Toward fully networked cars

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Summary

- Introduction
- Standardization
- NEMO Basic Support
- Work in progress related to NEMO
- NEMO in operation
- Conclusion
Introduction
Telecommunications in ITS
Introduction

Evolution in telecommunications

- Development and deployment of various wireless access networks
  - IEEE 802.11a/b/g WLAN, IEEE 802.15 PAN, IEEE 802.20 MBWAN, or 3G WWAN…
  - Could be for dedicated purposes or public for generic purposes

- More diverse mobile computers/terminals
  - Smart-phones, PDAs, laptops, tablet PCs…
  - Specialized Hardwares (mobile routers)
  - But also various type of sensors and cameras

- Much more advanced mobile services
  - e.g., mobile commerce, tele-working, adaptive and self-configuring services, context awareness services…
  - That people need to access anytime, anywhere…
Introduction
Toward fully networked cars

- **Support of Internet services**
  - Navigation systems (update map, traffic information)
  - Entertainment (games, video, music)

- **Support of traditional ITS applications**
  - Vehicle tracking
  - Traffic assessment (upload speed information) and management

- **Support of next generation applications:**
  - Major push in Vehicle Safety Communication
  - v2v communications:
    - collision avoidance :-) ... Cooperative collision warning
    - Transit vehicle priority ...
    - Electronic brake light, collision warning ...
  - New commercial applications
    - made possible by high data rate & long range.
Introduction
Is network mobility management necessary?

- Host mobility (MIP on terminal)
- Network mobility (on a router)

- Each mobile manages its own mobility (MIP)
- Each mobile has few wireless interfaces
- Some devices should not have to manage mobility
- Spectrum and network resources are not used efficiently

- Each mobile has to reach the infrastructure using only its own resources
- Multiple Simultaneous Handovers

- Only the router has to reach the infrastructure
- Router could manage several interfaces and performs load sharing
- Low power (short range) transmission between devices and mobile router
- Devices could not manage mobility

- Each mobile does not manage mobility, it is just an IP terminal
- Each mobile needs only one wireless interface
- WiFi Access Network
Introduction
Is IPv6 necessary/useful?

Yes, for address space concerns
- Number of devices
  - 2.5 billions of mobile phone over the world
  - much more non-mobile devices
    - temperature sensor, wireless tyre gauge, security camera, ...
    - heart rate monitor, ...
- Number of vehicles
  - 600 millions of cars today
  - 3 billions forecast in 2050 (IMF)

Yes, for service deployability
- It remains possible to deploy IPv4 services, but ...
  - Difficult to evolve toward an open service architecture
  - Need to configure all the transmission chain (MR, HA, ISP network) for new services/applications
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What about standardization bodies?

- **IEEE** develops WAVE architecture

- **C2C-CC** designed an architecture and issued a manifesto that groups needs and requirements.
What about standardization bodies?

- **Work at IETF**
  - Host mobility
  - Network mobility
  - Multi-homing
  - Ad Hoc networking (MANET)

- **A first CALM architecture has been defined at ISO**
  - Provide users with transparent continuous communications
  - Open and evolutive architecture
CALM architecture
ISO TC204 WG16

Communications Access for Land Mobiles

IPv6
MIPv6
FMIPv6
NEMO

Source [CALM ISO 21217]
CALM Scenarii

- Single Media (dedicated)
  - Dedicated infrastructure
  - IPv6 but no Internet

- Single Media
  - Dedicated infrastructure
  - IPv6 but no Internet
  - No mobility management
  - Car-initiated communications

- Single Media
  - Public infrastructure (large range)
  - IPv6 but and Internet

- IPv6 Communication
- Dedicated Infrastructure

Application Server

Non IP Communication

Internet

IPv6 Communication

Tollgate
CALM Scenarios

Multiple Media
- Media switching and mobility management
- Bidirectional communications
- MIP and/or NEMO

IPv6 and
adhoc networking
- Multihop IPv6 Communication
- Mesh IPv6 Communication

IPv6 Internet and multihop adhoc networking
Simple CALM implementation

- Access Network
- 3G RAN
- Combined Antenna Pod
- Navigation System
  - CME
  - Socket TCP/UDP
  - Socket UDP
  - Internet Application
  - Traffic Management
  - CALM Routing IPv6
  - In-Vehicle Network
- On board Mobile Router (CALM Modem)
  - CME
  - NME
  - IME
  - CALM Routing IPv6 + Mobile IPv6 + MCoA + NEMO
  - GPS
  - V2X
  - C-V2X
  - GPS

Laptop Access Network
Internet Application
Traffic Management
CALM Routing IPv6
In-Vehicle Network
Combined Antenna Pod
CALM: Full Implementation

On board Mobile Router 1 (CALM Modem):
- CME
- NME
- IME
- IVN
- GPRS
- DSRC
- CALM M5
- GPS
- Combined Antenna Pod

On board Mobile Router 2 (CALM Modem):
- CME
- NME
- IME
- IVN
- CALM Routing
- IPv6
- Mobile IPv6
- MCoA
- NEMO

In-Vehicle CALM Network
- CALM Routing
- IPv6 + Mobile IPv6 + MCoA + NEMO
- Internet Application
- Traffic Management
- Socket TCP/UDP

OEM Network
- CALM Routing
- IPv6 + Mobile IPv6 + MCoA + NEMO
- Internet Application
- Socket TCP/UDP

Navigation System
- CALM Routing
- IPv6 + Mobile IPv6 + MCoA
- NEMO
- Internet Application
- Traffic Management
- Socket TCP/UDP

In-Vehicle Network
- CALM Routing
- IPv6 + Mobile IPv6 + MCoA
- NEMO
- Internet Application
- Traffic Management
- Socket TCP/UDP

Socket TCP/UDP

Display/Calculator
- In-Vehicle Application
- IVN

Sensors
- Sensor
- IVN

Seat seat screen
- CALM Routing
- IPv6 + Mobile IPv6 + MCoA
- NEMO
- Internet Application
- Traffic Management
- Socket TCP/UDP

Firewall
- IVN

Combined Antenna Pod

In-Vehicle Application
- Sensor
- Display/Calculator
- Firewall
- Sensors

IT/TB/RSM/GERME/JMB
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NEMO highlights

Correspondant

Mobile Router (MR)

Home Agent (HA)

Visited Mobile Node (VMN)

Local Fixed Node (LFN)
When the NEMO attaches abroad

- It registers its position (CoA) to the HA and announce the prefix it uses
- The HO route all packets for which the destination address belongs to this prefix to in the tunnel to the CoA of the router.
Simple NEMO scenario

When the NEMO moves

- It registers its new position (CoA) to the HA
- Addresses attached to node inside the NEMO do not change. They still belong to the NEMO prefix.

* Correspondant

* Home Agent

* MR

* RA

* MNP::/64

* MNP:if(LFN)

**Binding cache:**
- HoA(MR):CoA2(MR), lifetime

**Prefix Table:**
- HoA(MR):MNP, lifetime
Nested mobility with NEMO

Correspondant

Binding cache:
HoA(MR):CoA(MR), lifetime
Prefix Table:
HoA(MR):MNP, lifetime

Home Agent

Binding cache:
HoA(VMN):CoA(VMN), lifetime

Mobile Router

MNP::/64

MNP:if(LFN)

VMN (Visited Mobile Node)
**NEMO limitations**

- **What is missing to meet CALM specification requirements?**
  - Route optimization
  - QoS (for next CALM specifications)
    - QoS-aware routing and resource allocation
  - Specialized interface management
    - Management of DSCR, M5, Millimeter wave ...
    - Some of them introduce ad-hoc networking
    - Modification of the CALM architecture to introduce CALM FAST
  - Multiple MR management
    - Connectivity maintenance
    - Distributed flow binding decision
  - Distributed/Centralized resource allocation
    - Is the fully centralized architecture a good solution?
    - What about nested network?
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The routing optimization problem

For NEMO
- Car configure an address in each access networks (CoA) on the local global prefix
- Car will get a prefix from its Mobile Internet Service Providers (MNP)
- Embarked equipments configure global addresses in this prefix

For Route optimization
- Car configure addresses in a global well know prefix
- Use GeoCasting (or other MANET protocols) instead of normal Internet routing
- Traffic cannot cross over the Internet but can use RSU (Road Side Unit) that operate just like another cars
NEMO and MANET: MANEMO

- An adhoc network (MANET) attaches to a NEMO
  - Example, in order to reduce energy consumption in a train

- Few adhoc network nodes behave as NEMO MR
  - All together or each one at its turn (save energy)

- Adhoc networking instead of imbricated network
  - All together or each one at its turn (save energy)

- Nested NEMO instead of mesh or adhoc networking
  - Can extend the coverage (ex. LoCoSS project)
Multihoming and NEMO

Several interfaces:
- Several tunnels toward the HA and only one prefix
- Allow load sharing and redundancy
- Require routing policy at MR and HA
  - HA and MR has to exchange this routing policies
  ➡ Flow binding, XML based policy description

Binding cache:
- HoA(MR-ef1):CoA(MR-ef1), lifetime
- HoA(MR-ef2):CoA(MR-ef2), lifetime

Prefix Table / routing table:
- HoA(MR-ef1):MNP, lifetime
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Conformance and Interoperability testing

- ETSI
  - IPv6 test specifications and methodology (based on TTCN3 new testing language)
  - Plugtests
- TAHIPv6 and Moonv6 interoperability events
- European Commission and associated projects
  - STFs (236, 256, 276)
  - Go4IT, ANEMONE projects, …

IPv6 Logo Program World-Wide Initiative

- 5 teams in the technical committee (v6LC) linked to the IETF: Asia (TAHI, BII, TTA), USA (IOL-UNH), Europe (IRISA)
- NEMO Basic Support in Gold logo

Current trend in EC projects is towards IPv6 (& NEMO)

- a testbed is needed for evaluating scenarios and solutions in real-life conditions
- setting up required components of testbed is cumbersome
The ANEMONE project

- **FP6 STREP**
  - First large-scale IPv6 mobility-oriented testbed in Europe
  - [http://www.ist-anemone.eu](http://www.ist-anemone.eu)

- **Variety of test sites**
  - Wide-area outdoor & Indoor
  - Types: Campus / Metropolitan

- **Multiple IPv6 access technologies**
  - 802.11 a/b/g, HiperLan, UMTS, GPRS, WiMAX

- **Mobility services**
  - NEMO / MIP6 / MCoA
  - HA (with HA-HA)

- **IPv6 multimedia services**
  - Web, Voice over IP, IP TV, Video on Demand
  - Experimental IP Multimedia Subsystem

- **Security & Access control mechanisms**
  - TLS / IPsec
The ANEMONE platform
Few NEMO related projects

- **LoCoSS project**
  - Leverage on public wireless infrastructures to providing Internet connectivity to Firemen in operation

- **NEMO and applications:**
  - The REMORA project
The CVIS project

**Cooperative Vehicle-Infrastructure System**
- http://www.cvisproject.org
- From Feb. 2006 till Feb. 2010
- 61 partners / 12 countries / Total Budget: 41 Millions Euros

**Objectives**
- Develop, trial & demonstrate
  - Inter-operable architecture for vehicular communications
  - Novel applications for:
    - Cooperative traffic and road network monitoring
    - Cooperative road & traffic network management & control
    - Cooperative logistics & fleet management
    - Cooperative public transport & intermodality

**Vision**
- Use and extend existing standards (especially CALM)
- Produce open design and software (mainly base on Linux)
- Output intended to be reused by other EC projects
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IPv6 and ITS

■ ITS market
  - Use to be well organized around car manufacturers
  - Has to build vehicles operational for tens of years
  - Communications
    - Use different proprietary solutions/communication systems
    - Opening the market could reduce the cost and liberate the innovation

■ ITS stakeholders and IPv6
  - No experience in IPv6 deployment and operation
  - Do not aware of limitations related to IPv4
  - Think that IPv6 is transparent to their concerns
  - IPv6 is not an option for wide deployment
  - IPv4 will limit the development of an ecosystem
    - Service and connectivity providers have to remain stick together

■ ISO defines the CALM architecture
  - Use IETF open standards (IPv6, NEMO)
IPv6 initiatives in France

- French academics have been involved in the IETF specifications since the very beginning
  - INRIA has developed the first IPv6 stack
- G6
  - Association set up 10 years ago to ease IPv6 deployment between universities
  - IPv6 is fully operational within RENATER
  - IPv6 training (tutorial)
  - IPv6 book (in French)
- IPv6 task force France
  - Launched at the Sénat in September 2002
  - Part of the G6 since 2007: http://www.g6.asso.fr/ffb
  - Still not enough involvement from the industry
When beginning to work with IPv6?

- **Now!**
  - Strong incentive from EC to move to IPv6 in research project and in deployment

- **IPv4 address space exhaustion date has been recently revised**
  - IANA count down has been set to January 2011
    - [http://www.potaroo.net/tools/ipv4/](http://www.potaroo.net/tools/ipv4/)
    - [http://www.arin.net/announcements/20070521.html](http://www.arin.net/announcements/20070521.html)

- **Deployment and ITS related development**
  - Do consider IPv6 in the early stage of the design
  - Large testbed and operational IPv6 network are available
  - IPv6-only services could start very fast
  - All new application development should be IPv6 compliant
Questions or comments?