Business Process Improvements in Production Planning of ERP System Using Enhanced Process and Integrated Data Models

Premaratne Samaranayake

School of Management, University of Western Sydney
Locked Bag 1797, Penrith South DC NSW 1797, Australia
p.samaranayake@uws.edu.au

Abstract. This paper presents a framework for business process improvements for process integration, automation and optimisation in an ERP system environment. Main features of the proposed framework include (i) enhanced process models and integrated data models, incorporating many components and relationships/links and (ii) process optimisation through improved process logics and additional functionalities. Business processes are modeled using enhanced Event-driven Process Chain (EPC) methodology, incorporating additional logics and functionalities. Master and transaction data associated with business processes are modeled using unitary structures. Transaction data incorporate integrated master data and functional tasks such as good issue and receipt of production order cycle, for improved planning and scheduling of components. Potential improvements include simultaneous planning of many components, forward planning and finite loading of resources. The paper concludes that enhanced process and integrated data models improve functional applications and eliminate the need for separate and interfaced applications for process improvements in ERP system environment.

Keywords: Data structures, applications, integration, process improvements.

1 Introduction

Business process improvements through business process re-engineering projects and enterprise resource planning (ERP) systems have been the subject of considerable interests in many organisations. In this regard, ERP systems have emerged as the core of successful data, information and knowledge management through integrated functional applications across entire organisation. In recent times, the adoption of ERP systems are becoming more of supporting their businesses under ever changing and evolving environment of diminishing market shares, tough competition, increasing customer expectations and globalization. Despite widespread use of ERP systems, many companies are beginning to realize that the real impact of ERP systems on management styles and practices is actually well below expectations, especially on the front of organisational integration [1].

J. Yang et al. (Eds.): UNISCON 2009, LNBIP 20, pp. 165–177, 2009.

It has been recognized that Business Process Re-engineering (BPR) plays a significant role in ERP system implementations [2]; [3]. Martin and Cheung (2005) demonstrate through a case study that significant improvements through BPR can be achieved after the implementation of ERP systems. Further, process integration within ERP has a potential for bringing the maximum benefits of BPR [3]; [4]. However, it is a challenge for many organisations to carry out BPR project effectively [5]. With ERP systems, BPR has a dual role – one of result and the other as a prerequisite [2]. Moreover, BPR and ERP can be supportive of each other [6], where ERP systems can support BPR, through implementation of business process integration using applications and automation using workflows. Thus, success of ERP implementations and subsequent improvements on performance are dependent on how well benefits of BPR projects are achieved and maximized.

In recent times, research activities on business process improvements are confined to areas such as integration efforts, business process modeling, simulation, reference model for SMEs, and narrow spectrum of industries [7]; [8]; [9]; [10]; [11]; [12]; [13]; [14]; [15]; [16]; [17]. Recently, Davenport *et al.* (2004) concluded that factors most associated with achieving value from enterprise systems were integration, process optimisation, and use of enterprise systems data in decision making. However, there is limited research on those aspects to date. Beretta (2002) identified the lack of organisational integration with the business processes in ERP while McAdam and McCormack (2001) concluded that there is lack of research exploring the integration of business processes extending throughout supply chains.

On process automation and optimisation aspects, Lau *et al.* (2003) proposed a system with features of ability to reconfigure and customize business workflows of process automation, allowing the integration of workflow in a flexible way within industry environment. Samaranayake and Chan (2006) proposed a framework for integrating applications and workflows within an ERP system environment, based on enhanced Event-driven Process Chain (EPC) methodology. Further, limited literature on business process optimisation are confined to very narrow areas such as optimisation of: (i) business to business relationships [18], (ii) business process designs using mathematical model for minimizing cost and duration of the process [19], and (iii) ERP systems using roles, knowledge, better integration and user competencies [20].

In this research, the focus is business process improvements through enhanced process and integrated data models. A framework for process integration, automation and optimisation is proposed. Process optimisation is incorporated into functional applications, using improved process models and additional functionalities based on unitary structuring technique [21]. Process improvements are supported by integrated master and transaction data. Enhanced process and integrated data models are demonstrated using a numerical example within production order cycle of ERP.

This paper is organized as follows. The proposed framework for business process integration, automation and optimisation is presented first, followed by business process improvements using enhanced EPC methodology. Next, integrated master and transaction data in production planning of ERP is presented with a numerical example drawn from the industry. Finally, this paper concludes with research findings and recommendations for future research directions.

2 Framework for Business Process Integration, Automation and Optimisation

The framework for business process integration, automation and optimisation is based on enhanced process and integrated data models. Main features of the framework include (i) improved process models using enhanced EPC methodology [10], incorporating many components, relationships and links; and (ii) process optimisation with additional functionalities using integrated process/data models. Thus, the framework provides a basis for developing a set of transactions not only carrying out execution of process steps but also execution of relevant workflows and/or optimisation within the process. For example, the function "quotation to be created from inquiry" within the standard sales order process can be automated through the business workflow "quotation approval". Further, production order process can be optimized by incorporating scheduling functions for finite loading of resources into the production order creation function, with required data and organisational elements. This would not only eliminate the need for separate execution of applications and business workflows, but also provide required functionalities for optimizing complex processes as part of functional applications rather than separate applications in ERP system environment.

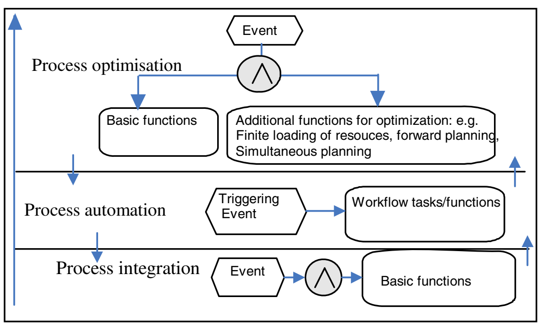

Fig. 1. Framework for process integration, automation and optimisation

The framework (Fig. 1) represents three building blocks of business processes: process integration, process automation and process optimisation. Business processes are improved at the integration and automation levels, before processes become candidates for optimisation. At the first level, process integration is represented by a combination of functions and events. Those functions are represented by combinations of many types of components (activities, resources, materials and suppliers) depending on the type of function and the purpose within the process. These components are linked together using three different relationships: parent-component (hierarchical), component-component (sequential) and activity precedence (closed-network). Similarly, process automation, supported by process integration, is represented by process components such as functions, events (triggering and terminating), resources linked with tasks and associated relationships between components.

In the proposed framework, basic functions at the integration level, functions and tasks at the automation and additional functions at the optimisation are represented by not only activities/tasks but also by associated resources, materials, suppliers, customers and relationships between components. Thus, functions with these components form the basis of enhanced process and integrated data models. Overall, business process integration, automation and optimisation are based on enhanced business process models using unitary structuring technique.

The proposed framework can be used to represent process cycles in terms of process components including workflow processes, data elements and structures involved, and relationships between components. Relationships are represented by links between components with appropriate precedence (parent-component, component-component and activity precedence). Moreover, the proposed framework provides the flexibility and maintainability of many process cycles, and can be used to simulate existing processes to achieve better planning and execution outcomes for all the components involved. The framework is also a basis for developing organization's business blueprint as part of ERP system implementation project. Once these individual models for process integration, automation and optimisation are developed, they can be linked together for relevant applications.

Therefore, business processes designed for integration, automation and optimisation can provide improvements beyond BPR principles and can be extended with additional functionalities for detailed scheduling and process optimisation. Further, constraints of logical operators in process functions are removed for incorporating additional functionalities as part of process optimisation. For example, logical operator OR in the process integration can become an AND operator when process integration is enhanced further with process optimisation. In general, business process optimisation through additional functionalities primarily focus on three aspects: (i) finite loading of resources, (ii) forward planning at execution phase depending on requirements arising from uncertainty (iii) simultaneous planning of all involved.

3 Business Process Improvements Using Enhanced Process and Integrated Data Models

Business process improvements outlined in the proposed framework are sought through enhanced process and integrated data models. In this regard, the main focus is to enhance business process models across many functional applications and associate with integrated data models in ERP system environment. Thus, business processes are modeled using enhanced EPC methodology, incorporating additional components and relationships into functions of business processes.

Enhanced EPC methodology [10] integrates business process components with data elements and structures at the modeling level. It has been shown that it can allow further improvements of business processes using enhanced models for existing functions in business processes as well as providing the flexibility and maintainability of many process cycles. This enables improvements in processes for planning, control and execution of various components. Similarly, process automation can be enhanced using unitary structures for functions associated with workflows in ERP system environment. The details of EPC methodology and process improvements with process automation are not presented here since it is beyond the scope of this paper. The next level of process improvements is to incorporate additional functionality as part of process optimisation, by removing some of the process constraints due to limitations within planning, control and execution cycles. One such limitation can be found in the production order cycle where there is no finite loading of resources at the time of planning of materials requirements.

Thus, production order cycle in ERP system environment is considered to demonstrate additional functionality for finite loading of resources, by eliminating manual capacity leveling of the current process, using enhanced EPC methodology. Further, production order cycle lacks simultaneous planning of all involved and forward planning of goods movements and other operations under uncertainty such as any breakdown of machines and unavailability of materials. Thus, various functions including production order creation and good movements can be considered as potential candidates for business process optimisation in ERP system environment. Thus, events related to those functions need to be handled using appropriate techniques at the time of order creation and linked with functions: finite loading in the case of overloaded capacity situation and forward planning of production, based on availability of materials leading to an event: materials and capacities availability, before releasing the production order. These additional events and functions can only be handled when the production order creation process is represented by enhanced EPC. Thus, enhanced EPC for production order cycle, incorporating additional functionality for finite loading of resources with relevant components based on unitary-structuring technique, improved process logics for compulsory events and associated functions and other possible functions is shown in Fig. 2.

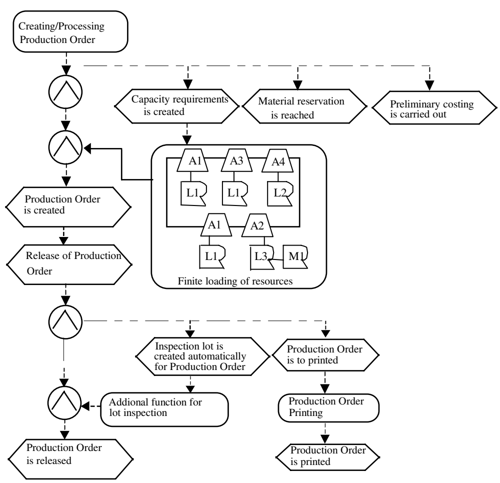

Fig. 2. Production Order Creation with Finite Loading Function

It can be noted from the production order creation process (Fig. 2) that the process is represented by a combination of existing functions and additional functions for optimizing the whole process. The enhanced process modeling and thereby process optimisation using additional functionality will result in additional transactions with workflows and optimisation aspects as necessary for some process cycles. For example, production order cycle demonstrated here, scheduling is based on availability of both materials and capacities at the time of order creation. Further, any unexpected situation during the execution phase can be handled since the production order cycle now contains not only hierarchical and sequential operations routings, but also other relationships between them. Overall, the production order cycle is improved through enhanced process models using improved integration, automation and optimisation.

The implementation requires a number of steps to be carried out within an ERP system environment. Further, it can result in improved transaction data where those functions are already built-in as part of the planning. First, business blueprint of ERP needs to incorporate enhanced process models, by expanding current functions and relationships beyond process elements. Once process map is implemented, business transactions are required to be modified, based on additional data and relationships. This requires some coding within the system, for combining current hierarchical data with enhanced process components. Additional functions involved in any process, as part of optimisation step, can be incorporated as a combination of additional functions within associated process areas. This step also requires some coding and is similar to that of incorporating expanded functions as part of process enhancements. Implementation of process improvements through a sample process cycle was carried out and will be reported later.

It can be noted from the production order cycle with additional functionality for finite loading (Fig. 2) that it is represented by various components and relationships at structural level. Since those components associated with functions are usually stored as master data in ERP systems and transaction data associated with those functions are based on master data, improving master and transaction data in ERP is vital for further improvements in processes in ERP. Improvements in master and transaction data are sought through structural integration, using unique method of unitary structuring technique [21].

4 Integrated Master and Transaction Data in ERP System Environment

In order to demonstrate the representation of production planning using unitary structure-based master and transaction data, a production planning business scenario involving various master data and transaction data in ERP system is considered. The business scenario is a make-to-stock (MTS) finished product with number of assemblies and raw materials, to be planned and executed using production management processes in an ERP system. Precisely, the finished product and assemblies are represented by a number of single-level BOMs and other required data including operations routings, work centres and cost centres attached to each work centre for costing purposes. Apart from master data described above, planning, control and execution generate and involve various transaction data including planned orders and production orders.

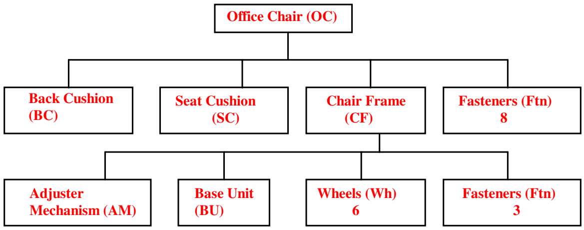

Fig. 3. Product Structure of Office Chair

In order to implement an MTS business scenario in an ERP system, it requires maintaining at least five key master data types: materials, bills of materials (BOMs), operations routings, work centers and cost centers. Thus, a product structure shown in Fig. 3 is considered as an example of MTS product for illustrating unitary structure-based master and transaction data. Since the product structure of office chair involves two single-level BOMs (one each for office chair and chair frame), master data for the office chair can be set in ERP systems using appropriate BOMs and operations routings. Since ERP system usually maintains single-level BOMs, there are two operations routings: one for each single-level BOM of the product structure. The details of resulting operations routings are shown in Tables 1 and 2.

Table 1. Operations Routing for Chair Frame

Opn. ID	**Description**	**Work Centre**	**Set-up (Min)**	**Machine (Min/Unit)**	**Labour (Min/Unit)**
10	Assemble AM (AAM)	R7	30	5	5
20	Painting AM (PAM)	R6	30	2	2
30	Cutting (Cu)	R10	30	2	2
40	Bending (Be)	R9	30	2	2
50	Welding (We)	R8	15	5	5
60	Painting (PBU)	R6	30	2	2
70	Assembly with BU (ABU)	R5	15	10	10
80	Inspection (ICF)	R4			5

Table 2. Operations Routing for Office Chair

Opn. ID	**Description**	**Work Centre**	**Set-up (Min)**	**Machine (Min/Unit)**	**Labour (Min/Unit)**
10	Fabric Cut (FBC)	R3	15	2	2
20	Ass. with BC (ABC)	R2	30	5	5
30	Fabric Cut (FSC)	R3	15	2	2
40	Ass. with SC (ASC)	R2	15	5	5
50	Final Ass. & Ins.	R1	15	10	5

When operations routings are maintained in ERP system, there are various functions associated with them including component allocation function for identifying the relationship between component and operation(s). The component allocation allows each material component assigned to an appropriate operation so that all the components are available for the relevant operation(s) at the time of execution of material and resource plans. In the case of the office chair (Fig. 3), base unit is required to be assigned to operation 30 (Cutting). Further, adjuster mechanism is assigned to operation 50 (Assemble AM) while wheels are assigned to operation 70 (Assemble AM/BU with CF). Similarly, all other components are required to be assigned to appropriate operation(s). It can be noted that all the master data with required functionality can be maintained for further processing during appropriate planning, control and execution processes. However, there are limitations within these data structures, which do not allow simultaneous and forward planning of all involved.

Apart from those two data structures, there are additional functions associated with the production order, including goods issues, goods receipts and order settlement. However, the production order as a transaction data at this level does not have the capability of adding those functions into a structured transaction data rather the information is copied into the order. Thus, the aspect of data being copied rather than being directly linked to the database, and need for separate functions during the order creation and beyond, limits the capabilities of smooth processing of production orders with these data elements. However, these issues can be handled using unitary structure-based transaction data.

Master data described above are candidates for integrated master data so that planning, control and execution can be streamlined and enhanced using additional functionality. For example, integrated operations routing with BOMs can eliminate component allocations in production order cycle. Further, longer lead times associated with sequential operations can be reduced when operations are integrated into BOMs using operations routing of both sequential and parallel operations. Thus, master data described above for this business scenario are integrated using unitary structures and presented next.

4.1 Master Data Integration Using Unitary Structures

Currently, the MTS scenario outlined above can be planned, controlled and executed using traditional ERP systems. However, there is lack of simultaneous planning, forward planning and finite capacity planning capabilities due to lack of true integration of data at the database level and inflexibility of planning techniques. As a first step of improvements for the planning, control and execution process, hierarchical BOM shown in Fig. 3 is integrated with sequential operations routing (Tables 1 and 2) to make a unitary structure-based one data structure. The resulting data structure is shown in Fig. 4.

It can be noted from Fig. 4 that original two routings and two BOMs are combined into one data structure. Further, it also provides built-in component allocation as part of the structure rather than separate activity in operations routing. In addition to integrated data structures, transaction data generated from this data can also be represented by unitary structure for effective execution of such transaction data. In many situations, transaction data are combined with various other events and associated functions outside the functional application the original process belongs. Further, there are many activities and resources in such functions and events, which require synchronous planning of all involved. For example, production order creation process involves various other functions including goods movement at two levels: goods issues to the production and goods receipts from production. These functions/tasks are required to be carried out at the correct time for timely completion of the production order. Using unitary structure, these functions/tasks can be incorporated and planned for better outcome of the overall process rather than manual intervention required by current systems. Due to page limitation of this paper, the details of integrated transaction data using unitary structures are not presented here.

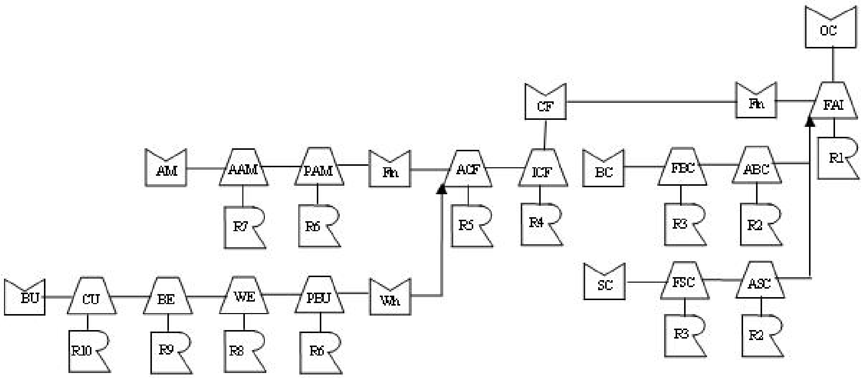

Fig. 4. Unitary Structure of BOM and Operations Routing for Office Chair

4.2 Production Planning and Execution Using Integrated Master and Transaction Data

This section illustrates planning and execution of various components using unitary structure-based master and transaction data of the business scenario described above. The planning of materials, activities and resources involved initiates with a set of planned independent requirements. For a given planned independent requirement, planning of materials, activities and resources are carried out using a scheduling method and scheduling paths developed earlier [22]. Scheduling paths determine the sequence for planning of components, taking all the relationships into consideration. In the case of backward scheduling, planning will start from the finished product while forward scheduling of all components starts from the last component in the lowest level of the BOM. Based on this approach, both bills of materials explosion and operations scheduling are carried out simultaneously. Thus, the complete planning and scheduling of components in the unitary structure shown in Figure 4 could result in start dates and times for activities and due dates and quantities for materials. The scheduling of operations routing for the same structure would result in operation start and finish times for all the operations, based on actual operation times rather than traditional lead times.

In this example, scheduling is based on the backward scheduling of all operations, with a due date and time of 28 November 2008 at 16.00 Hrs, for a quantity of 60 units. Operations scheduling is based on a working calendar of 8 hours, Monday to Friday between 08:00 hours and 16:00 hours. For the simplicity and numerical testing purpose, it is assumed that there is no break during the 8-hour shift. The scheduling of components of unitary structure-based master data is based on scheduling path depending on the type of scheduling (backward or forward) and the type of explosion depending on component relationships (parent-component, component-component and activity precedence) and component type (material, activity, resource, etc.). For backward scheduling, the scheduling path for each component in the unitary structure is a sequence of numbers starting from the office chair with a multiplication of 10. For the simplicity, it is assumed that each activity is associated with only one resource for both labour and machine categories. Thus, scheduling sequence is simplified by one sequence number for each activity and resource. All the components are planned in terms of start/finish dates and times for activities, due dates/times for resources, using BOM explosion and operations scheduling. The resulting scheduling path (identified by sequence numbers) for the entire unitary structure (Fig. 4) and planning results are shown in Table 3.

Table 3. Exploded Quantity and Time Schedule for each Component (Backward Schedule)

Seq. Number	**Component**	**Exploded**		**Ass. Qty**	**Due Date & Time**
	Name	**Qty**	**Duration (HRS:MIN)**		
10	Office Chair (OC)	60		60	28 Nov. 08 16.00
20	Final Adj. & Ins. (FAI)		15:15		28 Nov. 08 16.00
30	Fabric & SC ass. (ASC)		10:15		27 Nov. 08 08:45
40	Fabric cut for SC (FSC)		4:15		26 Nov. 08 14:30
50	Seat Cushion (SC)	60			26 Nov. 08 10:15
60	Fabric & BC ass. (ABC)		10:30		27 Nov. 08 08:45
70	Fabric cut for BC (FBC)		4:15		26 Nov. 08 14:30
80	Back Cushion (BC)	60			26 Nov. 08 10:15
90	Fastener (Ftn)	480			27 Nov. 08 08:45
100	Chair Frame (CF)	60		60	27 Nov. 08 08:45
110	Chair Frame Ins. (ICF)		5:00		27 Nov. 08 08:45
120	Ass. AM/BU in CF (ACF)		20:15		26 Nov. 08 11:45
130	Wheel (Wh)	360			23 Nov. 08 15:45
140	Painting BU (PBU)		4:30		23 Nov. 08 15:45
150	Welding BU (We)		10:15		23 Nov. 08 11:15
160	Bending BU (Be)		4:30		22 Nov. 08 09:00
170	Cutting BU (Cu)		4:30		21 Nov. 08 12:30
180	Base Unit (BU)	60			21 Nov. 08 08:30
190	Fastener (Ftn)	240			23 Nov. 08 15:45
200	Painting AM (PAM)		4:30		23 Nov. 08 15:45
210	Assemble AM (AAM)		10:30		23 Nov. 08 11:15
220	Adj. Mechanism (AM)	60			22 Nov. 08 08:45

In this example, the scheduling of components starts from the office chair (seq. no. 10) for a requirement of 60 units. Scheduling of components would result in exploded quantities for both materials and activities. The exploded material quantity is based on BOM explosion while exploded activity duration is a combination of setup, labour and machine times. Since there is only one resource unit per each activity, total resource requirements are same as those of activity duration. The exploded activity duration can be calculated by:

$$Total\ \ Activity\ Duration = \left\{ Setup + \left(\frac{Assembly\ Qty}{Base\ Qty} \right) * \left(\left(Machine\ Time\ /\ Unit \right) + \left(Labour\ Time\ /\ Unit \right) \right) \right\} \quad (1)$$

For example, activity duration for FAI and its associated resource is 15 Hours and 15 Min, which is the sum of setup time of 15 Min and 10 hours of machine (60*10 Min) and 5 hours of labour (60*5 Min).

It could be noted from planning results (Table 3) that many types of components involved in a unitary structure in manufacturing environment could be planned using two approaches as discussed above. It can also be noted that raw material of Base Unit (BU) is required around one week earlier (21 Nov. 2008 08:30) than the scheduled due date of completion of the office chair, making total lead-time around one week. Similar to scheduling of unitary structure-based components, production activity control (execution of material and capacity plans) can be carried out using unitary structure-based transaction data. In this case, the primary transaction data for execution is the production order. The resulting production order for the office chair is shown in Figure 4 as described earlier. In this case, production order is based on the unitary structure-based master data and consists of additional activities and resources for good movements and component allocation. Thus, execution of production order is based on due date and quantity derived from the scheduling of components and can provide scheduling of goods movement activities and resources using scheduling paths and explosion methods as described earlier. The complete production order execution including scheduling of goods movement activities and resources are not presented here due to page limitation of this chapter.

The methodology using integrated master and transaction data, when implemented in an ERP system, enables planning of many components and could result in planned orders and/or purchased requisitions depending on the type of components. Further, production order cycle can be improved through eliminating manual planning of goods movement activities and resources. Implementation of the methodology is being carried out and results would be published in the future. Thus, the integration of data structures for both master and transaction data provide flexibility of dynamically changing situation within many planning, control and execution cycles and allows critical path to be dynamically decided based not only on activities but also on availability of materials and resources during the execution phase. The methodology for planning these structures is not discussed here since it is beyond the scope of this paper.

5 Conclusions

The paper presented a framework for business process improvements using enhanced process and integrated data models for process integration, automation and optimisation.

Business processes are based on enhanced EPC methodology, incorporating many components, relationships and links and additional functionality for process optimisation. Main features of the framework are (i) enhanced process models using enhanced EPC methodology and (ii) integrated data models using various data elements, structures and relationships. The proposed framework is illustrated using a business process and a numerical example within production planning functional area of ERP system environment. It is shown that process improvements can be achieved through enhanced process models and integrated data models. The enhanced process and integrated data models, when implemented in an ERP system, can provide streamlined transactions combining process integration, automation and optimisation. In addition, it is capable of providing visibility, flexibility and maintainability for further improvements, in particular in process optimisation using additional functionality with enhanced process and integrated data models.

References

1. Beretta, S.: Unleashing the Integration Potential of ERP Systems: The Role of Process-Based Performance Measurement Systems. Business Process Management Journal 8(3), 254–277 (2002)
2. Sandoe, K., Corbitt, G., Boykin, R.: Enterprise Integration. John Wiley & Sons, New York (2001)
3. Sumner, M.: Enterprise Resource Planning. Pearson Prentice Hall, New Jersey (2005)
4. Hammer, M.: Re-engineering work: don't automate – obliterate, pp. 104–112. Harvard Business Review (July-August 1990)
5. Peppard, J., Rowland, P.: The Essence of Business Process Re-engineering. Prentice Hall, London (1995)
6. Koch, C.: BPR and ERP: realizing a vision of process with IT. Business Process Management Journal 7(3), 258–265 (2001)
7. Bhatt, G.D.: An Empirical Examination of the Efforts of Information Systems Integration on Business Process Improvement. International Journal of Operations & Production Management 20(11), 1331–1359 (2000)
8. Themistocleous, M., Irani, Z., O'Keefe, R.M.: ERP and application integration. Business Process Management Journal 7(3), 195–204 (2001)
9. Barber, K.D., et al.: Business-process modeling and simulation for manufacturing management – A practical way forward. Business Process Management Journal 9(4), 527–542 (2003)
10. Samaranayake, P.: Business Process Integration with Data Structures in Enterprise Resource Planning Environment. In: Parkinson, P.S., Shutt, P.J. (eds.) British Academy of Management Annual Conference, pp. 1–9. Niche Publications UK Ltd., Harrogate (2003)
11. Persona, A., Regattieri, A., Romano, P.: An integrated reference model for production planning and control in SMEs. Journal of Manufacturing Technology Management 15(7), 626–640 (2004)
12. Sandhu, M.A., Gunasekaran, A.: Business process development in project-based industry – A case study. Business Process Management Journal 10(6), 673–690 (2004)
13. Metaxiotis, K., et al.: Goal directed management methodology for the support of ERP implementation and optimal adaptation procedure. Information Management and Computer Security 13(1), 55–71 (2005)

14. Martin, I., Cheung, Y.: Business process re-engineering pays after enterprise resource planning. Business Process Management Journal 11(2), 185–197 (2005)
15. Serrano, A., Hengst, M.D.: Modelling the integration of BP and IT using business process simulation. Journal of Enterprise Information Management 18(6), 740–759 (2005)
16. Samaranayake, P., Chan, F.T.S.: Business Process Integration and Automation in ERP System Environment – Integration of Applications and Workflows. In: The 2nd International Conference on Information Management and Business, Sydney, Australia (2006)
17. Clegg, B.: Business process oriented holonic (PrOH) modeling. Business Process Management Journal 12(4), 410–432 (2006)
18. Kuechler Jr., W., Vaishnavi, V.K., JKuechler, D.: Supporting optimization of business-to-business e-commerce relationships. SDecision Support Systems 31, 363–377 (2001)
19. Vergidis, K., et al.: Optimisation of business process designs: An algorithmic approach with multiple objectives. International Journal of Production Economics 109, 105–121 (2007)
20. Worley, J.H., et al.: Implementation and optimization of ERP systems: A better integration of processes, roles, knowledge and user competencies. Computers in Industry 56, 620–638 (2005)
21. Woxvold, E.R.A.: Extending MRP II Hierarchical Structures to PERT/CPM networks. In: 35th International Conference - American Production and Inventory Control Society, Canada (1992)
22. Samaranayake, P.: Scheduling Paths for Merged CPM Networks with MRP Bills-of-Materials. In: Toncich, D. (ed.) Profiles in Industrial Research, pp. 1–9. Industrial Research Institute Swinburne (1998)