

Location-aware service discovery on IPv6 GeoNetworking for VANET

Satoru Noguchi¹, Manabu Tsukada², Thierry Ernst²,
Atsuo Inomata¹, Kazutoshi Fujikawa¹,

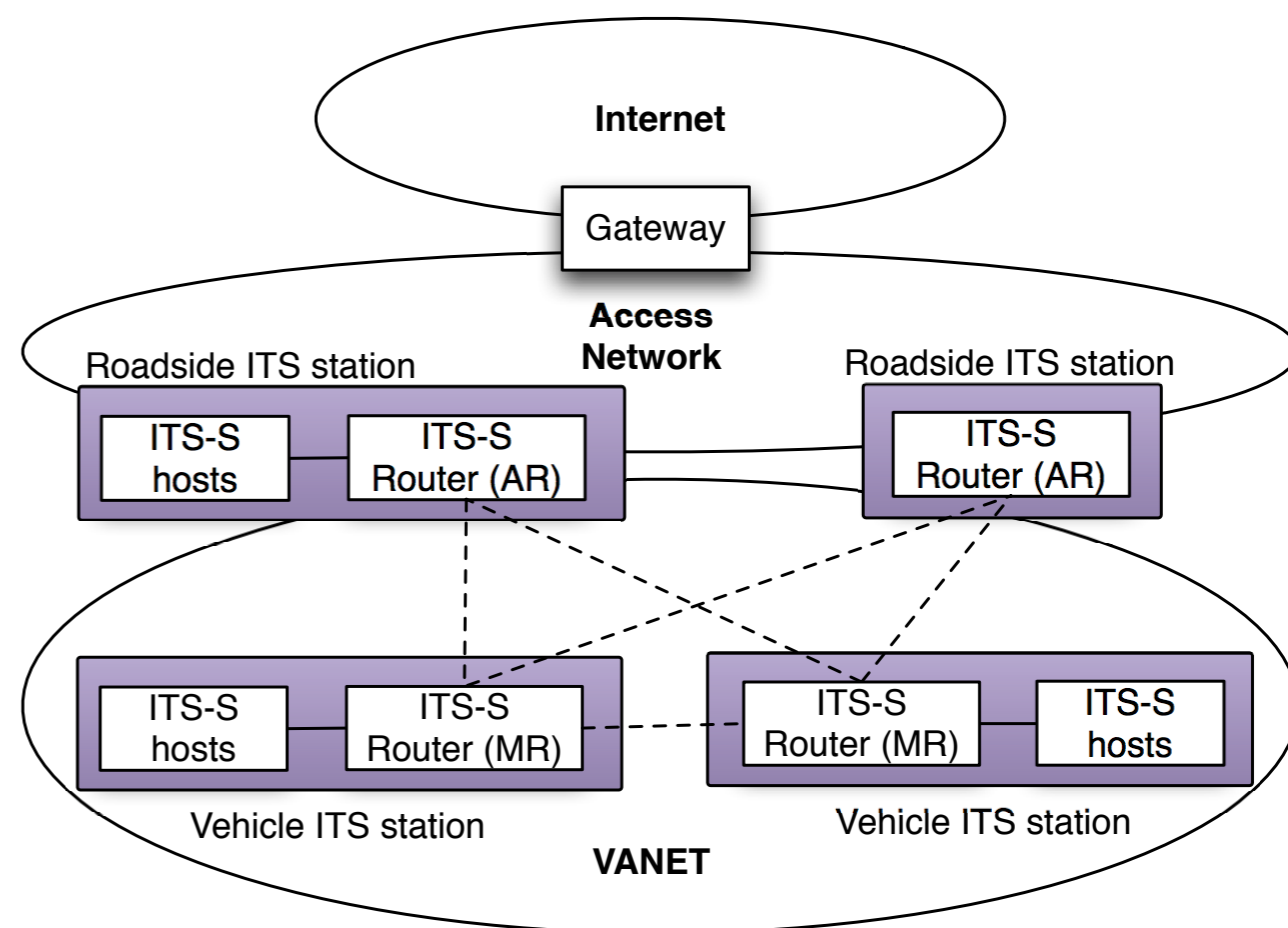
¹ Nara Institute of Science and Technology, Japan

² INRIA Rocquencourt/Mines ParisTech - CAOR Lab



ITS application and services

- Distributed application in Vehicles, Roadsides and Internet hosts integrated into ITS stations in vehicular communication systems
- Composed of wide variety of **services**:
 - Software and/or hardware entities providing a distinct capability



Service Discovery Protocol (SDP)

- ITS applications need to orchestrate multiple services remotely
- IP routing has already been deployed, but available/
appropriate services for a particular user are variable
 - Depending on time, driving condition, geographic location...
- SDP dynamically discovers available services
 - SDP: Locate communication endpoints (i.e. socket) of services with application specific criteria
 - IP routing: If a node knows destination's IP address, it can access necessary services

Requirements for ITS SDP in VANET

1. Geographical location aware: discover services according to geographical location
 - ITS-related services are highly dependent on geographical location
2. Low latency discovery (i.e. from 10ms to 1000ms)
 - For critical use cases
3. Low bandwidth usage
 - i.e. For highly-congested intersections

IPv6 GeoNetworking

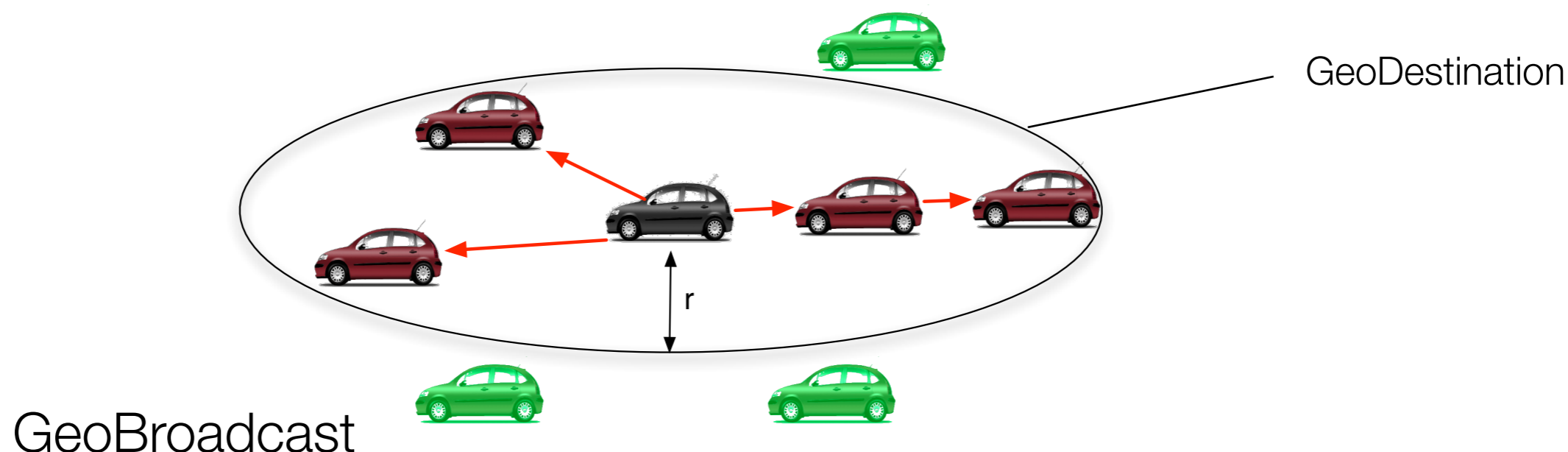


- Adaptation of IPv6 to **C2CNet layer**: supports geographical addressing and routing by means of encapsulating IPv6 packet with a C2CNet header
 - C2CNet header contains source and destination C2CNet identifier, source and destination geographic position
 - By nature C2CNet layer exchanges packets without IP
 - EU project GeoNet defined how to transmit IPv6 packets over C2CNet; *“IPv6 over C2CNet”*
- Reference specification has been published by GeoNet

Geographical routing



- Deliver IPv6 packets to all nodes inside a particular geographical area (GeoDestination)
 - i.e. A particular IPv6 address can be used as a GeoDestination; FF0E::1 -> a 500m radius centred from sender (GeoBroadcast)
- Upper layers can transparently use Geographical routing via regular IPv6 API

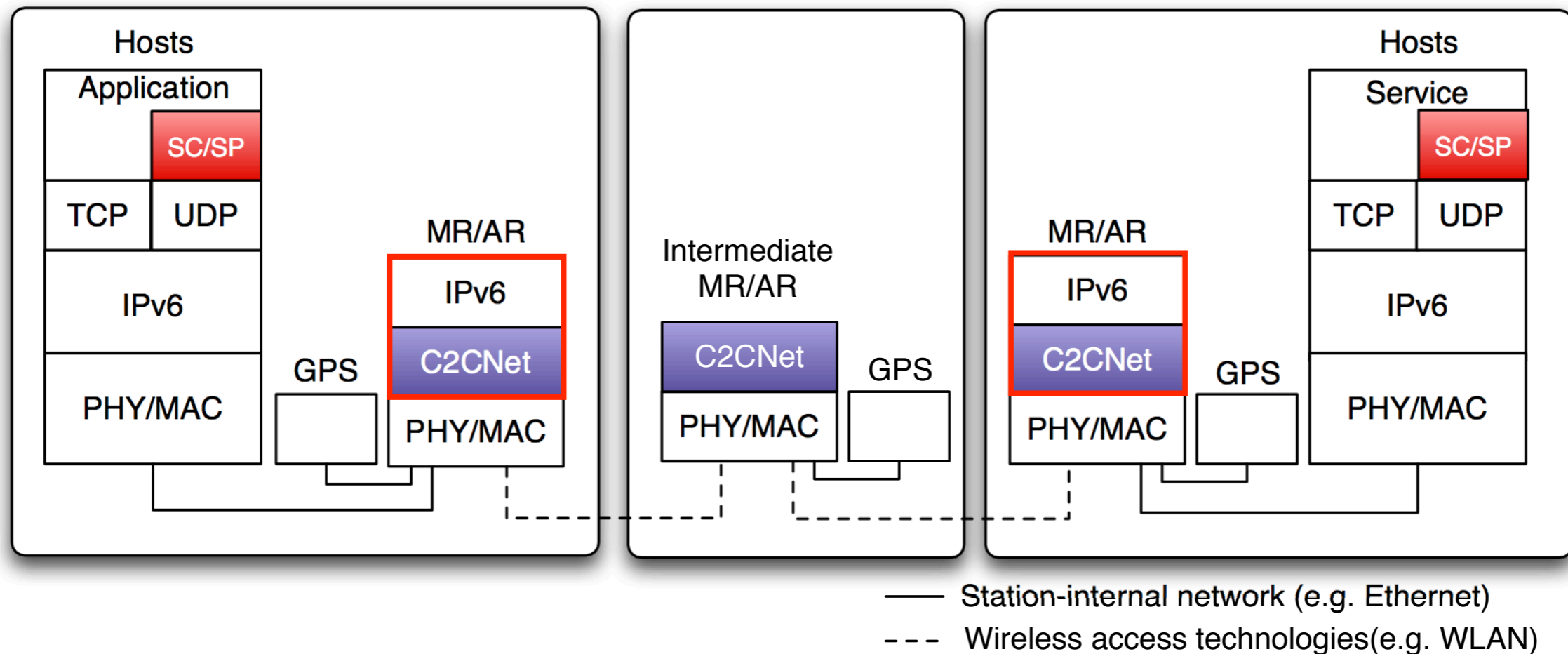


Service location protocol version2 (SLPv2) with IPv6 modification

- Standardized by IETF; RFC2608, 3111
- Discover services using IPv6 multicast
 - One multicast address for one service (Address range: $FF0x::1:1000 - FF0x::1:13FF$)
- Support centralized/distributed discovery with/without Directory Agent
- Pros: reduce unnecessary messages; deliver service discovery messages to a specific subset of nodes

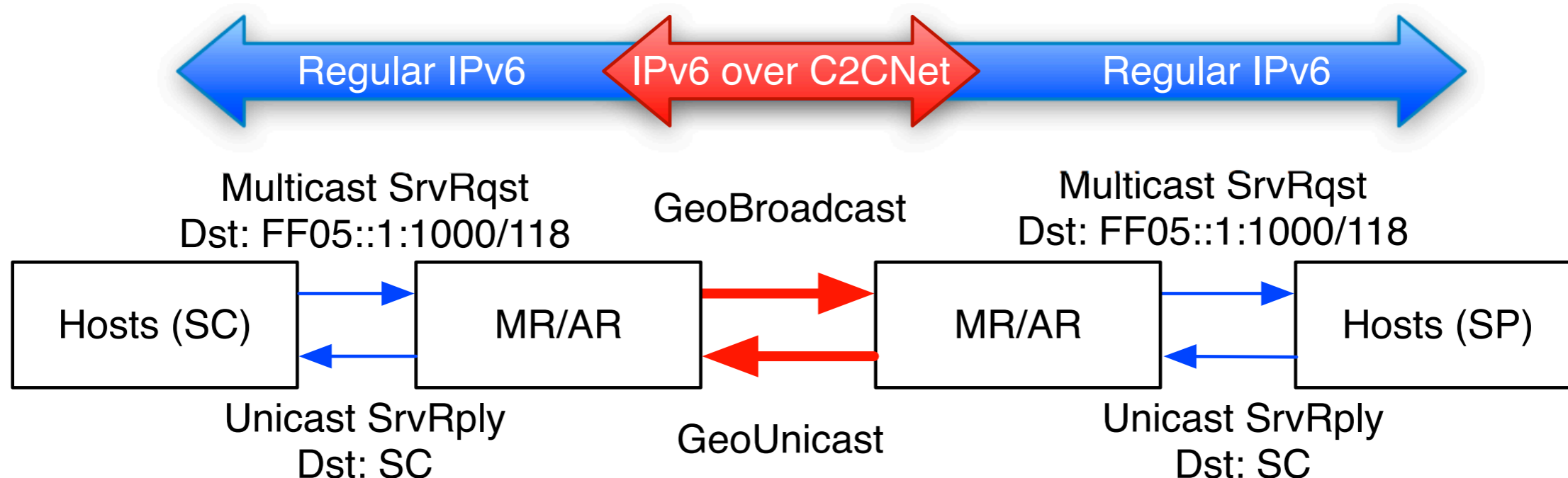
Multicast-based service discovery on IPv6 GeoNetworking

- Service discovery protocol: SLPv2 with IPv6 modification
 - Multicast request / Unicast reply
- VANET routing: IPv6 GeoNetworking
 - SDP Components: Service Consumer (SC), Service Provider (SP)

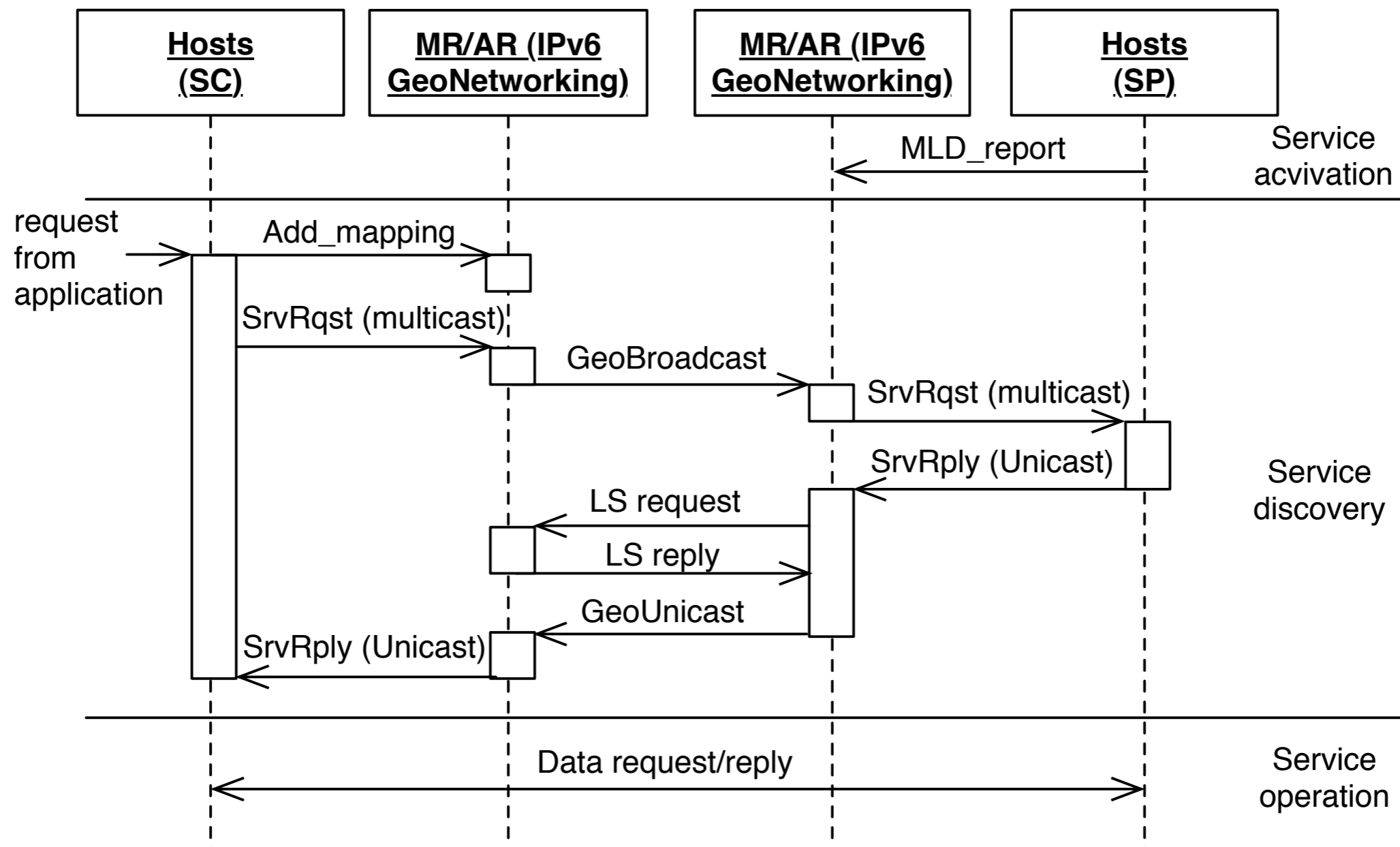


SDP Packet encapsulation

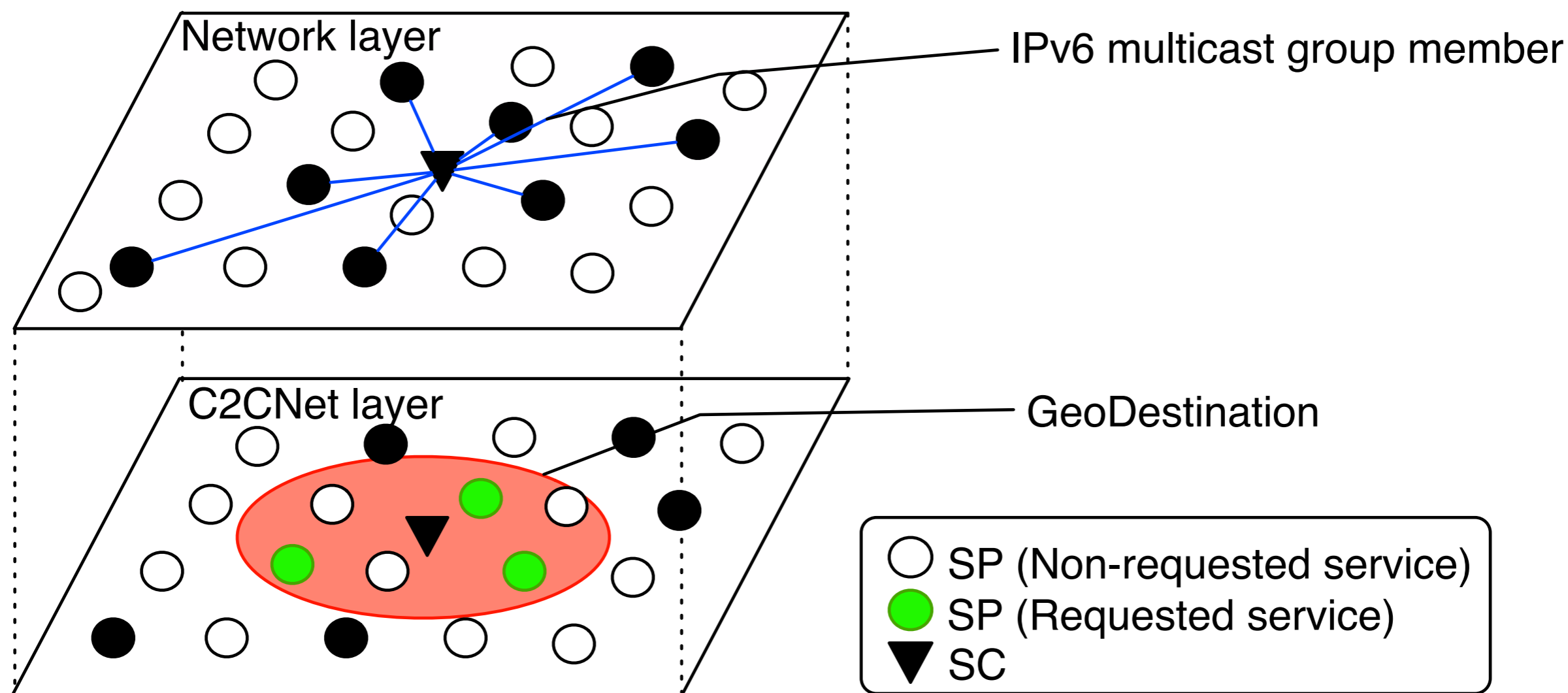
1. SC sends a service discovery request message (SrvRqst in SLP) through IPv6 multicast
2. Sender router encapsulates IPv6 multicast packet (SrvRqst) into GeoBroadcast packet and deliver corresponding destination
3. Receiver router decapsulate GeoBroadcast packet into IPv6 multicast packet and deliver it to SR



Message sequence



IPv6 multicast over GeoBroadcast



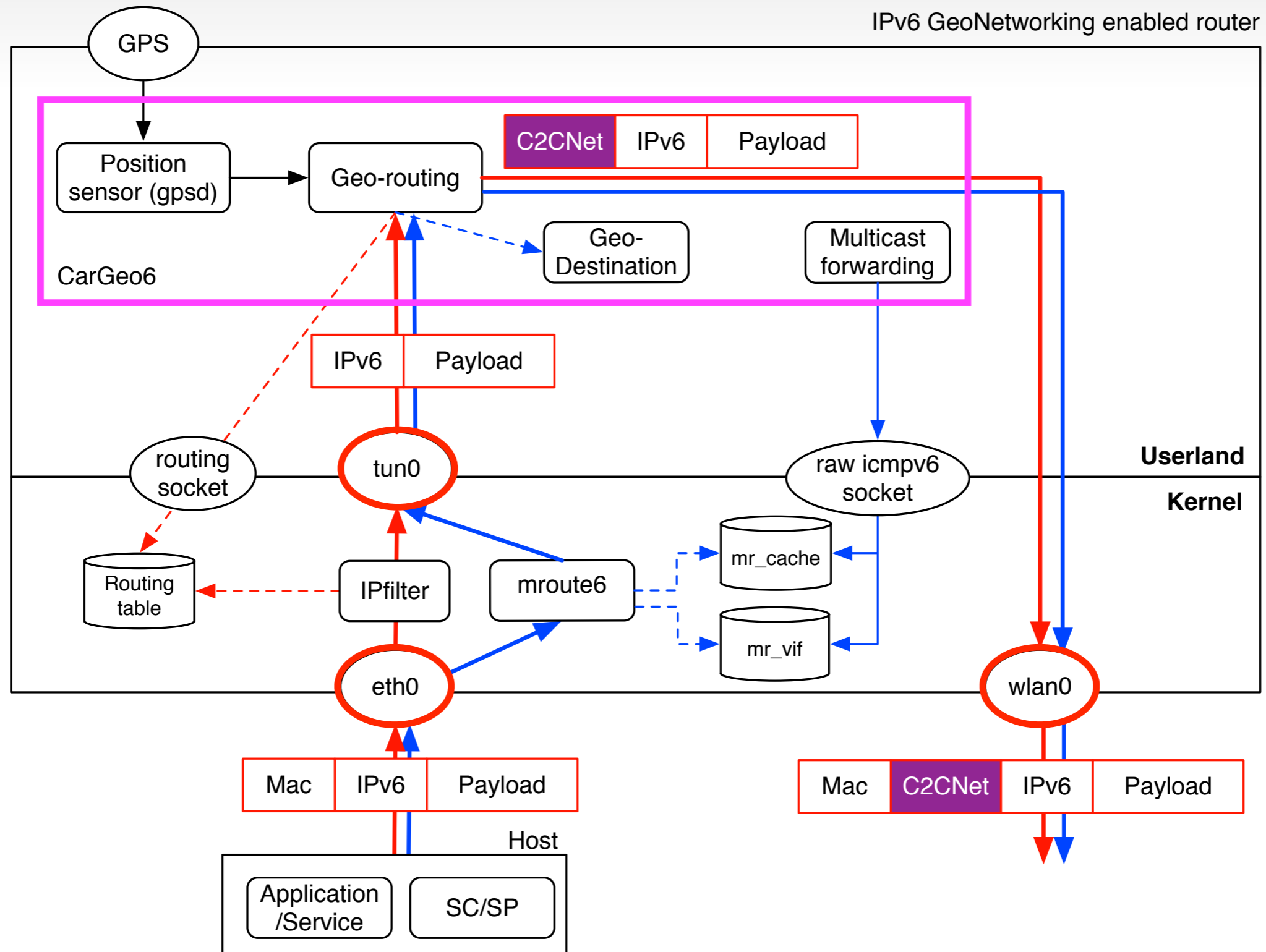
Implementation

- OS: Linux (Ubuntu 10.11, kernel 2.6.35 with IPv6 multicast forwarding support)
- SDP components: OpenSLP beta1
- IPv6 GeoNetworking: **CarGeo6** v0.9.8.1
 - Open implementation of IPv6 GeoNetworking reference specification by CarGeo6 Project
- IPv6 Multicast forwarding daemon (ingress <-> egress IF on router)
- gpsd-2.96



<http://www.cargeo6.org/>

Implementation (cont.)



Evaluation



- Field evaluation at NAIST (jp)
- 3 sets of ITS station (MR and Host)
 - 1 moving station (SC: Host1 and MR1), and 2 parking stations (SP1, SP2)
- WLAN (802.11 b/g)
- Duration: 720min

Entity	Parameter	Configuration
all Hosts	Number of services	100
Host1	Service discovery frequency	1Hz
	Radius of GeoBroadcast	Random (50m-200m)
all MRs	GPS position update frequency	1Hz
MR1, Host1	Driving speed	0-20km/h
	Distance from SP1(Single hop)	10m - 100m
	Distance from SP2(Multi hop)	120m - 200m

Evaluation Results

- End-to-end latency (min/max/average, ms)

- 1 hop: 3.59 / 23.3 / **7.86**

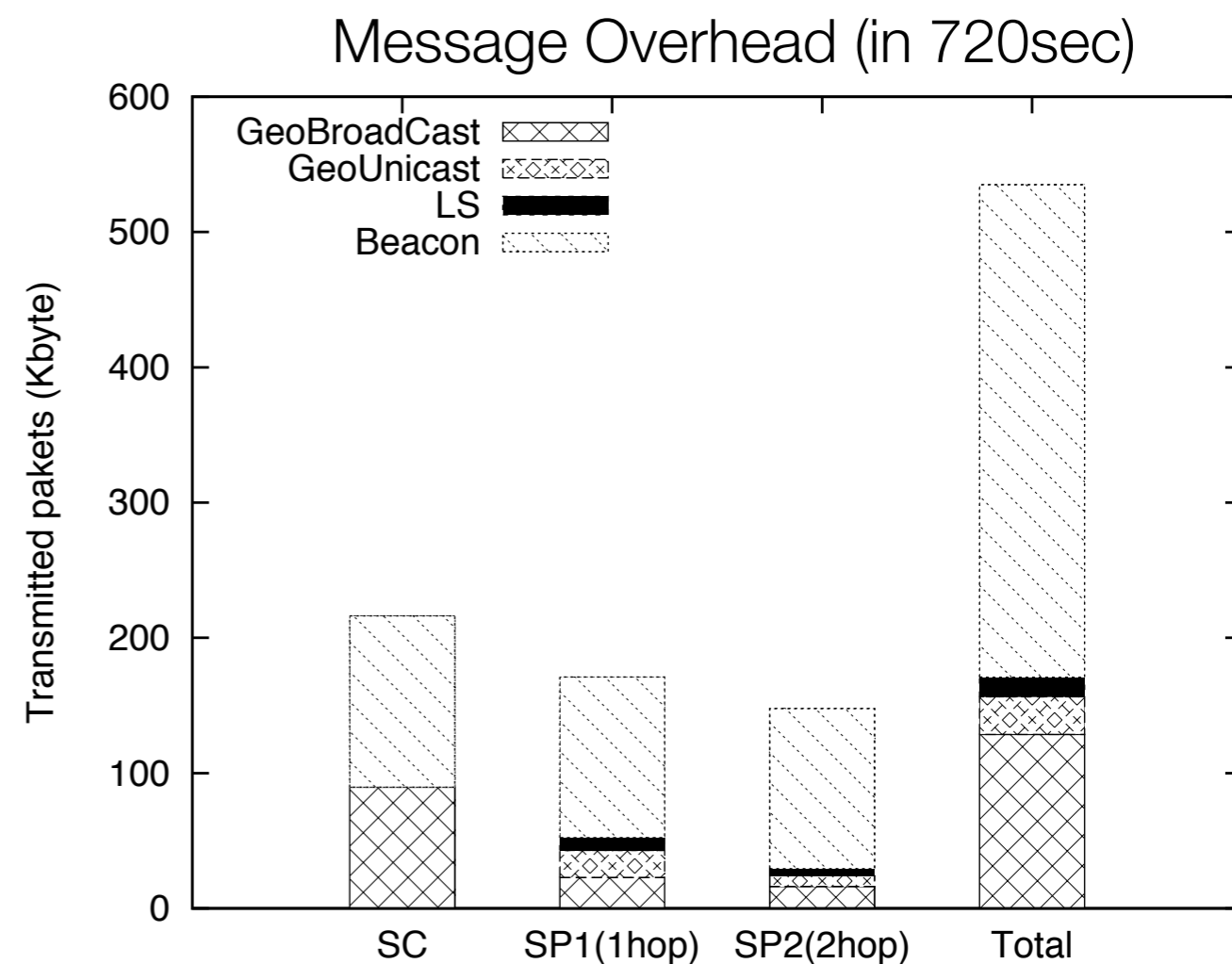
- 2 hops: 27.9 / 170 / **48.6**

- Message overhead

- 0.73kb/sec total

- Success late

- 1hop: 75%, 2hops: 52%



Visualization with AnaVANET

The screenshot displays a web browser window with the following elements:

- Browser Address Bar:** `dev.inet-lab.me/inet-doc/public/anavanet/ping-test-3stations-multi-20110504.html`
- Page Title:** Geographical Position Mapped Network Performance
- Map:** Aerial satellite view of a campus area with several buildings and a large circular structure. Three red location pins are placed on the map, labeled 1, 2, and 3. A green bicycle icon is positioned on a road in the lower-left quadrant.
- Control Panel (Left Side):**
 - Experiments:** A section with a title bar.
 - Control:** Includes navigation buttons (back, play, stop, forward) and a progress indicator showing "Step: 171/481 second (35%)".
 - Information:** Displays network performance metrics:
 - Distance(MR3-MR1) : 37.62 m
 - Distance(MR1-MR4) : 174.91 m
 - RTT : 3.42 ms
 - Speed of No.1 : 0 km/h
 - Speed of No.3 : 0.02 km/h
 - Speed of No.4 : 9.15 km/h
- Map Interface:** Includes a compass, a vertical zoom slider, and "Map" / "Satellite" toggle buttons in the top right corner.

Conclusion

- Multicast service discovery on IPv6 GeoNetworking for VANET
 - Based on GeoBroadcast and IPv6 multicast
- Low latency, Low bandwidth usage, geographical location aware service discovery mechanism
- Actual implementation on Linux PC and field evaluation
- Future work
 - Improve success rate:
 - **IPv6 GeoNetworking** Multi-hop handling of CarGeo6
 - **Service discovery** Timeout and Retry count configuration
 - Wide area service discovery via Internet