# Service Innovation Structure Analysis for Recognizing Opportunities and Difficulties of M2M Businesses

Naoshi Uchihira[1], Hirokazu Ishimatsu[2], Yoshiki Kageyama[3], Yuji Kakutani[4], Kazunori Mizushima[4], Hiroshi Naruse[5], Shigeaki Sakurai[6], Susumu Yoneda[7]

[1]Japan Advanced Institute of Science and Technology, Nomi, Ishikawa, Japan

[2]Japan University of Economics, Shibuya, Tokyo, Japan

[3]Toshiba Corporation, Kawasaki, Kanagawa, Japan

[4]Hitachi, Ltd., Yokohama, Kanagawa, Japan

[5]NEC Corporation, Minato, Tokyo, Japan

[6]Toshiba Solutions Corporation, Fuchu, Tokyo, Japan

[7]Softbank Mobile Corporation, Minato, Tokyo, Japan

## Abstract:

With the popularization of high-speed and high-capacity communication networks, Machine-to-Machine (M2M) communication has received significant attention. However, even though the related technologies have been actively investigated, creating new businesses based on M2M communication is not easy. This paper proposes a service innovation structure that visualizes the opportunities and difficulties of M2M businesses. In our proposal, opportunities are classified as two types of value creation (optimization value and identification value) using the Sharing-Connecting-Analyzing-Identifying (SCAI) model. In addition, difficulties are discussed using a fishbone chart. The SCAI model pays particular attention to the identification value, which tends to be ignored in other models. Opportunities and difficulties are structured as a map according to backcasting from a desired future. Using this backcasting map, we can discuss M2M businesses more clearly and strategically by recognizing the opportunities and the difficulties with stakeholders.

## I. Introduction

Recently, Machine-to-Machine (M2M) communication has attracted increasing attention from business and innovation perspectives as well as from scientific and technological communities. However, a number of large-scale and innovative M2M businesses are not as one would expect. This paper presents a structure analysis of M2M businesses by determining the opportunities and difficulties of M2M businesses.

We visualize opportunities and difficulties of M2M businesses based on a survey of

current M2M businesses. Two types of value creation by M2M communication are discussed: “optimization value” by big data analysis and “identification value” by big data search. We also visualize difficulties using a fishbone chart. Specifically, we focus on fragmentation of solution (“silo” solutions addressing specific vertical applications requirements) as a typical difficulty. These opportunities and difficulties are structured as a map by backcasting from a desired future. From this backcasting map (opportunity-difficulty map), we can visualize and discuss a strategic path to innovation in M2M businesses by identifying the opportunities and overcoming the difficulties.

We address the following research questions in this paper.

Major Research Question: What is the structure of innovative M2M businesses?

- ✓ Subsidiary Research Question 1: What are the opportunities of M2M businesses?
- ✓ Subsidiary Research Question 2: What are the difficulties of M2M businesses?
- ✓ Subsidiary Research Question 3: What are the possible paths to innovation that can be found by identifying opportunities and overcoming difficulties?
- ✓ Subsidiary Research Question 4: What strategies can be derived from a map of potential paths to innovation?

The remainder of the paper is organized as follows. Section II briefly reviews the literature on M2M businesses. M2M business opportunities and difficulties are described in section III and IV. We propose backcasting analysis and discuss them using a smart home example in section V and VI, and present our conclusions in section VII.

## II. Literature Review

Not a few studies have discussed the functional potential of M2M technologies. Lawton discussed the opportunities that M2M technology creates [1], and Wu discussed key M2M application requirements and technology gaps [2]. Niyato, Xiao, and Wang pointed out the challenges of M2M technologies, including standardization, traffic characterization, protocol re-design, spectrum management, and optimal network design [3]. However, technological possibilities are not always implemented in successful businesses. Recently, some studies have tackled M2M business analysis and have proposed M2M business models. Laya and Markendahl compared typical M2M cases, including smart cities, smart houses, e-home care, and smart energy systems, and analyzed the key factors of success and failure of M2M businesses [4,5]. Goncalves and Dobbelaere showed 11 roles and the value chain among these roles. They extracted three M2M business scenarios, i.e., application stream, mobile stream, and CE (Consumer Electronics) device stream scenarios [6]. Leminen et al. proposed a

framework for “Internet of Things” businesses, including M2M businesses. They analyzed several concrete cases from the automotive industry [7]. Although those analyses revealed some aspects of M2M businesses, they did not go beyond an analysis of currently implemented businesses. Thus, major gaps remain between current M2M businesses and future M2M businesses.

This paper visualizes opportunities and difficulties of M2M businesses and analyzes opportunities and difficulties using a backcasting approach according to an ideal future.

## III. M2M Business Opportunities

First, we analyze M2M business opportunities according to a case survey conducted by a research project of the Joint Forum for Strategic Software Research[1] (SSR-M2M project). Table 1 shows the created values of these M2M services, which are derived from our literature survey, interviews and discussion in the SSR-M2M project.

Table 1: Created values of M2M services

| Service Example | Created Value |
|---|---|
| Construction Machine Tracking System (Komatsu, Hitachi) | ・ Proactive maintenance by failure prognostic (1A)<br>・ Location monitoring as a protection against theft (1B)<br>・ Operational guidance based on operating record (1C) |
| Home Security System (SECOM, ALSOK) | ・ Sensor-based incident reporting and rushing to the site within the allotted time period (2A)<br>・ Insurance against loss or damage based on risk calculation (2B) |
| Home Energy Management System (Hitachi, NEC, Toshiba) | ・ Monitoring and visualizing energy consumption (3A)<br>・ Demand response optimization to save cost and energy effectively (3B) |

By carefully assessing values in these cases, we find that the value created by “big data” analysis, including statistics, data mining, and operations research, which we refer to as “optimization value,” is not the only important value even though M2M business is a typical target of “big data” analysis. Another important value is “identification value,” from which specific objects and states are searched and detected from exhaustive data.

[1] Joint Forum for Strategic Software Research (SSR) is a private funding agency established and managed by electrical industries, including Hitachi, NEC, Tome, and Toshiba, and supervised by academics.

Fig. 1 shows that M2M values consist of the connection value, the optimization value and the identification value, which can be expressed as a 2-dimensional map (covering ratio X volume). The connection value is created by M2M connections, which includes one-to-one device monitoring. The simple connection can be expanded toward two dimensions of "big data" mentioned above. These values can be classified into "closed" and "open" according to the target big data. For example, "closed identification vale" is created by searching closed big data, which is constructed by the company itself. On the other hand, "open identification vale" is created by searching open big data, which is constructed by sharing and connecting various types of data (original data, affiliated data, government data, and open free data). In the case of the construction machine tracking system, a location monitoring service started only for the company's machines (closed identification vale), then customers requested to monitor other companies' machines in the same system (open identification vale). The structure of the created values and the mechanisms for creating values are illustrated in Fig. 2. To create the optimization and identification values, fundamental functions, i.e., data analysis, data identification, data sharing, and data connecting, are required (Table 2). We refer to this structure as a "Sharing-Connecting-Analyzing-Identifying (SCAI) model," which is unique when featuring data identification, sharing, connection, and analysis. Table 3 shows the relationships among the created values and functions for the examples shown in Table 1. As can be seen, a few values are strongly linked to identifying rather than analyzing. This table (i.e., the SCAI model) can be used to recognize the values created by M2M businesses.

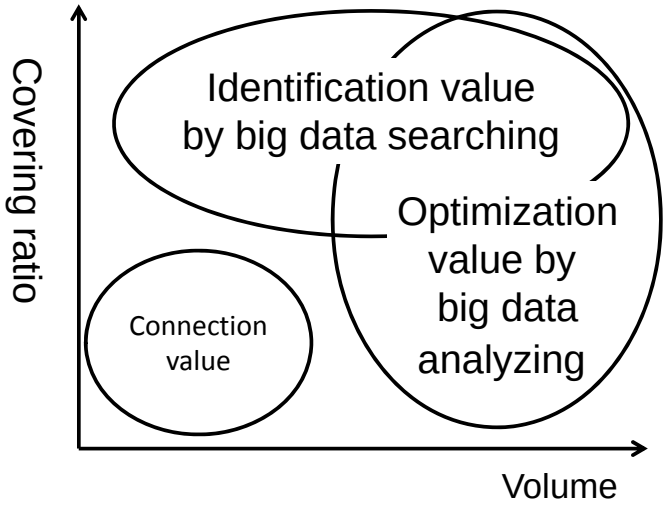


Figure 1. Two dimension of values created by M2M services

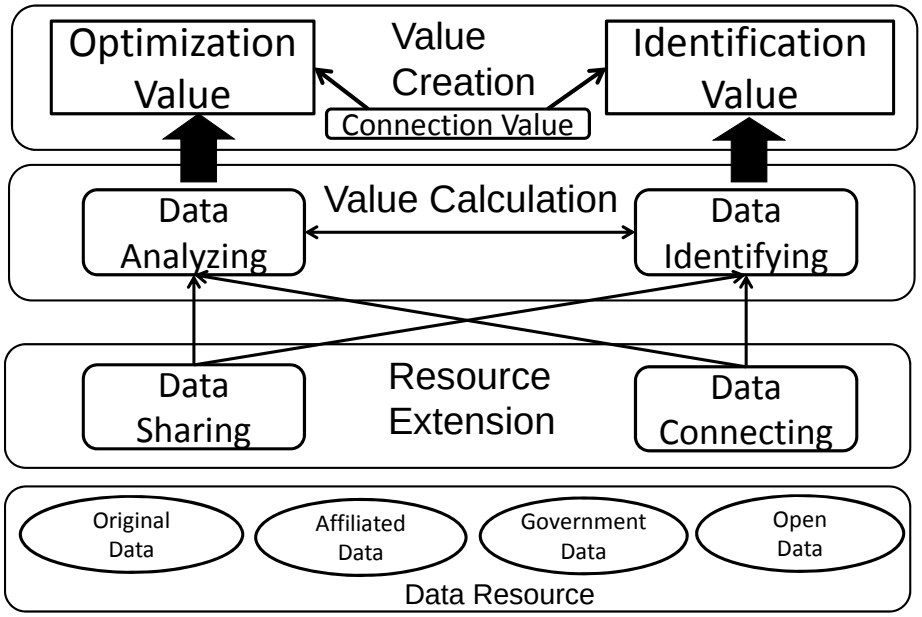


Figure 2. Sharing-Connecting-Analyzing-Identifying model

Table 2: Fundamental functions of SCAI model

| | |
|---|---|
| Data Sharing | Utilize not only original data but also open or affiliated data in order to create values. |
| Data Connecting | Connect and link related data from various resources in order to create values. |
| Data Analyzing | Create optimization value by statistics, data mining, and operational research. |
| Data Identifying | Create identification value by searching and detecting specific objects and states. |

Table3: Created values of M2M services (S: Strong, W: Weak, ---: No relation)

| Created Value Example (Ref. Table 1) | Optimization | Identification | Required functions |
|---|---|---|---|
| 1A: Proactive maintenance by failure prognostics. | S | W | Failure prognostic model |
| 1B: Location monitoring as a protection against theft. | --- | S | Global positioning system for all machines |
| 1C: Operational guidance based on operating record. | W | --- | Rule-based remote diagnosis |
| 2A: Sensor-based incident reporting and rushing to the site. | W | S | Comprehensive security guard network |
| 2B: Insurance against loss or damage based on risk estimation. | S | W | Risk estimation model |
| 3A: Monitoring and visualizing energy consumption. | W | W | Energy consumption pattern analysis |
| 3B: Demand response optimization. | S | S | Optimization engine for satisfying the given limit |

Fig. 3 shows a typical value evolution process of M2M services from a SCAI model viewpoint. In an early stage, optimization and identification values are developed for closed big data. Then, the open optimization and identification values are developed for open big data in a later stage.

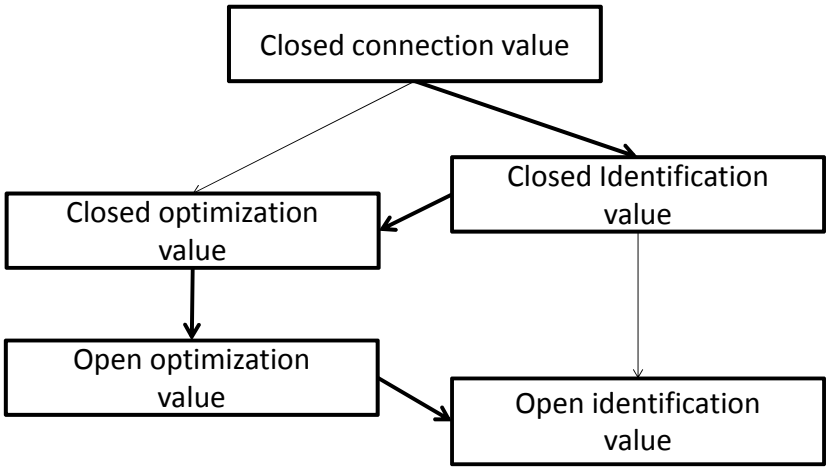


Figure 3. Value evolution of M2M services

## IV. Fishbone Chart Representing M2M Business Difficulties

Until now, successful M2M businesses have been primarily limited to business-to-business operational optimization (close optimization value) including monitoring services of machines and equipment (e.g., construction machine) and have not spread to other services. There are many difficulties and challenges to overcome. Here, we extract typical and critical difficulties from several studies [1, 2, 8] and our own interviews. These difficulties are summarized in Table 4. The difficulties can be classified into 4 categories (pure technological difficulties, technology policy and management issue, difficulties in application and use cases, and business model issues). We visualize them as a fishbone chart (Fig. 4). These difficulties have complexly intertwined cause and effect relationships; thus, it is difficult to determine a path to overcome them using current perspectives. For example, “fragmentation of solutions” is a major difficulty for breaking through the current business bottleneck; however, it has intertwined causal relationships with “numerous incomplete standards,” “national regulations,” and “too many stakeholders.” Therefore, we introduce a backcasting approach according to a desired future.

Table 4: Typical and critical difficulties of M2M businesses

| Category | Difficulty | Explanation |
|---|---|---|
| Pure technological difficulties | Network scalability | Ultrascalable connectivity is required. |
| | Communication protocol for M2M | There are great technological gaps between the traditional internet application and M2M communication. These gaps should be filled. |
| | Accuracy and computing time of data analysis | In M2M, data is extremely "big" and has 3V characteristics (volume, variety, and velocity). Accuracy and computing time of data analysis are a technological problem. |
| | Device management | Cloud-based mass device management is required. |
| | Device authentication method | Device authentication method for the interconnected providers is required. |
| Technology policy and management issue | Assurance of interoperability | Interoperability is very important and some assurance mechanism is required. |
| | National regulations | Regulations differ in each country. |
| | Security and privacy | Security and privacy must be controlled properly. |
| | Carrier portability | When providing M2M services in a wide area, portability among related carriers is necessary. |
| | Numerous incomplete standards | There are several standards adopted by many organizations. They should be unified. |
| Difficulties in applications and use cases | Fragmentation of solutions | The solutions have been developed and implemented for specific vertical application requirement. |
| | Network operator and company mismatch | Some M2M service companies require long term successive operations. There is a gap between these companies and network operators who want to shift to novel and better technologies. |
| | Data quality | There is a wide range of variations of devices, and quality control of data is not easy. |
| | Charging policy and method | A new charging policy and method are necessary for mass devices. |
| | Accountability and liability | Accountability and liability for failures of interconnected systems |
| | Various application management | Application management which are provided by third parties on the M2M infrastructure. |
| Business model | Costs of devices and | Initial costs of devices and communications are a |

| | | |
|---|---|---|
| issue | communications | bottleneck to introduce them and start services. |
| | Too many stakeholders | Too many stakeholders make business model complicated. |
| | Darwinian sea | There is a big gap (Darwinian sea) between an initial small business and a final big business. |

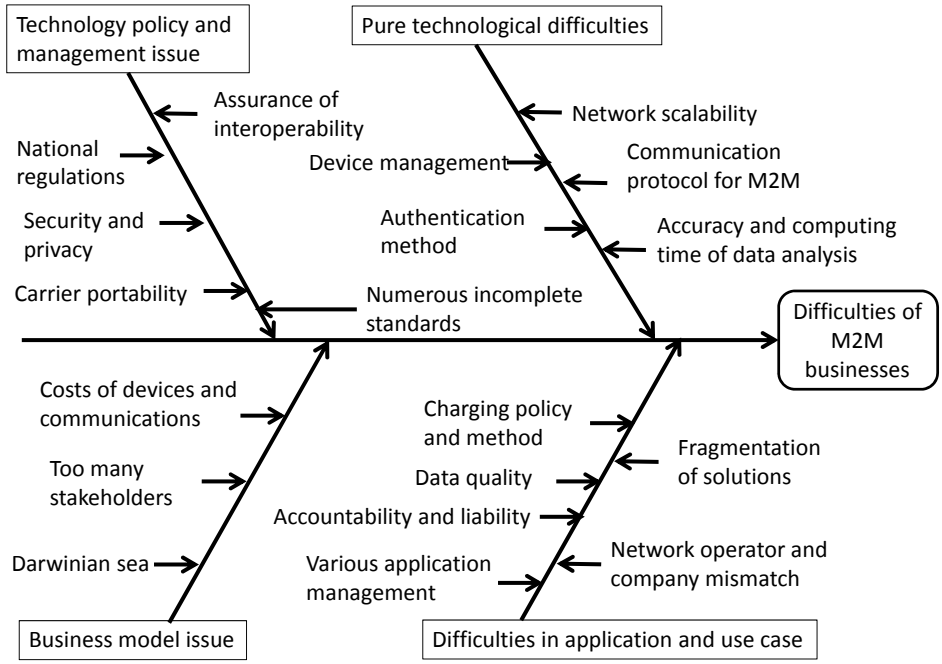


Figure 4. Fishbone chart of M2M business difficulties

## V. Backcasting Analysis from the Future M2M World

In the backcasting approach [9, 10], we must clarify the desired future. Then, we consider opportunities and difficulties from the future M2M world. Fig. 5 presents these considerations as a map (opportunity-difficulty map).

Future M2M world

Some M2M infrastructure, which exhaustively covers various M2M devices, has been established. This infrastructure is open and various service providers can use it at negligible cost.

(1) Difficulties of the future M2M world

By considering the future M2M world as a watershed, we can classify the difficulties mentioned in Section IV into two categories (“pre-difficulties” and “post-difficulties”).

Pre-difficulties are defined as difficulties which should be solved before establishing a future M2M world, and post-difficulties are defined as difficulties which will be solved after establishing the future M2M world. This categorization of pre-difficulties and post-difficulties can untangle the intertwined causal relationships. This categorization is motivated by Internet history, wherein many difficulties, including communication quality and security, were solved after the popularization of the Internet.

(2) Opportunities and the future M2M world

As mentioned in Section III, M2M businesses have two types of opportunities (optimization value and identification value). In the future M2M world, which will appear by transformation from vertical service structure to horizontal service structure, the emphasis on opportunities will shift from the closed optimization and identification values to the open values. In a vertical service structure, business prediction and optimization based on closed and accurate big data are important. On the other hand, many long-tail services (i.e., services created by the third parties like smart home applications) appear in the horizontal service structure, in which the open identification value becomes more important for these long-tail services. To encourage long-tail services, we believe that value-oriented standardization is more important than technology-oriented standardization. From the backcasting viewpoint, closed values and open values are regarded as "pre-opportunities" and "post-opportunities", respectively.

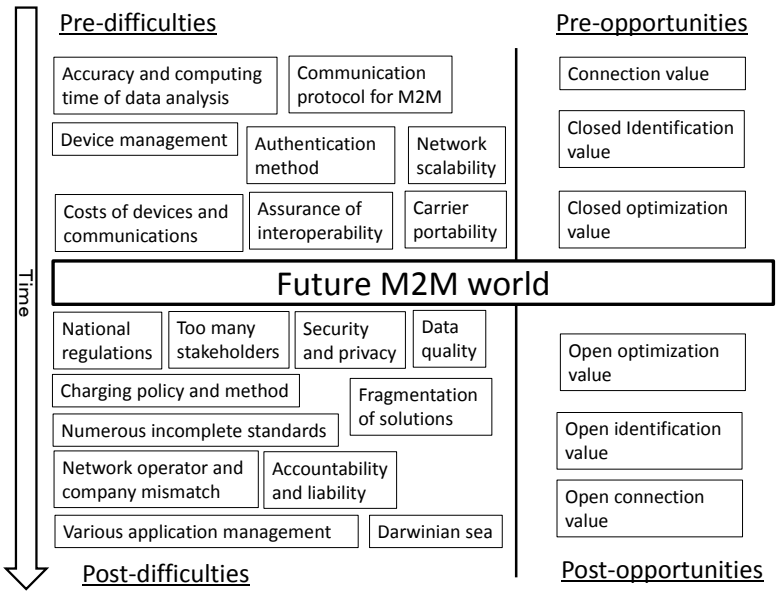


Figure 5. Opportunity-difficulty map from the future M2M world

## VI. Smart Home Example and Discussion

This chapter explains the backcasting analysis in detail using the smart home example. Especially, we try to show usage and effectiveness of the opportunity-difficulty map. Smart home is an intelligent home supported by information and communication technologies which make a home life more convenient, safer, and more efficient (Fig.6). Table 5 shows possible value propositions (an opportunity list) provided by the smart home. Here, 5 vertical start home services (1: home product remote maintenance, 2: home security, 3: home energy management, 4: home healthcare management, and 5: food delivery) are integrated on the M2M infrastructure. According to SCAI model, possible value propositions can be classified into "open/closed optimization value" and "open/closed identification value". The food monitoring and delivery services (5A, 5B) are classified into open connection value since these services are provided by a third party using the open shared M2M infrastructure. Due to service integration, one stop management and operational cost reduction are expected as additional values in Table 5. Table 6 shows difficulties of the smart home M2M services according to Table 4 and Fig.4. Each service proposition has own difficulties to achieve its goal. Fig. 6 is an opportunity-difficulty map of M2M smart home services, in which related difficulties are marked with bold lines and related value propositions are assigned into pre-opportunities or post-opportunities.

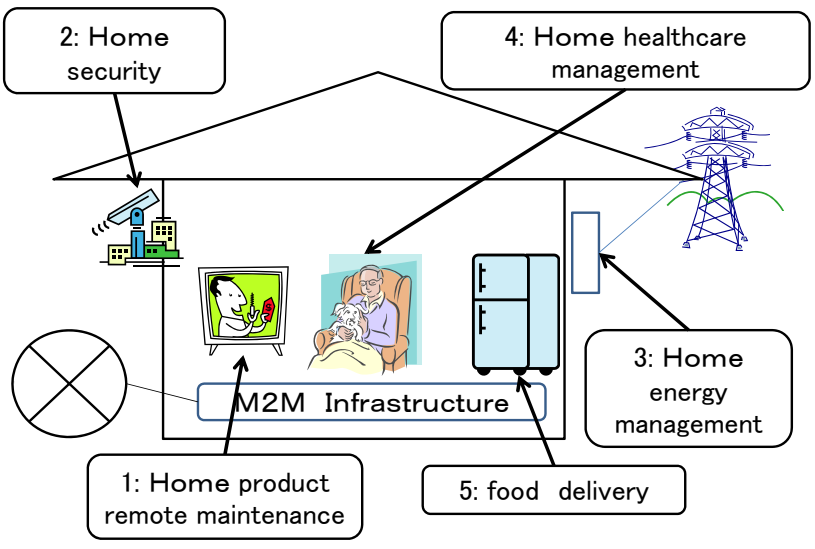


Figure 6. Smart home example

Table5: Created values of the smart home M2M services

(S: Strong, W: Weak, ---: No relation)

| Created value proposition | Optimization | Identification | Stage |
|---|---|---|---|
| 1A: Proactive maintenance of home products by failure prognostic. | S | W | Closed optimization value |
| 1B: Notification and management for home product recall. | --- | S | Open identification value |
| 2A: Sensor-based incident reporting and rushing to the home. | W | S | Closed identification value |
| 2B: Home insurance against loss or damage based on risk calculation. | S | W | Closed optimization value |
| 3A: Monitoring and visualizing home energy consumption. | W | W | Closed connection value |
| 3B: Demand response optimization for home energy management. | S | S | Open optimization and identification value |
| 4A: Healthcare monitoring and abnormality detection. | W | W | Closed connection value |
| 4B: Accurate diagnosis based on health monitoring data. | S | W | Closed optimization value |
| 5A: Food monitoring and management in a refrigerator. | --- | W | Open connection value |
| 5B: Meal deliveries based on food monitoring data for elderly people. | W | W | Open connection value |
| 6A: One stop and easy management for various home services. | --- | --- | Additional values due to service integration |
| 6B: Operational cost reduction. | --- | --- | Additional values due to service integration |

Table 6: Difficulties of the smart home M2M services

(#1-#6: ID of start home services)

| Category | Difficulty | #1 | #2 | #3 | #4 | #5 | #6 |
|---|---|---|---|---|---|---|---|
| Pure technological difficulties | Network scalability | | | | | | |
| | Communication protocol for M2M | | | | | | |
| | Accuracy and computing time of data analysis | | | X | | | |
| | Device management | | | | | | |
| | Device authentication method | | | | | | |
| Technology policy and management issue | Assurance of interoperability | X | X | X | X | | |
| | National regulations | | | | X | | |
| | Security and privacy | | X | | | | |
| | Carrier portability | | | | | | |
| | Numerous incomplete standards | | | X | | | |
| Difficulties in applications and use cases | Fragmentation of solutions | X | X | X | X | X | X |
| | Network operator and company mismatch | | | | | | |
| | Data quality | | | | X | | |
| | Charging policy and method | X | | | | | X |
| | Accountability and liability | | | | | | X |
| | Various application management | X | | | | | X |
| Business model issue | Costs of devices and communications | | | | | | |
| | Too many stakeholders | X | | X | | | X |
| | Darwinian sea | | | X | | | |

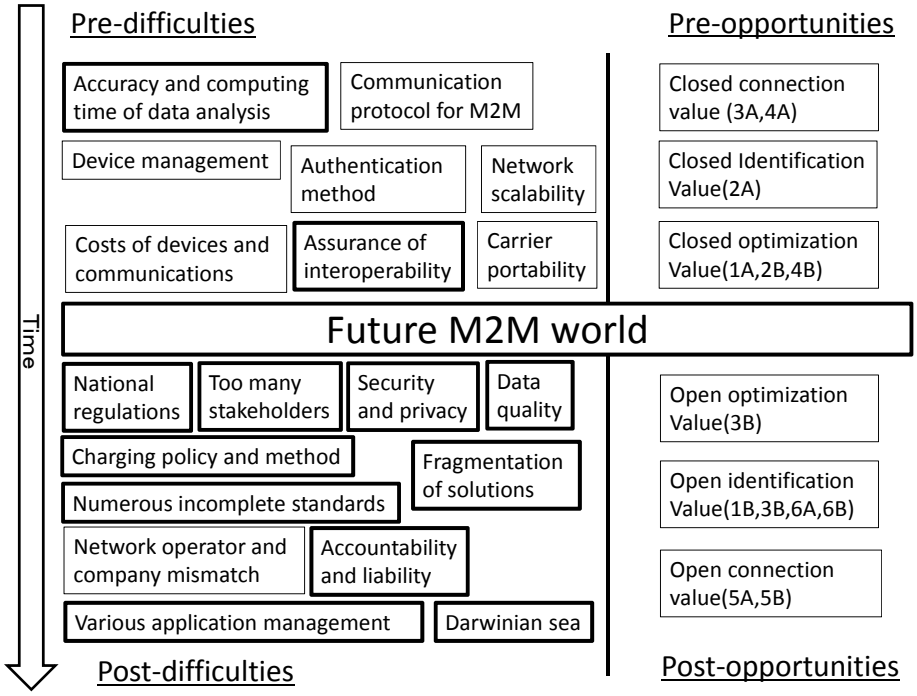


Figure 7. Opportunity-difficulty map (Smart Home Example)

It is possible to discuss a M2M service strategy using this opportunity-difficulty map. Although there could be numerous discussions depending on the actual business situation and background, we show a simple strategic discussion example in order to explain usage of the opportunity-difficulty map.

Example discussion of M2M smart home business strategy

- Strategy before establishing future M2M world
  - Home security service (2A) will gradually spread due to closed identification value, then may take healthcare monitoring service (4A) in its service menu.
  - Home energy management (3A, 3B) will be promoted by the government. In fact smart maters based on the home energy management system standard "ECHONET Lite" [11] will be installed in over 50 million homes in Japan. Home product maintenance service (1A) can use this M2M infrastructure. Here, difficulty about accuracy and computing time of data analysis should be solved.
  - Interoperability should be assured when home security and energy management services share M2M infrastructure in some level.
- Strategy after establishing future M2M world
  - Remaining difficulties will be solved after some troubles happen in the future M2M world. Solutions will come from assessment and analysis of difficulties and conflicts that occur in real businesses. For example, "numerous incomplete

standards" as a post-difficulty will be solved by some appearing de facto standards. A smart meter infrastructure (ECHONET Lite) is candidate for a de facto standard in Japan.

- This smart meter infrastructure can provide an application platform for various services in the smart home. It is important to acknowledge that major services (1B, 3B) and many tiny long-tail services (5A, 5B) can take advantage of this infrastructure.

## VII. Conclusion

This paper has presented an innovative structure for M2M businesses. First, we discussed opportunities and difficulties of M2M businesses, wherein the SCAI model was introduced (our subsidiary research questions 1 and 2). We then discussed paths to service innovation based on a backcasting approach using an opportunity-difficulty map. Usage and effectiveness of the opportunity-difficulty map is shown in a smart home example (our subsidiary research questions 3 and 4). The SCAI model seems academically unique and practically useful for understanding the fundamental values of M2M businesses. However, this work is an introductory analysis, and considerable future work is necessary to establish a substantial innovative structure for M2M businesses (our major research question).

## Acknowledgement

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