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

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***Abstract*—Vehicle-to-Everything (V2X) and Internet of Vehicles are complex multi-actor systems offering to vehicles capabilities to exchange data with other entities (vehicles, infrastructure, grid, pedestrians, etc.) The V2X services aim to improve the transport, safety and comfort on the roads and also to help autonomous driving. The 5G technology can provide a powerful support for V2X, in multi-tenant, multi-domain, multi-operator and end-to-end contexts. Particularly, the 5G slicing technology is able to construct dedicated slices, to serve V2X needs. The complexity of the V2X systems and the multitude of visions led to proposal of many variants of V2X business models and ecosystems, comprising several cooperating actors. The business models are important, given that they essentially determines the requirements and architectures; for V2X systems and is still an open research topic. This work in progress attempts to analyze some relevant business models for 5G slicing and discuss how they can be adapted for rich V2X environment. The paper can help the reader to understand what are the possible stakeholders sets in the V2X complex environment, their interactions and to define the architecture followed by the design of a particular V2X system.**

Keywords—Vehicle-to-Everthing; 2X; 5G slicing; Business models; Stakeholders; Management and Orchestration; Software Defined Networking; Network Function Virtualization; Service management.

I. INTRODUCTION

The Vehicle-to-Everything (V2X) communications and services include many use cases in single or multi-tenancy, multi-operator and multi-domain contexts. Consequently, different sets of service requirements exist, e.g., from enhanced real-time navigation systems on board, to a self-automated car, or a video streaming played on the in-vehicle infotainment system.

The basic vehicular communications have covered essentially vehicle-to-vehicle (V2V) and vehicle-to-road/infrastructure (V2R/V2I) communications. Recently, extended models and services are included in the V2X umbrella, like: vehicle-to-pedestrian (V2P) - direct communication, vehicle-to-vulnerable road user (VRU), vehicle-to-network (V2N) - including cellular networks and Internet, Vehicle to sensors (V2S), vehicle-to-power grid (V2G) and vehicle-to-home (V2H).

V2X allows vehicles to directly communicate with each other, to roadside infrastructure, and to other road users for the benefit of better road safety, traffic efficiency, smart mobility, environmental sustainability, and driver convenience. V2X contributes to fully autonomous driving development through its unique non-line-of-sight sensing capability which allows vehicles to detect potential hazards, traffic, and road conditions from longer distances. Typical use cases and services/applications for V2X comprise: active road safety applications (including autonomous driving); warnings, notifications, assistance; traffic efficiency and management applications; infotainment applications. Therefore, IoV extends the traditional basic functions like vehicles driving and safety to novel target domains such as enhanced traffic management, automobile production, repair and vehicle insurance, road infrastructure construction and repair, logistics and transportation, etc.

Internet of Vehicles (IoV) is an extension of the V2X, aiming to create a global network of vehicles – enabled by various *Wireless Access Technologies* (WAT) [1][2]. It involves the Internet and includes heterogeneous access networks. IoV can be seen as a special use case of *Internet of Things* (IoT); however, IoV contains intelligent "terminals" such as vehicles (maybe some of them - autonomous). The complexity of the V2X/IoV claims for a strong support infrastructure. The 5G slicing technology is considered to be an appropriate candidate.

The 5G mobile network technologies offer powerful features, in terms of capacity, speed, flexibility and services, to answer the increasing demand and challenges addressed to communication systems and Internet [3]-[5]. 5G can provide specific types of services to simultaneously satisfy various customer/tenant demands in a multi-x fashion (the notation –x stands for: tenant, domain, operator and provider).

The 5G network slicing concept (based on virtualization and softwarization) enables programmability and modularity for network resources provisioning, adapted to different vertical service requirements (in terms of bandwidth, latency, mobility, etc.) [6]-[9]. In a general view, a *Network Slice* (NSL) is 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. The NSLs functionalities are implemented by Physical/Virtual network functions (PNFs/VNFs), chained in graphs, in order to compose services dedicated to different sets of users. The slices are programmable and have the ability to expose their capabilities to the users. The actual run-time execution

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entities are instantiated slices, whose life cycles are controlled by the management and control entities belonging to the *Management, Orchestration and Control Plane (MO&C)*. The *Network Function Virtualization* (NFV)[10]-[13] and *Software Defined Networks* (SDN) technologies can cooperate [14] to manage, orchestrate and control the 5G sliced environment, in a flexible and programmable way. The 3GPP [4][5] has defined three fundamental categories of 5G slice scenarios: *Massive machine type communication (mMTC); Ultra reliability low latency communication (URLLC); Enhanced mobile broadband (eMBB).*

The 5G slicing is considered to be a strong candidate to fulfill the requirements of V2X systems. Several studies and projects deal with development of V2X systems based on 5G sliced infrastructure; some examples are [15]-[19]. The dedicated 5G slices can provide the required capabilities for multiple tenants, while working over a 5G shared infrastructure. However, it is recognized [15][16], that the heterogeneous and complex features of V2X services neither allow the straightforward mapping of them onto basic reference slice types – like eMBB, URLLC and mMTC services, nor the mapping into a single V2X slice. Additional customization is necessary in order to create V2X dedicated slices.

The V2X/IoV systems are highly complex, involving several technical and organizational entities which cooperate in a business *ecosystem.* Generally, a business ecosystem is a network of organizations/stakeholders such as suppliers, distributors, customers, competitors, government agencies, etc., involved in the delivery of a specific product or service through both competition and cooperation. The entities/stakeholders/actors interact with each other, in order to achieve together the goals of the system. An equivalent term is *Business Model* (BM) to define the set of stakeholders and their interactions.

In a V2X ecosystem new actors are involved, besides traditional Internet and network/service providers or operators. These new actors could be road authorities, municipalities, regulators and vehicle manufacturers *Original Equipment Manufacturers* (OEM).

The development of the 5G complex sliced systems supposes to initially define the BMs, which essentially determines the roles and responsibilities of the entities and then the system requirements and architecture. This need is equally true for V2X systems and today it is still an open research topic. Concerning V2X BMs, it is recognized (see 5G PPP Automotive Working Group, Business Feasibility Study for 5G V2X Deployment [22]) that 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. On the other side, the general BMs for 5G sliced networks should be adapted and refined in order to well serve the V2X system's needs.

Considering the above reasons, this work in progress attempts to analyze some relevant BMs for 5G slicing and discuss how they can be adapted for V2X environment. Due to space limitation, this text cannot afford to offer detailed explanations about the BMs presented; the objective is to identify the major points of similarity of different BMs for 5G slicing, then 5G-V2X approaches and to study their possible mapping. The paper contribution is mainly an overview and comparison of different solutions.

The paper structure is described below. Section II outlines the stakeholder roles in 5G slicing, given that such definitions determine essentially the overall system architecture. Section III refines the general BMs to be adapted to 5G V2X communications and services. Section IV performs an analysis of some factors that lead to different V2X-5G business models. Section VI summarizes conclusions and future work.

II. Business Model and Stakeholder Roles in 5G Slicing

The objective of this section is to present a few relevant BMs proposed for 5G sliced systems and to identify the main roles of actors, in order to prepare their customization for V2X case in the next section. The layered architecture of the 5G slicing strongly depends on the stakeholder roles defined by the BM. Different BMs have been proposed, aiming to support multi-tenant, multi-domain end-to-end (E2E) and multi-operator capabilities in various contexts. Several examples are summarized below.

A. Example 1

A basic model (see A. Galis, [7]) defines four main roles:

End User (EU): consumes (part of) the services supplied by the slice tenant, without providing them to other business actors.

Slice Tenant (SLT): is the 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. The SLT can lease virtual resources from one or more 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): can be typically a telecommunication service provider (owner or tenant of the infrastructures from which network slices are constructed). The NSLP can construct multi-tenant, multi-domain slices, on top of infrastructures offered by one or several InPs.

Infrastructure Provider (InP): owns and manages the physical 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.

Note that the scope of the above model is limited; it is operational only, i.e., it does not detail all external entities of the overall ecosystem, which may have strong impact on the operational model, e.g., Standards Developing Organizations (SDOs), policy makers, etc.

An important feature of the above BM is its recursive capability (see Ordonez et al., [8]); a tenant can at its turn, to offer parts of its sliced resources to other tenants, and so on.

B. Example 2

A recent document of the 5G-PPP Architecture Working Group [4] describes a more refined BM:

Service Customer (SC): uses services offered by a Service Provider (SP). The vertical industries are considered as typical examples of SCs.

Service Provider (SP): it has a generic role**,** comprising three possible sub-roles, depending on the service offered to the SC: *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 have to 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 and designs, builds, and operates virtualization infrastructure(s) (i.e., networking and computing resources). Sometimes, a VISP offers 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.

The hierarchy of this model (in the top-down sense of a layered architecture) is: SC, SP, NOP, VISP, DCSP. Note that in practice, a single organization can play one or more roles of the above list.

Several recent Public Private Partnership (PPP) Phase I/II collaborative research are running, having as objectives 5G technologies (see several examples in [A. Galis, [7]). Some of them extended the list of role definitions, to allow various possible customer-provider relationships between verticals, operators, and other stakeholders.

C. Example 3

The 5G-MoNArch European project [20] proposes an ecosystem model for 5G slicing. The *Mobile network operators (MNOs)* will change from a vertically integrated model, where they own the spectrum, antenna and core network sites and equipment, to a layered model where each layer might be managed or implemented by a different stakeholder. A stakeholder is defined in [20] as an individual, entity or organisation that affects how the overall system operates. The MoNArch stakeholder roles [20] are:

End User: the ultimate entity which uses the services provides by a Tenant or the MSP.

*Tenant***:** purchases and utilizes a network slice and its associated services offered by a *Mobile Service Provider (MSP).* Tenant examples are: *Mobile Virtual Network Operator (*MVNO), enterprise or any entity that requires telecommunications services for its business operations.

Mobile Service Provider (MSP): is the main entity which provides mobile internet connectivity and telecommunication services to its users. To this aim, the MSP constructs *network slices* and their function chains to compose services. Examples of slices can be eMBB or mMTC. The MSP set of tasks are: design, building offering and operation of its services.

Infrastructure Provider (InP): owns and manages the network infrastructure (antennas, base stations, remote radio heads, data centers, etc.), and offers it to the MSP, in the form of *Infrastructure-as-a-Service* (IaaS).

In practice a larger organizational entiy could exist, i.e., *Mobile Network Operator (MNO)* which operates and owns the mobile network, *combining the roles of MSP and InP*.

The Monarch model further refines the roles of some entities which can exist, as distinct actors:

Virtualisation Infrastructure Service Provider (VISP) may exist, as an intermediate actor between InP and MSP. It designs, builds and operates a virtualization infrastructure on top of the InP services, and offers its infrastructure service to the MSP.

At a lower logical level, an *NFV Infrastructure (NFVI) supplier* may exist, to provide a NFV infrastructure to its customers, i.e., to the VISP and/or directly to the MSP.

TABLE I. BUSINESS MODELS FOR 5G SLICING

<table>
<tr><th colspan="4">Relevant business models examples</th></tr>
<tr><th>Basic Model [7]</th><th>5G-PPP [4]</th><th colspan="2">MoNArch project [20]</th></tr>
<tr><td>End User (EU)</td><td>Service Customer (SC)</td><td colspan="2">End User
Tenant</td></tr>
<tr><td>Slice Tenant (SLT)</td><td>Service Provider (SP) (offers slices)</td><td colspan="2">Mobile Service Provider (MSP) - can belong to MNO</td></tr>
<tr><td>Network SliceProvider (NSLP)</td><td>Network Operator (NOP) (offers ggregated services)</td><td>Virtualisation Infrastructure Service Provider (VISP) – can belong to MNO</td><td>VNF supplier (it can be a separate entity)</td></tr>
<tr><td rowspan="3">Infrastructure Provider (InP)

Hardware supplier</td><td></td><td colspan="2">NFV Infrastructure (NFVI) supplier</td></tr>
<tr><td>Virtualization Infrastructure SP (VISP)</td><td colspan="2" rowspan="2">Infrastructure Provider (InP)

Hardware supplier</td></tr>
<tr><td>Data Center SP (DCSP)</td></tr>
</table>

A *VNF supplier* may also exist to offer virtualized software (SW) components to the MSP.

The last but not least is the *Hardware (HW) supplier* which offers hardware to the InPs (server, antenna, cables, etc.).

D. Example 4

The document 3GPP TR22.830 [21] defines a 5G business model. It is shown that 5G opens the door to new BM roles for 3rd parties, allowing them more control of system capabilities. 5G Three role models are envisaged in 5G for stakeholders: a. The MNO owns and manages both the access and core network; b. An MNO owns and manages the core network, the access network is shared among multiple operators (i.e., RAN sharing); c. Only part of the network is owned and/or managed by the MNO, with other parts being owned and/or managed by a 3rd party.

Note that the above different models cannot be exactly on-to-one mapped, given the different contexts and visions and also the degree of splitting into sub-modules. However, a general equivalence can be observed (see TABLE 1). Here, we consider the basic model the most orthogonal one.

III. BUSINESS MODELS FOR 5G V2X

The key technology enablers for 5G V2X communication and services are currently studied and understood in the wireless industry and standardization of 3GPP Release 16 V2X is in its final phase [22]. Apart from traditional vehicular services, it is forecasted that advanced CAM services (e.g., high-definition (HD) maps support, highway chauffeur, tele-operated driving, platooning, fully autonomous driving, extended sensors, etc.) will be enabled through next-generation 5G V2X starting with 3GPP Release 16. This section will provide two examples of BMs/ecosystems for 5G V2X.

The 5G PPP Automotive Working Group [23] has defined a general 5G V2X BM, capturing not only operational features but also business relationships. It identified the following key stakeholder categories involved in the deployment of 5G V2X technologies: *5G industry* (network operators, network and devices vendors), *automotive industry*, *Standards Developing Organizations* (SDOs), *road infrastructure operators, policy makers* and *users*. The interactions between them are shown in Figure 1.

5G industry: include any general business activity or commercial enterprise developing or using 5G or providing 5G-related services, e.g., *MNOs, Telecom vendors, Cloud providers*, device providers, software developers, etc.

Automotive Industry (AutoIn): includes car *Original Equipment Manufacturer (OEMs)* (e.g., car manufacturers), component manufacturers, Tier 1 suppliers, CAM service providers, HD map providers and other automotive-specific technology providers (it can also include other services such as the logistic sectors). This category brings the automotive expertise and services (including mobility services) to customers (business and consumers).

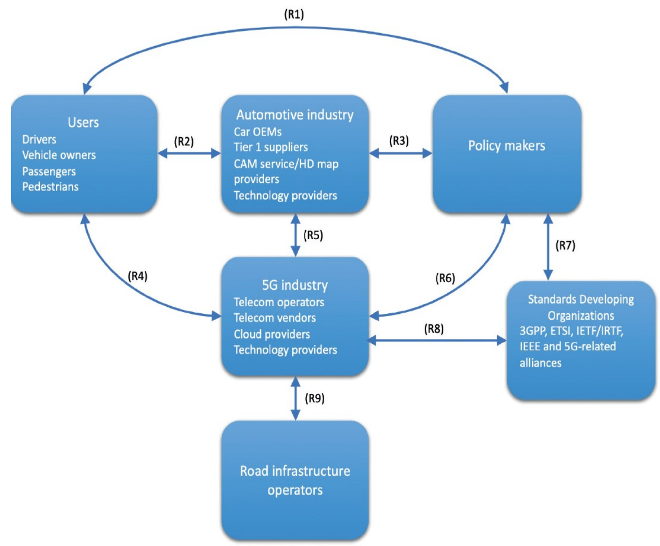

Figure 1. The main stakeholders and relationships in the context of 5G V2X deployment [23]

Standard Development Organizations (SDO): 3rd Generation Partnership Project (3GPP), European Tele-communications Standards Institute (ETSI), Internet Engineering Task Force (IETF), Internet Research Task Force (IRTF), Institute of Electrical and Electronics Engineers (IEEE) and 5G-related alliances such as Next Generation Mobile Networks (NGMN), Industrial Internet Consortium (IIC), 5G Automotive Association (5GAA) and Automotive Edge Computing Consortium (AECC). For safety-related 5G applications (e.g. *Advanced Driver Assistance Systems* - ADAS and autonomous driving), pertinent standards developing organizations such as International Organization for Standardization (ISO) may be also relevant players.

Road Infrastructure Operators (RIO): national or regional entities (public/private) performing deployment, operation and maintenance of physical road infrastructure. They may also manage road traffic operations, own or operate the toll system, etc.

Policy Makers (PM): provide the highest authorities and regulate the relationships within the whole stakeholder ecosystem, including 5G industry, automotive industry, SDOs and users. They are international or national government authorities or organizations defining the legal framework and policies, such as road and transport authorities or telecom regulators. The ITU as well as national spectrum regulators belong to this category.

Users: drivers, vehicle owners, passengers or pedestrian.

The detailed description of the interactions between the stakeholders is given in the 5G PPP Automotive Working Group document [23]. Shortly, the interactions are:

R1 (Users- PMs): to provide to the users the authority regulation to be followed (e.g., for environmental, safety and financial aspects).

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R2 (Users - Automotive Industry): to collect feedback from users in order to define the requirements and features of the new products, functionalities and services.

R3 (PMs– AutoIn): PMs define the regulation framework to be followed by AutoIn, while the latter provides feedback to the PMs to support definitions and improvement of regulations.

R4 (Users - 5G Industry): Users buy products and services from the 5G Industry. The latter collects feedback used as inputs to define the network requirements, in terms of Quality of Experience (QoE), and user needs for services and new applications.

R5 (AutoIn - 5G Industry): for inter – cooperation, allowing design a 5G V2X technology to meet the system and component level needs. The AutoIn defines the network requirements for their products and services; the 5G Industry should fulfill the functionality and performance requirements.

R6 (PMs - 5G Industry): PMs define the regulations that the 5G Industry must follow. The latter gives feedback to the PMs to influence the definition of new regulations.

R7 (PMs -SDO): SDOs have to consider regulatory conditions in standards development (e.g., ETSI work is regulated by the of the EU Commission).

R8 (SDO - 5G Industry): The SDOs define the standards to be implemented in the 5G deployments. E.g., for autonomous driving applications ultrareliable low latency are needed, based on safety standards.

R9 (5G Industry - RIO): RIO may participate in the deployment of 5G V2X and provide or facilitate licenses or other infrastructure requirements that are under their responsibility (PMs are also involved here). RIO may define network requirements for the 5G Industry. The 5G Industry shall offer communication services to the RIO based on commercial agreements. However, it is expected that 5G network providers will own and operate most or parts of the network infrastructure. A subset of actors out of the general model will cooperate within the *operational BM*, i.e.: 5G Industry, Automotive industry, users, and possibly - road infrastructure operators. However, the policy makers, SDOs and road infrastructure operators strongly influence the requirements and also the architecture of the V2X systems, as presented above in interaction description.

Usually, 5G network providers will own and operate most or parts of the network infrastructure. This entity can be split into RAN infrastructure provider (offering the physical infrastructure, e.g., antenna sites and the hardware equipment) and cloud infrastructure provider (it owns and manages local and central data centers providing the virtual resources, such as computing, storage and networking). In practice, the roles of 5G network providers can be taken by the MNOs, but is possible that Road Infrastructure Operators deploys or operate (parts of) the 5G V2X network, directly providing the necessary coverage for CAM services to the users.

The network deployment investment can be done by a single actor, called network operator (e.g., a traditional MNO). However, the model in Figure 1 is general, in the sense that potentially any actor (e.g., a road operator) could invest in network deployment.

The project 5GCAR [24]-[26] identifies a BM similar to that developed by 5G PPP Automotive Working Group. In the operational scenarios the following actors can interact: *5G Industry, Automotive industry, Road Infrastructure Operators* and *users.* Those stakeholders may assume 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 other entities presented in the general BM (Figure1), i.e., Policy makers, SDOs, influence indirectly the system requirements and specifications of the operational BM. It can be seen that the general basic 5G slicing operational BM (see Example 1) can be mapped approximately one-to-one onto the V2X operational BM.

IV. THE HETEROGENEITY OF 5G V2X BUSINESS MODELS

This section will summarize the factors leading to heterogeneity in the area of 5G V2X BMs and also affecting the particular architectures. Note that, given the topics complexity, this analysis cannot be exhaustive; some aspects are not touched, or only briefly mentioned.

A major factor which leads to many variants of BMs is the multitude of real-life players which can be active (directly or indirectly) in the 5G V2X system assembly and also the variety of V2X applications/services. Actors providing key services for the automotive sector can be split in two categories: service providers of enabling platforms, which manage the data and allow services to be built on top of the data; connectivity providers, which construct and manage connectivity facilities over cellular networks. Inside each category several types of actors can be included.

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, Freight, Car Rental, Taxi Fleets, Delivery systems, Emergency Response systems);

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Consumers (End user consumers, Families, Small Office Home Office (SoHo);

Application types (Mobility as a Service, Maps & NavigationTelematics / Tracking, Communications Safety & Maintenance, Media & Entertainment, Productivity).

Besides the above, *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.

The forecasts estimate that new actors will enter the auto industry (increase more than 45% by 2030, [27]). Therefore, in order to create a clear and stable ecosystem, the actors' roles/activities and interactions, should be defined. Cooperation is necessary: telecom operators will provide their infrastructure and licensed spectrum; the automotive suppliers will create the chips and sensors compatible with the technology. So, the typical value chain is transformed into a complex ecosystem; actors will share a part of knowledge and resources. The competition will exist and influence the ecosystem structure. From the above reasons, some relationships between possible actors are still uncertain today.

In [26][27], several variants of 5G V2X ecosystems are defined. In each one, a single actor provides the platform, e.g.: MNO, OEM, Automotive Supplier (AS), etc. Interactions between some of actors are established based on Service Level Agreements (SLA).

There are also other 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. Some examples of such factors are given below.

The *services deployment* is inherently heterogeneous, depending on applications to be supported. An example is the traffic locality property (at the edge of the network/slice or crossing the core part). An orchestrator should be aware of such traffic properties and, if necessary, deploy the corresponding network functions at the mobile edge. The orchestrator needs to have enough topology information of slices in order to be able to install appropriate functions at right places. The type of vehicular applications and services will determine the degree of pushing to the edge some functions.

The classical principle of *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.) could be preserved or not. The separation will require, respectively one orchestrator vs. separate network/service orchestrators. One can speak about *segregated* or *integrated* orchestration, respectively. Concerning slicing, one can define some slices offering essentially connectivity services and other dedicated to high-level applications. The clear separation of areas of responsibility over resources could be an advantage for operational stability (e.g., a segregated RAN orchestrator could still maintain basic RAN services even if an application-oriented orchestrator fails). On the other hand, the integrated orchestration could be attractive, in particular for operators, if both kinds of services could be orchestrated in the same fashion (and possibly even with the same orchestration infrastructure). These two options also determine heterogeneity at M&O architectural level.

Segregated orchestrators lead to a more complex overall architecture. One must assign areas of responsibilities from a resource perspective (which orchestrator controls - what resources); one should identify services pertaining to each orchestrator. The split of service is also a problem, i.e., the service description should define the "network" and "application-facing" parts of the service. Aligning the control decisions taken by these two kinds of orchestrators in a consistent way is also not trivial. In an integrated orchestration approach, all these problems disappear. However, an integrated orchestrator might be very complex if required to treat substantially different services (one-size-fits-all orchestration approach is rather not the best choice).

An integrated orchestrator is a more challenging piece of software (from both dependability and performance perspectives) but would result in a simpler overall architecture. Considering the above rationale, we defend the idea that from the slicing point of view, a segregate orchestrator is a better choice. However, in practice, both approaches have been pursued in different projects. Currently, a final verdict commonly agreed, on segregated versus integrated orchestration is not yet available. Apparently, there is no need to standardize this option, as long as both of them could be realized inside a meta-architecture. So, for the time being, we can state that M&O heterogeneity, from this point of view, will last.

Another architectural choice is on *"flat"* or *"hierarchical"* orchestration. In the flat solution, a single instance of a particular orchestrator type is in charge of all assigned resources. In the hierarchical solution, there are multiple orchestrators (a "hierarchical" model is needed, when orchestrators know to talk to each other). Note that a hierarchical orchestrator is *not necessarily* a segregated one, because all hierarchy members could deal with the same type of services.

Multi-tenant, multi-domain, multi-operator context of the planned 5G V2X system will influence the BM, making necessary to split the responsibilities among actors, for both categories: high level services and connectivity ones. *Multi-domain scenarios* create new problems [28] (e.g., in the case of a multi-domain "federated" slice). In a flat model, each orchestrator of a domain is actually multi-orchestration capable, i.e., it can discuss/negotiate with other domains' orchestrators. In the hierarchical model, a higher-level orchestrator could exist, in charge of harmonizing multiple organizations cooperation. However, several issues are not fully solved today: which entity would run that multi-domain orchestrator, trust issues, preservation of domains independency, assuring the fairness, etc.

Relationship of the *M&O system* and the 5GT V2X *slicing system* is another factor of BM architectural variability, depending on what the definition of a slice is. A largely agreed solution is to have a general orchestrator (configured offline), capable to trigger the construction of a new slice and then to install in this new slice its own dedicated orchestrator (before the slice run-time). To still assure the basic services outside any slice (e.g., packet forwarding at network level) one can construct an additional special orchestrator installed outside of all slices. Currently, many combinations have been proposed, and there is still no consensus on such matters. The convergence of solutions will be determined probably by the adoption of a more unique definition of a slice – which could assure better inter-operability.

V. CONCLUSIONS AND FUTURE WORK

This is an overview-type paper; it analyzed several business models/ecosystems for 5G slicing and then those for V2X and discuss how the 5G BM can be adapted for V2X environment. It has been shown that a large variety of proposals exist in various studies, standards and projects, given the multitude of V2X use cases and the rich set of business actors that could be potentially involved. Some major factors determining the heterogeneity of the BMs proposals have been identified in Section IV.

Considering the above analysis, and to conclude this preliminary study, we propose the steps to be followed to start a 5G V2X system development in slicing approach.

First, the V2X set of high level of services (seen from the end user perspectives) to be implemented should be defined among the rich possible ones (see Section IV).

The identification of the set of involved actors and a first assignment of their roles (especially from business/services point of view) is a major step. Here, some actors would provide only indirect actions (Policy Makers, SDOs, local regulators, etc.). Other actors will participate at operational phases (MNOs, OEMs, Service providers - e.g., OTT, Infrastructure providers, etc.) at run-time.

The multi-domain, multi-tenant, multi-operator characteristics of the 5G V2X system should be selected. Definition of interactions between the actors will complete the high-level description of the 5G V2X BM/ecosystem.

The following steps will refine 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 5G V2X slicing solution (for RAN, core and transport part of the network) should be selected. Here, the refinement of the BM is possible (see Table 1). Then, the system architecture (general and layered - functional) has to be defined, allowing further technical refinement of the system design.

Future work can go further to consider more deeply the multi-x aspects, related to the business models and impact of the BM upon the system management orchestration and control for 5G V2X dedicated slices.

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