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Research on Key Success Factors Model for Innovation Application of Internet of Things with Grounded Theory

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Abstract: With Internet of Things (IOT) theory, the essence of innovation theory and grounded theory, we collect and analyze the implementation information and data from 3 related IOT company. Then we identify 40 key success factors and establish key success factors model for innovation application of IOT in the view of technology, market and implementation. The purpose is to improve the success rate of IOT application implementation.

Keywords: Internet of things, application innovation, key success factors, grounded theory, technology, market, implementation

1. INTRODUCTION

Obama and American labor union held a "round table" in 2009, put forward the concept of "smarter planet" for the first time. European commission presented a report, namely Internet of Things -- an action plan for Europe in 2009. Japan proposed the "U-Japan"strategy in 2004, and South Korea established the "u-Korea" plan in 2006. In comparison, the development of Internet of Things (IOT) in China is still in its infancy, it exists many problems: application requirements present a situation -- low level, small scale, difficult to stimulate the industrial chain investment passion; the research and development of core technology is slow; lack of technical standards and guidelines; great industry barriers.

2. LITERATURE REVIEW

Prof. Sifakis from the VERIMAG Laboratory, the recipient of 2007 ACM Turing Award, argues that "Systems are instrumented, interconnected, and intelligent". He also advocates a coherent scientific foundation of system design and presents a vision on its development [1]. Robust networking enables these solutions to be globally managed and delivered, allowing companies to benefit from the utilization of scarce skilled human resources and effective operational support. Given these various technologies and resultant benefits, for the first time in human history, it is possible to build, integrate, and manage real-world solutions that are so complex, distributed, and sensitive to change that no person could manage them unaided. This combination of pervasive computing power, systems integration, worldwide networking, and autonomic control creates the environment referred to as Smarter Planet [2].

MIT Auto ID Center (1999) proposes: the IOT is on the basis of computer and Internet technology, through relevant technology such as RFID, wireless data communication, so as to realize the network coverage for all the things, achieve intelligent identification, information interconnection and information sharing [3].The international telecommunication union (ITU) argued that the IOT is an application extension of the Internet, the development of information and communication technologies changes from interconnection by anyone at any time, any place to anything interconnection, the interconnection of those anything consists the Internet of things, and to realize the IOT needs the support of the four core technology, namely RFID, sensor technology, nanotechnology and intelligent embedded technology [4].

The application areas of IOT include logistics and retail, public service, environmental monitoring, home

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furnishing, traffic and aerospace etc. [5]. The EPoSS report of "Internet of Things in 2020" that the development of IOT can be divided into 4 processes: the application areas focus on logistics, pharmacy and retail before 2010; the goal is to achieve object interconnection between 2010 and 2015[6]. It will enter semi intelligent age between 2015 and 2020. IOT will enter the intelligence era after 2020. T. Huang summarized and concluded that the application areas of IOT concentrate in the following: power management, environmental protection, traffic safety, health monitoring, precision agriculture, logistics management, home furnishing security, public safety, industrial automation and control, etc [7].

Kim. C.W and Mauborgne R explaine the 6 methods of value innovation and creating new market space, namely, search market through cross-industry strategic groups, search market through alternative industry, search market through buyer chain, search market through developing complementary products and services, search market through a functional and emotional cater to customers, search market through cross-time searching new market space [8]. W Chan Kim, and Renee Mauborgne argue [9]: To grasp the future, the enterprise can't just rely on competing with competitors, but also open their own "blue ocean", develop new market space, to achieve growing up and success.

There are three kinds of understanding for innovative implementation: Schultz and Slevin argued that the purpose of the implementation for managers is they can master the operation results and imply science achievements as a tool and method in the perspective of the operational research [10]. P. Keys, R. J. Boland and R. A. Hirschheim argued that implementation is a process, user can gradually and accept innovation through the process, make innovation become an indispensable part of daily life and work in the perspective of internal organization[11]. Leonard Barton argued that implementation is a dynamic process that information communication technology in particular era and specific environment influence and adapt each other in the perspective of dynamic process [12].

3.   RESEARCH ON THE KEY SUCCESS FACTORS FOR APPLICATION INNOVATION OF IOT

3.1 Grounded theory

Grounded theory is one kind of qualitative research method based on the data to find the clue and has the typical theoretical exploration function [13]. Through qualitative research to observe the real situation of information technology business incubator and the incubated business, the paper builds the theoretical model of influence factors close to information technology business incubators' status using grounded theory to analyze the influencing factors (Figure1). Sampling requirements of grounded theory is theoretical sampling and emphasizes the purposive sampling rather than random sampling. It requires samples should have certain representativeness and provide the maximum amount of information [14-15].
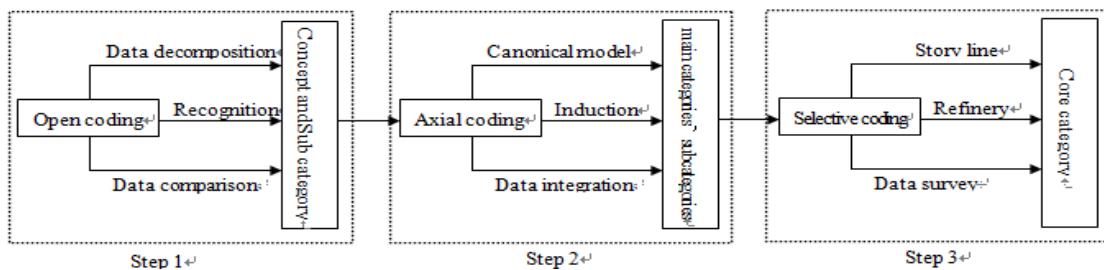
Figure 1. Routinization coding analysis steps of grounded theory [14]

3.2 Generate research question

After visiting some IOT enterprises, we find that the application and research of IOT are still at an early stage in China. Most of the IOT enterprises end up with failure or on the edge of failure. On the other hand, by reading literatures, it is found that the study on the key success factors for application innovation of IOT is still

at the exploration stage. We conduct an exhaustive study with grounded theory to offer a theoretical reference for raising the survival rate and developing IOT.

3.3 Collect data

The data collection method in grounded theory is mainly deep interview. We achieve the data through semi-structured questionnaire design (Appendix I). Based on the analysis procedure of classic grounded theory, we firstly select IOT enterprise A as the research sample, and form part of the conception and attribute according to the deep interview on relative persons in enterprise A. Then based on the analysis result of enterprise A, we again select enterprise B and C as the research samples, conduct deep grounded research on these three samples. Finally, we conduct continuous comparison, correction, combination and improve the conception and attribute which have formed, until the conceptions are saturated and there is a stable relationship between categories.

Sample 1: Enterprise A was established in 2006, which is one of the influential IOT enterprises in Guangdong Province. Enterprise A possesses the first-class team of experts and excellent development team in China, and employs international experts in areas of fiber communication, wireless area network and computer technology as technical guidance. It has broken through many key technologies in studying of Radio-over-Fiber exchange system and WiFi network device, and has successfully constructed a new generation of project information platform of IOT.

Sample 2: Enterprise B is a listed high-tech enterprise, which takes the development and service of the value-added business in areas of information and communication technology as the main business. As the first enterprise to enter telecommunications value-added service and to possess voice value-added service products, it successively launched more than 150 software products with proprietary intellectual property rights, such as voice added service platform, the integrated application switch platform, the construction platform for enterprises' application, converged communication platform, multimedia call center, telecom value-added application software, video security and monitor system, and so on.

Sample 3: Enterprise C is a high-tech enterprise, which takes the development, production and sale of electronic communication products and application solutions for IOT industry as the main business, and majors in providing services for wireless communication system, including the product development, system integration, technical support, etc. Based on wireless network platform, It provides professional application solutions in IOT industry, such as asset management, wireless location, supply chain management, warehouse logistics, transportation management, and so on, for different industries including government, production-manufacturing, army, police, traffic, power, finance, water conservancy, and education, etc.

3.4 Data analysis

The data analysis for classical grounded theory is divided into two steps: open coding and selective coding, we will give a concrete analysis for the above theoretical sampling.

Open coding is an analysis work for collected data by coding line by line, naming for the phenomenon by careful inspection and comparison, abstracting and analyzing the names into concepts. With a deep investigation for company A, B and C, we carry out open coding analysis on the data collected data (Table 1).

Table 1. Open coding on application innovation critical success factors of IOT (Selected)

Interview Transcription	Open Coding		
	Coding line by line	Conceptualization	Categorization
Manager M: Some famous enterprises in China, such as Huawei, ZTE, most likely have some competition with overseas big enterprises in capital, human power, such as Samsung and Intel, IBM, etc. But with a different environment background and bottleneck basic industry, we lack innovation compared to them.	With different environment background and bottleneck basic industry, we also are guided by other people	Lack basic industry	Technology identification
Manager M: When the technology or product enter the	We should provide different	User participation	Marketing

Interview Transcription	Open Coding		
	Coding line by line	Conceptualization	Categorization
new market, different users have different opinions, they maybe like them at soon, but sometimes they don't like to use them through they use them a long time. So we should divide user into different unions and provide them different products.	products to different user according to their needs.		promotion
Manager M: When IOT technology or product enter to the market, it is difficult to get scale application in a very short period of time, plus all aspects of current IOT technology are immature, it is difficult to really promote, so we only implement with pilot at the beginning. Now we are promoting our products to the school, gradually form demonstration effect, then implement big promotion.	The IOT technology is still immature, the product is not stable, it is difficult to form large-scale application, we only promote with pilot.	The demonstration effect of IOT industry	Marketing promotion
Manager M: The biggest problem we concerned is faking, we don't worry about our products are faking, but the ideas of the products. In the application of IOT, perception layer and application layer are all basically without difference, the only thing there is in the network layer, a lot of people in the stronghold.	Don't worry products are faking, but the ideas of the products	Intellectual property protection	Technology protection
Manager M: There is also a annoying problem, namely employee turnover, many employees choose job-hopping for improving their living conditions or other interests, leading to the plan moves to another company.	Employees choose job-hopping with plan originally belonging to the company for their interests.	Prevent the loss of plan because of the loss of employees	People and team management
Manager M: As IOT is a professional domain, so in order to satisfy the customers' demand and better use, when the IOT technology and products push to the actual market, we will be equipped with corresponding application process, so that production management don't chaos.	IOT is a professional field, we will be equipped with corresponding application process to make customers use the product better.	The technology process of IOT application	Technology utilization
Manager M: Now we are in an era of market leading demand, before we enter the field of IOT, we should analyze the market, whether the market is saturated, whether we have chance to enter, what's the advantage for entering the market area with our existing technology.	We need evaluate according to the characteristics of market leading demand and our existing technology advantages	Technology-Market analysis of IOT domain	Marketing feasibility study
Manager J: The IOT involves multidisciplinary and combine with multiple techniques, causing the standard is also varying. Due to the study of IOT on domestic and overseas is still at the initial stage, there are many disagreements between countries, the result is that the standard construction of IOT on domestic still has not a whole breakthrough, the system of "end-to-end" still need to strengthen.	Standardization is the first condition of development of IOT, the standard construction both at home and abroad still has not a whole breakthrough	Technology standardization	Technology protection
Manager J: IOT industry is a complex industry, the chain is also complex, including sensor provider, communication module providers, telecom operators, middleware and application developers, system integrators, service providers and users, so they need collaborate with each other.	IOT industry has a very complex chain, we need cooperate with other manufactures of both upstream and downstream	The cooperation between IOT chains	Marketing promotion
Manager J: The development of the Internet is dedicated electronic network, computer local area network (LAN), the Net, the Internet, World Wide Web. The current stage of IOT is Net, but these Nets are separate, not connect to each other, the Net information is scattered in the true sense, they don't get integration in the real meaning.	The current stage of IOT is Net, All Nets' information are separate, they don't to get integration in the true sense	The connection between IOTs	Technology utilization
Manager J: For now, compared with some developed countries abroad, our related technologies in domestic still have some gap. The main reason is that because our country starts late in many aspects, such as the research of basic technology, so they are not very mature, also the basic technology has a high barrier to enter and great competition. Of course it also accord with the life cycle of products and technologies	For now, compared with some developed countries abroad, our related technologies in domestic still have some gap, such as immature, low competitiveness.	The life cycle of IOT technologies	Technology identification

Interview Transcription	Open Coding		
	Coding line by line	Conceptualization	Categorization
Manager J: Any emerging technology and industry, not just IOT, will meet a lot of obstacles in the initial application process, so it must have the appropriate intervention of state and government, need them publish relevant policy to promote and support the application.	Emerging technology industry-IOT, will be confronted with difficulties in the application, they need the policies of state and government to promote and support	The promotion and policy support of state and government	Marketing promotion
Manager J: Now the IOT is not a sunrise industry, but a winter industry, numerous IOT enterprises have fallen. Through the observation research the recruitment advertising of various IOT enterprises in recent years, we find that the vast majority of the company recruitment is focusing on the research and development duty, there is little recruitment activities for market and sales. In fact, many IOT enterprises fail not because of no technology, no product or without advanced technology, but because of the disconnect with market	IOT enterprises fail not because of no technology, no product or without advanced technology, but because of the disconnect with market	IOT technology should connect with market	Technology utilization
Manager J: The commercial application innovation of IOT should be sure to combine IOT with specific industries, such as security IOT, home IOT.	IOT should combine with specific industries.	Industry IOT	Marketing promotion
Manager J: The end devices between before and after of IOT should connect, gather each other, and don't have to modify it. After connecting, acquisition and integration are a development direction in the future.	Gather, connect and integrate the end devices between before and after of IOT	The connection between IOT devices	Technology utilization
Manager J: Before the performance evaluation system online, it draws a lot of dissatisfaction of employees, they think it can't fair for every employee, after the performance evaluation system online, there is a great improvement effect. Also at the same time our company take various measures to motivate employees, such as praise, praise, salary, etc.	The employees' satisfaction has a great improvement after the performance evaluation system online, company take various measures to motivate employees.	Performance evaluation and incentive mechanism	People and team management
Manager L: We need analyze market feasibility from the perspective of IOT industry, whether the industry has a great development prospect, a big technical barrier, whether the industry exist industry monopoly, how much competitors exist in the same industry competitors, where our competitive advantage are.	Analyze the market feasibility from the perspective of IOT industry and competitors	IOT industry and competitor survey	Marketing feasibility study
Manager L: With competitive market and competitors, so for maintaining our competitiveness, we will continue to upgrade technology faster than our peers to protect our technology, otherwise, the risk will phase out.	Continue to upgrade technology faster than our peers to protect our technology, otherwise, the risk will phase out.	The continuous updating for IOT technology	Technology utilization
Manager L: Products and technologies have a life cycle, the user demand for the product will also change over time, so we should be continuously improve the product performance, appearance and so on improving the quality of products, let the customer can get a higher price according to the requirements of the market changes and customer feedback.	Continuously improve the product performance, appearance and the quality of products according to the requirements of the market changes and customer feedback.	The continuous improving ability for IOT products	Technology utilization
Manager L: Many people will produce fuzzy concept for market concept. As well as technology, market also has new market and old market, we should not go too much attention to find and develop the new market.	We have a fuzzy understanding for the concept of market, can not accurately grasp the connotation of market	Define the concept of market	Market positioning analysis
Manager L: When our products enter the market, in order to get better effect, we need to apply a variety of marketing strategy, including traditional channel such as newspaper, TV, public relations activities, also including current popular channel, such as Internet marketing, SNS, microblog, weixin, to achieve the best marketing effect.	We need use traditional and modern popular marketing methods to promote our products to market	Marketing strategy diversity	Marketing promotion

Selective coding is an analysis process for data which the researchers themselves determine, are both related and associated to the core category, after open coding and core categories are figured out. With the deep

analysis, 40 concepts, 9 subcategories and 3 main categories are identified after open coding, constantly analysis and comparison which analyze the original records once again, we get the selective coding for IOT application innovation critical success factors (concepts) (Table 2).

Table 2. Concept, category and core category after open coding

Concept	Subcategory	Main Category
Concept understanding of IOT technology	Technology identification	Technology dimension
Lack basic industry		
Owning IOT core technology		
The life cycle of IOT technology		
IOT upstream and downstream technology supporting facilities		
Technology-Market analysis of IOT field	Marketing feasibility	Market dimension
IOT consumer analysis		
IOT industry and competitor survey		
Marketing effect promoting analysis	Operation optimization analysis	Implementation dimension
Performance and sales analysis		
Customer feedback analysis		
Define the concept of market	Market positioning analysis	Market dimension
Market positioning in complex industrial chain structure		
Set market target		
Focus audience products		
Custom product features		
The obtained way and timing of IOT technology	Technology utilization	Technology dimension
Continuous update for IOT technology		
The technology process of IOT application		
The continuous improving ability for IOT products		
The connection between IOT devices		
The connection between IOTs		
Combine the IOT technology with market		
Safety and reliability	Technology protection	Technology dimension
Technology standardization		
Intellectual property protection		
Determine the marketing philosophy	Marketing and profit plan	Market dimension
Formulate marketing and profit model		
Prevent the loss of plan because of the loss of employees	People and team management	Implementation dimension
The cultivation of innovative talents and career planning management		
Performance evaluation and incentive mechanism		
Organize learning mechanism, team building and knowledge management system		
Integrate the internal and external human resources, form diverse application team		
The promotion and policy support of state and government	Marketing promotion	Implementation dimension
User participation		
Industry IOT		
The cooperation between IOT chains		
The demonstration effect of IOT industry		
Marketing strategy diversity		
Multiple channel construction		

Considering the results above, we get 9 categories and 3 main categories after open coding and selective coding, the 9 categories are technology identification, technology utilization, technology protection, marketing feasibility, market positioning analysis, marketing and profit plan, marketing promotion, people and team management and operation optimization analysis. The 3 main categories are technology dimension, market

dimension and implementation dimension. The result after this round of analysis prepares for the following theoretical construction.

3.5 Construct theory

We establish the initial IOT application innovation critical success factors model according to the paradigm model and the implied relationship between category and main category with the classical grounded theory, Then we visit companies once again, combine the encoding process, the original data of samples, literature review, modify the original model, we get the modified IOT application innovation critical success factors model (Figure 1).
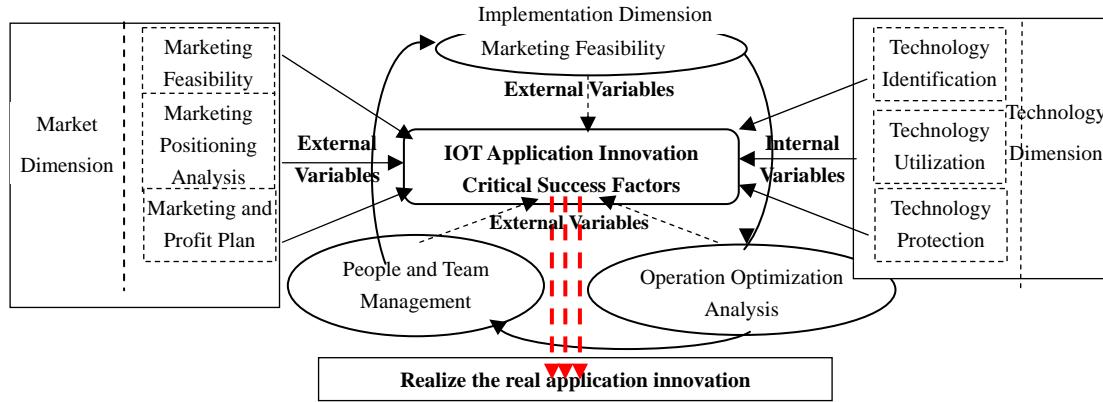

Figure 2. Model of key success factors for innovation application of IOT

The model illustrates that there are three important aspects for realizing the real application innovation, i.e. they are technology dimension, market dimension and implementation dimension. The technology dimension is an internal variable, including technology identification, technology utilization and technology protection. The market dimension is an external variable, including marketing feasibility, marketing positioning analysis, marketing and profit plan. The implementation dimension is an adjusted variable, including marketing feasibility, people and team management, operation optimization analysis. Within the process of business application, we should know that the roles of different dimension, technology dimension is the foundation, market dimension is guarantee for true implementation, implementation dimension is a way to examine whether the model is effective and how much the model has. We should take everything into account and balance the three aspects and realize the real IOT application innovations.

4. CONCLUSIONS

We research key success factors for innovation application of IOT with grounded theory in this paper. We identify 40 key success factors and establish the corresponding model in the view of technology dimension, market dimension and implementation dimension according to the coding program of classical grounded theory. Of course, we have only research for the model building of key success factors for innovation application of IOT. Whether the designed model has universal applicability, the weights of every index remain to be further studied and discussed.

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Appendix I Interview Outline

1. The general information of technology and products

(1) What is the industry sector for your company?

(2) What are the core products for your company?

2. The problems for IOT application innovation key success factors

(1) What the key factors will be taken into consideration during the commercial applications of IOT?

(2) So far, what the key success factors you met and are very important in the application process of IOT?

(3) Where are the managers of IOT commercial application project spending the longest time on? What's problem they encounter?

(4) What problem is your company worrying about current?

(5) What measures for your company take during testing and monitoring these key factors? What results have been achieved?

(6) In the business application process of IOT, can you talk about the valuable experience and shortcomings?