The Future of Smart Parking Systems with Parking 4.0: Creating Smarter Mobility Networks.

Abstract

Vehicular parking lies at the intersection of urban space and mobility management. The first generation, or Parking 1.0, hardly had any service offerings except for a simple space-renting model that was managed and operated manually. Parking 2.0 offered electronic services such as parking meters that partially automated the fee collection and auditing systems. The present generation, Parking 3.0, provides basic automation that allows users to independently navigate the complete parking life cycle – from knowing the parking occupancy status to ticketing, parking, and fee settlement.

The parking industry has witnessed steady growth in the recent past, with the global market size currently exceeding $2 billion. In fact, market analysts have a very bullish outlook on this segment for the next decade, projecting a compound annual growth rate (CAGR) of 17%[1], of which about 65% would be from software and services. This forecast is based on the observation that the current pace of urbanization and motorization will lead to an explosion in parking demands.

In the current context, increasing the parking capacity would be a challenge due to the growing scarcity of available urban space, while decreasing the demand will subdue citizens' mobility experience. It is here that the premise of Parking 4.0 brings together the best of Industry 4.0[2] and Business 4.0™. Leveraging advanced analytics, experience engineering, and newer business models, Parking 4.0 will increase the efficiency of parking systems with an urban optimization strategy encompassing both space and mobility dimensions.

Market Drivers for Parking 4.0

In this section, we present the key market drivers and barriers in the smart parking domain, especially those major trends that are early indicators of a future pivoted on Parking 4.0 for growing the global parking services market. We analyze these drivers under the following categories:

1. **Social:** Traffic congestion is a major outcome of growing motorization, which is expanding the demand for dedicated parking spaces, especially in central areas. In this context, the focus is fast shifting to off-street indoor parking as opposed to outdoor parking, as the latter consumes valuable and usable street space. In a recent survey conducted by Polycarpou[3] et al., it was reported that approximately 40% of drivers spend 10-30 minutes searching for a parking space. It was also noted that when space is not available, around 34% of them demonstrate negative behavior, such as unauthorized parking or canceling the planned activity. Besides, the increasing demand for smart infrastructure at airports, shopping malls, and similar public places is spurring the need for smart parking systems.
2. **Technological:** Parking status information is gathered by last-mile data collection systems that consist of sensors and access technologies. They range from general vehicle counting to more specific details of the occupancy status of each parking spot, and the parked location of each identified vehicle. Most parking lots invariably provide the basic general information with the help of barriers at the parking entrance and exit. But moving to a higher level of granularity requires dedicated sensors (or pucks) to be installed at each parking spot, along with an access technology to relay the captured data to a control center. Besides, keeping the end-to-end system operational for the service duration is a recurring overhead.
3. **Economic:** There have been several smart parking system deployments in various parts of the globe (such as in Moscow and Los Angeles[4]), with investment also steadily increasing over the years. Apart from the technical insights, these projects have also established that the one-time deployment cost is still very high[5] despite the technological drivers, and obtaining the necessary funding is a challenge without government subsidies. New business strategies have been formulated, especially in the recent past, to overcome this hurdle.

The introduction of an integrated multi-application approach is one such model. It involves the deployment of smart parking solutions in conjugation with other city applications such as smart street lighting. Such integrated solutions are expected to lower the deployment cost and increase the city parking revenue. The other popular strategy has been to reduce the number of sensors to alleviate the upfront instrumentation cost, while piggybacking on already deployed systems and advanced analytics for their management. Besides these, advertisement and marketing fees have always been a well-tested revenue model for people-centric applications, and parking systems are no exception.

Traditionally, organizational awareness of smart parking benefits has been low. However, there is now a greater realization of the extensive revenue potential and customer value enhancement that smart parking can deliver.

Implications

Smarter parking strategies are essential for smart cities and expected to be at the forefront in terms of technology development and deployment in the next two to five years. However, given the high instrumentation and system management costs, the economics of scale and complexity require advanced analytics with newer business models. This establishes the case for Parking 4.0 in the parking landscape. In fact, parking management systems (PMS) that leverage external ecosystems and involve the larger community will be the essence of smart cities.

State of the Market

In contrast to traditional PMS that provided only basic services, smart PMS are envisioned to offer a whole range of advanced services with a highly cross-functional management tool. Some features include:

- Parking availability monitoring ranging from general to granular information
- Space optimization
- Parking guidance and search time reduction based on operator interest, user preference, and so on
- Parking reservation
- Parking demand management

- Parking price and policy optimization (mostly dynamic)
- Parking enforcement such as detection of zones, payment, and overstay violations
- Routine services such as reporting, integrated payment support (through mobile apps featuring pay-by-text, pay-by-voice, pay-by-phone, and other such functionalities), and system management in terms of configuration and maintenance

In order to obtain adequate RoI, the trend in the smart parking market has been to reduce the dependence on dedicated hardware and increase utilization of software and analytics. Hence, the current business models are opex-based and rely more heavily on selling premium software and services on a monthly or annual basis.

In the recent past, heavyweights from the automotive, automation, ITS, and telecom industries have shown great interest in the smart parking market as part of a broader smart city and IoT strategy. In fact, many automotive OEMs are vertically integrating their portfolio from being a standalone mobility provider to a mobility ecosystem enabler with interests in car sharing, EV charging, parking, and payment solutions.

Strategic alliances across these sectors are noteworthy as multi-disciplinary organizations (dealing in parking, mobility, automotive equipment, and even mobile applications) are collaborating to offer integrated solutions and services in the parking industry[6]. It is a win-win situation for all stakeholders in the value chain. For example, parking operators are able to enhance as well as ease their operations with bundled services and applications, while automotive OEMs get an opportunity to build alliances with the parking and car sharing service providers. This is the new normal, and these are the early signs that the current market is ready to embrace Parking 4.0.

Parking 4.0: Future of the Market and Opportunities

The parking market and its business models fall into three broad horizontals. The first horizontal involves the development of specific sensors and techniques for new or more cost-effective observations. The second is the deployment horizontal, which focuses on building out to the scale of data gathering, data storage, and data curation needs of parking systems. The third horizontal model addresses the need for a

portfolio of analytical techniques to convert the gathered data into actionable information. While the first two have been the focus of precursor technologies, Parking 4.0 will generate opportunities in the third segment.

The parking industry is expected to grow as a smart and green industry with the commoditization of new technologies (especially, in the IoT/M2M/V2X[7] space). With the arrival of new ecosystem players and participants, it is anticipated that the early positive disruption of this market will (or is beginning to) happen with:

- Electric vehicles, which add another dimension to parking management with the need for charging (availability of charging stations, time of the day, charging duration, and pricing are becoming key decision parameters)
- Autonomous vehicles, which will fundamentally change the usage of cars and their parking modality with self-parking features and robotic valet parking
- Uberization of parking, which will create a highly reactive and real-time ecosystem connecting those who are interested in lending parking spaces with those who are searching for one

There is a growing apprehension that the widely prevalent on-demand shared mobility practices (such as ride-hailing and car-sharing) will negatively disrupt the parking market with reduced parking demands[8]. However, it must be acknowledged that these practices pose complex trade-offs, with no clear winning strategy for all kinds of mobility requirements.

Uberization is a popular mobility method in the last mile, short distance, or occasional commute segment for its economically rewarding and better travel experience. It will, therefore, continue to co-exist with other commute modalities for serving the broader portfolio of mobility demands. In fact, newer vehicle ownership models are being introduced with innovative offerings that epicenter the vehicle as a commodity, thereby resetting the focus onto privately leased vehicles and parking. Hence, in spite of healthy competition, the future seems to be quite promising for smart parking with Parking 4.0.

As the larger parking ecosystem matures into an integrated landscape, many of the routine operations are expected to migrate into in-car systems with parking apps, thereby alleviating the burden of deploying parking systems. This could be augmented with ubiquitous or rapidly growing mobility

infrastructure (such as the electronic toll collection [ETC] transponders) to achieve the desired scale and density at affordable costs, instead of relying on the massive deployment of custom sensor networks[9].

In addition, monetization engines and brokering services that help connect data consumers with data producers could be enabled using the building blocks of data ownership or incentive mechanism through recognition and attribution, barter, or monetary rewards[10]. As with all new innovation paradigms, these possibilities come with their own research challenges[11]. There have been numerous large-scale systems in the past (such as location-based services[12]) that bear a strong resemblance with the overall smart parking philosophy. Hence, learning from their initial failures and subsequent successes is crucial to better articulate workable technology and business roadmaps.

New Perspective: Intelligent Parking Exchange (IPX)

In order to gracefully transition from the current practices to Parking 4.0, an Intelligent Parking Exchange (IPX) will be the critical factor. It will be responsible for managing end-to-end parking services for multiple facilities in urban or suburban districts. The premise of IPX arises from the fact that parking services are locale-specific and parking operations are managed within the perimeters of a facility. There is no consolidated insight into the parking status in other co-located garages. While this model provides operational simplicity, it is a missed opportunity for individuals to get a better parking experience and for parking operators to increase their revenue.

In principle, IPX will be a modular, integrated, and AI-driven software platform that can support and operationalize a variety of parking services. It will pave the way for smarter management practices, such as incentivizing an individual near a congested parking facility to move to a nearby garage with lesser occupancy.

On the other hand, the surge pricing model can be implemented by keeping a few parking slots reserved for high-paying individuals. A combination of economic and behavioral aspects such as lower fee and priority parking could be exploited for designing the incentive mechanism. Besides demand-response management, an IPX can also forecast parking patterns in an area and predictively control space allocation in nearby facilities

to improve the quality of service. It can integrate with a larger traffic control system in a smart city ecosystem and receive regulatory control signals such as congestion periods to avoid directing users to parking lots near congested areas.

Conclusion

Business 4.0, which is integral to Parking 4.0, works on the principle of ecosystems and a sense of abundance. In this context, the future of parking will emerge as an ecosystem play, comprising individuals, parking operators, automotive OEMs, solution integrators, and other stakeholders. The sense of abundance will come from the provision of 'right parking at the right place at the right price'. We believe that Parking 4.0 has the potential to be a major game-changer not only in the smart parking segment, but also in the overall mobility ecosystem of present cities and smart cities of the future. By leveraging IPX, Parking 4.0 is poised to lead to more advanced outcomes.

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