ELSEVIER

Computers in Industry 42 (2000) 275–287

COMPUTERS IN INDUSTRY

www.elsevier.nl/locate/compind

Agility of networked enterprises — parallelism, error recovery and conflict resolution

Chin-Yin Huang [a,*], Jose A. Ceroni [b], Shimon Y. Nof [c,1]

[a] Department of Industrial Engineering, PO Box 985, Tunghai University, Taichung, Taiwan
[b] School of Industrial Engineering, Universida Catolica de Valparaiso, Chile
[c] 1287 Grissom Hall, School of Industrial Engineering, Purdue University, West Lafayette, IN 47907-1287, USA

Abstract

Globalization has transformed companies to enterprises over the last 50 years. Computing and communication have also transformed production and service organizations over the past 50 years. While parallelism, error recovery, and conflict resolution have been addressed by human workers since the early days of industry, they have recently been transformed by computer-integrated functions. A major concern in the global market is agility. The agility of enterprises is considered an increasingly important factor of economic competitiveness. We view it from two perspectives: *business and organizational agility*, and *operational and logistics agility*. In the business and organizational perspective of agility, our research has developed an analytic method called distributed parallel integration evaluation model (DPIEM). Its purpose is organizing/reorganizing resources among distributed, networked organizations, based on the parallelism theory of computing and communication. In terms of operational and logistics agility in such distributed organizations, our research has suggested that the connection between the autonomy functions and agility requires significant functions of *error detection and recovery* (EDR), and *conflict resolution* (CR). The impact of both functions on the operational and logistics agility is analyzed and illustrated. The article concludes with several theoretical observations about the role of information technology (IT) in modern, distributed and networked enterprises.

Keywords: Autonomous agents; Error detection and recovery; Distributed systems; Information technologies; Protocols

1. Introduction

The impacts of modern information technology (IT) on distributed, networked enterprise systems can be classified into three categories: (1) speeding up activities; (2) providing intelligent and autonomous decision-making processes; and (3) enabling distributed operations with collaboration along communication networks. All three categories lead to agility. The impacts of IT not only can improve productivity and quality of production and service activities, but also enable enterprises to intelligently alter themselves and the way they interact. They can now collaborate with each other to best adapt to various customers' demand changes in tastes, design, time, and quantity, while keeping the cost at a reasonable level. Such enterprises are hence termed *agile enterprises*.

One of the goals of enterprises is to satisfy customers' demands as much as possible within eco-

* Corresponding author. Tel.: +886-4-359-4319; fax: +886-4-359-1756.

E-mail addresses: huangcy@ie.thu.edu.tw (C.Y. Huang), jceroni@ucv.cl (J.A. Ceroni), nof@ecn.purdue.edu (S.Y. Nof).

[1] Tel.: +1-765-494-5427; fax: +1-765-494-1299.

0166-3615/00/$ - see front matter
PII: S0166-3615(99)00076-7

nomic and ethical constrains. Such a goal is usually difficult to achieve because of the following possible limitations.

(1) Automation equipment is unable to intelligently and on a timely basis handle high-level specification changes and unexpected breakdowns.

(2) Vendors and suppliers along the supply chain do not, themselves, have enough capacity in terms of resources, operations, and transportation to handle all the desirable changes within reasonable time.

(3) Required design changes cannot be efficiently delivered to all the associated departments, suppliers, and vendors.

(4) In order to handle complex demands from customers, an enterprise may have to maintain a huge organization. Such an organization usually encounters high overhead. Worse yet, the proportion of overhead becomes even larger in terms of production costs when the market demands decrease.

For decades, researchers have been seeking to develop an agile enterprise that can cope with the above limitations, while keeping costs at a reasonable level. Modern IT seems to have paved a way to achieve this goal. However, to effectively benefit from IT for agility, an enterprise must still rely on detailed and systematic design and implementation. In this article, enterprises are assumed to be internetworked, and enterprise agility is considered in two parts: *business and organizational agility* and *operational and logistics agility*. For business and organizational agility, the main concerns are focused here on studying the parallel relationships between tasks and resources among the distributed organizations, so the total integration cost can be minimized. For operational and logistics agility, the main concerns are the capability of each individual enterprise (or subsidiary) to handle its own errors and resolve conflicts while interacting and collaborating with other enterprises.

The organization of this article is as follows. In Section 2, associated ITs that influence networked enterprise agility are introduced with functions. Section 3 presents business and organizational agility from a perspective of parallelism, while Section 4 presents operational and logistics agility from perspectives of error detection and recovery (EDR), and conflict resolution (CR). Concluding remarks and future research are addressed in Section 5.

2. IT enables enterprise agility

An obvious premise is that without IT, enterprise agility at all the enterprise levels would be impossible. It is interesting to compare the role of IT along three related dimensions: productivity, flexibility, and agility. Consider, for instance, how IT can improve enterprise activities in the following functions.

Function (1): design

Powerful computation can speed up activities in enterprises. For instance, design activities can be improved with powerful CAD workstations.

Function (2): decisions

Powerful computation allows many simulation trials to find a better solution in decision-making. For instance, an optimal material handling equipment selection can be obtained through repeated simulation runs.

Function (3): sensing

Input devices (e.g., sensors, barcode readers, etc.) can gather and communicate environmental information to computers or humans. A decision may be made by computer systems based on the input information. The decision may also trigger output devices, e.g., robot arms, monitors, etc., to realize the decisions.

Function (4): recovery

Computer systems can apply techniques of artificial intelligence (AI), e.g., fuzzy rules, knowledge-based logic, neural networks, etc., to improve the quality of activities. For example, a robot system may be recovered automatically from error conditions through decisions made by AI programs.

Function (5): collaboration

Distributed designers can work together on a common design project through a computer-supported collaborative work (CSCW) software system.