Cloud Computing and the Internet of Things: Technology Innovation in Automobile Service

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Abstract. Aiming to explore the transforming role of information technologies in automobile service, this paper first introduces two major technology trends: Cloud Computing and the Internet of Things, as well as their applications in automobile service. After that, the paper focuses on investigating the technology innovations in automobile service, and how the innovations transform the traditional business. Future research directions are discussed finally.

Keywords: Cloud Computing, the Internet of Things, Service Applications, Technology Innovation, Automobile Service.

1 Introduction

The automotive dealership business is undergoing significant change triggered by advanced information technologies, especially Cloud Computing and the Internet of Things. Aiming to explore the transforming role of information technologies in automobile service, this paper first introduces two major technology trends: Cloud Computing and the Internet of Things, as well as their applications in automobile service. After that, the paper focuses on investigating the technology innovations in automobile service, and how the innovations transform the traditional business. Future research directions are discussed finally.

2 Technology Background

2.1 Cloud Computing

Cloud computing is changing the Information Technology (IT) industry fundamentally by transforming computing services to an on-demand model similar to electronic and water utilities [1, 2]. Utilizing cloud computing, IT providers deliver the subscription-based services at three different levels including infrastructure, platform, and software applications (as shown in Table 1). IT users access computing services over the Internet in a pay-as-you-go model without investing heavily on technology development and maintenance in house [2].

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Cloud computing benefits both the IT providers and the users. For the IT providers, cloud computing creates a data center on a virtual base, meaning the IT infrastructure such as hardware and software can be physically distributed but logically connected. This component-based architecture enables the IT providers allocate the IT resources efficiently and save costs at the same time. For the IT users, they are able to access the IT services anywhere anytime with competitive costs. Additionally, cloud services free the IT users from building complex IT infrastructure on site, thus allow them focus more on product innovation and increase core business value.

Cloud computing has great business potentials. IDC (International Data Corporation) anticipates the worldwide cloud spending will grow from $40 billion in 2012 to $100 billion annually by 2016 [3]. Moreover, Gartner Group identifies cloud computing as one of the top IT trends that will reach its peak in two to five years [4]. Cloud computing has been widely explored and deployed in various areas such as e-business (e.g., Amazon Elastic Compute Cloud), social networking (e.g., Facebook and Myspace), searching engine and portal (e.g., Google App Engine), online storage and collaboration (e,g., Dropbox and Microsoft Skydrive), infrastructure services (e.g., Sun Network/Sun Grid and IBM Blue Cloud Computing), and enterprise applications (e.g., Salesforce), etc.[5].

Cloud computing can be classified in terms of the service types and the service range. Table 1 illustrates the different models based on the two classifications.

Table 1. Classification of cloud computing models [6]

Cloud computing models		
Service models (Service type/level)	Infrastructure as a Service (IaaS)	Infrastructure such as network, servers, operating systems, and storage etc.
	Platform as a Service (PaaS)	Platform such as programming languages and tools, database, and web server etc.
	Software as a Service (SaaS)	Software applications such as client interface, and enterprise applications etc.
Deployment models (Service range/scale)	Public cloud	Available to general public
	Community cloud	Shared by several organizations
	Private cloud	Operated solely inside of an organization
	Hybrid cloud	Composed two or more clouds (private, community, and/or public cloud)

2.2 The Internet of Things

The Internet of Things (IoT) is another major trend that shapes the development of Information and Communication Technologies (ICT) by connecting "everything" to the Internet [7]. As an emerging paradigm, IoT converges three primary visions (as shown in Fig. 1) including things (the objects to track, things-oriented vision), networking (the connection of the objects to the Internet and communication between the objects, Internet-oriented vision), and representation (the representation of the objects on the Internet, semantic-oriented vision).

The “things” in IoT could be any objects that need to be tracked in practice, for instance, cars on road, products in inventory, and even pets on the run. The “things” feature three main characters; they have to be 1) identifiable, 2) able to communicate, and 3) intelligent [7, 8].

In order to capture the above attributes of the “things”, several technologies has been utilized [9]:

- **Identification technologies.** The essential component of IoT includes identifier such as Radio-Frequency Identification (RFID) tags and two-dimensional bar code. Those identifiers can be used to uniquely identify objects, as well as their status such as location, temperature, and movements, etc.
- **Sensing and communication technologies.** Sensors combined with communication technologies can be used to track the changing status of an object, and transmit the data to the Internet, for example, Wireless Sensor Networks (WSN) and RFID Sensor Networks (RSN).
- **Middleware technologies.** The middleware hides the details of different technologies, integrates the legacy technologies at lower level, and provides a unified interface to support the development of specific applications at higher level.

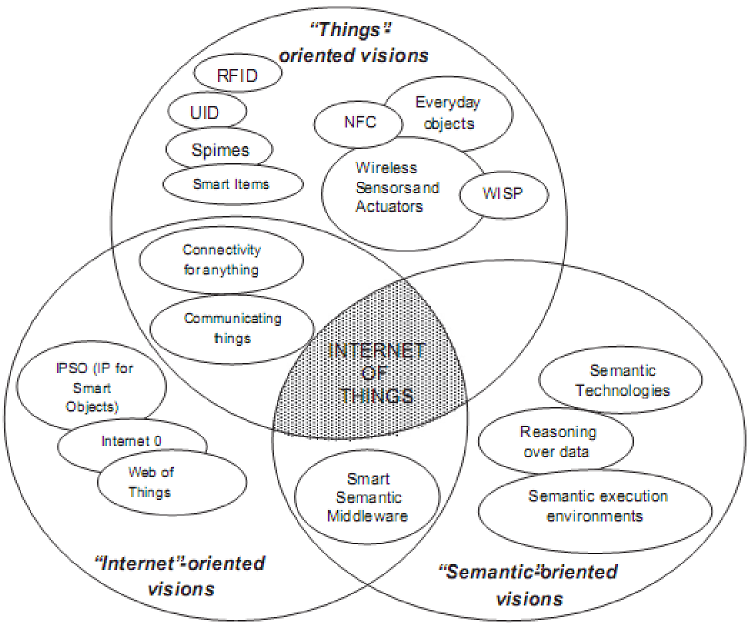

Fig. 1. “The Internet of Things” paradigm as a result of the convergence of different vision [9]

IoT creates a dynamic network of identified mobile "objects", which communicate and interact with one another in order to support business applications and management [8]. By tracking objects and connecting data to the Internet, IoT brought tangible business benefits such as increasing logistic efficiency, improving life-cycle management, and creating value-added services.

2.3 Current Applications and Challenges

Business Applications of Cloud Computing and the Internet of Things. In many situations, IoT and cloud computing have been used together to create the dynamic network of mobile objects. The former mainly focuses on tracking the physical objects and connecting the data to the Internet, while the latter emphasizes the storage and the management of the mass information over the Internet. Both work together to provide ubiquitous, convenient, and on-demand service to the users.

IoT and cloud computing have started to play an important role in various areas such as environmental monitoring, smart cities, inventory control, healthcare, and security vs. surveillance [7]. In automobile industry, for instance, manufacturers such as Honda introduce RFID to manage the supply chain. CarMax, the largest used car retailer in the U.S., attaches RFID tags to each vehicle, in order to track the life cycle of a vehicle from buy-in, refurbishment, to retail/auction [13].

BMW has adopted iDrive (intelligent-Drive) as an intelligent informatics system. Using various sensors and tags, iDrive keeps track of the driving data and the environment information in order to assist drivers make instant decisions and allow them to concentrate on road [12]. With an embedded GPS (Global Position System), iDrive is able to track the vehicle location and the road condition to provide driving directions. If a BMW is stolen, the driver could locate the stolen car through the BMW tracking system. Moreover, iDrive provides remote services such as medical rescue and remote diagnose.

In addition to BMW, other major manufacturers such as Toyota, GM, and Ford also deployed informatics system (i.e., Toyota G-Book, GM OnStar, and Ford SYNC) in their newly released models.

Challenges and Opportunities. Since cloud computing and IoT are still in their infancy, they face a few challenges. Security is the first critical issue to adopt IoT and cloud computing wide spread [7,10]. The main concerns include availability and stability of the service, data confidentiality and security, information privacy, scalability of the storage, and reputation of the providers, etc. [7]. The major cloud providers such as Amazon, Google, and Microsoft, all implemented security mechanisms aiming to provide reliable computing and secure communication [10].

The other main challenge is global standards. Global standard in the areas of security, privacy, architecture, and communications are essential to avoid conflict between and confusion of locally developed standards in enterprise or industry wise.

Though with challenges, IoT and cloud computing provide opportunities for technology innovation in industries, even for those brick-and-mortar companies. For instance, enabled by IoT and cloud computing, "things" such as vehicles can be connected to add security, analytics, and management capabilities [11]. Following we introduce two cases of the applications of IoT and cloud computing in automobile industry.

3 Technology Innovation in Automobile Service

3.1 Transforming Automobile Service

New information technologies such as IoT and cloud computing are transforming the traditional dealership process and operations. The life cycle of automobile service normally includes marketing and sales, service and survey, and finally recycling and used-car sales. Enabled by IoT and cloud computing, dealership is able to track car usage and analyze consumer preference along the life cycle, thus increase efficiency and improve customer satisfaction.

For instance, the future showroom could become an experience, education, and entertainment center, or even a social club rather than the traditional sales center. Since the majority of the pre-sale activities (such as model comparison, price enquire, and appointment scheduling) and sales operations (such as checking credit, signing contract, and shopping loan) can be completed online or through mobile devices, the main purposes of visiting a showroom change to gain experience (of new models or new technology embedded in car), education (on vehicle-related lessons), entertainment (on virtual games and kids club), or social interactions (with people of similar interests on driving, design, and car maintenance, etc.) The above vision breaks the "normal" pattern. It has to be supported by information technologies such as IoT and cloud computing by tracking and analyzing the mass data of driving behavior and consumer preference.

Table 2 shows the transformation of the automobile services enabled by information technologies such as IoT and cloud computing.

IoT and cloud computing initiate the technology innovation in automobile services. According to Francisand and Bessand [14], there are four different 'targets' of innovation:

- **Product innovation:** the development of new products or the improvement of existing products.
- **Process innovation:** the improvement of processes that create the product.
- **Position innovation:** a product is repositioned in a different user context.
- **Paradigm innovation:** meaning the dramatically changing business model requires a shift in organizational values and power structures.
- For each type, innovation can reach two different levels [14]:
- '**Do better**' innovation continues innovative activities along the same path.
- '**Do different**' innovations are innovations that completely change the current portfolio activities.

The technology-enabled innovation in automobile service mainly includes three different types of innovations: product (i.e., service) innovation, process innovation, and paradigm innovation. The innovation may reach different levels at different time frame (see Fig. 2).

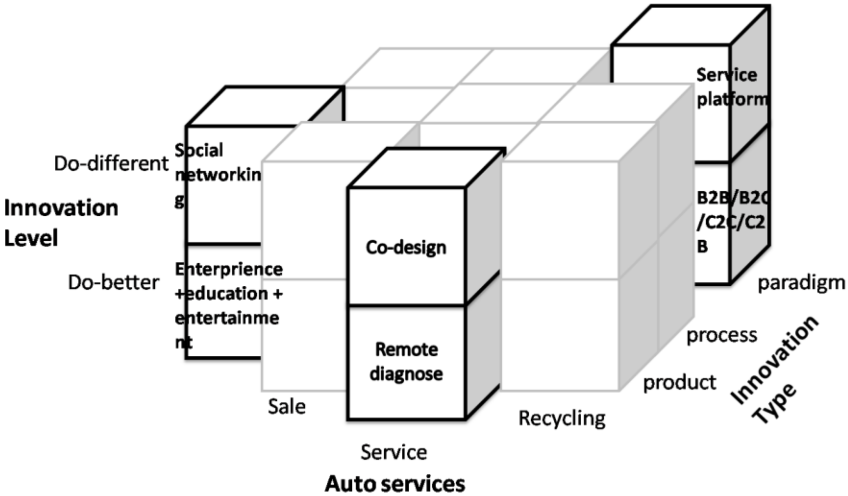

Fig. 2. Dealership service innovation

Table 2. Transformation of automobile service

Auto service	Traditional model	Transformed model
Sales	Test-drive, negotiate, check credit, shop auto loan, and sign contract.	• Experience center: experience new models and state-of-art technologies • Education center: gain knowledge related to model selection, car maintenance, and driving safety, etc. • Social networking: get together with people who share the similar interests related to automobile design, driving, and maintenance, etc. • Entertainment center: virtual driving games, kids club, etc. • Mobile commerce: offer pre-sale activities and sales operations via mobile devices
Service	Wait for customer to take the car to the garage, fix it, and notify the customer	• Track vehicle usage and road condition, assist driver to make instant decisions. • Provide remote services such as tele-diagnose • Initiate personalized service by offering entertainment, news, commercial information based on driver preference

3.2 Technology Architecture

Specific technologies have to be deployed to support the applications of IoT and cloud computing in automobile service industry. Identification technologies (such as RFID tags and sensors) can be used to track the status change along the life cycle of a vehicle, a customer, and auto service. Communication technologies (such as WSN and satellite network) can be used to connect the mass data to the Internet (i.e., cloud). Applications can be developed to analyze the tracking date in order to understand the customer behavior and the vehicle usage. These technologies together enable the innovation of automobile services (as shown in Fig. 3).

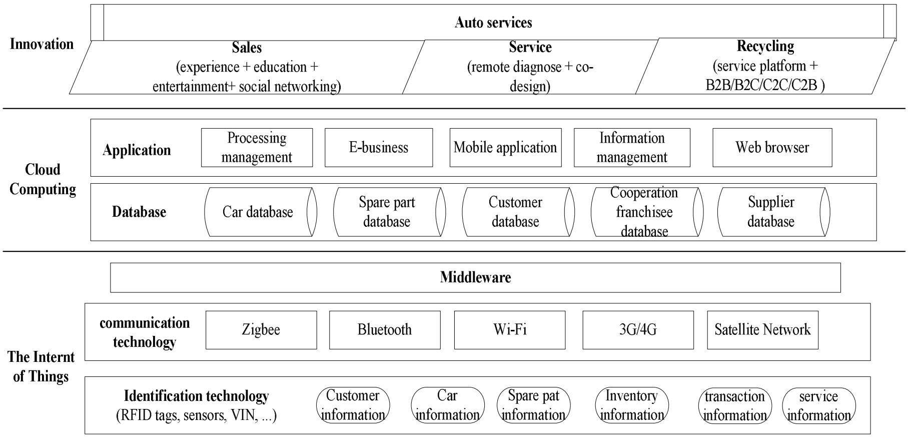

Fig. 3. Technology architecture in dealership innovation

4 Conclusion

The automotive dealership business is undergoing significant change triggered by advanced information technologies. This paper first introduced the two major technology trends: the Internet of Things and cloud computing. Using automobile service as an example, this paper then focused on the technology innovations that are transforming the traditional "passive" pattern to future "proactive" mode.

Future research may explore the methodologies of the innovation design, the procedures of the transformation in practice, as well as the issues raised during the implementation.

References

1. Armbrust, M., et al.: Above the Clouds: A Berkeley View of Cloud Computing. UC Berkeley Reliable Adaptive Distributed Systems Laboratory (2009), http://radlab.cs.berkeley.edu/
2. Buyya, R., Pandey, S., Vecchiola, C.: Cloudbus toolkit for market-oriented cloud computing. J. Cloud Computing 5939, 24–44 (2009)

3. Gens, F., et al.: Worldwide and regional public IT cloud services 2012-2016 forecast. IDC Market Analysis (2012), http://www.idc.com/getdoc.jsp?containerId=236552#.UTfUr0JDSXs
4. Fenn, J., LeHong, H.: Gartner's hype cycle for emerging technologies. Gartner Research (2011)
5. Buyya, R., Chee, S.Y., Venugopal, S., Broberg, J., Brandic, I.: Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility. J.: Future Generation Computer Systems (2009), http://dx.doi.org/10.1016/j.future.2008.12.001
6. Mell, P., Grance, T.: The NIST Definition of Cloud Computing (Draft). Recommendations of the National Institute of Standards and Technology. National Institute of Standards and Technology Special Publication 800-145, Draft (2011)
7. Miorandi, D., Sicari, S., De Pellegrini, F., Chlamtac, I.: Internet of things: Vision, applications and research challenges. J. Ad Hoc Networks 10(7), 1497–1516 (2012)
8. Vermesan, O., et al.: Internet of Things Strategic Research Roadmap (2009), http://www.internet-of-things-research.eu/pdf/IoT_Cluster_Strategic_Research_Agenda_2011.pdf
9. Atzori, L., Iera, A., Morabito, G.: The Internet of Things: A survey. Computer Networks (2010), http://dx.doi.org/10.1016/j.comnet.2010.05.010
10. Chen, Y.N., Hu, H.L.: Internet of intelligent things and robot as a service. Simulation Modelling Practice and Theory (2012), http://dx.doi.org/10.1016/j.simpat.2012.03.006
11. Evans, D.: The Internet of Things How the Next Evolution of the Internet Is Changing Everything. Cisco Internet Business Solutions Group, IBSG (2011), http://www.cisco.com/web/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf
12. BWM. iDrive, http://www.bmw.com/com/en/insights/technology/technology_guide/articles/idrive.html (accessed in 2012)
13. CarMax, CarMax Annual Report 2012, http://www.annualreports.com/HostedData/AnnualReports/PDF/KMX2011.pdf (accessed 2012)
14. Francis, D., Bessant, J.: Targeting innovation and implications for capability development. J. Technovation 25, 171–183 (2005)