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Visualization techniques in Logistics
-Case study on the strategy development for logistics network in Internet of Things era.

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List of Acronyms

IoT	Internet of Things
SCM	Supply Chain Management
RFID	Radio Frequency Identification
NFC	Near Field Communication
GPS	Global Position System
WSN	Wireless Sensor Network
MES	Manufacturing Executive System
ERP	Enterprise Resource Planning
SSM	Sales & Service Management
P/PE	Product and Process Engineering

Abstract

Twenty years ago, if someone said that every object could have its own identity, no one would agree and some might even think that was crazy. However, it turns out that the wild imagination is possible today. With the help of the Internet of Things (IoT), it is convenient to identify any objects with RFID (Radio Frequency Identification) and control the objects via the Internet. In the near future, people will even make the IoT network visible, thus all the information on the Internet can become dynamic and much easier to understand than numbers to be.

At the moment, Guiyang Municipal Science & Technology Bureau is planning to design and apply visualization technique to logistics, the focus of Guizhou Provincial logistic network in the IoT era. This is a good opportunity for different kinds of enterprises in the Guizhou district or even in the whole country.

This thesis focuses on three problems, namely, discussion on the use of visualization techniques in IoT, the necessary preparation of manufacturing industry to join in the visible IoT and measures available that the government can adopt. The exploratory case study in this thesis is about the visualization technique in IoT in manufacturing industry in the Guizhou Province. A company was selected for the case study to explore the situation in Guizhou Province. The related information was collected through interviews with relevant personnel and observation in the company. To bring a clear view of the situation and provide enterprises with information for reference, SWOT analysis is adopted to evaluate the strength and weakness in both the internal and external environment. Those measures that government can take to promote its development include unification in standards, support in research and development of technology and emphasis on personal privacy.

The conclusion shows that the use of visualization techniques in IoT can promote information transmission both in effectiveness and efficiency, and control the supply chain as well as special processes in an efficient way. Discussions have been conducted on four techniques which are able to realize visualization, including GPS, RFID, bar code and machine vision. The preparation that needs to be done in a progressive way, of manufacturing enterprises mainly involves three aspects: equipment, system, and management; which have been discussed in detail in this study. Only totally combining the three aspects, not a single one can be omitted, can enterprises achieve the goal of growth in benefit and costs reduction through the use of IoT. Due to immaturity of the emerging network and technology, in the future, the IoT still has a long way to go. Certainly, we should not ignore the followed huge benefit and improvement that IoT can bring.

Keywords: Manufacturing industry, Logistics, IoT (Internet of Things), Visualization

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Contents

1. Introduction

In today's world, logistics is the third profits source of firms. Logistic is a process concerning with plan, implementation, and control of product flow in an efficient way (Murphy & Wood, 2004). With the development of logistics, the supply chain management (SCM) appeared. At the same time, logistics became one part of SCM. SCM is a kind of managerial system to manage the relationship between the company and customers or suppliers, regarding the supply chain as an entirety, for the purpose of delivering higher customer value with lower cost (Christopher, 2005). Both logistics and SCM are becoming more and more important in today's firms. In order to gain competitive advantage, information is one of the key success factors. Therefore, the efficient utilization of information can help logistics and SCM to achieve benefit (Murphy & Wood, 2004).

Internet of Things (IoT) is an emerging Internet-based information platform to provide effective and efficient information for users. IoT is a new revolution of the Internet as well as a main part of the Internet in the future. Through identifiers, the IoT is regarded as the networked interconnection of objects, such as, sensors RFID (Radio-Frequency Identification) tags, and IP (Internet Protocol) addresses (Margery, 2010). The scope of objects covers the electronic devices in our everyday use, and the high technological products like vehicles and instruments. Moreover, things that usually are not thought of as electronic kinds at all, such as food, clothing, and all the things we may meet in everyday life, are involved in this area (SRI Consulting Business Intelligence, 2011). The process of application of the IoT to logistics brings a new opportunity to the whole world. In a certain period of future, more and more technologies will be applied, combining with the IoT, to promote the logistics development.

During the transmission of information, the huge and complex data often make manager confused and it difficult to receive all the information. Visualization is a necessary tool to make sense of the flood of information in today's world (Schroeder et al., 2006). Applying the visualization technique into IoT, the complex data is transformed into pictures, which give the manager and customer a clear and direct picture of the supply chain state. It is useful to help managers monitor and control the procedure.

At the moment, Guiyang Municipal Science & Technology Bureau is conducting a project to design and apply visualization technique to logistics, the focus of Guizhou Provincial logistic network in IoT era. The purpose of the project is to improve the level of logistics of Guizhou Province, guarantee that the logistics enterprises in Guizhou Province can be geared to the global logistics; increase the international competitiveness of Guizhou Provincial logistics industry; and promote the development of the entire industry. In this thesis, an exploratory study will be conducted on the application of visualization techniques in the IoT era.

2. Purpose

This thesis aims at investigating the conditions in the use of visualization techniques in the IoT era. As the effective and efficient information transmission is a key success factor in a company's management. The connections among the effective and efficient information transmission, visualization techniques in IoT, company and government are given in Figure 1 below.

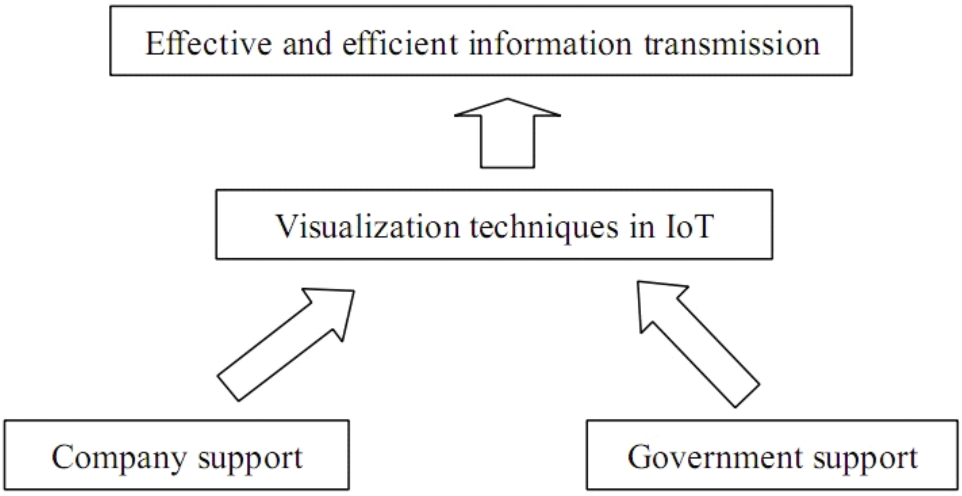

Figure 1: Connections among information transmission, visualization techniques, company and government

The research questions of this exploratory study are stated as following:

- What kinds of visualization techniques can be used in the IoT to improve efficient management for manufacturing companies?
- Which preparation work shall companies do to enable visualization techniques in IoT?
- How can government affect the development of IoT?

3. Methodology

In order to fulfill the exploratory study, four aspects of logistics in manner of literature review are taken into consideration to get the necessary knowledge, including manufacturing industry, the IoT, visualization and manufacturing execution system in IoT. And then, through learning the current IoT development state of manufacturing industry through a case study we can explore, summarize and analyse the problems which were listed in the purpose before. The company in the case study is chosen from more than 140 equipment manufacturing enterprises in Guiyang City as they can represent the most advanced development level of manufacturing industry in Guizhou Province.

3.1 Scientific approach

3.1.1 Case study approach

As a qualitative research, case study approach is useful in explorative studies. A case study approach can increase the understanding of research purpose and connect the research area with the real-life (Yin, 2003). Also, it can test theory and is helpful to the following analysis of this explorative study. Therefore, a case study is necessary for this report.

3.1.2 Case selection

A right choice of the case can make great contribution to the theory examination, problem analysis and question solving. In order to select an appropriate case, we need decide a suitable region which can meet the research questions.

The initiate research region was manufacturing industry in Guizhou Province, for the development of IoT in Guizhou Province still stays at the planning level so far. As the capital city of Guizhou Province, Guiyang can represent the most advanced development state of manufacturing industry in Guizhou Province. Therefore, the selected region has been narrowed down to manufacturing industry in Guiyang City. In Guiyang, equipment manufacturing industry is one of the pillar industries and plays a strategic position in industrial economy. Since most emerging technologies are first used in military field and then put into civilian usage with large-scale application after cost reduction, such new technologies as IoT and RFID are more possible be used in equipment manufacturing industry first to drive the development of other manufacturing industry in Guiyang City. As a result, we can make sure that the selected region is suitable for this study. Through an interview with Guiyang Science

Technology Bureau, we finally chose the case company from more than 140 equipment manufacturing industry enterprises. We took Guizhou Aerospace Kaifeng Science & Technology Limited Liability Company (called only Guizhou Kaifeng further on) as case company, for it represents the most advanced enterprises using high technologies for product tracking, which makes it definite for the enterprise to join in IoT in the near future.

During the process of case study, we visited the company and interviewed relevant staff to collect the information in logistics and manufacturing industry from Guiyang Municipal Science Technology Bureau. Afterwards, we explored how the visualization and what kinds of visualization technology that can be used in the manufactory industry in Guizhou district; summarized the preparation work to apply visualization to IoT, and analysed the preparation work to make visualization possible to be operated in IoT.

3.2 Data collection

The collected data can be divided into two types:

Primary data

The primary data has been collected, all by ourselves, through observations and interviews. Primary data has been collected specifically for this thesis. Thus these data are niche targeting and useful

Secondary data

The secondary data has already been collected by others before. In this thesis, literatures, company information and government reports belong to secondary data. In order to have a clear understand of the theory, the relevant literature has been learned. The government report and the company information were given to us by the interviewees at the case company. As the sources of the secondary data were verified by other authors and relevant departments many times before, thus, normally, the secondary data are reliable and can be used directly without any check work. But it is not absolute.

3.2.1 Observation

Observation can be done in either direct or indirect way. The direct observation means the researchers collect data by themselves, through their visit and observations in the real environment of studied phenomena. Indirect observation means using the secondary data which are collected by others, either open or hidden (Clausson, 2002). During visit at the case company, we used both direct observation and indirect observation to observe their production process. We visited the production line of the case company, collected photos about the sample of their products' barcode, every different production machines and the supervisory computer. Those data helped us to record the company's production situation and draw the flow chart of the production line in the thesis. Not only that, for indirect observation, we also got the detail information about the structure of their production line form the case company for us to summarize the system's characteristics.

3.2.2 Interview

Before doing formal interviews, the researchers need to prepare adequately in order to obtain enough information which is wanted to get from questions. It is necessary to understand the background and present situation of the selected company. As for the preparation of questions, researchers should forecast the possible answers the interviewees may give to prepare alternative questions. During the interview, the researcher should decide the way to record the answers, in audio recording or in handwriting. It is also important to make interviewees feel comfortable and relaxed (Suqian Evening News, 2010). In this case study, we used the face to face interview. First, we interviewed Mr. Xi Ren, who is a section member in new technology development and industrialization department from Science Technology Bureau of Guiyang Municipality in China. We prepared questions about our thesis to ask him. Through the interview with him, we decided the direction and the case company of the thesis. After that, with his help, we got in touch with Guizhou Kaifeng enterprise. Then, we interviewed Mr. Zhongjian Xiong, who is the deputy minister of technical quality in Guizhou Aerospace Kaifeng Science & Technology Limited. He introduced us the relevant information about Guizhou Kaifeng and their product tracking system to help us finish the case study part in the thesis. All the interviews are recorded in handwriting for respect the interviewees' wishes.

3.3 SWOT analysis

SWOT analysis is a very useful analysis tool to analyze the strengths, weaknesses, opportunities and threats for projects or organizations. In this thesis, SWOT analysis can help to increase the understanding of the actual situation of visualization techniques and IoT. Strengths and weaknesses are internal factors and opportunities and threats are external factors. SWOT analysis can support organizations to identify both positive and negative factors, and make decisions based on the analyzing result to adopt an optimal strategy. The different parts to be identified in a SWOT analysis are:

Strengths cover all internal superiorities, referring to finance, motivation, skill, technology, model, etc. These strengths can meet organizations' needs and fight with external threats.
Weaknesses are the internal problems that can hinder the development of organizations and make the projects fail, such as low efficient transportation, high production costs, etc.

Opportunities refer to all external situation and development trends, providing chance for organizations. Examples like new business market, released policies, tax preference and new technologies can increase the competitive advantages and bring new business opportunities for the organizations

Threats are the external trends, making negative influence on the organizations. For instance, the fierce competition, unstable market and incomplete policies will increase the investment risk for the organization (Lu & Li, 2010).

In general, SWOT analysis can help us to analyze the current positive and negative conditions and discuss the possibility of the development of visualized IoT network in the future.

3.4 Research quality

The four conditions for the research quality are construct validity, internal validity, external validity and reliability (Yin, 2003).

3.4.1 Validity

Construct validity means the authors must establish right operation ways to implement the thesis (Yin, 2003). During this thesis, multiple resources of evidence and informants review findings and conclusion were adopted to increase the construct validity of the thesis. Internal validity means the authors must make sure the cause-and-effect linkage between the related events in the thesis (Yin, 2003). Through the step by step reasonable inference the internal validity of this thesis was increased. External validity means the authors must ensure that the findings and conclusions of this study could be relevant for greater population than the actual case. Combine with the actual research situation, the case that has been chosen can represent the most advanced manufacturing industry in Guiyang City. As all the companies want to join in the visualized IoT network in Guizhou Province or even in China in the near future, they will inevitable encounter the same obstacles and barriers which were mentioned in the thesis. Thus, not only for the case company, the analysis and development plan can also be used for other companies with the same situation.

3.4.2 Reliability

Reliability is the possibility that the study can be done repeatedly for the same findings (Yin, 2003). Although the study may have different research findings over time because of the dynamic situation and changed conditions, but the reliability can be increased based on the continuous exploration and analysis in the future study.

4. Theoretical Framework

4.1 Logistics

4.1.1 Evolution of logistics

In this study, the concept of logistics refers to integrated logistics for better understanding of the application of IoT in different parts of logistics (Bloomberg et al., 2002). Nowadays, despite the fact that the logistics already developed to total channel integration, the definition of integrated logistics divides all logistics activities into three independent parts to make it easier for people to go deep in each aspect without understanding other activities. Figure 2 displays the evolution of logistics from David J. Bloomberg's view.

Fragmentation (1940s-1960s)	Logistics (1970s)	Integrated Logistics (1980s)	Total Channel Integration (1990s)
Inbound traffic Carrier selection Mode selection Public vs. Private carriage Purchasing Raw material inventory Demand forecasts Production scheduling	Materials Management	Inbound Logistics	
Warehouse planning Warehouse management Distribution center planning Distribution center management Plant site selection Work-in-process inventory Salvage/scrap disposal Material handing Packaging		Conversion Operations	Supply Chain Management
Outbound traffic International traffic Finished goods inventory Parts/service support Return goods handing Order processing	Physical Distribution	Outbound Logistics	

Figure 2: Evolution of logistics (Bloomberg et al., 2002)

At the beginning, enterprises paid little attention to logistics, so logistics activities were carried out in a decentralized form. After enterprises realized the importance of logistics, they reorganized logistics into two subsets, namely, material management and physical distribution. Regarding logistics as a kind of operation engenders the concept of integrated logistics. Afterwards, in order to control and manage the whole flow of goods and services, the suppliers, manufacturers and customers constitute an entire supply chain, i.e. supply chain management.

4.1.2 Concept of integrated logistics

Integrated logistics can be defined as the process which necessary capital, materials, labors, technologies and information are required, and goods and services networks are built and utilized to fulfill customers' needs and requirements in time (Bloomberg et al., 2002). Figure 3 show the integrated logistics process in detail.

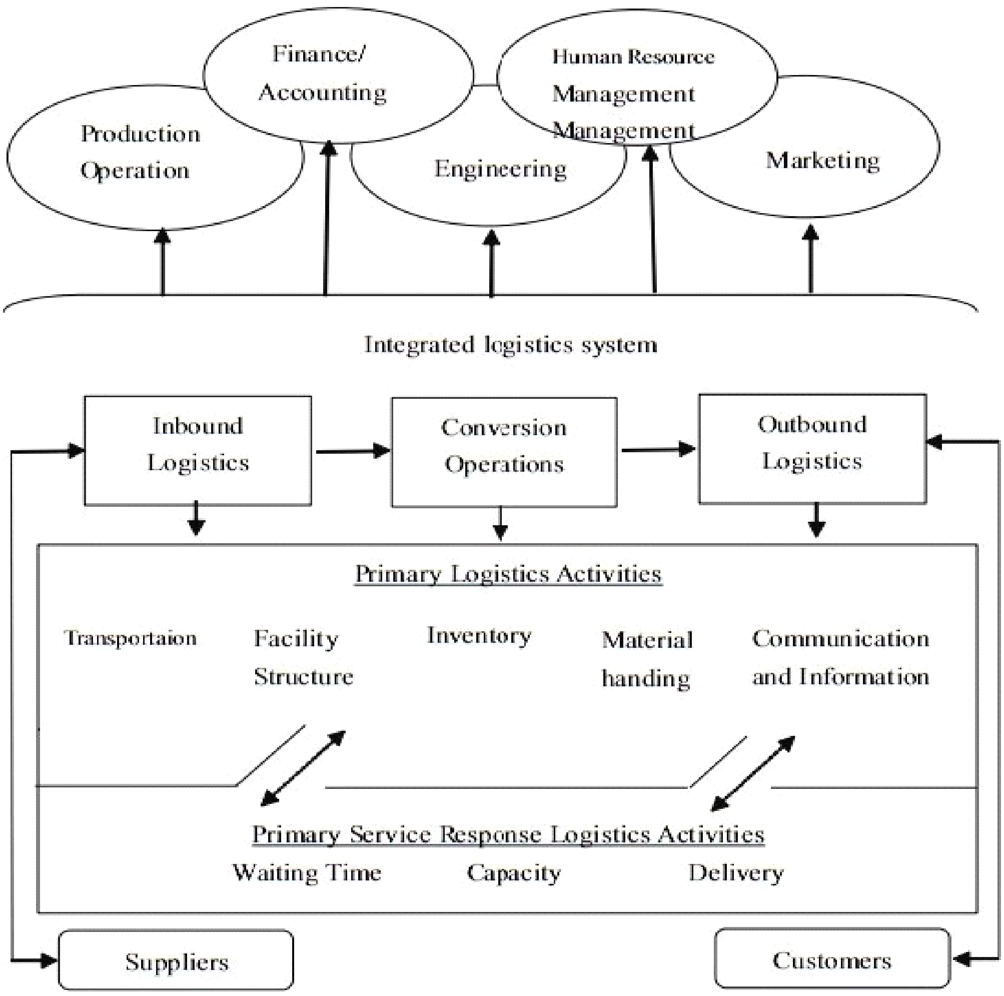

Figure 3: The Integrated Logistics Process (Bloomberg et al., 2002)

Integrated logistics includes inbound logistics, conversion operations and outbound logistics. Inbound logistics is the activities that materials are moved into the firm.

Conversion operation is the products internal movement in the plant and/or warehouse. Outbound logistics is the process that products move out from the plant and are delivered to customers.
Integrated logistics has two main subsets, namely, logistics activities and service response logistics activities. Logistics activities are used in goods movements, including transportation, facility structure, inventory, material handling and communication; while information service response logistics activities consist of waiting time, capacity and delivery, responsible for services movements to customers.

In the logistics activities, transportation includes products movement from suppliers into the plants, inside the plant and out of the plant. During the process, all the products are shipped by various transportation modes, including transportation by air, railway, sea, vehicle and pipeline. Transportation is the most costly logistics activity, since it accounts for more than 50% of the total logistics costs. Facility structure mainly involves the design and decisions about the number, location and types of warehouses. Inventory management is the buffer management of materials and finished goods. As the management of integrated logistics cannot be perfect, inventory management is vital for the entire integrated logistics process. Material handing is related to moving the products inside the warehouse effectively and efficiently, including packaging, choosing material handling systems and integration within the facility structure. The last but not the least logistics activity is communication and information. The two-way information flow is included in this logistics activity with order processing, demand forecasts and production scheduling. The last logistics activity can combine all steps of integrated logistics together as a whole system.

In the service response logistics activities, waiting time is the management of the time that customer need to wait before they receive the service. Capacity refers to management, schedule and staff employees and equipments needed to satisfy customers' needs and requirements by means of balancing the trade-offs between performance and expenses. Delivery is to provide service to customers via suitable distribution channels.

In order to create superior service for customers and most added values for companies, all the logistics activities must cooperate with each other. Thus, every activity is interacted with others. As shown in Figure 2, all the logistics activities integrate together and cooperate with both their suppliers and customers, establishing the most comprehensive definition, i.e. supply chain management.

Firms need to pay attention to the quality of the logistics information which can be evaluated from three aspects. First, the correctness of the information should be taken into consideration. Managers make decisions based on the information available. There are many factors influencing the correctness of information available, such as managers are uncertain what kinds of information they need, the information systems fail to offer the required information to managers, the right information around is difficult to get and so on. Second, the accuracy of information also plays a significant role. Accurate information is necessary for managers to make correct decisions. Finally, efficient communication is essential. One important logistics capability is information-based one which can help manufacturing industry to increase added values and save costs at the same time. It mainly includes information technology (IT) and information sharing. Combining the two parts, enterprises can improve logistics capacities, avoid the possibility of failure and show their willingness to share their critical information with their supply chain partners, which is the key success factor for corporation in supply chain (Shang & Marlow, 2005).

Logistics is one essential part in the manufacturing industry. Nowadays, logistics costs occupy the biggest part of the total costs of the manufacturing industry, thus, how to increase logistics efficiency, save logistics leading time and reduce logistics costs are the significant goals for the manufacturing industry.

4.2 Internet of Things

The IoT is an emerging Internet-based information platform in global supply chain networks, which can promote the exchange of goods and services to make it more convenient and easier (Weber, 2010). The IoT seamlessly integrates the physical and virtual “things” which have identities, physical attributes, and virtual personalities into the information network (Sundmaeker et al., 2010). IoT provides a platform for users in the fields of “things” identification, location, track, monitoring and control. The purpose of IoT is to provide a platform to exchange things in secure and reliable surroundings (Weber, 2010). Promoting information exchange and an efficient production cycle, IoT has been used in parts of industries, including logistics, manufacturing and retail industry (Commission of the European Communities, 2009).

4.2.1 Technology in IoT

The application of IoT technologies, such as RFID (Radio-Frequency Identification) and NFC (Near Field Communication) (Atzori et al., 2010) in logistics domain, deals with the real-time information processing to realize the real-time monitor in different parts of supply chain. Thus, the enterprises and the supply chain can sharply shorten the respond time to the changeable market. For example, for some traditional companies, they may need almost 120 days to finish a complete reaction plan from customer requirements to offer commodity, while for companies with IoT technologies, they just need few days to finish this work and almost with zero inventory.

Radio-Frequency Identification

IoT primarily uses RFID-tagged items as data communication tool from a technical view. Nowadays, RFID is widely used as an identity management system. The RFID is a technology which helps individual item encodes an Electronic Product Code (EPC) in an RFID tag with a unique, universal identification way; and it is used to identify, track and locate assets (Weber, 2010). Each tag has a unique identification number (ID) in the RFID system, and this ID can report back to the RFID reader through the tag when recognized by electromagnetic fields from the RFID reader. Thus, firms can use RFID tags to recognize different objects (Modaresi, 2010).

Near Field Communication

Near Field Communication (NFC) is a wireless technology, and a communication protocol between two devices—the initiator and the target. It allows the transfer of small amounts of data between two devices within a short range (less than 4 inches) (Nosowitz, 2011). It can be seen as a kind of evolution of RFID. But RFID can only support one-way direction in transfer, while NFC in two-way directions, both sending and receiving information. Also, NFC can read the information in RFID. Both NFC and Bluetooth are shout-range communication technology, but they have many differences. Comparing with Bluetooth, NFC operates much slower, but NFC has better security capacity and faster connective speed with much lower power consumption than Bluetooth. Moreover, NFC can operate without "Pairing" process.

There are three main concepts in the application of NCF, namely, "Transaction" "Sharing" and "Pairing" (Nosowitz, 2011). Transaction is the most obvious one. For instance, through NFC technology mobile users can conduct transactions by phone. The second application is sharing information. For example, users can share personal location or small capacity files with another device with NFC technology, and even large files will be possible to share in the future. The last application is "pairing". The connection between two NFC devices can be finished without any complex password during the pairing process. With the help of NFC, even Bluetooth can skip the pairing process directly.

Global Position System

Global Position System (GPS) is a navigation and timing system, based on satellites, and it is developed by the US Department of Defense (Sunehra et al., 2010). The GPS measures the time that the radio signal takes from the satellites to the receiver, so as to locate the position (Hermansson, 2010). In the GPS measurement, there are several errors resulting in a bias in time. The small angels between the satellites and the receiver may lead to a false measurement, so the application of geometry is important. In addition, the inaccurate estimation of satellite positions can result in a false measurement. The last one, the different satellite combinations may also bring out different errors (Hermansson, 2010).

Wireless Sensor Network

Wireless Sensor Network (WSN) consists of wireless nodes endowed with sensing capabilities, and these nodes are deployed for different applications. WSN can be used in environmental monitoring, disaster assessment and industrial process control (Basagni et al., 2007). In general, WSN follows a well-established special paradigm of communication (Basagni et al., 2007). For WSN, network lifetime is a key characteristic (Dietrich & Dressler, 2009). Because the network can only achieve its purpose as long as it works.

The SWOT analysis of the four technologies in IoT is given in Table 1 below.

Table 1: SWOT analysis of technologies in IoT

	Strength	**Weakness**	**Opportunity**	**Threat**
Radio-Frequency Identification	• Read in batch; • Read data in long distance • Not easily soiled; • High safety and security level of information; • Save cost on labour;	• More Expensive than bar code; • High investment;	• Adapt to the modern logistics development;	• High investment restrict the development; • Potential security problem.
Near Field Communication	• Easily connect different kinds of electronic equipments;	• Transform data only in close distance;	• Increase promotion to let customer be aware of the convenience and benefits;	• The huge investment restrict the market promotion.
Global Position System	• Simple operation; • Positioning precision;	• Imperfect map in some locations;	• Widely used and adapt to future development;	• Raise potential risk to driver.
Wireless Sensor Network	• Large amount of sensor nodes; • Cover a large scale;	• Limited capacity of data transmission;	• Motivate intelligent and automatic development;	• Technology development.

4.2.2 Architecture model of IoT

The architecture model of IoT is a complex and diversified application system. The architecture model of IoT is divided into four layers, showed in Figure 4.

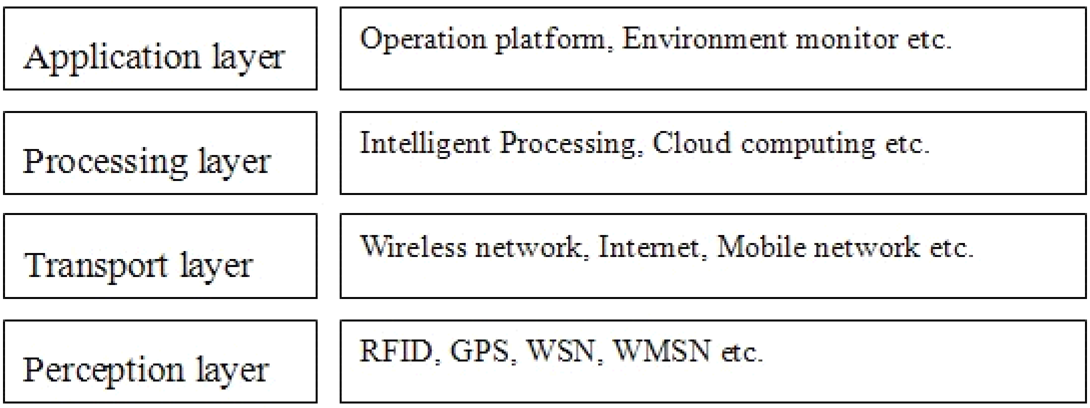

Figure 4: Architecture model of IoT (He, 2010)

The four layers are perception layer, transport layer, processing layer and application layer (He, 2010).

- The Perception layer: Various sensors are used to perceive the physical properties of objects, such as their locations, temperatures etc; collect the objects' information and convert information to digital signals. In the perception layer, various techniques are put into use, such as RFID, GPS and WSN;
- The Transport layer: This layer is transmitting data received from the Perception layer to the processing center. The main purpose of this layer is transporting data. The techniques used in this layer include 3G, Wifi, and Bluetooth;
- The Processing layer: This layer stores the information of objects receiving from the Transport layer, then, process the information after the analysis. Main techniques included in this layer are database, cloud computing, and intelligent processing;
- The Application layer: This layer provides all kinds of applications for each industry which operates based on the data processed in the Processing layer. There are diverse applications of IoT, like logistics management, intelligent transportation, and environment monitoring.

4.2.3 Barriers to develop the Internet of Things

Security and privacy

The security and privacy can be seen as a significant problem of IoT (Sarma & Girão, 2009). The right of privacy means the personal information should be considered as a basic and indivisible human right. The data or the traces of "things" are stored in cyber space. Therefore, individuals can get information on the Internet, even though he has no ideas about the tags of objects. However, after the introduction of IoT, many issues concerning with security and privacy appear simultaneously. Taking RFID as an example, the central issues on applying RFID to Supply Chain are mainly around privacy and the understanding of privacy in real application (Florian et al., 2007). For example, in the real-world, the information sent from RFID may be snapped up by competitors, thus they can estimate the firms' conditions or even predict the firms' future planning according to the information. Another potential problem is that since information is sent from various resources with correlative RFID, it may bring about disorder and makes it hard to ensure the safety of personal data.

In the future, not only the government but also private actors, such as marketing enterprises, are interested in gathering the data (Weber, 2010). Thus, the design of IoT must take privacy, security as well as users' requirement into consideration at the very beginning. What's more, in order to build trust, it is necessary to be able to adjust technical systems' functions and properties (Commission of the European Communities, 2009).

In order to improve the reliability of IoT, the security and privacy requirements for the enterprises are described as the following (Weber, 2010):

- System can avoids single points of failure and adjust itself to node failures;
- Retrieved address and object information must be identified;
- Facing the provided data, information providers must have the capability of implementation in access control;
- Through observing the utilization of some lookup systems confined to specific customers, it is necessary to take measures based on the inference, but it is hard to conduct inference.

Legislation could also help to create a secure and reliable environment for IoT by government. Nowadays, the European Commission is aware of the importance of security and privacy in IoT. The European Commission investigates the national legislation in the RFID application of every member state, according to the EU Data Protection Directives. In 2009, the European Commission invites the member states to put forward the guidance to ensure the RFID application's design and operation in a lawful, politically acceptable, social and ethical way (Weber, 2010). The purpose of this guidance is to improve personal data protection and privacy in a legal way.

Standardization

Standardization can lower entry barriers to new customers and reduce operational costs for usage, and it can provide the industry with better competition at international level by prerequisites for interoperability and scale of economics (Commission of the European Communities, 2009).

The development of IoT is facing the same challenge, which may prevent the step of its process, with the RFID standardization. IoT should focus on rationalizing the existing standards or developing a new one meeting practical needs (Commission of the European Communities, 2009). Lots of standardizations have been developed by different organizations, and leading enterprises to meet the following challenges with the use of RFID (Sundmaeker et al., 2010);

- It is difficult for users to distinguish and identify the standards which they actually need in a clear way;
- Lack of interoperability of standards leads the conflict among standards and makes it hard to use standards together;
- Redundancy work will be done from the lack of communication and information sharing between standards.

4.3 Visualization

4.3.1 Definition of visualization

Visualization can be defined as in order to amplify cognition, represent data through the use of computer-supported, interactive and dynamic visual (Meyer & Cook, 2000). This technology aims to represent, manipulate and exploring data and information to gain understanding and insight into it (Silva et al., 2011). Visualization can be divided into three classes, i.e. information visualization, scientific visualization and software visualization. Scientific visualization manipulates data with use of computer graphics, in order to test the hypothesis, and gain insight and general introduction. Software visualization combines the human computer interaction system with the use of typography, animation and cinematography, in order to promote the understanding of computer software. Information visualization is a process where non-visual data is transformed to visual information (Folorunso & Ogunseye, 2008). In this thesis, we do not search deeper in these three classes. Visualization means the process of transforming date or information into pictures, and it is an efficient and simple medium to deliver complex and vast information (Schroeder et al., 2006).

Applying the visualization technology to the information communication, the visualization information can give people a clear and intelligible picture. The visualization information makes people easier to collect and understand the information, and then to plan and control the process. Using computer simulation, the visualization can make contributions in financial industry, such as, product cost reduction and time saving to market (Schroeder et al., 2006).

There are six major ways of visualization in amplifying cognition (Card et al., 1999);

- Adding resources available in process and memory to users;
- Decreasing the information search;
- Using visualization representation in order to strengthen the perceive of patterns;
- Applying perceptual operation;
- Using perceptual mechanisms for monitor;
- Encoding information in a steerable medium.

4.3.2 Machine vision

Due to increasing requirements on high quality and traceability of products and documents, machine vision gradually becomes a key technology in manufacturing industry (Steger et al., 2007). Machine vision is an analytical tool which extracts data through analysis of images for processes and activities control (SRI Consulting Business Intelligence, 2011). Consequently, machine vision can be regarded as a software systems, which integrate mechanical skill, optical principle, with electronic application, to examine natural objects and materials, human artifacts and manufacturing processes for the purpose of defects detect, quality improving, efficient and safe operation of products and processes. It is also used to control machines used in manufacturing (Graves & Bruce, 2003). The basic hardware components of Machine vision are made up of three parts, namely, a CCD (Charge Coupled Device) camera, an image acquisition card and a computer (Pei et al., 2002). The CCD camera is responsible for collecting products' image and relevant data, the image acquisition digitizes signal collected by CCD camera and sends the processed signal to the computer which undertakes information identifying and processing (Pei et al., 2002).

Machine vision can rapidly acquire large amount of information and deal with these information. The application to the automatically manufacturing industry of machine vision can mainly be summarized as follows (Steger et al., 2007):

- Object identification: identifying different kinds of objects so as to control material flow and decide the performance inspections;
- Completeness checking: checking whether the right components have been assembled at the right place in the finished product, after the product assembly process finished;
- Shape and dimensional inspection: checking the product geometric parameters to make sure the product always has the required areas or checking the product which already has been put into use to ensure the product still can meet the requirements;
- Surface inspection: checking the finished goods to make sure whether they have scratches, indentation or protrusions.

A SWOT analysis of using machine vision in IoT is given in Table 2 below.

Table 2: SWOT analysis of using machine vision in IoT

Strength	**Weakness**
• Strongly control process; • Improve fault management.	• Employees need training for the use of new technique; • Investment is huge; • Time to adapt to new technique.
Opportunity	**Threat**
• Adapt to future development tendency.	• Immature technology.

Actually, Machine vision can distinguish not only objects' identities but also their behaviors. Machine vision seems to have a great potential to be used to indentify things in the IoT area or even replace the use of RFID (SRI Consulting Business Intelligence, 2011).

4.4 Manufacturing execution system

4.4.1 Definition of MES

MES (Manufacturing Execution System) is a new strategic tool and a control system used in the manufacturing area which can link the business system in firms' management with control in plants together (Calusson, 2002). It is the methods for system analysis and is the goal for all manufacturing organizations to achieve their optimal performance (Weygandt, 1996). Using real-time, accurate and dynamic collected information, MES makes a lot of contributions in promoting the efficient operation of the execution manufacturing, tracking down root causes of problems, providing information to other software systems, such as ERP, SCM and SSC, demanding flow scheduling to link the systems together and increasing additional benefit (Deepdyve, 2004).

MES in manufacturing industries helps the firms improve the process of planning, managerial control, and process of execution in manufacturing level, secure material flow, increase products' quality and openness of the process and information, reduce lead time, stock and problem of documents, as well as optimize the retrieval function of historical data in order to fulfill firms needs.

In spite of all merits of MES, it also has some demerits illustrated as following: First, high risk. If the malfunction happens within the system, extremely serious problem for the company may emerge since there is no alternative system. Second, it is hard to define and quantify the systems benefits and costs.

4.4.2 Functions of MES

MES mainly has eleven functions (Hakansson, 1997):
(1) Product tracking and genealogy
This is one of key functions of the MES system. It can make all information of products open, including location, time and operator. Such information, like the supplier and serial number of the product, the responsible person for the product, current product conditions and any existing alarm, are available to track. There are three administrative measures for product tracking. The first measure is batch management, which means to classify products with different batch numbers based on their components, materials and procedures. The second one is date management. Firms can use this way to track products through record date of products. The last one is serial number management. Firms can track products according to the unique serial number of these products.
(2) Resource allocation and status
Providing historical records of materials and components, and real-time status, resources must be available to support the operation, including documents, machines, tools, labor skills and materials. Managers can use these resources to make appropriate dispatching to meet the operation objectives.
(3) Operations/Detail Scheduling
MES can arrange time, which must be calculated accurately, in detail and in sequence for the operation.
(4) Dispatching production units
With the help of MES, firms can manage the production units flow. It can give orders to send materials, dispatch information, and adjust the established schedule if necessary.
(5) Document control
The records managed by MES need to be maintained regularly. Sending instructions and data to the operation process, this system can control the process and manage operators.

(6) Data collection
The system is used to collect various data in the operation process, both in an automatic and manual way.
(7) Labor management
By means of real-time records, this system can administer and track employees' working time and attendance and optimize the resource allocation to decide appropriate personnel assignment.
(8) Quality management
This system can collect and provide real-time analysis of the measurements and data to ensure a superior product quality. It can also suggest if revisionary actions should be taken.
(9) Process management
The system makes decisions, based on the result of monitoring, to adjust the in-process activities accurately. It includes the alarm management to remind or even warn the change of the production activities.
(10) Maintenance management
It can be used to track and monitor the maintenance activities of equipments and tools and record the historical data in order to ensure the regular maintenance and the availability for manufacturing.
(11) Performance analysis
It can generate reports to compare the actual operation results with historical data or expected results. It can provide data, such as cycle time, resource availability and resource utilization.

4.4.3 Links between MES and other systems in the IoT area

In order to join IoT, the MES system is the key determining factor for manufacturing industry. However, the IoT not only includes the MES system, but also refers to other categories of management software system. MES can provide real-time and analytical information and data to support the daily operation of these systems. In other words, MES is the link and the bridge between the various systems in IoT as indicated in Figure 5.

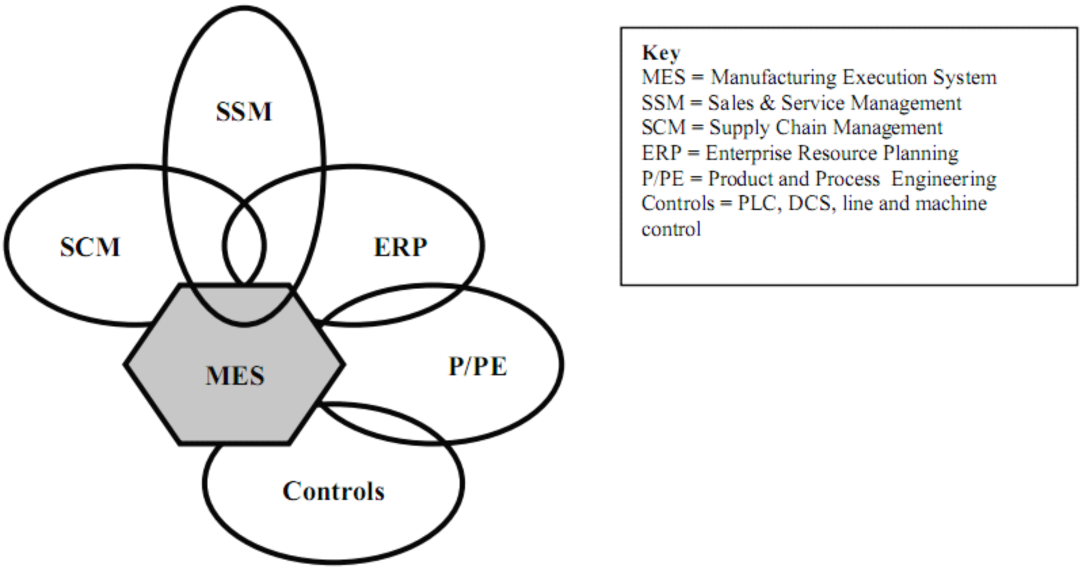

Figure 5: MES context model (Calusson, 2002)

With the links to other management software systems, MES controls can receive instructions on optimum operation status of equipments at an established time. Product and process engineering can be adjusted, based on the product yield and quality that MES measure. Sales and service management can get real-time production process information from MES. Even more importantly, the SCM (Supply Chain Management) system can receive actual order data and production capabilities. ERP can receive information about costs, cycle time, production capacities and other kinds of production performance data through the link with MES. In addition, MES can also receive information from these systems to make sure the openness of the information and guarantee the flexible information distribution from the MES system.

5. Case description

The manufacturing industry will become an important group in IoT application in the future. At present, the development of IoT in Guizhou Province still stays at the planning process. The capital city of Guizhou Province, Guiyang represents the most advanced development status of manufacturing industry in Guizhou Province. In Guiyang City, equipment manufacturing industry is one of the pillar industries and plays a strategic position in industrial economy. Until 2009, there are 140 equipment manufacturing enterprises in Guiyang City, and the total annual profit reaches 969,600,000 RMB (Guiyang Municipal Science and Technology Bureau, 2010). Equipment manufacturing industry mainly covers seven lines of production, including airbus components, automobile and automotive components, engineering machinery and components, construction machinery, numerical control machine and components, electric power equipments and electronic products, characteristic basic components, as well as new kit (Guiyang Municipal Science and Technology Bureau, 2010). Since many of these lines of production belong to military products, and most emerging technologies are first used in military field before expanded to civilian use in large-scale with cost reduction, such new technologies as IoT and RFID are more likely to be first used in equipment manufacturing industry to drive the development of other manufacturing industry in Guiyang City.

5.1 Background

Guizhou Aerospace Kaifeng Science & Technology Limited Liability Company, which called Guizhou Kaifeng, is a member of China Aerospace Science and Industry Corporation 061 base. The enterprise was founded in 1968, and carried out reforms and reconstruction in 2001. Nowadays, the company has more than 400 employees with over 180 professionals, and a large work team with highly specialized technologies in design, research and development, manufacture and after-sale service.

Guizhou Kaifeng is the only enterprise in Guizhou area to engage in R&D and production of automotive airbags, with annual output reaching 150000. Guizhou Kaifeng has more than 2000 international advanced radio testing instruments, highly precision CNC (Computer Numerical Control) processing equipments and some advanced circuit design software systems. It also owns several high-low temperature test chamber for electronic product and environmental stress laboratories which consist of electromagnetic vibration generator systems and a production line for SMT (Surface Mount Technology). All these provide guarantee to the enterprise's solid strength in following aspects: precision machining, electronic product development, production control, testing and commissioning. In 2003, Guizhou Kaifeng had been approved by ISO9001 quality management system. This year, the company is certified of TS16949 quality management system which is the special requirement for auto production and related components, it is suitable for the organization form of auto manufacturing supply chain (Guiqian Talent Network, 2010).

5.2 Present situation

As an automotive airbag manufacturing enterprise, Guizhou Kaifeng's main customer is Changfeng Actuman. Recently, they have already signed contracts with Lotus and Victory Auto，indicating that they successfully will become the supplier in automotive airbag of these two brands. Next step, they plan to establish cooperation with Changan and Zotye Auto in the near future.

An automotive airbag system is made up of six main parts, including lord airbag module, ballonet module, steering wheel, steering circuits, front crash sensor and other components. Guizhou Kaifeng is specialized in the manufacturing of lord airbags and ballonet modules. Before the start of the manufacturing process, all the materials will be inspected and classified. The production line totally includes 21 operation processes. During the production process, every component needs to have a barcode in its surface for production tracking. Guihou Kaifeng mainly adopts two measures to support its production tracking, batch management and serial number management measures. In terms of those key components, like airbag gas generator, they adopt the serial number management to mark a unique barcode number for each specific component; while for assistant components, like belt rail and screw, they choose the batch management to use a same barcode number for all components. Figure 6 shows an example of the barcode which is used by GuiZhou Kaifeng.

Figure 6: Example of barcode used in Guizhou Kaifeng

The barcode is composed of six parts: 500 represent the supplier code; "CA" the acronyms of the customer, here is Changfeng Acuman; "240107" the product code; "YA" the color, which is beige, the alternative choice is dark blue marked in "BA"; the number "11304" the time, which is marked in the form of YYMDD; and the last "A9+" the product's serial number. In this way, the enterprise can track the product continently via scanning the barcode on the surface. They can get various kinds of information, such as, the component's supplier, customer, production date and the responsible person.

5.3 Supervising and managing system in the production line

5.3.1 Overview of the system

There is a supervisory computer in the factory to monitor other computers and machines, responsible for the production line, and to collect data which is sent from those computers connected with production machines. All the procedures and equipments are administrated and dispatched uniformly by computers. This computer administration system can conduct procedure control, process monitoring, manufacturing data recording and production output management during the production process.

Based on the interview with Mr. Zhongjian Xiong, we drew Figure 7 to show the production flow chart of Guizhou Kaifeng.

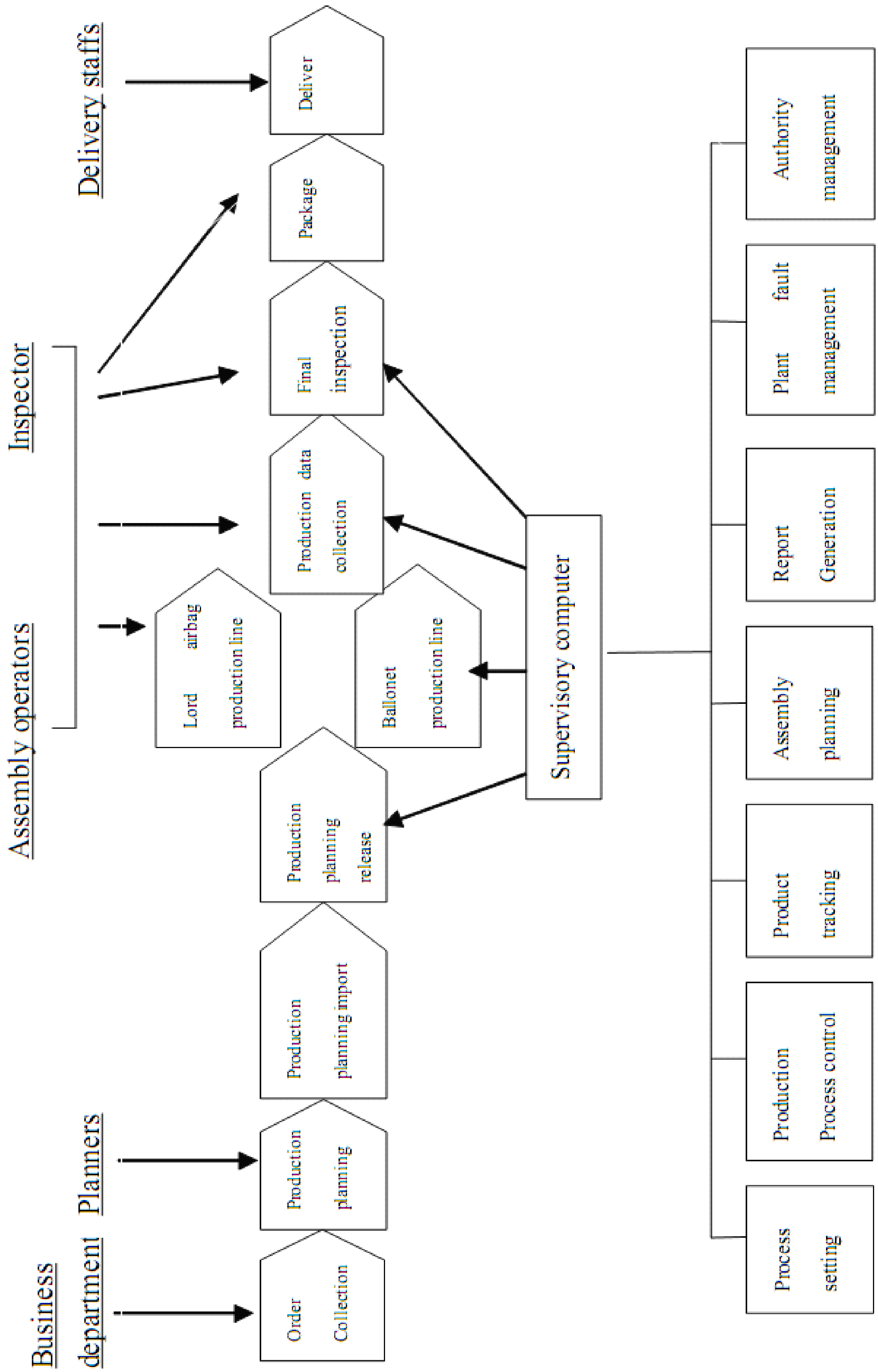

Figure 7: Production flow chart of Guizhou Kaifeng

As Figure 7 shows, the first step is to collect orders, which is implemented by business department. Based on the orders, planners draw up the production planning and input the planning into the supervisory computer. Afterwards, the supervisory computer dispatches the processing sequence to both lord airbag production line and ballonet production line and keeps controlling the whole production process. During the production process, assembly operators are required to inspect every component passing by the work station. Meanwhile, the computers in every work station record the production data and send them to the supervisory computer in real time. Before the packaging process, there is a process to recheck the products and label barcodes to promise that all the products are qualified. After the packaging process, the automotive airbags will be stored in warehouse and delivered to customers by delivery staffs.

The supervisory computer is responsible for the production steps, from production planning statement to final product inspection. In general, the supervisory computer can help the enterprise to control production process, generate report, realize product tracking and retrieve and manage plant fault.

5.3.2 System's characteristics

There are four characteristics of the system shown in Figure 7. These are illustrated in following four aspects:

(1) This system is a real-time data collection and handing system. The staffs can input the detail product planning into the supervisory computer, and the system can transfer the processing sequences to each work station, based on different product types. In this way, the enterprise can increase production rate, improve accuracy and standardize operating process.

(2) Digitize the production process. Based on the barcodes on the surfaces of product and components, the enterprise can track all the relative information of the product in the production process. It is good for the improvement of production engineering and the management efficiency.

(3) The system can implement parameter detection for the key technologies during the production process to avoid unnecessary processes of the unqualified semi-finished products. The enterprise can ensure product quality and save costs under the help of the system.

(4) The plant fault management function can help equipment managing staffs to effectively manage equipments in production line.

5.3.3 Functions of the software

The functions of the software can be interpreted in seven aspects:

(1) Process setting

After the staffs input the production planning and processing parameters, the supervisory computer will convey the processing sequences to work stations. The information will be displayed on the computers in words. All the process documents can only be modified after password authentication, and the historical documents will be retained in the system. If any equipment in the production line is malfunctioning, the system enables continuous working of the production after the staffs modify processing sequences, to ensure the regular production.

(2) Production process control

Production process control is a very important function in the whole system. It sets the required parameters in every work station. Therefore, if unqualified components appear, the light on the work station will flicker and the color of the indicator light on the screen will change from green to white; and the color will turn into green again until the parameters of the components meet the required ones, otherwise, the system will generate an alarm ring and remove the unqualified products at last.

(3) Product Tracking

Based on the numbers on the barcodes, the enterprise can track the products supplier, customer, production date and the responsible person.

(4) Assembly planning

The enterprise can change assembly planning according to the new requirement, or the staffs can adjust the parameters without changing the original planning.

(5) Report generation

This system can generate reports, such as, daily, monthly or yearly output report, work diary about working process and plant fault analysis report.

(6) Plant fault management

The system can record plant fault in the production line in time and put forward solutions available to help staffs maintain the equipments.

(7) Authority management and system maintenance

- Blockade function: during the maintenance process, the system can blockade all operating actions to ensure staffs' safety.
- Data backup function: based on different requirements, the system can backup necessary production data.
- Backup and restore function: if the production data was destroyed or lost, the system can restore the last backups automatically.
- Permission setting function: system administrators can set permissions to different staffs to ensure safety and separate responsibilities.

6. Case analysis

Guizhou Kaifeng has successfully applied the production tracking system to its manufacturing process. Actually, this production tracking system, with a complete internal data platform, is a part of a MES system. Powerful functions includes process setting, production process control, product tracking, assembly planning, report generation, plant fault management and authority management. Also, it can manage staffs through specific worker encoding, avoid mixing batches and materials, as well as eliminate neglected loading and short shipped.

However, the enterprise still does not implement an integrated MES system. First, it does not have an ERP system to help managers to draw up the production planning and implement information interchange in real time. So far, the information transferring between managerial level and manufacturing level is just written in paper, and then the staffs input the planning into the supervisor computer to accomplish the following steps. Second, the present supervisory computer cannot conduct quality analysis and control chart.

In the near future, Guizhou Kaifeng may plan to join IoT to operate more effectively and efficiently in manufacturing industry. Yet, there still exist some aspects they need to improve in the future. The fist one is RFID technology. In the present production process, Kaifeng uses barcodes to track product information, but as barcode is easy to be destroyed and cannot connect with the Internet to send the product's information by itself, it will limit the development of the enterprise in the future. To adopt RFID technology is imperative. The second aspect is relationships with other members in the supply chain, including both customers and suppliers. It needs to build more close relationship with them to accelerate information interchange and enhance tight cooperation. It will be much better than the present situation where they connect and exchange information only by phone and e-mail, which is not conducted through the same Internet network and information platform. The third aspect is also the development goal of Kaifeng in the next three years. They plan to adopt an office automation system to combine with their future MES system to build an integrated manufacturing system, making production planning transferring automatically. The last but not least aspect is the transportation data collection. In the future, the visualization GPS position system should be useful for the enterprise to track the transportation process on the Internet and collect data in real time.

In general, Guizhou Kaifeng already plays as a leading role in Guizhou's manufacturing industry. It was ahead of other enterprises and tried to use product tracking system first, which is a part of MES system. Now, they already have been successful to use this tracking system. They laid a good foundation for future development of joining in the Guizhou IoT network. More detailed programming for manufacturing industry will be described on the following.

6.1 Internet of Things

An introduction of Guizhou Kaifeng was presented above. The current information platform has just referred to the manufacturing process and the electronic communication among supplier, customer and other internal departments are not integrated. To achieve an efficient communication, the company must expand the scope of the information platform as well as build an efficient information network.

For the sake of expanding the scope of communication, the information platform could be build, based on all activities, from purchasing to sales, in the supply chain. If the information platform covers all these sections, the company can reduce the time of information transmit and increase the extent of resource sharing. An illustration of an integrated information platform is given in Figure 8 below.

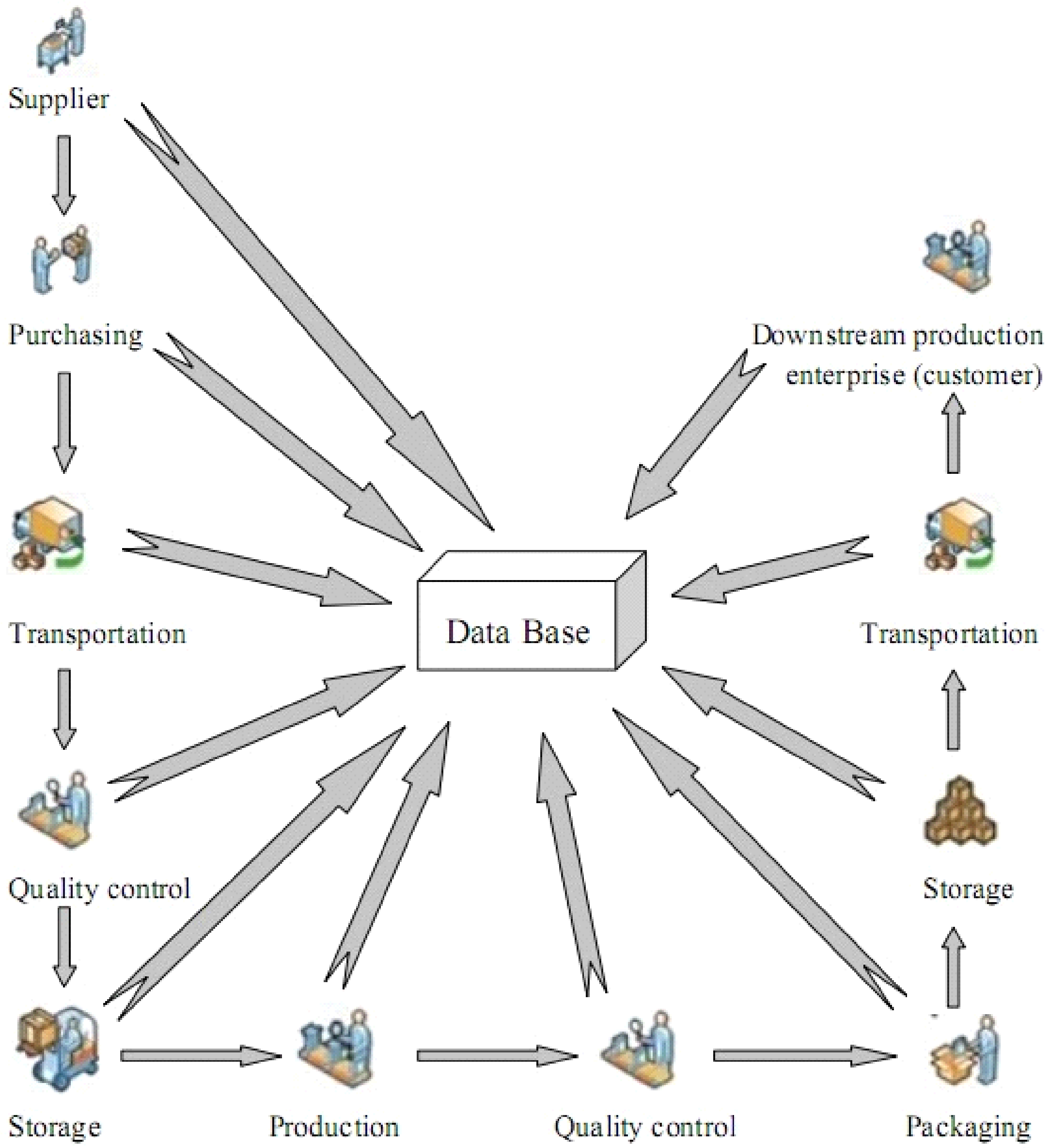

Figure 8: Activities in Supply Chain

Presently, the Guizhou Kaifeng has already been equipped with a product tracking system, a part of MES. As mentioned above, the MES can support the application of other systems, such as ERP and SCM. What is more, the data system in MES can be used as a supporting system to integrate with other systems so as to meet the requirements of IoT. For the purpose of reaching highly efficient communication in the company, Guizhou Kaifeng can choose IoT as an information network. Based on this suggestion, an imaginary architecture model of IoT in Guizhou Kaifeng is given in Figure 9 below. Bar code and RFID are used to collect data, and then the data are transformed to the MES data system. Thereby the applications of MES, ERP, SCM and other systems can be supported by the MES data system.

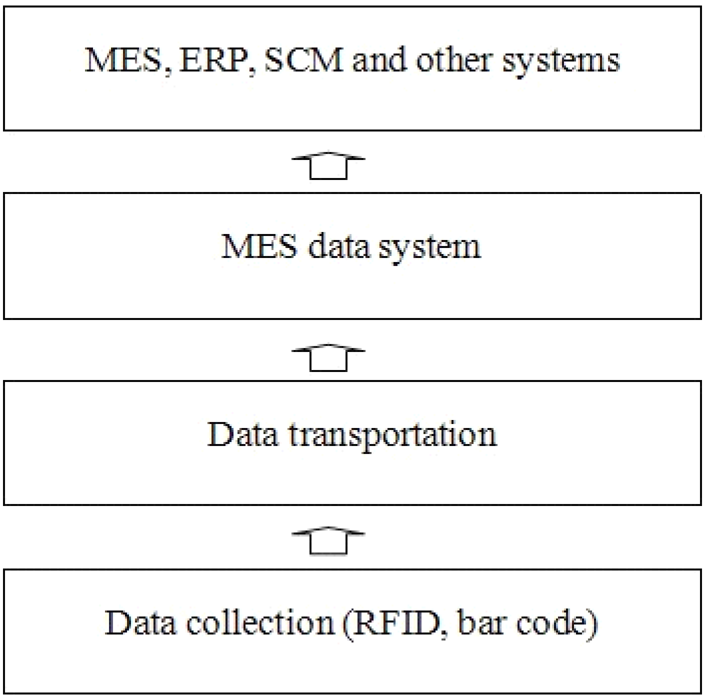

Figure 9: Imaginary architecture model of IoT

6.1.1 RFID technique

RFID takes many advantages over the bar code. First, RFID can be read in batch, but bar code cannot. Second, the distance of RFID between tag and reader is longer than bar code. Third, the information storage of RFID is larger than bar code. Fourth, the bar code is easily soiled, but RFID is not easily soiled cause of the information is in a protected chip. RFID is an important technique in the use of IoT. The most dominated problem of RFID is that it is costly, much more expensive than bar code. That is why the bar code is widely used in Guizhou Kaifeng now. If all the barcodes are replaced with RFID, it will be costly. From the perspective of economics, the RFID can be used in two ways; one, for the finished product, and the other is for the identification of workers.

When there is a problem on the air bag, the bar code on finished product is an important evidence to track the production information. The duration time is unpredictable, from the finished product assembled into a car to possible problems emerges. This duration time may last several days or even several years in some special manufacturing companies. Therefore, the bar code should be abrasion-resistant to ensure the security of production information. As a result, Guizhou Kaifeng gives the finished product a new bar code and then packages it. As RFID is solid, labeling RFID on the finished goods can guarantee the security of information. Using RFID instead of bar code will eradicate the risk of information missing. The RFID's function batch read, can reduce the operation time of scanning bar code in next storage and transportation sections.

In order to make sure the detailed information of every process can be tracked in the future, every worker must enter the identification number before operating machines every time. The length of the ID number is 13, three letters on the first plus 10 numerals. Entering the ID number can guarantee the separation of responsibility on every work and avoid the channeling work, but it takes too much time. To apply RFID in the identify verification phase can save the time of enter number and makes the identify phase easier. When the worker operates the machine, the RFID reader can read the tag of the worker. The computer system can record the information directly without any worker's activities.

6.2 Using visualization technique in IoT

Based on the literature review, there are two kinds of visualization ways that can be used in IoT. The first one is to collect information with technologies, such as GPS, RFID, and then create picture by means of computer to visualize the information. For example, the data of a car's position collected from GPS is displayed with the help of a computer in the form of a dynamic map instead of an address or coordinate. Comparing with digital data, pictures can give people a clearer and easier image to gain the same information. Thus, with a map, people can recognize the car's location in a clearer and easier way than digital data. The other means is using machine vision to achieve the visualization state. Machine vision is a kind of technology which collects objects' information in pictures instead of in data, and then a computer can process the information to build a 3D model. Even though the machine vision technology is useful, the complex techniques and expensive cost will be the barrier of using this in IoT. As an exploratory study, the way of using application is more important than consider the cost. Therefore, these two visual ways can be combined to achieve visualization in IoT.

Guizhou Kaifeng can use MES data base as the supporting one of IoT. This MES data base should include the whole supply chain shown in the figure above. Now, the product information received in each link is gained by barcodes. In the following sections, where should visualization be used and what kinds of visualization technologies should be used, are discussed.

6.2.1 Simulated model

A simulated model of the whole supply chain should be built. This simulation includes all the links in the supply chain and performance by icons which are connected in line. Employee can click the icon of one link, and then a list of products that are processing in this link and their detailed information will be presented. Employees enter the number of a product or component into the computer, then the icon of the link where the product or the component is will be different with other icons. Detailed information of the product or component will display after clicking the icon. Time can also be an indicator to show the products or components' states. Enter any point in time, then click any icons, the product or component in this duration will be presented. This simulated model can help managers to monitor and control the whole process, and track the products. It uses pictures instead of complicated data, and delivers information to the user in a clearer and more direct way.

6.2.2 GPS

To enhance the function of the simulated model, the GPS technique, locating the position of object, can be used in the transportation links. The data of an object's position is transmitted to a computer, and then the data will be presented in a map in order to give the user an understandable and distinct view on the position. GPS is useful to track the object's position, but if this technique is used on every product; it will be expensive and unnecessary. For the purpose of high utilization and low cost we have mentioned before, GPS can be used in one way to track the position and avoid high cost at the same time, i.e. using GPS on every vehicle. Because the products or the component have their unique barcode on the packages; the data should be input into a computer before the next process. The system can be combined with GPS technique in the simulate model, so when users click the icon of transport, the position of this vehicle will be presented in a map, and the list of products or component will be displayed at the same time. Other information will also be presented, like the starting point, destination, duration, and the rest time to the duration to enhance the control and monitor of the transportation link.

6.2.3 Machine vision

As Guizhou Kaifeng is a manufacturing company, its production is one of the most important activities in the whole supply chain. Machine vision is a useful analytical tool to control the manufacturing process. This technique gains the information in graphic form and can make 3D models, so the employees in manufacturing can monitor and control the process.

If the machine vision is used in the production section, it can timely discover the unqualified components. When an unqualified component is discovered, the production line of this component will be stopped until the causes are found. Operating the process in this way can avoid the excess waste from two aspects; one is avoid the unqualified component being processed continuously to waste material and resources; the other one is to avoid the rest of the components being unqualified because of program errors or wrong operation by workers.

6.2.4 Architecture model of IoT with visualization techniques

Based on the imaginary architecture model of IoT, we added the visualization techniques and applications of visualization to it as shown in Figure 10 below.

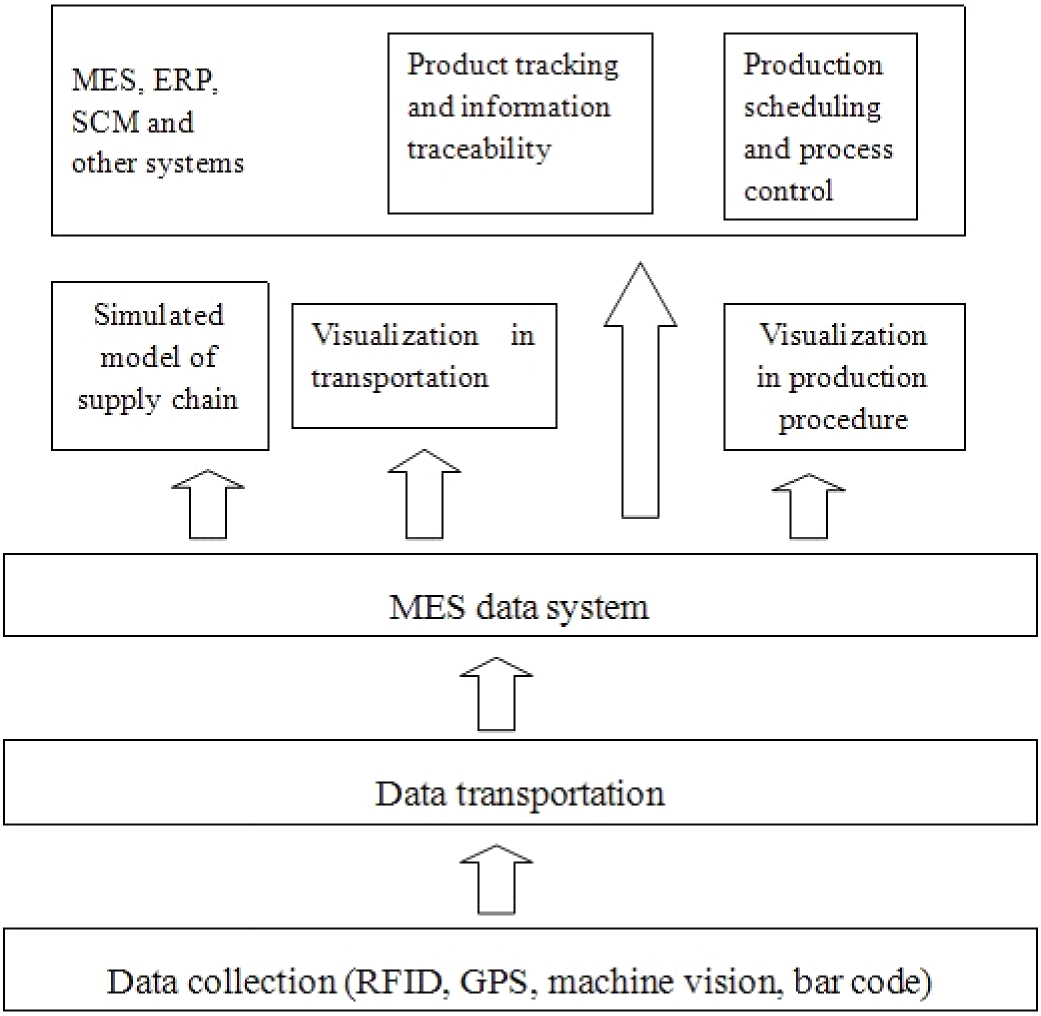

Figure 10: Architecture model of IoT with visualization techniques

With the use of GPS, machine vision, RFID and barcode, the system can handle the data in a simulated model of the supply chain. It can achieve the visualization in transportation and production procedure. A simulated model can build to monitor the whole supply chain. Thereby, the company can use these applications to control the process in a clear and well understandable way.

6.3 Preparation work to achieve visualization in IoT

IoT is a complex network as well as an information platform. Using visualization techniques in IoT can help manager control the process and supply chain in a more direct and easier way. Three aspects, namely, equipment, system, and management, to build an IoT with the use of visualization are to be discussed in the following.

6.3.1 Equipment

As the IoT is a complicated and huge network, a list is made, in Table 3, to display the basic needs of equipments for the sake of using visualization technique in IoT.

Table 3: Techniques and application of using visual technique in IoT

Equipment	**Application**
Bar code	Store the product information.
RFID	Store the product information.
GPS	Collect the position and surrounding environment of vehicle.
Network senor	Collect the information of RFID in one region, and then transfer the information to the data base.
Machine vision	Control and monitor the standard and quality of products in processes.
Computer	As an operating platform to apply and manage the system and applications.
Server	Receive and store the information.

In these technologies, some of them are widely used such as bar code; while others are emerging ones and need further exploration and improvement. Even if all the technologies helps to the Guizhou Kaifeng's management and control, the cost of using these technologies, especially the emerging technologies, is often expensive and complicated, such as, machine vision.

6.3.2 System

In the previous analysis, the system aspect in IoT has not been discussed. Because this study focuses on choosing the equipment to collect data and the applications for management, we do not explore the system program in IoT. As IoT is using a network to manage and analysis the data collected by the equipment; the data base in IoT must support the huge amount of data and various applications. How to transfer the data, how to handle the data and how to store the data are the three main aspects in building IoT. What is more, the standardization in the use of IoT and how to protect the privacy are also significantly important aspects to build a reliable IoT in the future. The standardization of the products' numbering can lower the entry barrier to new companies and guarantee the correctness of products' information transfer to avoid the mistake that different products are marked with the same code. Privacy is a kind of human right, but the complexity involvers in IoT raise a risk of personal information reveal.

6.3.3 Management

As IoT is an emerging network, but has not been widely used yet. A company who wants to build an IoT must be prepared well and take a risk. The IoT requires the information to be shared among supplier, manufacturer and customer which a lot of stakeholders are involved in. How to persuade the involved to share information is the first and significant important step to build an IoT. In the use of IoT, computers are the platform to manage and control the process and activities. The information is communicated between computers in an effective and efficient way. Computers and machines release people from demanding and complex repeated work. The thoughts of employees must change because the operation mode is different from the traditional one that uses both computers and paper documents. Training employees is necessary to ensure the successful usage of new technologies and management systems.

6.4 Barriers government faces and measures available

6.4.1 Barriers government faces

The government plays a significant role in the process of IoT construction. The IoT network is difficult to be built only by enterprises. Enterprises can only become members of the IoT network to gain profit, share information, monitor actions and make the IoT network complete to be used by all stakeholders. Therefore, the key infrastructure construction, application and dissemination activities need to be under the charge of government. At present, the construction of IoT in Guizhou still stays at the planning and exploration stages. With the occurrence of new technologies, the IoT network will become visualized in the future, which will indubitably increase the challenge. Therefore, the government should not overlook the combination between new visualization technologies with the IoT network when they are considering the development of IoT. Presently, there still exist many factors in the IoT market hindering the development of IoT in large scale. Those factors are listed below:

(1) The limitation in regional and technological development. The developed regions can afford more facilities.

(2) Guarantee of security and privacy, information exchange and resource sharing. The establishment of IoT always starts with equipment deployment, and then it connects with the network. What's more, there is no one take responsibility to guard

the IoT network nodes. All these increase the risks for the use of IoT (Zhonghua Gongkong Network, 2011).
(3) Immature standard system, the bottleneck of the research and development of key technologies (Chen & Wang, 2010).
(4) There are too much different IoT standards in the world and they are applied in different areas (Business Herald in 21 Century, 2010). In Western countries, there exist many IoT standards for different types of business, without a uniform standard to promote the wide use of visualized IoT.
(5) The intersected responsibility in government makes it difficult to establish coordination between different departments so as to build the visualized IoT network (Daily Economic Information, 2011).
(6) It is hard to apply new technologies in a conservative environment (Daily Economic Information, 2011). Many customers, enterprises and even governments have traditional model of thinking, so they are not interested in new technologies, and they will not change their mind to just have a try in new technologies before they see the considerable business opportunities and benefit by themselves.
(7) Conflict between high costs and enterprises' economical conditions (Daily Economic Information, 2011). These are two contradictory conditions. Many small and medium size enterprises cannot afford the high price of the basic facilities and use the equipment in large scale. On the other hand, the manufacturing costs will decrease only after a large-scale use of the facilities.
(8) Without a good and suitable business model, it is hard to attract enterprises to join in the visualized IoT network.
(9) The lack of top design and decision. The enterprises in different regions struggle alone before the government starts to emphasis the IoT, and plan to popularize it.
(10) Some governments are shortsighted (Daily Economic Information, 2011). They are only willing to invest in successful projects so as to avoid taking risks and responsibilities.

6.4.2 Measures available

In order to jump over those barriers and promote the large-scale development of a visualized IoT network, there are some measures available that government can adopt to clean the barriers before implementation of IoT.
(1) Solving technology problem.
At present, the key technologies related to visualized IoT include these that can help to large-scale network in visual control and synergy, network security and authentication, network node maintenance, troubleshooting as well as programmable and testable network sensors (Chongqing Municiple Government, 2011). The government should pay more attention to the definition and technologies of visualized IoT, and provide a special fund to encourage the research and development in new technologies. The cultivation of the application-oriented core technologies and innovative production is very important.
(2) Building infrastructures, solving data sharing issue.

The visualized IoT operation platform can provide support of IoT operation services and terminal management for IoT operation enterprises all over the country and satisfy the large-scale application of IoT technology and production. Government should negotiate actively with wireless service enterprises to build a visualized IoT operation platform. In this way, it can finally implement statistical analysis, information management, customer service, fault monitoring of visible IoT service and functions like position, terminal monitoring, terminal configuration, terminal upgrade and complaint handing to provide the service support for the operation of IoT network for IoT operation enterprises in the country, the management support of terminal management and also satisfy the large-scale application of IoT technology and products in the country.

(3) Solving security issues

It is one of the most difficult issues in the development process of a visualized IoT network. In this aspect, government needs to regulate the operation behavior and market competition, reduce illegal actions to make sure the communication security as soon as possible. At present, some enterprises protect their information security in the way of information encryption (Zhonghua Gongkong Network, 2011).

(4) Unifying standard.

Until now, there is still has no uniform standard for the use of visualized IoT network, not only in China but also in western countries. To formulate a uniform standard is an imperative thing. The government should participate actively in the formulation of an international uniform standard.

(5) Developing related policies.

The government can make special policies related to visualized IoT to ensure the operation security of IoT and to guarantee fairness and stability. To conduct tax preference and provide special fund can also accelerate the development of IoT and encourage more enterprises to join in.

(6) Solving profit distribution issue.

The visualized IoT network relates to many different kinds of enterprises such as network operators, wireless service operators, and electronic product operators. There exist a lot of competitors in different links, thus, it is significant to balance the profit distribution between different enterprises. Government needs to encourage the enterprises to develop IoT network preferentially, taking social benefit, national economy and people’s livelihood into consideration, and guarantee fair competition between enterprises and release policies to regulate enterprises’ behaviors at the same time.

(7) Playing the leading role.

The last measure requires government to act as an initiator. The government should take responsibility to encourage other enterprises to work together so as to promote the development of visualized IoT. At the same time, aiming to utilizing large-scale economic to reduce costs and attract investment, the government have to pay attention to market cultivation to bring about the convenience and business opportunities with the emergence of visible IoT network as soon as possible under the efforts of enterprises and citizens.

7. Discussion

7.1 SWOT analysis of using visualization techniques in IoT

In the following, the situation of using visualization techniques in IoT is analyzed with the SWOT analysis in four aspects, strength, weakness, opportunity and threat as given in Table 4.

Table 4: SWOT analysis of using visualization techniques in IoT

Strength	**Weakness**
• Effective management of whole supply chain; • Effective and efficient information transmission; • Decrease logistic cost; • Enhance procedure management and product tracking; • Improve fault management.	• Employees need training for the use of new technique; • Investment is huge; • Time to adapt to new technique.
Opportunity	**Threat**
• Government policy can promote the development; • Adapt to future development tendency; • Increase promotion to let customer be aware of the convenience and benefits.	• Potential security problem; • Standardization is difficult to achieve; • Immature technology; • No-large scale development; • Fierce competition; • Government does not have well planning and policy support.

7.2 Strategy development of the usage of visualization technique in IoT

To achieve the goal of applying visualization technique to IoT, companies must prepare a lot with huge investment. In the long run, using visualization technique in IoT will bring many benefits to companies, such as management improvements, logistic cost reductions, and efficient information transmission and so on. However, there are still many potential threats and difficulties behind these benefits.

IoT is a network involved in a lot of participants. The IoT scope of the case in Guizhou Kaifeng includes suppliers, customers (downstream producer) and the company itself. For the purpose of successful communication by the use of IoT, the standardization is a key point, which means that the product codes should be uniform among the three participants. To achieve the standardization, participants must strengthen their cooperation among each other and find out the balance point of interests conflicts. The case of Guizhou Kaifeng is not a complex case, because there are not so many involved. If there are many participants, the standardization among these participants is more complicated and the conflict of interests can be hard to compromise. Standardization is one of the barriers in the development of IoT.

As IoT is a network to provide information transmission and the participants are many and complex, the sharing of information raises a potential security problem. The participant's privacy, a human right, should be protected. Effective protection of personal privacy in an information sharing platform is also one of the barriers in the development of IoT.

In China, government has the power to promote the development of IoT and compromise the interest conflicts among these participants. Comparing with government, the enterprise is lack of public trust and powerful strength in economic and technology. With the support and help of the government, the creation of an IoT network can solve the problem of standardization and security problems simpler and more efficient.

For a company to build an IoT network, the situation of the company itself should be objective with careful analysis. Even though IoT has many advantages, it is necessary for the company in decision on building this network. The company should consider the problem that whether the pay back of this huge investment to build IoT is worth the efforts. For Guizhou Province, Guizhou Kaifeng is standing on the lead of the manufacturing in the product tracking area. The analysis of Guizhou Kaifeng is presented in the previous part. If Guizhou Kaifeng wants to join in IoT and use visualization techniques, there are lots of preparation work to do and huge investment for the equipment, system maintenance, employee training and so on. The cost is high to apply visualization technique to IoT. Taking investment and the benefits into consideration, it is hard to say if it is worth it or not. However, the IoT's development tendency in the future is that the development and technology will be more mature. If the network in Guizhou Province gains a large scale development and gets policy's support, the cost will be lower and the development will be easier. The use of visualization technique in IoT is absolutely providing functional and efficient benefits, and the return on investment is considerable.

8. Conclusions

An exploratory case study on the use of visualization technique in IoT was presented above. In this study, Guizhou Kaifeng as a case company has been discussed. From a general view, the analysis and discussion of the applying of visualization techniques in IoT are also adopt to other manufacturing companies cause of these companies have mostly same activities in supply chain. What is more, the situation of different company is different. In order to apply visualization techniques in IoT appropriately, the companies' own situation should be consider to adjust the application.

Four techniques were mentioned to achieve visualization, GPS, RFID, bar code and machine vision. Bar code and RFID collect the product flow information, and then use icons to express the flow of product. GPS can identify the location of vehicle and present it in a map. Machine vision can gather the information in pictures, so this technique can build a 3D model to monitor and control the process. Using visualization techniques in IoT can provide effective and efficient information transmission, as well as control the supply chain and special processes in an efficient way.

Manufacturing industry companies should be prepared in three aspects; equipment, system, and management. In order to achieve the application of new techniques, company should use new equipments, such as RFID and GPS. A secure operating system is necessary to realize the application of new equipments. Computer will replace some human's work to monitor the process, so the management mode should adopt the new environment.

Through the related policy, the government can promote the development of IoT mainly in three aspects; unifying standards, technology development and personal privacy protection. In this study, detailed descriptions have been given on the barriers of the development in IoT and measures available that the government can do to support the development.As IoT is an emerging network and technology is not mature yet, the exploration and development of IoT has a long way to go in the future.

The limitation of this study lies in that this study focuses on providing an imaginary picture of the use of visualization techniques in IoT, in terms of equipment and application. In addition, the system, dealing with how to transfer, store and handle information in IoT, has not been discussed. Another limitation of this study is that is a qualitative study with only one case company. This limits the possibilities to generalize the findings and conclusions.

This thesis is an exploratory study about the application of visualization tools in IoT networks. One of the key aspects of future studies is the practical application of visualization tools. In sum, future studies can focus on these questions: (1) what kinds of tools can be used to collect data? (2) How can the data collection process be simplified? (3) How can data be transferred in a fast and safe way? (4) What kinds of tools and systems can be used to handle the data to realize an effective and efficient management?

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Appendix

Appendix A: Interview questions part 1

Interviewee: Xi Ren, section member in new technology development and industrialization department, Science Technology Bureau of Guiyang Municipality in China, interviewed 2011-05-23.

Question 1: Hello, Mr. Xi Ren. Nice to meet you! We heard that you are working in Science Technology Bureau of Guiyang Municipality, we are really curious about your job. Could you mind telling us something about you job?
Answer: Yes. In Science Technology Bureau of Guiyang Municipality, I am a section member in new technology development and industrialization department. Briefly, our job is to audit all the scientific projects in Guiyang City area and allocate funds. It sounds easy, but, actually, we have to do it very discreetly!

Question 2: Could you please briefly introduce the basic information about IoT situation of manufacturing industry in Guizhou Province?
Answer: Well, so far, the development of IoT in Guizhou Province still stays at the beginning level. Guiyang as the capital city of Guizhou Province is the most advanced development place in IoT area. Thus, I suggest you can choose a company in Guiyang city as the example for you case study.

Question 3: As there are many different kinds of companies in manufacturing industry can have the potential to join in the IoT network in the near future, which kind of manufacturing industry do you think we should choose?
Answer: As I know, equipment manufacturing industry is one of the pillar industries and plays a strategic position in industrial economy in Guiyang City. I think that will be a good choice for you.

Question 4: What are the main products in equipment manufacturing industry?
Answer: Equipment manufacturing industry in Guiyang City mainly includes seven kinds of products: airbus components, construction machinery, numerical control machine and components, electric power equipments and electronic products, characteristic basic components, as well as new kit.

Question 5: Through you description, can we say that many products in equipment manufacturing industry are belonged to military products?
Answer: Yes, that is it. Most emerging technologies are first used in military field before expanded to civilian use in large-scale with cost reduction. Thus, such new technologies as IoT and RFID are more like to be first used in equipment manufacturing industry to drive the development of other manufacturing industry in

Guiyang City. That also can be a reason for you to choose the case company in equipment manufacturing industry area.

Question 6: Could you tell me how many equipment manufacturing enterprises in Guiyang City now?
Answer: According to the data, until 2009, there are 140 equipment manufacturing enterprises in Guiyang city, and the total annual profit reaches 969,600,000 RMB.

Question 7: Is there has any outstanding equipment manufacturing enterprise which is using high technologies in IoT area in Guiyang City?
Answer: Let me see, there is an enterprise called Guizhou Aerospace Kaifeng Science& Technology Limited Liability Company is eligible. It is the only enterprise in Guizhou area to engage in R&D and production of automotive airbag. They are good at production tracking technology. I think you can consider this enterprise.

Question 8: That great! If it is possible, would you please help us to contact this enterprise？
Answer：Yes，I will. I would like to help you！

Appendix B: Interview questions part 2

Interviewee: Zhongjian Xiong, deputy minister of technical quality, Guizhou Aerospace Kaifeng Science& Technology Limited, interviewed 2011-05-24.

Question 1: Hello, Mr. Zhongjian Xiong. Nice to meet you， it is our honour to interview you. Through the introduction from Mr. Xi Ren, we knew that Guizhou Kaifeng is the only enterprise in Guizhou area to engage in R&D and production of automotive airbag. Could you introduce more about Guizhou Kaifeng?
Answer: Hello, nice to meet you too. Welcome to Guizhou Kaifeng. Guizhou Kaifeng is a member of China Aerospace and Industry Corporation 061 base. It was founded in 1968, and carried out reforms and reconstruction in 2001. It has more than 400 employees with over 180 professionals, and a large work team with highly specialized technologies in design, research and development, manufacture and after-sale service.

Question 2: How about Guizhou Kaifeng's productivity?
Answer: The annual output of airbag can reach 150,000.

Question 3: How about the high technology application aspect of Guizhou Kaifeng?
Answer: Guizhou Kaifeng has more than 2000 international advanced radio testing instruments, highly precision CNC (Computer Numerical Control) processing equipments and some advanced circuit design software systems. It also owns several high-low temperature test chamber for electronic product and environmental stress laboratories which consist of electromagnetic vibration generator systems and a production line for SMT (Surface Mount Technology). All these provide guarantee to the enterprise's solid strength in following aspects: precision machining, electronic product development, production control, testing and commissioning.

Question 4: Have Guizhou Kaifeng been approved by ISO9001 quality management system?
Answer: Yes, it has been approved in 2003, and this year, it is certified of TS16949 quality management system which is the special requirement for auto production and related components, it is suitable for the organization form of auto manufacturing supply chain.

Question 5: Which enterprises are Guizhou Kaifeng's main customers?
Answer: Our main customer is Changfeng Actuman. Recently, we have already signed contracts with Lotus and Victory Auto，that means we will become the supplier in automotive airbag of these two brands. Next step, we plan to establish cooperation with Changan and Zotye Auto in the near future.

Question 6: Can you introduce the automotive airbag system?
Answer: An automotive airbag system is made up of six main parts, including lord

airbag module, ballonet module, steering wheel, steering circuits, front crash sensor and other components. Guizhou Kaifeng is specialized in the manufacturing of lord airbags and ballonet modules.

Question 7: How about the manufacturing process?
Answer: The production line totally includes 21 operation processes. During the production process, every component needs to have a barcode in its surface for production tracking. Guihou Kaifeng mainly adopts two measures to support its production tracking, batch management and serial number management measures. In terms of those key components, like airbag gas generator, they adopt the serial number management to mark a unique barcode number for each specific component; while for assistant components, like belt rail and screw, they choose the batch management to use a same barcode number for all components. In the factory, there is a supervisory computer in the factory to monitor other computers and machines, responsible for the production line, and to collect data which is sent from those computers connected with production machines. All the procedures and equipments are administrated and dispatched uniformly by computers. This computer administration system can conduct procedure control, process monitoring, manufacturing data recording and production output management during the production process.

Question 8: Can we visit the factory to see the production line later?
Answer: Yes, of course. Come with me!