A novel end to end IPv6 architecture for cooperative ITS, FOTsis and SCOREF

6th ETSI ITS workshop in Berlin

Session 5 Deploying IPv6 in cooperative ITS

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Agenda of the presentation

- Presentation of SCOREF and FOTsis projects
- Cooperation of cellular and vehicular networks
- E2E IPv6 architecture : ITS stack
  - vehicle ITS station, road side ITS station and central ITS station
- Performances of IPv6 architecture in cooperative ITS
- Conclusion and next steps
SCORE@F
Système Coopératif Routier Expérimental Français

- Field Operational Tests (FOT) in open field for V2I and V2V cooperative systems
  - French collaborative project (pôle de compétitivité Mov’eo/BPI)
  - From September 2010 to September 2013
  - 17 partners: Renault, PSA, Hitachi, Cofiroute, Orange, IFSTTAR, UTAC, Néavia, Marben, INRIA, Eurecom, …
  - more than 20 use cases in road safety, traffic efficiency and mobility/comfort (POI services)
  - V2V / V2I communications

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FOTsis
European Field Operational Test on Safe, Intelligent and Sustainable road operation

- Large scale infrastructure oriented FOT for the test of road infrastructure management systems (Spain, Portugal, Greece and Germany)
  - European project (FP7 call 6: ICT for Mobility of the future)
  - From April 2011 to September 2014
  - 23 partners: OHL Concesiones, GMV, Planestraada, Orange, Optimus, UPM, UMU, SICE, INDRA, TRANSVER …
  - 7 close to market cooperative services in 4 countries, 10 test sites (road safety, traffic efficiency and mobility services)
  - V2I communications
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Cooperation between cellular and VANET networks

Operator vision
- Control, security and billing
- High Coverage
- Low density
- OBU in vehicle
- Cellular Network
- Vehicular Network
- Service provider
- 3G Offload + Data aggregation for B2C or B2B2C services
- V2I Cellular communication
- V2V adhoc communication

Automotive industry vision
- Real Time
- High Density
- deploy a new infrastructure
- Cellular Network
- Vehicular Network
- Service provider
- 3G Offload + Data aggregation for B2C or B2B2C services
- V2I Cellular communication
- V2V adhoc communication

Traffic information
- emergency
- Remote navigation
- Remote diagnostic
- Mobility/comfort

Fleet management
- POI services
- Software download
- Video streaming

Cooperative
- traffic lights
- Hazard warning
- Intersection assistance

Collision
- avoidance
- Lane departure
- Lane change support

IEEE802.11p ad-hoc ITS G5

3G/HSPA
4G/LTE

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ITS stack used in IPv6 architecture

2 communications links:

1. ITS G5 dedicated infrastructure deployed in IPv6
2. operated cellular network mainly deployed in IPv4

- **vehicle ITS station : V2V/V2I links**
  - access: 3G/4G and ITS G5 radio interfaces
  - network: geonetworking over ITS G5, DSmipv6 over geonetworking over ITS G5 and DSmlIPv6 over 4G, DSmipv6 over ITS G5
  - facilities: DENM and POI messages

- **road side ITS station: V2I links**
  - access: ITS G5 and ethernet radio interface
  - network: IPv6 over geonetworking (GVL operated around the RSU) and IPv6 over ITS G5
  - facilities: DENM and POI messages

- **central ITS station**
  - IPv6 stack, virtualized HA and service platform (backbone)
IPv6 implementation in vehicle ITS station mobile router (1/2)

- **3G/HSPA/LTE Monitoring module:**
  - Configuration of 3G/4G Wireless modem
  - Monitoring of 3G/4G connection
  - Notification of setup and failure of a data session

- **ITS G5 Monitoring module:**
  - Configuration of 802.11p device (Tx power, channel, data rate)
  - Monitoring of G5 connection (congestion control)

- **IPv6 Generic movement detection module:**
  - Detection of RA (router advertisement)
  - IPv6 auto configuration notification
  - Used on ITS G5 communication links
IPv6 implementation in vehicle ITS station mobile router (2/2)

- **DSmip (Dual stack Mobility) management is responsible for**:
  - Management of IP mobility on IPv4/v6 network
  - Simultaneous multiple links with multihoming on ITS G5 and 4G
  - Enabler to transport IPv4/IPv6 packets on IPv4/IPv6 communication links

- **IETF standards involved in mobility management**
  - Mobile IPv6 Support for Dual Stack Hosts and Routers (RFC 5555)
  - Mobility Support in IPv6 (RFC 3775)
  - Network Mobility (NEMO) Basic Support Protocol (RFC 3963)
  - Flow Bindings in Mobile IPv6 and Network Mobility (NEMO) Basic Support (RFC 6089)

- **ETSI ITS standards involved in ITS station**
  - EN 302 636-6-1 (geonetworking, transmission of IPv6 packets over geonetworking)
  - EN 302 636-4-1 (geonetworking, media independent part)
  - EN 302 636-4-2 (geonetworking, media dependant part)
  - EN 302 663 access layer for ITS in the 5GHz frequency band
E2E IPv6 network architecture: SW architecture

**mobile router side**

- Generic Movement detection IPv6
- HSPA / LTE monitoring
- ITS G5 monitoring

**home agent side**

- DSMIP mobility management module (MR mode)
- DSMIP mobility management module (HA mode)

**open linux platform**

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Ground-server
- configuration files
- logs files

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IPv6 architecture in FOTSis (Planestrada in Portugal)
Highway network + service platform
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Handover ITS G5/3G versus elapsed time (SCOREF)
POI service traffic (web browsing, video streaming + downloading)

POI transmission versus elapsed time

Elapsed time

14:54 14:55 14:56 14:57 14:57 14:58 14:59

POI service traffic (http, ftp) (Kbps)

0 500 1000 1500 2000 2500 3000 3500 4000

3G/HSPA 3G/HSPA

ITS G5 ITS G5
Traffic test (UDP) : handover 3G/ITS G5 (FOTsis)

UDP traffic Handover 3G > ITS G5 > 3G (RSU2)

Throughput (Kbps) vs Elapsed Time (S)

- 3G/HSPA
- ITS G5

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Display of POI service traffic in 3D curves
RSU located at entrance of INRIA site (Rocquencourt)
Display of handover ITS G5/3G in 3D curves

- UDP traffic transmitted from the vehicle
- switching between cellular and vehicular network
- efficient handover:
  - 3G > ITS G5
  - ITS G5 > 3G
Display of UDP traffic in DSmip tunnels

Iperf UDP traffic in IPv6NEMO tunnel over 3G
HO ITS G5 > 3G
mipv6 tunnel over 3G

Iperf UDP traffic in IPv6NEMO tunnel over ITS G5
HO ITS G5 > 3G
mipv6 tunnel over ITS G5

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FOTsis S7 service demonstration (fleet management)

- GMV OBU traffic routed through MR towards GMV MOVILOC server
- PVT (position, velocity and time) messages transmitted on 3G and ITS G5 links

Fleet management display (courtesy of GMV)
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**Conclusion**

- A novel E2E IPv6 architecture deployed in ITS networks is a future proof ITS architecture for ongoing deployments:
  - a very efficient solution to optimize overhead since the double stack avoids mounting of useless tunnels (reduced encapsulation impact)
  - very good overall performances achieved in terms of delay, throughput (real capacity of the communication links) and handover
- Combination of heterogeneous networks complementarities and IP mobility management to enable efficient ITS communications delivering service continuity to vehicular customers
- E2E network cooperation architecture will support the delivery of full fledge of ITS services, road safety, traffic efficiency and mobility/comfort thanks to extended coverage and improved capacity and delay
- Operation of V2V and V2I communications to create new opportunities of cooperative services

**Next steps**

- Deployment and experimentation of an eMBMS architecture on top LTE network to demonstrate unicast and broadcast applications across ITS G5 and LTE communication links