GeoNet: Geographic addressing and routing for vehicular communications

Why IPv6 GeoNetworking is needed for ITS ?

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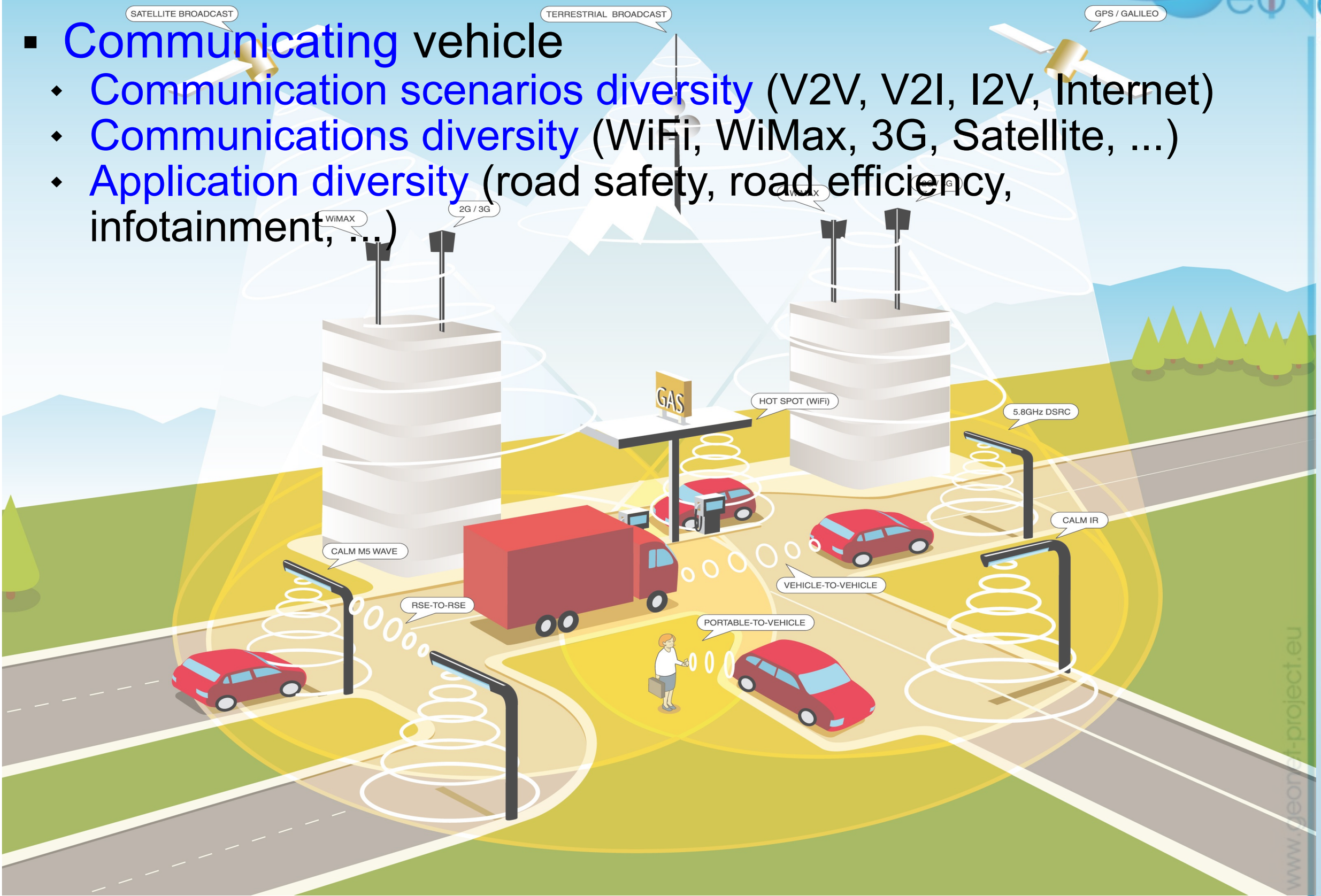
Motivations

- ITS Vision: everything connected
- Why IP (Internet Protocol)
- If IP, why IPv6 and not IPv4 ?
- Why IPv6 GeoNetworking

ITS Vision: Communications

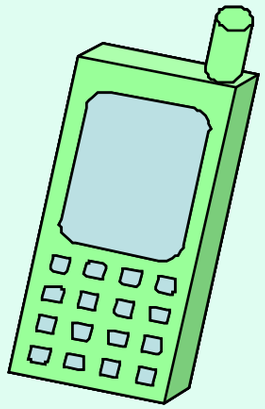
- Communicating vehicle
  - Communication scenarios diversity (V2V, V2I, I2V, Internet)
  - Communications diversity (WiFi, WiMax, 3G, Satellite, ...)
  - Application diversity (road safety, road efficiency, infotainment, ...)



ITS Vision: Everything connected

COM Safety

Personal

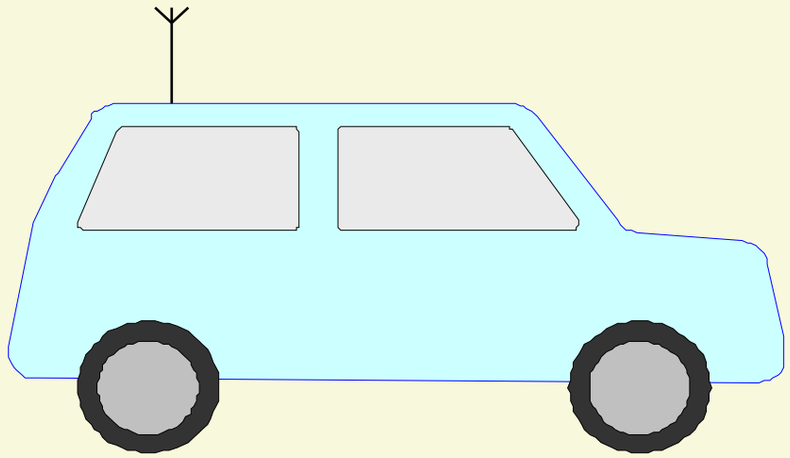


Central

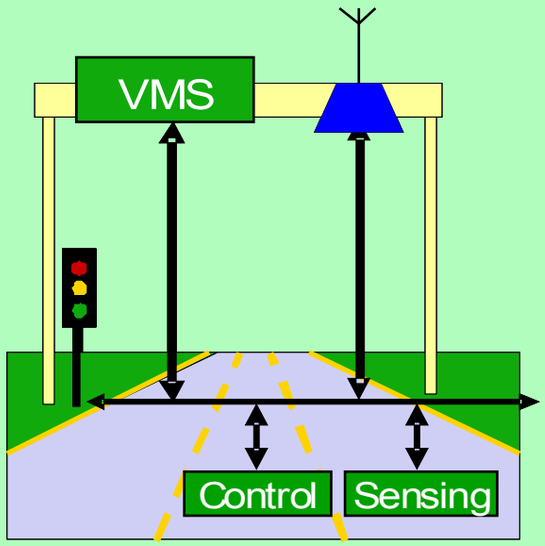
Central System

Communication Networks

Vehicle



Roadside



ITS Vision: Standards

- We need standards for uniform exchange of information
  - In vehicular cooperative systems (V2X)
  - between cooperative systems and anything on the Internet (Internet-based)
  - between communication systems developed in all sectors
  - ITS and the Internet of Things

- The Internet Protocol (IP) is the de facto standard
  - ITS communication architectures must interoperate with it

ITS Vision: Why IP ?

- IP provides an unification layer of underlying technologies
  - 2G/3G, 802.11 a/b/g, 802.11p, 802.16, satellite, ...
  - Any application running over IP is media-agnostic

- IP ensures interoperability
  - IP everywhere: ITS, education, health-care, army
  - Not limited to dedicated ITS application
  - End-host running in a vehicle can communicate directly with an end-host running at the car manufacturer's HQ, parking lot, emergency crews, driver's home

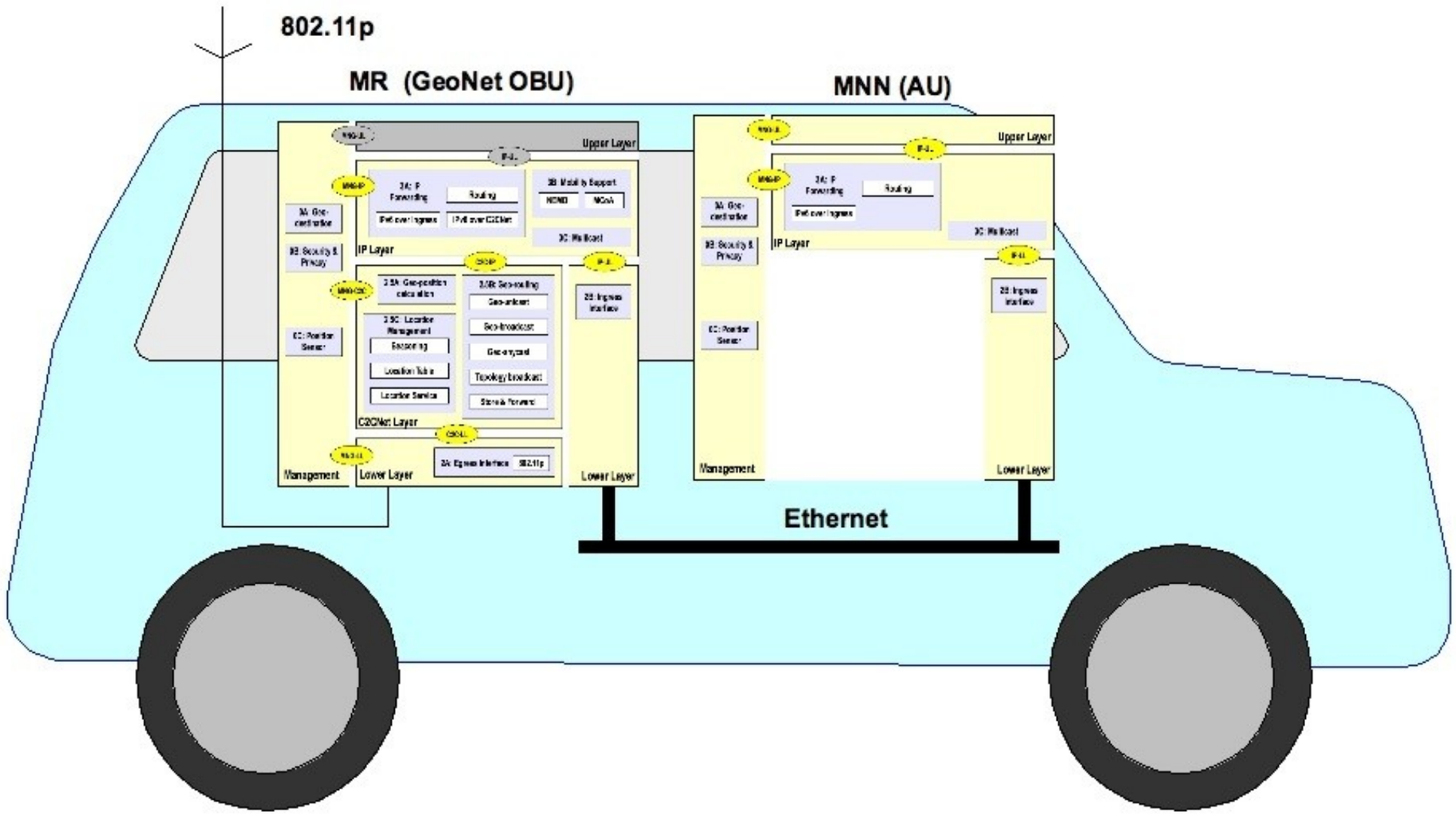
- IP ensures portability
  - Ordinary uses of the Internet can be brought to the vehicle (web browsing, video streaming, peer-to-peer, etc)

- IP ensures wider deployment
  - IP equipments are cheaper to develop
  - Products can be updated constantly (security holes, new features)

ITS: IP address requirements

- Vehicles will be connected to the Internet
- In-vehicle IP network
  - On-board units (OBU / Router) maintaining **Internet access** through **several** medias (3G, 802.11p, ...)
  - Application Units (AU / Host) running **ITS applications**
  - Hand-held devices running **multimedia applications**
  - OEM: Gateway between IP and CAN

=> Several IP addresses per vehicle

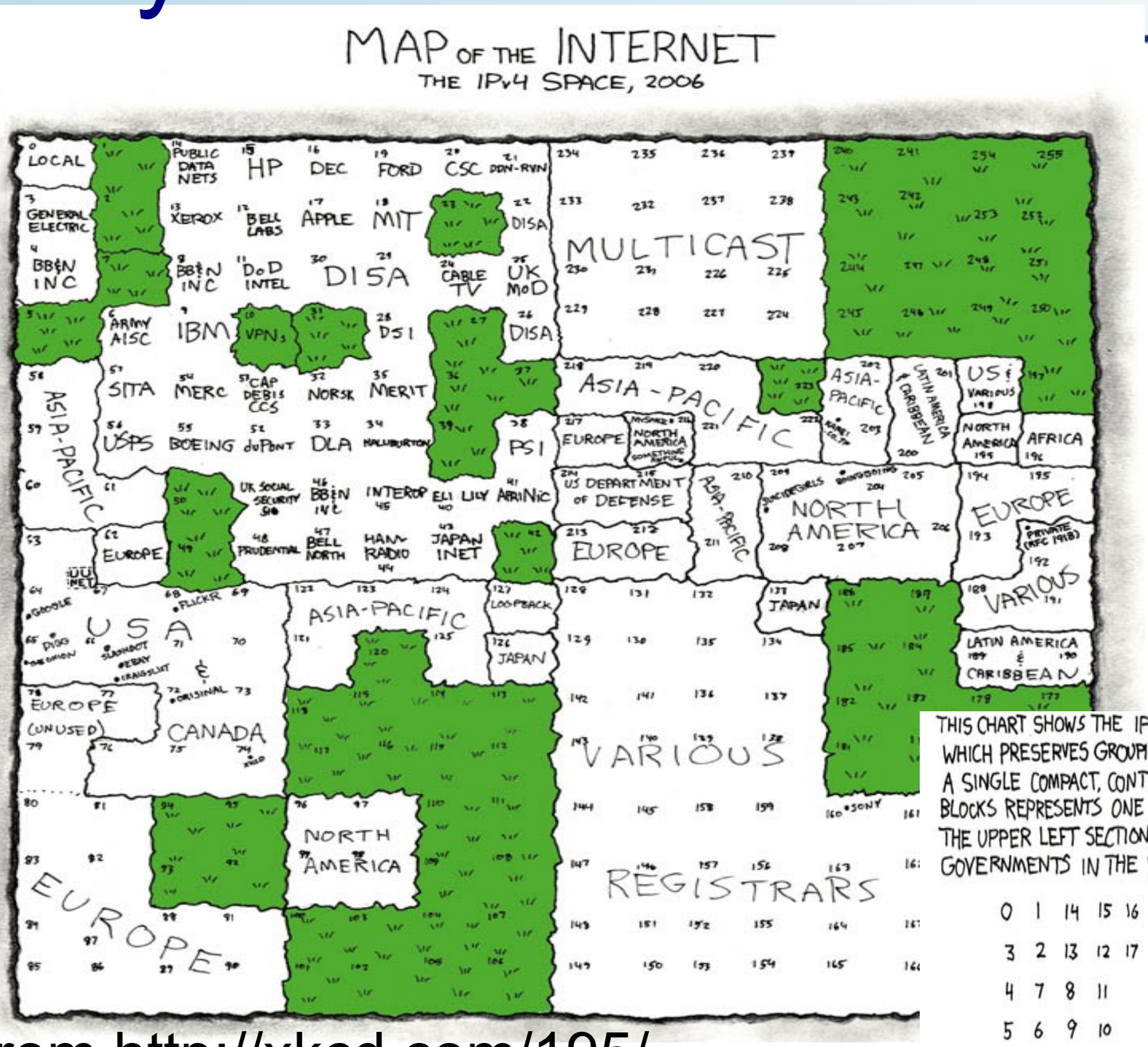


ITS: IP address requirements

- Number of cars worldwide
  - 1997: 600 millions
  - 2030: 1200 millions (at present trend)

- IPv4 does not fit to ITS deployment
  - 2^{32} = 4,294,967,296 addresses only
  - IPv4 address exhausted by 2011 / 2012
  - Too many vehicles for NAT
  - Limited mechanisms for IP session continuity

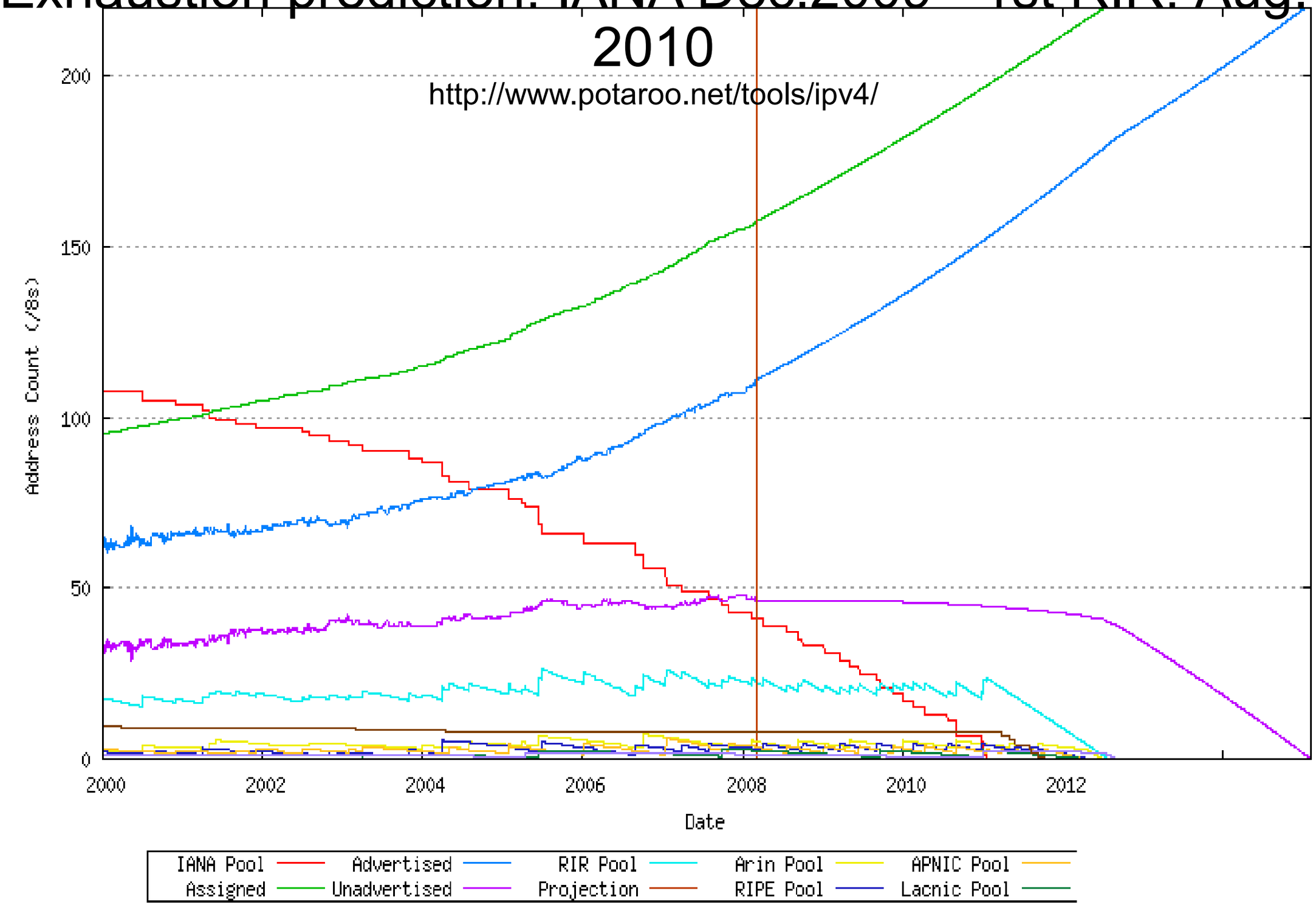
Why not IPv4: Address Depletion



from http://xkcd.com/195/

Why not IPv4: Address Depletion

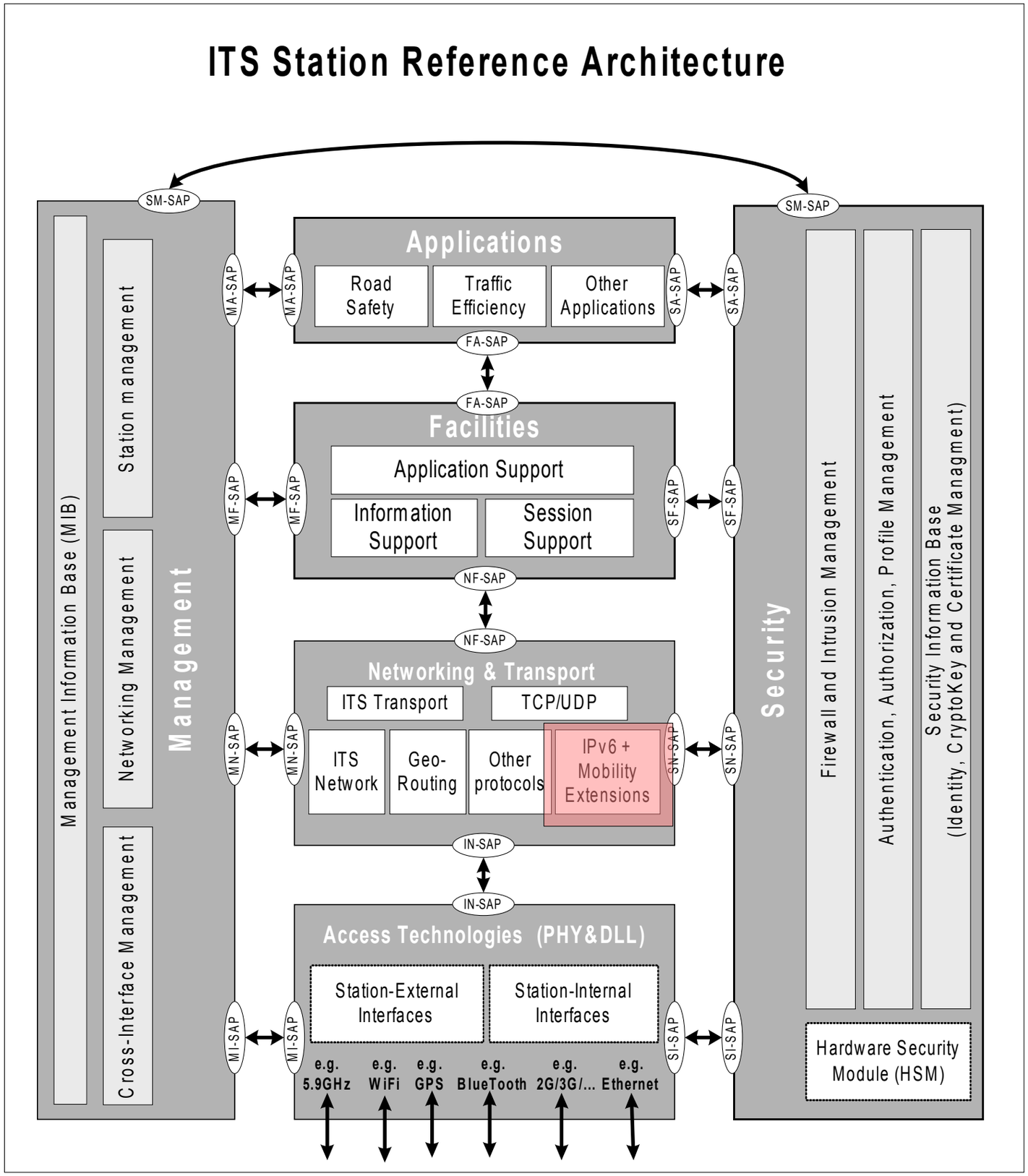
Exhaustion prediction: IANA Dec.2009 - 1st RIR: Aug. 2010



Why IPv6 ?

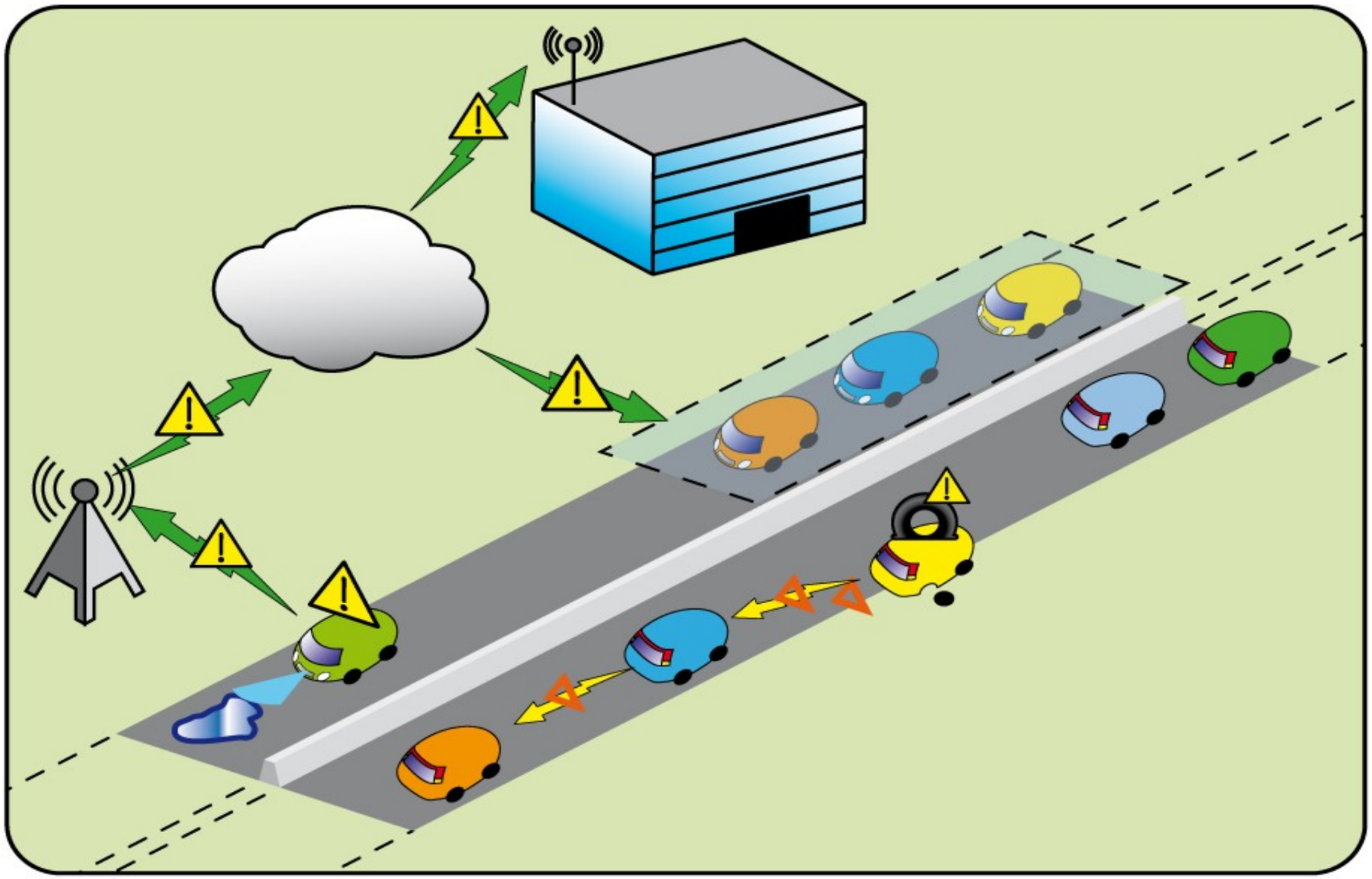
- IPv6: Internet Protocol version 6
  - Designed by the IETF since 1995 as a replacement of IPv4
- IPv6 is an evolution of IP
  - New IP header
- IPv6 addressing
  - 128 bits instead of 32 (2^{128} addresses instead of 2^{32})
  - Up to 3 911 873 538 269 506 102 addresses / m^2
  - An address for **everything** **on the network**
  - Fully specified, implemented, operational deployment started
- IPv6 comprises new features absolutely needed by ITS architectures, e.g.:
  - Auto-configuration
  - IP session continuity (**NEMO**,mobile edge multihoming, etc.)

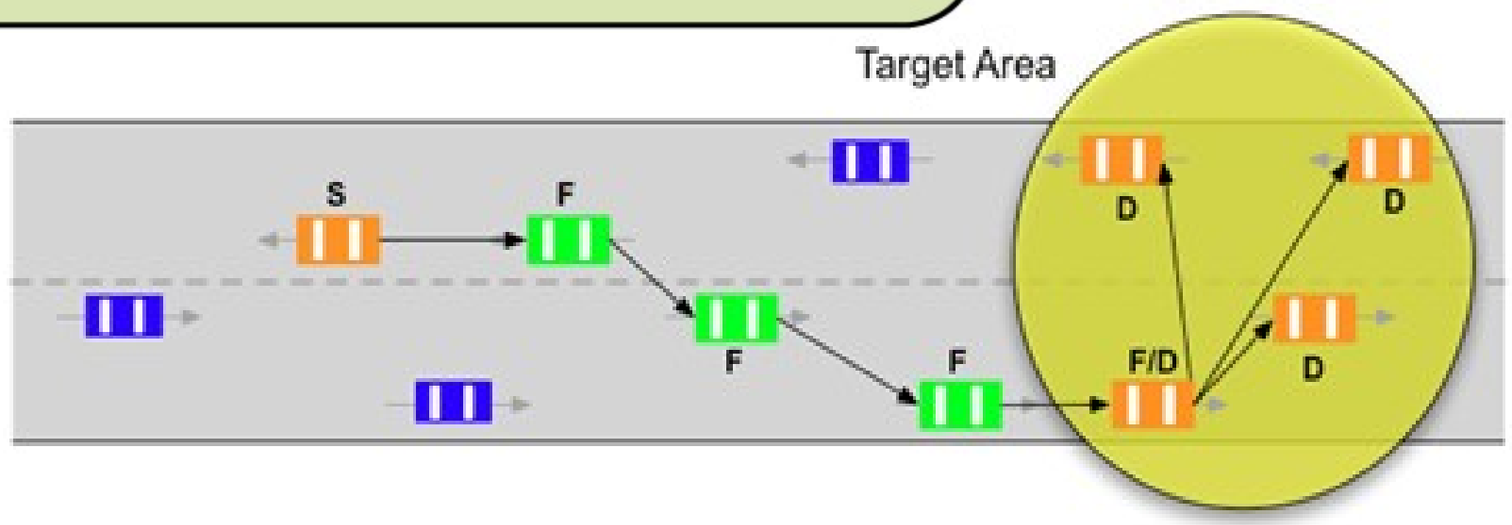
Why IPv6: ITS architectures



- ITS community mostly agree that IP means IPv6
  - ISO TC204 WG16 (CALM)
  - C2C-CC
  - COMeSafety
  - ETSI TC ITS
  - WAVE

GeoNetworking





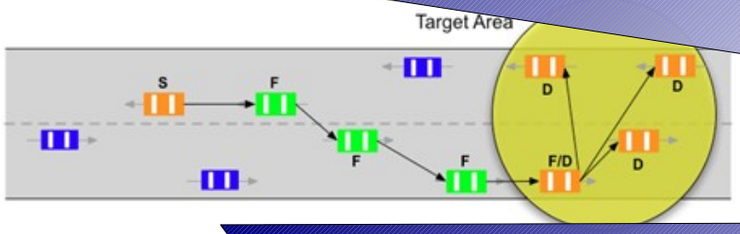
IPv6 GeoNetworking

- V2V: GeoNetworking is the addressing and routing packet forwarding approach favored in ITS communication architectures
  - C2C-CC
  - COMeSafety
  - ETSI TC ITS
  - ISO TC204 WG16 (CALM)

- ITS Architectures must also support Internet-based communications
  - Combination of IPv6 and GeoNetworking

IPv6 GeoNetworking: Background

GeoNet inherits from two mainstream topics
(non exhaustive list)



GeoNetworking discussion in C2C-CC

GeoRouting as networking basis in C2C-CC manifesto

1st GeoNetworking experiment in Network-on-Wheels

GeoNetworking Requirement: CVIS (FP7)

GeoNet project develops a baseline solution

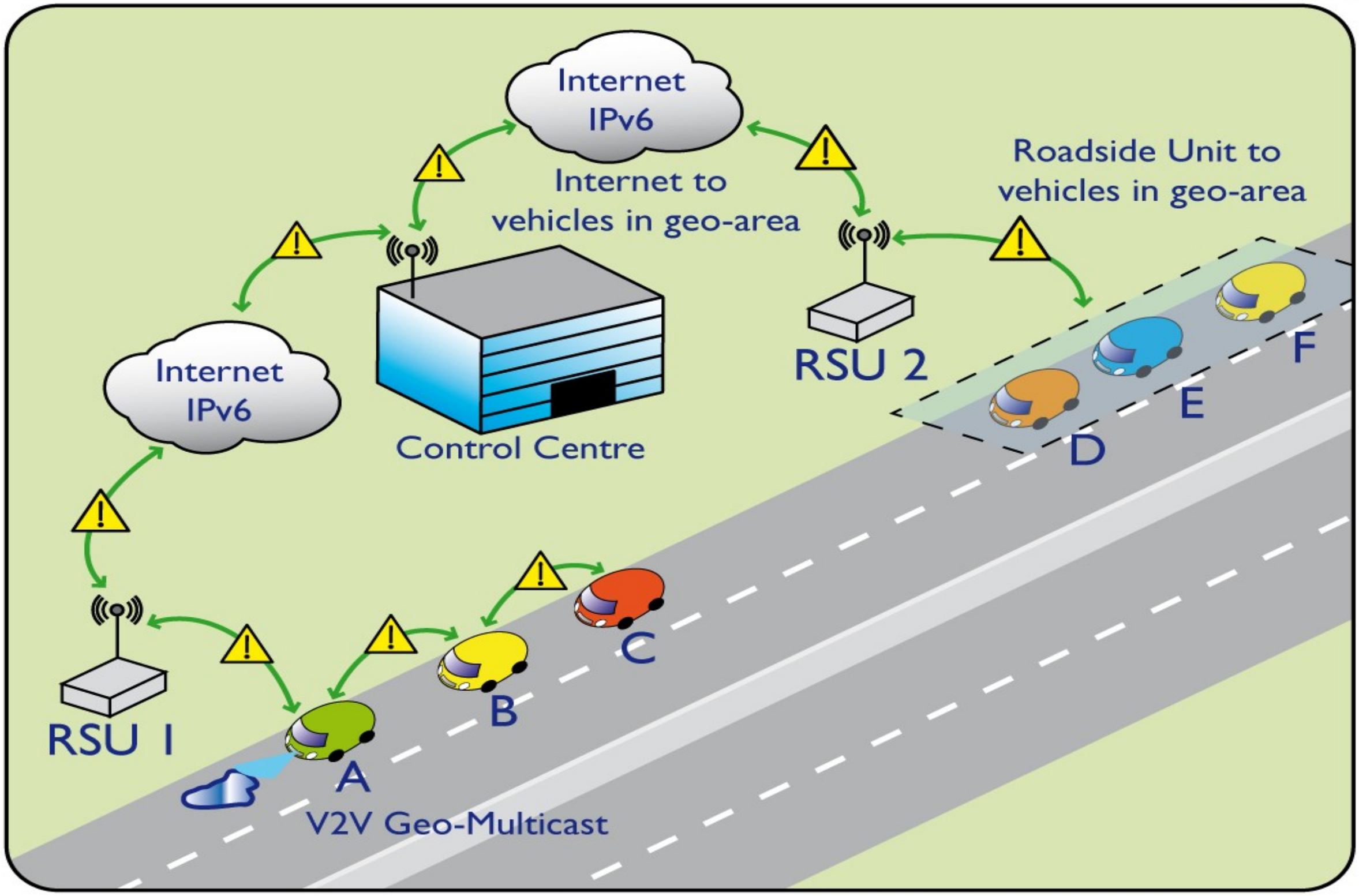
1st IPv6 NEMO ITS experiments: OverDrive (IST), InternetCAR (Keio), Nautilus6 (WIDE)

IPv6 NEMO in ITS standards: ISO CALM IPv6 Networking

2002 2003 2004 2005 2006 2007 2008 2009

Year

IPv6 GeoNetworking Scenarios



IPv6 GeoNetworking Scenarios

- GeoNet: scenarios requiring both IPv6 and GeoNetworking

- Scenario Type 1: sender is in the Internet
  - Packets are transmitted in IPv6 until the RSUs serving the geographic area where they are GeoRouted through intermediate vehicles to the final destination(s).

- Scenario type 2: receiver is in the Internet
  - Packets are GeoRouted through intermediate vehicles (using GeoUnicast) until a RSU where they are transmitted in IPv6 to the final destination.

- Scenario type 3: sender and receiver(s) are only reachable through the Internet
  - Combination of Scenarios Type 1 & 2 where source and destination(s) are out of multihop wireless range

Conclusion

- ITS systems connected to the Internet must speak IP
- IPv6 is necessary for wide development of IP-based ITS applications
  - IPv6 scales to millions of vehicles, each requiring several IP addresses & provides new functionalities
  - IPv6 is currently being deployed (not an utopia) and will be fully operational by the time ITS systems get deployed
- ITS community mostly agree that IP means IPv6
  - ISO TC204 WG16 (CALM)
  - C2C-CC's IPv6 adaptation layer (FP7 GeoNet)
  - COMeSafety: European ITS Communication Architecture
  - ETSI TC ITS
  - WAVE
  - CVIS: proof of concept of CALM
  - ELSA: European Large Scale Action in Transport
- GeoNetworking currently missing in IPv6
  - GeoNet: combination of IPv6 and C2C-CC GeoNetworking

Lessons learned on IPv6

- ITS community still lack understanding on what is IPv6 and training of their engineers
  - How to get trained on IPv6
  - Where to get IPv6 access from
  - How to adapt IPv6 standards to ITS needs (e.g. geonetworking, addressing, security)
- Hands-on experience of the ITS sector largely not sufficient
- Urgent to develop **IPv6 awareness and know-how** within the ITS community
  - Avoid disruption of business due to bad design and lack of vision
  - Considering IPv6 at the earlier design stage will further ease the transition from IPv4 to IPv6 and save costs
  - IPv6 compatibility must be ensured now