

ONLINE COLLABORATION SYSTEM FOR PRODUCT DEVELOPMENT IN VALUE CHAINS OF SMALL AND MEDIUM MANUFACTURING ENTERPRISES

S.-Y. Jung, H.-Z. Choi, J. Oh and B. H. Kim

Keywords: online collaboration system, small and medium manufacturing enterprises (SMMEs), collaboration hub

1. Introduction

In recent years, the management trend of enterprises has shifted from an age of monopoly by conglomerates to an age of collaboration among enterprises with different areas of expertise. Small and medium manufacturing enterprises (SMMEs) are making multifaceted efforts to survive the change in the manufacturing paradigm, but they face many difficulties due to changes of manpower, lack of capital, poor technology, and other factors. In particular, as the manufacturing business areas and roles which were held by large enterprises are being transferred to partner SMMEs, the problems caused by a lack of collaboration among SMMEs directly affect quality. Thus, a joint goal is to strengthen the competitiveness of a value chain through collaboration among enterprises [Kim et al. 2010].

Against this background, Korea Institute of Industrial Technology (KITECH) has been receiving support from the Government of the Republic of Korea since 2005 and operating to establish an Online Collaboration-Hub (OCH) for SMMEs to perform collaborative product development. The OCH is designed to vitalize internal and business-to-business technology and combined information technology in order to innovate manufacturing operations such as product development, design, procurement, and production. The OCH enables decision to be made quickly and accurately by allowing participants to collect, analyze, and share production related data in real time [MKE 2012].

This study examines the definition and classification of collaboration in various aspects and describes how collaboration types to affect collaboration activity. It also introduces the coverage and functions of the OCH mainly supporting the collaboration among SMMEs.

2. Collaboration among small and medium manufacturing enterprises

Most manufacturing enterprises collaborate with other enterprises in different ways in order to survive in rapid competition environment. However, they conduct collaboration activities at their own style because of the different situations they confronted. This section classifies the level and kind of collaboration with criteria and describes them in detail with respect to the collaboration among enterprises.

2.1 Classification of collaboration

First of all in this study, the collaboration is defined as the business activity that a person, department, or enterprise shares specific objects and cooperates with other ones in order to achieve common goals. According to the objects shared, the collaboration is classified into four levels as shown in Table 1.

Here, the main agents of the collaboration are able to perform higher level of collaboration as the range of shared objects enlarges. As described in Table 1, information level collaboration (ILC) enables enterprises to share simple data or processed data, and system level collaboration (SLC) expands the sharing range to applications, middlewares, and databases treating data and information. Process level collaboration (PLC) is able to share or connect business processes among departments or enterprises. Lastly, strategic relation level collaboration (RLC) enables to expand the sharing range to operation strategy and core capability of enterprises [Mathew 2002], [Ryu et al. 2010].

Table 1. Levels of collaboration

Level of collaboration	Targets of sharing for collaboration			
	Data, information	Application, middle, DB	Business process (partial/overall)	Operation strategy, core capability
Information level collaboration (ILC)	✓			
System level collaboration (SLC)	✓	✓		
Process level collaboration (PLC)	✓	✓	✓	
Strategic Relation level collaboration (RLC)	✓	✓	✓	✓

Even though the collaboration is able to be classified in various points of view, this study only treats the collaboration related to enterprises according to the scope of collaboration, the relation among enterprises, and the duration of collaboration. Figure 1 and Table 2 shows meaning and collaboration types in those three criteria respectively.

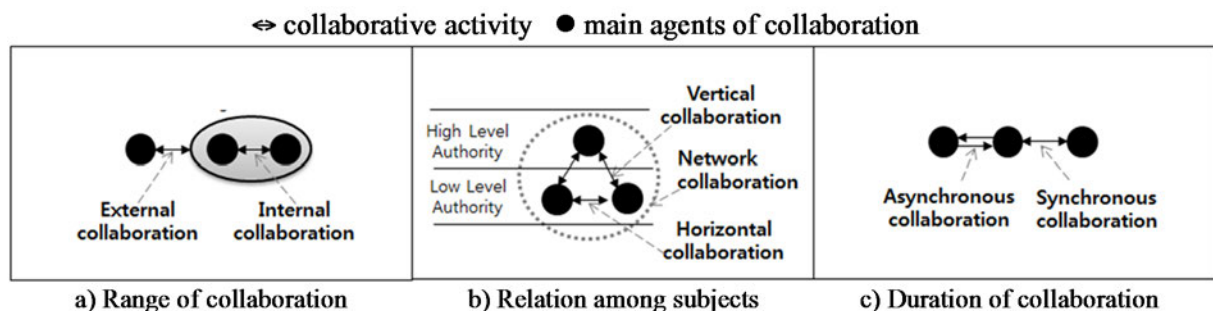


Figure 1. Meaning of collaboration criteria

Table 2. Collaboration type

Criteria	Collaboration type
Scope of collaboration	Internal collaboration (IC)
	External collaboration (EC)
Relationship between main agents	Vertical collaboration (VC)
	Horizontal collaboration (HC)
	Network type collaboration (NC)
Duration of collaboration	Synchronous collaboration (SC)
	Asynchronous collaboration (AC)

Firstly, the collaboration is divided into internal collaboration (IC) and external collaboration (EC) according to the scope of collaboration. The IC is the collaboration among individuals or departments in an enterprise, while the EC is the business activities among enterprises. There is more realistic difficulties to establish higher level of the EC due to interests conflicted with enterprises. Secondly,

according to the authority among main agents of the collaboration, the collaboration is divided into the vertical collaboration (VC) implying the relationship between subordinates and superiors, the horizontal collaboration (HC) having equal rights, and the network type collaboration (NC) including vertical and horizontal collaboration. Thirdly, the collaboration is also consisted of the synchronous collaboration (SC) and asynchronous collaboration (AC) depending on the duration of collaboration activity. The SC is interactive collaboration activity performed in real time, while the AC is collaboration activity performed sequentially or with a time difference [Camarinha-Matos et al. 2009], [Bahinipati et al. 2009], [Ryu et al. 2010].

2.2 Collaboration among enterprises

Collaboration among enterprises is carried out for tasks or work-related functions or processes, since the main agents of collaboration are enterprises. It is able to be divided into strategic collaboration and tactical collaboration based on each enterprise's strategic aspects. While strategic collaboration refers to the activities of enterprises formulating competitive barriers and differentiating their businesses from other enterprises to create long-term profit, tactical collaboration refers to the improvement of operation and business efficiency for short-term profit in the business.

In general, enterprises are very negative to share data and information for collaboration because of the security of technical information and knowhow. The inter-enterprise collaboration is the EC in the scope of collaboration and is able to perform the SC and AC theoretically in the duration of collaboration. Here, enterprises prefer to the SC to reduce the time of business activity because the AC causes to delay the collaboration activity. Because it is not easy to carry out the SC in practice, an information system like the OCH is required to support systematically [Zhan et al. 2003].

2.3 Collaboration among manufacturing enterprises

Collaboration among manufacturing enterprises focuses on market research, product planning, sales, R&D, and post-sales services initiated by manufacturing enterprises as the main agents of collaboration to create value in the manufacturing process. In general, manufacturing enterprises participated in value chains play their own roles independently and take part in the collaboration activity at the same time to increase common goals. Manufacturing enterprises have used to organize vertical value chains in manufacturing activities such as product development and production. The demanding enterprise has usually more right than supplying enterprises in a vertical value chain organized by them.

2.4 Collaboration among small and medium manufacturing enterprises

Manufacturing value chains consist mostly of SMEs which locate on their lower section. Especially in Korea, the SMMEs less than 300 employees or capital of 8 million US dollars take 98.8 percentage of the total manufacturing enterprises. It is very hard for Korea SMMEs to conduct the collaboration activity with information systems because of the difficulty of workforce securement and low investment. To overcome those problems, this study have developed the OCH supporting the SC among SMMEs systematically [MKE 2012].

3. Online collaboration system

3.1 Online collaboration-hub

An Online Collaboration-Hub (OCH) is a virtual space and tool to help enterprises to increase productivity with the collaboration. Enterprises participating in value chains are able to utilize the OCH with no constraints of time and space. The distinct feature of the OCH comparing to other collaboration systems is very fair to support the collaboration activity of each SMME. Existing information systems organized and developed collaboration functions centred on the enterprises located on the upper section of value chains.

Because those enterprises manage the information systems by themselves, they have more rights than the SMMEs which located on the lower section of value chains and usually confront with

unfavourable situation in the collaboration. To overcome those problems, the OCH is positioned at a neutral zone and allocates an independent collaboration space to each enterprise. Furthermore the OCH accords all enterprises equal right, and the modification or change of the right given is conducted only by the consensus of the value chain.

3.2 Features of online collaboration-hub

Table 3 shows the main features of OCH covering five areas and consisting of major ten functions and describes the collaboration level and type of each function.

Table 3. Features of online collaboration-hub

No	Supporting area	Major functions	Level	Category
1	Collaborative management of product information	BOM based collaborative design	SLC	EC/NC/AC
		Design change management among enterprises	SLC	EC/VC/AC
2	Exchange and usage of product data	Format transforming/weight lightening/viewing of 2D/3D data	SLC	EC/NC/AC
		Realtime conference of document/drawings	SLC	EC/NC/SC
3	Collaborative management of product development stage	Project management of product development	PLC	EC/VC/AC
		Process management of product development	PLC	EC/VC/AC
4	Collaborative management of product production stage	History trace and management of material flow	PLC	EC/VC/SC
		Monitoring of production records and schedule	PLC	EC/VC/SC
5	Management of quality information	Quality criteria based quality control	RLC	EC/VC/AC
		FMEA based quality control	RLC	EC/VC/AC

3.2.1 Collaborative management of product information

Major functions of this area are BOM-based collaborative design and the design change management among enterprises. BOM based collaborative design which helps several SMEs with creating a new BOM collaborately supports the VC between a demanding enterprise and supplying enterprises, the HC among specialized enterprises or organizations, and the NC. Design change and history arising inevitably in product development are also managed by the function of the design change management. Those two functions are the SLC and the AC in the collaboration level and type [Kim et al. 2009].

3.2.2 Exchange and usage of product data

Exchange and usage area of production data provides the functions of format transforming, weight lightening, and viewing of 2D/3D data and the realtime conference of document/drawings. Figure 2-a) shows an image of the viewing function which displays the CAD model of a part transformed, and Figure 2-b) depicts the online conference function that two more enterprises conduct talks about technical problems over checking the CAD model lightened synchronously. Those two functions are also the SLC and the NC.

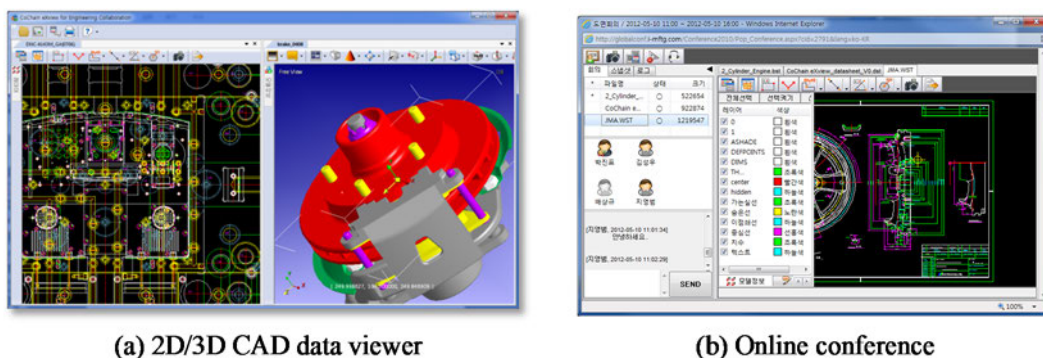


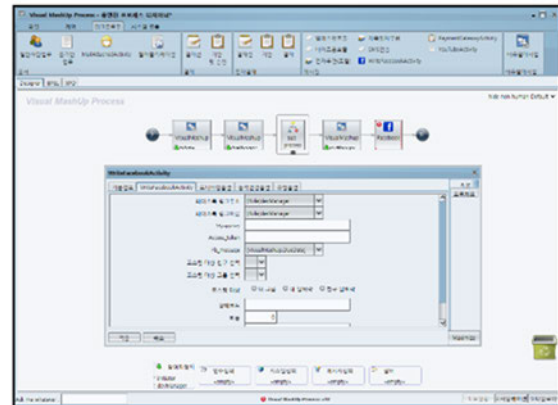
Figure 2. Functions of product data exchange and usage area

3.2.3 Collaborative management of product development stage

Project management of product development is similar to existing project management system (PMS) and has the differentiation which manages product information, schedule information, and output information among SMMEs organizationally. Figure 3-a) displays the progress state of on-going projects with colors. Process management of product development mainly focuses on the EC while the existing business process management (BPM) treats mostly the IC. Figure 3-b) shows an example of defining a collaborative process among SMMEs. Those functions are PLC because of that SMMEs share business process partially.

No.	프로젝트명	프로젝트명	프로젝트명	프로젝트명	프로젝트명	프로젝트명	프로젝트명	프로젝트명	프로젝트명	프로젝트명
28	프로젝트명	11022003	11022003	프로젝트명	2011-02-22	2012-02-21	프로젝트명	프로젝트명	프로젝트명	프로젝트명
25	프로젝트명	11022002	11022001	프로젝트명	2011-02-22	2012-02-14	프로젝트명	프로젝트명	프로젝트명	프로젝트명
24	프로젝트명	11022001	11022001	프로젝트명	2011-02-22	2012-02-21	프로젝트명	프로젝트명	프로젝트명	프로젝트명
23	프로젝트명	0221	프로젝트명	프로젝트명	2011-02-01	2012-02-20	프로젝트명	프로젝트명	프로젝트명	프로젝트명
22	프로젝트명	2011-0221	2011-0221	프로젝트명	2011-02-01	2012-02-05	프로젝트명	프로젝트명	프로젝트명	프로젝트명
21	프로젝트명	0F09-0003	2011-02-21	프로젝트명	2011-02-01	2012-02-20	프로젝트명	프로젝트명	프로젝트명	프로젝트명
20	프로젝트명	0F09-0003	0F09-0003	프로젝트명	2011-02-01	2012-02-20	프로젝트명	프로젝트명	프로젝트명	프로젝트명
19	프로젝트명	0218-0001	0218-0001	프로젝트명	2011-02-18	2012-02-25	프로젝트명	프로젝트명	프로젝트명	프로젝트명
18	프로젝트명	0217-0001	0217-0001	프로젝트명	2011-01-01	2012-02-01	프로젝트명	프로젝트명	프로젝트명	프로젝트명
17	프로젝트명	1102166	1102166	프로젝트명	2011-02-17	2012-02-20	프로젝트명	프로젝트명	프로젝트명	프로젝트명
16	프로젝트명	0F09-1111	0F09-1111	프로젝트명	2011-02-16	2012-02-23	프로젝트명	프로젝트명	프로젝트명	프로젝트명
15	프로젝트명	11021405	11021405	프로젝트명	2011-02-14	2012-02-13	프로젝트명	프로젝트명	프로젝트명	프로젝트명
14	프로젝트명	33030303	프로젝트명	프로젝트명	20101214	2011-01-30	프로젝트명	프로젝트명	프로젝트명	프로젝트명
13	프로젝트명	24242424	프로젝트명	프로젝트명	12345	2011-01-30	2011-03-12	프로젝트명	프로젝트명	프로젝트명
12	프로젝트명	2313122	프로젝트명	프로젝트명	12345	2011-02-01	2011-03-12	프로젝트명	프로젝트명	프로젝트명
11	프로젝트명	0F09-0002	0F09-0002	프로젝트명	2011-01-01	2012-02-15	프로젝트명	프로젝트명	프로젝트명	프로젝트명

a) Collaborative project management



b) Collaborative process management

Figure 3. Functions of collaborative management in product development stage

3.2.4 Collaborative management of product production stage

This area supports the history trace and management of material flow and the monitoring of production records and schedule. With those two functions the demanding enterprise monitors the production information of supplying enterprises partially according to the right assigned. The technical issues arising in monitoring process are resolved by the consensus of enterprises. The functions are also PLC because of the permission to monitor their production process each other partially.

3.2.5 Management of quality informaiton

Product quality as the knowhow of enterprises and the result of their core capability is an important control point in manufacturing. Emerging the importance of quality control again in manufacturing recently, the enterprises making end products are expanding the scope of quality control to their subcontractors. To take into account that situation, this study provides quality control functions based on quality criteria such as advanced product quality planning (APQP), process sign-off (PSO), ISO 9001, etc. and based on failure mode effect analysis (FMEA). Those functions are RLC because of sharing with business strategy like the level and method of quality control among enterprises.

4. Summary

Our daily living environment has been changing rapidly, and the business environment of enterprises is also transforming as a result. Since the state of the art technology is developing at a fast speed, the product life cycle is shortening day by day. As SMMEs face constraints in terms of their ability to catch up with this speed of change, it seems necessary to reinforce competitiveness of value chains through the collaboration among enterprises. Already, a great number of enterprises have collaborated via the OCH portal described in this study, in which they utilize for real-time information gathering and simultaneous multiple decision-making. Although cultures, traditions, and manufacturing environments are different in different countries, it is expected that the principles, functions, and tools of the OCH are shared and utilized by all SMMEs.

Acknowledgement

This paper is supported by the i-Manufacturing project funded by the Ministry of Trade, Industry and Energy (MOTIE) of Korea. The authors would like to thank for their support.

References

- Bahinipati, B. K., Kanda, A., Deshmukh, S. G., "Horizontal collaboration in semiconductor manufacturing industry supply chain: An evaluation of collaboration intensity index", *Computers & Industrial Engineering*, Vol. 57, No. 3, 2009, pp. 880-895.
- Camarinha-Matos, L. M., Afsarmanesh, H., Galeano, N., Molina, A., "Collaborative Networked Organizations – Concepts and Practice in Manufacturing Enterprises", *Computers & Industrial Engineering*, Vol. 57, No. 1, 2009, pp. 46-60.
- Kim, B. H., Jung, S. Y., Baek, J. Y., Lee, S. J., Lee, S. W., Choi, H. Z., "Design of Collaborative BOM Management System for Small and Medium Enterprises", *Proceedings of the Conference on Society of CAD/CAM Engineering*, 2009, pp. 254-260.
- Kim, B. H., Jung, S. Y., Lee, S. W., Baek, J. Y., Kim, H. W., "Process based Collaborative Product Data Management System", *Proceedings of the 20th International Conference on Flexible Automation and Intelligent Manufacturing 2010, CA, 2010*, pp. 862-872.
- Mathew, E. M., "The State of the Art Technologies and Practices in Enterprise Business Collaboration", *Infosys Technologies Limited*, 2002.
- MKE, "i-Manufacturing Project Report", *Ministry of Knowledge Economy, South Korea*, 2012.
- Ryu, K. Y., Kim, B. H., Choi, H. Z., "Analysis of Collaboration and Extraction of Technologies to Develop Collaboration Systems for Manufacturing Companies", *IE Interfaces*, Vol. 23, No. 2, 2010, pp. 182-192.
- Zhan, H. F., Lee, W. B., Cheung, C. F., Kwok, S. K., Gu, X. J., "A Web-based Collaborative Product Design Platform for Dispersed Network Manufacturing", *Journal of Materials Processing Technology*, Vol. 138, No. 1-3, 2003, pp. 600-604.

Hon-Zong Choi Dr.-Ing., Principal Researcher
IT converged Process Research Group, Korea Institute of Industrial Technology
1271-18 Sa3-dong, Sangrok-gu, Ansan, Gyeonggi-do, 426-910, South Korea
Telephone: (+82) 31-8040-6162
Telefax: (+82) 31-8040-6170
Email: choihz@kitech.re.kr
URL: <http://www.kitech.re.kr>