

A 3-dimensional View Model of IoT-empowered Business Model Engineering Towards Borderless Business Reengineering

Toshihiko Yamakami

IoT Business Unit, ACCESS

Toshihiko.Yamakami@access-company.com

Abstract— IoT, Internet of Things, has been a key part of ICT, Information and Communication Technologies. An increasing need of IoT-empowered business model engineering presents a challenge for a wide range of non-ICT businesses. It provides a broad challenge in business design processes, which ultimately leads to an organizational change. The author proposes a framework of IoT-empowered business model engineering using a 3-dimensional approach. This is a novel framework to construct IoT-empowered business reengineering, which is shaping emerging business landscapes.

Keywords— IoT; business model; 3-dimensional approach; business model engineering; IT-empowered business engineering;

I. INTRODUCTION

IoT, Internet of Things, represents interconnection of physical objects with the Internet technology. The concept dates back to early 1990's when the term "ubiquitous computing" was coined. Advance of sensor and wireless communication technology leverages the potential of IoT. Self-identified objects with mining and AI technologies provide new opportunities of real-time business innovation. Dynamism of IoT-empowered business model engineering leads to needs of organizational change in a wide range of businesses. For example, cost reduction with operational changes triggers a need for organizational change in non-ICT industries. This is an industry-agnostic trend. Requirements of dealing with this trend add needs of organizational change in many non-ICT industries.

Emerging intelligence in things connected to the Internet plays an important role in business model engineering. In order to facilitate IoT-empowered business model engineering, it is necessary to provide a novel framework that suits IoT-based business construction. IoT-empowered business model engineering both of technological design of IoT in the enterprise contexts and IoT-empowered organizational reengineering. This requirement leads to a new requirement for business reengineering in the everything-connected industrial context. In this paper, the author presents a methodological framework where business reengineering is captured in the IoT-empowered context.

II. BACKGROUND

A. Purpose of Research

The aim of this research is to identify a methodological framework of business model engineering in an IoT-empowered context.

B. Related Work

IoT research dates back to middle of 1990's. We can find the term "Internet of Things" in the second half of 1990's. IPv6 aimed at solving address scarcity of IoT. The first draft of IPv6 was published in 1995 [1].

There are three categories of past literature of business model engineering of IoT. The first is general business model framework and methodologies accommodating IoT. Dijkman et al. identifies building blocks of IoT-focused business models through literature and experts survey and interviews [2]. Thoma et al. analyzed IoT services in literature review of public funded projects and classified IoT services by physical entities and their lifecycle [3]. Westerlun et al. discussed three major challenges for business ecosystem for IoT : the diversity of objects, the immaturity of innovation, and the unstructured ecosystems [4]. Bucherer et al. discussed four business model scenarios of IoT: Product as a Service, information service providers, end-user involvement, and "real-time business analysis and decision making" [5].

The second is application-specific business model engineering and IoT deployment in business contexts. IoT covers many domains such as manufacturing, transportation, energy, health care, smart homes, agriculture. Different IoT deployment deal with the different aspects of domain-specific business model engineering. Perera et al. discussed Food-IoT and Healthcare-IoT and proposed the Business-Technology Co-Design approach [6]. Lee et al. discussed Agriculture-IoT and proposed open API in the agriculture-oriented IoT platform[7].

The third is business process reengineering in regards to IoT. In 1990's, Hammer et al. initiated business process reengineering in the rapidly changing business environment [8]. Business process reengineering required information



Fig. 1. A 4-stage evolution model of the Internet.

architecture changes, which triggers new research domain [9]. Haller et al. discussed hurdles of IoT-based business processes [10]. Barnaghi discussed semantic aspects of IoT to the real world data [11]. Meyer et al. discussed IoT-aware process modeling to integrate IoT devices as business process resources [12].

The past research lacks the building blocks of business model engineering methodology to facilitate borderless aspects of IoT. Whitmore et al. surveyed IoT research and reported that only 3 % of them covered business models [13]. The originality of this paper lies in identification of a dimensional model to facilitate IoT-empowered business model engineering.

III. METHOD

The author performs the following steps:

- capturing high-level transition of the Internet,
- identifying the aspects that are important to business reengineering in IoT, and
- identifying a methodology to systematically classify the IoT business models.

IV. OBSERVATION

A. High-level Transitions of the Internet

The Internet has pervaded everyday life in the last two decades. The profound changes empowered by the Internet reach the entire planet. We can still witness emerging technologies and accompanying changes to lives, businesses, and societies. A four-stage evolution model is depicted in Fig. 1. Each stage is accompanied with a turning point which brings about changes beyond expectation except the final one which is upcoming. The past and possible future turning points are depicted in Table I. The final one is upcoming and described from the author's viewpoint.

B. Struggles in IoT design and deployment

The term IoT has been around for two decades. Many companies have been trying to catch up the so-called IoT trend. IoT, Internet of Things, leverages the huge opportunities because it leverages the scattered things around the world to work in favor of each business. Network-empowered things can act as delegates, guardians and supporters of business. They work sometimes as cost cutting devices and sometimes as additional value creating devices.

A trend like Industry 4.0[14] facilitates manufacturing industries to work in reengineering their business using emerging new capabilities embedded in things.

Even with the high hype of IoT, there are many struggling efforts in a wide range of industries. The examples are depicted in Table II.

TABLE I

TURNING POINTS OF THE INTERNET.

Turning point	Initial reaction	Consequence
Birth of the Internet	The Internet as a public transfer was opposed with regards to the original research purpose of the Internet.	Drastic cost reduction of data communication provided a huge potential for public and businesses.
Birth of the mobile Internet	The CPU-, memory-, display-, and bandwidth-constraint micro-browsing of mobile web was skeptically accepted.	The 24-hour 365-day always-on Internet pervaded the everyday life.
Birth of the social Internet	Facebook was born as an information sharing service within university dormitories. Business model engineering was unknown.	Attention and evaluation have become the currency of the 21st century. The Internet incorporated human relationship provided the strong new base for businesses.
Birth of the IoT	Some people considered that the interconnection of devices with IP-addresses is no drastic change to the original Internet.	Full digital transformation of business provides the new underlying structure of business engineering.

TABLE II

STRUGGLING EFFORTS IN IoT ADOPTION IN ENTERPRISES.

Pattern	Description
Top-down	IoT-empowered business innovation is driven by top down. There are confusions and down-layer people are lost in design space without any specific clues to deal with.
Just-monitor	IoT-empowered business innovation is driven by local adoption of monitoring systems. Monitoring business status is one of the least friction aspect of IoT, but it lacks the further roadmap.
Copy and Go nowhere	IoT deployment examples are copied without consideration of location-specific and application-specific issues. Neglecting the underlying issues lead to the going nowhere status.
We-know-best	Some Japanese manufacturers have pride in their state-of-art manufacturing technology. They are skeptical to lead to any open innovation leveraged by IoT digital technologies in regards of their in-house manufacturing technology.

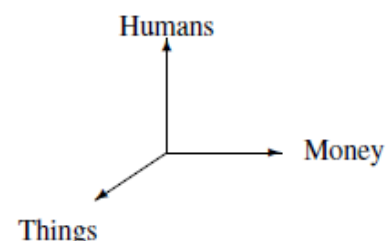


Fig. 2. A 3-dimensional view model of business capitals



Fig. 3. A 2-stage shift model of business reengineering

In the deployment level, it is becoming visible that thing-only approach does not work well in business contexts. We are still in the learning curve, however, the author thinks that the difficulties to cope with relate to the balanced design of IoT-empowered business environment.

The basic structure of business capitals is depicted in Fig. 2. Many IoT trials are things-focused with the lack of total management of other business capitals. Therefore, the IoT design has been focused in money-agnostic and human-agnostic manners, which does not properly address the IoT-empowerment of business.

C. New Business Reengineering

To cope with IoT challenges, it is important to manage all business capitals in a coordinated manner. This leads to a business reengineering perspective. Considering IoT, this type of reengineering is a complete departure from the original business reengineering in 1990's.

In a retrospective view, business process reengineering in 1990's involved a radical formation of intranet combining workstations and PCs. It started in the pre-Internet era. It was the state of art technology to move forward enterprises at that time, however, it had a serious limitation of information sharing only. It was a great change of gears thirty years ago, however, it did not touch any serious business skeleton.

A comparison of business reengineering in 1990's and 2010's is depicted in Table III.

The 3-dimensional model of business capitals are primitive, therefore, it is necessary to provide a theoretical framework to facilitate business model engineering. In order to develop a systematic methodology, the author analyzes existing business model patterns.

Nine patterns of IoT-based business model engineering are depicted in Table IV. There are multiple characteristics on IoT that relate to business aspect. Characteristics of IoT and their impacts on business model engineering are depicted in Table V.

This comparison leads to the primary focus of cross-border characteristic of IoT in business model engineering. From the viewpoint of how existing borders are transformed by IoT technology, the author proposes a 3-dimensional model of IoT-empowered business model engineering, depicted in Fig. 4.

TABLE III

COMPARISON OF BUSINESS REENGINEERING IN 1990'S AND 2010'S.

1990's coverage	Businesses were not fully empowered by the Internet. Business reengineering was limited to what people can control, internal business processes [8].
2010's coverage	IoT-empowered technology enables full digital transformation of business [15]. The technology advances leverages potentials of border-less business transformation.

TABLE IV

NINE BUSINESS MODEL PATTERNS

Pattern	Description
Additional Customer	NCC Roads in Sweden sets road traffic monitors during its road construction work. It provide road traffic monitoring services to private transportation companies.
IoT API unbundling	M2M technologies in Japan provides its senior care service APIs in an unbundled manner. Senior care service provides can use a subset of APIs according to its business need.
Customer resource use	A printer vendor provides a DIY repair for its overseas customers. It was expensive to maintain repair offices overseas. The vendor provides a monitor with its printers. Customers call from that monitor to customer centers in Japan in order to get advice for DIY repair.
Customer optimization	A transportation company provides a customer-optimized delivery to EC logistics base. For the base, it is troublesome to deal with incoming delivery all day. The transportation company customized the delivery from wholesaler companies (more than 2000 nationwide) to the base. Delivery is customized to the unit size of daily operation and done only once in the morning. This customized delivery enables 24-hour outgoing delivery for EC with the minimum incoming delivery.
Vendor-managed inventory	Inventory systems are shared with manufacturers and the manufacturers take responsibility of inventory management using the customer-provided inventory management guideline rules.
Servicization	GE provides "Flight Efficiency Service" which sells flight time instead of engines. Customers pay per flight time and GE provides the expert services to maximize flight efficiency.
Financialization	GMS in Japan provides car lease in the developing countries. It converts sales of new cars into car lease services to low credit customers. IoT devices control the engine of cars in order to enforce monthly payment.
Use-based insurance	Some insurance companies provide use-based charges of insurance for light users. Use is monitored by IoT devices. User pays as they use instead of fixed payment.
Real-world integration of home-security service	Home security services provide technology-empowered watch with on-demand delivery of security staff.
Multi-time-dimensional monitoring services	In automatic control systems, there is an initial unstable conditions before the machine reaches the stable control status. The initial unstable state is useless for real-time control, however, the monitoring of the unstable state leads to improved prediction of machine disorder. This multi-time dimensional monitoring provides better availability of machines.

TABLE V

CHARACTERISTICS OF IoT AND THEIR IMPACTS ON BUSINESS MODEL ENGINEERING.

Characteristics	Description	Impact
Cross Border	IoT works with things without intervention of owners. This cross-border nature has a large impact on business model engineering.	Large
Big Data	A massive number of IoT devices provide an underlying infrastructure of data mining. It depends on the size of IoT device deployment.	Medium
Orchestration	Things can collaborate without human intervention. It depends on the interwork of IoT devices.	Medium
Real-time-ness	IoT devices can provide machine-based real-time monitoring and control.	Medium

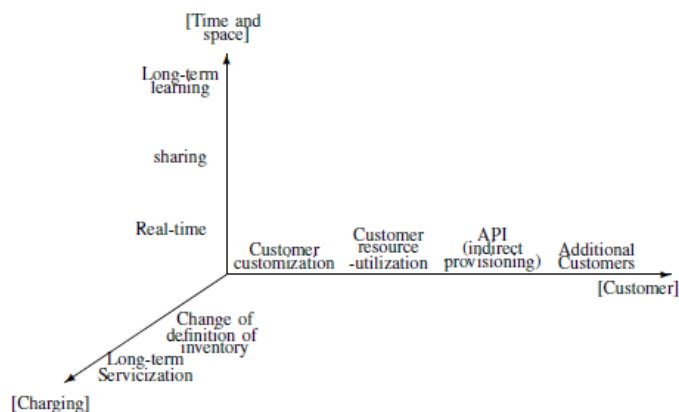


Fig. 4. A 3-dimensional model of IoT-based business model engineering

V. DISCUSSION

A. Advantages of the Proposed Method

The advantages of the proposed method are depicted in Table VI.

The rapid advances of sensor and wireless communication technologies provide a wide range of opportunities surrounding intelligent things. This easily leads to pitfalls of things-biased approach. Considering the interrelated nature of business capitals including things, the changes to things need reflecting in other business capitals. The proposed methodology provides a base for holistic approach to the borderless business model engineering in the IoT-empowered enterprises.

B. Limitations

This paper is descriptive and qualitative. It deals with just concepts of IoT-empowered business reengineering. Verification and quantitative analysis of the proposed methodology remain for future study. It lacks an in-depth quantitative analysis of quantitative experiments or real-world examples.

Business engineering methodologies beyond the borderless aspect remains unexplored in this paper.

TABLE VI

ADVANTAGES OF THE PROPOSED METHOD.

Item	Advantage
Exploration of new business models	The dimensions provide a clue to coin new borderless business models.
Comparison	The dimensions provide a sorting measure of different business models.
Value source classification	The dimensions provide a classification measure of newly create values. It leverages awareness of new value creation of borderless engineering.
Coverage	The dimensions cover the analyzed instances of new business models in a balanced manner.
Generality	The proposed dimensions are generally industry-agonistic, region-agonistic and technology-agonistic.
Flexibility	The proposed dimensions have flexibility to incorporate upcoming new business models.
Organizational impacts	The dimensions clarify the impacted organization from the new business models.

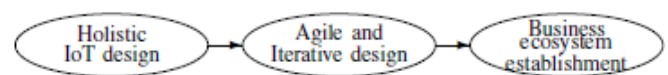


Fig. 5. A 3-stage strategic deployment of IoT.

The proposed model can be applied to a wide range of business models. However, the boundary between what it applies to and what it does not to apply to is not investigated in this paper.

Social factors like social acceptance and cultural impacts are not studies in this study. Business domain-specific features of methodologies are not covered in this paper.

In order to successfully include this framework into business engineering process, it needs to incorporate multiple aspects such as growth and competitor analyses.

VI. CONCLUSION

IoT has significant business implications as considered in the framework of full digital transportation. Digital transportation was discussed in early 2000's in the context of emerging e-commerce. This time, IoT presents challenges of total reconsideration of business frameworks including customer relationships.

Considering the expected massive deployment of IoT, we are still in the early phase of realization of IoT. From the best practices of IoT deployment today, it is important to have a balanced view of business capitals in IoT design, not things-focused. This holistic approach leads to the necessity of business model engineering in implementation of IoT-empowered enterprises.

The author analyzes IoT from the viewpoint of business reengineering. Compared to the early business reengineering in 1908's, the coverage of information technology has been drastically improved. IoT enables the total business reorganization including customer relationships.

The author considers characteristics of IoT and chooses border-less property as the foundation of business model engineering. In order to manage IoT-based business

innovation that deal with the whole business capitals, the author proposes a 3-dimensional view model of business model engineering. This model is coined for the analysis of existing IoT-based business model engineering.

IoT design covers a wide spectrum from cost reduction to full digital transformation of business. The latter presents significant challenges without systematic design and deployment methodologies.

The proposed framework will facilitate a systematic analysis that from the starting point of full digital transformation expected in the near future.

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Toshihiko Yamakami received the B.E.I.S. and M.S.I.S. from University of Tokyo, Japan, in 1982 and 1984 respectively. He received the Ph.D. degree in reliability information system engineering from Kagawa University, Japan, in 2007. He was engaged in International standardization of systems in the application layer and mobile Webs in ISO, W3C, and WAP(OMA). His research interests include service engineering, gamification, and organizational knowledge and change management. He is a specialist at ACCESS, Japan. He has been a member of the ACM since 1982, and is its life-time member. He obtained the IPSJ Yamashita Award in 1995. He published 160 international conference papers.