Int. J. Production Economics 136 (2012) 1–12

Contents lists available at SciVerse ScienceDirect

Int. J. Production Economics

journal homepage: www.elsevier.com/locate/ijpe

Design of a Global Decision Support System for a manufacturing SME: Towards participating in Collaborative Manufacturing

Hao W. Lin [a,*], Sev V. Nagalingam [b], Swee S. Kuik [b], Tomohiro Murata [c]

[a] Harbin Institute of Technology, Shenzhen Graduate School, Rm. 424, Bld. D, HIT Campus, Xili University Town, Shenzhen, Guangdong 518055, P.R. China
[b] School of Advanced Manufacturing and Mechanical Engineering, University of South Australia, Australia
[c] Graduate School of Information, Production and Systems, Waseda University, Japan

ARTICLE INFO

Article history:
Received 15 February 2007
Accepted 5 July 2011
Available online 22 August 2011

Keywords:
Collaborative Manufacturing
Collaborative networks
Global Decision Support System
System interoperability
Multi-objective optimisation

ABSTRACT

This paper discusses the conceptual design of a Global Decision Support System for a manufacturing Small or Medium Enterprise (SM/E), which actively participates in Collaborative Manufacturing. In order to implement the proposed concept, a Web Services based system architecture is proposed to offer maximum interoperability between all the distributed participants of a Collaborative Manufacturing Network (CMN) and their management information systems. Furthermore, this conceptual design utilises a Collaborative decision-support model that effectively interacts with the decision-makers and the management information systems/tools exist in the network, and provides appropriate support to all necessary decision-making steps towards the attainment of the network's strategic goals, while making full benefits of the network resources.

1. Introduction

In recent years, many manufacturing enterprises that are operating worldwide show an interest for Collaborative Manufacturing (CM). This new business strategy offers manufacturers the critically needed competitive advantages (Camarinha-Matos and Macedo, 2010; Chung et al., 2004; Johansen et al., 2005). CM is a concept that involves the establishment of Collaborative Manufacturing Networks (CMNs) in order to fully exploit the core competencies of every manufacturer within a network. The strategy is aiming to achieve best possible fulfilment of customer demands and improvement of their overall net profit, agility, and competitiveness towards the global market (Danilovic and Winroth, 2005; Kuik et al., 2010). However, CM heavily relies on improved data, information, and knowledge transparency typically a commonly recognised decision-making approach to achieve balanced profits, costs, and risks among the participants (D'Amours et al., 1999; Lagerstrom and Andersson, 2003; Li and Lai, 2005; Zhang et al., 2004). This reliance suggests that an integrated manufacturing decision-support infrastructure is essential for a CMN to successfully deliver the positive outcomes. Enhancing the existing capabilities on supporting the management and production activities are traditionally restricted to in-house operations and department-oriented operations. Advancing to the CM era, a corresponding new generation of manufacturing systems must also expand their features to administrate collaborative activities between the local enterprise and its business partners within the CMN (Chiu and Lin, 2004; Cil et al., 2005; Perrin et al., 2003).

Since, collaborative activities are highly complex and dynamic (Cil et al., 2005; Perrin et al., 2003; Xu et al., 2009), adequate interoperability between manufacturing systems that are distributed across the CMN is essential for the success of this network. To a certain extent, this interoperability issue is not properly addressed by most of the conventional integrated manufacturing systems (Chiu et al., 2006; Lin et al., 2009). Especially these systems are established by closely coupling computer systems with inflexible interfaces that are hard-coded to accommodate the purpose of a Business-to-Business (B2B) relationship. Under a customised interface, these systems fulfil the objectives of information sharing, and they proved adequate in sustaining the automation of most pre-defined business operations. However, hand-coded interfaces are not readily adaptive to the frequent changes as experienced within a CMN. As a result, participants within the network must invest invaluable resources in performing substantial updates just to maintain the operation of their existing systems. In order to conform to these integration architectures, the system must be commonly endorsed by all business partners to ensure smooth transaction of collaborative management activities. Furthermore, the schema of shared information and knowledge must be updated accordingly whenever the CMN

* Corresponding author. Tel.: +86 755 2603 3148.
E-mail addresses: h.lin@y.kurenai.waseda.jp (H.W. Lin), sev.nagalingam@unisa.edu.au (S.V. Nagalingam), swee.kuik@unisa.edu.au (S.S. Kuik), t-murata@waseda.jp (T. Murata).

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doi:10.1016/j.ijpe.2011.07.001

changes its formation. The maintenance cost of these systems is therefore a critical drawback.

The current manufacturing integration architectures for CM business activities are facing heavy technical and financial burdens (Brunnermeier and Martin, 2002; Chiu et al., 2006). These issues are significantly apparent for Small and Medium Enterprises (SMEs) due to scarce financial resources and limited technical abilities. Instead of rapidly expanding the manufacturing capabilities and capacities to cope with the highly dynamic global market, CM usually constitutes lower risks and is more financially justified for manufacturing SMEs to achieve the same effects of internal expansion (Danilovic and Winroth, 2005; Johansen et al., 2005; Lin et al., 2005; Loeser, 1999; Nadvi, 1995; Wang et al., 2004; Wheelen and Hungar, 2000). Furthermore, a survey of Australian Manufacturing Industry in 2005 demonstrated the willingness of the organisation to collaborate with other organisations (Intelligent Manufacturing Systems, 2005). In our work, the development of a Global Decision Support System (GDSS) enables optimised decision-making via facilitating interactions amongst the stand-alone manufacturing systems, and the adoption of a generic collaborative decision-making model. Subsequently, the GDSS is critical in building up the willingness for networked collaboration.

This paper is organised as follows: in Section 2, the background on manufacturing SMEs, CMN, and business process (BP) modelling are presented. In Section 3, the system architecture for the GDSS is discussed. In Section 4, a process-based collaborative decision-support model (CDSM) is proposed. The CDSM depicts the execution of global decision-making processes within a Small or Medium Manufacturing Enterprise (S/MME) and its business partners. Section 5, a real case example is given to illustrate the conceptual design of the GDSS. Finally, the concluding remarks and future work are discussed in Section 6.

2. Background

The authors of this paper have performed extensive literature reviews and on-site business analysis of an enterprise's business activities in association with CM. The outcomes of these studies demonstrated the need of an improved GDSS for supporting the current CM business phenomena by more readily attaining successful decision-making outcomes.

2.1. Critical success factors for manufacturing SMEs

The definition of manufacturing SMEs varies among countries, but generally the classifying parameters being the number of employees (under 200 employees in Australia) (Australian Bureau of Statistics, 2002) and the annual turnover (maximum of 40 million euros in Europe) (Small Business Service, 1996). These two parameters have defined manufacturing SMEs characteristics that are considerably different to large enterprises. Huin (2003) surveyed the characteristics of manufacturing SMEs among 30 companies by conducting 95 interviews with executives, and identified the key strategic and operational characteristics of an S/ME. Based on Huin's findings (2003) and our previous work (Nagalingam and Lin, 2000), it is concluded that there are three key business objectives that are critical to the success of manufacturing SMEs. Firstly, management activities throughout every organisation unit of the S/ME must be integrated to the maximum, so that the workflow across all functional and management boundaries are better aligned with the strategic goals of the enterprise. Furthermore, since external factors are highly influential to an S/MME, business partners must also participate in relevant decision-making activities whenever appropriate. Secondly, SMEs should adopt knowledge management as an essential activity so that work transition can be accomplished smoothly in events of task transferring and unexpected staff turnover. Thirdly, the S/MME must be proactive with decision-making, so that the organisation is capable of confronting forecast distortions, unexpected events, and demanding customers in an effective manner.

2.2. Participating in a Collaborative Manufacturing network

From the perspectives of a manufacturing oriented S/ME, a CMN is formed when the S/ME establishes highly transparent collaborative relationships with its business partners, who include customers, suppliers, and contractors such as illustrated in Fig. 1. The key objective of the collaborative strategy is to coordinate all the resources of the S/MME, suppliers, and contractors to best fulfil the demands of the existing customers and

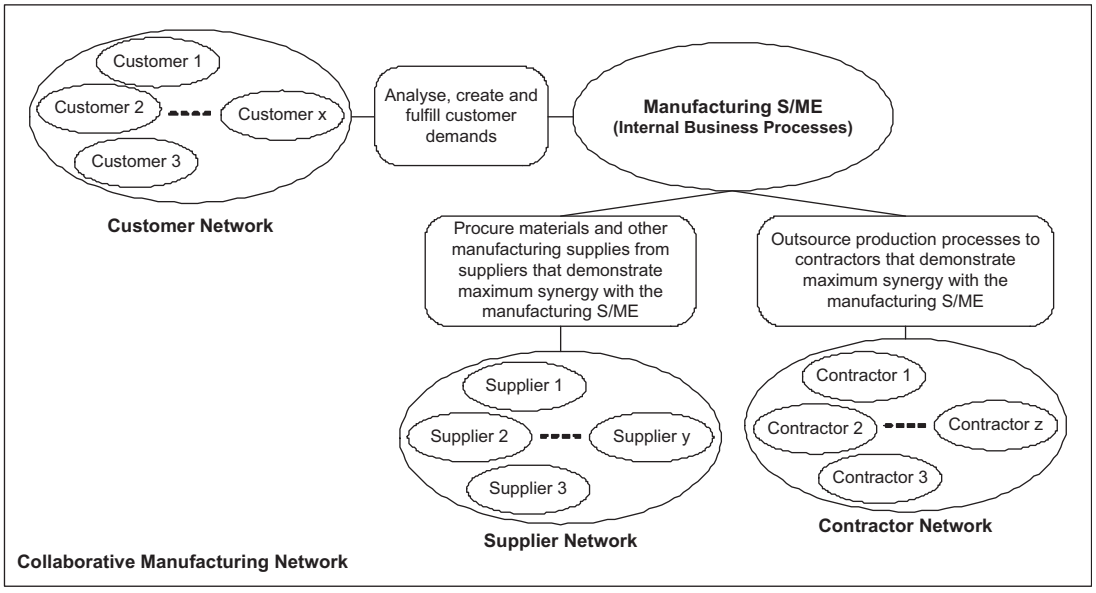

Fig. 1. CMN topology.