



Enterprise Collaboration and Interoperability in China: Barriers and Challenges

Prof. Xiaofei XU - COIN Angel

Xiaofeng Liu – Report Editor
Harbin Institute of Technology – Harbin - China

Table of Contents

1.	Introduction	2
1.1.	Background	2
1.2.	Objective	2
1.3.	Scope	2
1.4.	Structure of this document	3
2.	Review of EI/EC in China	4
2.1.	History of Manufacturing Enterprise Informatization in China	4
2.1.1.	A brief review of the cooperation between China and Europe in the domain of “ICT in Manufacturing and Enterprise”	6
2.2.	State of the Art of Enterprise Interoperability and Enterprise Collaboration in China	8
2.2.1.	A category of Chinese enterprises	8
2.2.2.	EI/EC in Large Enterprises	9
2.2.3.	EI/EC for SMEs	13
2.2.4.	EI/EC policy of Government.....	22
3.	EI&EC Barriers & Challenges in China.....	24
3.1.	Motivation of EI/EC for Chinese Enterprises.....	24
3.2.	EI/EC Barriers.....	24
3.3.	EI/EC Challenges.....	29
3.4.	Other important aspects for EI/EC in China	31
4.	EI&EC 2020 Vision for China.....	31
4.1.	Vision Statement	31
4.2.	The Enterprise Context.....	32
4.3.	The Government Policies	32
4.4.	The Research Context.....	33
4.5.	A roadmap for 2020 Vision.....	33
5.	Concluding Remarks.....	34
6.	References.....	35

1. Introduction

1.1. Background

According to COIN¹'s vision, by 2020 enterprise collaboration and interoperability services will become an invisible, pervasive and self-adaptive knowledge and business utility at disposal of the European networked enterprises from any industrial sector and domain in order to rapidly set-up, efficiently manage and effectively operate different forms of business collaborations, from the most traditionally supply chains to the most advanced and dynamic business ecosystems. Obviously, this vision can also be extended to the areas outside Europe. China, as a developing country, is playing a more and more relevant role in the globalized economic environment. Hence it is natural to know behind the label of “Made in China” how the Chinese enterprises are categorized, how they behave in the domain of enterprise collaboration and interoperability (state of the art, barriers and challenges), what about their vision of enterprise collaboration and interoperability by 2020, how to achieve the vision.

The cooperation between Europe and China in the domain of “ICT in Manufacturing and Enterprise” has been lasting for 20 years now (dating back 1991) and will be no doubtfully enhanced in the future. The knowledge about enterprise interoperability and collaboration in China will be greatly helpful for the stakeholders both from industry and research who are interested in Sino-Europe cooperation. This document is a result of the cooperation in terms of the subcontract between COIN and ICES research center², Harbin Institute of Technology, China.

1.2. Objective

The primary objective of the document is to introduce the state of the art and problems when Chinese enterprises, both large enterprises and SMEs, are implementing enterprise collaboration and interoperability. Also it would like give a vision by 2020 of the business environment in China and roadmaps for different stakeholders, i.e. enterprises, researchers and government to achieve the vision.

1.3. Scope

The overall scope of this document covers those areas which relate to the collaboration and interoperability of Chinese enterprises. These areas therefore include:

¹COIN is an integrated project in the European Commission Seventh Framework Programme - EU FP7 Project 216256, <http://www.coin-ip.eu>.

²ICES is the research center on Intelligent Computing for Enterprises and Services in Harbin Institute of Technology, China.

- how they achieve enterprise Informatization,
- what kind of problems and requirements the Chinese enterprises meet when they need to collaborate and interoperate,
- how Chinese enterprises collaborate and interoperate.

The present document is a dissemination white paper. The scope of this document has been carefully defined to introduce the background, state of play and problem space, EI/EC 2020 vision, challenges and barriers for Chinese enterprises in the field of Enterprise Interoperability and Collaboration, without seeking to prescribe the details of the research, whilst attempting to reinforce the collaborative nature of research.

Different types of enterprises have different strategies and address different situations of collaboration and interoperability. Two types of enterprises will be introduced: large enterprises and SMEs, and this document intends to give more concern on SMEs according to COIN's background.

1.4. Structure of this document

This document comprises five chapters which are organized as: Introduction (Chapter 1), Review of EI/EC in China (Chapter 2), a description of EI/EC barriers and challenges in China (Chapter 3), EI/EC 2020 vision for China (Chapter 4) and concluding remarks (Chapter 5).

2. Review of EI/EC in China

The precondition of EI/EC is enterprise Informatization which aims at promoting the competition capability of enterprises by combining ICT (Information and Communication Technology), automation technology and modern management technology to encourage the innovation of product design, enterprise management mode, and collaboration relationship between enterprises. The typical engineering related to enterprise Informatization are C4P (CAD/CAPP/CAM/CAE/PDM), MES, PLM, ERP, CIMS, SCM etc.

This chapter will firstly give an introduction about enterprise Informatization process of Chinese enterprises from 1986-2010. And then review the EI/EC situation especially for large enterprises and SMEs based on the holistic analysis of Chinese enterprises.

2.1. History of Manufacturing Enterprise

Informatization³ in China

Initiated from 1986, Chinese government started a national High-tech program named as “863 program” to support the research and industry in 7 high-tech areas including 20 subjects. The 863 Program is the largest R&D Program in China. It can be said that from 1986 part of Chinese enterprises started to promote themselves systematically as pilot projects for enterprise Informatization and engineering and further these pilot projects lead to more and more Chinese enterprises to implement ICT and other advanced technologies for surviving to the intense competition of the market. The subject CIMS (Computer/Contemporary Integrated Manufacturing Systems) is a sub-program of China national High-Tech R&D Program. The targets of China 863 program on CIMS are:

- To help enterprises to achieve optimal performance, to enable agile response to changing markets;
- To enhance enterprises innovation capability and global competitiveness through combining information technologies, management science and manufacturing technologies together;
- To integrate activities and resources of intra-/inter-enterprises in the product lifecycles and business processes of enterprises;
- To break through the strategic, new frontier and cutting-edge technologies that can promote enhancements of Chinese manufacturing industries;
- To develop the CIMS application software, platforms and toolkits with Chinese Intellectual proprietary rights;
- To promote industrial innovations and development and increase the overall competitiveness of domestic manufacturing industries;
- To promote industrial transfers of CIMS technologies by commercializing the enabling

³ Manufacturing enterprises are playing the most important role in Chinese economy. Hence this document focuses on this type of enterprises in China, in the rest of the document enterprises implicitly means manufacturing enterprises.

- software packages;
- To establish consultancy services for industrial Information Technologies applications.

From 1986 to 2000 863/CIMS (Computer Integrated Manufacturing Systems) Program focused its work mainly on CIMS technology and application demonstrations, e.g. research achievements on CIMS technology including 3 SME Lead Awards, 10 series of software products on CIMS, 200 demonstrated CIMS application factories, CIMS R&D bases and more than 10,000 CIMS R&D people involved. Since 2001 MIE (Manufacturing Informatization Engineering) became a main topic for 863/CIMS with the aim at applying IT to enhance the competition capability of Chinese industrial enterprises. More than 2000 enterprises in 24 provinces were involved. From 2001 to 2005 the main research topics supported by 863/CIMS included: management and implementation technology of manufacturing network / manufacturing grid; enterprise modeling methodology and support tools; resource sharing technology of manufacturing network; ASP-based service platforms; enterprise integration/interoperation platforms: EAI, PLM; integrated platforms for virtual enterprises collaboration; application pilots of networked manufacturing etc.

After 2006 the main research contents supported by 863/CIMS are:

- digital design (multi-disciplines and multi-domains knowledge-based collaborative digital design methodology and technology);
- digital manufacturing (networked, quantitative, collaborative and intelligent digital manufacturing and quality assurance technology);
- digital management (intelligent and coordinative resource management systems among enterprises in the environment of value network and mobile business);
- **integration and interoperability methods and technology** (principles and modes of integration and interoperability of heterogeneous digital systems; the model driven MDA/MDD methodology of modeling and evaluation of integrated systems; framework, protocols and middle-ware of interoperability; semantics based sharing and mapping of data and knowledge in multi-domains in/ among enterprises; **integration platforms to develop PLM-based integrated** product development; coordinative enterprise resources management platforms; collaborative Manufacturing Execution System platforms; EAI-Server-based enterprise application integration/ interoperability platforms; ASP based networked manufacturing platforms); demonstrations of industrial application etc.)

The framework of 863/CIMS on MIE is described on Fig.1.

Both enterprises and researchers benefited a lot from MIE (Manufacturing Informatization Engineering) supported by 863/CIMS. They can get funds to trace the advanced Informatization techniques, implement the IT systems they need. More important the successful demonstration projects can greatly encourage other enterprises to implement Informatization engineering.

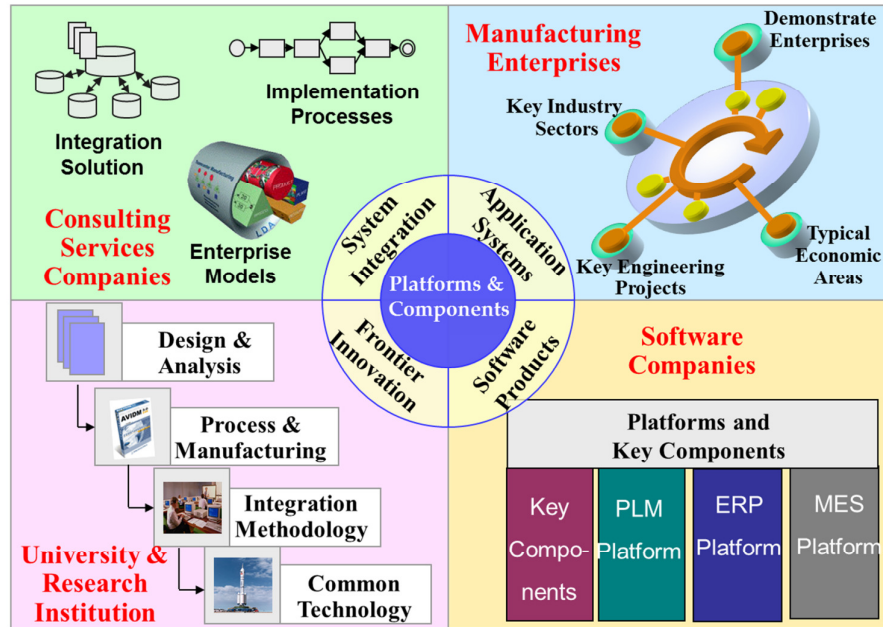


Figure 1 The framework of 863/CIMS on MIE

One important point has to be mentioned that European Commission was involved in the MIE of China from a very early time in terms of collaboration projects; this will also be reviewed in this chapter.

2.1.1. A brief review of the cooperation between China and Europe in the domain of “ICT in Manufacturing and Enterprise”

The cooperation between Europe and China in the domain of “ICT in Manufacturing and Enterprise” (“Manufacturing and Enterprise Informatization” as formulated in China) started 20 years ago in 1991.

Since 1989, the European Commission, particularly DGXIII (today DG INFSO), under the responsibility of Michel Carpentier, General Director, launched a study to determine in which condition a cooperation programme in the domain of ICT in Manufacturing could be established between Europe and China. Michel Carpentier has anticipated that China will become an important economic actor and a major partner for European Industry.

In 1991, an initial decision was taken by the EC to form a European team under the coordination of University Bordeaux 1 (FR) (Prof. Guy Doumeingts), with RPK University of Karlsruhe (DE) (Prof. Grabowski), ITIA CNR Milan (IT) (Prof. Claudio Boer), University of Galway (IE) (Prof. Jim Browne) and CAP Gemini (BE) (Johnny Huysentruyt).

The reason was that the SSTCC (State Science and Technology Committee of China), the former MOST, has already appointed a Chinese coordinator, Prof. WU Cheng, from Tsinghua University with a group of five Universities and research centers: Tsinghua University, Institute of Automation of Academia Sinica, Nanjing University of Science and Technology and Beijing University of Aeronautics and Astronautics.

In 1991, a preliminary mission of 10 days was organized by the EC to meet the main partners in China. The European delegation was composed of Jean-Pierre Lebrun (EC), Guy Doumeingts and Johnny Huysentruyt from CAP GEMINI.

The originality of the cooperation was to think at long term and to act at short term. Usually industrial cooperation is more at short term: two companies decide to cooperate with some objectives; when the objectives are met, the cooperation could stop.

So the proposed strategy was to create cooperation at the research level in order to establish a long term agreement then to use this support to develop industrial cooperation. One argument behind this strategy is the very strong link in China between the most advanced research centers and the Industry.

We will demonstrate that this vision was right because several projects were launched at an industrial level with the support of this “Research Bridge” created between China and Europe. The cooperation is still alive through INTEROP-VLab, the European Virtual Laboratory for Enterprise Interoperability and other cooperation which were launched based on this initial cooperation.

The list of projects since this period is given hereafter:

- 1992-1994: First Cooperation Programme in the area of CIM (9 partners from both side)
- 1995-1996: SECIIM, Second Cooperation Programme on Integration in manufacturing (19 partners)
- 1997: SECIIM Follow up (11 partners)
- 1998-1999: CENIM, China Europe Network for Integration in manufacturing (9 partners)
- 1998-1999: CEEMM, Concurrent Engineering and Enterprise Modelling Methodology (8 partners)
- 2001-2002: CENNET, China Europe Network on the Net (9 partners)
- 2001-2004: DRAGON, Development of an interactive Engineering Portal for Open Networks (11 partners)
- 2004-2007: INTEROP NoE (Interoperability Research for Networked Enterprises Applications and Software - Network of Excellence): this Network of Excellence was created by University Bordeaux 1 with 48 partners. Harbin Institute of Technology was associated to the Network of Excellence and associated to the programme of work.
- 2007-Now: INTEROP-VLab. More than 50 European partners and totally 16 universities and organizations in China joined.
- 2008-Now: COIN, Enterprise Collaboration and Interoperability. Harbin Institute of Technology is associated.

The cooperation between China and Europe is a win-win program in the domain of “ICT in Manufacturing and Enterprise”. Chinese enterprises can provide a huge market of the technique and products from Europe. All the stakeholders (enterprises, IT solution providers, and researchers) can benefit from the cooperation. The cooperation should be continuously enhanced in the future.

Many Chinese enterprises and organizations (universities, research institutes etc.) have benefited from such cooperation. For example, in aviation industry, China and Europe has cooperated for a long time. The joint projects, e.g. advanced technology and control aircraft noise estimate method, flow control, drag reduction techniques and gas bombs, large titanium structural parts casting, can help Chinese aviation enterprises improve the manufacturing level and competition ability. Also some joint-research program help China cultivated more researchers, e.g. the AMS02 program between Shandong University and CERN etc.

2.2.State of the Art of Enterprise Interoperability and Enterprise Collaboration in China

2.2.1. A category of Chinese enterprises

Since 1980's China started the reformation policy to develop its economy. The composition of Chinese enterprises has undergone tremendous changes: from the previous single state-owned enterprises to different scales (large, small and medium), different ownership (state-owned, joint ventures, private) and other types of enterprises. Among the many types of enterprises, this document concerns the large state-owned enterprises and SMEs due to the special position they occupy in China's economy.

The **large state-owned enterprises** are always the object that government supports and fosters. Comparing with SMEs they can dominate more resources (funds, policies, equipment, human resources etc.). In many sectors they even have monopoly position, e.g. communications industry, petroleum industry etc. They are the backbone and pillar of state-owned economy. Note that one state-owned large enterprise usually means a group of enterprises which are organized in an optimized way to improve their competition capability.

On the other side, in China over 99% of the total enterprises are **Small and Medium Enterprises** (SME). By 2012 the total number of SMEs in China will be over 50 million. These SMEs create 60% value of GDP, provide over 75% of the total jobs, own 65% of invention patent and 80% of new products development. SMEs in China play an irreplaceable role in Chinese economy. Table 1 gives the criteria for the classification of SMEs.

Table 1 Criteria for the classification of small and medium enterprises(S: Small, M: Medium)
(From “Report of Chinese SME e-business development 2009”)

Sector Type	Scale	Number of employee	Sales(Million Euros)	Total capital
Industry	M	300-2000	3-30	4-40
	S	<300	<3	<4
Building industry	M	600-3000	3-30	4-40
	S	<600	<3	<4
Wholesale	M	100-200	1-15	-
	S	<100	<1	-
Retail	M	100-500	3-30	-
	S	<100	<3	-
Transportation	M	500-300	3-30	-
	S	<500	<3	-
Postal Industry	M	400-10000	3-30	-
	S	<400	<3	-
Accommodation and catering	M	400-800	3-15	-
	S	<400	<3	-

In China the large state-owned enterprises and SMEs have very different and unbalanced Informatization levels which affect their strategy on EI/EC situation. We will introduce them respectively.

2.2.2. EI/EC in Large Enterprises

The large state-owned enterprises are the backbone of the national economy. In the list of top 500 Chinese enterprises, 60% are state-owned enterprises and the top 10 are all state-owned large enterprises. Most large state-owned enterprises invest about 1% of sales to research and development, and some invest even 2%. They are in the technological leading position in Chinese enterprises.

Informatization is the base of EI/EC. We would like to firstly introduce the state of the art of Informatization of the large state-owned enterprises and then discuss EI/EC of them.

The Informatization of large state-owned enterprises

Since 2000 Chinese government built a special working group which aimed at improving the Informatization of large state-owned enterprises. And with these enterprises as pilot models, Chinese government can improve Informatization of the other enterprises. After a few years development, the Informatization engineering is bringing a lot of positive changes for these enterprises. 77.5 % of them decreased their costs (procurement cost etc.), 67% of them shortened manufacturing period, 64.6% of them enlarged the income of sales, 66.3% of them increased circulating fund turnover rate and 36.7% of them improved the ability of delivery on

time. The state of the art of the Informatization of state-owned large enterprises can be concluded as following.

- 1. Information technology infrastructure has been basically completed**
Most large state-owned enterprises are equipped with a number of computers and related equipment, some of them also equipped with large-scale computer systems. Petroleum and petrochemical, financial, telecommunications, aerospace and other industries of state-owned enterprises even equipped with hundreds of large-scale parallel computer systems with hundreds of CPUs or cluster systems. ICT Network installation has also seen a rapid development: almost all of the large state-owned enterprises have set up their own enterprise network. Even the scale and application level of the network are quite different, almost all of them have hardware platform on which an internal exchange of information can be achieved. In addition, based on the enterprise networks the public services (such as email, corporate sites, etc.) and network security systems have been initially established. The infrastructure satisfied the requirement of the information technology for enterprise computing, information transmission and sharing, production monitoring and control, scientific research, as well as learning life needs.
- 2. Professional application software systems are generally in use**
Large state-owned enterprises generally have a large number of organizations, many of the staff team, and the complex relationship between business types. The Informatization must be around the main business to develop and deploy different kinds of professional applications, e.g. CAD, CAPP, CAM, ERP, OA etc. Now most of them are running these systems, but due to the lack of overall planning the integration of the systems, duplication of deployment is still a very serious problem.
- 3. Database systems are already completed**
Initiated in 1980s database technique has been applied in the large state-owned enterprises. By 2000 most of the enterprises have established very completed database systems, e.g. financial assets database systems, human resource database system, materials management database system, business management database system and some professional application-oriented database systems. The completion of database systems paved the way for the ongoing improvement of business integration and systems integration.
- 4. The team and organization of Informatization have been established**
From the latter of 1980's the large state-owned enterprises started to establish the information centers of related departments. By 2000 this work has been finished by most of them. Some of them have even more than one thousand IT employees. Few of them have completed differentiation process between the information technology management and service personnel, i.e. in the upper level they have people to manage and plan; in the lower level they have people to support in technical way. However the IT employees in large state-owned enterprises have very different technical level and always are not very enthusiastic about the work, the outflow of them is widespread.
- 5. The importance of Informatization is gradually understood**
By a lot of pilot Informatization projects people in large state-owned enterprises, whatever a normal employee or the leader have gradually known more about the meaning of enterprise Informatization that it can bring great economic benefits and keep enterprise continuously

development.

6. **Informatization planning has been a strategic planning of enterprise**
With the gradually in-depth of Informatization, it has been promoted to key business areas of enterprise. Information technology has become an important component of development strategy, and information technology planning has become the key element of strategic planning. Many enterprise organized external experts, internal experts, engineers, and managers together to make very careful information technology planning. More than 73% of the large state-owned enterprises have started or finished the construction of enterprise framework, e.g. TOGAF (The Open Group Architecture Framework).

Compared with the enterprises in developed countries, the Informatization level of Chinese large state-owned enterprises is still very low, about 10 years gap. They still have a long way to go.

During the process of Informatization of Chinese large state-owned enterprises, one basic pattern is to introduce the computers (e.g. Mainframes), software (e.g. MRPII) from western countries which have developed these systems firstly. And the Chinese engineers re-develop these systems according to the specifications of the enterprises their own. Also the successful experiences of implementing these systems of western enterprises are studied and applied to Chinese enterprise. Some IT companies from western countries have sold quite a lot of enterprise application software to Chinese enterprises, e.g. SAP has owned more than one hundred thousand customers in China and achieved the income of more than 100 million Euros until 2011.

Enterprise collaboration of the large state-owned enterprises

Large state-owned enterprises always can get strong financial support from government, bank etc. They still need to collaborate with other different kinds of enterprises to improve the core competition capability, decrease cost (sales, logistics etc.), and enlarge the market. As mentioned before, one large state-owned enterprise always includes a group of tight-coupled enterprises (subsidiaries) which play different roles in the group, e.g. headquarter, manufacturer, supplier and other branches etc. Almost all the large state-owned enterprises have established the collaborative platform, e.g. collaborative supply chain management, collaborative OA etc. But a lot of legacy systems (ERP, OA etc.) exist in the departments and subsidiaries in the group and other partners. So the seamless collaboration is still hardly achieved within or between the large state-owned enterprises.

The collaboration of large state-owned enterprises can be mainly categorized into 3 patterns.

1. **Vertical internal collaboration.** This collaboration pattern usually happens between headquarter and the branches (departments, subsidiaries) inside the enterprise. Headquarter is responsible to make the development strategy for the whole enterprise, the departments and subsidiaries run themselves under the instruction of strategy. However the instruction is more directional guidance without detail planning and milestone control. It needs to be decomposed into an explicit schedule of actions, e.g. the manufacturing targets and financial targets of the enterprise are decomposed to explicit executable plans of each departments and subsidiaries. The traditional collaboration ways (daily document exchange,

mail, real-time message exchange etc.) can't satisfy this requirement. So far more than 40% of large state-owned enterprises have achieved a group-wide vertical internal collaboration on design, planning, sales and procurement etc. XIAN XD Switchgear Electric CO., LTD. has successfully implemented Citrix management platform to integrate the headquarter and its branches, customers.

2. **Horizontal internal collaboration.** This collaboration pattern usually happens between the branches (departments, subsidiaries) inside the enterprise. The main target is to re-organize the resources inside the group to achieve the right strategy. It needs to identify the requirements of collaboration between the branches firstly. Basically the collaboration is implemented in three different levels: information, process and organization. Only about 25% of large state-owned enterprises achieved horizontal internal collaboration.
 - a) Collaboration on information level. A lot of information is transferred between the departments of subsidiaries, e.g. shipping information, storage information etc. Such a information plays an important role between the business activities. They are both the end of a business activity, but also the beginning of a business activity. The enterprise integrated the information systems to guarantee the real time information exchange and sharing. The typical information systems are Procurement Management System (PMS), Inventory Management System (IMS), Sales Management System (SMS), Customer Relationship Management (CRM), etc. YTO group corporations which produce mechanics for agriculture, industry etc. implemented PMS, SMS and BI of Kingdee software to improve its procurement and sales management, the level of providing accurate decision information.
 - b) Collaboration on process level. This kind of collaboration is based on information collaboration and is the main form of organization collaboration. The target is to break the limitation of duty in the departments and satisfy the customer's requirement. The typical process collaboration can be bidding process, inventory replenishment etc. A bidding system has successfully implemented in Zhejiang electricity which cut down greatly the cost of the bidding process.
 - c) Collaboration on organization level. The collaboration on this level emphasizes on the seamless cooperation between different departments. It is based on information collaboration and achieved by process collaboration. Every department identifies its collaborative duty according to the role it plays in the group-wide supply chain. Geely group is one of China's top ten auto manufacturers and also among the country's top 500 firms. It owns a group-wide supply chain platform which has more 300 users (suppliers and buyers) and highly integrated with ERP system.
3. **Horizontal external collaboration.** This kind of collaboration happens between large enterprises themselves or between large enterprises and other SMEs in the same industry sector. The former collaboration can be of strategic relevance, e.g. sharing the market or products, or just in terms of traditional supply chain. In the latter collaboration the large enterprise usually dominates the collaboration on the price, quality and delivery time etc. of products. Compared with the internal collaboration inside the enterprise, it is more loose-coupled, i.e. more on the business and strategy level, less on the technical level. And the integration of the IT systems of partners is rarely achieved. In Guangdong province the government has established such collaborative platform for the larger enterprises

themselves to find partners and extend their business.

The large state-owned enterprises in China have finished the basic Informatization engineering. Now they are paying more attention on the **collaboration platform**. Due to the understanding and technique limitation on collaborative business they still have a long way to achieve the real seamless collaboration by IT software.

Enterprise interoperability of the large state-owned enterprises

After years of Informatization engineering, the large state-owned enterprises have established relatively complete information systems, e.g. CAD/CAPP/CAM, OA, ERP, CRM, SCM, Financial management system etc. Each of the systems can work well to achieve its own function. However the integration of these systems is not finished yet. Only part of the enterprises achieved the integration of CAD/CAPP/CAM by PDM. When some enterprise implemented ERP, SCM etc. by the same software vendor, the integration can be solved without too much difficult. The interoperability problem then is not so critical. In fact most large enterprise implemented the IT systems in different times and by different IT solution providers. Even in the same large enterprise the departments and subsidiaries have different information systems, e.g. two subsidiaries might use two ERP systems from different vendors. When they try to work together, interoperability becomes a trouble. Some enterprises have to search third-party middleware or software to solve the problem, but due to the big difference on data and processes most solutions work not very well. Only less than one third of these systems can interoperate with each other, 59% enterprises can achieve partly information sharing and 33.9% enterprises have no integration between the systems.

Today more and more the large enterprises turn to the newest system architecture, e.g. SOA, ESB etc., but still all those legacy systems can't be abandoned or substituted due to cost considerations. How to deal with the interoperability between the old and new systems is still a big problem for most large enterprises.

2.2.3. EI/EC for SMEs

The Informatization of SMEs

Comparing with the huge number of SMEs and the contribution to the whole Chinese economy, the level of Enterprise Informatization in SMEs of China is not so satisfactory. Basically the implementation of Enterprise Informatization is still in the early stage, e.g. the application of Informatization mainly focus on financial management and basic material management, the application of Internet mainly just keep publishing and acquiring information rather than implementing E-commerce for the integration of management. It can be said that the potential development of Enterprise Informatization is large and SMEs need to move to a higher stage of Enterprise Informatization with the effort of their own as well as the support of the government. The following will describe the current situation of Enterprise Informatization of SMEs in China

from 7 areas.

1. Investment

By 2010, the total investment on Enterprise Informatization of SMEs reached 22 Billion RMB (About 2.2 billion Euro). More than half SMEs (About 52%) are intending to increase the investment on Enterprise Informatization. 23.4% SMEs keep the same investment. The corporation of the total investment in 2010 is shown in Fig. 2.

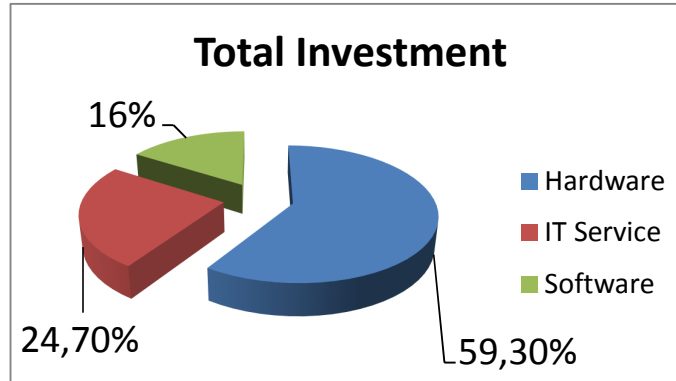


Figure 2 The corporation of the total investment in 2010

In different regions the investment shows some unbalances, e.g. the east of China (Shanghai, Zhejiang province etc.) occupies over 30% of the total investment and the northwest of China (Xinjiang province etc.) only occupies 1.9% of the total investment. It shows that the enterprises in different regions in China have various development situations.

Another noteworthy point is that the number of investment for a single SME. Statistic data shows that many SMEs still prefer to spend little money on Enterprise Informatization. This situation can be shown in Fig.3.

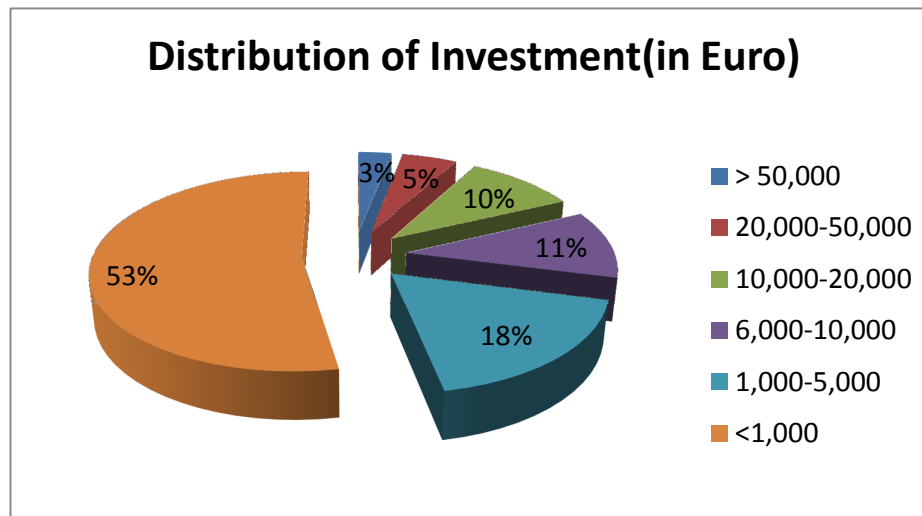


Figure 3 The distribution of investment

In different sectors of SMEs the level of Enterprise Informatization is also different, e.g. Electronics manufacturing industry, retail, and Chemical industry have a comparatively big scope of Informatization, Machinery Manufacturing and Auto Parts are enlarging the scope of Informatization, the traditional sectors like Textile and Apparel still have very big space for improvement.

2. Hardware

- a) Host computer: 6.4% of SMEs own UNIX servers with the number of normally less than 3; 41.9% of SMEs own PC servers normally with the number of less than 3; 100% SMEs have PCs with the number of normally less than 100; 33.4% of SMEs own notebooks with the number of normally less than 5.
- b) Network hardware: 43.8% of SMEs own switches; 34.6% of SMEs own routers; 21.1% of SMEs own firewall products.
- c) Storage product: 7.2% of SMEs own disk arrays; 3.6% of SMEs own CD library.

3. Application of network infrastructure

- a) LAN: About 40% of SMEs established Local Area Network which mainly aimed at financial management and simple office affairs. Only 6.9% of the LANs cover all the departments; 55.9% of the LANs cover 40%-80% of the departments; 22.8% of the LANs cover less than 40% of the departments.
- b) Internet and its application: 30% of SMEs established their websites and the application of the websites can be shown in Fig. 4.

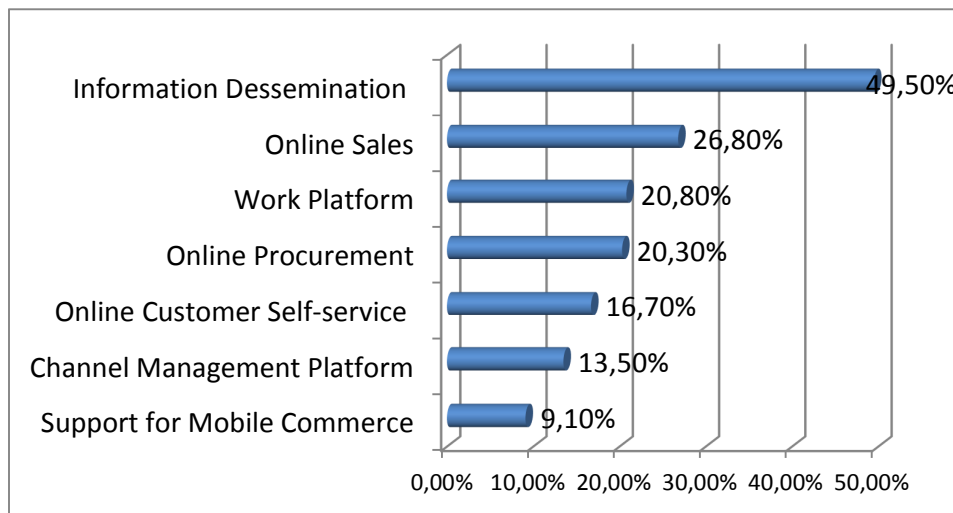


Figure 4 Websites and its application of SMEs

4. Internal aided strategy

- a) Planning of the development of Informatization: two-thirds of SMEs have their plan of the development of Informatization and most of SMEs have Informatization management system.
- b) Institutional situation: SMEs are paying more and more attention to Informatization. 76% of SMEs have set special department for Informatization; in 30% of SMEs vice presidents are in charge of Informatization and 10% of SMEs especially set CIO position.
- c) IT employee: To improve the Informatization level SMEs still need to enhance the training in IT application. About 12.7% of SMEs have no IT employees. And less than 50% non-IT employees in SMEs have only basic computer application ability. These situations greatly limit the implementation of Informatization.

5. Security

SMEs also give great importance to information security. 72.1% of SMEs established information security system. 26.5% of SMEs has relatively complete access control means;

51.8% of SMEs use technical means to prevent virus; 45.1% of SMEs can back up their data regularly; 10% of SMEs has emergency plan and disaster recovery.

6. Application of main information systems

Software is the core of Informatization. SMEs are spending more and more money on different software, e.g. platform software (operating system, database management system, software development tools etc.), middleware (middleware software, information security software, collaboration software etc.), management software (ERP, CRM, SCM, BI etc.) and industry software (CAD, CAM, CAPP, CAE etc.). Among of these software management software and industry software is the most popular software which SMEs prefer to implement. The next paragraphs will introduce the application of main information system.

- a) Product design and process design system: 25.9% of SMEs use CAD system; 22.1% of SMEs use CAPP system; 25.3% of SMEs use PDM system.
- b) ERP: As an advanced enterprise management mode, ERP has become the best solution for enterprise management. For SMEs in China, however, the lower level of Informatization as mentioned above greatly limit the implementation of ERP. Only 3.8% of SMEs established ERP system covering the whole business of enterprise. And among these 3.8% SMEs only less than 10% SMEs successfully implemented ERP! The intense competition in the market force SMEs to improve their management, e.g. implementing ERP, meanwhile such a low success rate makes SMEs fall into a very embarrassing situation.
- c) SCM: Supply Chain Management is still a shortcoming for SMEs. The detail will be described later in the state of the art of SMEs collaboration. Only 15.4% of SMEs established Supply Chain Management system. The main applications are shown in the following figure.

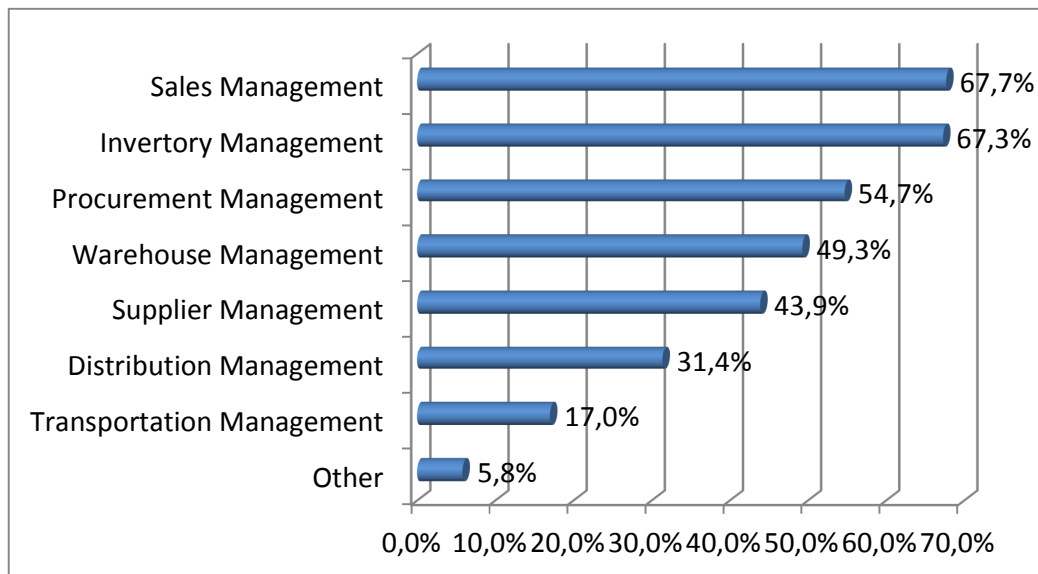


Figure 5 Main applications of SCM in SMEs

- d) CRM: For Customer Relationship Management comparing with the saturated market in large enterprises, many SMEs just start to implement CRM with a simple acknowledgement that CRM is just to serve the customers. Only 19.2% of SMEs established CRM system and the main applications are service automation, sales

- automation, marketing automation, analysis and decision etc.
- e) Financial management system: Financial management system is usually the first choice for SMEs to implement Informatization. 100% SMEs have established financial management system with more or less functions, e.g. general ledger management, fix assets management, cost management, budget management etc.
 - f) Human resource management system: Most SMEs in China lack long-term human resource planning. Only 20.1% of SMEs established human resource management system with the functions like personal information management, employee attendance management, compensation management, contract management, recruitment and termination etc.
 - g) Office Automation (OA): 47.8% of SMEs established office automation systems which evenly cover 74.7% of all the departments. 65% of the OA systems have been simply integrated with other systems; only 6.3% of the OA systems have been highly integrated with other systems; 28% of the OA systems are independent. About half of the main applications of OA systems are e-mails, documents management, and information dissemination. 32% of the applications are document approval.
7. Status of information resource sharing
- a) System sharing and integration: Among the SMEs which has implemented Informatization, 34.6% SMEs achieved the resource sharing between design departments and manufacturing department, 26.8% SMEs achieved the integration between different systems, 38.5% SMEs achieved the collaborative application between systems.
 - b) Integration between management and manufacturing: Among the SMEs which has implemented Informatization, 7.9% SMEs achieved the total integration between management and manufacturing, 51.6% SMEs partly achieved and 40.5% SMEs don't implement any integration between management and manufacturing.
 - c) Application of decision support and BI: Among the SMEs which has implemented Informatization, for the decision data oriented to the leaders 13.1% SMEs update in real time, 20.9% SMEs update every day, 18.4% SMEs update weekly and 47.6% SMEs update in an uncertain time.
8. Successful stories of SME's Informatization
- a) SME A: In Shanghai, manufacturing plastics components for car, home electricity etc. This SME benefited mainly from BI system which helps them to analyze the data from multi dimensions and find out the most valuable customers and sellers.
 - b) SME B: In Tianjin, manufacturing paper products. Funding flow is the most important business for this enterprise, i.e. how much to pay in what time etc. By integrating the material flow, funding flow and information flow the manager can know exactly the financial situation of the enterprises.
 - c) SME C: In Jiaozuo, manufacturing mechanics and providing related services. C's main problem is the efficiency of management. After implementing T6 system (a MIS system), C achieved the integration of manufacturing, selling, HR, financial affairs and inventory, the accuracy and efficiency of management is improved greatly.

Enterprise collaboration of SMEs

Due to the lack of the funds and marketing capabilities, enterprise collaboration is always a good, even necessary, choice for SMEs all around the world to share resources, improve the capability of competition and innovation. Chinese SMEs are also no exception. Compare with SMEs in western countries Chinese SMEs face even worse environment (IT application, investment, market etc.). This situation makes the enterprise collaboration of Chinese SMEs more complex and uncertain. And the pattern of collaboration ranges from very simple way based on basic trust to complex way based on advanced IT technologies. The typical collaboration pattern will be introduced as following.

1. Supporting components maker for large enterprise.

In some industry sectors (automobile, petroleum etc.) the collaboration between large enterprises and SMEs can effectively promote the development and structure optimization for the sector. The collaboration is involved in supply of raw materials and parts, production, sale, technique development and technique innovation etc. For SMEs the collaboration can bring more orders and promote the technique, management level. Also it brings more job positions for the society. For large enterprises the collaboration can also get benefits, e.g. decrease the transportation cost, improve the efficiency of forming a complete set for the products, and enlarge the service items, hence to improve the competition capability.

For this collaboration pattern the large enterprise always plays a key role as the initiator and the government plays a role as a bridge. There is very big unbalance between SMEs and large enterprises, e.g. economic strength. The less communication between them causes the asymmetric information to each other. It is always very difficult for SMEs to contact with large enterprises. So the government needs to build the “bridge” for them, e.g. organize the related meeting, set up policies etc. From central government to local governments many policies are drafted to support collaboration between the SMEs and large enterprises, some of them even build special platform to help the enterprises find collaboration chance. Note that for the local government they prefer to improve the collaboration between local SMEs and local large enterprises.

Large enterprises always have a long term development strategy and this brings SMEs more collaboration chance, e.g. produce the parts for large enterprises. One typical example is in automobile industry. In Changchun, a city with very big automobile industry, the target in the future 5 years is to achieve 50% parts of a car from collaborated enterprises, around 15 billion Euros. This means it needs at least one thousand SMEs to manufacture the supporting components!

2. Local cluster supply chain

In some economically developed areas of China, e.g. Zhejiang province, Guangdong province, there is a typical collaboration pattern between SMEs called **local cluster supply chain**. After years development in some special area some SMEs collaborate with each other around

same industry or related industrial chain with different roles, e.g. manufacturers, supporting components makers, suppliers, logistics providers, distributors, vendors etc. These SMEs are located in the same local area; hence form a new network supply chain which coupled cluster and supply chain, named local cluster supply chain. The area is called block economic region.

In Zhejiang province the GDP of all block economic regions occupies 53.4% of the whole province's GDP. And the block economic regions involve most industry sectors, e.g. electrical machinery and equipment manufacturing, textiles, textile and garment, shoes, hat manufacturing, transportation equipment manufacturing. We can see the GDP scale of block economic regions by the following table.

Table 2 GDP scale of block economic regions in Zhejiang province in 2007

GDP Scale(Billion Euros)	<0.1	0.1-0.5	0.5-1	1-2	2-3	>3
Number of block economic region	100	250	53	37	8	14
Proportion (%)	21.65	54.11	11.47	19.4	1.73	3.03

Let's take an example to explain the block economic region more in detail. In a town named Liushi, the SMEs in this town mainly produce low-voltage electrical equipment. In recent years, the economic expansion of core business resulted in the increasing scale of low-voltage electrical industrial cluster in this region. The supply chain of low-voltage electrical equipment has been formed including raw materials, spare parts supply, parts manufacturing, product assembly and distribution. There are hundreds of thousands low-voltage electrical components, e.g. metal parts, alloy materials, plastic injection parts etc. 70% of them can be purchased in local area of Liushi. The suppliers of the other 30% components have established the local sales outlets. It means that all purchases of low-voltage electrical components can be achieved within 5 kilometers.

The features of this kind of industrial clusters can be summarized as following:

- a) Product complexity is not high, but with many types of specifications. The low-voltage electrical industry clusters in Liushi include all low-voltage electrical products, sales, involving more than 200 categories thousands of models on thousands of specifications. However, the complexity of low-voltage electrical product itself is not very high, and the levels of supporting components are relatively small.
- b) The development of regional industrial clusters is driven by some core enterprises. In Liushi "Chint", "Delixi" and other enterprises gradually developed themselves to be the core enterprises by enlarging production scale with grouping and specialized production. The number of this kind of core enterprises in regional industrial clusters is very small and they are mainly responsible for product design, assembly, quality control and the many SMEs within the region provide business collaboration and complementary services.
- c) The enterprises have very complex relationship during business coordination and cooperation. Core enterprises gather a large number of SMEs in their own surroundings through sub-contracting system. The SMEs are responsible to provide raw materials and components. Both competition and cooperation exist between the SMEs. Based on their size and business relationships the SMEs may also supply many core enterprises, even

have their own outsourcing factories which means they have more collaboration relationship with other enterprises.

- d) Within the supply chain surrounding one core enterprise even the SMEs have competition with each other to some extent, they still prefer to collaborate at most time. However there is existing very strong competition between core enterprises due to the similar products.
- e) The enterprises in one industrial cluster have very different Informatization level. The core enterprises usually have successfully implemented IT system like production management, resource management etc. and can achieve business collaboration with suppliers and distributors by e-business platform. As for upstream SMEs, some of them have some IT systems for management, some of them even lack of basic IT hardware to support the business. Most downstream SMEs have lower Informatization level. So far most business collaboration between the core enterprises and their suppliers, distributors is preceded by fax, telephone or mail.

The local cluster supply chain maintains a good momentum of sustained development. It brings many advantages which can be described as following:

- a) Lower cost. The most resources can be purchased in the local area and it is very easy to find cooperation partners for enterprises. The cluster can absorb more customers coming to enlarge the sale channels. All of these can greatly decrease the business cost, e.g. purchasing, transportation, negotiation etc.
- b) Plenty and complete product categories. The industrial cluster can produce as many as the product categories and they have the ability to develop new and special products. Customers can almost get everything they want in this industry.
- c) Complete and optimized social resources. The continuing development of core enterprises helps the complement and optimization of the social resources like public infrastructure, service, training, logistics, and human resources. The efficiency of the machines and people of SMEs is greatly improved due to providing components for multi enterprises.
- d) Strong sales channel. The core enterprises have established a large sales network all over China with thousands of sales centers covered main industry cities, medium cities and counties. In Liushi more than 20 enterprises have established agency abroad and more than 500 enterprises have carried out international business.
- e) Brand advantage. All the core enterprises started to cultivate their own brands at the beginning. After years development some famous brands have been achieved.

However the pattern of local cluster supply chain also has its own barriers during development, this will be discussed later in this document.

3. Collaboration based on third-party service platform for SMEs

For regional and industrial collaboration between SMEs, another important pattern is third-party public information service platform. The third-party could be an IT company or

the government (central and local). This kind of service platform integrated both e-business and supply chain management. It has four main features:

- a) Extending the management of supply chain from internal to external enterprise including upstream suppliers and downstream customers with the online applications, e.g. ERP, CRM, SCM and OA systems etc.
- b) Extending e-business from information publication, collaboration partners finding to e-procurement, integrity certification, electronic payment, collaborative working etc. In some industry the service platform can help SMEs share their resources, e.g. a design-oriented service platform is applied in a region name Shaoxing, and it helps more than 2500 clothing and textiles SMEs share the design ability between each other, hence greatly improve the competition capability.
- c) Integrating the SaaS(Software as a Service) mode into the application of management and e-business software. SaaS is a software application mode based on providing software application through Internet. In the SaaS mode, SaaS vendors build the necessary software and hardware platform and network for enterprises, deploy the application software on their own servers and is responsible for application software maintenance and upgrades; enterprise users connect to the Internet simply by computer, phone or other device, wired or wireless, then they can rent software services according to their needs. The renting fee depends on the type of rented service and the period of renting time. SaaS mode provides a brand new way for SMEs to achieve Informatization and collaboration. It greatly decreases the cost for SMEs to implement the software application like ERPs. From 2004 most IT solution companies in China have developed their product of SaaS service platform. The market size will achieve 5.21 billion Euros in 2012. The typical services are online CRM, online ERP, and online AIS (Accounting Information System) etc.

One successful case of SaaS is a car rental company in Tianjin. After careful investigation, the manager of this SME decided to select the SaaS model for the management system to save the cost. With the cooperation with a User friend software company, this SME established the service platform and integrated it with the portal. After implementing this system, the response time to the customers is cut down greatly. In 2 months 80% of the business is finished online and a lot of cost is saved.

4. Collaboration based on social network

This pattern is the most original collaboration mode between SMEs. It always happens in a local area and enterprises which know each other very well for quite a long time. In this collaboration pattern, the relationship between people is always family or friends. They usually cherish the credit very much and the collaboration is rather stable even without the support of IT applications.

As for the scope of collaboration, traditional functions, e.g. procurement, logistics, co-design, etc. are still the main fields. Recently years CRM (Customer Relationship Management) is getting more and more attention. But many SMEs didn't realize CRM is not only an IT product but a

management method. So far there are not many mature CRM products designed especially for SMEs and not many successful cases in CRM.

Enterprise Interoperability of SMEs

Enterprise Interoperability (EI) is becoming more and more important for SMEs in China. From basic data exchange to the interoperability in the advanced cloud computing environment EI is a ubiquitous requirement in the large number of Chinese SMEs. Based on the review of enterprise Informatization we know the level of IT implementation of Chinese SMEs is still very low and very unbalanced between different SMEs. This brings more difficulties for SMEs to achieve EI.

Every SME implemented enterprise application systems according to its own feature, e.g. manufacturing mode, business process etc. Some of them may choose the commercialized general software with some modification which can be purchased directly from software vendors. Some of them developed the systems. So the different systems from different vendors construct the heterogeneous environment of SMEs. So the level and scope of EI is still very low. Few SMEs achieved the integration of management and manufacturing. Between the SMEs there are very few systems which can interoperate with each other due to the heterogeneity, e.g. different semantics, data formats, platforms etc.

2.2.4. EI/EC policy of Government

During this Informatization process government plays a role as a director in terms of pilot projects, policies, standards, platforms, training etc.

1. Pilot projects. Generally Informatization of Chinese enterprise is a process spreading large enterprises to small and medium enterprises which is a strategy of government. By implementing these pilot projects the government and enterprises can learn more experiences. Based on these experiences more and more enterprises started their own Informatization engineering.
2. Organizations and policies. Since year 2000 the government started the Informatization engineering which aimed at improving the Informatization of the large state-owned enterprises. Since then a series of laws and official documents related to enterprise Informatization were released. And many official organizations were established, e.g. every province established special office serving for SMEs, more than 1200 productivity improving centers were built to provide the technical support for enterprise Informatization.
3. Standards related to EI/EC. Standardization is critical for EI/EC. Since 2003 the government set up a working group “Enterprise Informatization standardization working group” to build the related standards. Now China has published 723 standards about ICT and 118 standards about different sectors of industry, e.g. standard of Chinese proceeding, specification of CAD, PDM, EDI, e-government and ERP etc. The specifications of CRM, CPC, MES and OA are in proceeding. The certification of IT products based on these

specifications and standards are also carried out.

4. Platforms. The Informatization public service platform is a very common measurement for government to provide more opportunity of collaboration. 11% SMEs have used the platforms established by government and 44% of them are satisfied with the platforms. Platforms of **cloud services** are also strongly supported by government.
5. Training. By 2010 280 counselling Stations have been established which covered most provinces except Tibet. These counselling stations organized more than 6 thousands lectures and other training activities for enterprises to study the experiences of Informatization. More than 300,000 SMEs are benefited from these activities.

The government has done a lot of work on enterprise Informatization in the past. EI/EC is becoming the main priority of work in the future.

3. EI&EC Barriers & Challenges in China

Chinese enterprises have been stepped on the way of Informatization for more than 20 years. And they even got some preliminary achievements in EI/EC. However the Informatization of Chinese enterprises is still at a very initial stage. EI/EC needs very strong support from Informatization engineering. For most Chinese enterprises EI/EC, as a vision in the future, is still a very hard work to finish. The Chinese enterprises have to face a lot of barriers and challenges to achieve EI/EC. Considering the emphasis of this report, we will discuss more about SMEs while large enterprises will be mentioned as necessary.

3.1. Motivation of EI/EC for Chinese Enterprises

For most of Chinese SMEs, cost control is always the NO.1 strategy of running business. The main reason is that SMEs in some of the industry is relatively concentrated, such as general equipment manufacturing, textile, non-metallic mineral products, chemical materials and chemical products manufacturing, electrical machinery and equipment manufacturing etc. The SMEs have to choose “low price, low benefit” to face the competition. Also the low cost of labor, land use and policy of the export tax rebate are helpful for Chinese SMEs to execute the strategy.

However, all these advantages will not exist anymore in the future. Higher cost of labor, land use, environmental issues, and raw material scarce availability will be definitely a tendency in China. How do SMEs face this situation?

Firstly, for SMEs themselves, the rising costs and reduced market requirement will not “push” them to do technique innovation. Research has shown that SMEs may postpone or even give up the technical innovation when they face very strong competition from outside. For single SME it has very limited capability of technical innovation (funds, human resource etc.). So how about improve the efficiency of current resources? In fact SMEs almost get to the up limit of using the critical factors (human resource, equipment), only very limited cost can be saved but not enough to absorb the rising costs.

Secondly, global manufacturing leads to collaboration on global industry chains. Chinese SMEs have chances to join the global industry chains, but only with enough collaboration capability. Based on internal and external motivation above, the Chinese SMEs have to change and Enterprise collaboration and interoperability is the key solution, even some barriers and challenges are ahead.

3.2. EI/EC Barriers

A barrier is a physical structure which blocks or impedes something. Here we define the EI/EC barriers: something that hinders the achievement of EI/EC, being it referred to the strategy, the

technical level or factors outside the enterprise. The large state-owned enterprises and SMEs have different conditions, environment, Informatization level and collaboration pattern. We will mainly discuss the barriers for SMEs; the large state-owned enterprises will be mentioned only whenever necessary. The barriers below have been discussed during the COIN workshop on Oct 20th at the presence of a qualified panel of Chinese and European experts.

A. EI/EC barriers A: The insufficient integration of information systems

Priority: HH

SMEs don't have enough funds to implement a set of whole and complete enterprise application systems. They can only do it step by step and select they system from different vendors which are suitable for them. So far in many enterprises IT applications are mainly running for single function separately, e.g. CAD, CAM, CAPP, OA, financial mgt., ERP, SCM etc. The integration between these applications is far insufficient. Not only inside the same enterprise, there is lack of information "gateway" between information systems in different enterprises. It is difficult for enterprises to exchange information.

Also the data formats between these enterprise information systems are not uniform. The SMEs are using different products from different vendors. Heterogeneity not only exists inside the SMEs, but also between the SMEs, e.g. two different ERP systems in two different SMEs. These heterogeneous enterprise application systems cannot be abandoned due to cost consideration.

The main reason of so much difference is the lack of strategic planning in the beginning of Informatization. Most of the SMEs have no long-term planning for EI/EC.

COIN is implementing several advanced EI/EC services, but the main innovation of the project is the possibility to easily and freely access EI/EC services from the Future Internet, thanks to a federation of service delivery platforms properly connected with the collaboration platforms operating in enterprise networks. COIN could therefore be very useful in bridging interoperability gaps among a few on-premises enterprise systems by means of local EI/EC services provided by the collaboration platform. However, the full potential and take-up impact of the COIN vision is achieved when ESA services are taken from the Internet (Cloud Computing for instance) dynamically and on the fly. In this case, it is quite natural that business processes are built on top of different services taken from very different service providers and automatically solving interoperability and collaboration issues becomes of extreme importance for networked SMEs.

B. EI/EC barriers B: Lack of effective collaboration platform

Priority: HH

Most Chinese SMEs are lacking funds to buy the software, so public service platforms are becoming good choices for them. SMEs need just to pay for the software and functions they need which are implemented on the servers of the third party. Many IT solution providers have published the related products to support the collaborative business, e.g. Lotus Sametime, IBM Websphere suite, Mysap.com etc. These solutions are too heavy and complex for the average Chinese SME. The enterprises still need more light, flexible and

professional collaboration platforms to support the collaborative production planning, collaborative project management etc.

Moreover, a collaboration platform suitable for SMEs still needs to be improved, e.g. type and quality of services. There is not enough support for the exchange of information with different formats and semantics on the collaboration platform. This is limiting the adoption of EI/EC for the enterprises greatly. Investigation also shows that SMEs use the collaboration platform in a quite limited way, less than 50% SMEs even didn't try to use the platforms and the other SMEs which tried only did it in very few functions and frequencies. And the SMEs pay more attention the simple services of OA, mail, financial management etc. rather than collaboration services for mobile users the platforms provide almost no support for the collaborative business.

Obviously for Chinese SMEs the on-demand services are what they really need instead of whole complete enterprise systems.

It is not in the objectives of COIN developing next generation, SME-oriented, easy-to-use enterprise systems. However, the mission of COIN implies that

- i. Core (value-added) services are provided on-demand and under pay-as-you-go business models, this way simplifying a lot the interaction with the user who will be invited to learn just the services he/she is interested in. This will also reduce the entry barriers to sophisticated enterprise solutions by SMEs.
- ii. Non-core (utility) services which at the moment are wired into on-premise monolithic applications, are instead extracted from such systems and put as a service in the open Internet, available to all and at a very low (zero) cost.

Both of the above will have a dramatic impact on the accessibility of advanced ESA solutions also by SMEs with reduced budget for IT systems.

C. EI/EC barriers C: Lack of agility of business

Priority: HH

Now many SMEs are involved in multi-industry chains with multi IT systems. The dependency on other enterprises leads SMEs to a very passive position during collaboration. It means they have to adjust their business flexibly to satisfy the requirement of partners which change all the time. Unfortunately most of the SMEs are lacking IT systems to face these diverse businesses, e.g. Methods and tools to organize private business processes to collaborate with different partners. Also they are also lack of the ability of adjusting knowledge, business process during collaboration with different partners.

For large enterprises, they also have a big number of partners to collaborate. Large enterprises have large amount of data, documents which are stored by means of paper, database. They also have more complex business processes and administrative management rules. They have the similar problems with the SMEs on how to make their business more agile.

In China seldom enterprises model their business very seriously. The lack of valid enterprise models limited the abstraction of their business and hence the agility of the business.

The COIN federated interoperability services aim at bridging interoperability gaps in the

absence of an integrated standard or of a reference model (ontology) which to refer to. This is typically the case of hybrid supply chains (e.g. textile for automotive; furniture for shipbuilding; food for chemistry) where low technology SMEs have to collaborate with sectors (and large state-owned enterprises) where advanced technologies do exist. In this case, complete, lossless cross-sector models transformations are impossible to achieve and more agile solutions need to be adopted, like case based reasoning, rule based expert systems or ecosystems of micro-services solving very specific but frequent interoperability problems.

D. EI/EC barriers: Asymmetric enterprise application systems

Priority: M

The collaborative partners always are in very different informatization maturity levels. Some of them equipped the IT system with very good design and implementation. Some of them do the business in a very traditional way, e.g. telephone, fax and even “face to face”. This leads to a very low efficiency and high cost of collaboration.

It is impossible to avoid this asymmetric situation. Every enterprise has its own condition to implement Informatization. The best way is to find a way to reduce the difference.

COIN is supporting the reduction of this barrier by two measures:

- i. An EI/EC maturity assessment framework, including a methodology and a set of tools to evaluate and benchmark the as-is and to-be situation of SMEs and support them in the change management processes;
- ii. An intelligent, agent-based mechanism for service discovery and orchestration which is able to identify the most suitable EI/EC services according to the maturity of the requester and the business collaboration context. For instance, in the case of a textile SME willing to exchange orders and invoices with a Large automotive OEM, but not willing to be fully integrated in the automotive Interoperability standard systems (because it has solid business also in other domains like clothing or healthcare), the COIN expert system will choose lightweight federated interoperability services just in order to be mutually understood.

E. Cross-organizational cultural conflict

Priority: HH

In China, Large enterprises usually have their own enterprise culture developed along a long-term development. However most of SMEs don't have enterprise culture due to the reasons of lack of funds, professional employees' competencies, long-term strategy etc. It has been proved that the enterprise culture cannot be ignored, sometimes as the critical factor, when enterprises collaborate with each other, especially in international collaboration enterprises. Chinese SMEs have to join the global market, and then they have to deal with the cross-organizational cultural conflict very well.

The cultures between China and western countries have a lot of differences. Even after more than 30 years of opening process, China still needs to learn more about the outside world, and vice versa.

The **COIN training program** (<http://videlectures.net/coin/>) is a valid support to disseminate and create awareness around modern IT supported EI/EC. Six main training programmes have been prepared and are constantly updated, each targeting a different category of users: Academia, Industry, Policy makers, Multipliers, Service Developers, General Public. Lastly a new programme has been created for Enlarged EU Countries (those Countries joining just recently the EU). Moreover, a Knowledge Sharing Community has been created with the objective i) to facilitate the unconditional knowledge sharing between COIN and wider industry and academic community; ii) to help establishing a strategic scientific, industrial and social impact; iii) to create high quality training materials and services. We believe that on-line advanced and interactive tools like the COIN training program could be very useful to bridge the cultural gap between China and Europe.

F. Environment for Collaboration

Priority: M

Besides the barriers above, there are also some other barriers which are more related to the environment for collaboration. These barriers can't be ignored as well.

- 1) **Financing.** For most SMEs in China it is very difficult to acquire the loan from the banks. It means SMEs have no enough money to invest the necessary Informatization engineering for collaboration. Even they can get money from private organization with very high rate, they prefer to use the money on daily management like procurement, manufacturing or sales. Financing is becoming a very serious bottleneck for EI besides the technique and management problems.
- 2) **Logistics.** The issues of logistics for SMEs mainly include: high logistics cost, limited service range, long transportation time, goods lost, bad service of logistics company, fraud etc.
- 3) **Payment and credit.** For SMEs they have more risk on payment and credit when they collaborate with other enterprises. The size of SME is smaller, the risk is bigger. The payment and credit issues include: not knowing the status of integrity of collaboration partners, security of liquid cash, excessive payment (commission charges, earnest money), excessive prepayment, complex payment process etc. The issues are more serious in the inland of China.
- 4) **Security.** Many SMEs didn't realize the issue of information security and invest very little money on it. Especially they seldom have information security solution during collaboration.
- 5) **Lack of necessary collaboration strategy.** In most provinces except Zhejiang, Guangdong etc. the local collaboration between SMEs and the large enterprise in the same region is rather weak. For example 90% of the components of a large enterprise in Dalian are supplied by the enterprises in the south of China, not in the local area of Dalian. The SMEs need to find more opportunities to collaborate with large enterprises in the same region to decrease the collaboration cost. Large enterprises have better competition advantages, e.g. plenty of resources, core products etc. And they can always acquire relatively good policy, financial support etc. from government and banks. Many of them

have monopoly position in China. This makes part of the large enterprises lack of collaboration intention. Even collaborating with other enterprises like SMEs they occupy a positive position. Recent year this situation becomes better. The large enterprises have realized the benefit from collaboration, but still needs to be improved.

COIN recognises the importance of the above barriers but it wasn't meant to provide support to solve them.

3.3. EI/EC Challenges

“A challenge is a general term referring to things that are imbued with a sense of difficulty and victory” [Wikipedia]. For EI/EC, Challenges are the measures and methods, which are difficult to take, to cross the barriers for achieving EI/EC.

1. **Equip enterprise(Especially SMEs) with IT-enabled technology**

IT-enabled technology is the base to achieve EI/EC. The Chinese enterprises, especially SMEs, have relatively low level of IT-enabled technology. So the first challenge of EI/EC will be to fuse the data, process, product, R&D, sale etc. of the enterprises with IT-enabled technology, to update the level of business management and prepare for collaborative business. COIN vision says that EI/EC IT services should be considered among those services which are necessary for SMEs to run their collaborative business, beyond network connectivity and basic communication services. EI/EC IT services are the electricity, water, gas supply for SMEs.

2. **More open business**

Enterprises have to adapt to multi-industry chains and multi-platforms. It means that the business must be more open and interoperable, i.e. how to organize the private business to participate a collaborative business. For example, when enterprises collaborate with each other, they may sometimes hide part of the business to the partners. So the enterprises should have the methods and tools to support them to encapsulate the private process with suitable business rules to join a collaborative process. Different partners need different views of same private process to join different collaborative processes. Also when a collaborative process is organized, the enterprises need to make sure about the soundness and correctness of the open business. To make business more open and interoperable is big challenge for Chinese enterprises. COIN supports SMEs to join new business opportunities by reducing the impact of interoperability and collaboration problems in the IT procurement processes. Let's imagine a very brilliant micro enterprise with a very advanced solution for a niche problem. The barrier to interoperate this niche solution with the rest of the information systems (provided by other vendors obviously) prevented so far industry to adopt such a brilliant niche solution in its processes: the risk is to pay X for the niche solution and to pay many times X for its interoperation. If you suppose that interoperability is not a problem any longer (also thanks to the availability in the open Internet of the so-called COIN ISU), this will disclose several new business opportunities to such a micro enterprise.

3. **EI/EC-oriented knowledge management**

Enterprise collaboration should be knowledge-oriented collaboration. Research tools and methodologies are needed for acquiring, retaining and accessing the expanding range of knowledge available within individual enterprises and in VOs to enhance efficiency and productivity in collaboration, maximising the benefit of both long and short term knowledge sharing, whilst maintaining necessary commercial confidentiality and encouraging mutual trust.

In this context, knowledge is an instrument to drive and support collaboration. Knowledge users are, potentially, contributing to the body of knowledge on collaboration. Whilst some knowledge may be freely shared within enterprises or some VOs, commercially valuable knowledge may be made available as a product, thus contributing to a knowledge economy. Enterprises need to enhance the management of knowledge with better “explanation” of their business, information and data etc. with knowledge representation tools, acquisition of Knowledge, BI etc. COIN supports the transition from private business processes (and related knowledge sources) to public views, ready for collaboration. This transition is explicitly modelled and described by proper visibility-privacy-security rules and automatically run by the COIN BPM facility when running a collaborative BP.

4. **EI/EC standards**

Standards are very important for EI/EC. They can be used to exchange information during EI/EC. In China many standards have been implemented, e.g. the PDES, STEP for product design, BPMN, BPML, BPEL, BPD, UML, WS-CDL, XPDL etc. for business process, WSDL, SOAP, UDDI for web service etc. And specification and standard of ERP, PDM, PLM, CRM, CPC, SCM, etc. have been or are being developed. However Chinese enterprises need more new standards related to EI/EC. In this domain there is still a lot of work to do. The COIN project has a twofold role here: in the presence of standards COIN offers the possibility to join the EI/EC service delivery platforms federation by new service or platform providers; in the absence of standards (integrated interoperability form), COIN promotes the use of unified and federated ways for achieving interoperability.

5. **Enhanced platforms**

With more and more EI/EC requirements come, enterprises need new and enhanced platforms to provide support. These platforms should be built based on the newest technologies such as cloud computing. And more services should be provided on these platforms. The quality and price of the platforms should be acceptable by the enterprises. The ability of EI/EC for enterprises will be improved by these platforms and services centers. Although not natively deployed to a Cloud Computing environment, COIN has been designed and implemented for its future take up in Future Internet environments, including Internet of Services and Cloud Computing.

6. **EI/EC-oriented methodology**

Enterprises need new methodology to conduct the implementation of the reform for collaborative business, e.g. MDA/MDI etc. Most Chinese enterprises don't pay much

attention on methodology when they implement the informatization engineering. This has shown some negative results, e.g. duplicated implementation or even failure. EI/EC needs a long-term planning with suitable methodology. Reference EI/EC model will be critical measure for enterprises to adapt to the environment of Future Internet. And also the tools for applying methodology are necessary. COIN is not developing its own (yet another) methodology for EI/EC but stems upon results achieved by successful research projects of FP6, e.g. Interop NoE and ATHENA for EI, ECOLEAD and DBE for EC.

3.4. Other important aspects for EI/EC in China

1. Government's support

Economy in China is a kind of government-dominated market economy. That means that the government plays a dominant role in the economy. The policy made by the government can affect the enterprises' running environment to a great extent. As mentioned before the environment is a high barrier for EI/EC adoption which can be changed a lot by the government. Besides, the government can coordinate the resources of industry (enterprises), universities and research institutes to provide necessary support for the challenges of EI/EC.

2. Cooperation between China and Europe in EI/EC

Since 2000, European Commission has started the research of Enterprise Interoperability. It has the frontier technology of EI/EC as well as experience. So, Chinese government, universities, research institutes and enterprises need to cooperate with Europe. Europe can provide technology of EI/EC and China has big market of it. It will be beneficial for all the stakeholders.

4. EI&EC 2020 Vision for China

4.1. Vision Statement

We envision a future by 2020 in which the business environment in China will comprise the basic public IT infrastructures, public business services, a diversity of continuously evolving industry sectors of enterprises, within and across which enterprises will collaborate as well as compete with one another. Most of the enterprises, both large and small, will basically be able to do business depending on well-running IT systems, and part of them have the ability to collaborate with other enterprises based on related software and IT services.

The ability to adapt to changes in the environment dynamically and exploiting new opportunities rapidly by software and services can be improved. Collaborative business will turn to main task of enterprise. Interoperability of enterprises will be a key requirement and solution for the collaboration.

From the COIN IT perspective, interoperability will be a **utility-like** capability that enterprises can invoke on the fly in support of their business activities. In some industry sector specific IT

functions for collaborative business will be delivered as services that are cheap, fast, reliable, and without major integration efforts. IT will become a routine, and not a problem. It will be a major measure to finish the business operation.

Only all of enterprises, researchers and government successfully address their responsibilities together, this vision can be achieved.

4.2. The Enterprise Context

China is still a developing country which partially finished the task from a planned economy to a market economy. Many enterprises, especially large state-owned enterprises, did business in a planned economy system for years. Part of them implemented the reformation of organization and management successfully, part of them failed.

They are trying to adapt to the change in the market economy, but it takes time. For SMEs, the pressures of survival push them to select the most direct and simple way to do business. Even now some enterprises have very lower requirement of IT system. Chinese enterprises need to realize that in the future Informatization is the base to promote the competition ability, collaboration is the routine of successful business operation, and interoperability is the guarantee to achieve collaboration.

The Chinese enterprises:

- ✓ should establish the strategy of Informatization and increase the investment on it
- ✓ should analyze the real requirement of IT systems for management and collaboration
- ✓ should implement the IT systems which can really solve problems
- ✓ should have a long-term planning for Informatization and collaboration

4.3. The Government Policies

For both large enterprises and SMEs they have barriers and challenges on EI/EC which they cannot solve by themselves. Government plays very irreplaceable role during achieving EI/EC for enterprises in China. The main challenges for the government's contribution to EI/EC of enterprises are:

- ✓ Laws and Policies. Both central government and local governments needs to make related laws and policies to encourage enterprises especially SMEs to implement Informatization engineering, e.g. MIE, e-Business etc.
- ✓ Services. EI/EC needs more social services to support: land use, human resources introduction, bank loans, industry association, training schools and centers, public services etc. All these services need the government's instruction, monitoring and evaluation.
- ✓ Construction of the infrastructure for Informatization and EI/EC. Now the infrastructure for Informatization and EI/EC needs to be strengthened, e.g. improve the he payment and credit system, the logistics system, the information exchange platform and collaboration platforms for the enterprises.
- ✓ Officially technical and financial support. Government should build the complete supporting

systems of demonstration, technical service and technology research by means of high-tech program of government. At the same time, adequate financial support is also critical.

4.4. The Research Context

EI/EC needs very strong technical support which only be provided by research. Now there is gap between the requirement of Informatization and the services provided by IT systems in enterprises. Only small part of the enterprises satisfies with the effect of IT systems. The EI/EC research :

- ✓ should be decoupled from the business models of existing supply side incumbents
- ✓ Should not replicate what already exists or is in the pipeline
- ✓ Should not reinvent what is in principle already achievable on the market
- ✓ Should focus on problem-solving, rather than pure theoretical pursuits, so that Enterprise
- ✓ Interoperability solutions result that are directly beneficial, applicable, and easy to use

4.5. A roadmap for 2020 Vision

For enterprises achieving EI/EC is a gradual process. To achieve the 2020 vision, the following tasks need to be accomplished.

- 1) Pilot EI/EC projects in large enterprises. In some large enterprises
 - a) To establish the collaboration platform for co-design, co-supply, co-service
 - b) To develop the interoperability services supporting the collaboration platform

COIN is supporting both traditional hierarchical supply chains, dominated by an OEM, and less hierarchical ecosystems, where large enterprises just represent the center of gravity of the collaboration. **COIN Collaboration Platform.**

- 2) Pilot Informatization projects in SMEs
 - a) To do research on service mode based on SaaS
 - b) To develop public service platform for SMEs with services like data management, enterprise resource management, e-business, project management, CRM, OA
 - c) To do research on the collaboration platform for SMEs: credit guarantee, security, standard, interoperability services

COIN is supporting SME driven collaboration by providing in the open Internet both the platforms and the services needed to collaborate. **COIN Service Delivery Federation.**

- 3) Advanced technology on manufacturing Informatization: cloud manufacturing, manufacturing service life-cycle management, EI technology and related product etc.

COIN is supporting mostly manufacturing industry. Among its successful 12 pilots we could mention cases in automotive, aeronautics, space, ICT, pulp & paper, civil engineering, railways, logistics, marine shipping and many others. **Success stories and measured business benefits are key for the success of any manufacturing informatization project.**

- 4) Manufacturing service system and support environment
 - a) To setup the alliance for manufacturing Informatization including software vendor,

system integration provider, Informatization service provider

- b) To build the infrastructure for manufacturing Informatization, including the standard, training system, third-party monitoring service etc.

Service innovation in manufacturing is the main target of another research project, follow-up of COIN. The name of the new project is MSEE (manufacturing service ecosystem) and new pilots could be foreseen in China in this respect.

5. Concluding Remarks

This document introduced the state of the art of Chinese enterprises' Information and EI/EC, and gave a vision by 2020 with a roadmap how to achieve this vision. It is partly based on some reports about Chinese SMEs' Informatization.

Generally the level of enterprise Informatization in China is still at an early stage. Note that large enterprise and SMEs have very different strategy and environment on Informatization and EI/EC. So this document discuss them respectively, but more about SMEs.

The large enterprises, especially state-owned, are better than SMEs. From 1980s part of the large enterprises were selected to try Informatization and got very strong support from government. For SMEs the situation is not very optimistic. The "cost control" strategy decided that SMEs are very careful to invest on Informatization. For EI/EC, the importance of collaboration has been realized by both large enterprises and SMEs. But during the implantation of collaboration there are still a lot of technical and strategic problems.

Both large enterprises and SMEs have to face many barriers & challenges on EI/EC comparing with enterprises in Europe. The barriers and challenges are both technical and strategic. Government and researcher also play a key role for EI/EC of Chinese enterprises. The cooperation between China and Europe will be great beneficial for both sides.

COIN project will outcome EI/EC services and service delivery platforms and Chinese SMEs need services based on SaaS as well as without barriers of EI/EC which can be just provided by COIN. Also COIN needs more knowledge of Chinese culture to cooperate with the SMEs in China. This report believes the results of COIN bring Chinese enterprises, especially SMEs, a very positive affection for EI/EC.

Overall, this document describes a basic situation about EI/EC in Chinese enterprises, analyze the requirements of EI/EC in China. It can be a reference for related stakeholders in this domain (industries, IT companies, universities, research institutes etc.) to understand, to study and to find more cooperation chances with Chinese partners. With the continuously development of Chinese enterprises, this document should be updated in the future.

In conclusion, China represents a formidable opportunity for large scale deployment and experimentation of advanced research solutions in the field of EI/EC. Thanks to the COIN project,

such solutions will be soon available to all and at a very low (zero) cost. The next steps of the Europe-China cooperation in the field of enterprise systems should consider COIN outcomes as an outstanding starting point for such a co-operation.

6. References

- 1) SME department of Ministry of Industry and Information of China, "Report of Chinese SME Informatization development", 2007.
- 2) SME department of Ministry of Industry and Information of China, "Report of Chinese SME e-business development", 2009.
- 3) SME department of Ministry of Industry and Information of China, "Report of Chinese SME market investigation and development of Informatization service", 2010.
- 4) Ministry of Science and Technology, "Annual report of national High-tech program", 2010
- 5) Vicki Cui, " Architecture for the future: Report of Chinese manager of enterprise architecture", 2010
- 6) ZHU Chuanbao, "Research of group supply chain for SMEs", University of Electronic Science and Technology Press, 2009.
- 7) Doumeingts, G., J. Miller, et al. (2007). Enterprise Interoperability: New Challenges and Approaches, Springer Publishing Company.
- 8) Yannis Charalabidis, G. G., Karl Moritz Hermann, Cristina Martinez (2008). Enterprise Interoperability Research Roadmap.
- 9) Vernadat, F. B. (2007). "Interoperable enterprise systems: Principles, concepts, and methods." *Annual Reviews in Control* 31(1): 137-145.
- 10) Werth, D., S. Balzert, et al. (2010). 10P. About the Nature of Enterprise Interoperability. CONF-IRM 2010 Proceedings Montego Bay, Jamaica.
- 11) Chen, D., G. Doumeingts, et al. (2008). "Architectures for enterprise integration and interoperability: Past, present and future." *Computers in Industry* 59(7): 647-659.
- 12) Panetto, H. and A. Molina (2008). "Enterprise integration and interoperability in manufacturing systems: Trends and issues." *Computers in Industry* 59(7): 641-646.
- 13) Facca F.M., Komazec S., Guglielmina C.; Gusmeroli S. (2009): "COIN: Platform and Services for SaaS in Enterprise Interoperability and Enterprise Collaboration", IEEE International Conference on Semantic Computing, ICSC '09, September 2009, Berkeley.
- 14) Patrick Sitek, Sergio Gusmeroli, Marco Conte, Kim Jansson, Iris Karvonen (2011): "The COIN Book : Enterprise Collaboration and Interoperability", ISBN 3-86130-713, Verlagsgruppe Main publications, 2011.
- 15) COIN Partners (2008, 2009, 2011): COIN project Description of Work, ICT-216256 Contract Technical Annex.
- 16) Michele Sesana, Sergio Gusmeroli, Srdjan Komazec, Davide Cerri, Drago Trebežnik (2011): The COIN Front End for Generic Service Platform Federation Consuming; The COIN Book ISBN 3-86130-713, Verlagsgruppe Main publications, 2011.
- 17) Michele Sesana, Sergio Gusmeroli, Jens Eschenbächer (2011): The COIN Collaboration Platforms Federation for Enterprise Networks and Business Ecosystems. The COIN Book ISBN 3-86130-713, Verlagsgruppe Main publications, 2011.

- 18) Mikko Uoti, Kim Jansson, Iris Karvonen, Martin Ollus, Sergio Gusmeroli (2011): Project Alignment: A Configurable Model and Tool for Managing Critical Shared Processes in Collaborative Projects” Fifteenth IEEE International EDOC Conference (EDOC 2011), "The Enterprise Computing Conference" 29.8.-2.9. 2011 - Helsinki FI.
- 19) Stefan Huber, Cyril Carrez, Hannes Suttner (2011): Development of Innovative Services Enhancing Interoperability in Cross-organizational Business Processes - IWEI 2011 - The International IFIP Working Conference on Enterprise Interoperability; 2011 ,March 23-24 in Stockholm
- 20) Cyril Carrez, Enrico Del Grosso, Stefan Huber, Hannes Suttner (2011): “Detection of Interoperability Gaps in Cross-Organizational Business Processes” - ICE 2011 17th International Conference on Concurrent Enterprising – Aachen – Germany - 20.-22.06.2011