Routing Optimization
for Vehicular NEMO Networks

2007. 7.

Bo-Kyung Lee

Korea Polytechnic University

CONTENTS

- Motivation

- Network Mobility (NEMO) Networks

- Vehicular NEMO Networks

- Advanced Intelligence Control Entity (AICE) Structure

- Handover Optimization

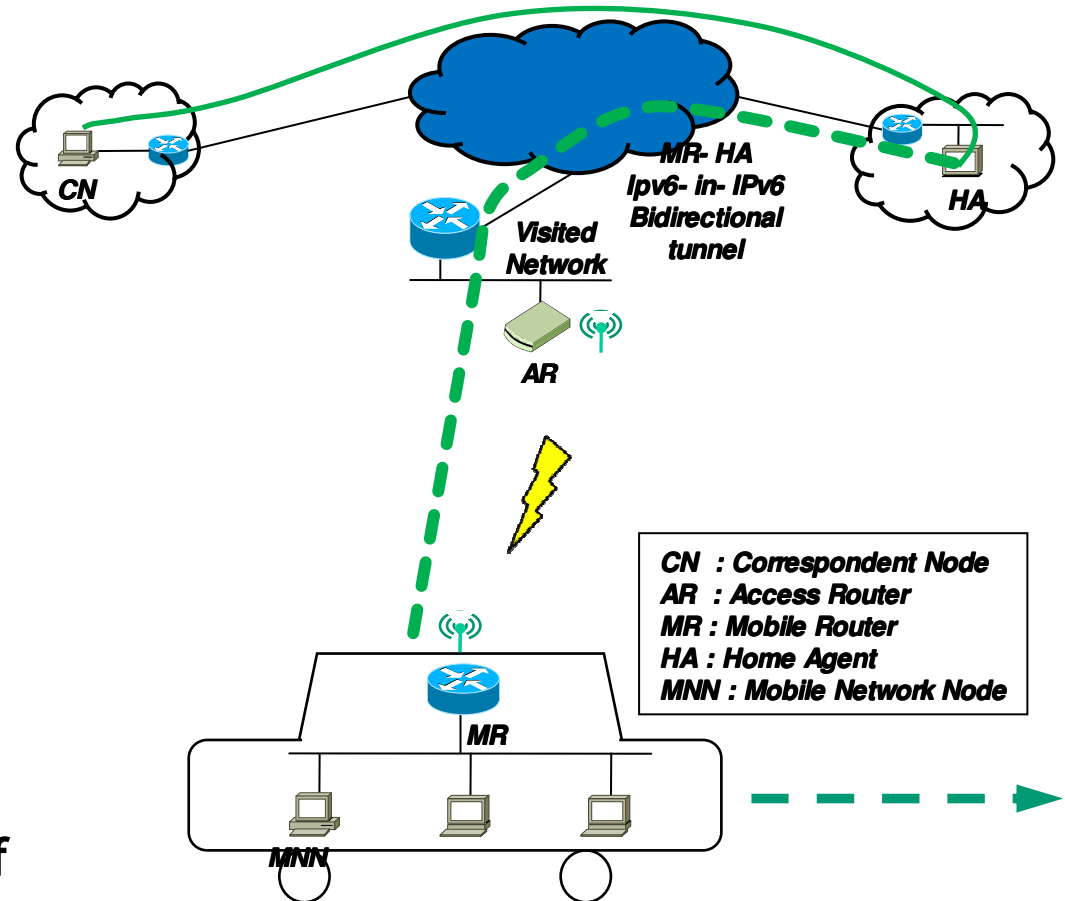- Routing Optimization

- Future Internet

- Conclusion

Motivation

○ **Explosion of Mobile Devices**

○ **LANs and PANs become mobile networks**

○ **Network Mobility (NEMO)**

○ **Vehicular NEMO Networks**

○ **Context-awareness**

○ **Handover Optimization**

○ **Routing Optimization**

Network Mobility (NEMO) Networks[1]

○ **Entire network mobile as a unit and attached to the internet via Mobile Router**

- One or more IP Subnets
- One or more Mobile Router

○ **Mobile Router changes its point of attachment**

– Only MR changes its IP address
– Nodes behind MR don't change their own point of attachment

MR- HA
Ipv6- in- IPv6
Bidirectional
tunnel

CN

HA

Visited
Network

AR

CN : Correspondent Node
AR : Access Router
MR : Mobile Router
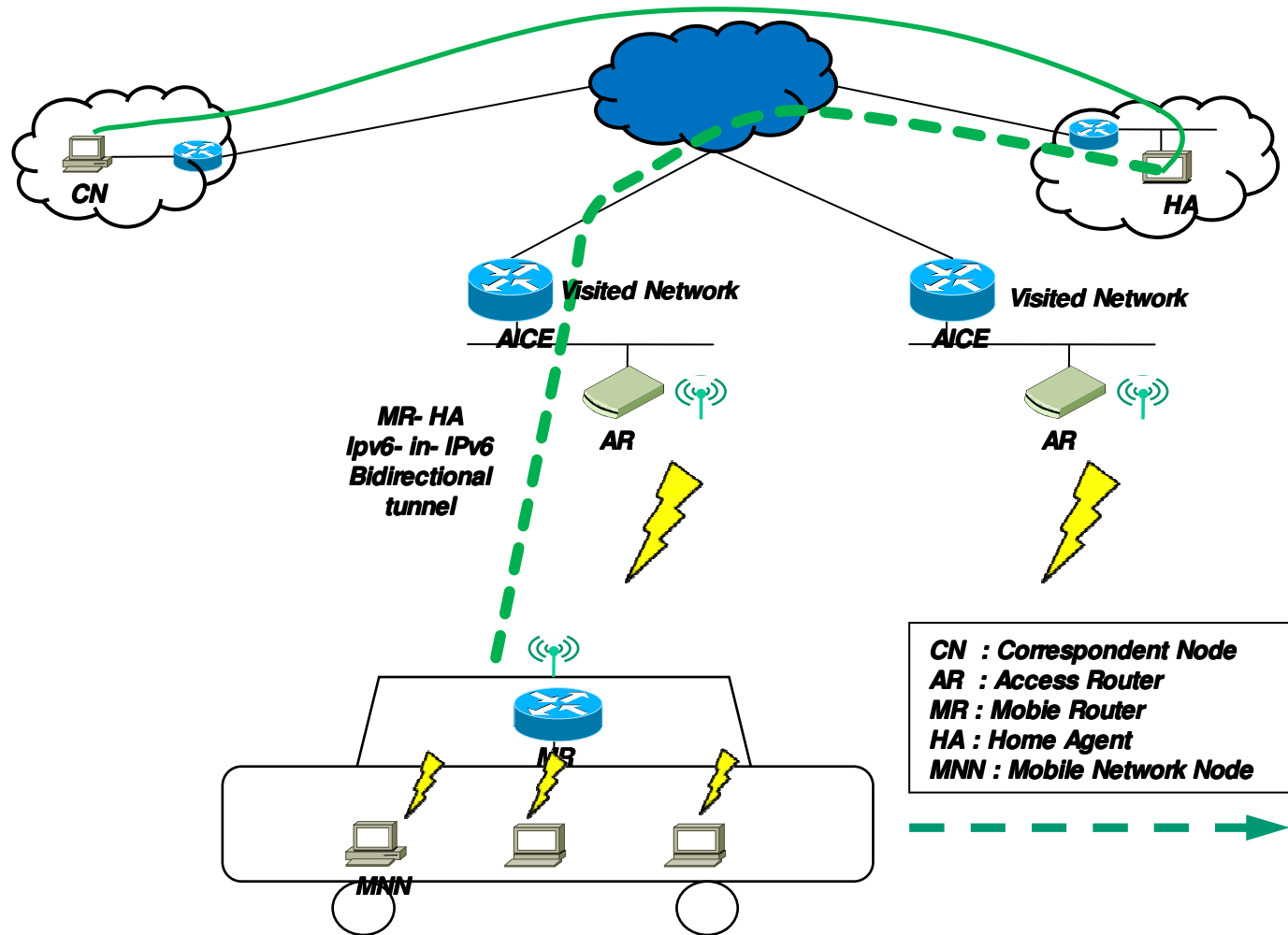HA : Home Agent
MNN : Mobile Network Node

MR

MNN

Vehicular NEMO Networks [I]

○ NEMO attracts vast interest for vehicle mobile networks.
○ Vehicular NEMO Networks
○ Main Issue : Session Maintenance
○ Bi-directional tunnel between MR and HA
○ Routing
  - Encapsulation between HA and MR in both directions
  - Not optimal solution, but guarantee mobile networks are
    supported with minimal effort
○ Goals
  - Reducing signaling overhead
  - fast data delivery
○ Routing Optimization
  - residence time
  - distance
  - vehicle's velocity

CN

HA

Visited Network

AICE

Visited Network

AICE

**MR- HA
Ipv6- in- IPv6
Bidirectional
tunnel**

AR

AR

CN : Correspondent Node
AR : Access Router
MR : Mobie Router
HA : Home Agent
MNN : Mobile Network Node

MR

MNN

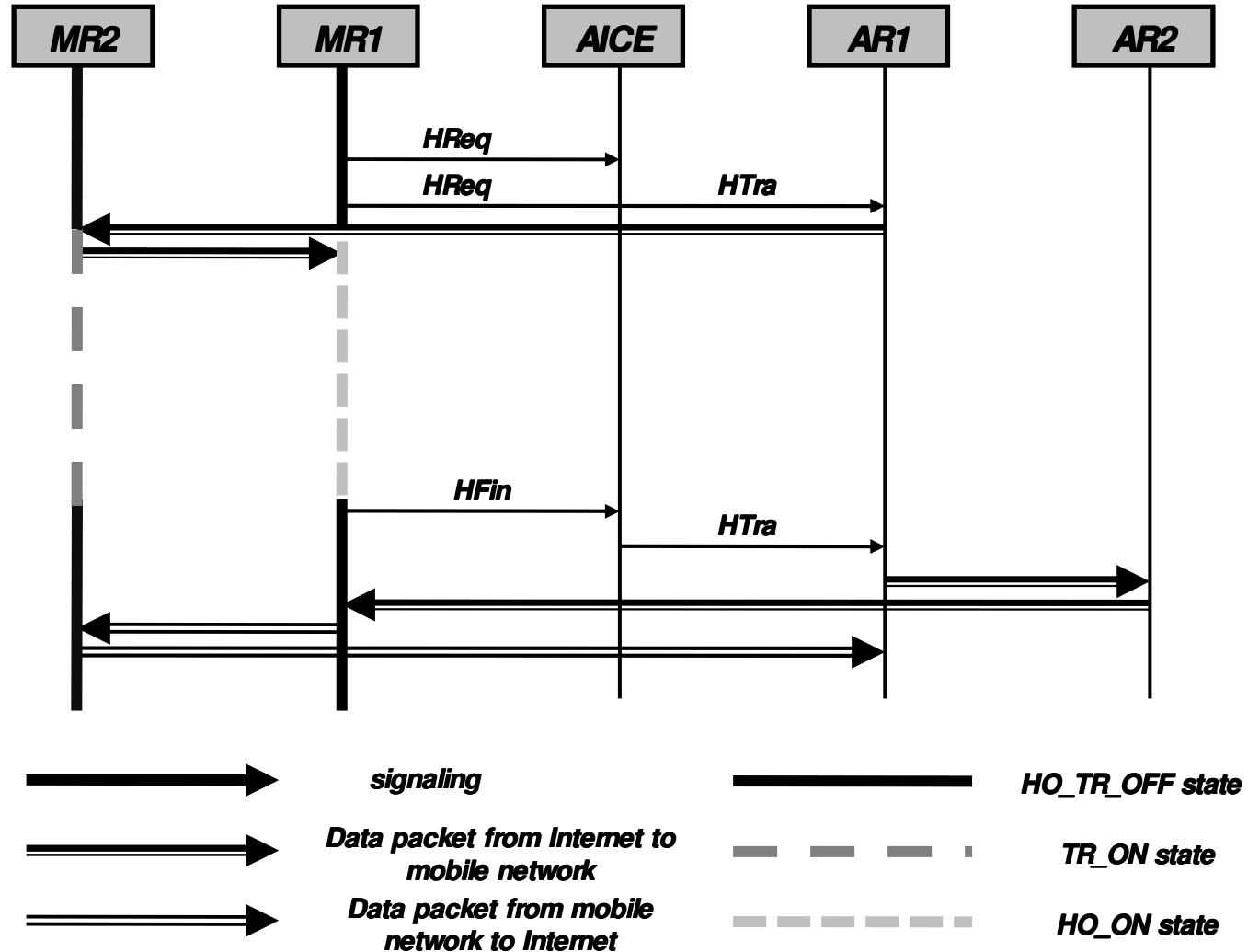# Advanced Intelligence Control Entity (AICE) Architecture

- ○ AICE Domain

- ○ Networks Information
  - Access Router's address
  - Capacity
  - load
  - AP's list
  - attached MRs

- ○ Vehicle Information - MRs
  - residence time
  - distance
  - velocity

Handover Procedure[6]

MR2   MR1   AICE   AR1   AR2

HReq

HReq   HTra

HFin

HTra

signaling   HO_TR_OFF state

Data packet from Internet to
mobile network   TR_ON state

Data packet from mobile
network to Internet   HO_ON state

Korea Polytechnic University

8

Routing Optimization [I]

- Nested NEMO Tree Discovery[2]
  - aims at avoiding routing loops by organizing and maintaining a tree structure within the network of nested NEMO

- Approaches like Reverse Routing Header[3]
  - uses the recording of the sequences traversed Mobile Routers on the way out of the nested NEMO network

  - in order to forward traffic efficiently in the nested NEMO Networks

- Approaches like Optimized Route Cache Protocol[4]
  - insuring some level of optimized routing inside

- Approaches using Optimized Link State Routing Protocol[5]

Routing Optimization [II]

○ Context-awareness is considered.

○ Vehicle contains mobile routers.

- Vehicle's residence time in AICE area
- Vehicle's residence time in AR area
- Size of AICE
- vehicle's velocity

○ Average Residence time in *(i, j)*

- *(i,j)* : j Area of Access Router in i AICE area
- *L* : the number of visiting of mobile router in *(i,j)*
- $t_{i,j}(l)$: residence time of *lth* visiting
- $T_{i,j}(l)$: average residence time in *(i,j)*
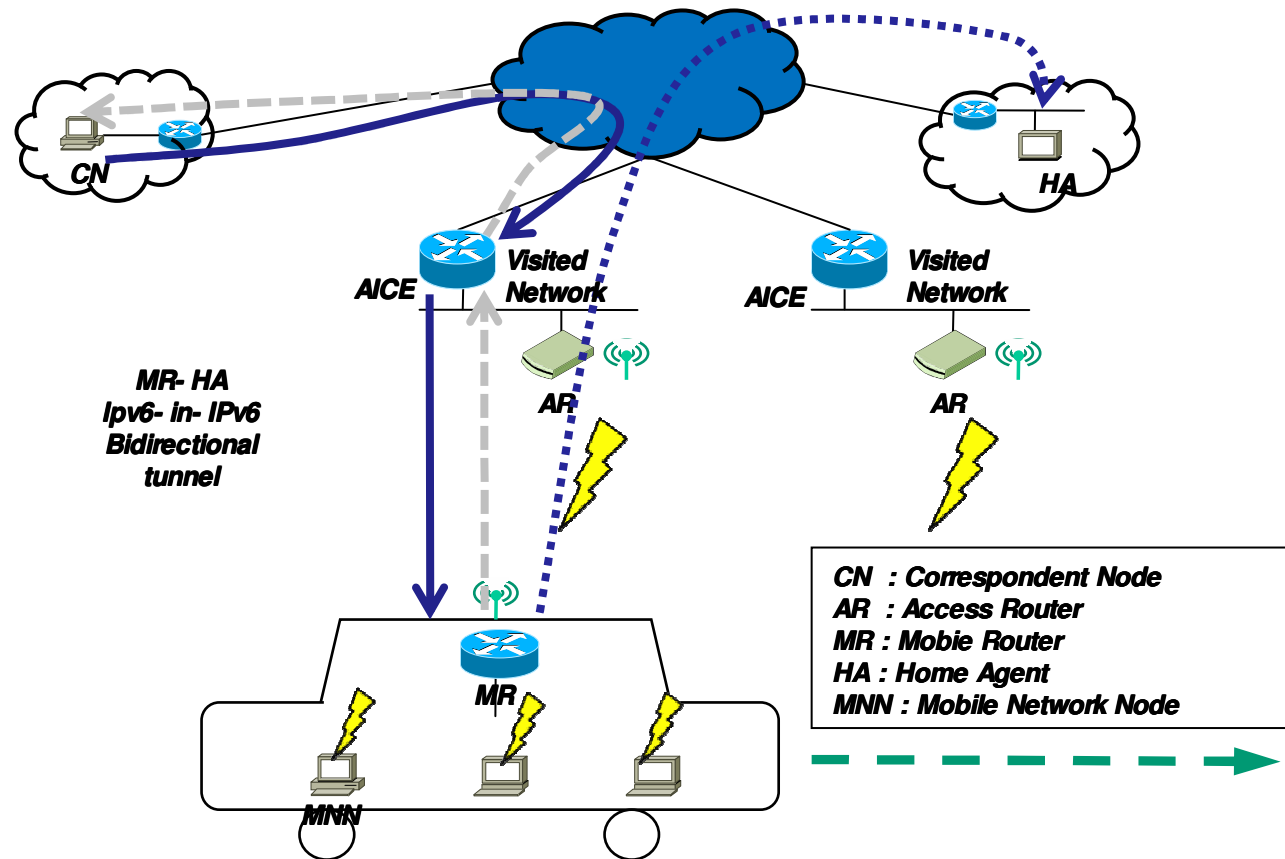- $T_{i,j}(l) = 1/L \ \Sigma t_{i,j}(l)$

Routing Optimization [III]

○ **Average Residence time in access router area in AICE area**

    – k : the number of Access router
    – $T_{i},.$: average residence time
    – $T_{i,j}(l) = 1/L \; \Sigma t_{i,j}(l)$
    – $T_{i},. = 1/k \; \Sigma T_{i,j} = 1/k \; \Sigma 1/L \, \Sigma t_{i,j}(l)$

○ **Average vehicle's velocity ;** $V_{i,j}(l), \; V_{i},.$

○ **If** $V_{i,j}(l) > V_{i},.$ **, then CoA is from Access router**
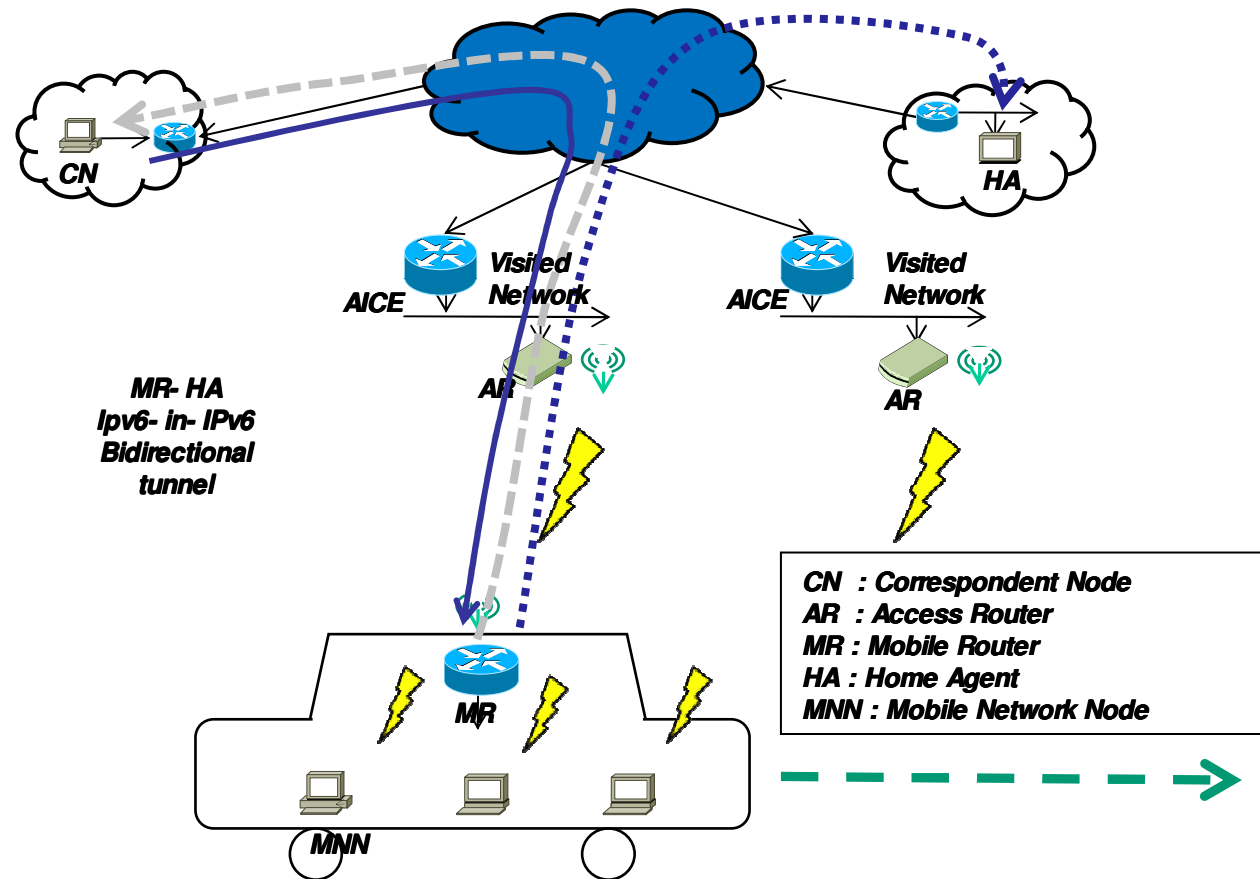   **else CoA is from AICE.**
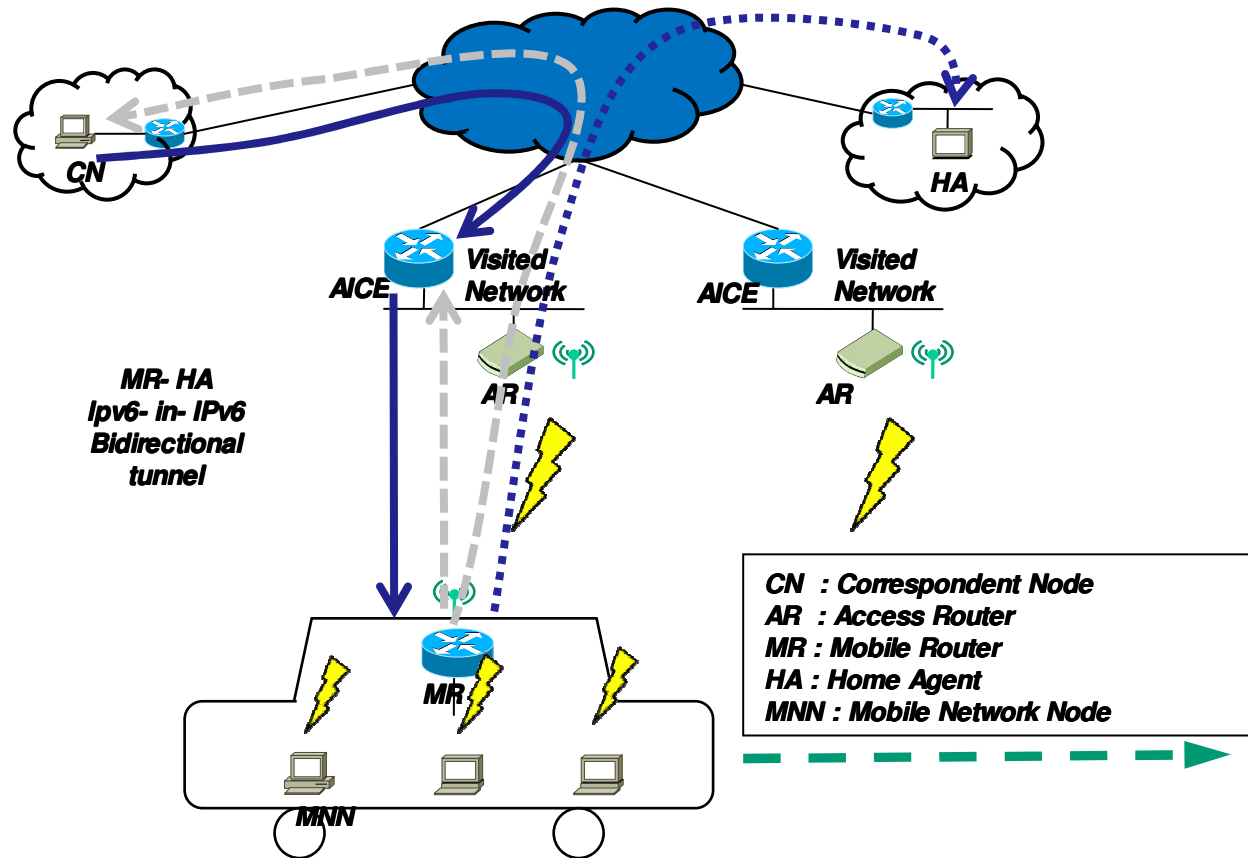
Routing Optimization (IV)

○ **BU - low velocity**

MR- HA
Ipv6- in- IPv6
Bidirectional
tunnel

CN

HA

AICE Visited Network

AICE Visited Network

AR

AR

MR

MNN

CN : Correspondent Node
AR : Access Router
MR : Mobie Router
HA : Home Agent
MNN : Mobile Network Node

Korea Polytechnic University

Routing Optimization (v)

○ **BU - high velocity**

MR- HA
Ipv6- in- IPv6
Bidirectional
tunnel

CN : Correspondent Node
AR : Access Router
MR : Mobile Router
HA : Home Agent
MNN : Mobile Network Node

○ **Data Delivery : CN has MR's location.**

CN : Correspondent Node
AR : Access Router
MR : Mobile Router
HA : Home Agent
MNN : Mobile Network Node

○ **Data Delivery : CN has no MR's location.**

MR- HA
Ipv6- in- IPv6
Bidirectional
tunnel

CN : Correspondent Node
AR : Access Router
MR : Mobile Router
HA : Home Agent
MNN : Mobile Network Node
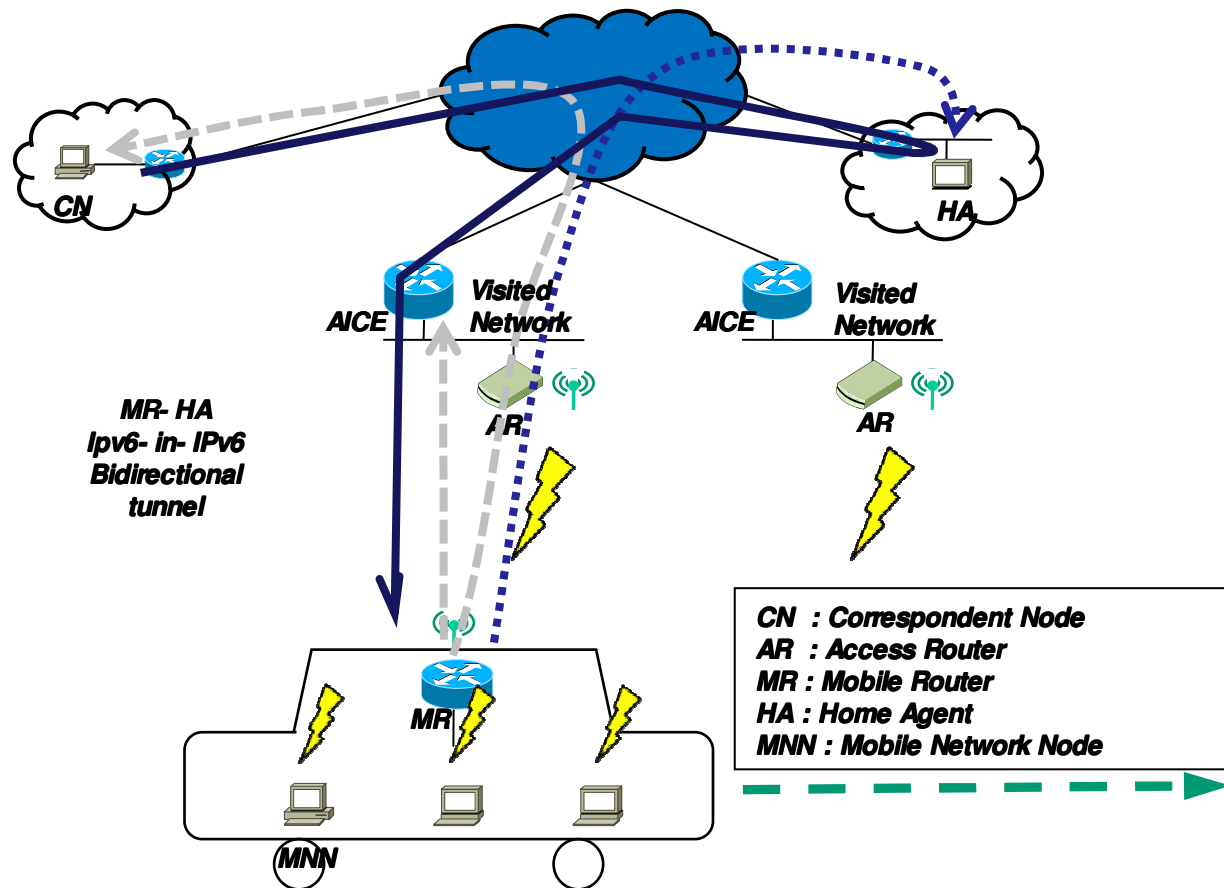
Future Internet

○ **Some main features of wireless subnet in GENI**
- **Mobility Support**
- **Location Services**
- **Sensor Network Integration**
- **Vehicular Network Integration**
- **etc**

Korea Polytechnic University

Conclusion

○ Vehicular NEMO Networks will be integrated into Future Internet.

○ Vehicular NEMO Networks support frequent handovers between various ARs.

○ Context- awareness is important for efficient data delivery.

○ AICE has information related to vehicle's mobility and networks.

○ By using vehicle's mobility information, routing is optimized.

References

[1] Devarapalli, V., Wakikawa, R., Petrescu, A., and P.Thubert, Network Mobility (NEMO) Basic Support Protocol, RFC 3963, January 2005

[2] P.Thubert, N. Montavont, Nested NEMO Tree Discovery, Work in progress, draft-thubert-tree-discovery-00.txt, IETF, May 2004

[3] P.Thubert et al, IPv6 Reverse Routing Header and its application to Mobile Networks, Work in progress, draft-thubert-nemo-reverse-routing-header-06.txt, IETF, September 2006

[4] R.Wakikawa, M. Watari, Optimized Route Cache Protocol, Work in progress, draft-wakikawa-nemo-orc-01.txt, IETF, October 2004

[5] T. Clausen, E.Baccelli, R.Wakikawa, Route Optimization in Nested Mobile Networks(NEMO) Using OLSR

[6] Hai Lin and Houda Labiod, Handover Optimization for vehicle NEMO Networks, NTMS 2007