



# Digital Services in the Automotive Industry

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Until recently, the automotive industry has been primarily dominated by a few giant original equipment manufacturers (OEMs). However, car manufacturers are now being challenged by the software and service industries. Apple and Google have released car platforms that leverage mobile service platforms customized for navigation, infotainment, and communication, and that provide intelligent, personalized, and contextual driving experiences. Tesla and Faraday Future debuted a futuristic car that is greener, embraces advances in IT, and provides a better user experience. Countless startups with different business models have also been actively innovating and adopted by the market, such as Uber, Waze, and Mojo.

Faced with challenges from new players in the automobile segment, OEMs are strategically investing more in digital services and new business models, shifting focus from traditional hardware platforms toward software and service platforms, from improving the in-car driving experience toward engaging in the user's daily life, and from onboard and local computing toward scalable cloud computing with machine learning and the Internet of Things (IoT). For ex-

ample, Toyota has just established Toyota Connected to develop the *connected car*. Ford uses big data to rapidly accelerate its car development and innovation. GM uses big data gathered from its fleet of cars to develop 360-degree customer profiles. As Figure 1 shows, BMW has launched a personal mobility companion, called BMW Connected, which supports and learns your routine mobility needs and is powered by the Open Mobility Cloud, an intelligent, continuously learning platform built using Microsoft Azure. This vision represents an intelligent, contextual, highly personalized world of digital services that integrate the vehicle seamlessly into the user's life. These trends are exciting and have great potential to disrupt the automotive industry and improve our lives.

## Innovation and Disruption

In the past, business impact from innovation originated from hardware and its logistic supply chain. Business and sales models with dealership and ownership have remained unchanged for decades. Now, innovation moves much faster and brings greater business impacts, leading to big challenges and opportunities. In the future, vehicles will drive themselves, be connected to the Internet and its environment,

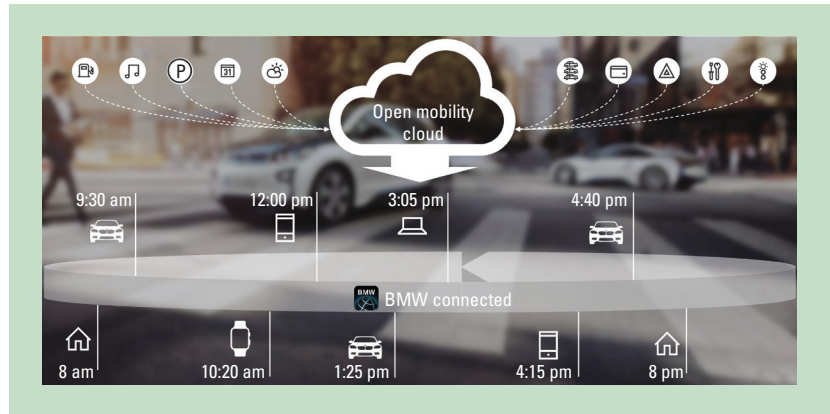
and communicate driving and traffic data. A smart traffic management system will find the best route and coordinate cars moving across an intersection. This change is fundamental and disruptive because it brings hectic competition both inside and outside the automotive industry. It will change the way we use cars and have huge effects on many professionals who drive vehicles to transport people and goods from one place to another. How can we embrace this revolutionary change, which will radically reshape the automotive industry?

- Technical innovations will bring greater impact only if they are combined with innovations in business and service models.
- Changes in user interaction and daily life will occur. The in-car experience will become a natural part of our daily lives. Self-driving will open up opportunities to redefine people's interactions with the cyber-physical world.
- Increasing automation and smart services will challenge our education systems to adapt to job market changes as some occupations are replaced by "robots."
- Major transformations (possibly radical) in business, sales, maintenance, dealership, and ownership models will occur.

- Future businesses and economies will primarily be driven by the IT and developer ecosystem, strengthening the ties and positions with content providers and the developer community.
- Value chains are shifting from traditional hardware components with suppliers and dealerships toward digital content with service providers and a developer community.
- Intellectual property will play a more vital role than ever before.

OEMs are better positioned to successfully embrace emerging trends because they can provide native in-car experiences, including interaction, integration, user touch points, vehicle association, trusted rich data sensing, and privacy preservation. Innovation, however, must be accelerated to compete with IT and software companies and startups. Due to low costs, scalability, and real-time processing that the cloud, big data, and machine learning services provide, traditional IT companies that are strong in these areas, such as Apple and Google, have already entered the connected car industry. These companies have the advantage in that they have well-established infrastructure, maps, navigation, and content. They also have a well-established ecosystem with developers and content providers. *Onboard diagnostics* (OBD) in cars make it easy for developers and startups to gather automotive and user data. Many startups, such as Mojo, have created services and in-car applications around real-time automobile maintenance and usage, and have built connected car platforms with developer support for APIs, which have been used for predictive analytics, driver behavior prediction, and improved safety.

Due to the high costs of ownership, traffic congestion, and parking woes in the city, many people use



**Figure 1. BMW digital service. The platform creates seamless mobility experiences across all touch points, powered by the Open Mobility Cloud.**

ride-sharing services such as Uber or Lyft, or car-sharing services such as BMW's ReachNow or Car2Go. This business model is disrupting the car industry, as people only need to get a car on demand by using an application on their phone. Uber collects data on its drivers and, based on the locations and destinations of Uber customers, uses big data and cloud and machine learning algorithms to match an Uber driver on the road to a customer within minutes. Customers can also easily book and drive a car, such as with ZipCar and ReachNow.

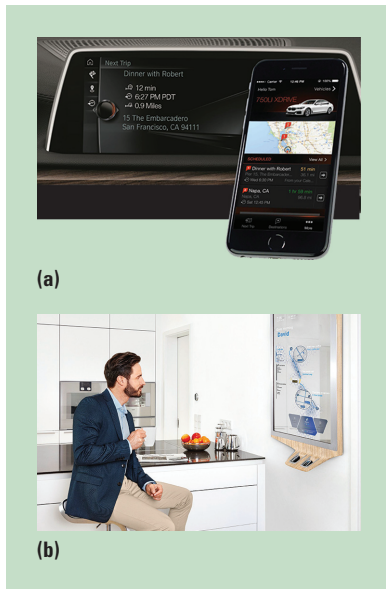
### Personalized and Contextual Services via Machine Learning

To enable seamless mobility support by providing the right information at just the right time, a driver's mobility-related context needs to be considered. Thus, personalized models must be generated using machine learning algorithms to learn driving behavior, predict personal destinations, learn routes and preferences, recommend relevant content, and extract contextual features that are relevant for personal mobility. Exemplary methodologies include using *clustering-based stops and moves of trajectories* (CB-SMoT)<sup>1</sup> to preprocess raw traces into stops and movements, as well as graphi-

cal models such as random forests and hidden Markov models to distinguish between a person's travel modes based on sparse, out-of-the-car data from smartphones.<sup>2</sup>

In these approaches, spatiotemporal features are used to distinguish between segments of a trace in which a person is traveling, and segments in which a person is stationary. Based on the same input data, several features are used as input for models to make inferences about the mode of transportation being used at the time the data was recorded. Based on such models, a person's mobility context can be acquired and used to provide users with mobility assistance not only in the car, but even before a trip starts or after a ride ends. A backend-based system could, for instance, predict upcoming habitual trips and notify users of traffic or provide recommendations along the route via their smartphone-based mobility companion before they get into the car (Figure 2a), or even via household appliances such as an intelligent mirror (Figure 2b).

**T**o realize the emerging vision of the automobile's future, some key challenges must be successfully addressed, not only on the technological side but also



**Figure 2. Mobility assistance applications.** Assistance can be provided (a) in the car, as with the BMW Connected personal mobility companion app and service, or (b) before a trip starts, as with a smart mobility mirror.

on the organizational side. First, the challenge for automotive companies is to operate and innovate like IT companies and make the car a central part of an ecosystem that merges cyber-physical content and social networking, as well as agile processes for development. Second, a considerable amount of vehicle and user data are collected during the 50 hours per month average that a user spends on the road. Thus, a significant issue is how to create a platform that is scalable and capable of real-time streaming, and mash that up with the vast amount of IoT data around users and partners while ensuring data privacy and adhering to the legal ramifications of sharing data with third parties. Third, there needs to be a paradigm shift in providing the user experience and driver interaction—for example, by embracing augmented reality (AR). Last but not least, the automotive services industry must heavily invest in using mo-

bile, cloud, and AI technologies to stay ahead of the competition, and must provide high security, uptime, performance, fault tolerance, redundancy, and safety, given that people's lives are at stake. ■

## References

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