# On Business Models for Vehicle-to-Everything Systems Based on 5G Slicing

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- **Expertise:** teaching and research activities in specific domains of telecommunications and computer networks architectures, technologies and services, like:
    - network architectures and services, management/control/data plane, communication protocols, quality of services assurance over multiple domains networks, multicast and multimedia services over IP networks and heterogeneous access.

- **Recent research interest and activities** : new technologies like Software Defined Networking (SDN), Network function virtualization (NFV), Cloud/fog/edge computing, 4G/5G networking and slicing, vehicular communications.

- **Publications:** 6 books, 4 textbooks and over 200 scientific or technical papers and scientific reports

- UPB team leader in many national and int'l European research projects

# Contents

# 1. INTRODUCTION

- **Vehicle-to-Everything (V2X) and its extension- Internet of Vehicles (IoV)**
  - **Complex multi-actor systems**
  - Vehicles can exchange data with other entities (vehicles, infrastructure, grid, pedestrians, etc.)
  - **V2X services** - improve the transport, safety and comfort on the roads and also support autonomous driving
  - **5G technology** - powerful solution for V2X, in multi-tenant, multi-domain, multi-operator and end-to-end contexts
  - **5G slicing -** dedicated slices, can serve specific V2X needs
  - **V2X complexity** → multitude of visions and many variants of **V2X business models (BM)/ ecosystems (ES)**, including several cooperating actors
  - **BMs/ESs essentially determine the requirements and architectures for V2X systems and still are open research topics**

  - **Objective of this work (in progress):**
    - to analyze some relevant BMs models for 5G slicing
    - discuss how they can be adapted for rich V2X environment
    - present variants of stakeholders sets in the V2X environment, their interactions
    - guideline the preparation of the architecture definition and design for a particular V2X system

# 1. INTRODUCTION

- **Types of V2X communications**
    - **vehicle-to-**
        - vehicle (V2V), road/infrastructure (V2R/V2I)
        - pedestrian (V2P) - direct communication
        - vulnerable road user (VRU)
        - network (V2N) - including cellular networks and Internet
        - sensors (V2S), power grid (V2G), home (V2H)
- **V2X use cases and services/applications**
    - active road safety applications (including autonomous driving); warnings, notifications, assistance; traffic efficiency and management applications; infotainment applications
- **IoV extends the V2X services** to novel target domains
    - e.g.: enhanced traffic management, automobile production, repair and vehicle insurance, road infrastructure construction and repair, logistics and transportation, etc.
- **5G and its slicing technology** - powerful candidate to serve V2X needs
    - high **capacity, speed, flexibility** and **large range of customizable services**
    - 5G can provide specific types of services to satisfy various customer/tenant demands in a **multi-x** fashion (the notation –x stands for: **tenant, domain, operator** and **provider**)

# 1. INTRODUCTION

- **5G Network Slice (NSL)**
  - A managed logical group of subsets of resources, organized as virtual dedicated networks, isolated from each other (w.r.t. performance and security), but sharing the same infrastructure
  - NSLs functionalities -implemented by **Physical/Virtual network functions** (PNFs/VNFs), chained in graphs, in order to compose services dedicated to different sets of users
  - **Network Function Virtualization (NFV)** and **Software Defined Networks (SDN)** technologies can cooperate to manage, orchestrate and control the 5G sliced environment, in a flexible and programmable way
- **V2X BM-ES - new actors are involved**, besides traditional Internet and network/ service providers or operators
  - road authorities, municipalities, regulators and vehicle manufacturers *Original Equipment Manufacturers* (OEM)
- The 5G sliced systems development needs to initially define the BMs
  - **BM-ES:** defines **roles and responsibilities** of the entities, **interactions** and precedes **the system requirements and architecture definition**
- V2X- BMs - still open research topic
  - *5G PPP Automotive Working Group,* Business Feasibility Study for 5G V2X Deployment : "there is still some lack of insights into the required rollout conditions, roles of different stakeholders, investments, business models and expected profit from *Connected and Automated Mobility* (CAM) services"

- **Example 1** *(ref [7])*
- **End User (EU):** consumes (part of) the services supplied by the slice tenant; it does not provide services to other business actors
- **Slice Tenant (SLT):** generic user of a specific slice, including network/cloud/data centers, which can host customized services
- A SLT can
  - request from a **Network Slice Provider (NSLP)** to create a new **slice instance** dedicated to support some SLT specific services
  - **lease** virtual resources from NSLPs in the form of a virtual network, where the tenant can realize, manage and then provide **Network Services (NS)** to its individual end users.
    - A NS is a composition of **Network Functions (NFs),** defined in terms of the individual NFs and the mechanism used to connect them. A single tenant may define and run one or several slices in its domain
- **Network Slice Provider (NSLP):** typically a telecom Service Provider (owner or tenant of the infrastructures)
  - It can construct multi-tenant, multi-domain slices, on top of infrastructures offered by one or several InPs
- **Infrastructure Provider (InP):** owns and manages the PHY infrastructure (network/cloud/data centre)
  - It could lease its infrastructure (as it is) to a slice provider, or it can itself construct slices (the BM is flexible) and then lease the infrastructure in network slicing fashion

## 2. BUSINESS MODEL AND STAKEHOLDER ROLES IN 5G SLICING

- **Example 2 -5G-PPP Architecture Working Group** *(ref  [4])*

- ***Service Customer (SC):*** uses services offered by a SP. The vertical industries are considered as typical examples of SCs
- ***Service Provider (SP):*** it has a generic role**,** comprising three possible sub-roles:
  - ***Communication SP*** offers traditional telecom services
  - ***Digital SP*** offers digital services (e.g., enhanced mobile broadband and IoT to various verticals)
  - ***Network Slice as a Service (NSLaaS) Provider*** offers a NSL and its services
  - The SPs design, build and operate high-level services, using aggregated network services
- ***Network Operator (NOP):*** orchestrates resources, potentially offered by multiple *virtualized infrastructure providers* (VISP)
  - The NOP uses aggregated **virtualized infrastructure services** to design, build, and operate network services that are offered to SPs
- ***Virtualization Infrastructure SP (VISP):*** offers **virtualized infrastructure services**
  - designs, builds, and operates virtualization infrastructure(s) (i.e., networking and computing resources). VISP can offer access to a variety of resources by aggregating multiple technology domains and making them accessible through a single ***Application Programming Interface*** (API)
- ***Data Center SP (DCSP):*** designs, builds, operates and offers data center services. A DCSP differs from a VISP by offering "raw" resources (i.e., host servers) in rather centralized locations and simple services for consumption of these raw resources

# 2. BUSINESS MODEL AND STAKEHOLDER ROLES IN 5G SLICING

- **BUSINESS MODELS FOR 5G SLICING- EXAMPLES**

TABLE I. BUSINESS MODELS FOR 5G SLICING

| Relevant business models examples | | |
|---|---|---|
| **Basic Model [7]** | **5G-PPP [4]** | **MoNArch project [20]** | |
| End User (EU) | Service Customer (SC) | End User Tenant | |
| Slice Tenant (SLT) | Service Provider (SP) (offers slices) | Mobile Service Provider (MSP) - can belong to MNO | |
| Network SliceProvider (NSLP) | Network Operator (NOP) (offers ggregated services) | Virtualisation Infrastructure Service Provider (VISP) – can belong to MNO | VNF supplier (it can be a separate entity) |
| Infrastructure Provider (InP)<br><br>Hardware supplier | | NFV Infrastructure (NFVI) supplier | |
| | Virtualization Infrastructure SP (VISP) | Infrastructure Provider (InP) | |
| | Data Center SP (DCSP) | Hardware supplier | |

# 3. BUSINESS MODELS FOR 5G V2X

- **5G PPP Automotive Working Group, "Business Feasibility Study for 5G V2X Deployment"** *(ref [23])*
- The BM captures **operational features** and also **business relationships**
  - Stakeholder categories involved in the deployment of 5G V2X: *5G industry* (network operators, network and devices vendors), *automotive industry, Standards Developing Organizations* (SDOs), *road infrastructure operators, policy makers* and *users*
  - Interactions are specified ( see details in the paper)

InfoSys 2020, ICNS, September 27, October 01, 2020 - Lisbon, Portugal
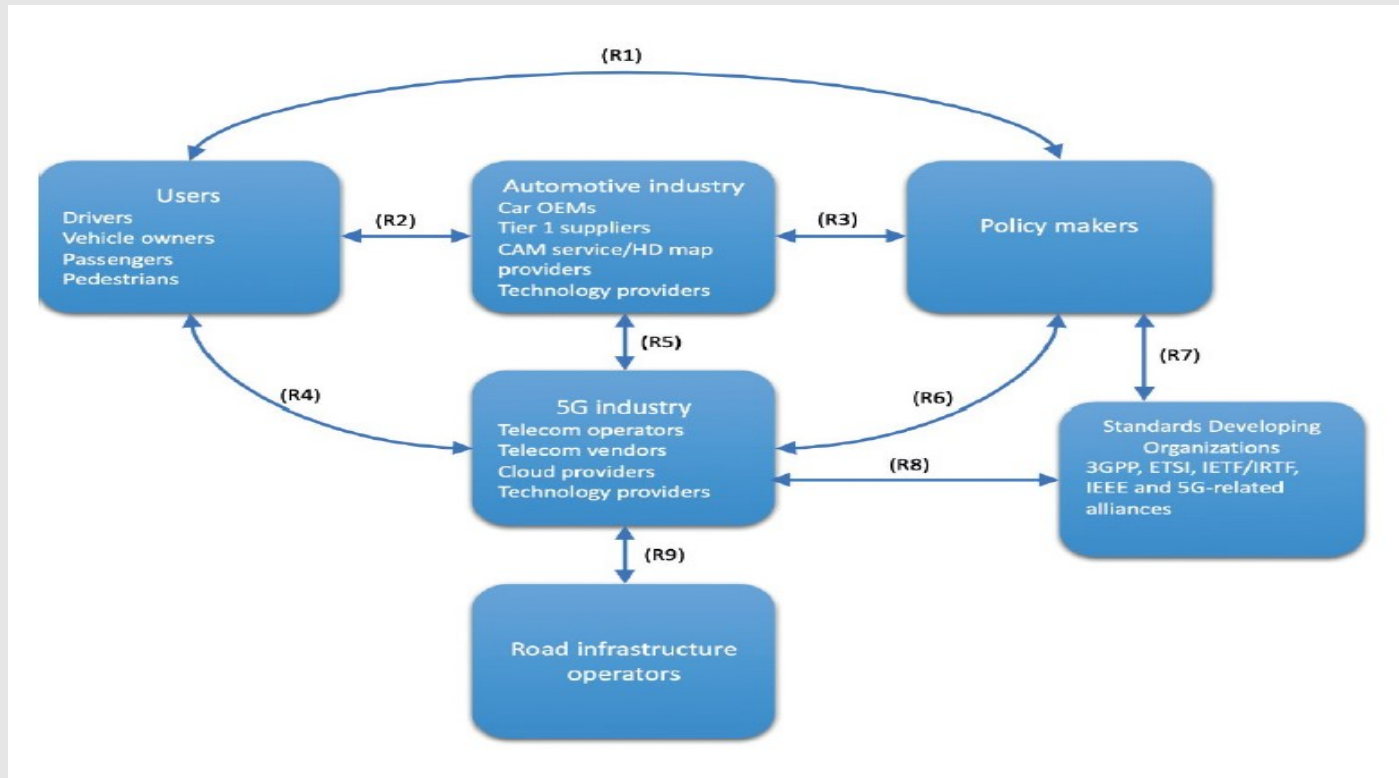
# 3. BUSINESS MODELS FOR 5G V2X

- **Project 5GCAR BM** - similar to that developed by 5G PPP Automotive Working Group
  - *[5GCAR, Fifth Generation Communication Automotive Research and innovation Deliverable D2.2 "Intermediate Report on V2X Business Models and Spectrum", v2.0 ] (ref [26])*
- In the operational scenarios the following actors can interact:
  - *5G Industry, Automotive industry, Road Infrastructure Operators* and *users*

- These stakeholders may have  different roles identified in the application of the network slicing feature:
  - **Tenant entity:** rents and leverages 5G connectivity. Note that Road operator, OEMs or other organization may also have this role.
  - **Mobile Service Provider (MSP):** provides to different tenants 5G, dedicated slices for customized services.
  - **The 5G infrastructure providers (5GInP):** can be divided into cloud and RAN providers; they offer the elements needed for the MSP to implement the slices.
  - **Non-V2X (supplementary) service provider:** can provide passenger targeted services such as enhanced infotainment, mobile office, etc.

- **The general basic 5G slicing operational BM (see Example 1) can be mapped approximately one-to-one onto the V2X operational BM**

# 4. The Heterogeneity of 5G V2X Business Models

- **Major factor which lead to many variants** of BMs
    - multitude of real-life players active (directly or indirectly) in the 5G V2X system
    - large variety of V2X applications/services
- A non-exhaustive list of actors comprises:
    - ***Connectivity Players*** (MNOs, Transport Services Providers, (TSPs), ICT Solution & Cloud Platform Providers, Intelligent Transportation System (ITS));
    - ***Automotive OEMs*** (Cars, Trucks);
    - ***Suppliers*** (Tier 1 & 2 (System Integrators), Wireless Module Vendors, Chipset Vendors, Software/Solutions, Middleware, Over the Top Services Providers (OTT), Connectivity/ Bluetooth, Databases, etc.);
    - ***Application platforms*** (Software - based, Fleet/ Commercial, Autonomous Driving, Smartphone Platforms)
    - ***Business Users*** (Public Transport, Company Fleets, etc.)
    - ***Consumers*** (End user consumers, Families, Small Office Home Office (SoHo);
    - ***Application types*** (Mobility as a Service, Maps & Navigation Telematics / Tracking, Communications Safety & Maintenance, Media & Entertainment, Productivity).

- ***Other additional stakeholders*** can play specific roles:
    - Insurance, Dealers, Auto Repair, Regulatory Bodies, Local Authorities (Government, Law Enforcement, Smart City, Road Operators), Location-based commerce players, Security infrastructure and services providers

# 4. The Heterogeneity of 5G V2X Business Models

- **Lower level technical factors,** determining the heterogeneity of 5G V2X BMs and architectures for slicing solutions
    - The management, orchestration and control subsystem is directly involved within these aspects
- **Examples of such factors**
    - heterogeneous, *services deployment* - depending on applications to be supported (e.g. traffic locality property)

    - *vertical separation of services* in *network-related* (i.e., connectivity–oriented) and *application-level services* (e.g., caching, video transcoding, content-oriented, web server, etc.) – the separation principle can be preserved or not

    - *segregated* or *integrated* orchestration
        - *Segregated orchestrators* lead to a more complex overall architecture
        - *Integrated orchestrator* - challenging piece of software (from both dependability and performance perspectives) - simpler overall architecture
    - architectural choice:  on "*flat*" or "*hierarchical*" orchestration

    - *multi-tenant, multi-domain, multi-operator context* of the planned 5G V2X systemwill influence the BM, making necessary to split the responsibilities among actors – having also impact on  in slicing solution

    - *relationship* of the *M&O system* and the 5G V2X *slicing system*

# 5. Conclusions

- Several business models/ecosystems have been analyzed for 5G slicing and then those for V2X and discuss how the 5G BM can be adapted for V2X environment

- Some major factors determining the heterogeneity of the BMs proposals have been identified in Section IV

- Steps to be refined on the BM and go to the requirement identification and architectural definition
  - The main connectivity and processing/storage technologies should be identified

  - The regulations, standards, etc., to be enforced have to be identified; they will define but also limit the system capabilities and scope

  - System requirements identification will follow, considering requirements coming from all actors involved in BM

  - The system architecture (general and layered - functional) has to be defined, allowing further technical refinement of the system design

  - The slicing solution should be selected

# Thanks!
# Questions?

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