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

Upper layer

IP

1. IP Forwarding
2. NEMO
3. Geographic addressing/Position calculation
4. Geo-routing (Position based routing)
5. Location Management
   - Beaconsing
   - Location Table
   - Location Service
6. IPv6 over C2C NET

C2C NET

1. Routing
2. IPv6 over C2C NET
3. Geographic addressing/Position calculation
4. Geo-routing (Position based routing)
5. Location Management
   - BeamConing
   - Location Table
   - Location Service
6. IPv6 over C2C NET
7. Lower layer (egress interface, 802.11p)
IPv6 over C2C NET

GeoNet WP2 IPv6-C2C NET

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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
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
(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
(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 ]

![Diagram showing NDP extension and IP routing table on OBU1]

IP Routing table on OBU1
- [ default route (::/0) -- fe80::C2CID3 ]
- [ 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 $\rightarrow$ need specification in C2C NET
  II. (1) Static route configuration $\rightarrow$ Only for demo
  III. (2) Dynamic routing protocol $\rightarrow$ Easy solution

### Approach comparison

<table>
<thead>
<tr>
<th>Approach</th>
<th>Difficulty</th>
<th>Scalability</th>
<th>Signaling overhead</th>
<th>Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Static route configuration</td>
<td>Easy</td>
<td>no</td>
<td>No overhead</td>
<td>No delay</td>
</tr>
<tr>
<td>(2) Dynamic routing protocol</td>
<td>Easy</td>
<td>yes</td>
<td>Periodic signaling</td>
<td>Depend on frequency and RTT</td>
</tr>
<tr>
<td>(3) HNA like extension</td>
<td>Difficult</td>
<td>yes</td>
<td>Optimized signaling</td>
<td>Depend on frequency and RTT</td>
</tr>
<tr>
<td>(4) RA extension</td>
<td>Difficult</td>
<td>yes</td>
<td>Periodic signaling</td>
<td>Depend on frequency and RTT</td>
</tr>
<tr>
<td>(5) DNS like discovery</td>
<td>Difficult</td>
<td>yes</td>
<td>Once for each OBU</td>
<td>RTT between server and client</td>
</tr>
</tbody>
</table>
### SAP 1.4 (IPv6 - C2C)

#### Classification by destinations

<table>
<thead>
<tr>
<th>Destination</th>
<th>IPv6 layer</th>
<th>C2C NET layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>A node in a specific vehicle</td>
<td>unicast</td>
<td>geo-unicast</td>
</tr>
<tr>
<td>Nodes in vehicles in area</td>
<td>multicast</td>
<td>geo-broadcast</td>
</tr>
<tr>
<td>Nodes in vehicles x hops away</td>
<td>multicast</td>
<td>topo-broadcast</td>
</tr>
<tr>
<td>A node in a certain vehicle in area</td>
<td>anycast</td>
<td>geo-anycast</td>
</tr>
</tbody>
</table>

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

#### GeolIPv6 (Type, Destination, Payload)

- **IPv6 layer**
  - Unicast - geo-unicast
  - Multicast - geo-broadcast
  - Multicast - topo-broadcast
  - Anycast - geo-anycast

- **C2C NET layer**
  - Unicast address
  - Multicast address
  - Multicast address
  - Anycast address

- **C2C header**
  - Location table
  - Latitude
  - Longitude

- **Routing table**
  - IP next hop

- **Multicast address**
  - Last 112bit
  - Area ID
  - Radius

- **Hop limits**
  - Last 64-bits
  - Hop limit
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
1. Add rule to the policy that the packet from MNP to routing table "9"
   
   \[\text{ip -6 rule add from 2001:1000:2000:3000::/64 fwmark 0x9 lookup 9 prio 301}\]

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

3. Activate routing table "9" (Mark packet as "9")
   
   \[\text{ip6tables -t mangle -F PREROUTING}\]
   \[\text{ip6tables -A PREROUTING -t mangle -j MARK --set-mark 9}\]
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
# ip6tables -A PREROUTING -t mangle -j MARK --set-mark 9
```
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
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- 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
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

<table>
<thead>
<tr>
<th>RFC</th>
<th>8</th>
<th>4</th>
<th>4</th>
<th>8</th>
<th>8</th>
<th>64</th>
<th>32</th>
</tr>
</thead>
<tbody>
<tr>
<td>3306</td>
<td>11111111</td>
<td>flags</td>
<td>scope</td>
<td>reserved</td>
<td>plen</td>
<td>Network prefix</td>
<td>Group ID</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>8</td>
<td>64</td>
<td>Area ID</td>
<td>Radius</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>8</td>
<td>8</td>
<td></td>
<td></td>
<td>32</td>
<td></td>
</tr>
</tbody>
</table>

**Diagram:***
- **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.

- **Location Table**:
  - Latitude
  - Longitude
  - 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

<table>
<thead>
<tr>
<th>Multicast address</th>
<th>Radius</th>
</tr>
</thead>
<tbody>
<tr>
<td>FF0E::500</td>
<td>500 m</td>
</tr>
<tr>
<td>FF0E::1000</td>
<td>1000 m</td>
</tr>
<tr>
<td>FE0E::1500</td>
<td>1500 m</td>
</tr>
</tbody>
</table>

Should Listener AUs subscribe all the multicast address such as: From FF0E::1 to FF0E::500?
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
  - 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)
Thanks for your attention
- Manabu Tsukada <manabu.tsukada@inria.fr>
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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