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Prototyping Business Models for IoT Service

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Abstract

The Internet of Things (IoT) generates new business opportunities by connecting physical objects with a multitude of sensors. IoT research mainly focused on technology and business models are relatively unexplored, although developing IoT business models is important for successful IoT service. The existing literature on IoT business models are industry or context-dependent. The aim of this research is to develop a generic business model framework for IoT business through literature analysis and interviews. To test the proposed business model framework, we undertake case studies of current IoT companies. The findings suggest that capability for data analytics is an essential element for IoT service. Also, open ecosystems help companies provide new integrated service and offer greater value for consumers. This research acts as a starting point for designing or developing business models for IoT services.

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Keywords: Internet of Things; Business Model; IoT

1. Introduction

The Internet of Things (IoT) has become one of the hottest topics in both academia and industry today. The objects around us are becoming an integral part of the Internet, which makes the Internet a more pervasive presence [1]. Internet-connected things bring massive benefits to consumers and can improve the quality of their lives. For example, consumers can reduce monthly electric or water bills by remotely monitoring and controlling whether their home appliances are on or off at certain times. In addition, these devices learn consumer's habits to implement the optimal control based on individuals' daily lives. The Nest, a thermostat for homes, is a popular example. From the perspective of business, companies in every industry are incorporating communicating and interacting sensors into their business. The IoT can bring major business benefits as well, such as process optimization, complex autonomous systems, and sensor-driven decision analytics [2]. General Electric (GE) can manage and repair important engine parts preemptively by collecting

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information from a multitude of sensors, which adhere to the engine, when it is running low or malfunctioning. Thus, the IoT is expected to have a considerable impact on individual lives and businesses.

The IoT provides a number of new services and business opportunities, and helps companies create new value [3]. The inter-connected nature of IoT leads to openness and collaboration across industries, which makes building business models complex. Companies need to rethink their current business model strategically to dominate the emerging IoT market. However, many companies have difficulty developing IoT business models because IoT-driven market dynamics are not explicit in the model [4]. There has been no killer application for IoT so far. Although developing IoT business models is important, IoT research has mainly focused on technology, leaving business models relatively unexplored [5, 6]. Thus, the purpose of this paper is to derive a well-grounded theoretical and practical generic business model framework based on a business model canvas. To accomplish this, we utilize exploratory research design featuring mixed methods, which leads to strong conclusions [7]. Firstly, we conducted a comprehensive and relevant literature analysis focusing on the IoT business model. Secondly, eight experts, who are working for IoT companies, were interviewed to verify the framework. The results of this analysis can be represented as key components for an IoT business model: key partners, key resources, key activities, and value propositions. Finally, we conducted case studies to examine the appropriateness of proposed business model frameworks and discuss current IoT companies' business models in a structured way. This study will provide a useful guideline for companies that initiate IoT products or services.

2. Internet of things

2.1. Definition

IoT has become a new paradigm in that all objects around us are connected to the network. Although the term "IoT" is now broadly used, the universal definition of IoT is still in the formation process [8, 9]. The International Telecommunication Union (ITU) defines IoT as "a global infrastructure for the information society, enabling advanced services by interconnecting physical and virtual things based on existing and evolving interoperable information and communication technologies" [10]. According to Cluster of European Research Projects on the Internet of Things (CERP-IoT), IoT is a dynamic global network infrastructure with seamlessly integrated active participants, things [11]. Despite the argument on the definition of IoT, sensors and communication devices are rapidly developed by many organizations [12]. Basically, the IoT can be treated as a combination of the Internet, near field communications, and networked sensors. Convergence of these technologies leads to new business opportunities (e.g., intelligent thermostats, automobiles with built-in sensors, and jet engines that are equipped with sensors for remote monitoring). Tiny networked smart sensors are used in various domains, such as smart home, logistics, and factory automation. Devices with smart sensors have identifying, sensing, networking, and processing capacities. The devices generate unprecedented vast data by giving each device a unique identifier, which leads to new possibilities for business.

2.2. Market growth and trends

Gartner predicts that 6.4 billion things will be connected worldwide in 2016 and will reach 20.8 billion by 2020 [13]. Many companies have started to develop various IoT-related products, applications, and services. Google acquired Nest, a smart thermostat company, for $3.2 billion and Samsung took over SmartThings, the open smart home platform [14]. Verizon launched ThingSpace, an IoT developer platform, to help the development of IoT applications [15]. Telecommunications companies such as KT and NTT DoComo are developing 5G trial services, which can feed all of Internet devices' needs [16]. Governments and companies increasingly recognize the IoT as a business opportunity and they are ready for IoT. The United States started

the Smart Cities Initiative to support the IoT and allocated $160 million in R&D funding [17]. The Korean government has planned $5 billion investments in IoT, ranging from wearables to smart cars, through 2020 [18]. A national strategy and companies' aggressive investments in IoT would create new business opportunities and substantial social and economic benefits.

2.3. Architecture

The generally accepted architecture of IoT consists of three layers: perception (sensing), network, and application [19, 20]. The perception layer plays the role of the five senses of IoT and its main function is to identify objects and collect information, which is formed by sensors and RFID tags in short-rage and local networks. The network layer aims to transmit large real-time information that is obtained from the perception layer. Companies can collect customers' behavioral data and use it to provide optimized and personalized services. Not only does information exchange between people and things, but information interchanges among things autonomously. The application layer is a combination of data processing and intelligence analysis to meet the industry needs to realize an intellectualized industry. Through the application layer, companies can achieve different types of intelligent application solutions and determine business strategies. Although many researchers have focused on the perception layer and network layer, management methods and business models that embrace all three layers are scarce [21]. The combination of the three layers is required to create new products and novel business models, and we pay more attention to operable business models.

3. Business model for the Internet of Things

The business model concept became prevalent during the proliferation of the Internet in the 1990s, and it has gained momentum since then [22]. From that time on, many characteristics and perspectives have been suggested by scholars and business practitioners [6].

Table 1. Comparing literatures on IoT business models

Author(s), Year	Business Model	Business category	Findings
Li & Xu (2013) [23]	MOP Model	None	The multidimensional structure composed of technology dimension, industry dimension, policy dimension, and strategy dimension
Sun et al. (2012) [19]	DNA Model	Smart Logistic	The basic visual structure and relationships between the DNA blocks – design, needs, and aspirations are the same at any level of the business model.
Qin & Yu (2015) [24]	Value Net Model	Tele-communication	The strategy of customer centered, information sharing, and resource integration
Leminen et al. (2012) [6]	2x2 matric dimension	Automobile	B2C solutions through IOT technology in the automotive industry
Bucherer & Uckelmann (2011) [25]	Business model canvas	Information Systems	The importance of information as a major source for value creation and the value proposition
Chan (2015) [26]	None	None	Three-dimensional model (collaborators, networks, tactic, inputs, service/processing/packaging, benefits, strategy, content/information product)
Dijkman et al. (2015) [27]	Business model canvas	None	Building blocks that are relevant in the IoT and identifying the relative importance of these building blocks

Business models can be considered a structure of components, the relationship between the components, and dynamics [28]. The business model typically defines how companies generate revenue and make a profit through the overall structures of process, customers, suppliers, channels, resources, and capabilities [29]. The critical goal for a business is how to minimize cost and maximize revenue.

Changes in technology require changes in business models [5]. For example, mobile technologies have driven new business models such as mobile payment, mobile advertising, and location-based services. Fast change in technology implies that companies must quickly adapt to market challenge. The characteristics of IoT, pervasiveness and ubiquity, drive the development of new business models. Moreover, companies need to collaborate with competitors and other companies across industries because of the nature of the IoT ecosystem [26]. Thus, traditional business models are not adequate for IoT service.

To date, only a few scholarly attempts have been made to increase understanding of the emerging IoT business models (Table 1). Some researchers developed IoT business models based on the business model canvas framework, which consists of nine key components: key partners, key activities, key resources, value propositions, customer relationships, channels, customer segments, cost structure, and revenue streams [19, 25, 27]. The key factors adduced by these studies focused on specific business areas such as logistics. Other researchers created different business models, such as the MOP model and Value Net model [6, 23, 24]. These business models are too abstract to characterize key factors of IoT services.

4. Qualitative analysis

4.1. Literature analysis

We adopt a business model canvas, the framework by Osterwalder and Pigneur [30], in order to analyze different types of IoT business models. The business model canvas is useful to understand, discuss, create, and analyze business activities [19].

Table 2. Components covered in existing IoT business models

Main Perspectives	Components (Building blocks)	Key Elements	References
Infrastructure	Key partner	Software Developer, Data Analyst, Device Manufacturer	[23, 25-27]
	Key resources	Software, Information, Customer Resource	[19, 24, 25]
	Key activities	Product Development, Platform Development, Partner Management, Platform & Resource Integration Ability	[24-27]
Value proposition	Value proposition	Convenience, Performance, Customization, Share	[6, 19, 23, 24, 27]
Customer	Customer relationship	Co-creation, Self-service Communication, Fast Feedback	[4, 25]
	Customer segments	Mobile Users, Companies	[6]
	Channel		
Financials	Cost structure	IT Cost, Infrastructure	[19, 23, 27]
	Revenue structure	Subscription Fees, Usage Fee	[25, 27]

The business model canvas framework suggests four main perspectives: infrastructure (key partners, key activities, key resources), value proposition, customer (customer relationship, channel, customer segments), and financial perspectives (cost structure, revenue structure). The model has been referenced by many researchers and has been used in practice (e.g., [25, 27, 31]).

For a comprehensive understanding of business models for IoT, we analyzed existing business models, represented in Table 1, based on nine building blocks of the business model canvas (Table 2). Many literatures are focused on infrastructure (key partner, key resources, and key activities) and value proposition. On the contrary, less attention has been paid to customer and financial perspectives and the key elements within these two perspectives do not have different characteristics from the elements of traditional business models.

4.2. Interviews

The interview was done to identify and verify correctness of elements within building blocks for IoT business models, which are summarized in Table 2. First, companies were searched based on the IoT architecture, which consists of three layers. Because these layers are not stand-alone and mutually influence each other from the perspective of business models, choosing sectors that are related to each layer is necessary. Among many related companies, we found eight practitioners who have specific experience with IoT products or services. The questions were designed in the following two ways: 1) Check whether the given key elements in Table 2 are significant for IoT business, and 2) Change from the existing elements to more specific and understandable elements for a better business model framework.

Table 3. Interview participants

Participant	Sector	IoT product/service
1	Device & Platform	Smart Home
2	Device & Platform	Smart Home
3	Device	Wearable Devices
4	Device	Wearable Devices
5	Network	IoT Infrastructure
6	Network & Platform	Healthcare
7	Network & Platform	Healthcare
8	Network & Platform	Healthcare

Practitioners emphasized the importance of infrastructure and value proposition among four main perspectives in the business model canvas. Like the results from the literature analysis, they mentioned that data collection and analysis are the key factors for IoT business. They expected that the data provided by the IoT is helpful to grasping consumer needs and analysis of the data helps to create novel products or services, which finally leads to generating new values. Because the data is changing the nature of existing products or services, companies should rethink what they make and sell. Through analysis of data, companies can deliver personalized and customized IoT products or services to consumers.

Also, they asserted that open and extensible platforms for IoT are required from a platform integration perspective. IoT platforms should be based on open and industry standards to minimize vendor lock-in, which will lead to creation of new and integrated products or services. For example, IBM launched the Internet of Things Foundation to help companies develop applications for the IoT. The service makes it possible for developers to simplify the process of collecting data from Internet-connected devices, such as sensors and using data for developer’s business goals [32].

4.3. business model framework

Our findings are based on the literature analysis and interview results. Table 4 shows a generic business model framework, which consists of nine building blocks and elements in each block. Three elements in the key partners block, *software developer*, *data analytics company*, *and device manufacturer*, were emphasized in both literature analysis and interviews. In the key activities block, *platform development* and *platform & resource integration ability* were combined because these have similar meanings in IoT environments. Through the interviews, *customer resource* was removed and *capability for business analytics* was added in the key resources block. Business analytics uses statistical modeling to analyze data, which is so vital to business operations, and provides new business insights. Value proposition is focused on delivering superior performance and meeting the needs of consumers for convenience and customized services. In the cost structure block, *maintenance* was added because numerous networked sensors and devices cause increased maintenance expenditures.

Table 4. Business model framework for IoT services

<table>
<tr><th>Key Partners</th><th>Key Activities</th><th>Value Propositions</th><th>Customer Relationships</th><th>Customer Segments</th></tr>
<tr><td rowspan="2">· Software Developer
· Data Analytics Company
· Device Manufacturer</td><td>· Product Development
· Partner Management
· Platform Integration</td><td rowspan="2">· Convenience
· Performance
· Customization</td><td>· Co-Creation</td><td rowspan="2">· General Customer Segment
· Vertical Market
· Global Market</td></tr>
<tr><td>Key Resources
· Sensors
· Cloud Service (Software)
· IoT Dedicated Network
· Capability for Business Analytics</td><td>Channels
· Internet
· Mobile</td></tr>
<tr><th colspan="3">Cost Structure</th><th colspan="2">Revenue Streams</th></tr>
<tr><td colspan="3">· IT Cost
· Maintenance</td><td colspan="2">· Profit sharing
· Subscription fee
· Product sales</td></tr>
</table>

5. Case studies

The case studies provide information about current IoT services and serve as test bed for the business model prototype. IoT services encompass the whole business sector. According to BI Intelligence, Business Insider's research service, the manufacturing, transportation and warehousing, and information sectors will invest the most and will provide various IoT services [33]. Thus, we selected a total of three IoT services, one in each sector: Google (Nest), GE (industrial Internet), Car2Go (transportation).

Google's Nest is a learning thermostat for smart-home services. The Nest learning thermostat automatically learns from the user's behavior and optimizes heating and cooling of homes based on a machine learning algorithm. It needs a week or less to customize these features. Nest also provides an application which customers can use to control the temperature or view energy usage regardless of the time and place. The Nest learning thermostat provides a wide range of benefits, such as saving energy and auto schedule. Auto Away is a useful feature when home owners have to leave home unexpectedly. Nest is positioned to move from a smart product itself to a facilitator of smart homes. It works with many kinds of things – smart door locks, light bulbs, wearable devices, and so on.

General Electric (GE) has launched Predix Cloud, a cloud service based on its industrial equipment monitoring and analytics platform. The industrial network of connected machines with data analytics creates competitiveness in various sectors such as aviation, manufacturing, automotive, energy, and healthcare. The cloud service analyzes data generated by sensors embedded in industrial equipment and proactively manages the equipment's condition [34]. This service also can integrate seamlessly with services on other cloud platforms. GE can monitor aero engines' usage and operation statistics in real time, and they can look at historical data to identify problems before they really happen. Industrial IoT provides a range of benefits, such as predictive maintenance efficiency, real-time data tracking, and increased revenues.

Table 5. Business model for case studies

Building Blocks	Elements	Google (Smart Home)	GE (Industrial IoT)	Car2Go (Transportation)
Key Partners	Software Developer	In-house development	In-house development	Outsourcing
	Data Analyst	In-house analysis	In-house analysis	In-house analysis
	Device Manufacturer	In-house development	In-house development	Manufacturer for maintenance and repairs
Key Resources	Sensors	Sensors	Sensors	Sensors
	Cloud Service (Software)	Mobile application Analysis software	Predix Cloud (Software platform)	Mobile application Analysis software
	Capability for Business Analytics	In-house analyst	In-house analyst	In-house analyst
Key Activities	Product development	Thermostat (3rd generation)	All industrial parts equipped with sensors	Fleet management with sensors (e.g., optimization)
	Partner management	Partnership with other IoT services (e.g., light bulbs)	IoT alliance (e.g., Intel, Cisco)	-
	Platform integration	'Works with Nest' integration	Industrial Cloud-based platform	Transportation platform (city transit services)
Value Proposition	Performance	Efficient operation	Predictive maintenance efficiency	Intelligent mobility for customers
	Convenience	Automation	Real-time data tracking	Flexible urban mobility
	Customization	Customized schedule	Customized total solutions	On-demand access

Car2go provides a car-sharing service in European and North American areas. The company can monitor individual vehicle performance and collect data through a multitude of sensors. Collected data enables the

company to optimize usage (e.g., dormant vehicles) and to notify predictive maintenance. The car-sharing service allows for partnerships with adjacent industries. For example, operational and user-centric data can be leveraged by the car manufacturers and insurance companies. Manufacturers can identify hardware or software problems preemptively and can optimize engineering processes [35]. Insurance companies can provide consumers with customized insurance policies depending on their trips and vehicle usage.

Literature analysis indicated that the infrastructure and value proposition are the most important perspectives within the perspective of a business model canvas. It is also in line with the results from the interviews. Besides these two perspectives, although customers and financials are considered to be important perspectives, these two perspectives in IoT environments are not quite different from perspectives in traditional business models (e.g., mobile environment). Thus, the results of case studies are illustrated based on interface and value proposition perspectives (Table 5).

A multitude of sensors are utilized to capture data from products like a thermostat, jet engines, and vehicles. The use of sensors helps to collect enormous data from multiple sources more autonomously and accurately than companies ever have before. However, without excellent analysis, sensors will not give a competitive edge. While organizations often lack analytical capabilities due to absence of skill sets possessed by data scientists, three companies commonly have data analysts and develop data analysis in-house. Three companies understand the importance of analytic capabilities in driving critical business values. For example, by using massive amounts of data and fleet analytics, GE learned that harsh environments like the Middle East clogged engines, thus requiring more frequent maintenance [36].

The IoT ecosystem is changing from a closed private ecosystem to open networked ecosystems [6]. Car2Go services are provided to consumers through a closed private ecosystem, while products or services by Google and GE work on open and integrated ecosystems. Nest is trying to make the Nest learning thermostat the center of smart homes. Home appliances, such as smart light bulbs, are fragmented and are controlled by a separate application. As part of open networked ecosystem, the Nest developer program enables other home appliances such as lights and washers to interact with the Nest learning thermostat. By making connections with various appliances, Nest can provide consumers with a seamless and personalized experience. Integrated services reframe the products and services of companies and offer far greater value for consumers.

6. Conclusions

IoT allows companies to collect and exchange data and to accomplish tasks that were previously impossible, thus requiring new business models for a highly connected world. This research presented a generic business model specifically for IoT services. Through literature analysis and interviews, we identified the essential elements that are relevant to IoT business models and established the building blocks of an IoT business model based on the business model canvas. We also examined case studies based on current IoT companies to test the proposed business model framework. This framework can serve as a starting point when practitioners design and develop their business model in the IoT environment. It is important for companies to identify critical elements of their business model to create value in IoT services, enabling them to provide better value proposition to their customers.

In a future study, case studies can be extended to various industries to develop an adjusted business model framework, as IoT services vary enormously and are still expanding. In addition, any failed or proposed services can be analyzed from the perspective of the framework.

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