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USING ERP SYSTEM TO IMPROVE INTERNAL SUPPLY CHAIN COORDINATION

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Original scientific paper

In today's competitive global market, one of the most effective ways towards achieving competitive advantage has been the ability to accelerate the supply chain process through ERP (Enterprise Resource Planning) systems. ERP enables a more efficient internal and external supply chain. Enterprise resource planning system is an information system that manages all aspects of a business (production planning, sales, distribution, accounting, purchasing and customer services). Planning system is the core of an ERP system. The aim of this paper is to propose a hierarchical planning and scheduling model based on just-in-time principle to improve internal supply chain coordination for one-piece and small batch production. The model is implemented into the system ERPINS (Enterprise Resource Planning ININ Solutions) that is developed for metal processing industry, wood and food processing industry and construction industry.

Keywords: *coordination, enterprise resource planning, just in time, scheduling, supply chain management*

Primjena ERP sustava za poboljšanje koordinacije internog dobavljačkog lanca

Izvorni znanstveni članak

Na današnjem konkurentnom globalnom tržištu jedan od najučinkovitijih načina postizanja konkurentne prednosti je sposobnost ubrzanja procesa dobavljačkog lanca pomoću ERP (Enterprise Resource Planning) sustava koji omogućava učinkovitiji interni i eksterni dobavljački lanac. Enterprise resource planning sustav je informacijski sustav koji upravlja svim aspektima poslovanja (planiranje proizvodnje, prodaja, distribucija, računovodstvo, nabava i korisničke usluge). Sustav planiranja je glavni dio ERP sustava. Cilj ovog rada je dati model višerazinskog planiranja i terminiranja koji je zasnovan na just-in-time principu sa svrhom poboljšane koordinacije internog dobavljačkog lanca za pojedinačnu i maloserijsku proizvodnju. Model je primijenjen u sustavu ERPINS (Enterprise Resource Planning ININ Solutions) razvijenom za metalopreređivačku, drvnu, prehrambenu i građevinsku industriju.

Ključne riječi: *koordinacija, planiranje resursa poduzeća, just-in-time, terminiranje, upravljanje dobavljačkim lancem*

1 Uvod
Introduction

The current manufacturing systems are faced with the pressure caused by fierce competition. This is the result of a dynamic business environment, shorter product lifecycles, globalization, customer specific demands oriented manufacturing and ever-shorter production time and launching of a new product on the market. The increasing pressure of competition owing to the rapid development of information and communication technologies has brought the supply chain planning to the fore in most manufacturing and service organizations. A supply chain can be viewed as 'a group of distinct entities (e.g. raw material supplier, manufacturer, transporter, retailers, etc.) interacting to transform raw material into finished product and then final delivery of the product to the customer to satisfy their demand in time at least possible cost' [1]. The supply chain planning includes the coordination and integration of key business activities from supply of raw material to delivery of the finished product to the customer [2]. The main goal of SCM is to satisfy customer demands most efficiently. For manufacturing companies it means to produce the required product, for a specific customer, in required quantity and stipulated time [3], according to the just-in-time principle. Efficient implementation of the JIT principle depends on the coordination of production schedules with the supplier's timely delivery of materials and parts and delivery of finished products to the customer in due time. Thus, close coordination is necessary of all partners in the supply chain as well as linking of production plans. To make the supply chain efficient it is necessary to provide undisturbed and timely flow of information, materials and finances and this is what the implementation of the ERP system makes possible.

The most important industrial trend today is the integration of supply chain and ERP [4, 5]. Our paper is focused on internal supply chain coordination for one-piece and small batch production. The aim of the paper is to present a hierarchical planning and scheduling model so as to improve coordination between various parts of organization (production, assembly and sales department) within the internal supply chain with regard to quantity and time limits. The model of hierarchical planning and scheduling describes the supply chain activities as a mathematical programming model. It refers only to a part of the entire supply chain and is integrated into the Croatian solution of ERP system called ERPINS. ERPINS is developed for metal processing industry, wood and food processing industry and construction industry.

The paper is structured as follows. Introduction is followed by a review of relevant literature on SCM and ERP. In Section 3 the mathematical model of hierarchical planning and scheduling as internal supply chain is presented. Section 4 deals with solution algorithm. In Section 5 the model implementation into ERPINS system is presented. Conclusions are given in section 6 which also ends the paper.

2
Literature review
Pregled literature

The supply chain management coordinates and integrates all activities within a company and with environment. The terms 'internal' and 'external' supply chain are widespread in literature, e.g. [4, 6-12]. ERP renders internal and external supply chain more efficient [9]. In the next subsection a short review of the literature on supply chain management is given. After that follows a short review of the literature on ERP systems.

2.1
Supply chain management
Upravljanje dobavljačkim lancem

Enterprises cannot compete with maximum effectiveness on the market separated from suppliers and other partners in a supply chain. On a global market companies no more compete one with the other but it is the supply chains that compete among themselves [13]. Supply chains are more and more often described as supply networks [14-17]. Coordination in supply chains is of great significance, but in literature the mathematical models of coordinated decision making in supply chains are still under-represented [18]. The coordination issue is treated by [18-20]. The companies coordinated and integrated within a supply chain are more efficient, with superior quality, lower investments in inventory, reduction in the cash flow cycle time, reduced cycle times, lower material acquisition costs, higher employee productivity, increased ability to meet deadlines requested by customers and lower logistics costs [21, 22]. After analyzing 442 papers in three magazines during five years exploring supply chain management the paper [23] concluded that there is a trend leading from exploratory to the phase of developing models and their testing for the purpose of solving real problems. SCOR model is 'an international standard for process description and reorganization and considers five main supply chain processes: planning, sourcing, production, delivering, and return activities' [24]. The SCOR model describes the intra-organizational and inter-organizational linking. Supply chain is a 'pull' system operating according to orders among various entities in supply network [25]. Authors of paper [26] are given mathematical formulation of model for supply chain management. In the paper [3] 2004) the authors gave a just-in-time distribution requirements planning system for supply chain management. The supply chain coordination problem in a just-in-time environment where the supply of the component is uncertain due to an uncertain availability of the capacity by the supplier is treated in the paper [6]. The author of the paper [27] writes about just-in-time supply chains. He focuses his attention on mass customization in a just-in-time automotive supply chain. In the paper [28] author describes software components for supply chain management. One of the components is ERP system.

2.2
Enterprise resource planning
Planiranje resursa poduzeća

ERP systems can be regarded as ‘one of the most innovative developments in the information technology of 1990s’ [29]. A review of the literature in the field of ERP systems shows that research conducted has concentrated on implementation [30-32] and post-implementation issues [33]. There are also papers dealing with the design of ERP system [34] and reasons for ERP implementation failure [11, 35, 36]. A review of ERP systems is given in papers [10, 33, 37]. In the paper [38] the authors proposed taxonomy for ERP research. In the paper [10] the authors gave a brief overview of ERP systems and highlighted their implications for operations function. The papers [39, 40] are focused on the influences and characteristics of ERP acquisition process. In the paper [41] the authors present their study about the effects of ERP implementation on marketing and manufacturing integration. In the literature there are various definitions of ERP system. According to [10] Enterprise Resource Planning systems 'effectively integrate islands of information and structure systems with transparency and real-time information sharing across the intra-organizational processes (e.g. major functional areas) as well as inter-organizational processes (e.g. suppliers and customers)'. Lately, the introduction and implementation of ERP systems has become a widely used method of application of information technology as a means for achieving competitiveness. ERP systems are among the most rapidly developing areas as regards development of information technology and software implementation. Research into U.S. Fortune 1000 companies found that over 60 % have implemented an ERP system [42]. A number of published researches on advantages of ERP systems implementation testify to the improvements in business performance. According to [43] the results for improvements in profitability are stronger in the case of early adopters of ERP systems. Adopters of ERP systems gain a competitive advantage over non-adopters [44]. The results of their research indicate that return on assets, return on investment, and asset turnover are significantly better over a 3-year period for adopters as compared to non-adopters. According to [45] with successfully implemented ERP system can be gained significant benefits such as improved customer service, better production scheduling, and reduced manufacturing costs. Information flows in supply chain are more transparent by adoption of ERP system [38]. The authors of papers [44, 46] notice that productivity and quality improvement in key areas (product reliability, customer service and knowledge management) represent potential benefits of an ERP system.

Due to the mentioned benefits an increasing trend in ERP systems development has been noticed in spite of the problems arising when they are being implemented [11]. From the paper [47] it is evident that small, medium and large companies as well as government agencies and non-profit organizations are using ERP systems. According to [42] the market penetration of ERP systems varies considerably from industry to industry: a report by Computer Economics Inc. stated that 76 % of manufacturers, 35 % of insurance and health care companies, and 24 % of Federal Government agencies already have an ERP system or are in the process of installing one. There is a variety of ERP software available on the market. ERP vendors such as Infor, Sage Group, Microsoft, Lawson, and Epicor have a greater orientation to the small and midsize business, but Oracle and SAP continue to dominate the market among the world's largest corporations [48]. Figure 1 presents market shares of ERP system vendors according to AMR Research[1] [48].

ERP vendors are still mostly focused on the coordination for internal supply chains [49, 50]. The research [51] compares several ERP systems (recognized world solutions and Croatian solutions) used in Croatia. There is an ample supply of the software for financial operations, management of human resources and payroll accounts while the supply of the software for commodity and material transactions is less adequate. However, the supply of production software and that for production management in particular is completely inadequate. The mentioned research has shown that compared to imported commercial packages the Croatian solutions are better and cheaper and easier to implement.

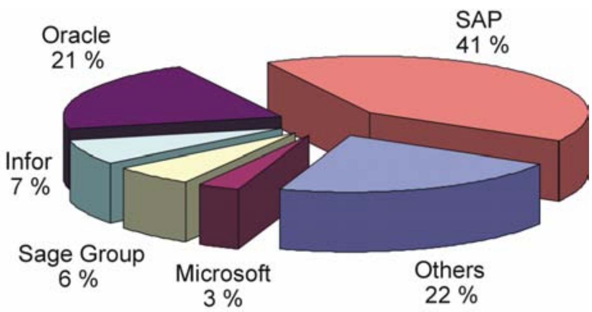


Figure 1. Market shares of ERP system vendors for 2006 (source: AMR Research)
Slika 1. Udjeli na tržištu dobavljača ERP sustava za 2006. (izvor: AMR Research)

[1] With permission of the **AMR Research, Inc.**, Boston, www.amrresearch.com

3 Mathematical model of hierarchical planning and scheduling

Matematički model višerazinskog planiranja i terminiranja

The chief aim in connecting three levels of planning by the application of just-in-time principle is to increase effectiveness of production, timely delivery of finished products/services to the customer or parts and subassemblies to a higher hierarchical level and to increase the logistics system functionality. The best suppliers must be chosen while production scheduling must enable the costs of real production plan to be as low as possible. The model is developed for the needs of one-piece and small batch production to meet the specific demands of customers. The model of internal supply chain incorporates the processes which include customer orders, manufacturing and assembly of a product and delivery of the product to the customer. The higher and lower levels of planning are interdependent in terms of the Japanese just-in time business philosophy principle and because of this dependence special attention must be given to coordination between the three levels of planning. The coordination between higher and lower levels is completely realized when the third level production element (manufacturing operations scheduling) is transferred to the following phase (assembly) right after it has been finished depending on the date required by the superior plan at the level of assembly activities planning or sales department planning, respectively.

In the hierarchical approach a production plan of sales department is developed followed by an assembly plan that can take the output of higher-level production plan. After that a detailed part schedule that can take the output of assembly planning model is generated [52, 53]. Figure 2 presents the concept of hierarchical planning in ERPINS for internal supply chain coordination. The internal supply chain must also be coordinated with the external supply chain.

The solution of a higher planning level is a constraint to be imposed on the lower planning/scheduling level. Thus, the schedule that is used at each level depends on the requirements at the higher level. One of the main objectives of hierarchical planning model is to keep the due date equal to the required date in order to meet customers' demands. In the following subsections the models for three levels of planning and scheduling are given.

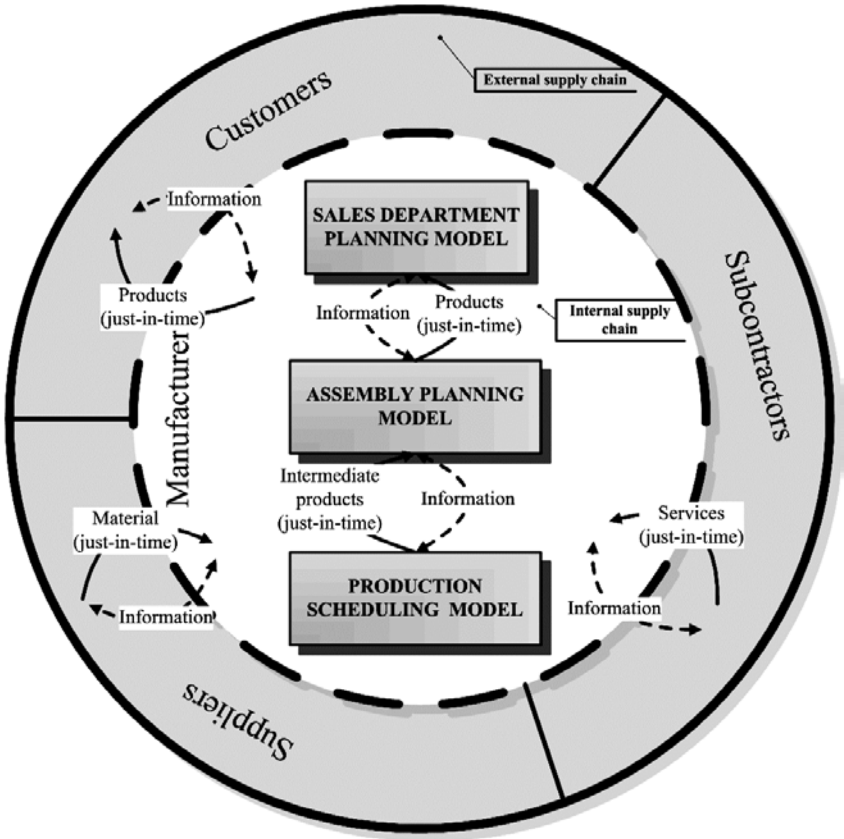


Figure 2. Concept of hierarchical planning and scheduling for internal supply chain
Slika 2. Koncept višerazinskog planiranja i terminiranja za interni dobavljački lanac

3.1 Sales department activities planning model
Model planiranja aktivnosti odjela prodaje

This level plan specifies quantities of each finished product in a given planning horizon *T*. Based on this, demand quantities of components and parts for production and materials procurement can be calculated using data from hierarchical structure of product through dependence of one item on another item. Production quantities are known at the moment the customer orders are received. Each order has the following attributes: arrival date, due date and technological requirements (series of operations to be accomplished according to the established routing, each on a certain capacity). When sales department establishes that the delivery of goods ordered by the customer can be made by the due date, the order will be accepted. The planned release date of an order is determined as difference of its due date Z_m and the planned lead-time for operations on items of order. According to this, sales department develops the plan for the purchasing of required materials and components from suppliers. Selection of batch size and sequence of work order releasing depends on agreed due dates, available capacities, readiness of resources (documentation, materials and tools) [54]. The output of the first level is the due date Z_m which is at the same time the input for the second level model. Coordination between sales department and production department is very important, especially when bids are made.

3.2 Model of assembly planning
Model planiranja montaže

The plan of assembly activities of item *a* (main assembly unit) is developed on the second level of planning according to the given due date Z_m from the first level. Each order consists of a series of assembly activities which are interrelated by technological precedence constraints. Initial plan of assembly activities is developed upon predetermined sequence of activities and duration of estimated activities based on bar chart and critical path methods. Initial time completion is calculated according to (1). The sum of durations of activities with influence of lead/lag times $L_{i,j}$ on critical path equals the time of assembly plan completion. Reliable forecasting of delivery time is very important for competitive advantage today.

$$DT_{CP} = \max_{P} \sum_{j2=1}^{n} \sum_{mj2}^{Mj2} x_{j2,P} \cdot x_{j2,mj2} \cdot \left(t_{a,j2,mj2,rn} + L_{i,j}\right) \quad (1)$$

$$x_{j2,P} = \begin{cases} 1 & \text{if} \quad j2 \in P \\ 0 & \text{if} \quad j2 \notin P \end{cases} \quad (2)$$

$$x_{j2mj2} = \begin{cases} 1 & \text{if} \quad mj2 \in j2 \\ 0 & \text{if} \quad mj2 \notin j2 \end{cases} \tag{3}$$

$$\sum_{mj2}^{Mj2} x_{j2,mj2} = 1, \ \forall j2 \tag{4}$$

$$tp_{a,j2,mj2,rn} = tp_{a,i2,mj2} + t_{a,i2,mj2,rn} + L_{i,j} \tag{5}$$

$$tz_{a,j2,mj2,rn} = tp_{a,j2,mj2,rn} + t_{a,j2,mj2,rn} \tag{6}$$

where

$x_{j2,P}$ - 0-1 integer variable defines belonging of assembly activity $j2$ to path P

$x_{j2,mj2}$ - 0-1 integer variable defines mode of execution of assembly activity $j2$

$j2$ - assembly activity

P - path - activities linked by technological constraints

$t_{a,j2,mj2,m}$ - planned duration of assembly activity $j2$ in mode $mj2$ on main assembly unit a at order rn

$DT_{\mathrm{CP}}{}^{\mathrm{II}}$ - delivery time (duration of critical path of assembly plan).

If $DT_{\mathrm{CP}}{}^{\mathrm{II}} > Z_{rn}$ then an alternative assembly plan must be developed (realization of assembly activities in other modes $mj2$) in order to shorten the duration of assembly plan with the aim of attaining the given due date $DT_{\mathrm{CP}}{}^{\mathrm{II}} \leq Z_{rn}$ if a timely completion of the assembly of the customer order is possible. The outputs of the second level are starting times of assembly activities that required certain item pe. These times are due dates $z_{pe,rn} = \{tp_{j2} \mid pe \in j2; \forall pe, rn\}$ of items pe that must be manufactured on third level. An assembly activity is not started until all required components are finished by the manufacturing operation.

3.3 Production scheduling model

Model terminiranja proizvodnje

The function of production scheduling is to assign operations for all released items (parts and subassemblies) on capacities according to priority of items and orders. Schedules are affected by several factors such as part priorities, due date requirements, release dates, capacity availability, technological constraints, resource requirements and resource availability. The objective of the scheduling of operations on third level is to determine the start and end times of the planned operation on items pe comprising the known time of completing the last operation and with encompassing the availability of capacities. The method is based on the known starting time of assembly activity on second level that requires parts and subassemblies from third level. That starting time is imposed as completion time of the last operation on parts and subassemblies on third level according to just-in-time principle. Operation pre-emption is not allowed.

The notation and mathematical formulation for production scheduling on third level is as follows:

t_S - actual time unit

$q_{pe,p}$ - quantity of item pe required to produce one unit of item p

$Q_{p,m}$ - quantity of item p (subassemblies, product) at order rn

$q_{pe,\mathrm{r}}$ - quantity of resource type r required to produce one unit of item pe

$q_{pe,T}$ - quantity of item pe produced for the whole plan

$q_{r,t}$ - quantity of resource type r available in time horizon t

$q_{pe,rn}^{pro}$ - quantity of item pe at order rn that is required for fabricating

$q_{pe,rn}^{s}$ - forecast quantity of waste item pe at order rn

$q_{pe,t}^{Z}$ - inventory quantity of item pe in time t

$tp_{pe,s(j3),ms,rn}^{\mathrm{III}}$ - start time of operation $s(j3)$ that succeeds to operation $j3$ on item pe (according to technological constraint),

$tp_{k,s(jk)}^{\mathrm{III}}$ - start time of operation $s(jk)$ that succeeds to operation $j3$ on the capacity k.

The objective is to minimize the total tardiness.

$$\min T_Z \tag{7}$$

subject to the set of constraints:

$$\sum_{j=1}^{jj} \sum_{mj=1}^{Mj} (t_{pe,j,mj,rn}^{\mathrm{III}} + mo_{i,j}) \cdot x_{pe,j,mj,rn} \leq z_{pe,rn} - tp_{pe,1,mj,rn}^{\mathrm{III}} \quad \forall pe \tag{8}$$

$$z_{pe,rn} = tp_{s,j2,mj2,rn}^{\mathrm{II}} \tag{9}$$

$$\sum_{j=1}^{jj} \sum_{mj=1}^{Mj} x_{pe,j,mj,rn} = 1 \quad \forall rn, pe \tag{10}$$

$$tp_{pe,1,mj,rn}^{\mathrm{III}} \geq t_s \quad \forall pe, rn \tag{11}$$

$$q_{pe,rn} = \sum_{p \in rn} q_{pe,p} \cdot Q_{p,rn} \tag{12}$$

$$\sum_{j=1}^{jj} \sum_{mj=1}^{mj} \sum_{t=1}^{T} x_{j,mj,t} \cdot pk_{j,mj,k} \leq rk_{k,t} \tag{13}$$

$$x_{j,mjt} = \begin{cases} 1 & \text{if} \quad j \in t \\ 0 & \text{if} \quad \text{otherwise} \end{cases} \tag{14}$$

$$\sum_{t}^{T} \sum_{j=1}^{jj} \sum_{mj}^{Mj} x_{j,mj} \cdot x_{j,mj,t} \cdot q_{j,mj,r} \leq Q_{r,T} \tag{15}$$

$$\sum_{pe=1}^{PE} q_{pe,r} \cdot q_{pe,T} \leq q_{r,T}, \quad \forall r \tag{16}$$

The integer period index is designated by t where period t is defined as the time interval $(t-1, t)$, $t = 1,2,...,T$.

Constraint (8) defines that the summation of operation times and interoperation times must be less than or equal to the difference between due date $z_{pe,m}$ and starting time of first operation of component *pe*. In constraint (9) due date $z_{pe,m}$ for components of order *rn* that are fabricated on third level is imposed by starting time $tp^{\mathrm{II}}_{s,j2,mj2,rn}$ of assembly activity *j*2 on second level which requires these components (parts and subassemblies). Constraint (10) ensures that each operation *j* at each order *rn* is performed in only one mode *mj*. Constraint (11) guarantees that the starting time of first operation of component *pe* is greater than or equal to actual time t_s. Constraint (12) defines gross requirements for item *pe* at order *rn*. Constraint (13) and (14) enforces capacities requirements by ensuring that no operations will need more capacities of type k than are available. Constraint (15) ensures that total quantity of renewable resources (e.g. tool, mechanization) for the whole schedule does not exceed available resources of type *r*. Constraint (16) guarantees that the consumption of total requirements quantity of non-renewable resources (e.g. material) does not exceed available resources in time horizon *T*.

4 Algorithm
Algoritam

Each item type *pe* that must be fabricated on the third level has a known set of operations according to technological routings. Operations are supposed to be executed in increasing order of operations indices. Operations are assigned to capacities according to defined priority of items type *pe*. Plans are generated taking into account the current status of the capacities. The following algorithm is developed in the paper.

1. Calculate quantity of item *pe* that is required.
   $q^{pro}_{pe,rn} = \max\left[0, \left(q_{pe,rn} + q^{s}_{pe,rn}\right) - q^{Z}_{pe,t}\right]$
2. The resource availability checking. If $R^{rasp}_{r,t} \geq R^{pot}_{r,t}$ then available resources of type *r* at time unit *t* exist and parts and subassemblies can be put into production ($R^{rasp}_{r,t}$ - available resources of type *r* at time unit *t*; $R^{pot}_{r,t}$ - required resources of type *r* at time unit *t*).
3. Generate the list of operations of releasing *pe*. Operations on the list are available for scheduling according to defined priorities and technological constraints with checking of capacities' availability. Calculate available capacity *k* for time period *t* $K^{rasp}_{k,t}$.
4. Take the next *pe* from the list (according to priority).
5. Start with last operation on each *pe*: $j3 = jj3$.
6. Check the required capacity availability for the operation ($K^{rasp}_{k,t}$ - available capacity *k* for time period *t*; $K^{pot}_{k,t}$ - required capacity *k* for time period *t*). If $K^{rasp}_{k,t} \geq K^{pot}_{k,t}$, then operation *j*3 is assigned to capacity. Otherwise, the operation waits till the capacity becomes free. Whenever a capacity is ready, schedule the operation of the list which is available for processing, according to priority. The completion time for the last operation *jj*3 on capacity *k* is equal to the minimum of the due date $z_{pe,m}$ and start time of operation *s*(*jk*) that succeeds to operation *jj*3 on capacity *k*. The completion time of all preceding operation *j*3 is equal to the minimum of the start time of operation that succeeds to operation *j*3 and start time of succeeding operation on capacity *k*.
   $tz^{\mathrm{III}}_{pe,jj3,mjj3,rn} = \min\left(z_{pe,rn}, tp^{\mathrm{III}}_{k,s(jk)}\right)$

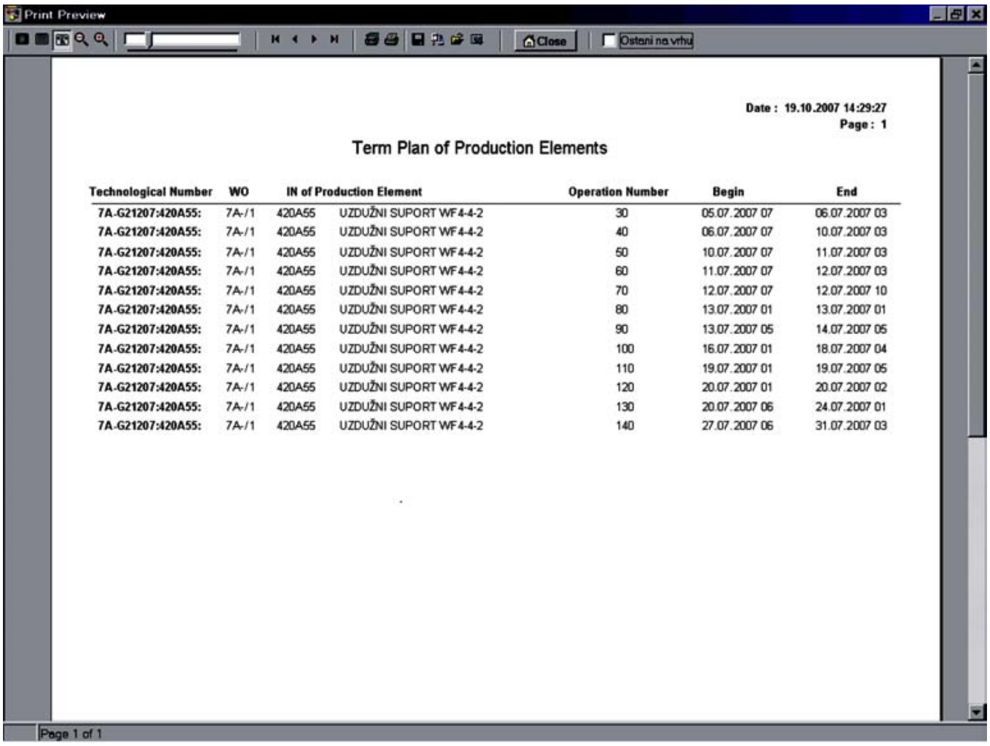
   For other operations on item pe completion time is determined according to:
   $tz^{\mathrm{III}}_{pe,j3,mj,rn} = \min\left(tp^{\mathrm{III}}_{pe,s(j3),m,rn} - mo_{j3,s(j3)}, tp^{\mathrm{III}}_{k,s(jk)}\right)$
   $tp^{\mathrm{III}}_{pe,j3,mj3,rn} = tz^{\mathrm{III}}_{pe,j3,mj3,rn} - t^{\mathrm{III}}_{pe,j3,mj3,rn}$
7. Update the available capacity:
   $K^{rasp}_{k,t} = K^{rasp}_{k,t} - K^{pot}_{j3,k,t} \cdot x_{j3,t}$
   $x_{j3,t} = \begin{cases} 1 & \text{if} \quad j3 \in t \\ 0 & \text{if} \quad j3 \notin t \end{cases}$
   and calculate new state of resource availability.
8. Take the next operation on *pe* from the list: $j3 = j3 - 1$.
9. Check if all operations on item *pe* are scheduled; delete the scheduled *pe* from the list and check if all items *pe* are scheduled; (check if $tp^{\mathrm{III}}_{pe,rn} \leq t_S$; generate new schedule with other modes of operations (alternative capacities); if $tp^{\mathrm{III}}_{pe,rn} \geq t_S$ it is feasible schedule); otherwise go to step (4); if all operations on item *pe* are not scheduled go to step (6).

5 The model implementation into ERPINS system
Implementacija modela u sustav ERPINS

Costly, complex and software demanding ERP systems are not available to small and midsize companies, especially if some peculiarities exist and the ERP system has to be customized [55]. Therefore to satisfy the needs of one-piece and small-scale production

ERPINS[2], Croatian solution of ERP system has been developed, adjusted to suit the specifics of Croatian manufacturers. The mathematical model of hierarchical planning and scheduling presented above has been built into ERPINS system. Some screenshots of the developed planning and scheduling system are given below.

[2] Enterprise Resource Planning ININ Solution, ERP software by ININ plc, Slavonski Brod, www.inin.hr



Print Preview

Ostani na vrhu

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Page : 1

Term Plan of Production Elements

Technological Number	WO	IN of Production Element		Operation Number	Begin	End
7A-G21207:420A55:	7A-/1	420A55	UZDUŽNI SUPORT WF4-4-2	30	05.07.2007 07	06.07.2007 03
7A-G21207:420A55:	7A-/1	420A55	UZDUŽNI SUPORT WF4-4-2	40	06.07.2007 07	10.07.2007 03
7A-G21207:420A55:	7A-/1	420A55	UZDUŽNI SUPORT WF4-4-2	50	10.07.2007 07	11.07.2007 03
7A-G21207:420A55:	7A-/1	420A55	UZDUŽNI SUPORT WF4-4-2	60	11.07.2007 07	12.07.2007 03
7A-G21207:420A55:	7A-/1	420A55	UZDUŽNI SUPORT WF4-4-2	70	12.07.2007 07	12.07.2007 10
7A-G21207:420A55:	7A-/1	420A55	UZDUŽNI SUPORT WF4-4-2	80	13.07.2007 01	13.07.2007 01
7A-G21207:420A55:	7A-/1	420A55	UZDUŽNI SUPORT WF4-4-2	90	13.07.2007 05	14.07.2007 05
7A-G21207:420A55:	7A-/1	420A55	UZDUŽNI SUPORT WF4-4-2	100	16.07.2007 01	18.07.2007 04
7A-G21207:420A55:	7A-/1	420A55	UZDUŽNI SUPORT WF4-4-2	110	19.07.2007 01	19.07.2007 05
7A-G21207:420A55:	7A-/1	420A55	UZDUŽNI SUPORT WF4-4-2	120	20.07.2007 01	20.07.2007 02
7A-G21207:420A55:	7A-/1	420A55	UZDUŽNI SUPORT WF4-4-2	130	20.07.2007 06	24.07.2007 01
7A-G21207:420A55:	7A-/1	420A55	UZDUŽNI SUPORT WF4-4-2	140	27.07.2007 06	31.07.2007 03

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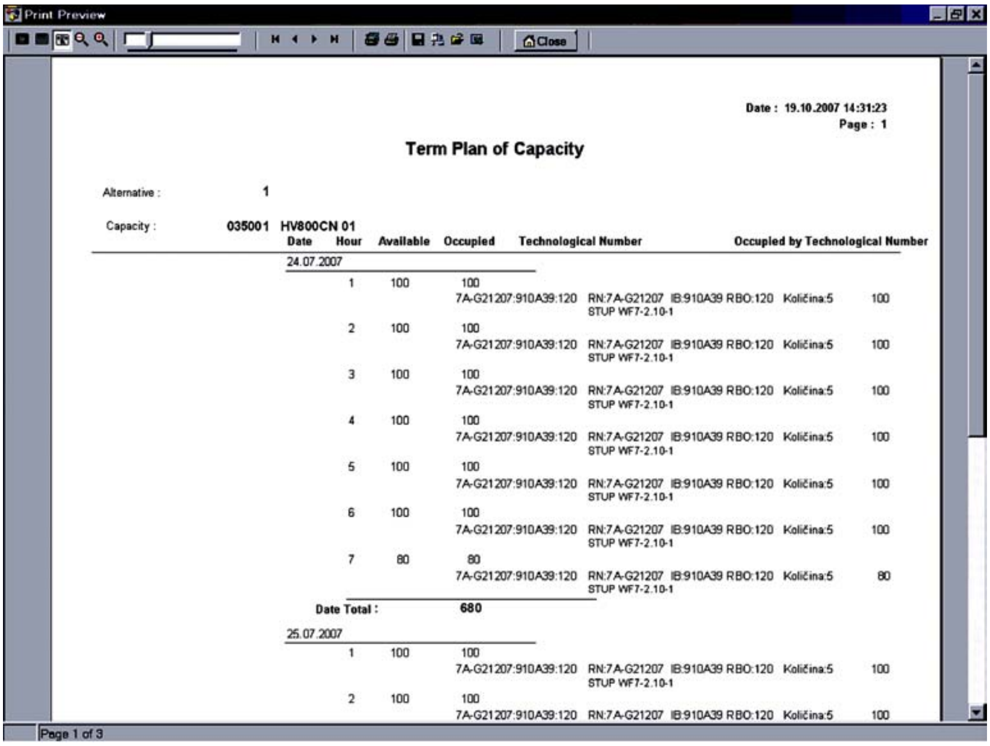
Figure 3. Work schedule for selected part
Slika 3. Termin plan izrade izabranog dijela



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Term Plan of Capacity

Alternative : 1

Capacity : 035001 HV800CN 01

Date	Hour	Available	Occupied	Technological Number		Occupied by Technological Number
24.07.2007						
	1	100	100	7A-G21207:910A39:120	RN:7A-G21207 IB:910A39 RBO:120 Količina:5 STUP WF7-2.10-1	100
	2	100	100	7A-G21207:910A39:120	RN:7A-G21207 IB:910A39 RBO:120 Količina:5 STUP WF7-2.10-1	100
	3	100	100	7A-G21207:910A39:120	RN:7A-G21207 IB:910A39 RBO:120 Količina:5 STUP WF7-2.10-1	100
	4	100	100	7A-G21207:910A39:120	RN:7A-G21207 IB:910A39 RBO:120 Količina:5 STUP WF7-2.10-1	100
	5	100	100	7A-G21207:910A39:120	RN:7A-G21207 IB:910A39 RBO:120 Količina:5 STUP WF7-2.10-1	100
	6	100	100	7A-G21207:910A39:120	RN:7A-G21207 IB:910A39 RBO:120 Količina:5 STUP WF7-2.10-1	100
	7	80	80	7A-G21207:910A39:120	RN:7A-G21207 IB:910A39 RBO:120 Količina:5 STUP WF7-2.10-1	80
Date Total :			680			
25.07.2007						
	1	100	100	7A-G21207:910A39:120	RN:7A-G21207 IB:910A39 RBO:120 Količina:5 STUP WF7-2.10-1	100
	2	100	100	7A-G21207:910A39:120	RN:7A-G21207 IB:910A39 RBO:120 Količina:5	100

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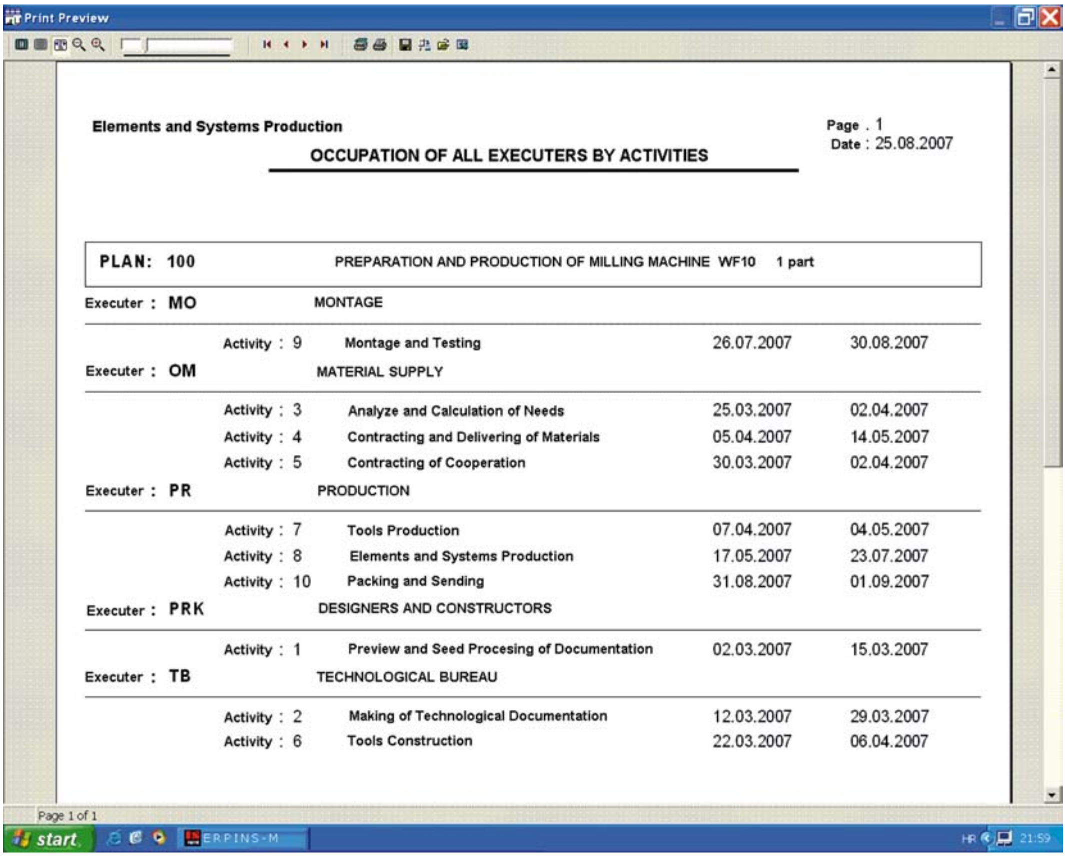
Figure 4. Term plan for workplace WP= 0350001 and date 24.07.2007.
Slika 4. Termin plan za radno mjesto RM=0350001 za 24.07.2007.


Print Preview

Elements and Systems Production

Page . 1
Date : 25.08.2007

OCCUPATION OF ALL EXECUTERS BY ACTIVITIES

PLAN: 100 PREPARATION AND PRODUCTION OF MILLING MACHINE WF10 1 part

Executer	Activity	Description	Start	End
MO		MONTAGE		
	9	Montage and Testing	26.07.2007	30.08.2007
OM		MATERIAL SUPPLY		
	3	Analyze and Calculation of Needs	25.03.2007	02.04.2007
	4	Contracting and Delivering of Materials	05.04.2007	14.05.2007
	5	Contracting of Cooperation	30.03.2007	02.04.2007
PR		PRODUCTION		
	7	Tools Production	07.04.2007	04.05.2007
	8	Elements and Systems Production	17.05.2007	23.07.2007
	10	Packing and Sending	31.08.2007	01.09.2007
PRK		DESIGNERS AND CONSTRUCTORS		
	1	Preview and Seed Procesing of Documentation	02.03.2007	15.03.2007
TB		TECHNOLOGICAL BUREAU		
	2	Making of Technological Documentation	12.03.2007	29.03.2007
	6	Tools Construction	22.03.2007	06.04.2007

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Figure 5. Basic plans for work order RN=23 participants
Slika 5. Osnovni planovi po sudionicima na radnom nalogu RN=23

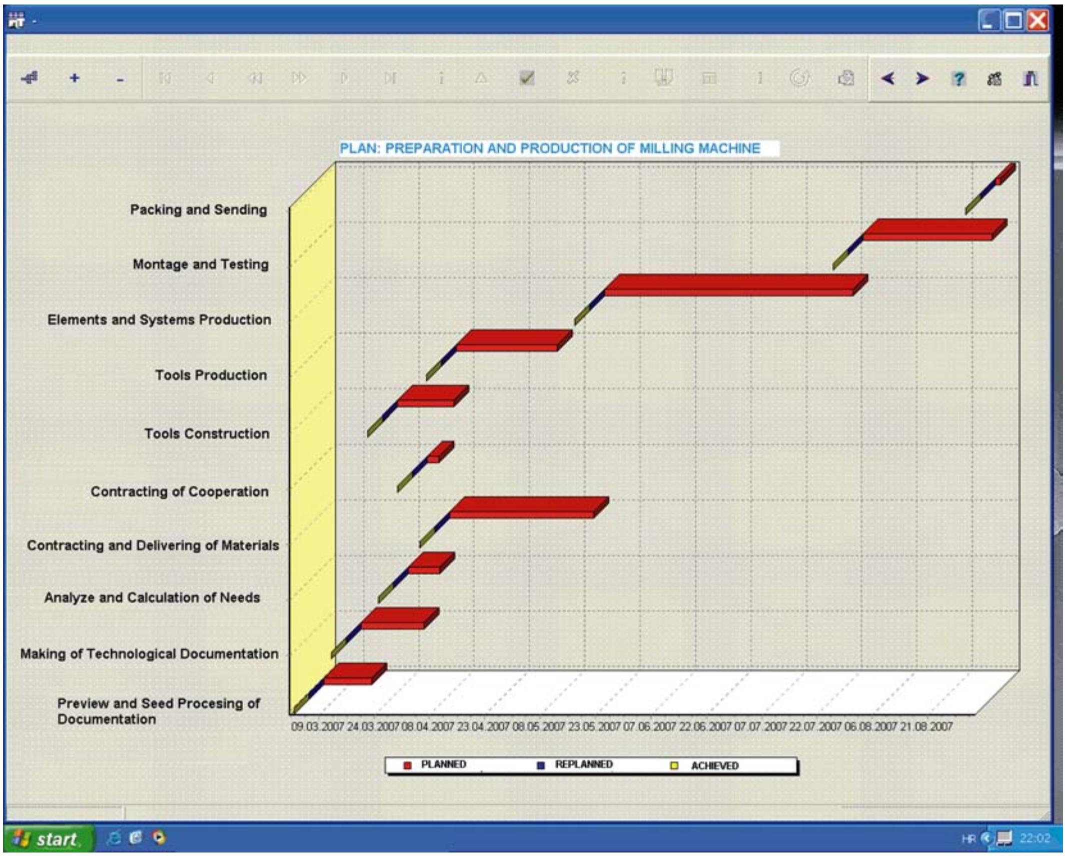

Figure 6. Graphic presentation of the plan for work order RN=23
Slika 6. Graf plana za radni nalog RN=23

6 Conclusion
Zaključak

Supply chain coordination is of crucial importance in various industries. Ever more intensive global market competence and market demands to meet individual customers' needs through customized products, diversity of demands and rapid technological development exert increasing pressure on manufacturers. Products become more complex with a constantly growing number of variants, ever-shorter time duration of production and product lifecycles. It becomes necessary to reduce production series and introduce a make-to-order production system in an attempt to make products that satisfy customer specific needs, in limited quantities and short production cycles with just-in-time delivery. At the current level of market competence enterprises are to get organized in effective networks of production systems in order to meet market demands. This can only be achieved by the application of production management information systems aimed at coordinating different manufacturing units. ERP system provides managers with accurate information quickly and enables them to make the best possible decisions. It has turned out to be an effective way for planning and managing all resources in an enterprise. What is more, it has an important role in supply chain management. The paper has demonstrated ERP system application to internal supply chain coordination. It has also defined the concept of hierarchical planning and scheduling for internal supply chain scheduling of a manufacturer, i.e. to a part only of the entire supply chain. The authors have presented a model for improving the performance of internal supply chain processes by coordinating three levels of planning and scheduling in just-in-time environment with regard to quantities and dates. The model has been implemented into ERP system called ERPINS. Future research will focus on the development of a mathematical model for the entire supply chain.

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