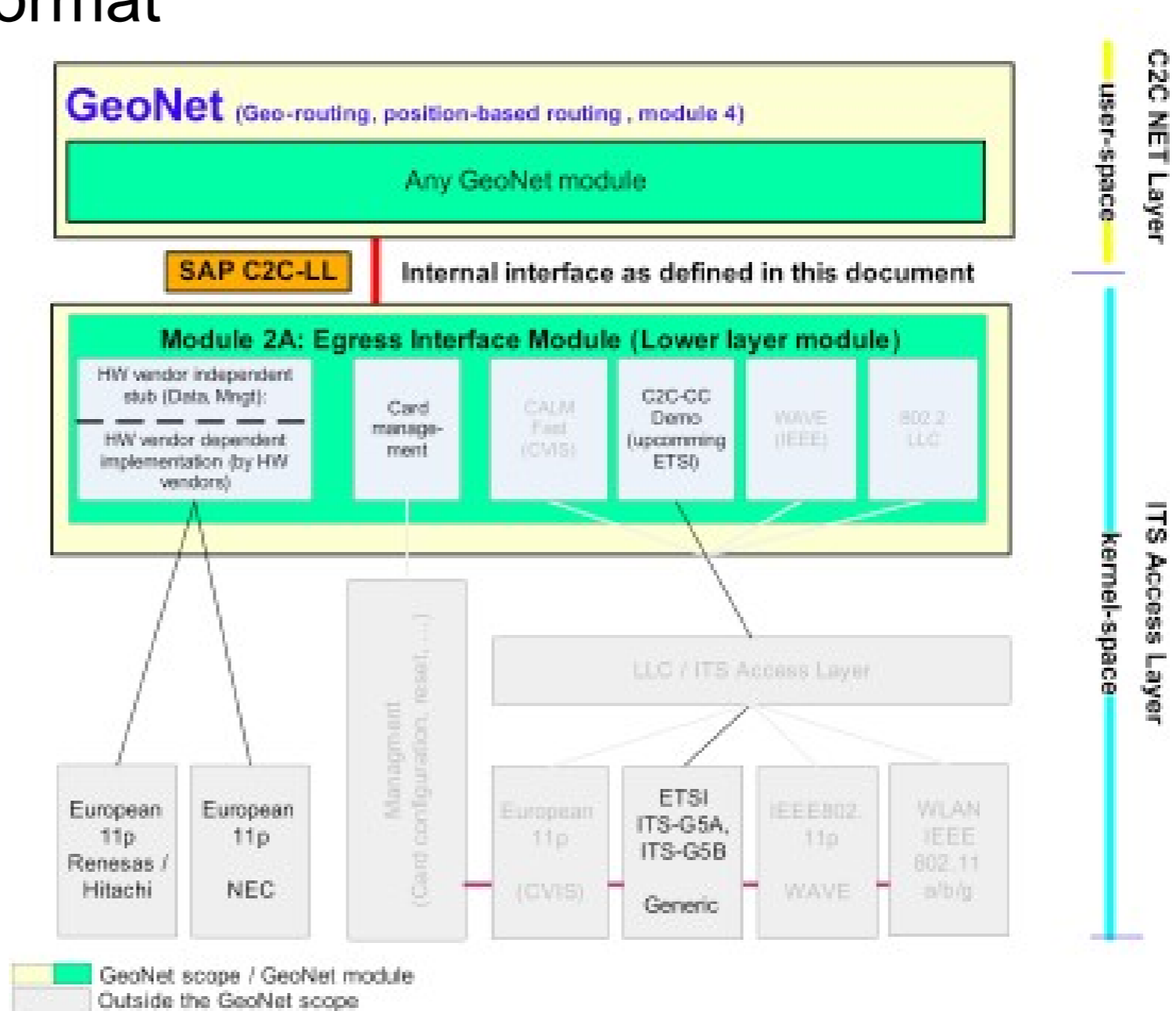
Summary: GeoNet output

- **C2CNet Layer:**
  - 2 independent implementations (Hitachi + NEC)
  - Multihop forwarding
  - Position-based routing

- **IP Layer: extensions of the Linux IPv6 stack / UMIP**
  - SAP C2C-IP
  - MNP provisioning: exchange of in-vehicle IPv6 prefixes
  - IP multicast configuration

- **A conformance testing suite is available for validating future implementations**

GeoNet Limitations & future work

- C2C Transport layer over C2CNet is to be defined yet

- Only single radio channel is defined currently, multi-radio support is to be defined yet (multiple instances of the C2CNet demon can be run in parallel presently)

- Congestion control has not been specified

- A mechanism for sharing Location Table (i.e. neighbor awareness data) with Application layer has been described, but not fully specified

- The most suitable alternative(s) for multicast destination area encoding should be analyzed and selected

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Next steps for ETSI TC IST WG3

- Feedback for perfecting the resulting GeoNet specifications

- Adopting contributed specifications into existing ITST WI:
  - GeoNetworking
  - IPv6 GeoNetworking [ETSI-TS-102-636-6-1]

- Extending according to issues listed on previous slide

Thank you for attention

Geographic addressing and routing for vehicular communications

Thierry Ernst INRIA – Mines ParisTech (LaRA)

Technical Coordinator

Andras Kovacs Broadbit

Wenhui Zhang NEC

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Older Slides
(content and figures must be updated according to published D1.2 and D2.2)

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C2CNet: Introduction
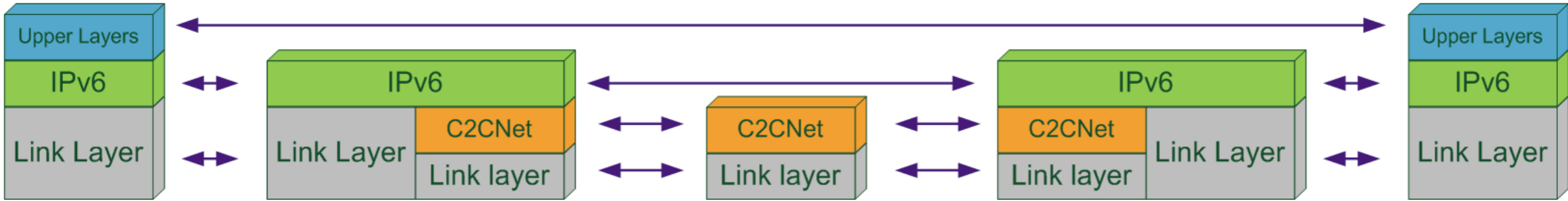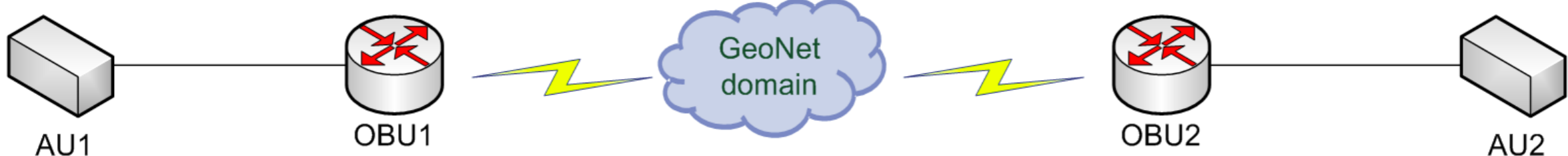
GeoNet GeoUnicast

- Packets are forwarded from the source to the destination based on geographical information.
  - *In GeoNet, we consider greedy forwarding mechanism.*
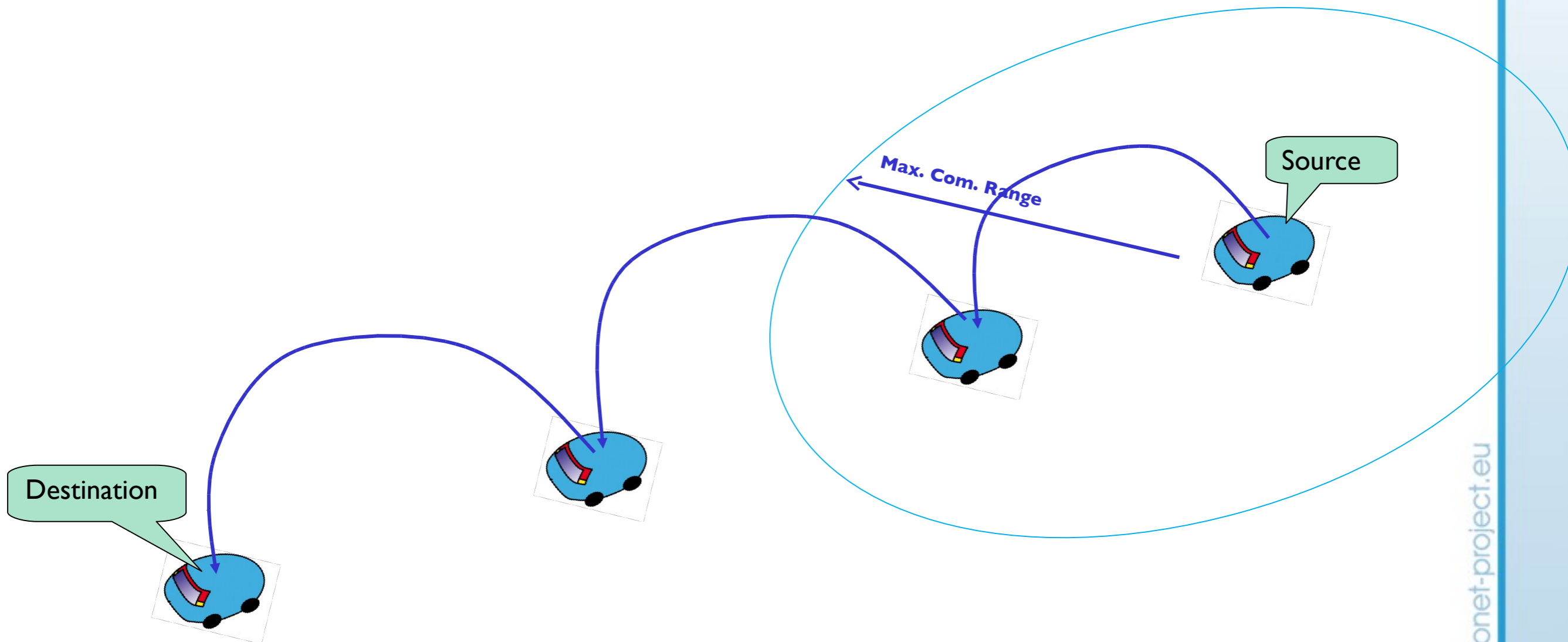
GeoNet GeoBroadcast

- Packets are forwarded from the source to all the nodes geo-located within the geographical area.
  - *In GeoNet, we consider geo-flooding mechanism.*
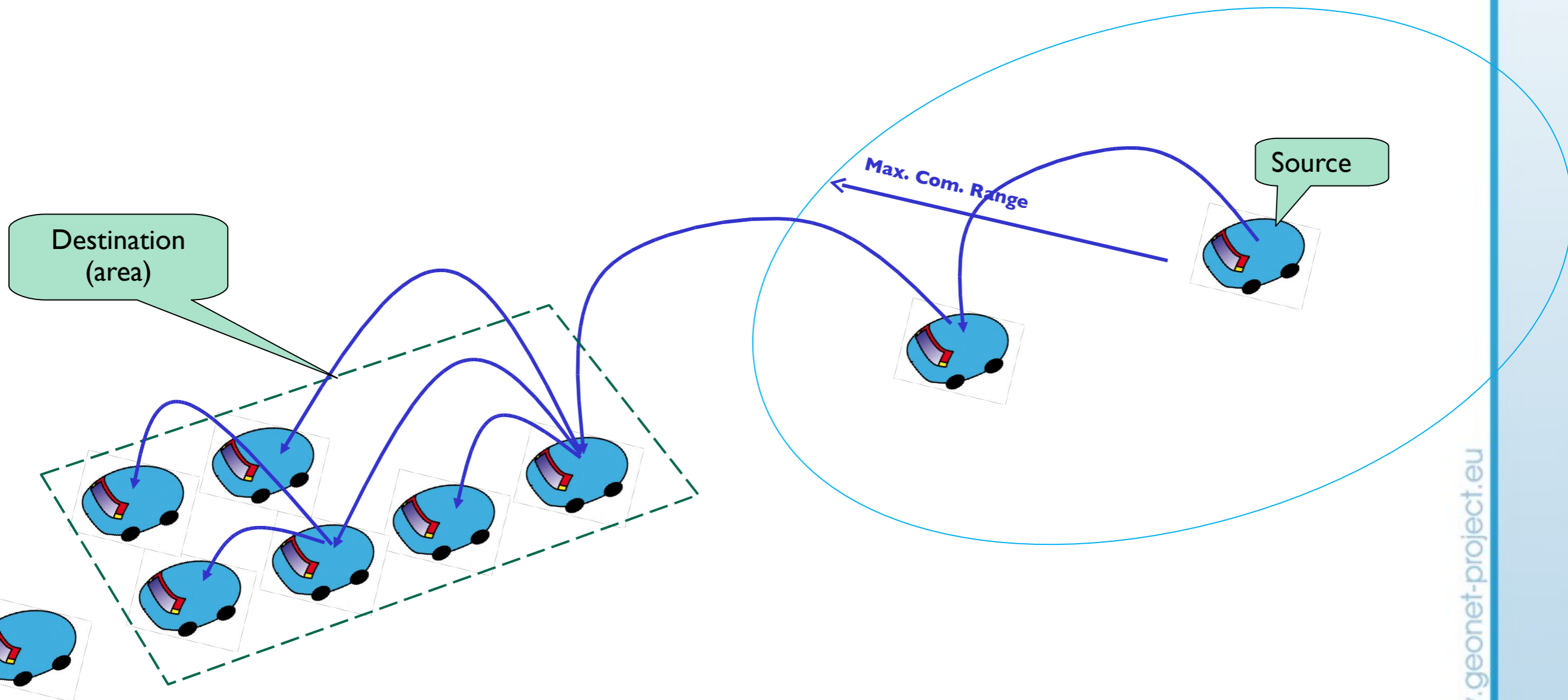
GeoNet GeoAnycast

- Packets are forwarded from the source until reaching any node geo-located within a certain area.
  - *In GeoNet, we consider greedy forwarding mechanism.*
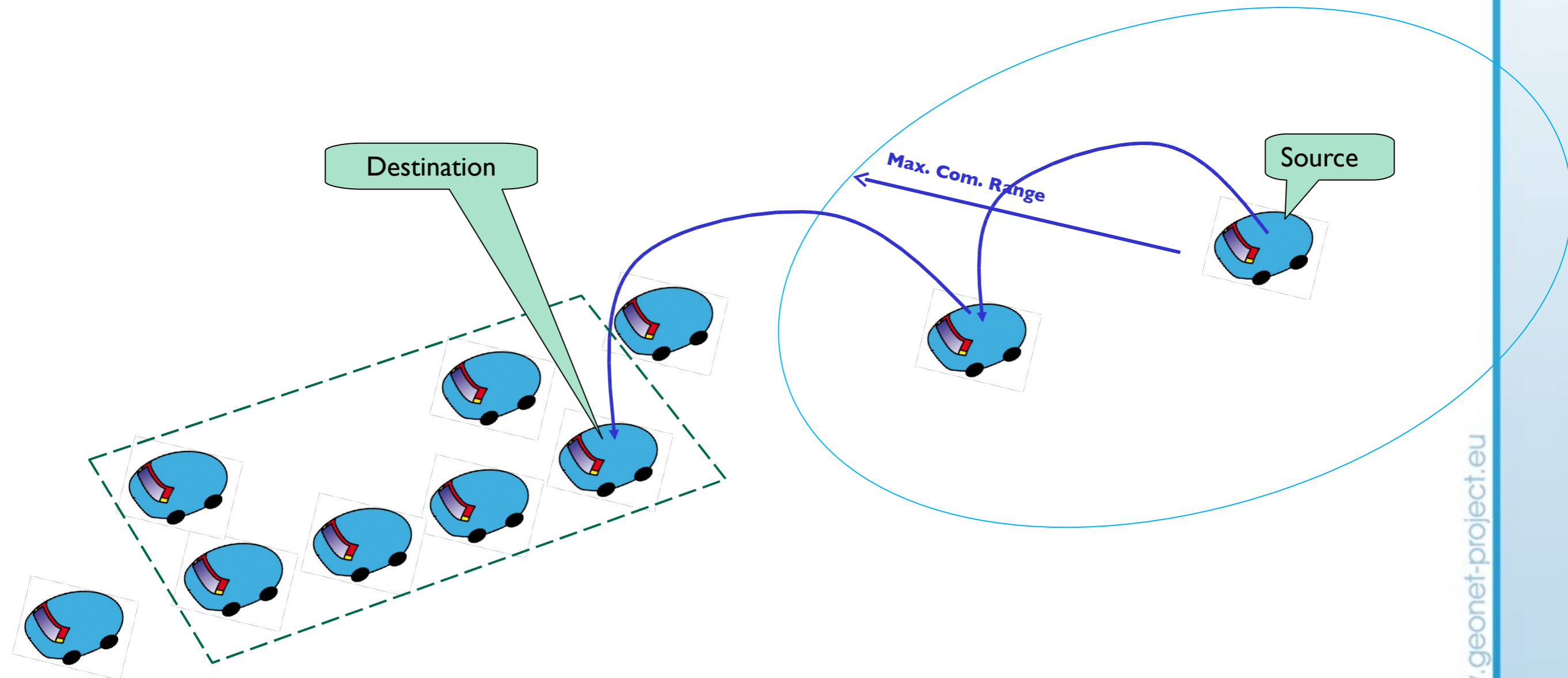
GeoNet topo-broadcast

- Packets are forwarded to all surrounding nodes, hope by hop, up to a certain distance (in hops).
  - *In GeoNet, we consider flooding mechanism.*
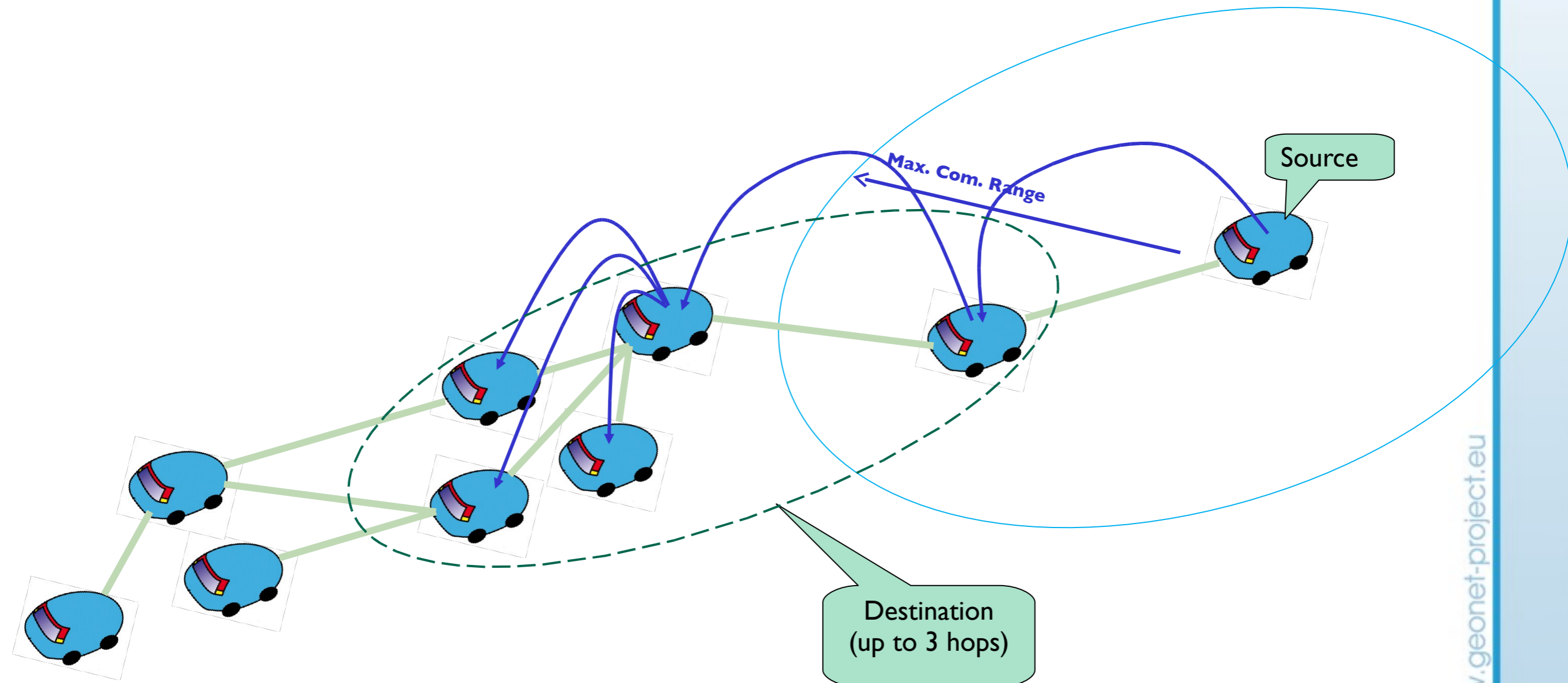
GeoNet: Vehicle testbed

GeoNet Emulation (NCTUns)
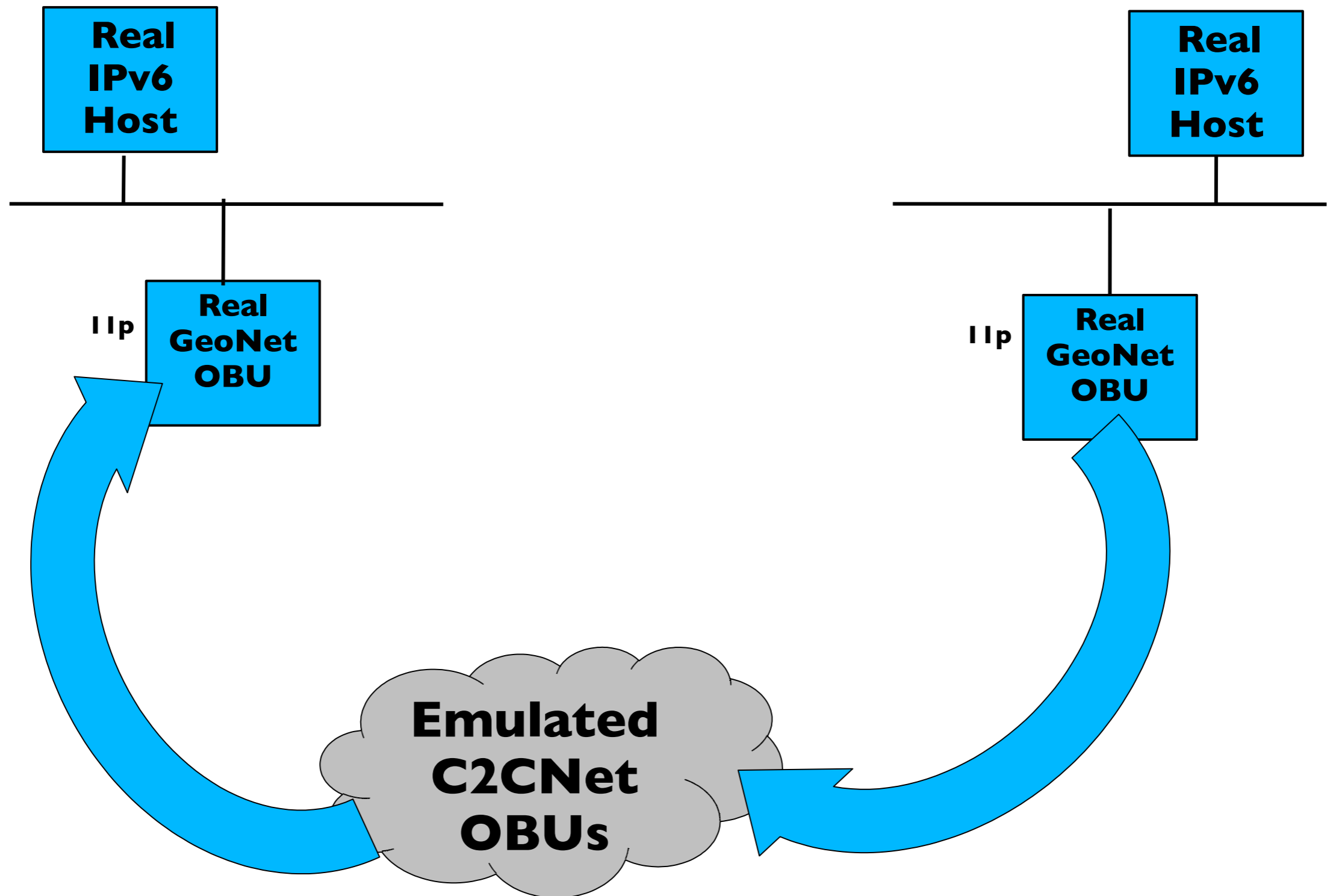
Wrong Way Driver Warning

Ghost Driver

Slow down

Broadcast/Push
Roadside unit → Vehicle
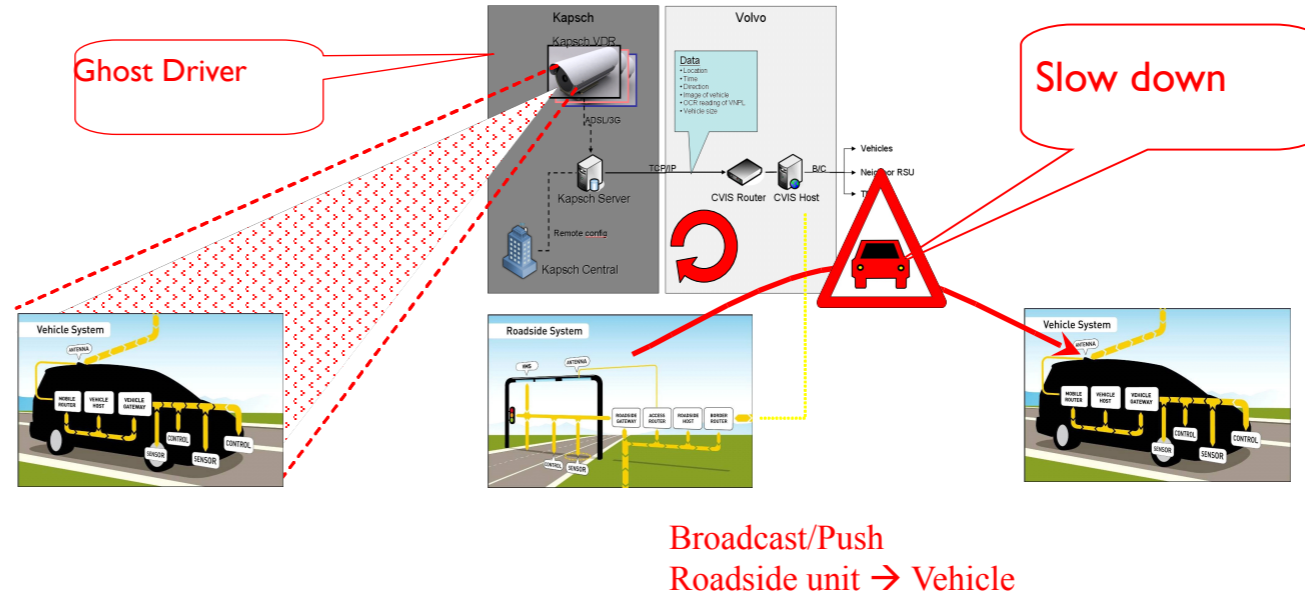
Traffic Hazards Warning

Hazard

Slow down

Broadcast
Vehicle→ Vehicle
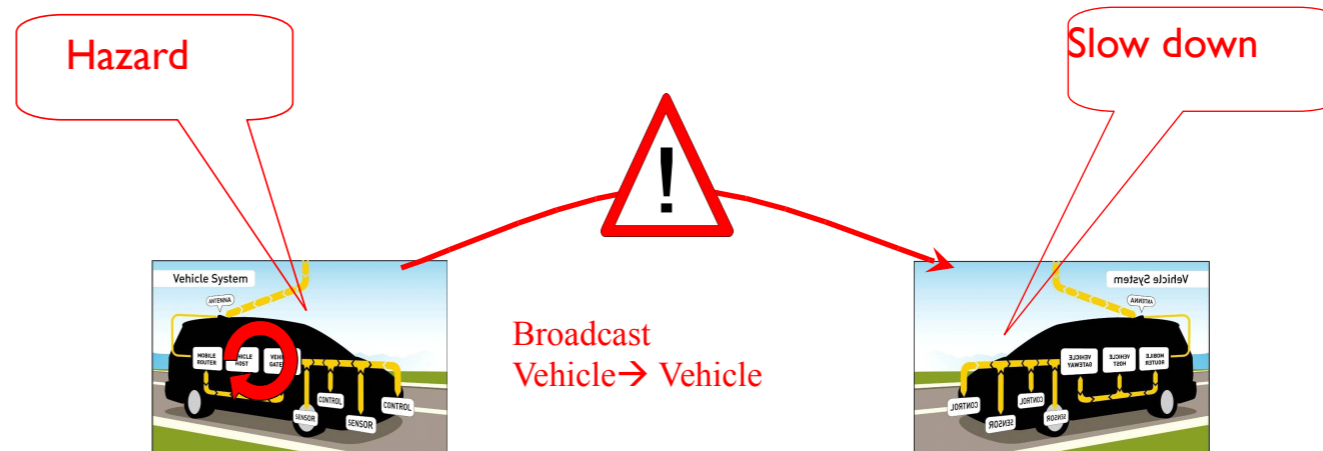
Traffic jams, Broken down vehicle

Dynamic Speed Limit Warning

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Speeding

Broadcast
Roadside unit → Vehicle

Road works warning

Slow down

Broadcast
Roadside unit → Vehicle

Conclusion
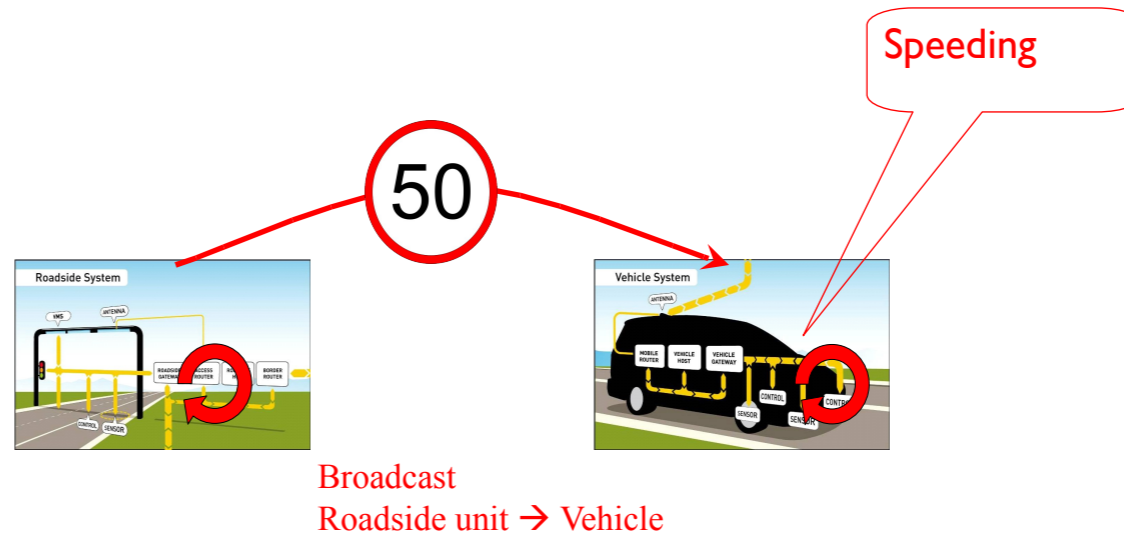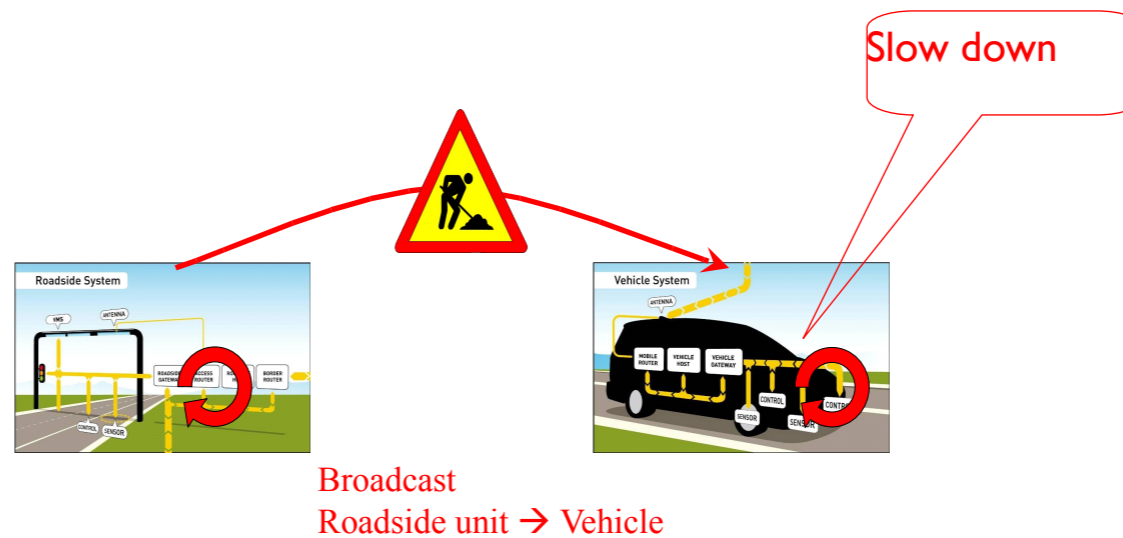
- **IPv6 & geonetworking are combined**
  - IPv6 multicast is hiding geonetworking from the application layer => IPv6 applications could exploit geonetworking without modification
  - C2C-NET is providing for geonetworking

- **Status**
  - 1 reference specification, 2 prototype implementations
  - Experimentation on a fleet of 4 vehicles
  - Emulation with NCTUns and real vehicles
  - CVIS selected as the target platform

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Enabling Technologies

- Geographic addressing
- Geographic routing

- IPv6 geonetworking
- IPv6 support with backward compatibility
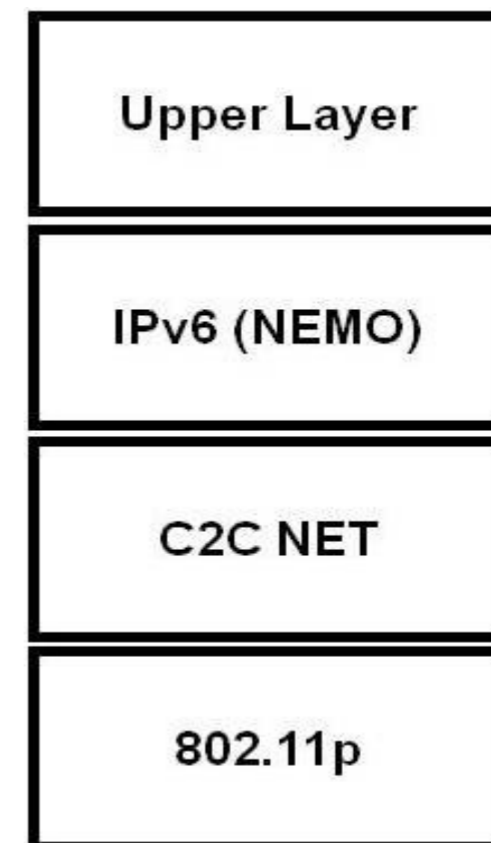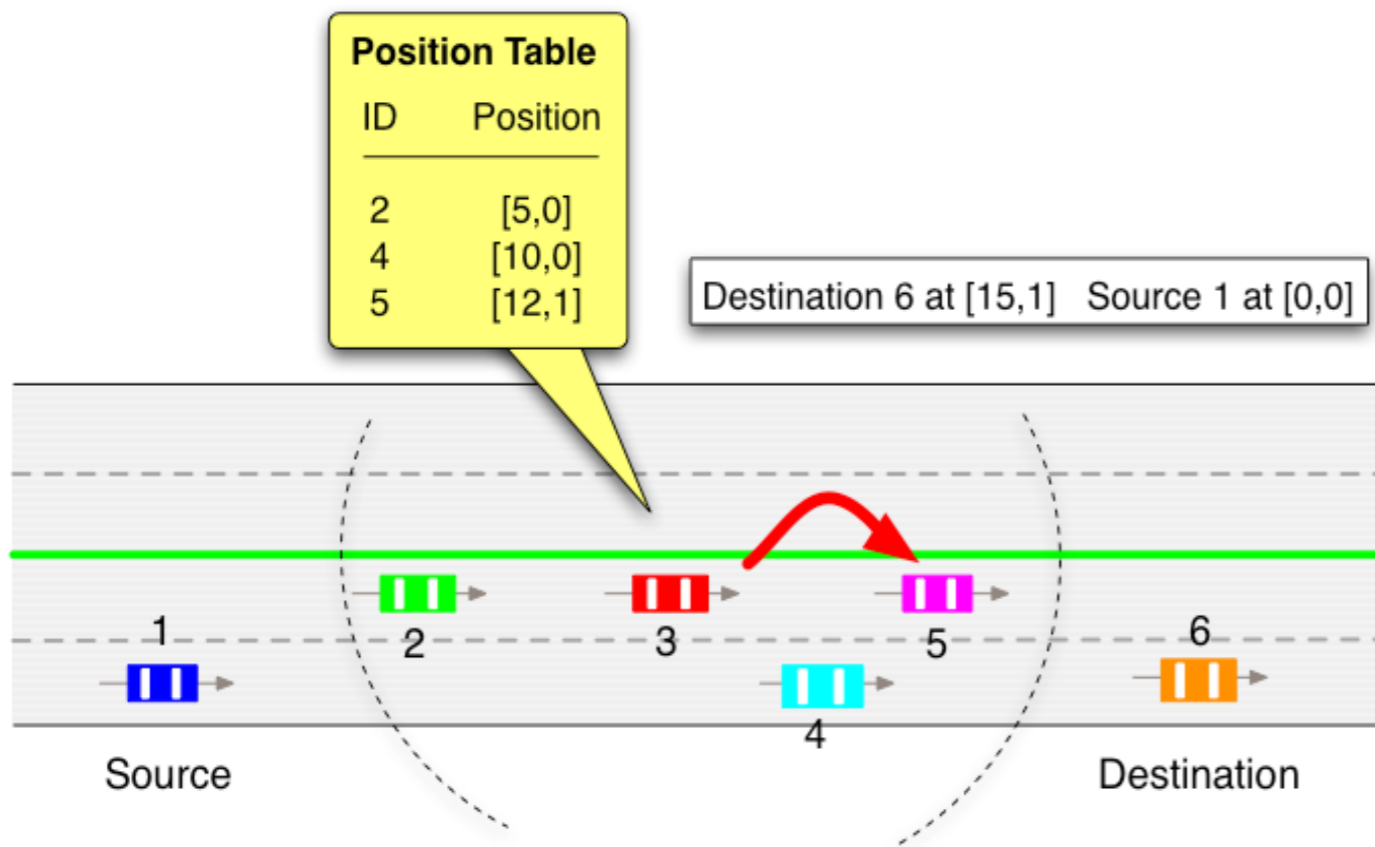
C2C-NET Forwarding Types

- Geo-unicast
- Geo-anycast
- Geo-broadcast
- Topologically scoped broadcast
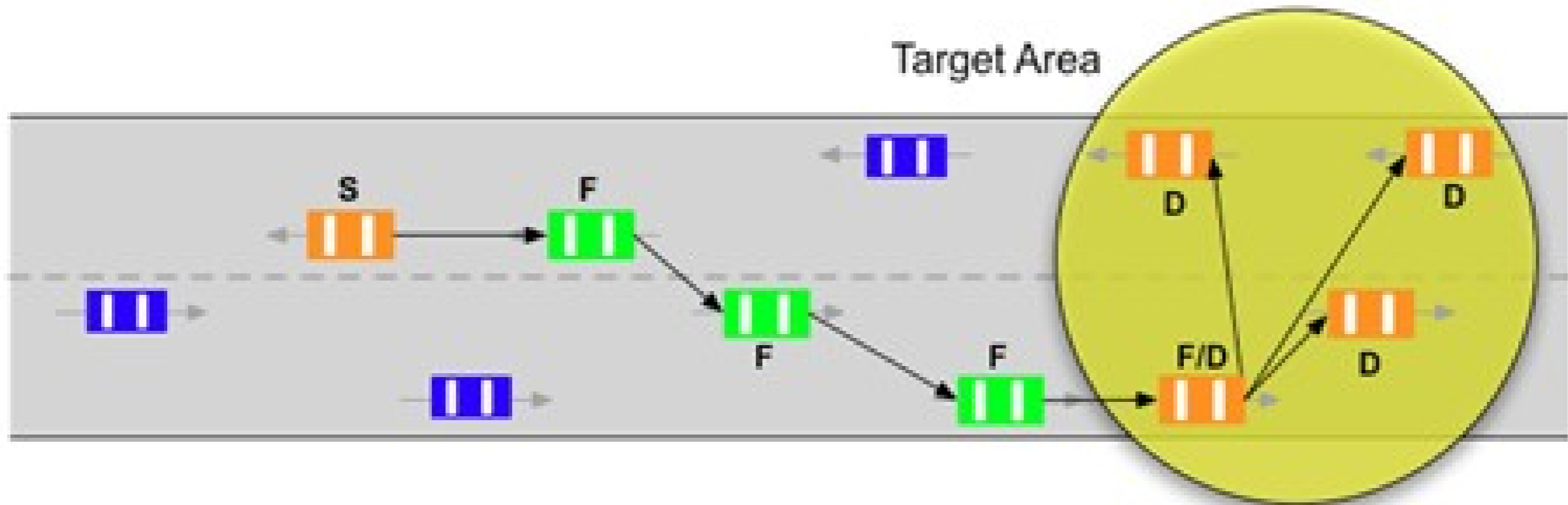
Geo-broadcast

IPv6 Forwarding

- IPv6 over C2C-NET
- Support IPv6 NEMO tunnel
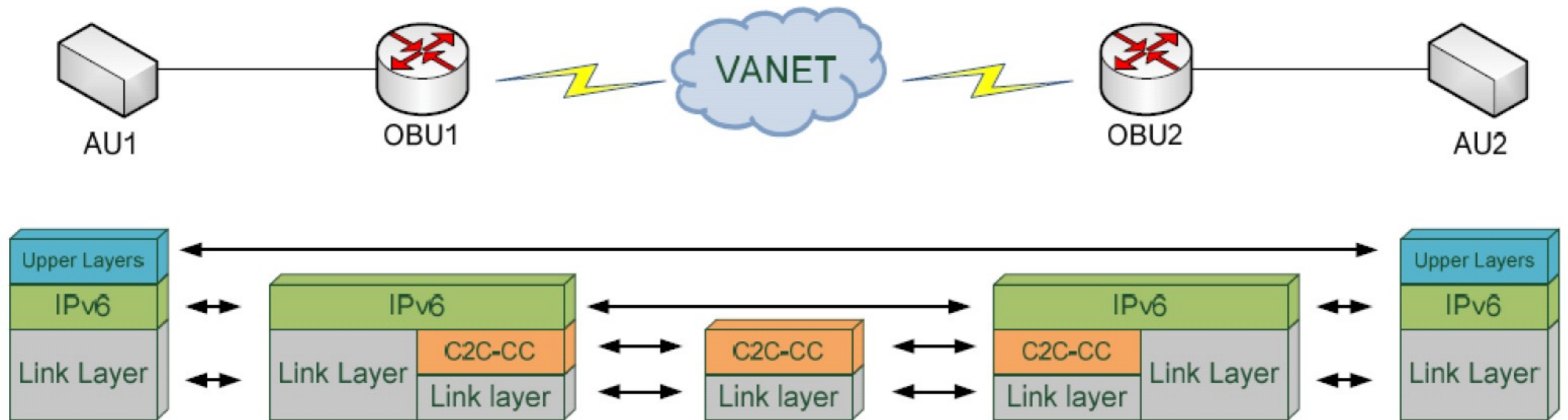
Conclusion

- IPv6 & geonetworking are combined
  - IPv6 multicast hides geonetworking from the application layer
  - Very few modification required for IPv6 application
  - C2C-NET provides geonetworking

- Status
  - 1 reference specification
  - 2 prototype implementations
  - Experimentation on a fleet of 4 vehicles
  - Emulation with NCTUns and real vehicles
  - CVIS selected as the target platform

- Standardization challenge

IPv6 Addressing

- Permanent IPv6 prefix (MNP) is configured in the vehicle
  - Allows vehicle nodes to be reached at a permanent address
  - Allows correspondent to retrieve the address in the DNS
  - Allows to maintain session continuity while moving (NEMO)
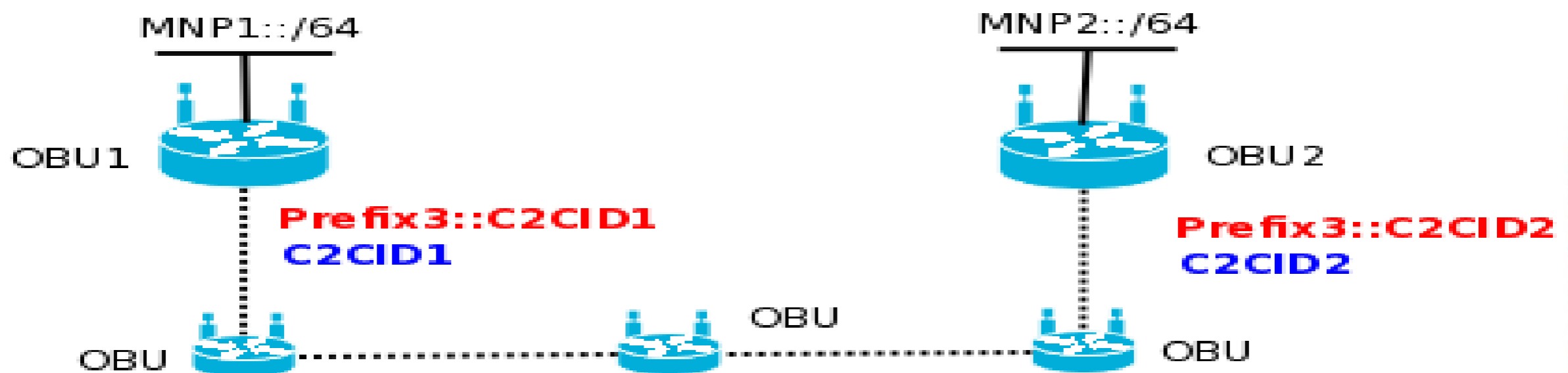
IPv6 Mobility Support (NEMO)

- Vehicle keeps IPv6 prefix (MNP)
- OBU/MR configures a transient global Care-of Address (CoA) from the IPv6 prefix announced by each subsequent RSU/AR
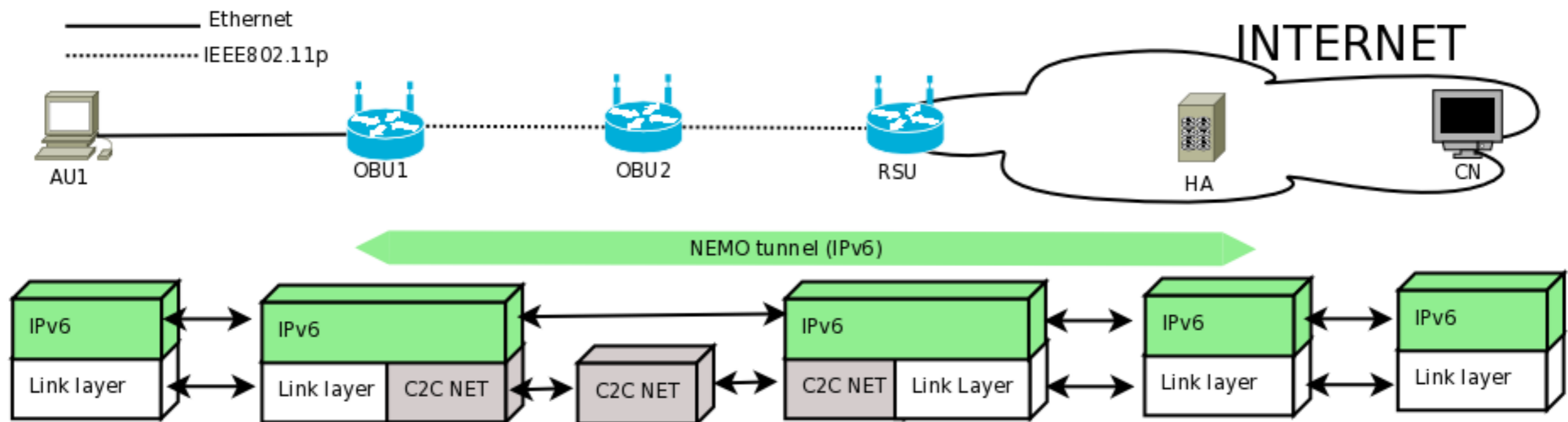
IPv6 Forwarding: V2V

- OBU1/MR1 needs to discover MNP of OBU2/MR2
- NDP extensions to announce MNPs to all OBUs/MRs on the C2C-NET IPv6 link
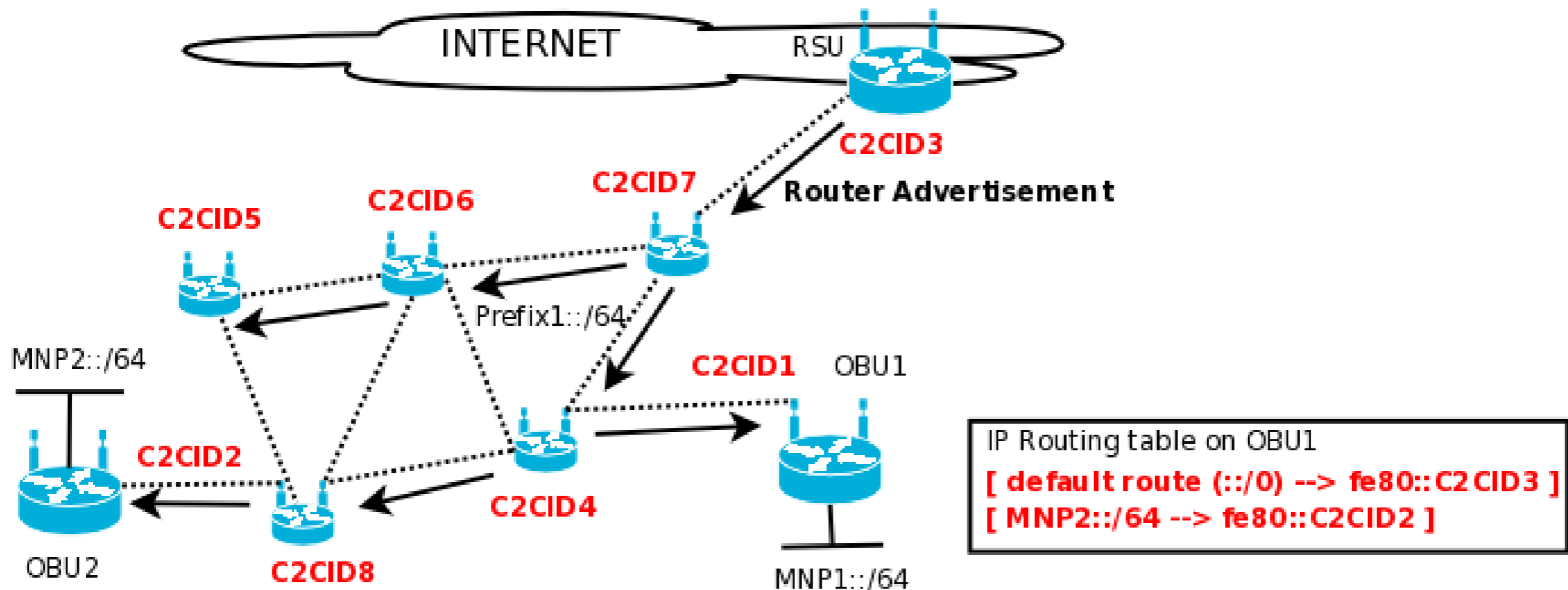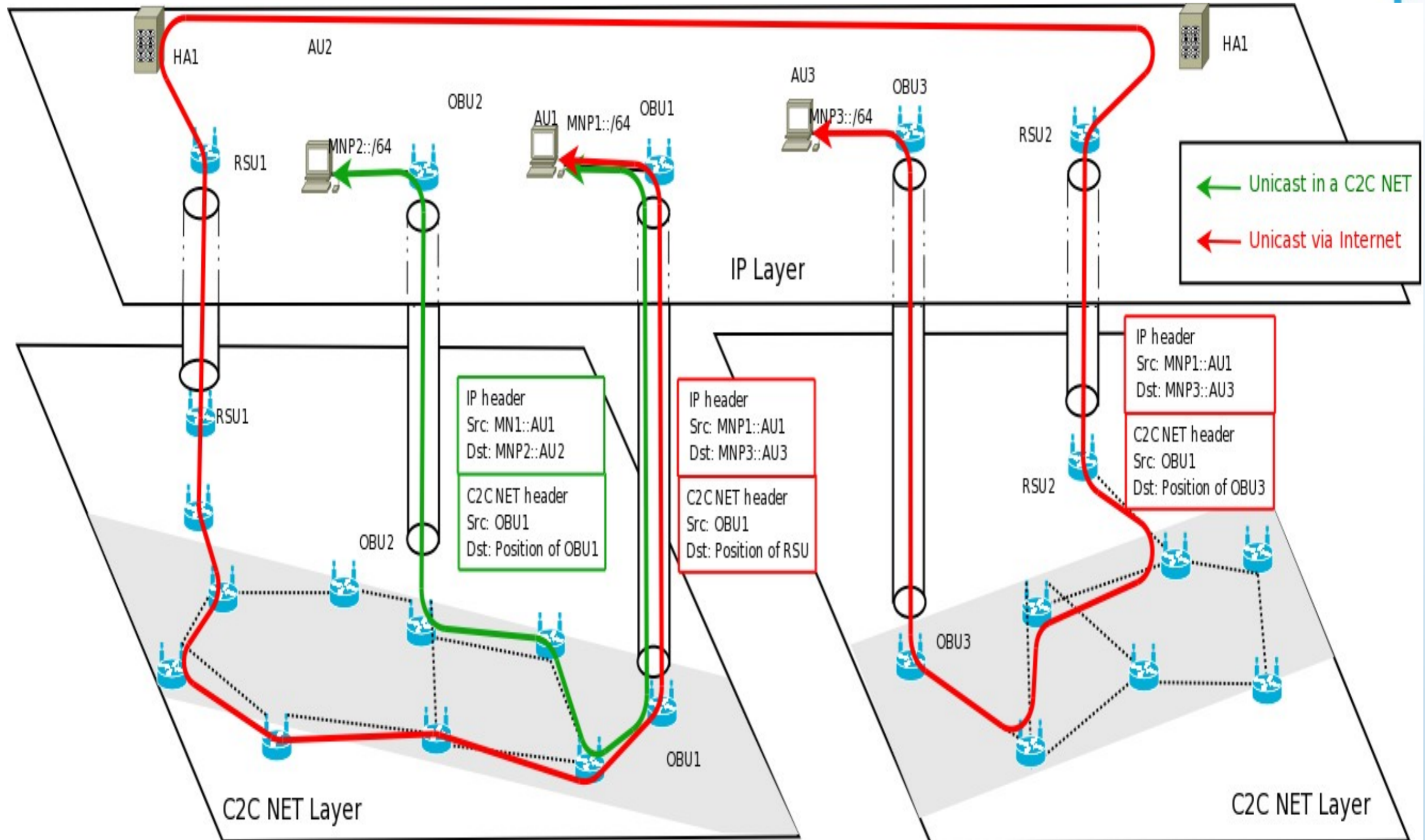
IPv6 Forwarding: Next Hop

- Routing: Sending OBU determines next IP hop to OBU serving IP destination
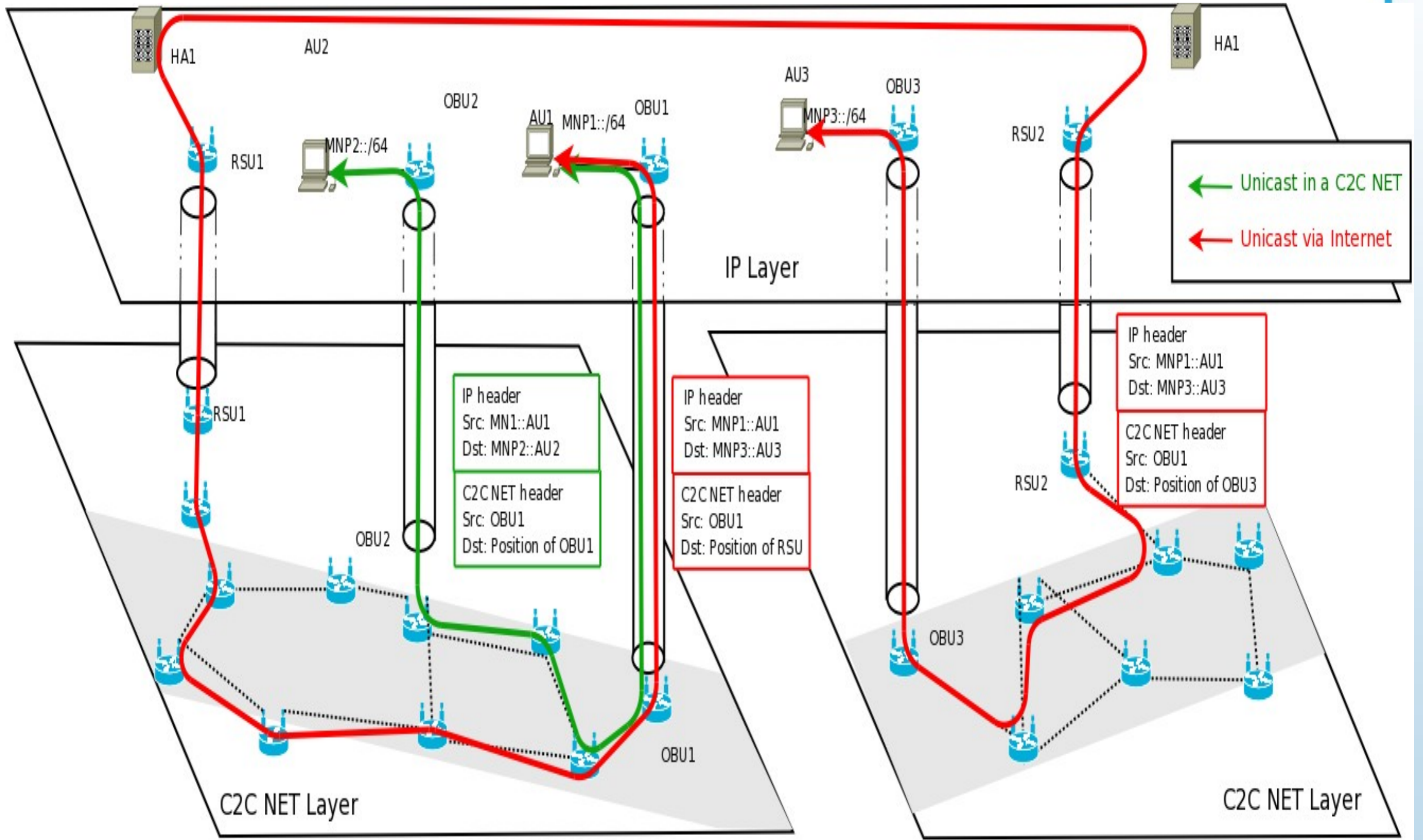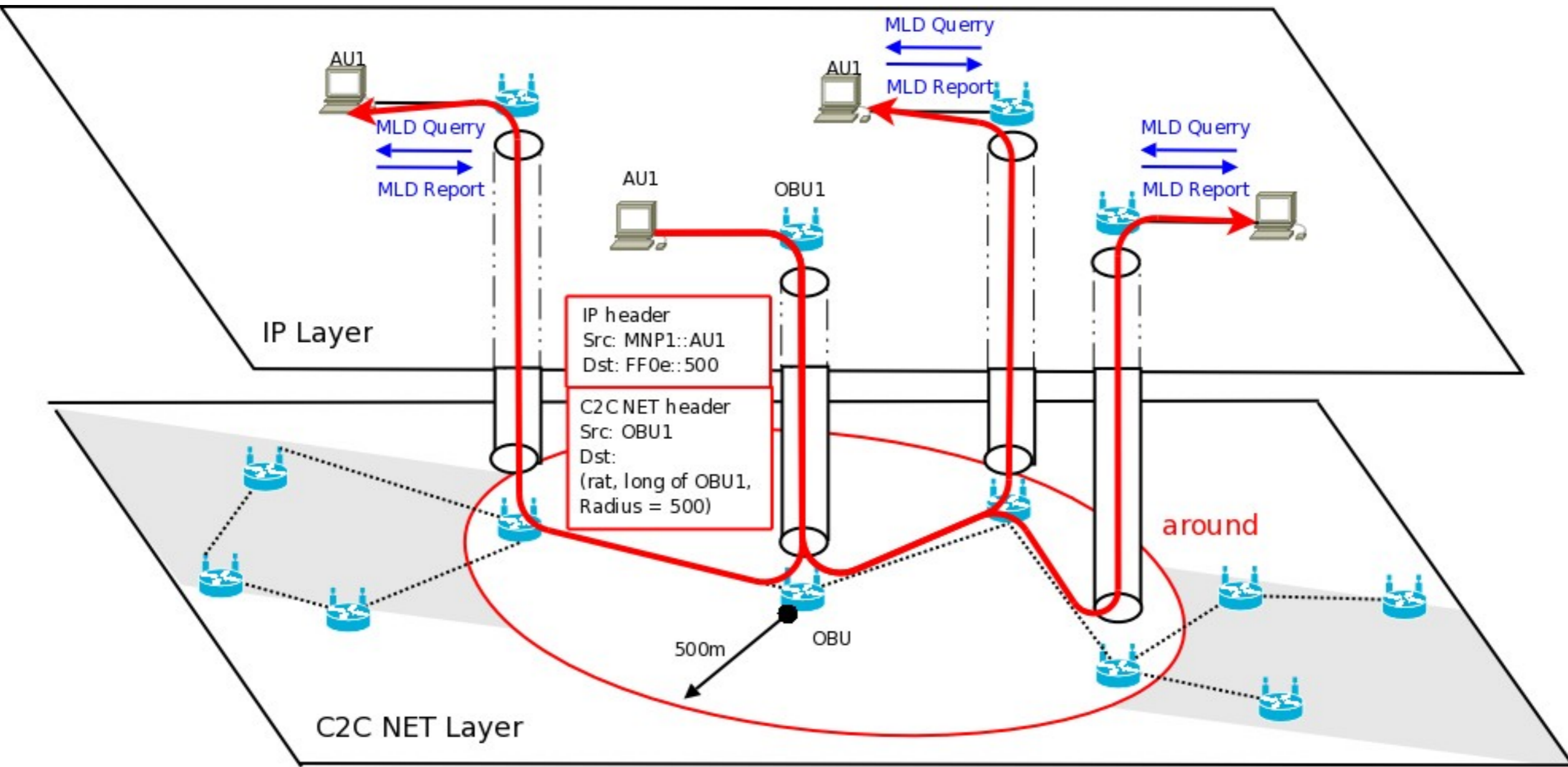
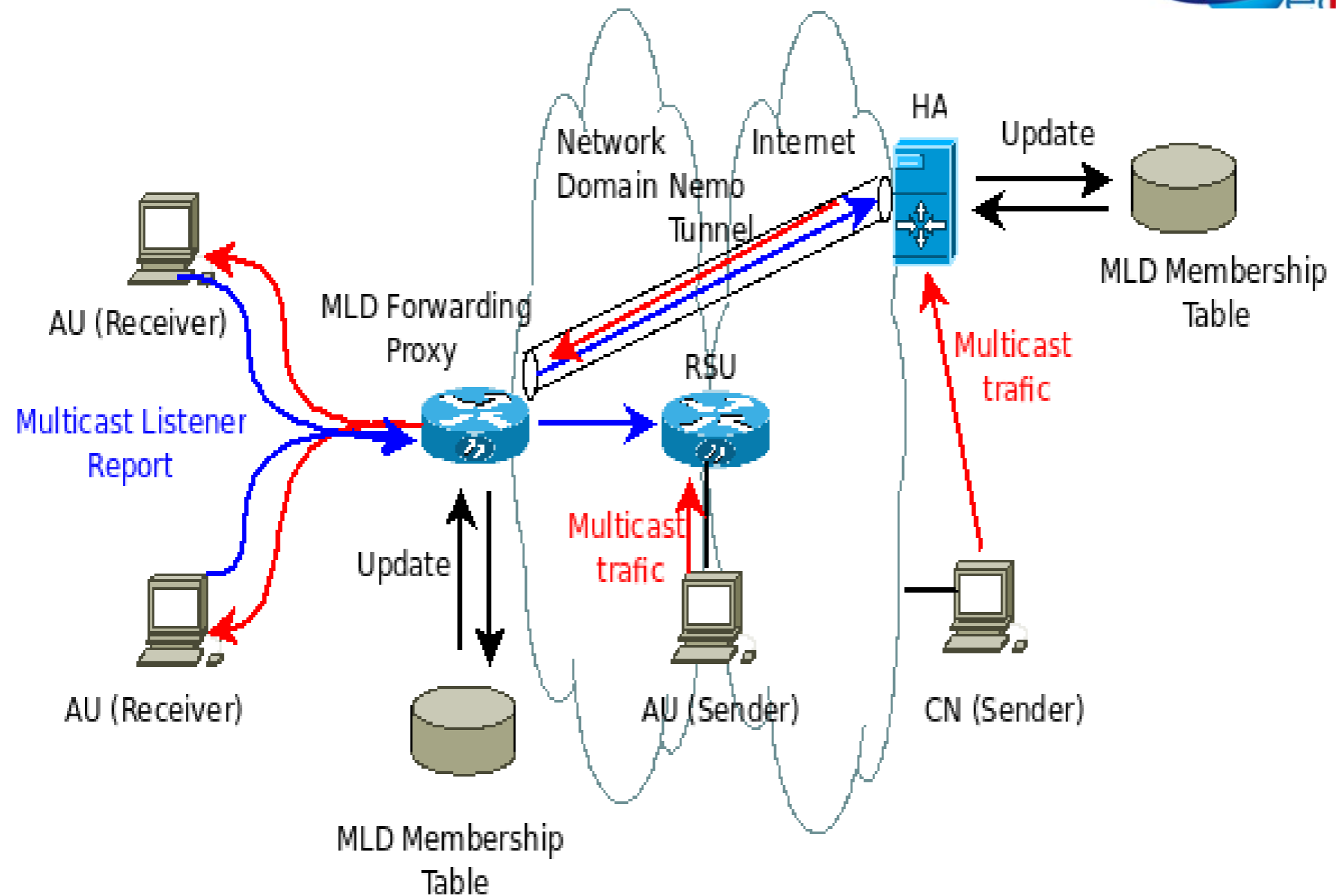- Diagram: Finding OBU3 from destination IPv6 address
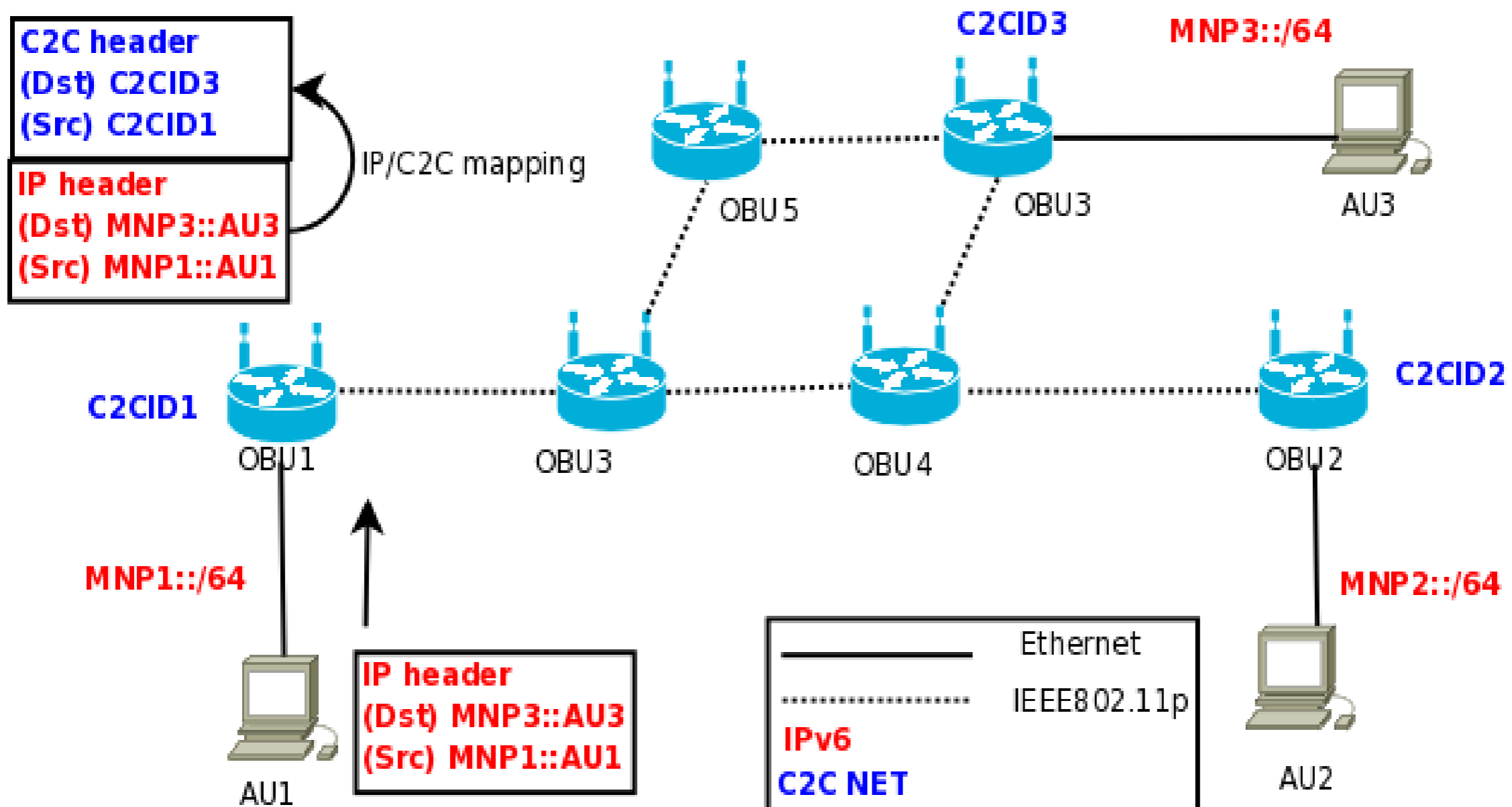
IPv6 Multicast

- Group ID = identify a group of nodes interested to receive a given service
- Nodes in given geographic area interested in the service must join the group
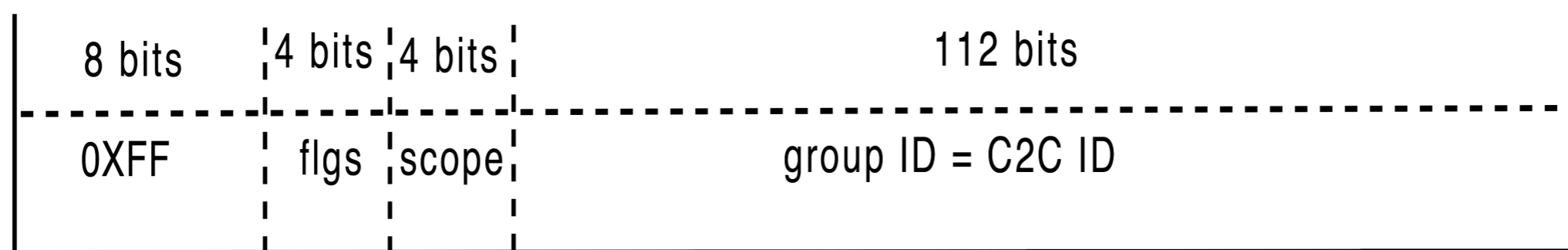
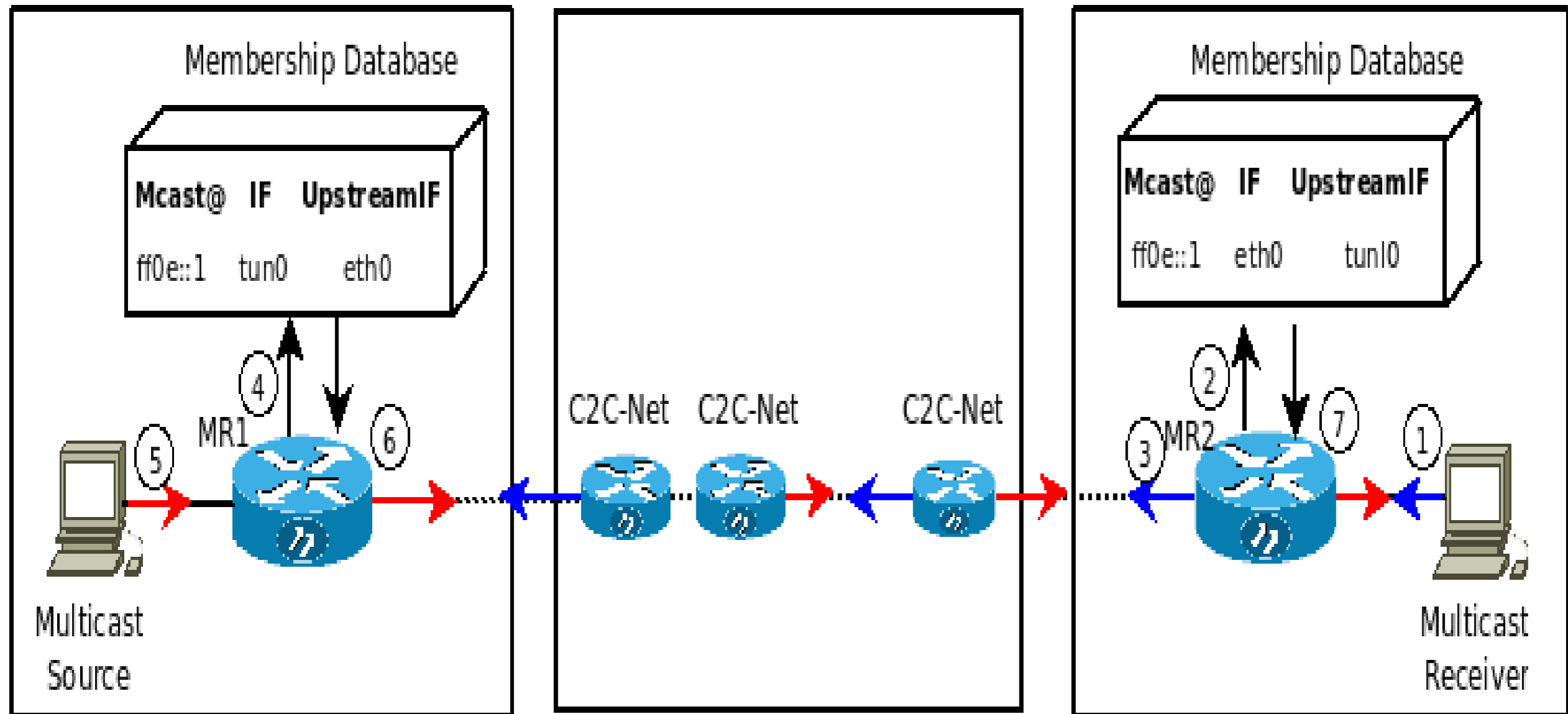| 8 bits	4 bits	4 bits	112 bits
0XFF	flgs	scope	group ID = C2C ID

IPv6 Routing

AU1

MLD Querry

MLD Report

MLD Querry

MLD Report

AU1

MLD Querry

MLD Report

AU1

AU1

OBU1

MLD Querry

MLD Report

IP Layer

IP header
Src: MNP1::AU1
Dst: FF0e::500

C2C NET header
Src: OBU1
Dst:
(rat, long of OBU1,
Radius = 500)

around

500m

OBU

C2C NET Layer

MLD Forwarding Proxy

Static Multicast Delivery

IPv6 Mobility Support

Conclusion

- **IPv6 & geonetworking are combined**
  - IPv6 multicast hides geonetworking from the application layer
  - Very few modification required for IPv6 application
  - C2C-NET provides geonetworking

- **Status**
  - 1 reference specification
  - 2 prototype implementations
  - Experimentation on a fleet of 4 vehicles
  - Emulation with NCTUns and real vehicles
  - CVIS selected as the target platform

- **Standardization challenge**