Efficiency in Emergency medical service system
An analysis on information flow

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Abstract

In an information system which includes plenty of information services, we are always seeking a solution to enhance efficiency and reusability. Emergency medical service system is a classic information system using application integration in which the requirement of information flow transmissions is extremely necessary. We should always ensure this system is running in best condition with highest efficiency and reusability since the efficiency in the system directly affects human life.

The aim of this thesis is to analysis emergency medical system in both qualitative and quantitative ways. Another aim of this thesis is to suggest a method to judge the information flow through the analysis for the system efficiency and the correlations between information flow traffic and system applications.

The result is that system is a main platform integrated five information services. Each of them provides different unattached functions while they are all based on unified information resources. The system efficiency can be judged by a method called Performance Evaluation, the correlation can be judged by multi-factorial analysis of variance method.

Keywords: information system, efficiency, information flow, reusability
Acknowledgement

This thesis is the result of my graduation that carried out in Emergency Medical Service System. The past four months had been a very great experience. This is also the first time I was challenged to conduct my own research. I have gained a lot that can be useful in the future. Although it was an individual project, a lot of people helped me during my research.

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Chapter 1 Introduction

In this chapter, I will talk about following themes:
Paragraph 1: Background. First, I will introduce something about Emergency Medical Service System’s background information.
Paragraph 2: Problem Definition. I will explain the problems existing in current EMSS, and why improvement is required.
Paragraph 3: Objectives & Research Questions. After problem definition, I will narrow my research into certain objectives.
Paragraph 4: Thesis Arrangement. I will show how this thesis can be read in this paragraph.
Paragraph 5: Research Results. The final research results will be shown here.

1.1 Background

Since my research is based on emergency medical service system, I will tell some relevant information about its workflow, history and applied technologies.

1.1.1 Workflow Chart of EMSS

![Image of Workflow Chart of EMSS]

Figure 1 Workflow Chart of EMSS
1. In EMSS, all the work starts when a telephone is called in. 
2. Then the entire system starts working with Digital Record System recording. 
3. After the operator’s quick assessment to the case scenario of the person in distress, all the information will be sent to the Main Information System. All the relevant information from different databases will be picked out and showed on the big screen in front of the admin staff. 
4. Through the analysis of the case, the admin staff will send command to different appropriate staffs while the ambulance (or other vehicle carrier) will also be dispatched immediately. 
5. Then, through the monitoring by vehicle carrier information system, admin staff will send command to appropriate staff when required. 
6. After the task finished, an act report should be held to the admin staff from each staff.

1.1.2 EMSS History

Through the studies for EMSS History provided by Wikipedia (EMSS_Wiki, 2007) and Inventor.com (EMSS_Inventor, 2007), I listed the short history as following:

- The first emergency number system to be deployed was in London on June 30, 1937.
- The first North American emergency number was the 999 system deployed in Winnipeg, Manitoba, Canada in 1959 at the urging of Stephen Juba.
- The very first American 911 call was placed on February 16, 1968 in Haleyville, Alabama made by Alabama Speaker of the House.
- Canada switched to using 911 as its emergency number in 1972.
- The European Union subsequently adopted the 112 number as a standard on 29 July 1991.

1.1.3 Technologies

It is doubtless that EMSS is an information system. An information system is the entire infrastructure, organization, personnel, and components for the collection, processing, storage, transmission, display, dissemination, and disposition of information, including software, firmware and hardware (INFOSEC-99). An information system is based on data management system including data schema and data applications (Richard D. Holowczak, 1996).

In an EMSS, Database (DB), Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), SAP modules, Geographical Information System (GIS), E-business Portal Website are the main technologies that have been used.
already. With the rapid development of the science, more and more technologies will be applied in this field.

1.2 Problem Definition

According to a study carried out in U.K. by OASIG, 1996 (a special interest group of the Operational Research Society in the U.K. concerned with the organizational aspects of IT), up to 90% of information technology projects failed to meet their goals; 80% are late and over budget; and 40% are in low efficiency (Peltu, M., 1996).

Today, EMSS is a classic integrated information system that covers so many different departments, industries, domains, and even different countries. How to maximize and accelerate the communications and transmissions of the information flow among different information systems becomes the most important and troublesome problem we have to confront.

With the development of information technologies and the appearance of Internet, the applied way of communication has changed a lot. While the informatics develops rapidly, we are still not able to control the new information flow that the advanced technology brought to us. Even instead of making life easier, the information system often produces much greater costs than anticipated, and in addition, generates more work than before it was implemented (Reynolds, 1991).

Another reason is our lack of experience. While the rapid development of the technologies, more and more advanced technologies have been applied in the new system, at the same time we can not ensure that every operator is professional enough to manage the effects brought by new information flow. Therefore always the result is the system has been built and implemented already, but most operators still do their work the same as before when there was no such new systems.

- Each department does their own work independently as a single island. They have their own applications and system. It is difficult to retrieve and process data since systems are running on different platforms and based on different modules. Usually the data format and protocol are complex, heterogeneous and incompatible.

- Delays. The diversity of Information System causes delay in giving information as applications are not integrated (Marinos & Zahir, 2002). The reason is that each information system has its own data format and data protocol. When the information is required from other system, it will first be transformed to another format which the system required and then transmit to the system. Otherwise, the information is unreadable and useless. In this case, it becomes a useless material.
Overall, the core problem is the non-effective communication and transmission among different information systems implemented in different departments. I will discuss these problems further in Paragraph 3.3.

Here, the problem will be defined as: how to measure the non-effective communication and transmission in order to prepare for a further improvement.

1.3 Objectives & Research Questions

My initial goal was to find a way to measure the efficiency of EMSS. More specifically, I wanted to find the answer to the question: “Is the current system efficient enough?” Since the EMSS is a multi-system which is integrated of several applications; we can rephrase the question to: “how to improve the transmission and communication of information flow among sub-systems?” However, during the step-by-step investigation, the answer soon turned out to be too diverse; therefore I narrow it to some sub questions which test the system in different ways as following:

**Theory part:**
- ✓ What is information flow?
- ✓ How can information flow impact the system?
- ✓ What are information flow patterns?
- ✓ What are communication protocols and data format standards?

**System part:**
- ✓ How is the current system actually integrated?
- ✓ What are the functionalities of each sub system?
- ✓ How to define these sub systems?
- ✓ How to evaluate system efficiency?

My thesis is focused on finding a solution/suggestion for the above mentioned questions which does allow both system users and managers to get a better understanding of their own emergency medical service system in the sight of information flow. Then, they can manage and improve their current applied system much more easily.

1.4 Thesis Arrangement

My thesis is arranged from begin to end that everyone can read it directly. But at the
same time, since there are some sub-systems in EMSS, my chapters or paragraphs are arranged naturally by sub-systems or its specific characteristics. So the reader who is familiar with EMSS or sub-system can skip directly to the chapter which he/she is interested in.

In figure 2, we can see my thesis is arranged in such a way that each chapter depicts one special thing separately.

In each chapter, it contains following information:

- **Chapter 1: Introduction.** The first chapter serves at the introduction to the rest of the thesis. The introduction includes a brief description of the EMS system’s background; problem definition; research questions I will answer my research questions during the length of this chapter and research results.

- **Chapter 2: Methodology:** I introduce the methodologies I used in my thesis.

- **Chapter 3: Correct Cognition.** My research is based on the theories of information flow. In this chapter, I will introduce some important aspects of the information flow and tell the correct cognition to information flow. At the end, I will use a model to define information flow and information flow system.
Chapter 4: Non-function Factor Analysis. In this chapter, I will introduce non-functional factors in two aspects. First, it is Cultural Difference. Every country has its own culture, people from different countries has different attitudes when they face the same thing. I start by explaining the main concepts of culture differences. After cultural differences, I will introduce hardware infrastructure, since hardware is the base while software is the soul. Here, I will introduce the EMSS infrastructure framework.

Chapter 5: System Study. In this chapter, I will introduce six parts of the system includes: Main information systems, Queuing Liaison system, Digital record system, Geographical information system, Video transmission system, and Sub emergency center system.

Chapter 6: Evaluation. In this chapter, I will introduce an algorithm to evaluate the system.

Chapter 7: Discussion. In this chapter, I will discuss some problems I found in current system.

Chapter 8: Conclusion. In the final chapter of this thesis, I will summarize my conclusions.

1.5 Research Results

Overall, my thesis is a step-by-step investigation of the problems. And in context of my investigation, here list some research results as following:

- My research model is shown in Section 2.1.
- My research methods are shown in Section 2.3.
- My data acquisition methods are shown in Section 2.4
- The definition of information flow is in Section 3.1
- The information flow could impact the system in many ways. The properties are introduced in Section 3.2; the relationship between information flow and information system is in Section 3.4.
- Information flow patterns are in Section 3.5.
- Communication protocols are in Section 4.1.4, and data format standards are in 4.1.5.
- The impact brought by culture differences to information system is introduced in Section 4.1.
- The hardware requirement and deployment are introduced in Section 4.2
- The integration of applications of the current system is introduced in Chapter 5. It includes six sub systems.
The functionalities of main information system is introduced in section 5.1; the functionalities of queuing liaison system is introduced in section 5.2; the functionalities of digital record system is introduced in section 5.3; the functionalities of geographical information system is introduced in section 5.4; the functionalities of sub emergency station system is introduced in Section 5.6.

The qualitative evaluation is in Section 6.1, it includes security, reusability, and system model.

The information interdependency evaluation is in Section 6.2.1.

The performance evaluation is in Section 6.2.2.

The limitation of my thesis is talked about in Section 7.6
Chapter 2 Methodology

In this chapter, I will tell the methods I used in my thesis:
Paragraph 1: Research model. First, I will introduce my research model.
Paragraph 2: Research Journey. I will depict the research journey during my research from the beginning to the end.
Paragraph 3: Research Method. After the description of research journey, I will talk about the methods I used to formulize my study.
Paragraph 4: Data Acquisition. I will talk about the acquisitions I used to collect and gather data in different ways.
Paragraph 5: Writing Process. At the end, I will roughly depict my writing process.

2.1 Research Model

The model I chose for my thesis is Jenkin’s (2004) model of the research process contains eight sequential steps.

![Jenkin’s 8 Sequential Steps](image)

Figure 3 Jenkin’s 8 Sequential Steps

2.2 Research Journey

My research journey is following Jenkin’s eight sequential steps. First, I decided to write my thesis about e-health. Then, with my supervisor’s suggestion, I formed my
initial idea about emergency medical service system. After that, I read several books and articles in library and e-library. Till I found enough theories to support my initial idea, I decided that I will study the efficiency of information flow in information system.

I decided to analyze both China’s EMSS and Sweden’s SOS Alarm as my case study, but not just study in theoretical research. Through the comparisons of both systems, it will make my thesis much more impressive.

First, I read a lot of literatures to systematize my knowledge about information flow. Finally, I found a theory to help me form a model to define information flow. After that, I did interview and read the profiles provided by the system manager. Then, I generally depicted the system’s function. And data capture was finished at this second.

I found an analysis method from china informatization quotient, a department of Chinese Academy of Sciences. This method provides me a direction to define the system’s function and to judge these functionalities. I also found some other methods used for evaluating information system in security and artificial intelligence. According to these methods, I final chose Performance Evaluation in my study.

After evaluated both systems, I presented the results at the end of my thesis.

2.3 Research Methods

When comparing the research method, I finally chose four methods in my thesis for further evaluation:

◆ Grounded Theory (main method)
◆ The conceptual analytic approach
◆ Inductive and deductive research approach
◆ Case Study

My thesis was formed up of two parts: theoretical part and case study part. The theoretical part is about the theories of information flow and evaluating methods of information flow. The case study part is to analyze systematical functions and compare process of SOS Alarm system and 120 EMSS.

2.3.1 Grounded Theory

In theoretical part, I chose grounded theory since Glaser and Strauss (1967, p. 2) said
their basic theme in the grounded theory was the discovery of data systematically obtained from social research.

Strauss and Corbin (1990, p. 23) have the following definition:

“*A grounded theory* is discovered, developed and provisionally verified through systematic data collection and analysis of data pertaining to the phenomenon under study.”

In this thesis, what the author has done is all related to this theory. First, systematic data was collected from interviews to the manager of the Sweden’s SOS Alarm, and so did the blueprint of China’s EMSS.

GT questions also tend to be oriented toward action and process (Strauss and Corbin 1990, 38). The research question is how efficient the current EMSS is? It is analyzed towards its running process. So the contents are suited well to ground theory’s definition.

Then in open coding, two analytic procedures are basic to the coding process. The first pertains to making of comparisons, the other to the asking of questions (Strauss and Corbin 1990, 62). Comparisons are the most important part in this study. The author did comparisons in many aspects to find the advantages and disadvantages for each system.

### 2.3.2 The conceptual analytic approach

The conceptual analytic approach is applicable for my theoretical part. Theory analysis is needed to show the correct perspectives for information flow. It represents theory model into reality very well, especially the communicating process among information systems.

When begin to do the comparison, it is impossible to manage the whole system in macro analysis. Therefore the system had been divided into several certain sub systems according to the part’s own functionalities or characteristics. It seems to be of more worth in more details with great division.

### 2.3.3 Inductive and deductive research approach

Inductive and deductive research approach is used for investigations on empirical and logic point. In my study, some models achieved from other researchers had been used.

First, the information flow theories were induced and an information flow model and
an information flow system model were presented. Then, the entire emergency system was divided into six sub systems, and induced their functionalities in each paragraph. After an initial function analysis, a qualitative evaluation and a quantitative evaluation had been done. In quantitative evaluation, an algorithm was applied to evaluate the system efficiency.

2.3.4 Case Study

Case study method approach is an empirical inquiry that investigates a contemporary phenomenon within its real-life context (Robert, 2003). Via the case study, we can get a better understanding of what it is in reality. With no doubt, it is a part of this thesis. I studied and compared Sweden’s SOS Alarm and China’s 120 EMSS through interview and literature studies.

In case study, the system was presented in five aspects—the main information system, digital record system, geographical information system, video transmission system, queuing liaison system, and sub emergency center system.

2.4 Data Acquisition

Data acquisition methods I used are documents studies and interviews.

2.4.1 Document Studies

In theoretical part, the perspective was represented through reading books and articles in research area. The books were found in school’s library, and most articles are found in e-library such as ACM and IEEE.

2.4.2 Interviews

A face-to-face interview with the manager of Växjö’s SOS Alarm was done, and an e-meeting interview to the manager of Jingmen’s 120 EMSS. I asked both managers some prepared questions while they depicted a lot of scenarios that I had not mentioned as well.

2.5 Writing Process

First, it was a theoretical analysis to information flow since information flow itself is a fuzzy concept, it is extremely necessary to define it clearly at the beginning. After concept definition, several misunderstandings were illustrated to the information flow. Since someone mistook information flow equals information system, different
perspectives from different parts of information systems were showed, and finally a clear viewpoint of information flow was given. Then, information flow properties, popular information flow patterns, communication protocols, and data format standards were introduced.

After theoretical part finished, it would go to case study part. Through studying a reference (Appendix 2) provided by China Informatization Quotient, a department of Chinese Academy of Sciences, this thesis started with culture differences and hardware infrastructure as non-functional part, and then depicted six sub systems as functional part. The division was made by the functionality.

The next part is the evaluation. It is a summarizing process to the ideas from both theoretical part and case study part. Then, the research results were written down.

According to the evaluation, the conclusions were presented at the end of my thesis.
Chapter 3 Correct Cognition

Organizations consist of complex islands of technology, with diverse information formats, heterogeneous computing platforms, and various programming models (Swenson and Cassidy, 1993). In this case, in organizations, there is no more single system, more and more systems integrated of complex functions have been applied. Through the application integration, although it is originally created to each determined application among systems, the nature of information flow has changed. It brings information flow complexity from simplicity. Therefore, the correct cognition to information flow is one the key factor we should mention first before the research to informatics.

In this chapter, I will talk about following themes:
Paragraph 1: Definition to information flow. I will define information flow in this paragraph through the summarizing of this area.
Paragraph 2: Properties of information flow. I will introduce the properties of information flow in layer and complexity.
Paragraph 3: IS<>information flow. I will explain the relationship between information system and information flow.
Paragraph 4: Information Flow System Model. I will introduce an information flow model which roughly depicts the information flows.
Paragraph 5: Information Flow Pattern. Then, I will talk about the patterns widely used in information systems

3.1 Definition to Information Flow

In the search for one widely accepted definition of the information flow, it was realized impossible to descript the definition. In different areas, information flow defines different concepts. In Bilingual Chinese-Modern Machinery Manufacturing Technology Dictionary, it has the following definition:

“Information flow is the organized graphic process of data collection, processing and final reporting.”

Barwise and Seligman (1997) defined information flow is:

“x carries/bears/conveys the information that y.”

Based on Barwise and Seligman’s theory, Jianjun Shen and Sihan Qing (2007) deduced information of more exactitude as following:

“Exec(s, p) may cause information to flow from variable v1
to v2. This can be represented by a quadruple: \((s, p, v1, v2)\)’’

Meta-Flow \((s, p, VI, v)\) indicates that the value of state-variable \(v\) after \(\text{exec}(s, p)\) has relevancy to the input from \(s\); while \((s, p, v, VO)\) indicates that \(\text{exec}(s, p)\) returns some information about \(v\)’s value to \(s\). Actually, \((s, p, VI, v)\) exists so long as \(s\) is capable of altering \(v\) by executing \(p\), for \(s\) can at least choose whether or not to invoke \(p\) to transfer information to \(v\) (Jiangjun et. al, 2007).

Dan Wang (2002, 04) has the following definition in logistic area: “Information flow serves for business flow and logistic flow, and Guide these flows in the correct operation and transmission of the logistics and economic information generation during the entire process.” Hong Fan (2001, 01) has the following definition in Medical information management: “Information flow is the object which is flowing on the Internet/Intranet within the targets of some certain rules. The carrier is the Internet/Intranet. It depicts the information transmission direction and the handling process to the information.”

### 3.2 Information Flow Property

Information flow is a very popular word in current society. In conceptual way, it is transcendental current information technology. Every communicating process in our daily life itself is the transmission of information flow. What current information technology brought to us is to build a more efficient channel and to supply a faster information carrier. This is a very important perspective for us to distinguish different information technologies and to know how good it can support the information system.

There are many ways to circulate information flow. In old time, voice is the basic communicating way. People circulated it in face-to-face talking, or took a verbal message; in modern time, it was replaced with telephone or mobile phone. At the same time, words & image transmission developed from classic printed way to fax, e-mail, Internet website, and MMS (multimedia message service), etc.

#### 3.2.1 Layer

The information technologies used to circulate information flow are separated to different layers.

- Physical Layer: The installation of wire line/wireless communications equipment, lay of telephone line and cable are the constructing process for information flow on physical layer;
- Logic Layer: The serve for modem, ISDN, ADSL, DDN, T1 is the constructing process on logic layer.
Through the construction on physical layer and logic layer, there forms up an entire network for information communication. At the same time, a carrier is needed to transfer our information flow. The carrier is the information system we used everyday.

### 3.2.2 Complexity

Since there are a lot of information systems implemented in networks, information flows can be divided into simple information flow, complex information flow, and entire complex information flow.

- Simple information flow application always adopts standard communication procedure or network management procedure. Such as EMAIL, NFS (Network File System), FTP (File Transfer Protocol procedures), TELNET (remote network management protocol procedures), RLOGIN (Remote System Login procedures), information browser on the Internet, ICQ/MSN chatting, SMS (short message service). The reason why they are simple implementation is the system designers do not need to do anything else but use these implementations directly when they need them during the system developing process.
- Complex information flow application is the organization’s management for information system, ERP (Enterprise Resource Planning), and the development for E-business website. This kind of applications needs to satisfy organization’s specific requirements. The transmission process involved the collection, processing, searching and publishing procedure of business information. While this phase of the information technology has reached a higher level, it still can not satisfy the requests from the organization in logistic or the production-oriented organization.
- Entire complex information flow application is aiming at logistics organization and the production-oriented organizations who think much of supply chain. In these organizations, the closeness among information systems still seriously hindered the information flow’s effective applications.

So how to enhance the transmission efficiency of entire complex information flow among different information systems is the most difficult problem we have to face.

### 3.3 Information System <> Information Flow

The core perspective is that single information system can hardly represent the information flows. In recent years, a new subject called Enterprise Application Integration becomes very popular. What EAI brings to us is basically reducing the waste of system material, money and time caused by repetition of information flow through the integration to the domains of similar functions. As a result, the system we have to face is definitely a complex system composed of several sub systems. On the other hands, the value of information produces in flowing process from system to
system, thus only one system can hardly give an exact description of what information flow really did. Therefore all sub systems are introduced step by step. At present, the most popular developing directions of current information systems are investigated in the sight of information flow application.

3.3.1 MIS (Management Information System)

MIS aims at one special department or the combination of some departments who have the same functions. Beyond all doubt, it is an information system with simple structure and single function. Data collection, processing, and decision-making are the basic functions. In physical working process, it led the information carrier which was paper before in both traditional business and management service pattern changed into computer floppy disk now. Thus, the functions of search, statistic, analysis, report are applied much more automatically and conveniently.

MIS always focus on only one producing/management link, the system developing process is emphasis on small-scale construction, short cycle, but low risk, strong pointed. But such a system is unable to manage multi-business. Therefore, it is not fit for huge enterprise/organization using for its complex business requirements.

3.3.2 ERP (Enterprise Resource Planning)

The mentality of ERP system design focus on the overall situation and harmony of each department’s service and interworking. The enterprise’s internal ERP construction always comes with the business process re-engineering and affects multitudinous departments in the enterprise. The successful construction of informatics will be advantageous to break the barrier in enterprise development and management. Of course, the benefit will increase while the efficiency and reusability will be enhanced.

At the same time, as ERP project involves so many departments and links with big-scale construction, long circle but high risk. Analyzing in the sight of information flow, ERP module solved the communicating problem among departments and links of information flow. But fundamentally it does not break the barrier among different business processes. For instance, current enterprise always has parallel businesses at one time, if information flow communication is required among these parallel businesses, what can we do? In EMSS, it has six sub information systems. Therefore only ERP system is not enough for EMSS.

3.3.3 E-Business Portal Website

As a new technology, e-business portal website provides remote information
publication and information transmission. Using this technology can help the users accelerate the transmission speed of the information flow; enhance the serving efficiency and quality. But unfortunately, the practical effect from the applications is inferior to designer’s anticipated targets.

Analyzed in the sight of information flow, the important reason is lacking of effective information origin and information handling capacity. E-business portal website always lacks of the support from business process management. So it can neither get data collection from business process directly, nor process information/data flow like MIS or ERP did. Thus, it should get supports from other systems, only e-business portal website itself is nothing. It is just a subsidiary technology.

In order to break the barriers among MIS, ERP and e-business portal website system, we have to redesign the information flow transmission process, to solve the communicating process among different portals in different information system. We should try to enhance the system’s transmission efficiency. And this is exactly my research motivation.

3.4 Information Flow System Model

Over times, the studies to information flows have become more concerned about the systems. When study the information flow, the study to the systems is required. Pure fundamental research to information flow seems to be nonsensical. In other words, the research to information flows should be built on systems. We should consider the influence that the information flow brought to the system. Thus, in the research, the research objects are the information flow system.

Take a further look to definition of an information flow system from Jianjun et. Al (2007), more details will be represented in Appendix 1. Refer to JIANJUN et. Al’s module, I designed a simple module for my evaluation.

- Information flow is an execution that may cause flow (Jianjun et. Al, 2007). It is defined by: \(<S, R, D, V >\). S is a set of sender; R is a set of recipient; D is a set of dimension; V is a set of volume. (V is equal to L*I L is a set of length; I is a set of intensity.) It is a multi-sequence that includes unidimensional information flows. An information flow \(<S, R, Dn, L, I>\) can be expanded as \(<(S, R, D1, L1, I1) (S, R, D2, L2, I2) (S, R, D3, L3, I3)…(S, R, Dn, Ln, In)>\).

- A channel is an information flow that can transmit information from one subject to another (Jianjun et. Al, 2007). It is a one-dimensional array that denotes all possible channels. It is \(Cn\), the number \(N\) is considered by the amount of unidimensional information flows. \(Cn\) can be expanded as \(\{C1, C2 ... Cn\}\).

- Information system is the recipient for the information flow. It can be defined by: \(M= <S, R, Su, V, SS>\). S is a set of sender, R is a set of recipient, Su is a set of
subjects; V is set of system volume; SS is a set of system-state. Su is a multi-sequence that includes unidimensional sub system. It can be expanded as $<(S, R, Su_1, V, SS) (S, R, Su_2, V, SS) ... (S, r, Su_n, V, SS)>$ When the information flow entered the system, it will be divided to different parts first and then sent to appropriate subjects. Whether the information flow can enter the system is considered by V and SS. Only in the condition when the system is open and there is enough volume can move in the flow. Otherwise, this flow will be refused.

Using this model, we can roughly depict what this procedure exactly is, how the information flow moves into the system.

A simple case is illustrated here for a further impression. An information flow Fx is sent from System A to System B, it is a four dimensional array, the total volume is 30. The amount of channels between these two systems is 12. The recipient system B is composed of 6 subjects, the system state is open, and the rest volume is of 200.

In this case, it can be represented as:

- **Execution 1:** $<\text{System A, System B, 4, 30}>$
- **Channel:** $\{c1, c2, c3, c4, c5... c12\}$
- **System B:** $<\text{System A, System B, 6, 200}>$

A more clear description is in Figure 4.

![Figure 4 System Model](image)

**3.5 Information Flow Pattern**

Adding information flow applications into informatization construction can help us exploit mentality in informatization construction, and reduce risk. In the developing process of information system, there derived some kinds of information flow patterns.
3.5.1 Collaboration Pattern

Collaboration pattern is the way built up for data transmission among information systems. It can automate the information exchange in related business. Using this pattern can bring the enterprise a lot of benefits:

✓ Sharing the data from different systems to the entire organization.
✓ Get rid of the fetter from ERP universal design mentality; adopt the advantages such as small-scale construction, strong control, and local development in MIS. In order to reduce risk and fund pressure, it distributes first and then integrates everything into strategy layer.
✓ Get rid of the dependence on single system developer, adopts the strategy of selecting the better qualification in part first, and then unified integration of these better qualifications. So there is almost no risk when update the systems or change the software providers.
✓ New system can be parallel with old ones. We can add new systems whenever we need without interrupt the working process of current system.
✓ Enhance the sharing rate of information in each sub system.

3.5.2 Data Centric Pattern

Carrier (1999) defines data centric as the automation and integration of data flow that are exchanged between information systems. In data centric pattern, it includes several information systems and a data centre. According to the direction, start point, and end point of the information flow, data centric mode can derive many different embranchments. Each MIS can upload data to data center, data will be integrated and
saved in data center. At the same time, data center can also publish data to each MIS. Here, data center acts a role as a data inquiry service center, or news-publish center. If the information flow transfers from a MIS through the data center’s processing then arrives at another MIS, the data center is a data exchange center.

Usually, data center is built for information flow applications in the needs from organization’s internal structures. For instance, in EMSS, the communication between main information system and sub emergency station’s system should use data centric pattern.

While the collaboration pattern is focus on data exchange, data centric pattern is focus on available sharing of information flow.

**3.5.3 Network Collaboration Pattern**

Network collaboration pattern exists in the enterprise/organization that has an entire complex structure of information system. In this case, there are several information systems existing in the enterprise/organization. These information systems naturally form a network structure. But at the same time, this structure always lacks of suitable management. In the initial period of network collaboration pattern’s development, business needs for information is the motive power leads the intercommunication between system and system, therefore it is of strong operationality. The disadvantage of this pattern is lack of macro management. When it developed in a higher level, it will make a huge number for maintenance cost.
Chapter 4: Non-functional Factor Analysis

According to an evaluation method from China Informatization Quotient, culture differences and hardware infrastructure are the key factors during evaluating. They will bring great tremendous influences to system resources use factor. (The evaluation method is in appendix 2.)

I will talk about these themes as following:
Paragraph 1: Culture Differences. I will talk about the culture differences and what the differences will bring to us.
Paragraph 2: Hardware Infrastructure. I will talk about the requirement, main framework, and some unified factors.

4.1 Culture Differences

The term culture is difficult to define because it is multiple and often conflicting definitions across different scientific disciplines and different countries (Pfeil, Zaphiris and Ang, 2006). Culture differences are the very factors that should be considered first between two different countries, especially between eastern and western. People in different countries have different backgrounds, live in different environments. In that case, when facing a same problem, people of different cultures have different perspectives. It is a special question with no answer while everybody knows the reason—culture conflicts. In Richard’s culture research, it is reported that in many cases, eastern people has quite different perspectives from western people (Richard T, 1998.4). It is therefore important to study people behaves from different cultures; this can lead to a better understanding of cultural diversity (Stengers, De Troyer, Mushtaha, Baetens & Boers, 2004).

I will therefore investigate culture differences in some ways as following:
Paragraph 2: Degree of Social Development. Developing VS. Developed.
Paragraph 3: Populations. Small amount VS. Big amount.
Paragraph 4: Handle Manners. The different attitudes when people in same condition.
Paragraph 5: Communication Protocol. After the patterns, I will talk about the popular communication protocols used in information system.
Paragraph 6: Data Format Standard. I will talk about the current popular data format standards used in information systems.

4.1.1 Socio-political System

China is a socialism country while Sweden is a capitalism country.
In China, the Communist Party of China (CPC) is the party of power. The CPC is a unified entity organized according to its program, constitution and the principle of democratic centralism (China e-gov, 2007).

“Sweden is a parliamentary democracy, which means that all public power proceeds from the people. At the national level, the people are represented by the Riksdag which has legislative power. The Government implements the Riksdags decisions and draws up proposals for new laws or law amendments. (Sweden e-gov, 2007)”

4.1.2 Degree of Social Development

China is a developing country while Sweden is a developed country. “China's economy developed at an unprecedented rate, and that momentum has been held steady into the 21st century. In 2004, the government further strengthened and improved its macro control, and the economy entered its best ever development period of recent years (China e-eco, 2007).” The gross domestic product (GDP) for 2004 amounted to 15,987.8 billion yuan, 10.1% higher than the previous year. And in 2005 and 2006 the data is shown below (Static.cn, 2007).

From Figure 3.1, it is found China is a classic developing country with a rapid increasing rate. And in 2007, experts forecasted that it will reach 10.9% in government’s economic blueprint for primrose season (Gov Blueprint, 2007). All these data represents China is a developing country.

“Sweden’s economic upswing is continuing. GNP is growing rapidly, and employment will increase by 162,000 persons from 2005 to 2008. General government finances are robust, and in 2010 a budgeting margin of SEK 15 billion will be available for reforms; from the standpoint of economic policy, this margin should be saved until the next economic downturn.” (National Institute of Economic
4.1.3 Population

Population is another very important factor. China is a big country with a population of 131759 1254 (CPDRC, 2007) while Sweden is 9,122,269 (Stat. Se, 2007).

In this case, it means the differences existing between two countries’ emergency systems are reasonable. For instance, in Sweden only 18 centers can cover the whole country. But in China, it is incredible. In normal sense, a middle size city in China is of a 300 million population in average level. This number means only one EMSS center in the city can not manage to cover the whole city. This question will be discussed in the following chapter.

4.1.4 Communication Protocols

Communication Protocol roles the same as envelope working standards existing in letter delivery system. In a network system with open communication protocols, every data socket flows in certain physical and logic information flow channels while there exist a lot of protocols existing in current information system. Here are three kinds of communication protocols which are most popular in current use.

TCP/IP & UDP/IP

This protocol is the most general data communication protocol at present among different information systems. In the development of systematic applications, all general language environments for development have made the essential seal based on this protocol which greatly simplifies the procedure’s complexity. The information system, based on TCP/IP, is usually of high transmission speed, but small data quantity. On the Internet, although information flow can be transferred in high speed, it is always considered by the network condition. Compared with Internet, in Intranet information flow can be transferred under a better network condition which is much
more reliable, and stable.

While the potential threat is considered during the transmission process through the Internet. In this process, how can we handle the lost data packets? So UDP has to be added to substitute TCP in order to reduce the data transmission capacity. Using both TCP and UDP in the information systems can effectively organize and cooperate the relationships among different departments. If a system is of highly integration, both these two protocols are required.

**FTP**
When a single information system needs to exchange information with other systems, a loosely coupled data exchange pattern may be of more operationality. FTP is such a protocol. And it is really in widely used solve this kind of problem.

The general solution is running a small executing file which was embedded in FTP client, but at the periphery of the information system. This file is response for observation and tracing the events and activities happened in the system and diverse related information flow to data files. And then under the control of remote FTP order, the data files will be sent to another information system’s FTP server. There is a data synchronization system existed between the FTP server and information system. What it does is monitoring the files sent by FTP client, and then guiding the file to the right place in the system. In this place, we can run operations in reversed direction. It means that the information flow can transfer in both directions.

The FTP’s advantages are of big transmission capacity, strong stability in which the file conditions can be monitored in the transferring process.

**HTTP**
In recent years, with the rapid development of Internet, HTTP applications are used more and more widely. The data transmission based on HTTP under the safe condition has nice openness and workability

**4.1.5 Data Format Standards**

Data format standard ensures the contents of the information flow received at the correct place in time. But as a result of the differences between transmitting information system and receiving system, the contents of the information flow should be transformed first. In this case, the receiving system is able to identify the information. But if there are a lot of information systems who have entirely different structures, we should transform the information again and again. Obviously, these works have wasted much money and time that it is not realistic when it happened in physical world while we can not spend so much time and money on this process.

In order to solve this problem, a data format standard has to be made to simplify the
transforming process. A perfect data format standard can save a lot of time and money and reduce the time cycle. In this case, the information flows will be transformed into a unique format, and then communicate with other systems. It seems everyone speaks his patois in his/her home town, when s/he goes out of his/her home town, s/he should speak native language to communicate with others but not speak patois.

**EDI (Electronic Data Interchange)**

EDI, the most popular data format standard in the world which provides the most comprehensive, careful description and definition for the business information flows in every process, is always widely implemented between international enterprises/organizations.

**XML (Extensible Markup Language)**

In recent years, with the development of e-business, new XML which provides all kinds of agile data structures and relationships challenges to the fixed ossified EDI. And it also can give a clear translation to the data contents which are transferring in the system in this very second. Another great advantage is that XML is composed by PARSER, BUILDER, and XSLT. PARSER is the part for data analysis, BUILDER is the part for conformation technologies, and XSLT is for format transformation.

Since each part has its own functions, XML technologies can be implemented separately also. Sincerely speaking, this is a very obvious superiority to compete with other data format standards

**Other data format standards**

Except above two kinds of data format standards, there are also other kinds of data format standards. They are used in special systems, such as ASCII.

Overall, the differences are inevitable existed there. We have to face them. Nevertheless, difference is just difference, it never means disparity. What we can do is trying to reduce but not to eliminate or to evade its negative influences.
4.2 Hardware Infrastructure

In this paragraph, the system’s main infrastructure will be introduced, including the main system’s and sub system’s infrastructure as well and some material which should exist with hardware infrastructure together.

At the beginning of this paragraph, one thing I have to emphasize about is the reason why I depicted hardware infrastructure in my thesis. It is said that: “For an information system, hardware is the base while software is the soul (Jing Huang, 2003).” And Allen Newell and Herbert Simon said the relation between hardware and software is similar to that between brains and minds (Allen Newell & Herbert Simon, 1976). The hardware description therefore is necessary.

4.2.1 Requirement

In an EMSS, it should satisfy:

- System objective is high efficient information management. Furthermore, the aim is to build up a system to dispatch manpower with the help from computers in informatics. In the system constructions, efficiency is the key factor we consider first. Therefore the structure of EMSS is quite different from other information system. Generally speaking, the system is a platform integrated different applications, but not provides any independent application. Many times, the system has to be divided into sub systems according to different functionalities.

- It supports dynamical organizational structure of the system. The dynamical organization structure means that every case scenario is different, none of the applications can be considered as a unified one to manage all case scenarios. When system starts working, the system will provide required applications. Concretely, the system functionalities, information flow pattern and system structure will change as soon as the system requirement changes.

- Application Integration. The structure of application integration is depicted in Figure 10. The system could mainly be divided into three parts—hardware infrastructure, sub system, and EMSS main information system. The information flow transmission can be sorted into three kinds. The first one is direct transmission between hardware infrastructure and main information system such as unified time clock; the second one is that the information flow first arrives at sub system, after processed in sub system, it will be unified into the standard that the data can be identified in main information system, such as call information via telephone; the third one is a little different from the second one, it lacks of a unified process comparing with in the second way, such as geographical information and electronic medical record.
Standardization. The standardizations to different applications are quite different. The bottom line for standardization is that the whole system applies unified communication protocols, data format standards, and time clock. At the same time, since this system adopted application integration, most of the information is directly picked from sub systems. Therefore, it is impossible to set all data in a unified format. The solution to this problem is to provide a platform which can identify all sorts of data and show it on the screen.

Furthermore, it can be depicted concretely as following:

- Keep the telephone channels unimpeded: A telephone link of high quality and big volume between EMSS control center and civil telephone network should be built.
- Assistance from computer: We should ensure the links to each sub-system is in good condition that we can get all the information we need in shortest time and the commands can be sent to appropriate staffs in time.
- The network communication: The links to other local emergency medical service systems are also important. In several cases, we have to ask help from other centers.
- Organic synthesis to other systems: The synthesis to vehicle carries information system, Radio traffic system, and automatic call system.
- Data management: All the data will be managed under control in unified databases. When required, relevant information will be sent out as soon as request
accepted.

Overall, our aim is to build up a huge integrated system that uses a main information system as a platform, and integrates a lot of other sub information systems of different functions. Such as digital record system provides the each phone’s record; GIS system provides the geographical information to the ambulance driver and the admin staff; vehicle carries information system ensures the communication between the ambulance and control center.

4.2.2 Main Framework

In order to satisfy the requirements, such a network should be built up. Yang Yi proposed that: “The construction to information flow network should include the network, system software and application software. In network layer, they are cable, switchboard, and other facilities for network management; in system software layer, they are the systems existed for controlling the systems; in application software layer, they are the applications designed for each special-purpose system(Yang Yi, 2004).”

In this case, we can divide this system into two layers.

**Network Layer**
This is the map for network layer:

![Diagram of Information Flow in Network Layer](image)

In figure 4.1, it depicts how information flows into a system. First, it needs to get the request from system. Then the system identifies which level of authentication it will get. After done so, information flow obtains jurisdiction and it will be processed soon. Then, it will be sent to database through middleware. It occurs when either an
information flow need to enter the system, or an information flow is sent out.

**Main Information System**

EMSS is a huge information system includes several sub information systems inside. These sub information systems are under the control of one main information system which is also the management core of EMSS.

Here is the structure of the whole EMSS on system & software layer:
(The direction of arrowhead represents the flowing direction of information.)

![Figure 12 Structure of Emergency System](image)

In the EMSS center, main information system is the core part of the whole system. It is considered as a unified platform, every information flow has to go through its channels. And there are five sub information systems existing in this system. Each of them takes the charge of its own fields. The communications among these sub systems are very frequent with two-way exchange.

When a phone is called in queuing liaison system, its content is automatically recorded in digital record system while the call information is shown in main information system at the same time. The system will record down the dialogue, and the operator is able to then find the right position on the e-map provided by GIS. Then, the admin staff will make decisions according to the content recorded in digital record system, the geographical information from GIS, and relevant personal electronic medical record from electronic medical record provided by hospital. In large-scale accident, the admin staff has to take a further look on e-map to find the best way for succoring initiatively. After all information has been checked, commands will be sent to appropriate staffs to start work. In this period, all the information will be showed on a wall comprised of screens which provides the information from different sub
information system through video transmission system. The admin staff will make commands according to the situation around that time showed. Whether the situation is out of control, we ought to ask help from another emergency center. In this case, entire information will be shared to our partners initiatively. As well the partners can ask us for the required and relevant information.

Figure 11 represents the hardware infrastructure of EMSS:


Figure 13 Hardware Structures of EMSS

This map of IT infrastructure represents what depicts in Figure 4.1 & 4.2 actually is in physical world. Appendix C represents Jingmen’s 120 EMSS structure. It depicts in Figure 4.3 in more details.

4.2.3 UPS (Uninterruptible Power System)

The whole information system is based on electronic facilities. Without electricity, the system can be no more operating. Therefore, one thing to be emphasized here is that the UPS should exist in every emergency medical service system. Through using a
special electric power supply system to ensure EMSS itself open 24 hours a day, and 365 days a year. When the power supplied by regional power network is shut down suddenly, UPS will supply the power automatically to ensure the EMSS under work in any second. Otherwise, we can not image what the result would be in the case that EMSS is out of service when someone were in distress and called 112/120.

4.2.4 Unified Time Clock

Time is the unique factor mentioned in hardware analysis of its great importance. The essential purpose of building such an emergency medical service system is to short the processing time to help the people in distress. So we can not permit time waste, even one second’s waste. Such one second’s delay may cause the people lose vital chance to be survived. If this very second’s delay occurred in the misunderstanding of time during the communicating process, it should be a serious mistake that will never be forgiven by others. In order to avoid these stupid mistakes/misunderstandings, in EMSS, it adopts unified time clock in all information systems while it is of synchronization with other related networks.

It is very pleasant to see unified time clock is using in both Sweden’s SOS Alarm and China’s EMSS. In SOS Alarm’s summary relief it is said that at a minimum all SOS centers are double manned around the clock, feature triple reserve systems and alternative alarm routes (SOS summary, 2005). In 120 EMSS’ blueprint, it is said in order to improve the entire system’s agility and uniformity, all the equipment in the system should adopt unified time clock (Jingmen 120’s blueprint).

4.2.5 Operation System & Database

The choice for operation system and database directly determines the system’s functionalities. A good combination for operation system and database will provide a perfect external environment of good security and stability.

China

In Jingmen’s 120 EMSS, it adopts:

- Windows 2000 Server as Network Operation System
- Microsoft SQL 2000 Server as Database
- Windows 2000 Professional as Operation System
- GIS Platform MapX 1.5
- Chinese 7th electronic signal order as communication signal
**Sweden**

- Sun Solaris as Network Operation System
- Oracle Spatial as Database
- Mac OS and HP-Unix as Operation System
- GIS Platform MapXtreme Java

In Vaxjo’s SOS Alarm, it adopts:

Zenit provides by Erisson instead of CoordCom as data and tele-system

### 4.2.6 Communication Protocol

It is considered by the technologies applied in the information system. Since different software vendors adopted different technologies in its developing process, it is impossible to unify these applied systems at the beginning. Furthermore, each system has its own standards to differ with other systems. Therefore, a core platform with unified communication protocols should be established first to limit vendors’ decentralized approach to applications.

Normally, we adopt such communication protocols as follows:

- TCP/IP is adopted among intranet in all EMSS centers.
- TCP/IP is adopted between GIS and main information system.
- TCP is adopted between EMSS and civil network
- TCP is adopted between digital record system and main information system.
Chapter 5: System Analysis

In this chapter, system analysis will be presented. First, the entire system is divided into six sub systems according to its function. And I will depict these sub systems in a decentralized way.

Paragraph 1: I will introduce main information system. It is the core element of the entire system; it is also the platform for integrating all applications.
Paragraph 2: I will introduce queuing liaison system. It is the portal of the emergency system. All the first hand information is obtained here.
Paragraph 3: I will introduce digital record system. It is nearly an unattached element in the system. It has recorded down all details in one action.
Paragraph 4: I will introduce geographical information system. It is mainly the base of emergency system. In action, all the tracks and important position will be tagged on the e-map shown on the big screen through video transmission system.
Paragraph 5: I will introduce video transmission system. It is the output of the system. All the information will be shown on the big screen.
Paragraph 6: I will introduce sub emergency station system. It is a supplement to current system. Whether a large-scale accident occurred, the nearest EMSS center is able to ask help from other centers.
5.1 Main Information System

In this chapter, I will introduce the core element in both Sweden’s SOS Alarm and China’s EMSS. It is considered as the platform of the entire system; all the sub systems are based and integrated on it. All the functions can be applying on main information system.

Main information system is the core part in the whole system. It provides such a platform to integrate all related information systems through the implementation which called application integration. According to Linthicum (1999), application integration is the

‘unrestricted sharing of information between two or more enterprise applications. A set of technologies that allow the movement and exchange of information between different applications and business processes within and between organizations.’

Linthicum (1999, p354)

Through the integration, legacy systems can be now well working on a unified platform with standard formats. It makes the system much more manageable and maintainable.

5.1.1 Task Tracing

The task tracing starts as soon as the phone calls in. Then, all the operations will be entirely recorded down as a copy to this special period, no matter the operation itself is useful or not. In appropriate staffs, their operations are also under traced. But the tracing part in each staff is considered by its own duty in the emergency process. In the tracing period, everything under tracing can be shown on the big screen through video transmission system, which will also be recorded in digital record system.

5.1.2 Link to E-Map

While the operator takes the phone, the geographical information system will automatically start work as other sub systems. The electronic map will be showed on the screen. As the mouse icon’s moving, the map will automatically change to the very region that the mouse pointing at while the relevant word information will be showed in another form next to the e-map.
5.1.3 Command & Dispatch

After the rapid initial assessment for current condition and situation, the operator will send first command to appropriate staffs and dispatch ambulance or other vehicle carrier to get the person in distress as soon as possible.

Then, after the information check in electronic medical record and other relevant information, s/he will send further command to appropriate staffs again for further activities. Of course, the command from admin staff will also be transmitted to appropriate staffs in the first time.

5.1.4 Electronic Medical Record

After sent out the first command, the operator will check the relevant information in electronic medical record provided by hospitals about the person in distress. S/he can see the person’s entire health-care information recorded in hospital’s system, such as Drug Allergy. Whether special information is found, it should immediately be sent to the appropriate staffs for reminding.

5.1.5 Vehicle Dispatch Record

Vehicle carrier is an importance resource in EMSS. The emergency rescue ability is considered by the amount and sort of vehicles. EMSS center can help the person in distress in time when there is vehicle carrier in center. Otherwise, the operator has to call other center for help. In this case, vehicle dispatch record becomes very important. When the vehicle carrier has to go out of the center, no matter what motivation it is, it should record in the system before its leaving. Otherwise, it should not be allowed to leave the center. Whether the amount of vehicle carrier would nearly touches the bottom line in a special time, the center will call to other center for help. This is a serous attitude to all the citizens’ life.

5.1.6 Data Management

Data management is a basic function while it is also the most complex part in information system at the same time. As an information system, especially an application integration information system, the more applications it includes, the more complex the system is, and the more information the system has. All the attributes of all information flows should be sorted carefully. Each sort of information is provided by different staffs according to their duties, each staff takes in charge of one or two sorts of information.
In the main information system, it will manage the information as following:

<table>
<thead>
<tr>
<th>Number</th>
<th>Information Sort</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Employees in EMSS Center</td>
<td>Job rotation record, personal information, business duty, personal functional authority, etc.</td>
</tr>
<tr>
<td>2</td>
<td>Vehicle Carrier Information</td>
<td>Properties, dispatch information, return record, personnel information, etc.</td>
</tr>
<tr>
<td>3</td>
<td>Digital record</td>
<td>Call-in time, conversation time, phone number, phone taker’s name, etc.</td>
</tr>
<tr>
<td>4</td>
<td>Electronic Medical Record</td>
<td>Provider, record time, description, etc.</td>
</tr>
<tr>
<td>5</td>
<td>Case Record</td>
<td>Dealing time, result, person in charge, etc.</td>
</tr>
<tr>
<td>6</td>
<td>Telephone Data</td>
<td>Phone number, Address, etc.</td>
</tr>
<tr>
<td>7</td>
<td>Symptom Database</td>
<td>2600 kinds of Toxicant symptom, 52 kinds of common emergency, 1300 kinds of Chemical dangerous materials, etc.</td>
</tr>
</tbody>
</table>

Figure 14 Data Management Table

Geographic information is under certain management from the vendor of GIS since it is a very professional subject. It will not be considered here.

5.1.7 Multiple Information Searches

Multiple information searches are one basic function in information system. It helps operators to find required information in a quite easy way. The operator can search the information materials required in many different ways such as number, name, or blur search.

The search efficiency is considered by the sorting for information in database. Information is the most important elements in database. The more details it has, the less time the search process will cost. In other words, we can examine the system’s shortcomings through information search. Furthermore, it will be of great reference and applying values.

5.1.8 Report

Report is a summarizing process. Every staff should hand in their work report to the admin staff. Then admin staff will check each staff’s working process. In Appendix D, there is an emergency response flow chart developed by Occupational Health & Safety in University of Alabama at Birmingham (Res_EMSS, 2004), it shows clearly that every staff in emergency procedure should report to admin staff after their
emergency rescuing. The purpose is for summarizing and record.

Overall, the main information system is the basic platform of the entire system. The system functionalities and agilities are directly considered by main information system.
5.2 Queuing Liaison System

In this chapter, I will explain about the most important sub system existing in this information system. And I will talk about it through its working process.

“Dix et al. (1993) states that interaction is always the communication between the user and the system. The communication is most often performed as a dialogue.” (Dix et al. 1993) Queuing liaison system is the portal of the whole system. Its task is to do the interaction between phone caller in distress and EMSS center or call for help from another EMSS center.

5.2.1 Interactive Voice Response

It is a familiar technology used in call center for reducing cost. This program will be applied while plenty of phones are called in at the same time. In this case, except the phone which taken by the operator, other phone will be interviewed by the computer and recorded down automatically. There is another condition, if the phone number is recorded on the malice telephone list, the IVR system will tell the person automatically that his phone number is banned in 20 minutes or longer, and then record down the number again on call-in list.

5.2.2 Malice Telephone Shield

False alarm call happens very often. It is always caused by adult’s misunderstanding to emergency system’s responsibility or false alarms made by children. Even, it is made by someone in malice. Anyway, no matter what the motivation is, it will bring negative effect on the EMSS center, especially when there rings a real phone called by a person in distress. As a result, we adopt one automatic diagnosis system to record phone number called in and an interactive voice response system to reply to the false alarm call automatically.

5.2.3 Call Information Handling

According to the content in the phone communication, the operator will record them down first and then classify the information s/he just got from the caller and typed them down in right forms in the system. To the number which just called in, the operator can find the relevant information rapidly form system’s CRM. In this way, it reduces the service time further.
5.2.4 Automatic Record

After call information dealing, all the relevant information and data include phone information, handling information, dispatch information, and digital record information will be saved in databases with the operations records. At the end of the action, other information from vehicle carrier, emergency rescue room and other staffs will also be processed and then saved in database as well. These sorts of information are recorded together with the case number and phone number in the purpose for future task check by the administrator.

5.2.5 Statistical Phone Information

After the call information handling process and automatic record finished, all the information will be saved in a standard form in database. In this way all details will be listed such as called in time, telephone number, conversation time, etc. When statistic is required, relevant information will be picked out easily and rapidly.

5.2.6 Job Rotation Record

Each person’s energy is limited; we can not make sure that the operator can be of spiritual centralism in every second. But to this special work, it is extremely necessary, basically speaking. How to solve this problem? Suitable job rotation is a perfect choice. Three or four operators work in one day, each of them works several hours and then rotate with another operator. Anyone who is new entering the system should record the time and his/her ID down on the job rotation record.
5.3 Digital Record System

In this chapter, I will discuss the digital record system. It is nearly an unattached sub system in the system, but includes a lot of important materials. Now designers are tried to tie it to other system more closely to help themselves better.

Since emergency itself is closely bound up to the person in distress, every step in emergency process should support information transmission and communication in best conditions. Among these sub processes, digital record system is the most direct one for getting initial information—the phone interviewing record. Furthermore, it is the most persuasive and realest evidence for afterwards accident inquires.

In digital record system, every record file is linked to a very emergency event. All the words talked in the phone will be recorded down automatically.

5.3.1 Functions

This is a recording system; whatever occurred in the system will be recorded down automatically. Here lists all the functions of this sub system:

*Parallel Digital Record*
In order to ensure the record’s integrality, two parallel digital record systems are required. So in the recording process, whether one procedure shut down suddenly, the other one will go on recording. It ensures that every call record will be entirely recorded in the system.

*Instantaneous Record*
When interviewing the caller, every word is importance. We can not image what the result it would be caused by even one tiny word’s missing. Furthermore, this result is the very one that we try to avoid. In other words, we should carefully record down every word from the caller; no matter they are of use or uselessness.

*Listing Details*
After recording process finished, the record file’s information will be showed on the screen in the call list. The information includes time, phone number, phone conversation time, call times, etc.

*Hardware Volume Prompt*
The volume for each record hard-disk is another important factor. We should make sure that in any case the volume is enough to record one call. So the volume check is a must in daily maintenance. After that, in the system design a set for hard-dish volume prompt is considered. Before it is in use, we should set a bottom line for the volume. When the volume reaches at the bottom line, we should compress the record
or replace another hard-disk instead. Overall, we should make sure there is enough space to record call in any case.

**Record Search**

When information examination is required, the operator can search the information in many ways. (E.g.: time, phone number, phone conversation time.)

Overall, this system should be able to send out unified standard signal to the main information system and video transmission system. In other words, the record file should be of a unified standard media format that can be used in any computer in the EMSS center.
5.4 Geographical Information System

In this chapter, I will discuss another very important sub system. It is mainly the base of emergency system. All the data flow could be put onto this platform and then consider what command will be made.

Electronic map is one of the most importance foundation data. The better use of this material can help us find more accurate position and collect more information. At the same time, vehicle carrier information system also requires more precise geographical information to arrive at the right place in shortest time.

Generally, a geographical information system includes a basic platform and digital geographical information and maps. Digital geographical information includes roads, crossroads, residential area, and symbolic constructions. Any construction that represents a special region will be recorded on the geographical information lists.

5.4.1 Positioning

In this sub system, it supports several kinds of positioning as following:

- Positioning through typed key words. When the operator types key words in, the corresponding map as well as corresponding geographical information to this map will be shown on the screen.

- Positioning through index diagram of the map atlas. This way is common since it is the way Google Earth used. First, it is the mini map of the whole area in front. You should use mouse or keyboards to enlarge the map and then find the very part you needed.

- Fuzzy positioning. When interviewing the caller, perhaps we can not get all the information we need, some information might be not clear enough. In this case, guessing is the only way we can use. By typing a half-baked words or address into the computer, and then all possibilities will be shown on the screen.

- Positioning through phone number. If the caller used a classical telephone, we can get the caller’s position easily by checking the registered address of the phone number in the telephone company. If the caller used a mobile phone, it will be more difficult. The mobile phone company will send the call’s codes information to EMSS center. Through the de-compilation of the codes, we can get the local distributed situation where sent out the signal. It will dwindle the scope in which sent out the telephone signal to a very small region. Then, we can use digital cruise to carry on more pinpoint positioning.

- Positioning through environment description. If the caller did not know where he was, but depicted the surrounding environment. The operator should check
the map rapidly to find the most suitable position.

5.4.2 Zoom

The system supports the functions for stepless enlarging and dwindling. We can also directly enter the number for scale or clicking mouse on the map to enlarge or dwindle. The geometric accuracy connects closely to the map’s visibility.

When enlarging the map, relevant information will be shown somewhere around mouse icon on the screen; on the opposite, when dwindling the map, relevant information will be hidden automatically to avoid blocking other information. In doing so, it is a good way to help.

5.4.3 Digital Cruise

On the screen, there are two forms for maps, one occupies most part of the screen which shows the map with relevant details; the other exists in the corner of the screen, occupies a small part of the screen which shows the map information in branch contents.

When we click mouse on the main map form or click on the branches, the map or information showing in other form will keep synchronizing at the same time. Either form can be stepless enlarging and dwindling.

5.4.4 Information Display & Manipulation

When we click mouse on the map, the relevant information about the click position will be showing on the screen in a second. Furthermore, important information will be shown in different colors.

For special users, there will be more manipulations. For instance, to an ambulance that has a vehicle carrier information system or GPS, if we need to call the workers on the car, or they have to call out in a certain place, the relevant information will be shown on the screen in a conspicuous color.

There is another function of great use—distance measurement. First, use mouse clicking on the map, then the distance between the clicking positions will be measured and showed in another form.

5.4.5 Map Layer

A clear sorting and coding to entire geographical information is required. Since one
city is made up of heterogeneous sorts of information which involves different domains of rich contents. How to integrate and apply such information is the key factor that influences the application efficiency of the database furthermore influences the whole emergency system. In this procedure, we should not only consider how to invoke data in this sub system, but also consider how it exchange/invite/integrate with other data from other sub systems of different forms. If they can be linked successfully, a coupling-relationship network has been established. In this case, each sort of information flow can be combined and used with other information flows together at will.

The map showed on main form is not one single map; it is comprised by several map layers. Each layer depicts one sort of geographical information such as road, residential area, symbolic constructions, rivers, railways and mountains. In each layer, writing descriptions to each building or material is required. It should include the details as following:

✧ The name, size of the road, river, mountain
✧ The name, number and surround environment description of bus stop (& underground entrance).
✧ The name, contact method of company, hospital, hotel, residential area, and other important public places.

More details are in Appendix 4 and 5.

**5.4.6 Maintenance**

The map profiles also need to be corrected or improved or updated. During the implementation, we may find disadvantages and wrong data. In order to correct this wrong information, systematic examination and maintenance are required.
5.5 Video Transmission System

Video transmission system is an auxiliary system of high degree visualization. It is used in the condition when admin command is required, or cross helps is required. In that case, the functions provided by large video screen are considered of great importance. With its help, such factors as cartographic information, literal information can be visualized easily in the emergency process. Furthermore, other more information and details such as intersection transportation condition will be showed through Video Supervisory System. Using this sub system enhances the center’s grasp ability to large-scale accident during the first aid progress. In other words, it helps first aid significantly.

The effect of video transmission system can be impressed not only in the controlling during first aid, but also on the workers. Workers could even breathe the air as they themselves were salvaging at scene. It makes the workers in EMSS center experience their own sense of responsibility much more clearly.

5.5.1 Structure of Video Transmission System

![Structure of Video Transmission System](image)

1. Projector 2. VGA signal converter 3. EMSS’ signal

From Jingmen 120’s blueprint, 2006

Figure 15 Structure of Video Transmission System

This is a simple linear structure. The signal sent from EMSS center’s computer to the
VGA signal converter. After the signal’s transform, all the related information will be showed clearly on the large screen.

Of course, the core part is the large screen. It is the same one as we adopt in college education. The only request is space. This system should be installed in a room huge enough like a lecture amphitheater in order to launch the entire screen. To the projector, there are no more requests. Either fixed suspended ceiling or temporary installation is all right. It is better to set a fixed suspended ceiling projector there for no wasting time in any case. Anyway, at the same time no one hopes there always were large-scale accidents. In fact, large-scale accident seldom happens.
5.6 Sub Emergency Station System

EMSS network is deemed as the whole emergence medical service relationship network. It is comprised of all the emergency centers located in different areas who take charge for its own regional events. A comprehensive technology development program is currently in progress to make the entire technical platform digital and to link all SOS centers in a network (SOS Alarm Introduction, 2007).

In the virtual deployment Figure 4.4, it is linked to other centers of EMSS and the medical information system and patient information system in hospital which represents that one center of EMSS is not a lonely island in the working process. If required, the center can ask the other center or hospital for help not only in technology, but also in manpower, especially in large-scale accident.

![Figure 16 Structure of EMSS Network](image)

5.6.1 China

The situation in China is a little different. The population is a very big number in China. In Jingmen, it is a city with 3.00 million inhabitants occupies a total area of 12400 square kilometers (Jingmen e-gov, 2007). It means that only one center in city is not enough with no doubt. In that case, more EMSS centers should be put on city map in order to cover all the citizens.

As Jingmen is composed of six towns, in my research only the situation in the city center was studied. The city center is composed of two towns with 381 000 inhabitants and occupies 44.6 square kilometers (Jingmen e-gov, 2007). In city center, there is one EMSS control center and three emergency station centers. These four centers are put on the map according to the civil densely populated region. When the
phone is called in at the center, it will be transferred to the nearest center automatically. Four centers are with no differences on the same level as showed in Figure 17.

The structure is different when large-scale accident happened. In the case of large-scale accident, the phone will be transferred to the EMSS control center. The admin staff in control center will command the emergency operation. The other 3 centers should get ready for order as necessary. In this condition, the EMSS control center is the admin staff of three other centers. Obviously, it is one level higher than the other three centers. However, the links to hospital’s medical and patient information system are the same as showed in Figure 18.
5.6.2 Sweden

Since Sweden’s population is much smaller, it is unnecessary to build such a huge network in one city. In Sweden’s entire SOS Alarm system, totally only 18 centers are enough to cover the whole country. It is divided into five areas naturally by the geographical position.

In Figure 19, we can find Vaxjo is in Business Area South. In this area, there are another two centers. These three centers compose the south emergency network. When a phone called in the system, it will be directed to the nearest center. Then, after the initial assessment to the case scenario, Vaxjo SOS Alarm center could ask help to Jonkoping and Halmstad.

In this case, the SOS Alarm is applied the standard structure shown in Figure 16. All SOS Alarm centers in each area are on the same surface separately.
Chapter 6 Evaluation

In this chapter, I will evaluate in qualitative way and quantitative way.

Paragraph 1: Qualitative Evaluation. I will evaluate the system’s security, reusability and the system modeling in intranet and extranet.

Paragraph 2: Quantitative Evaluation. I will evaluate the system again based on some data I gathered.

6.1 Qualitative Evaluation

First, I did a qualitative evaluation about security, reusability and the system modules.

6.1.1 Security

Security is classified to static factors; it does not vary with the change of system states. It is judged from two aspects, first it is the management security, and the other is content security.

Management Security

Security is defined independently because of the complexity and its great importance. The standards of security requests are extremely strict:

✓ To the operator: ID and password are required when the operator starts his/her work. And significant change either in operating or daily record will cause alarm ringing in the center.

✓ To all the users: ID and password are required when they enter the system. None of them has the right to delete and modify the data and information.

Content Security

Content security is represented as the protection and maintenance to the stored profiles and data. A further description is shown as following:

<table>
<thead>
<tr>
<th></th>
<th>Authentication</th>
<th>Authorization</th>
<th>Auditing</th>
<th>Confidentiality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital Record</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Geographical Information</td>
<td>●</td>
<td>●</td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Employee Information</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td></td>
</tr>
</tbody>
</table>
## Vehicle Carrier Information

<table>
<thead>
<tr>
<th></th>
<th>●</th>
<th>●</th>
<th>●</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Case Record</th>
<th>●</th>
<th>●</th>
<th>●</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Job Rotation Record</th>
<th>●</th>
<th>●</th>
<th>●</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Symptom Database</th>
<th>●</th>
<th>●</th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Maintenance Record</th>
<th>●</th>
<th>●</th>
<th>●</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Telephone Information</th>
<th>●</th>
<th>●</th>
<th>●</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Electronic Medical Record</th>
<th>●</th>
<th>●</th>
<th></th>
</tr>
</thead>
</table>

### Figure 20 Security Evaluation

- **Authentication**: All the information flow should be authenticated before stored in databases.
- **Authorization**: The invoking command, no matter from which staff it is, is required authorization before the invoking to the information flows.
- **Auditing**: After the profiles and data stored in database, auditing process will be done to ensure its validity and veracity.
- **Confidentiality**: In this system, some of the profiles and data are of great confidentiality. They are necessary to the emergency rescue process while they should not be disseminated to the public.

From Figure 20 we can see that all the invoking processes to raw data are under control. At the same time, the validity and veracity of the profiles can obtain perfect guarantee.

### 6.1.2 Reusability

Since this system is an integrated system with plenty of applications, the reusability is obviously one key factor when evaluating the system. The transmissions of information flows among six sub systems are frequent, so obviously the reusability among sub systems is in nice condition.

When considering the reusability of the information materials, the information can be defined by the number of used times, mainly it includes: one time used information flow, and more times used information flow.
<table>
<thead>
<tr>
<th>Information Resource</th>
<th>One Time</th>
<th>More Times</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital Record</td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Geographical Information</td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Employee Information</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Vehicle Carrier Information</td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Case Record</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Job Rotation Record</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Symptom Database</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Maintenance Record</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Telephone Information</td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Electronic Medical Record</td>
<td></td>
<td>●</td>
</tr>
</tbody>
</table>

**Figure 21 Reusability Evaluation**

In Figure 21, I only consider the reusability of the information resources in one case action. During the rescue process, all the integrated application will be running from the beginning till the end. Obviously, the more times the material is invoked in the system, the more important it is to the system.

### 6.1.3 System Modeling

When modeling the system, there are mainly two sorts of information flow—external information flow transmission and internal information flow transmission. When modeling this process, I only considered the recipient.

In Section 3.4, I introduced a method to define the information flow system. During the qualitative analysis, I had already formed this information flow system. We first set all the systems are in quiescent state and it is in open state that any information transmission is accepted. In Figure 22, it represents the differences between internal information flow transmission and external information flow transmission.
### Table

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>F</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal Transmission</td>
<td>Sub System</td>
<td>Same</td>
<td>Extranets</td>
</tr>
<tr>
<td>External Transmission</td>
<td>Entire Emergency System</td>
<td>Same</td>
<td>Intranets</td>
</tr>
</tbody>
</table>

Figure 22 Differences between Internal and External

From Section 3.4, information flow system is defined as $M= < S, R, Su, V, SS >$, the information flow can be defined $F$ as a set of sequences, each sequence denotes an element/dimension of the flow; the channels can be defined $C$ which denotes all the possible channels. In this case, any information flow transmission can be defined by a MFC matrix.

Here, the difference is external flow needs to be integrated and packaged first and then transferred to the recipient. The recipient has to decompress this package before sorting the information to the appropriate database. If the transmission occurs in intranet, the one-dimensional units can be sent directly to the recipient.

### 6.2 Quantitative Evaluation

After the qualitative analysis, I will discuss the quantitative analysis. I will judge information interdependency and performance evaluation in quantitative analysis. Since I can not collect enough data, in some of the evaluation I just gave my calculating algorithm to the factors.

#### 6.2.1 Information Interdependency

In the system, there are six sub systems. Most parts of the transmissions are among these six sub systems. At the same time, each system needs time to manage these data flows. What is the relationship between these two factors? Here, I used multi-factorial analysis of variance method. First, we set a coordinate system, $X$ represent the amount of information flow transmission, $Y$ represents the time system spends on managing data. It is as following:

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}}$$
R represents the interdependency between X and Y; X represents the amount of information flow transmission M; Y represents the system N; i represents the number of the data. In order to improve the degree of accuracy, I will first calculate the average value $\bar{x}$ and $\bar{y}$. Then calculate the value $T$ (the sum of $\sum (x_i - \bar{x})(y_i - \bar{y})$). After that, I will calculate $Q$ (the root for the sum of the square). At the end, $T$ divided by $Q$ is the correlation coefficient.

The next step is the evaluation to the degree of interdependency. The bigger the value of correlation coefficient is, the higher the degree of interdependency it will be. We therefore set an evaluation standard here:

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.95 +</td>
<td>Extreme</td>
</tr>
<tr>
<td>0.8 +</td>
<td>Very</td>
</tr>
<tr>
<td>0.5 +</td>
<td>Normal</td>
</tr>
<tr>
<td>0.5 -</td>
<td>Little</td>
</tr>
<tr>
<td>0</td>
<td>Irrelevance</td>
</tr>
<tr>
<td>0 -</td>
<td>Abnormity</td>
</tr>
</tbody>
</table>

Figure 23 Correlations and Degree

According to Figure 23 and the calculated results, we can define the degree of interdependency between information flow M and sub system N. A further description is in Appendix G.

6.2.2 Performance Evaluation

In performance evaluation, based on Appendix B, I will assess the strategic role, hardware infrastructure, applications, manpower, and security.

<table>
<thead>
<tr>
<th>Number</th>
<th>1st Level</th>
<th>2nd Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Strategic Role</td>
<td>Chief Information Manager’s Role in entire system, Informationization Construction</td>
</tr>
<tr>
<td>2</td>
<td>Hardware Infrastructure</td>
<td>Network Capability, Computerize working process, Overcasting Rate</td>
</tr>
<tr>
<td>3</td>
<td>Applications</td>
<td>Database, Informatics Rate.</td>
</tr>
<tr>
<td>4</td>
<td>Manpower</td>
<td>Human Resource Skill Level</td>
</tr>
<tr>
<td>5</td>
<td>Security</td>
<td>Management Security, Content Security</td>
</tr>
</tbody>
</table>

Figure 24 Performance Evaluation Guideline
Strategic Role
The chief information manager’s role in the entire system and informationization construction will be assessed. The degree of emphasis to informatics is considered by the role of chief information manager. The informationization construction is considered by long-term planning.

- If the chief information manager is the top administrator of the entire system, the score is 100; if it is the associate administrator, the score is 70; if it is the department manager, the score is 50.
- If the informationization construction is in long-term planning, the score is 100; otherwise, the score is 0.

Hardware Infrastructure
Network capability, computerizing working process and overcastting rate will be assessed. The network capability represents the degree of the integration and sharing. The computerizing working process represents the degree of computer using. The overcastting rate represents the application degree of computer.

The network capability is judged by network bandwidth and integrated rate.

- If the bandwidth is less than 128K, the score is 30; if the bandwidth is less than 512, the score is 50; if it is less than 2M, the score is 70; if it is less than 10M, the score is 80; if it is less than 100M, the score is 90; if it is more than 100M, the score is 100.
- The integrated rate is equal to the amount of the computer in the network divided the amount of the computer in use.

The computerizing working process is judged by the applications.

- If there is no intranet network or extranet network, the score is 0.
- If the network is in use, it will be judged as: Tracing, 5 points; external exchange of electronic document, 5 points; document sharing, e-mail, digital record, job rotation record, e-meeting, e-business website portal, CRM, the methodology integration for decision-making, unified time clock, 10 points each.

The overcastting rate is the application condition in the whole system. In this system, here are 6 sub-systems. One system application values 16, if all 6 sub-system all used computer, the score is 100.

Applications
Database and informatics rate will be assessed. The database represents the degree of data integration; data collection represents the information quality; the informatics rate represents the actual using condition.

The application of database can be divided into 3 levels: Primary, Intermediate and
High level. It will be judged as: The primary level, 50; Intermediate, 80; High, 100.

✓ Primary Level: Stored all data.

✓ Intermediate Level: The data has been sorted; single dimensional array can be initial statistics.

✓ High Level: The procedure can be starting and provide relevant information automatically.

The informatics rate can be divided into 3 levels: Primary, Intermediate, and High level. It will be judged as: The primary level, 50; Intermediate, 80; High, 100.

✓ Primary Level: Computer is used in every sub system. It covers the main processes. But each of them works separately, there is nearly no transmissions between sub systems.

✓ Intermediate Level: It covers 80% of the entire processes. The data sharing can be received on time.

✓ High Level: 95% of the processes can be managed in optimizing way.

**Manpower**

Human resource skill level of the operator will be assessed. It represents the percent of how many workers in the system can manage the system. It will totally be calculated as the amount of workers who can manage the system divides the amount of the workers in the entire system. For further details, the data will be collected in each department directly. The standard is as following:

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>90</td>
<td>95</td>
</tr>
<tr>
<td>85</td>
<td>90</td>
</tr>
<tr>
<td>80</td>
<td>85</td>
</tr>
<tr>
<td>75</td>
<td>80</td>
</tr>
</tbody>
</table>

Figure 25 Standards for Manpower Evaluation

**Security**

Management security and content security of the data will be assessed. The analysis has been done in Section 6.1.1.

✓ For management security, the score for ID and password login system is 50; Job Rotation Record, Maintenance Record, Vehicle Carrier I/O Record is 16 each. If all these record are under control, the score is 50.

✓ For content security (see in Figure 18), each factor values 2.5.

After all above scores have been made, I will do a final macro evaluation. The method will be
\[ I = \sum (P_i \times W_i) \]

The total score of the system is represented as following: \( P_i \) represents the score of the \( i \)'th element (full score for each element is 100); \( W_i \) represents the weight of the \( i \)'th element (the sum of all weights is 100%).

The weights are defined by the importance of the factors, different organizations can define the weights themselves. For instance, when I want to evaluate a system A, the set of weights will be: strategic role, 10%; hardware infrastructure, 20%; applications, 50%; manpower, 15%; security, 5%; when I evaluate a system B which is almost the same as A, the set of weights will be: strategic role, 15%; hardware infrastructure, 15%; applications, 50%; manpower, 5%; security, 15%

The result of Performance Evaluation is considered by the comprehensive score that we just got above. The standards are as following:

<table>
<thead>
<tr>
<th>Score</th>
<th>Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>95</td>
<td>++</td>
</tr>
<tr>
<td>90</td>
<td>+</td>
</tr>
<tr>
<td>85</td>
<td>0</td>
</tr>
<tr>
<td>80</td>
<td>-</td>
</tr>
<tr>
<td>75</td>
<td>--</td>
</tr>
</tbody>
</table>

Figure 26 Standards for Comprehensive Evaluation

“++” represents the system is in perfect efficiency; “+” represents the system is in high efficiency; “0” represents the system is just efficiency; “-” represents the system is in low efficiency; “--” represents the system need to be improved immediately.

Overall, according to the evaluated method in section 6.2.1 & 6.2.2, this model can be used for sub system evaluation as well. For the information interdependency, each functionalities in the system will cause information flowing and the handling process will spend time. We can also list \( X \) as the amount of information flow, and \( Y \) as the cost time. For the performance evaluation, functionality will take a certain weight, and the applied level will be defined at the same time. We can also use \( I = \sum (P_i \times W_i) \) here to calculate the score of each sub system.
Chapter 7 Discussion

In this thesis, it is an investigation of how information flow is applied in emergency medical service system. In order to operate effectively, a good integrated platform is needed. Today, the current system is in a relative information system of high efficiency. The thesis point is how to judge this efficiency. While at the same time, there are some questions that can not be solved.

7.1 The division of Labor

The division of labor is at the portal of the system. In Sweden’s SOS Alarm, the queuing liaison system takes all the responsibilities from rescue service, police, fire brigade, and sea, mountain & air rescue while in China’s 120 EMSS, the system only allowed rescue service.

The advantage for Sweden’s SOS Alarm is that it integrates all emergency applications. Any emergency request will be taken at the first time. And then referring to the contents from the person in distress, the operator will select which service is required. And the materials such as electronic medical record from hospital, telephone number information from Telephone Company, unified geographical information from one vendor, etc. In this way, it can minimize cost, unify domain material, and maximize the manpower.

The disadvantage is that the delays during dialogue via phone. The operator should first judge the service sort, and then ask for serving. Generally speaking, the worth of time at this point is hard to consider. Even, when there occurred a large-scaled accident, since the system integrated all emergency services, is the manpower strong enough at that very moment? It is hard to judge.

The advantage for China’s 120 EMSS is that it has a clear division of labor. The person in different sorts of distress will call different numbers. (119 for fire, 110 for police, 120 for rescue) When the person called in is really in distress, what s/he required is definitely ambulance. The delay in a centric call center does not exist in this system. It shorts the time to get the very person in distress although this delay is very short. When there occurred a large-scale accident, it is easy to control since there are approximately 3 times’ manpower than SOS Alarm.

The disadvantage is that each service has its own data, when it needs help from other systems, the data format may be not unified. Even we can not make sure the numbers and context description are the same. The question here is whether the information we get is not the same, which one should be used? In another part, because of the division of labor, the number of workers in 3 systems is much more than SOS Alarm, and of
course the maintenance fees are more than 3 times. The total cost is much more than SOS Alarm.

Overall, we can not say either system is better than the other one. Each of them has its own advantages and disadvantages. But they are all relative; none of these key points are absolutely better or worse. In some ways, it is caused by culture differences as well.

7.2 Deaf or Speech Impaired Person

Deaf or speech impaired person can not call the emergency system via telephone. The deaf people can install a special phone which only has the function to call the number 112. But for the speech impaired person, we can not manage the impaired degree since it must be caused by an accident but not by initiative activities. And the damage to the person is out of control by himself/herself. In this case, how can the person contact with the emergency center?

When I did interview to the manager of Jingmen 120 EMSS, he said that they never considered this case scenario since in control are of EMSS it is impossible to find a relative place with no person. When I did interview to the manager of Vaxjo SOS Alarm, he said that in advanced telephone system, the SMS (short message service) is allowed. So the best case scenario is that the person is able to send a SMS to SOS Alarm center. But at the same time, another problem comes. How much percentage is the possibility? Furthermore, how many people actually know the advanced telephone system in SOS Alarm supports SMS?

For this problem, it is very difficult to handle since the first hand information is almost collected through dialogue. If the person can not make the dialogue via telephone, it is impossible to find another way that transmits information in such a short time.

Nevertheless, we should consider every case scenario that may occur. Every citizen is important to the country, even to the world. We can not easily give up one person’s life. Anyway, it is not only for me or for you, but for the entire society. Although it is a Gordian knot, we have to consider it carefully in further study.

7.3 How to improve record quality?

It is said that all details had been recorded down in Section 5.3. When checking record is required, the user can assign out the record and broadcast it. In the interviews to both centers’ managers, they said that the record will be exacted directly with no extra disposal. The reason is that they should make sure the record is real, effective, and complete.
Although the purpose for no disposal is necessary and reasonable, while at the same
time, other problems come. The entire record takes so much space, and a lot of the
information flow recorded is useless. As a result, in the checking process, we waste a
lot of time on reading useless information.

The problem is how to improve the record quality while kept its reality and integrity
at the same time. Otherwise, the quality improvement seems to be insignificant. If we
set a new functional process for improving record quality, where should we put it?
Will it be in main information system managed by administrator of the entire system
or in digital record system managed by the professional system operator? It is also
difficult to define.

7.4 Is current system highly effective?

Seen the analysis above, the answer is yes. The reasons are as following:

- The entire system is under the control of a unified information system.
- All the data are in electronic version and stores in different databases. And the
data format and communication protocol are unified as well. No manual profiles
  are accepted in the system.
- All the actions are under tracked in the system. They will also be shown on the
  big screen through video transmission system.
- The communication network to relevant units (hospital, Telephone Company, etc.)
  has been already built.

7.5 System Openness

Although now the current system is highly effective, we can not ensure that it will be
always in high efficiency. Nevertheless, nothing is perfect. So the process
reengineering and process improvements are still required. Since these procedures are
continual; they can not be operating in a closed system. We should therefore consider
the system openness. Is the current system a closed one? Can it easily add advance
technologies into the current system?

The answer is yes. The core element of the current applied emergency system is a
main information system. It acts as an application platform that integrates different
sorts of applications. All the applications have been integrated on this platform. This
is very familiar with application integration. When an advance application has to be
added into the system, the only things to do is linking the sub application system with
the platform.
7.6 Limitation

During my research, I found several difficulties. The biggest problem is that I am not able to collect enough data for my evaluation. First, the collection to the amount of data flowing is difficult since there is no tool used for micro statistical data.

7.6.1 Evaluation Method

When I chose the evaluation method, I studied Analytic Hierarchy Process, Fuzzy Comprehensive Evaluation, and Performance Evaluation. All these three methods are used for quantitative evaluation to invisible factors.

Analytic Hierarchy Process is a mathematical method that supports the pursuit of an optimal solution in a transparent manner through the use of Qualitative and Quantitative decision analysis, Simple evaluation and representation of solutions through a hierarchical model, and checking quality of your decision (AHP_Wiki, 2007). The first step is to set up the system; the second step is to consider which attribute will be used and then calculate its weights; then compare the builds on each attributes; finally Aggregate Weights to Produce Final Evaluation. More details can be found at. The shortage of this method is that it just evaluated one component of the system. But actually our aim is to judge the entire system’s efficiency.

Fuzzy Comprehensive Evaluation can give an estimate to things affected by multi-factor as a whole (Guan, et al, 2004, p228). The first step is to set up the model of the system; the second step is to consider which attribute will be used and then set up the factor set and evaluate set; the next step it to build up a weighed fuzzy subset; then forms up the matrix and calculates the product of weighed subset and evaluate set; finally, we transform the evaluated result into different degrees. The shortage of this method is that it evaluated all factors on the same level. If we have to judge the sub factors, it seems to be too complex.

Performance Evaluation is the very method that I chose in my investigation. It can give an objective and scientific evaluation to the efficiency and practicability of the system. It is judged by the weights and different hierarchies of the attributes. First, we used the statistical method in factor analysis to sort all attributes; then according to the each one’s importance in the system, we set the weighed subset; then according the hierarchies of the attributes and weighed subset, we calculate the results. A more detailed evaluation process is depicted in Section 6.2.2. The reason I chose this method for my study is that it not only covers the attributes in sub system, but also gives a macro result to the entire system.
7.6.2 Calculate Method

When I chose the calculate method, I studied multi-factorial analysis of variance method, Analysis of Variance.

In analysis of variance, first it defines total variance, between group variance, within group variance; then we calculate the sum of squares of deviations from mean.

\[
SS_T = SS_B + SS_W
\]

Commonly referred to as:
- Sum of Squares Among, or
- Sum of Squares Between, or
- Sum of Squares Model, or
- Among Groups Variation

Commonly referred to as:
- Sum of Squares Within, or
- Sum of Squares Error, or
- Within Groups Variation

The shortage of this method is that it can only judge the interdependency of two certain factors. It can not represent the universality of the system. After we had evaluated the interdependency between A&B and A&C, if we wanted to evaluate the interdependency between B&C, we can not adopt the result from former result, but calculate the data again separately. The aim of my thesis is to find a way to enhance reusability; obviously we can not adopt this method for my study.

So I adopted multi-factorial analysis of variance method for my study. This method will be expounded in Appendix G. Using this method we can get a further understanding to the correlation between all attributes in entire system.
Chapter 8 Conclusions

The aim of this thesis has focused on the system efficiency in the sight of information flow. There have been a couple of keywords that have been following me, namely reusability, application integration, information system. Reusability and integration somehow are the key factors directing us to success. A single application may be powerful or functional enough for one case scenario, but our aim is to ensure any case scenario is under control.

In order to enhance reusability and integration, the system adopted a lot of advanced technologies such as Customer Relationship Management, Application Integration, E-business Portal Website, and Enterprise Resource Planning. Such advanced technologies’ adoption brought remarkably good results to the system. Through the combined integration of digital record system, geographical information system, queuing liaison system, main information system, video transmission system, and sub emergency station system, it provided us a dynamic and powerful information system. The functionalities it provided are dynamically changing as soon as the requirement changes.

Since this information system is a multi-system. It can not be evaluated as a whole. Through the investigation, I found that the system can be defined by information flow in mathematical way. I used an Information Flow System Model to represent the data flowing process. In this case, the transmission can be defined by a MFC matrix. Then, in qualitative evaluation, it is divided into six sub systems including main information system, queuing liaison system, digital record system, geographical information system, video transmission system, and sub emergency station system. At the end, I chose multi-factorial analysis of variance method to evaluate information interdependency, and performance evaluation method to calculate system efficiency.

Through the study, it was found that the system efficiency can be judged in the sight of information flow in a mathematical way, but unfortunately I was not able to collect enough data to support my calculation.
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http://www.sosalarm.se/grafik/sosalarm/generella/About_SOS_Alarm.pdf

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Vip.6to23.com, 2004. 10, ANOVA, Total Variation Algorithms


Suggestion Reading:

Fuzzy Comprehensive Evaluation
http://www.ecpmi.org.cn/uploadfile/jsdt/0002/0684/03052101.htm

AHP:
http://msdn.microsoft.com/msdnmag/issues/05/06/TestRun/
http://mat.gsia.cmu.edu/mstc/multiple/node4.html

Multi-factorial Analysis of Variance Method
http://hanh.blogdriver.com/hanh/862135.html
Appendix A

Meaning List of Jianjun Shen and Sihan Qing, 2007’s Theory

Subject – A subject is the abstract delegate of a group of active entities with the same identity.

Primitive – Primitives comprise the interface of an information system to subjects. A subject can invoke a primitive, called one execution. The execution of a primitive may alter the system state.

We use \( \text{exec}(s, p, ss) \) to denote the execution of primitive \( p \) by subject \( s \) in system-state \( ss \); \( \text{exec}(s, p) \) is also used when we do not care the system state.

State Transition – A transition of the system state takes place when an execution of a primitive returns.

State Variable – State-variables are information containers in an information system. A state-variable shall satisfy: 1) It is alterable and referenceable (in some primitive executions), that is, information is possible to flow in and flow out of a state-variable; 2) Its value keeps during a state-transition if it has not been deleted. Note that state-variable does not equal object in our model. We view (see section 2) an object as an abstract entity which is the target of access control and is associated with a security label.

System State – A system-state corresponds to a set of “state variable - value” pairs. It defines the value of each existing state variable in the system at a given time point.

Input / Output Variable – Two special variables, \( VI \) and \( VO \), represent the input from and output to the invokers of primitive executions, respectively.

An information flow system \( M \) is defined by: \(<S, P, V, SS, IN, T, Mf, Ss0>\).

- \( S \) is a set of subjects. \( P \) is a set of primitives. \( V \) is a set of state-variables. \( IN \) is a set of inputs.
- \( SS \) is a set of system-states. It defines the value space of state-variables.
- \( T \) is a state transition function: \( S \times P \times SS \times IN \rightarrow SS \). \( T(s, p, ss, in) \) defines the new system-state after \( \text{exec}(s, p, ss) \) with input \( in \) returns.
- \( Mf \) is a function: \( S \times P \times SS \rightarrow (V \cup \{VI\} \times V \cup \{VO\}) \). \( Mf(s, p, ss) \) defines the meta-flows generated by \( \text{exec}(s, p, ss) \).
- \( Ss0 \in SS \) is a constant. It defines the initial system-state.
Note that $Mf(s, p, ss)$ does not depend on the input to $exec(s, p, ss)$. It indeed reflects the ability of subject $s$ to arouse information flows by invoking primitive $p$ in system-state $ss$.

A sequence of information-flows that occur in succession shape an **information flow**: $< (s_1, p_1, v_0, v_1) (s_2, p_2, v_1, v_2) \ldots (s_i, p_i, v_{i-1}, v_i) (s_i, p_i, v_{i-1}, v_i) \ldots (s_n, p_n, v_{n-1}, v_n) >$. We also write a flow sequence as $v_0 s_1 (p_1, v_1) s_2 (p_2, v_2) \ldots s_n(p_n, v_n)$ for short, where $s(p,v)$ means: $exec(s, p)$ extends the flow to a next variable $v$.

A **channel** is an information flow that can transmit information from one subject to another. It looks like: $VI s_1(p_1, v_1) s_2(p_2, v_2) \ldots s_i(p_i, v_i) \ldots s_n(p_n, VO)$, $s_1 \neq s_n$.

- $subj(mf)$ gets the subject element of meta-flow $mf$; $prim(mf)$ gets the primitive element of $mf$. $src(mf)$ gets the source variable of $mf$; $dest(mf)$ gets the destination variable of $mf$.
- $len(f)$ gets the length of flow sequence $f$; $f[i]$ gets the $i$'th information flow of $f$.
- $sender(f) = subj(f[1])$, $recver(f) = subj(f[len(f)])$;
- $src(f) = src(f[1])$, $dest(f) = dest(f[len(f)])$. 


## Appendix B

<table>
<thead>
<tr>
<th>No.</th>
<th>1st level</th>
<th>2nd level</th>
<th>3rd level</th>
<th>Comment</th>
<th>Example</th>
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<tr>
<td>1</td>
<td>Developing Degree</td>
<td>Strategy</td>
<td>The degree of informatics development</td>
<td>Main businesses</td>
<td></td>
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<tr>
<td>2</td>
<td>Technical Application</td>
<td>Informatics Rate</td>
<td>The applied advanced technologies</td>
<td>EAI, ERP, E-business portal website</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Database Application</td>
<td>Informatics Rate</td>
<td>Management to informatics</td>
<td>How to apply informatics</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Security</td>
<td>Informatics Rate</td>
<td>How to use database</td>
<td>Database integration</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Operating Condition</td>
<td>Operating Network</td>
<td>What are System operation conditions</td>
<td>Operating with no error and least delays</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Internal Culture</td>
<td>Operating Network</td>
<td>What is hardware infrastructure and network structure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Information</td>
<td>Operating Network</td>
<td>The influence caused by culture factors</td>
<td>Data format standards</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Management</td>
<td>Operating Network</td>
<td>How to manage the system?</td>
<td>Command center</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Agility</td>
<td>Operating Network</td>
<td>How to dispatch and command actions?</td>
<td>The process from phone called in to send out ambulance</td>
<td></td>
</tr>
</tbody>
</table>

Published 2007-4-19

This is an analysis method for Internal Information Flow Analysis in information system provided by China Informatization Quotient, one department of Chinese Academy of Sciences.
This method evaluates the suitability and agility of the information system.
It judges the suitability in strategy, application, hardware infrastructure, and culture differences.

- In strategy aspect, the degree of informatics development and advanced technology applications are the key factors. In informatics development, it focuses on the informatization construction towards the main businesses. In other words, it is judged how information flow technologies are used in current system. The technical application focuses on the advanced technologies application. How can an advanced technology be applied in current system.

- In applications, the key factors are the informatics rate, database applications, and security. Informatics rate represents the utilization to information system. Database applications represent the utilizations for data storage and integration. Security represents the protection to the data.

- In hardware infrastructure, the key factors are the operation condition and operation networks. The operation networks include hardware infrastructure, intra network structure and external network structure. It represents the application integration degree of the system. Operation condition represents the working conditions. Are there errors or bugs existed in current system.

- In culture, the key factor is the culture difference. Culture difference exists everywhere, not only between countries, even between persons. Facing the same thing, different people has different perspectives. It is a factor we must take in consideration.

It judges the agility in information, management, and communication.

- In information, it represents how to collect data.

- In management, it represents how to manage the system.

- In communication, it represents how to dispatch and command all the staffs participating in the action.
Appendix C

1. No. 1 Call Taker Desk  2. No. ** Call Taker Desk  3. Digital Record System
The Department of Occupational Health and Safety

Emergency Response Flow Chart

Definition: For the purpose of this flow chart and in order to stay consistent with emergency planning language used in the University Hospital Emergency Management Plan, the term “emergency response” refers to an event or series of events, natural, technological or man-made (including), that OHS can not address through everyday operating procedures and provides activation of the OHS Command Center (CC). However, this flow chart will also address emergencies that may not require activation of the CC, but still require an organized response with clear lines of communication between divisions and specific decision points.

Notices:
- Call comes to Admin staff
- Telephone assessment
- Emergency Response Call Checklist used to trigger call

Business Hours:
- Full report submitted to AVP OH&S
- Division response plan or procedure implemented, i.e., Bio, Chem, Radi, Gen
- OH&S Director page to report to Command Center for instructions. All other staff page to report readiness to Director.
- OH&S Command Center Activated
- Limited Response Required
- OH&S Director page to report to Command Center for instructions.
- UAB Police at OHS staff at home or on call
- Telephone assessment
- Full report submitted to AVP OH&S
- Division response plan or procedure implemented, i.e., Bio, Chem, Radi, Gen
- OH&S Director page to report to Command Center for instructions. All other staff page to report readiness to Director.

Non-Business Hours:
- Full report submitted to AVP OH&S
- Division response plan or procedure implemented, i.e., Bio, Chem, Radi, Gen
- OH&S Director page to report to Command Center for instructions. All other staff page to report readiness to Director.
- OH&S Command Center Activated
- Limited Response Required
- OH&S Director page to report to Command Center for instructions.
- UAB Police at OHS staff at home or on call
- Telephone assessment
- Full report submitted to AVP OH&S
- Division response plan or procedure implemented, i.e., Bio, Chem, Radi, Gen
- OH&S Director page to report to Command Center for instructions. All other staff page to report readiness to Director.

NOTE:
Some after hours activities are not considered part of this emergency response plan and do not require this process, i.e., radiation presence, radon surveys, medical or other waste chemical spills, etc.

Administrative Notification:
Primary or secondary responsible party for the laboratory or department building.
The AVP for OHS must be notified of all other hour incidents.
VP for Research shall only be notified by AVP of OHS or designee.
AVP for Facilities and VP for Administration will also be notified by AVP of OHS or designee.
Other possible notifications include:
- EO or ARO
- Media Relations
- Risk Management and Insurance
# Appendix E

## Map Layer Properties

<table>
<thead>
<tr>
<th>No.</th>
<th>Layer</th>
<th>Details</th>
<th>Geo. Property</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Highway network—central road</td>
<td>Highways, central roads, 1(^{st}) class roads, 2(^{nd}) roads, 3(^{rd}) roads, Multi-level crossing bridge, and path</td>
<td>Line, different kinds roads of different colors</td>
</tr>
<tr>
<td>2</td>
<td>Roadway Sideline</td>
<td>Highways, central roads, 1(^{st}) class roads, 2(^{nd}) roads, 3(^{rd}) roads,</td>
<td>side</td>
</tr>
<tr>
<td>3</td>
<td>Residential area</td>
<td>Common houses and buildings</td>
<td>side</td>
</tr>
<tr>
<td>4</td>
<td>Multi-level crossing bridge</td>
<td>All the portals</td>
<td>side</td>
</tr>
<tr>
<td>5</td>
<td>Bridge</td>
<td>Railway bridge, road bridge, double deck bridge, footbridge</td>
<td>line</td>
</tr>
<tr>
<td>6</td>
<td>railway</td>
<td>Trunk railway, lateral railway</td>
<td>line</td>
</tr>
<tr>
<td>7</td>
<td>underground</td>
<td>underground</td>
<td>line</td>
</tr>
<tr>
<td>8</td>
<td>Mongline river</td>
<td>Bourn and aqueduct</td>
<td>line</td>
</tr>
<tr>
<td>9</td>
<td>Crewel river</td>
<td>river</td>
<td>side</td>
</tr>
<tr>
<td>12</td>
<td>Reservoir, lake</td>
<td>Reservoir, pool, lake</td>
<td>side</td>
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<td>13</td>
<td>Greenbelt</td>
<td>Roadway greenbelt, park greenbelt, multi-level crossing bridge greenbelt</td>
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<td>14</td>
<td>Buildings</td>
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<td>15</td>
<td>Ambit</td>
<td>Area Ambit</td>
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# Appendix F

## Building Codes Table

It is provided by Jingmen 120 EMSS.

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<thead>
<tr>
<th>1&lt;sup&gt;st&lt;/sup&gt; Class Content</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; Class Content</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt; Class Content</th>
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<td>1. Government (101000)</td>
<td>Government</td>
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<td>Court</td>
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<tr>
<td></td>
<td>Clan &amp; Parties</td>
<td>Gerocomium</td>
<td>101501</td>
</tr>
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<td></td>
<td></td>
<td>Orphanage</td>
<td>101502</td>
</tr>
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<td>Hospital</td>
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<td></td>
<td>Clinic</td>
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<td>Drugstore</td>
<td></td>
<td>102201</td>
</tr>
<tr>
<td></td>
<td>Health-care Department</td>
<td>Blood Service</td>
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<tr>
<td></td>
<td></td>
<td>Sanatorium</td>
<td>102302</td>
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<td>Research Center</td>
<td>103101</td>
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<td></td>
<td>Design Center</td>
<td>103102</td>
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Appendix G

Multi-factorial Analysis of Variance Method

1. Set two groups of factors:  \( x_1, x_2, x_3, \ldots, x_n \) and  \( y_1, y_2, y_3, \ldots, y_n \).

2. Calculate the average value:  \( \bar{x}, \bar{y} \) and the standard deviation:  \( S_x, S_y \).

3. Calculate the covariance:

\[
S_{xy} = \frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})
\]

4. Calculate the Correlation Coefficient:

\[
r = \frac{S_{xy}}{S_x S_y} = \frac{\sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n} (x_i - \bar{x})^2} \sqrt{\sum_{i=1}^{n} (y_i - \bar{y})^2}}
\]

5. Set the degree of interdependency, the scope of value is between -1 and 1, value 0 is point of discontinuity. If the value is less than 0, the interdependency is abnormal; if the value is