Platforms and Ecosystems for Connected Car Services

Micha Bosler[1], Christopher Jud[2] and Georg Herzwurm[2]

[1] University of Stuttgart, Chair of General Business Administration, esp. Innovation & Service Management, Keplerstr. 17, 70174 Stuttgart, Germany
micha.bosler@bwi.uni-stuttgart.de
[2] University of Stuttgart, Chair of Information Systems II (Business Software), Keplerstr. 17, 70174 Stuttgart, Germany
{jud, herzwurm}@wius.bwi.uni-stuttgart.de

Abstract. Value-adding services are introduced in more and more industries. Often such services are delivered by platforms as in the example of connected cars. In this industry, a broad range of platforms appears to provide actors like customers and owners of vehicles with services. Consequently, complex ecosystems are developed around the connected vehicles. This article deals with platform concepts in the mentioned area. A study with qualitative research design identified different platform types for connected cars.

Keywords Connected Cars · Connected mobility · Platforms · Ecosystems

1 Introduction

Within the automotive industry, the digitalization effects a fundamental change towards vehicles equipped with data connectivity. The resulting connected cars (CC) are based on the integration of information technology and telecommunication components into the vehicle architecture. This enables network functionalities and allows the exchange of data and information over mobile networks. Consequently, the mentioned digitalization ultimately transforms cars into cyber-physical systems: virtual telematic features extend the primary mechanical and electronical capabilities of the vehicles [1]. The described development enables novel digital services that generate added value for customers. Needs for information and entertainment complement the need for mobility in the car. These digital services are offered through platforms. Next to the original equipment manufacturers (OEMs) also suppliers, as well as IT companies, want to participate in the industry change and pursue own platform offerings. Thereby, underlying concepts and business models vary considerably between different actors, due to various initial situations. The resulting heterogeneous platform landscape is intransparent.

Based on this complex situation, the aim of this paper is to analyze and characterize connected car platforms. The research question, therefore, is: *"What state-of-the-art digital platform concepts in the field of the connected car can been characterized and classified?"*

The developed classification of CC platforms organizes the range of platform concepts based on generalized types and explains the different types as well as their interaction in the superordinate ecosystem of CC. The used criteria to structure the overserved object of study have been literature-based (on previous publications which deal with general classifications of platforms and associated characteristics) of [2], [3] and [4]: customer group, value proposition, participating actors, the degree of openness, and entry barriers for complementors. An exploratory literature review in the preparation of the research yield to results which have been very technical or describe fundamental concepts regarding the CC. Especially platforms and the emergence of ecosystems have been not analyzed in depth so far. Due to the scientifically unexplored nature of connected cars, the authors chose a qualitative research design including expert interviews with representatives from different relevant connected car platforms. The paper is structured as follows: The next chapter handles the theoretical foundations. Section 3 defines different platform concepts in the field of connected cars and discusses interactions between the classified solutions. Concluding, in the last chapter, the results are summed up and discussed as well as an outlook is given.

2 Theoretical foundations and state of the art

The exchange of digital products and services often takes place on IT-platforms. Therefore, platform concepts are an intensively studied object in the literature [2,5]. Tiwana et al. (2010) define a platform as the extensible base of a software-based system that provides core functionality shared by modules as well as interfaces to the interoperation of the components. A module is described by Tiwana et al. (2010) as an add-on software subsystem that connects to the platform and provides additional functionalities [5]. Examples for platform modules can be found in applications for mobile operating systems or plug-ins for web browsers.

Sometimes, a module is offered by a complementor instead of the platform owner. Complementors are external actors who don't operate an own platform but use a different platform to distribute their developed complementary modules [2]. Researchers on platform-related phenomena identified complementors as an essential factor for the success of a platform because they increase the available modules for the platform users. Therefore, the number of complementary modules influences the benefit of a platform for existing and potential end users (network effects). Conversely, a large number of end users attracts more additional complementors to join the platform [6]. From the perspective of the platform owner, the integration of complementors promises an increasing growth of the platform through the mentioned network effects. However, the participation of complementors varies from platform to platform. At this point, the openness of a platform is a relevant criterion. The open platform allows free access to any complementor, who acts within the guidelines. Owners of a closed platform cooperate exclusively with selected complementors [7]. In the latter case, a platform access without invitation by the owner is excluded. Within the business of connected cars, most platforms are closed. The platform

owners decide on the offered services and the participated players. The design and diversity of the existing platforms depend on the degree of maturity of an industry. If an industry is still in the phase of development, the spectrum of different platforms is very high. In mature industries, a relatively homogenous range of platforms can be found. The emerging ecosystem surrounding the field of connected cars is characterized by a considerable heterogeneity of platform concepts. OEMs, as well as suppliers and IT-companies, developed platform-based solutions for connected car services. Their various business models cause the complex platform landscape.

In scientific literature, new services and thus also platforms in the context of the connected cars have been analyzed extremely cautious, besides to the high level of relevance and current development in the field of this topic. For this reason, the present paper investigates and classifies different concepts of CC platforms.

3 Types of platforms in Connected Car domain

The superordinate value proposition of connected cars relies on the implementation of new digital services for the customer. This requires a suitable technical infrastructure inside and outside the vehicle. Regarding the connectivity, most vehicles have a communication module with integrated SIM cards. Also, a screen to display connected car services is required in the car. Screen and belonging processor and operating system constitute the so-called head-unit. A complex IT landscape with backend servers as well as databases, that handle and store all car-specific or customer-specific data work in the background of the platforms [8]. The described infrastructure and equipment represent the technical requirements for the supply of digital services through CC platforms. Being of great importance in practice but not yet in scientific research, the mentioned platforms are considered as the main object of investigation in this paper.

As already discussed above, the uncharted character of the field of study required and authorized a qualitative research design. More precisely, the gain in knowledge in this article is predicated primarily on the systematic analysis of expert interviews with executives from different platform owners in the context of CC. Also, secondary data like press releases, annual reports or official service descriptions were used as additional information on the respective platforms. Comparable cases were included in the investigation to confirm or adjust the findings.

For analysis of the different platforms, a multiple case setup has been used [9]. In a first step, the platforms had been analyzed based on public available documents like reports or guidelines to gain insights regarding the characteristics, technologies and uses cases of different platforms. In a second step, semi-structured interviews have been executed following the advice of Yin (2014) and Eisenhardt (1989) [9,10]. Potential interviewees have been contacted via two online platforms for professionals, XING and LinkedIn, as well as via email. Based on the positive responses, a regional reference of the research emerged focusing German OEMs as well as participants. Nevertheless, all participants with the research worked for leading companies that offered services and products for CC worldwide. For the interviews, a questionnaire

has been developed and pre-tested with Ph.D. students to verify comprehensibility as well as clarity. The interviews took in average 60 minutes. Six interviews had been conducted in the course of the research. Applied data triangulation with multiple sources of evidence (expert interviews an secondary data analysis) increased the informative value of this research. For structuring the findings, we used literature-based classification criteria extracted from respected platform research. Gawer (2009), Thomas et al. (2014) and Gawer (2014) deal with general platform classifications [3,11,12]. Comparing the studies, we developed a consensus on the used classification criteria: level of analysis, stakeholders, value proposition, and architecture. The level of analysis refers to the platform scope, whereas the stakeholder criterion is divided into the customer group and other involved actors. The platform scope and the interaction between the actors result in the creation of value and hence in the value proposition of the platform. The latter is closely related to the platform architecture, which determines the underlying formal structure. In addition to the mentioned points, we added the criterion of openness, because the degree of openness is essential concerning the integration of complementors. In this context, we refer to the work of Benlian et al. (2015) [4].

Finally, the research design identified three alternative platform concepts which currently dominate the ecosystem of CC. Those are platforms of OEMs, platforms for smartphone integration and the "Platforms as a Service"-approach for CC (see table 1). The essential characteristics of each platform concept are described in the following. In the next section interactions and relationships between the platform concepts are discussed.

3.1 OEM platforms

The customer in person of the driver or owner of a CC deals initially with the OEM platform. Many automotive OEMs operate own platforms to offer services for CC. This is equally true for premium and medium-class as well as volume OEMs, who primarily branded their solutions. Examples include Audi Connect, BMW ConnectedDrive, Mercedes me connect, VW Car-Net or Porsche Car Connect. In contrast, Tesla does not use a branding for his platform and services [13]. Platforms of OEM aims to offer customers of CC additional value-adding services – both inside and outside the car.

A common core of connected car services exists across the various OEMs. While driving, the customer benefits from a wide range of infotainment applications like live traffic, weather data, news or music streaming services. Further, applications for mobile devices as well as web portals allow remote access via the mobile network (for example open or lock the door) and relevant vehicle data (for example fluid level, range or parking position). All those additional digital services improve the value for customers. Also, the transfer of car data to the OEM increases customer safety. In case of an accident, specific information are sent to the emergency call center of OEM, and necessary actions like emergency call (eCall) or triggering a brake-down service are triggered based on that information. Besides that, diagnosis based on telematics data leads to an optimization of the maintenance of cars.

The actuality of the topic leads to a highly competitive pressure. This requires a permanent development and release of new services on the platforms. For some services as well as new functionalities, software updates are necessary. To deliver such updates, several alternatives are available for OEMs. The existing mobile radio connection to cars enables a new way for upgrades. Particularly Tesla provides updates using the cellular network to update the software of the car and deploy additional services and functions over the air. Tesla even supplements the described options with functionalities that go beyond the scope of digital services and relate to the immediate driving behavior of the car. In case of the Model S, the OEM added various driving assistance systems such as an automatic emergency brake or an autopilot via over-the-air updates after-market launch. Besides the provision of additional services, over-the-air updates offer options to fix failures and malfunction in the software but also with systems of the car. Therefore, the digitalization of vehicles avoids costly recalls. In the future, services based on car-to-X communication will be an essential component of the OEM platforms. This means that hazard situations registered by vehicle sensors (for example the end of a traffic jam or obstacles on the road) are automatically reported to the backend. The platform evaluates and aggregates such information and warns the following drivers at an early stage via the head unit.

About the underlying architecture, OEM platforms according to [1] consist of front-end and back-end areas. The front-end serves the interaction with the customer and comprises the display unit in the cockpit, the smartphone application as well as a web-portals. The backend refers to a complex IT infrastructure that implements the handling of the services, the communication between vehicle and platform, the data management and the data storage. Also, the back-end architecture needs interfaces to cooperating partners like mobile radio providers for the provision of the Internet connection in the vehicle or IT service providers. For a vibrant ecosystem, complementors play an important role. In this context, two different roles for complementors exist. Either they act as the content provider for in-car data (traffic, wheater, etc.) or they deliver fully developed service respectively service bundles. In latter case, the OEM outsources the service development. In general, the OEM as platform owner decides which third parties are granted access to the ecosystem based on legal cooperation agreements. Based on that circumstances, the platforms, as well as the ecosystems emerging around them, are seen as closed ecosystems.

OEMs could earn additional revenues by selling CC services related to the platforms as additional equipment for a certain premium. The customer usually has several options to book service packages for an extra charge. Sometimes OEMs link the availability of selected services to the availability of certain premium head-units. As a result, platforms and the services partially generate additional exclusive values for the premium head-units, which also need to be bought as additional equipment. Convincing customers of benefits to investing in such additional equipment, free trial phases are included in the car purchase. Although, the supply and price conception of such additional equipment as well as services varies considerably between OEMs.

3.2 Integration of Smartphone Platforms in Connected Cars

Solutions for the integration of smartphones in CC aim to enable the driver to use his smartphone in the car like through the built-in head-unit. This requires a connection via USB-cable or Wi-Fi between the smartphone and the car. Android Auto from Google as well as Apple's CarPlay are the most famous representatives in this area. According to this, an expansion of smartphone ecosystems to the CC domain takes place. Google and / or Apple in the role of the platform owner determine which smartphone applications are unlocked for the use in cars. Then, the corresponding developers receive necessary application programming interfaces to adapt functionalities for the application in cars. The adjustments are necessary because of restrictions for applications in cars like display applications in reduced form on screens in the car to minimize driver's deflection. Also, animations are not allowed for applications in cars to avoid the distraction of drivers. The use of CarPlay or Android Auto in cars always requires the agreement of the OEM which decides about the integration of the solutions provided by Google or Apple.

If the user activates the integration solutions by connecting its smartphone with the car, the corresponding interface appears on the screen in the cockpit. Apps (on the smartphone) which are certified by the platform owner (Apple or Google), can be used through the head-unit. The platform owners as mentioned above are responsible for the selection of applications as well as the design of the graphical user interface (GUI) of the integration solution. The GUI of the platform of the respective OEM is deactivated as long as the smartphone integration is active. The user therefore controls, whether available platform modules such as navigation, music streaming, or messages are used via the native platform provided by the OEM or via CarPlay respectively Android Auto. Despite the substitutional nature, the smartphone integration solutions of Apple and Google show an excellent availability among the OEMs [14,15]. This is based on the need of customers demanding the smartphone integration services and leads to pressure on the OEM to support such solutions. However, the OEMs can offer the integration solutions like CarPlay and Android Auto as additional equipment and thus benefit financially from the offerings. Car brands from the lower price segment sometimes don't have the necessary resources and capabilities to develop a platform, as participants of the interviews mentioned. In this initial situation, it is possible to use the smartphone integration instead of own platform solution.

3.3 Platform as a Service for Connected Cars

It's not necessary that OEMs develop the whole range of CC service portfolio by themselfs. They have the option to obtain selected CC service from third-party providers. Often, these providers operate own platform concepts for the delivery of services across the OEM to the end user. Their business model can be denoted as "Connected Car Platform as a Service" inspired from the terms used in cloud computing. In this context, an OEM obtains third-party platforms which are white-labeled, so the use of external platforms remains invisible to the customer. Some

representatives of this approach also provide hardware and software required in the car to use the service. This applies to companies such as QNX or Harman, which thus act as a provider of entire service bundles. A suitable example for service platform bundles without any dependencies is the INRIX OpenCar platform. The INRIX solution just requires a head-unit including a web-browser in the car. Services from INRIX are available via the web-browser, but the customer does not even notice the use of services from a third-party provider because the solution is completely integrated with the look and feel of the OEM platform.

The described "CC Platform as a Service"-approach focuses all OEMs who already offer an own CC platform or intend to introduce CC services in the future. In the future, two scenarios are likely regarding the use of such external service platforms: Particularly for volume or small OEMs, the opportunities arise, instead of developing own platforms, to obtain services platforms from third-party partners. On the other hand, brands from the upper price segment are likely to rely on proprietary platform solutions due to the strategic relevance of connected cars. They integrate selected external services into the existing service portfolios of their platforms to extend the range of services. Providers of the "Connected Car Platform as a Service" approach also work with additional complementors like content providers. In case of the OpenCar solution, INRIX follows a notable strategy regarding an open platform. First of all, the platform owner offers self-developed complementary proprietary modules like live traffic data or parking and fuel prices. Beyond that, every interested developer can register on the platform and publish new services using a software development kit (SDK). By keeping entry barriers for the complementors low, a service ecosystem should be evolved [16]. The OEM in the role of the direct customer decides for every available service – from INRIX or a registered developer – whether this is taken into the vehicle.

3.4 Discussion

The three identified and classified concepts of platforms are not to be understood as isolated concepts. In fact, they have supported, alternating or substituting relationships to at least one other platform concept. The interdependent ecosystem of CC results from the interaction of different platform concepts and their platform-ecosystems [7]. The core of the emerging CC ecosystem, are platforms of OEMs. The OEMs are responsible for the governance and security as well as legal defaults of vehicles and thus decide, whether other platform-based solutions are integrated with their cars (apart from the integration of necessary content providers). Smartphone integration solutions like Car Play and Android Auto have a substitute relationship regarding platforms of OEMs since the functional scope overlaps partially. On the other hand, smartphone integration solutions also extend services offered to the customer and the car brands gain additional revenues by additional equipment. For example, BMW ConnectedDrive supports Apple CarPlay, but this service needs to be obtained for a premium by customers and leads to additional revenues for BMW. Mercedes-Benz claims a charge of costs for Android Auto and CarPlay. The "Connected Car Platform as a Service" approach allows OEMs the integration of

external developed services into the own platform. This indicates an alternating relationship. Regarding interdependencies between the approach and the solutions for smartphone integration solutions, no general statements can be made. For example, Harman and QNX explicitly support CarPlay and Android Auto, while INRIX sees the OpenCar Platform as a competing and substituting product to the offerings of Apple and Google [17].

The explanations above represent the current state of the art of digital services in the domain of CC. Regarding the dynamism of the market and the intensive efforts of its stakeholders, the development will continue. We expect a consolidation of platforms as well as new offerings. Therefore, the classification with the identified platform concepts must be seen as the first generation of platforms in CC, which forms the basis for following evolution stages. Until now, efforts of the OEMs have focused mainly on offering functionalities and services in cars, which customers already know from smartphones (for example music streaming, news, e-mail, messages, calendar, or weather). With smartphone integration solutions like CarPlay and Android Auto, however, a serious substitute for those services arises. According to the expert interviewed, the tendency leads towards that customers prefer such services by using the smartphone integration. For this reason, OEMs and their complementors will need to focus on services for CC in the future, which are more integrated into the automotive architecture and use among other sensor data of the car as well as of its environment. Audi, BMW, and Daimler already joined a consortium and established the "Open Location Platform" by HERE's data. Data from vehicle sensors and systems are sent to the common platform, aggregated and analyzed to detect hazardous situations or provide services like free parking lots roadside or within car parks. The resulting information is provided to the other drivers by the respective OEM platform. Maybe in the second generation, a further relevant platform concept for cross-OEM cooperation emerge in the ecosystem of CC. Actors also could cover several of the classified platform concepts. Google, for example, announced to develop an own in-car system, similar to platforms of the OEM. Such a platform would substitute platforms of OEMs completely. Nevertheless, OEMs need to implement such substitutes in cars. Therefore, they are still gatekeeper of cars. Depending on the pressure of the market or scenarios where Google establish exclusive cooperation with automotive OEMs or offer own vehicles, the position of OEM may be attacked.

Also, completely new scenarios appear around cars which drive autonomous and the driver no longer has to concentrate on the road. In this case, the full attention of all passengers is available for the connected car services during the whole trip. To give an example, the "driver" could join a business video conference using the head-unit while the car navigates autonomously.

4 Conclusion, Implications and Outlook

The digitization of the cars is a megatrend in the automotive industry. OEMs, suppliers and new players like Google and Apple participate in the development of

platform-based digital services for connected vehicles. Consequently, the ecosystems surrounding the connected cars appears heterogeneous and highly fragmented. This article contributes to the structure of the non-transparent ecosystem of platforms in CC. With the practiced qualitative research design, three important platform concepts have been identified and characterized. As described above the development will continue. Despite the upcoming changes, it can be expected, that the identified platform concepts will continue to play an important role. However, the interviewed experts assumed a consolidation that will occur in the next years, thus reducing the number of platforms and maybe also platform concepts.

Based on the findings, managerial implications, as well as starting points for further research, can be derived. Up to now, OEMs are the dominating factor in the outlined ecosystem in CC. Currently, OEMs decide which digital services are offered to the customer in cars as well as which partners participate in development and offering of unique services and solutions. However, the power and influence of Google and Apple in the automotive industry are increasing. The thought whether OEM will continue to play such a prominent role in the future is justified. It seems to be likely that other platform operators gain significant impact and take the position of the OEMs of today, towards the contact and interaction with the customer. Further research could investigate, which core competencies are necessary to the success in a fully digitalized automotive industry.

For OEMs, we recommend a connected car strategy which is not limited to the imitation of existing smartphone functionalities. OEMs should focus on the development of services using sensor data that Google and Apple cannot cover with their (current) platforms. At the same time, the industry is also responsible for considering increasing traffic safety with certain services or optimize traffic flow by, e.g., communicating with traffic lights and inform the driver to adapt speed to avoid a stop. Such services are already in development by BMW or AUDI. Also, it is important to note that with the introduction of new services, the complexity of the ecosystem will inevitably increase. This creates, even more, challenges to operate the platforms and their services as well as to guarantee the related cyber-security of the vehicles. If the complexity cannot be handled, customer satisfaction will be reduced.

But not just customers of services need to be in focus, equally important are complementors, which in turn influence the platform value. It must be considered, that the platform of a single OEM has very limited number of cars. Compared to the range of mobile operating systems like iOS and Android with hundreds of millions of devices, the number of vehicles equipped with connectivity functionalities of a single car manufacturer represents a huge disadvantage. The lower the number of devices (and therefore the user), the more the profitability of platform memberships are questioned by complementors. Despite this, a complementors access to every closed OEM platform requires new development activities. Different requirements and several systems architectures need to be accommodated. From complementors, it seems more attractive to use smartphone integration solutions to offer their services on the head-unit of cars; despite the risk to depend on the platform operators Apple and Google. Regarding the INRIX OpenCar solution, a promising alternative is already available, that is not restricted to an OEM. The approach of INRIX relies on a

OEM-spanning cloud platform that offers services. The services can be chosen and integrated into cars based on requirements of OEMs. If the OEMs don't want to use this existing solution, they should jointly develop own industry standards, which allow complementors a fast platform entry and offering of services across several platforms of OEMs.

Regarding the findings of former platform and ecosystems research, we recommend opening platform boundaries to exploit their potentials. In principle, the more actors act on a platform, the higher is the value for all participants, as already discussed in the literature of two-sided markets. Furthermore, we advise OEMs to join consortia and cooperation like the HERE Open Location Platform to establish OEM-spanning standards whereby the number of users is not limited to one automotive brand. Also, the ecosystem like in CC needs further investigation. As described above, with OEMs in the field of CC, different alternatives of platforms can be integrated with their ecosystems. So far, such concepts are still under-investigated in current research in this field.

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Table 1. Classification of platform types for the CC

Platform type criterion	Platforms of OEM	Smartphone Integration	CC Platform as a Service
Level of Analysis	Ecosystem around the CC	Ecosystem around smartphone & CC	Ecosystem around the CC
Customer Group	Buyer, driver and owner of the vehicles	Driver or occupant with smartphone & OEM	OEM
Value Proposition	Smart services as added value for customers: remote access to the vehicle, optimized maintenance, a wide range of infotainment applications; in the future, over-the-air updates and car-to-X services are an increased objective of the manufacturers: Revenue by additional equipment based on such value-adding services	Use of selected smartphone applications during driving (reduced surface and interactions with driver). Objective: Integration of smartphones and related platforms in CC	Selected services or the complete Connected-Car portfolio provided by third party providers. Objective: Alternative to the self-development of the services (by OEMs)
Actors	Platform operators, customer (owner / driver), supporting IT service providers, mobile communications providers, operator of smartphone-integration-solutions, content providers or complementers, developers of third party systems (like CC Platform as a Service)	Platform operators (operators of mobile operating systems), smartphone users (drivers / occupants), OEMs, developers (complementors) of smartphone applications	Platform operators, OEMs (B-2-B customers), complementers (developers), owners and drivers of cars as users of the services
Components of Architecture	Frontend (Head-Unit, Webportal, Smartphone-Application), Backend infrastructure, interfaces towards supporting or additional actors, services or platforms	Smartphone including operating system, Head-Unit in the car (frontend of B2C-Plattform) & interface, technology for implemetation	Cloud-Infrastructure, developer tools for complementors, HMI layer for OEMs, Head-Unit including Webbrowser, interfaces between actors
Degree of Openness	Closed, meaning no free access for third parties; open for selected cooperation partners (especially content providers, chosen by OEM)	Open or limited open for developers of applications (from smartphone ecosystem)	Closed or open, depending on Platform & Strategy
Entry Barriers for Complements	Approval by the platform operator; Criteria: Best quality, lowest price respectively specific demand of end users	Platform operators decide which smartphone apps are unlocked for the integration in the CC	In case of an open platform: compliance to policies (what services offered are defined by OEMs)
Example(s)	Audi Connect, BMW ConnectedDrive, Mercedes me connect	Apple CarPlay, Google Android Auto	INRIX OpenCar