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Razvoj generične strukture in programskih modulov elementarnega delovnega sistema porazdeljenega tiskanja

Development of the Generic Structure and Programming Modules of an Elementary Work System for Distributed Printing

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Uveljavljena organizacija proizvodnih sistemov ni več skladna s potrebami današnjega tržnega okolja. Odgovor današnjim proizvodnim potrebam, kot posledice globalizacije in razvoja sodobnih informacijsko komunikacijskih tehnologij, so porajajoči novi vzorci proizvodnih sistemov. Med njimi so najbolj prepoznavni Holonski, Bionični[1], fraktalna tovarna ter zahtevni prilagodljivi proizvodni sistemi (ZPPS).

Pričujoči prispevek predstavlja zasnovo in tehnično rešitev porazdeljenega proizvodnega problema skladno z opredelitvami proizvodnih danosti in razmerij med njimi, kakor jih definira vzorec ZPPS. V rešitvi so uporabljene moderne informacijsko komunikacijske tehnologije (IKT) za uvajanje porazdeljenih informacijskih rešitev. Razvit je sistem porazdeljenega označevanja izdelkov za podjetje, razprostranjeno po več državah. Zamisel sistema, definirana v vzorcu ZPPS in izveden v tem delu, omogoča geografsko razširitev do poljubnih meja. Uporaba sodobnih informacijsko-komunikacijskih tehnologij omogoča funkcionalno razširitev do meja, omejenih samo s potrebami označevanja izdelkov.

(Ključne besede: sistemi proizvodni, kooperacija, sistemi delovni, strukture dejavne)

The traditional manufacturing system paradigm has deficiencies in the modern, global world related to market demands, which are changing so quickly that only the most agile manufacturers can follow them. In response, new manufacturing paradigms have evolved in recent decades. Of these, the holonic, bionic, fractal factory and complex adaptive manufacturing systems (CAMS) paradigms are the most popular.

CAMS principles are being used and CAMS objects (virtual work systems) are built in order to deliver a distributed solution for product labeling at various levels in a company that has production plants around Europe. Modern information and communication technologies (ICTs) are being utilized to build a system that produces labels at n locations based on the demands from m places. It is the company's policy, not the concept or the implementation issues, that limits the size and the functionality of the presented labeling system in a distributed environment.

(Keywords: manufacturing systems, cooperation, work systems, agent structure)

0 UVOD

Za današnjo produktivnost in kakovost proizvodnih postopkov je ključnih nekaj mejnikov. Proizvodnja devetnajstega stoletja je še obrtniškega značaja. V začetku dvajsetega stoletja Adam Smith utemelji proizvodni vzorec industrijske proizvodnje. V zadnjem delu dvajsetega stoletja nastajajo novi proizvodni vzorci kot odgovor na

0 INTRODUCTION

Several milestones have marked the way towards the current performance of manufacturing systems. In the 19th century, only craftsman-type manufacturing existed. At the beginning of the 20th century, Adam Smith laid the foundations for the industrial manufacturing paradigm, and at the end of the 20th century, new manufacturing paradigms evolved

[1] Izraz holonski je pridevniška oblika izraza "holon", ki ga je Arthur Koestler predlagal l.1989 v knjigi The Ghost in the Machine. Izraz holon je sestavljenka grških besed holos=celota in proton=del. Izraz bionični se nanaša na bioniko, t.j. na nauk med biologijo in tehniko, ki tehnična vprašanja rešuje po zgledih iz narave.

splošen napredek (in s tem povezane spremembe) in kot odgovor na nove možnosti za dejansko organizacijo in za izvedbo proizvodnih postopkov. Proizvodni postopki so tudi vedno bolj informacijsko podprti.

Petdeseta leta prejšnjega stoletja zaznamujejo prvi objektno grajeni programski prevajalniki, predhodniki današnjih objektnih programskih jezikov. Sodelava strojne in programske opreme je v zadnjih desetih letih omogočila izdelavo obsežnih informacijsko-komunikacijskih sistemov, znanilnikov prehoda iz industrijske v informacijsko oziroma poindustrijsko družbo.

Strojniški napredek (hiter in razmeroma cenen prevoz - letala, velike ladje, hitri vlaki) in komunikacijski napredek (splet, zanesljivo telefonsko omrežje) sta omogočila globalizacijo. Organizacijske in ekonomske vede postavljajo nove vzorce organizacij in ekonomije v novem okolju. Novo okolje se od starega razlikuje po raznolikosti sodelujočih kultur in po geografski razprostranjenosti enega samega gospodarsko - ekonomsko - ekološko - sociološkega sistema, ki je naenkrat nastal iz več manjših slabo povezanih sistemov z majhnim medsebojnim vplivom. V novem okolju je mogoča (in ekonomsko upravičena) izdelava in prodaja večjih serij izdelkov, delno lokaliziranih za posamezna tržišča. Proizvodnja se seli na področja z optimalno kombinacijo cene dela, še zadovoljive kulture dela in majhne oddaljenosti izdelkov od tržišč. Prodajni, razvojni in proizvodni sistemi postajajo porazdeljeni. Hitra dinamika globalnega mesta narekuje prilagodljivost sedanjih in prihodnjih proizvodnih sistemov.

V tem prispevku z uporabo sodobnih informacijsko komunikacijskih tehnologij rešujemo problem označevanja izdelkov, torej sledljivosti izdelkov v porazdeljeni proizvodnji globalno delujočega podjetja. Porazdeljeno proizvodnjo strukturiramo po vzorcu ZPPS [1].

1 TEORIJA

1.1 Zapleteni prilagodljivi proizvodni sistem (ZPPS)

Proizvodni sistemi novih generacij se odzivajo na zahteve trga. Načrtna proizvodnja je stvar preteklosti, hiter odziv na spremembo tržnih razmer je nujno potreben. Raznolikost izdelkov (tržne zahteve), inovacije oz. izboljšave (za zmanjšanje

in a response to general progress (and changes related to it), and as a response to new possibilities for the effective organization and for the implementation of manufacturing systems, mainly driven by contemporary information and communication technologies (ICTs).

In the 1950s the first object-built program compilers emerged - they were the predecessors of the current object-oriented programming languages. The synergy of hardware and software in the past ten years allowed the development of large information and communication systems - the precursors of the transition from the industrial society to the information society (i.e., post-industrial society).

Technical progress (for example, in logistics, i.e., fast and cost-effective transport by airplanes, large ships, fast trains and a network of motorways) and progress in communications (for example, the internet and a reliable phone network) made globalization possible. Organizational and economic sciences set new paradigms for organizations and the economy in the new environment. The new environment differs from the old one in the diversity of the participating cultures and in the geographic diffusion of a single business-economy-social system, which evolved from several smaller loosely linked systems with weak interactions. The new environment allows for economically justified manufacturing and the sale of products in larger series, partially localized for individual markets. Manufacturing is being transferred into regions with an optimal combination of labor cost, acceptable labor culture and a short distance between the products and the markets. Sales, development and manufacturing systems are becoming distributed. The fast dynamics of globalization calls for the adaptability of current and future manufacturing systems.

In this paper a solution for the labeling of products (by using contemporary ICT) is described, which also allows the traceability of products in the distributed manufacturing of a globally operating company. The CAMS paradigm, as defined by Peklenik [1], has been used to set up the distributed manufacturing structure.

1 BACKGROUND

1.1 Complex Adaptive Manufacturing System (CAMS)

New-generation manufacturing systems respond quickly to market demands. Planned production is a matter of the past; a quick response to market changes is essential. Product diversity (due to market demands), improvements and innovations stroškov ali za dodatno funkcionalnost) vodijo v zmanjševanje serij in v vse večjo zapletenost in zahtevnost proizvodnje. Hiter odziv na zahteve trga zagotavlja konkurenčno prednost in s tem tudi tržno prevlado.

Pomembne lastnosti sistema, ki izpolnjuje zahteve proizvodnih sistemov nove generacije, so [1]:
- prilagodljiva organizacijska struktura,
- podprtost postopka odločanja s kakovostnim in dobro vpeljanim informacijskim sistemom,
- ključne odločitve sprejema usposobljen osebek, oz. fizična oseba oz. načrtovalec postopkov, operater ali vodja skupine.

Za konkurenčnost na trgu je bistvena hitrost oziroma kratek reakcijski čas za tržne spremembe in spremembe v okolju. Gornje lastnosti proizvodnemu sistemu omogočajo hitro odzivanje.

Glavno vlogo pri doseganju razgibanosti proizvodnih dejavnosti zahtevnih prilagodljivih proizvodnih sistemov ima osebek s svojim znanjem in izkušnjami (pristojnost) pri opravljanju predpisanih del.

Generični model tovarne, kot proizvodni sistem novih generacij, je definiral Peklenik ([1] in [2]). Tovarna je strukturirana kot trinivojski zahtevni prilagodljivi proizvodni sistem, ki je sestavljen iz podsistemov s svojskimi funkcijami in lastnostmi. Le ti so uvajani v obliki med seboj povezanih osnovnih delovnih sistemov (ODS) različnih tipov. Vsak izmed ODS uvaja en delovni postopek (npr. načrtovanje, struženje, nadzor). ODS so povezani materialno (obdelovanci prehajajo med ODS) in informacijsko preko svojih informacijskih zastopnikov oz. dejavnikov oz. virtualnih delovnih sistemov (VDS) [3].

1.2 Moderne informacijsko komunikacijske tehnologije

Sodobni programski jeziki so C++, objektni Pascal in Java. Sodobni Operacijski Sistemi (OS) so Unix, Linux in Win32 sistemi oziroma MS Okna. Za zadnjih deset let je značilen izbruh komunikacijskih tehnologij. Nekatere se odlično dopolnjujejo, druge se popolnoma izključujejo [4]. Tretje so narejene zato, da omogočajo komunikacijo med sicer nezdružljivimi programskimi komponentami. V preglednem naboru tehnologij se omejujemo na tiste, ki so potrebne za usposobljeno uvajanje

(for the reduction of costs or for additional functionality) lead to smaller series and to the ever-increasing complexity of manufacturing. A faster response to market requirements ensures competitive advantage and thus market dominance.

A system that fulfils the requirements of a new generation of manufacturing systems should have the following important features [1]:
- an adaptive organizational structure
- a decision-support process should be implemented by using a high-quality and properly organized information system
- key decisions are made by a competent person, i.e., a procedure planner, operator or team leader.

A fast response to time-to-market changes and to changes in the environment is essential in order to retain a competitive advantage. The features mentioned above facilitate the fast response of a manufacturing system.

The person, using his/her knowledge and experience (competence) during his/her prescribed work, has the main role in achieving the dynamics of manufacturing activities for complex adaptive manufacturing systems.

A generic model of a factory as a new generation of manufacturing system was defined by Peklenik ([1] and [2]). It is structured as a three-level complex adaptive manufacturing system and consists of subsystems with specific functions and features. These are implemented in the form of mutually interlinked elementary work systems (EWS) of various types. Each EWS implements one work process (e.g., planning, product development, design, cutting). EWSs are linked material-wise (workpieces pass between EWSs) and information-wise (by their information agents, i.e., virtual work systems (VWS) [3]).

1.2 Modern Information and Communication Technologies

The modern programming languages are C++, object Pascal and Java. The modern operating systems (OSs) are Unix, Linux and Win32 systems (i.e., MS Windows). The past ten years have been characterized by a boom in new communication technologies. Some of them supplement each other perfectly, while others are mutually exclusive [4]. The third type of technology has been built in order to allow communications between otherwise incompatible programming components. Our overview of technologies is limited to those that are needed for a proper implementation of porazdeljenega proizvodnega sistema po načelih vzorca ZPPS.

Za razvoj porazdeljenih uporab obstoji več modelov (in istoimenskih tehnologij uvajanja), od katerih prednjačijo trije:

COM/DCOM/.NET (objektni model komponent/objektni model porazdeljenih komponent/mreža). To je model največjega proizvajalca programske opreme, Microsofta.

CORBA (arhitektura posrednikov zahtev skupnih objektov). To je model, katerega specifikacijo in podporno tehnologijo je skupaj pripravljalo in podprlo več ko 800 proizvajalcev z vsega sveta.

SOAP (standard za spletne storitve). To je standardizacija dostopa ter uporabe metod objektov specifičnih izvedb modelov COM in CORBA).

Vodilna pri postavljanju integracijskih standardov sta Sun z Javo in Web Services ter Microsoft s C# ter okoljem .NET.

Oba postopka, CORBA in .NET, imata svoje prednosti in pomanjkljivosti, predvsem glede na hitrost delovanja ter na prenosljivost programa. Vsi proizvajalci programske opreme sprejemajo tudi standarde XML in SOAP, katere postavlja skupnost W3C. Uporabnikom in načrtovalcem sistemov niti ni pomembno, kateri od obeh postopkov bo prevladal, saj bosta lahko predvsem zaradi standardizacije protokolov klicev oddaljenih funkcij ter uporabe tako imenovanih servisov oba postopka kljub različnemu ozadju lahko sodelovala v enovitih velikih porazdeljenih sistemih.

2 NAČRTOVANJE PORAZDELJENEGA SISTEMA TISKANJA

Postopek porazdeljenega tiskanja z m mest zahtevanja in z n mest tiskanja strukturiramo po vzorcu ZPPS v ODS zahtevanja in v izvedbi tiskanja ODS. ODS se sporazumevajo preko VDS, svojih zastopnikov v informacijskem okolju. VDS je strukturiran kot programski dejavnik (sl. 1).

Prenos podatkov med ODS in VDS pa poteka preko ustreznih vmesnikov. Zahtevanja ODS tiskanja so strukturirana kot posredniki. Njihove lastnosti so:

- zmožnost ustanovitve virtualne delovne skupine (grozdenje) in
- znotraj nje koordinacija celotnega opravila.

VDS vseh ODS, tako zahtevanja kakor izvedbe tiskanja, so sestavljeni iz štirih osnovnih

a distributed manufacturing system in accordance with the CAMS paradigm principles.

Several models (and implementation technologies) are used for the development of distributed applications; three of them prevail:

COM/DCOM/.NET (Component Object Model / Distributed Component Object Model / Net). This is the Microsoft's model.

CORBA (Common Object Request Broker Architecture). The specification and supporting technology of this model have been jointly prepared and supported by more than 800 companies from all over the world.

SOAP (Simple Object Access Protocol) model. This is standardization of access and use of object methods of various implementations of COM and CORBA models.

The leading companies that set the integration standards are Sun (Java and Web Services) and Microsoft (C# and .NET environment).

Both CORBA and .NET have their advantages and drawbacks, especially with respect to the speed of execution and the portability of the code. All software developers also accept the XML and SOAP standards set by the W3C consortium. For the users and system planners it is not really important which of these methods will prevail, because, due to the standardization of remote-function call protocols and due to the use of services, both methods will be able to cooperate in large uniform distributed systems despite their different backgrounds.

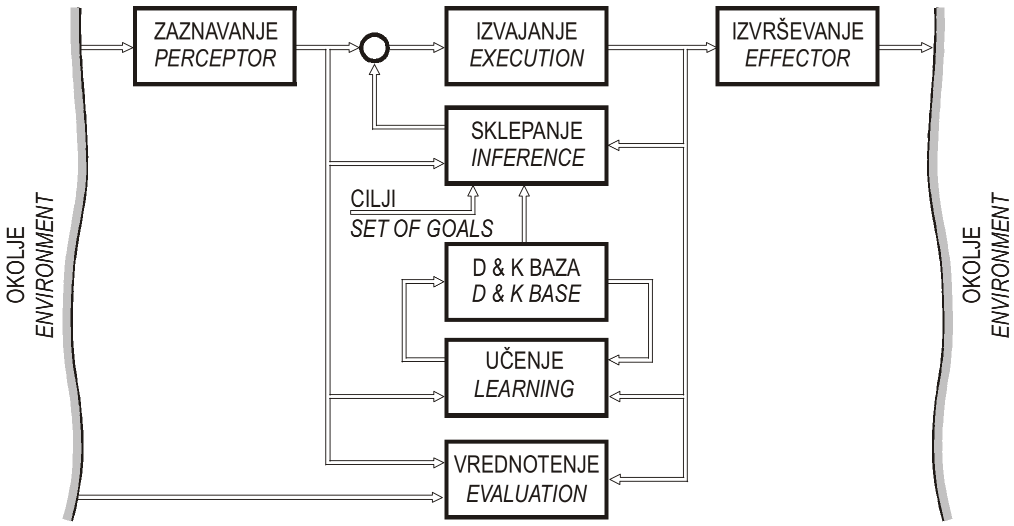
2 DISTRIBUTED PRINTING SYSTEM DESIGN

The process of distributed printing, based on the demands from m places and n printing locations, should be structured in accordance with the CAMS paradigm to the EWSs of demands and to the EWSs of printing locations. EWSs communicate via VWSs - these being their agents in the IT environment. A VWS has a structure of a software agent (Fig. 1).

Data between the EWS and the VWS are transferred via interfaces. The EWSs of printing demands are structured as mediators. Their features are:

- the capability of establishing a virtual workgroup (clustering),
- the coordination of the complete task within the workgroup.

The VWSs of all the EWSs (both those on demand and the execution of printing) consist of



Sl. 1. *Generična struktura dejavnika VDS [5]*
Fig. 1. *Generic VWS agent structure [5]*

elementov [5]:
- dojemanja,
- izvršilnega elementa,
- posledice in
- mehanizma sklepanja.

Vloga dojemanja (sl. 1) je v opazovanju dogajanja v informacijski mreži z razpoznavanjem zanj bistvenih informacij, ki jih posreduje izvršilnemu elementu.

Element izvajanja opravi zadano nalogo in preda rezultate posledični stopnji, ki jih sporoča nazaj v informacijsko mrežo. Mehanizem sklepanja nadzira postopke elementa izvajanja. Sklepanje temelji na podlagi znanih podatkov, učenja ter ciljev.

Posredniki, dejavniki porazdelitvenih zahtev tiskanja, v informacijski mreži iščejo tiste porazdeljene dejavnike ODS tiskanja, katerih ODS so tehnološko zmožni izvesti zahtevano tiskanje v zahtevani količini in v zahtevanem časovnem roku. Postopek iskanja rešitve naloge je sestavljen iz treh faz:

Ponujanje: V tej, prvi fazi posrednik oblikuje zahtevo po izpolnitvi naloge. Vsi dejavniki, ki imajo funkcionalne zmožnosti, odgovorijo s ponudbo. Nastane dinamična skupina medsebojno konkurenčnih dejavnikov ponudbe tiskanja.

Pogajanje: Posrednik začne pogajanje z VDS tiskanja. V sklopu pogajalske funkcije išče posrednik skupni optimum za izvajanje opravila, medtem ko posamezni dejavniki optimirajo lokalno opravilo. Pogajanje se krožno ponavlja, dokler posrednik ne ugotovi, da rešitev ustreza zahtevam opravila (s sprejemljivimi odstopanji).

four basic elements [5]:
- preceptor,
- executing element,
- effector,
- inference mechanism.

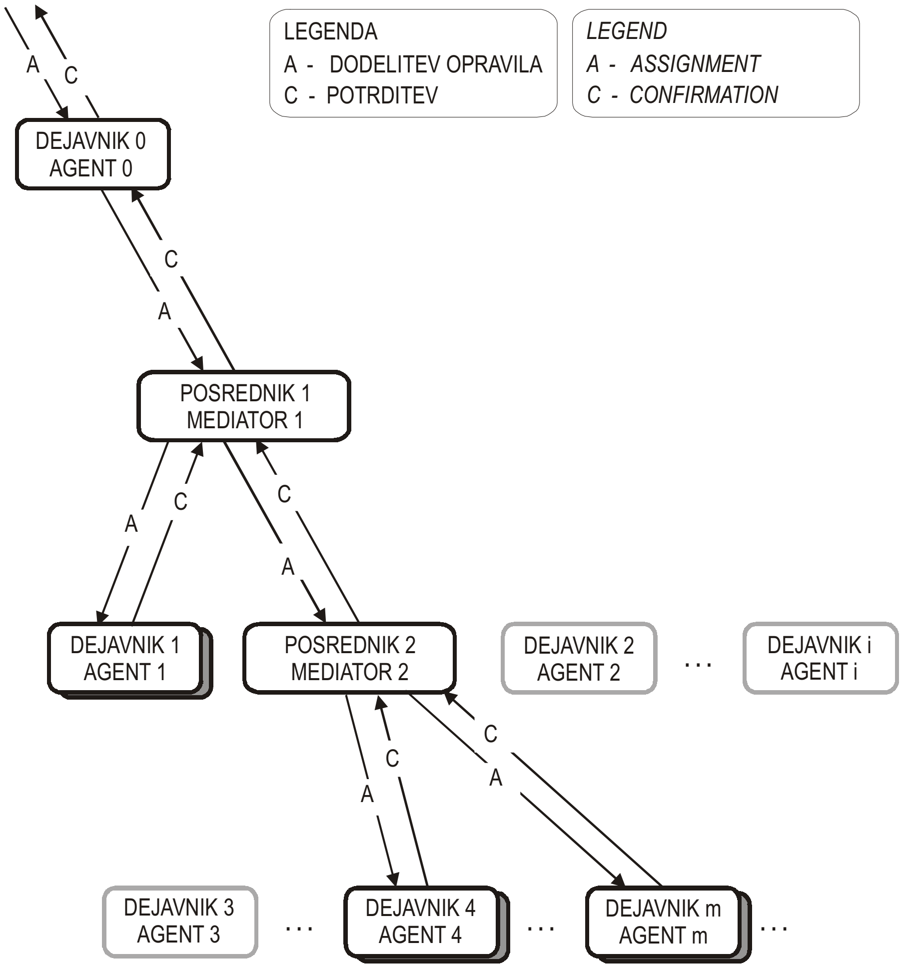
The role of a perceptor (Fig. 1) is to monitor the information network and to recognize the relevant data, which should be sent to the executing element.

The executing element performs the task given and forwards the results to the effector, which sends them back to the information network. The inference mechanism controls the executing element processes. Inference is based on the known data, learning and goals.

Mediators - agents of distributed printing demands - search those distributed agents of the printing EWSs in the information network, whose EWSs have technical capacities to perform the requested printing job in the requested volume and within the required time frame. The solution-finding process consists of three phases:

Offer: In this first phase the mediator forms a request for fulfilling the task. All agents that possess the required functional capabilities respond by sending an offer. Thus, a dynamic group of mutually competitive agents for the print offer is created.

Negotiating: The mediator starts negotiations with printing VWSs. Within the negotiating function the mediator tries to find the overall optimum for performing the task, while individual agents optimize the local tasks. Negotiations are cyclically repeated until the mediator finds a solution that fulfills the task requests (within acceptable tolerances).



Sl. 2. *Dinamična skupina dejavnikov v postopku dogovarjanja [5]*
Fig. 2. *Dynamic group of agents in the mediation process [5]*

Sklepanje dogovora: Posrednik dodeli opravila izbranim dejavnikom tiskanja, ki potrdijo veljavnost dodelitve in potem opravilo tudi opravijo.

Postopek usklajevanja med VDS zahtevkov in tiskanja se začne takoj, ko se v okolju pojavi novo, še ne opravljeno opravilo in kadar se pojavi motnja v izvajanju že dodeljenih opravil.

Uvajanje porazdeljenega sistema tiskanja z modernimi IKT v vzorcu ZPPS poteka na ravni uvajanja VDS, zastopnikov ODS in integracije VDS z informacijskim okoljem in z ustreznimi EDSi.

2.1 Uvajanje mreže zahtevkov VDS in tiskanja VDS

Vzorec ZPPS za reševanje porazdeljenih proizvodnih problemov ponuja a) obliko dejanskega

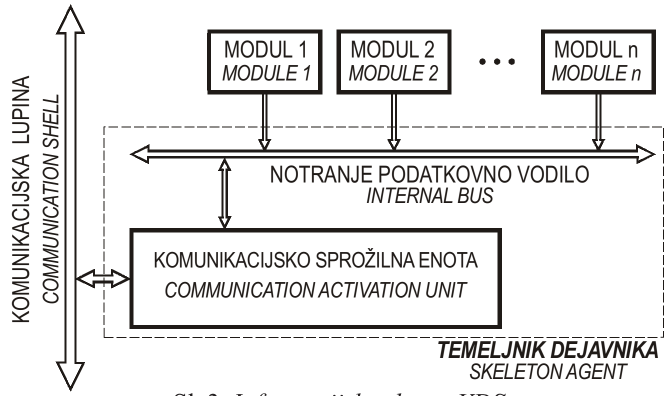
Agreement-making: The mediator assigns the tasks to the selected printing agents, who confirm the validity of the assignment and then they perform the task.

The process of coordination between the VWSs of demands and the VWSs of printing starts as soon as a new task appears, or in case of a disturbance, during the execution of previously assigned tasks.

Implementation of a distributed printing system using a modern ICT with the CAMS paradigm occurs on the level of the implementation of the VWSs, the EWS representatives and the integration of the VWSs with the information environment and with appropriate EWSs.

2.1 Implementation of a network of demand VWSs and printing VWSs

Using the CAMS paradigm for solving distributed manufacturing problems, one obtains a)



Sl. 3. *Informacijska shema VDS*
Fig. 3. *VWS information scheme*

strukturiranja problema, b) vsebino posameznih gradnikov (ODS, VDS), in c) vsebino informacijskih tokov med njimi. Moderne IKT pa predstavljajo potrebno komunikacijsko infrastrukturo in ponujajo potrebna orodja za reševanje praktičnih porazdeljenih proizvodnih problemov.

VDS zahtevkov in tiskanja so sestavljeni iz osnovnega gradnika - imenujemo ga temeljnik dejavnika - in iz nanj pripetih različnih delovnih modulov (sl. 3).

Temeljnik dejavnika s svojim naborom metod:
- se sporazumeva s temeljniki drugih VDS v informacijski mreži in
- omogoča vključitev različnih delavnosti v VDS za zastopanje različnih ODS tiskanja z uporabo različnih modulov.

Temeljnik VDS sestoji iz (sl. 3):
- komunikacijsko sprožilne enote in iz
- notranjega podatkovnega vodila.

Komunikacijsko sprožilna enota omogoča delavnost temeljnika VDS. Interno podatkovno vodilo omogoča notranji prenos sporočil med moduli in temeljnik dejavnika.

Pomemben del strukture VDS je namenjen tudi povezovanju z ustreznim ODS.

2.2 Delavni moduli VDS

Delavni moduli so sklenjene programske enote, v katerih izpeljemo različne delavnosti VDS:
- načrtovanje,
- uporabniški vmesnik,
- in vmesnik med ODS in dejavnikom.

Delovni moduli so strukturirani v drevesne strukture (sl. 4).

a form of effective problem structure, b) the contents of individual components (EWS, VWS), and c) the contents of information flows between them. Modern ICT represents the required communication infrastructure, and it provides for the required tools to solve the practical problems of distributed manufacturing.

Demand and printing VWSs consist of the basic component - the skeleton agent - and of various functional modules that are fixed to it (Fig. 3).

The purpose of the skeleton agent and its methods is:
- to communicate with the skeletons of other VWSs in the information network,
- to allow the activation of various VWS functionalities for the representation of various printing EWSs by means of various modules.

The VWS skeleton consists of (Fig. 3):
- a communication activation unit,
- an internal data bus.

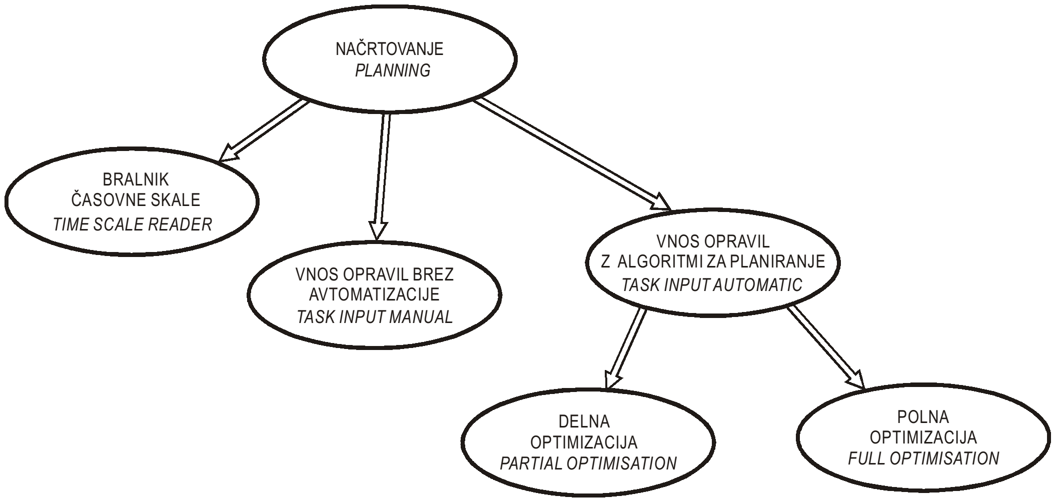
The communication activation unit enables the VWS skeleton functionalities. The internal bus enables the internal flow of data between the agent skeleton and the modules.

An important part of the VWS structure is allocated to connections with the appropriate EWS.

2.2 VWS functional modules

Functional modules are self-contained program entities that contain various VWS functionalities:
- planning
- the user interface,
- the EWS-agent interface.

Functional modules have the form of tree structures (Fig. 4).



Sl. 4. *Drevesna struktura modula načrtovanja*
Fig. 4. *Tree structure of a modular planning*

3 REZULTATI

3.1 Podjetje z porazdeljenim označevanjem izdelkov

Podjetje ETI d.d. je eden izmed pomembnih proizvajalcev električne zaščitne opreme na svetovnem trgu. Večino svojih izdelkov prodaja na tujih tržiščih. Izdelke izdeluje z lastno blagovno znamko in z blagovno znamko velikih kupcev (Siemens, Kopp, ECG in drugi).

Organizacijsko zrelost je podjetje dokazalo s pridobitvijo certifikata ISO 9000 že v daljnem letu 1993, danes pa ima pridobljen že tudi certifikat ISO 14000.

Potreba po stalnem večanju produktivnosti oz. potreba po nižanju stroškov je začela zahtevati tudi reorganizacijo podjetja. Strategija reorganizacije je običajna: - funkcije, ki pomenijo ožjo specialnost podjetja (core competences), naj ostanejo in naj se razvijajo znotraj matičnega podjetja. Preostale funkcije (izvajanje manjših oz. strateško manj pomembnih funkcij) pa naj izvajajo dobavitelji. Ekonomske analize pokažejo, da so za izvajanje manjših del kooperanti cenejši od dela v podjetju.

3.2 Dvojec ODS, VDS tiskarne nalepk

Tiskarna nalepk predstavlja dvojec ODS, VDS, ki ima bistvene lastnosti sklenjenega delovnega sistema:
- avtonomno delovanje oz. načrtovanje in obdelava podatkov naročil,

3 CASE STUDY: DISTRIBUTED LABEL PRINTING

3.1 Company with distributed labeling of products

The ETI d.d. company from Slovenia is one of the important producers of electrical protection equipment on the global market. The company sells most of its products on foreign markets. Some products of the company bear their own trademark and others are labeled by the trademarks of large customers: Siemens, Kopp, ECG and others.

The company proved its organizational competence by obtaining the ISO 9000 certificate in 1993, and today it has the ISO 14000 certificate.

Due to the need for a continuous increase in quality and productivity, the reduction of costs and due-date reliability the company has to be reorganized. The reorganization strategy is typical: functions that represent the core competences of the company should remain within the company (as well as development of these functions). The remaining functions (the execution of smaller or strategically less important functions) should be performed by suppliers. Economic analyses have proven that for smaller jobs the outsourcing companies are cheaper than manufacturing within the company.

3.2 Label printing EWS-VWS system

The label printing EWS-VWS system has the essential properties of a closed work system:
- autonomous operation, i.e., the planning and processing of orders,

- zmožnost komunikacije s sistemi v okolici ter preglednost delovanja,
- sprejemanje in potrditev naročil (iz poslovnega sistema in zunanjih naročil),
- načrtovanje lastnih virov in
- uresničitev opravil.

3.2.1 Struktura ODS

Na napravi za izvajanje postopka (NIP) poteka tiskanje (sl. 5). Postopek tiskanja obsega nastavitev tiskalnika (izbira tiskalnega traku, nalepk, tiskalnika) ter fizično izvedbo tiskanja. Povratna vezava postopka tiskanja in tiskalnika je kibernetska ponazoritev naravne povratne zveze fizikalnih pojavov (prihodnost je odvisna od preteklosti). (Primer: papir se zatrga - nadaljevanje tiskanja je drugačno kakor v primeru normalnega tiskanja).

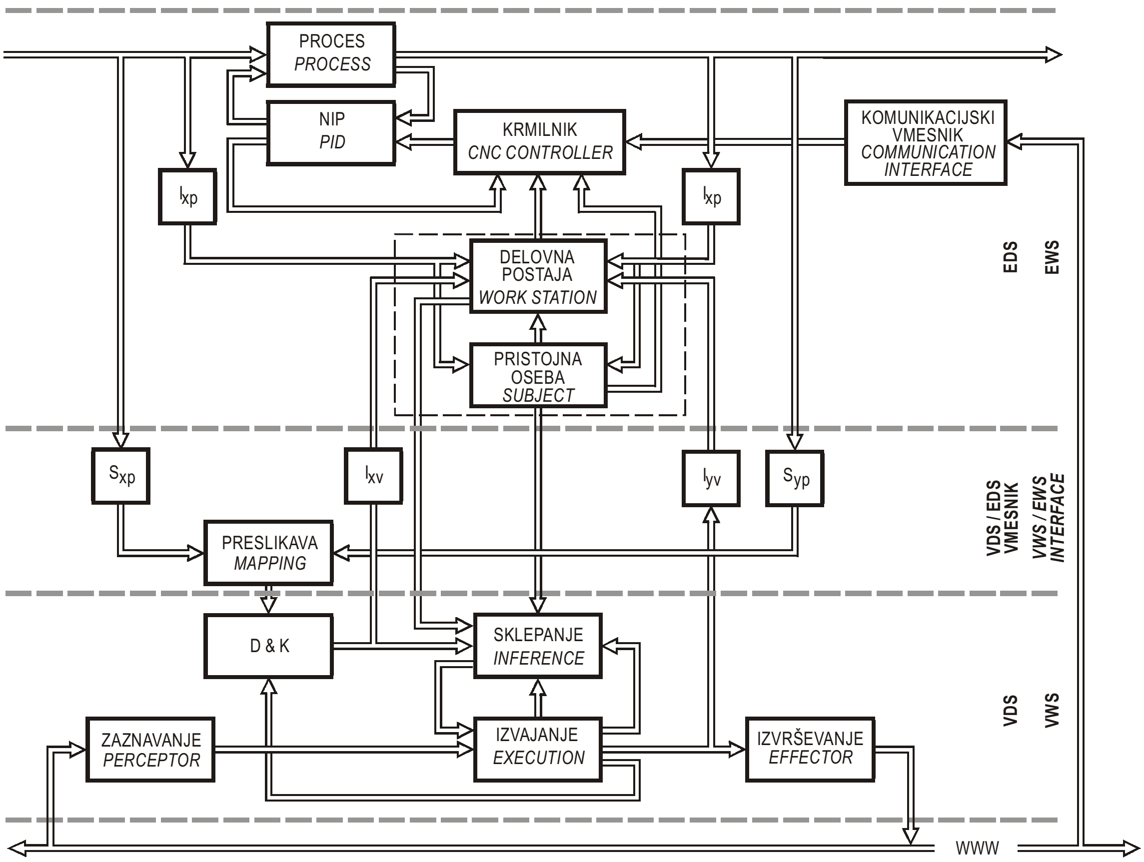
Vhodi v ODS tiskanja so:
- nalepke različnih oblik, velikosti, barve, predtiska,
- trakovi za tiskalnik različnih tipov, širine in barve

- capability of communication with environmental systems and transparency of operation,
- acceptance and confirmation of orders (from the business system of external orders),
- planning its own resources,
- accomplishment of tasks.

3.2.1 EWS structure

The Process Implementation Device (PID) performs the printing process (see Figure 5). The printing process consists of setting up the printer (selection of the printing ribbon, labels, and printer) and the printing process itself. The feedback between the printing process and the printer is a cybernetic representation of the natural feedback in physical phenomena (the future depends on the past). (For example, if a paper jam occurs, the printing continues in a different way than in normal printing).

The EWS printing inputs consist of:
- labels of various shapes, sizes, color and pre-print,



Sl. 5. *Tiskarna etiket ODS in VDS*
Fig. 5. *Label printing EWS-VWS system*

ter
- vsebinske ter nadzorne informacije.

Izhodi iz ODS so natisnjene nalepke v zahtevani obliki v skladu s predpisi označevanja predmetov.

Osebek, kot informacijsko podprta pristojna oseba preko vmesnikov Ixp, Iyp (sl. 5), nadzoruje postopek tiskanja. V primeru razlike med želenim in dobljenim izhodom z uporabo vmesnika na delovni postaji ali krmilnika tiskalnika vpliva na tiskalnik in s tem na postopek tiskanja.

Krmilnik (sl. 5) pretvarja podatke o strukturi nalepk ter podatke o potrebni količini natisnjenih nalepk v tiskalniku razumljivo kodo (rasterska grafika, specifični programski jeziki tiskalnikov). Povratna zveza od tiskalnika do krmilnika obvešča krmilnik o fizičnem tiskanju oziroma o nepravilnostih delovanja tiskalnika.

Nadzorne informacije (naročilo vrste in števila nalepk, prioriteta tiskanja, stanje tiskalnika) prehajajo z spletne mreže preko zaznavanja, vmesnika Ixv, delovne postaje in krmilnika v napravo za izvajanje postopka tiskanja. Izvajanje naročil pa poteka z informacijske mreže prek zaznavanja, modulov izvajanja in sklepanja, vmesnika Iyv, delovne postaje in krmilnika.

Podatki o označevalnih nalepkah prehajajo z internetne mreže preko perceptorja, vmesnika Ixv, delovne postaje in krmilnika v napravo za izvajanje postopka.

3.2.2. Struktura VDS

Tiskarne nalepk VDS zastopa Tiskarne nalepk ODS v informacijskem svetu oz. v informacijski mreži. Definicije dejavnikov [6] ne predvidevajo razmeroma obsežnega uporabniškega vmesnika med ODS in pripadajočim VDS. Zato je vmesnik definiran v ravni med ODS in VDS (sl. 5). Vsebinsko so vmesniki v tem, vmesni ravni dveh tipov:
- zaznavala (Sxp, Syp) ki omogočajo spremljanje postopka tiskanja ter preko elementa preslikave (sl. 5) polnijo bazo podatkov D&K;
- vmesnike (Ixv in Iyv) po katerih dobiva osebek bistvene podatke o delovanju dejavnika ter informacije o opravilih, ki jih mora ODS obdelati.

Vse informacije v elektronski obliki (naročila, dejavnosti pridobivanja posla, podatki o nalepki - recepti in drugo) prejema dejavnik VDS po zaznavanju. Zaznavanje je torej enota, ki iz mreže pobira za ODS, katerega predstavlja na mreži, bistvene podatke.

- printer ribbons of various types, width and color,
- content and control data.

The EWS output consists of printed labels of the required design, in accordance with the regulations on the labeling of goods.

The subject, being an information-supported competent person, controls the printing process using the Ixp and Iyp interfaces (Figure 5). In the case of a discrepancy between the reference value and the actual output, the subject influences the printer (and thus the printing process) using the workstation interface.

The CNC controller (see Figure 5) converts the data on the label structure and the data on the required quantity of printed labels to the code, intelligible to the printer (the raster graphics, the specific printer programming language). The printer- controller feedback informs the controller about the actual printing and about possible problems in the printer operation.

The control data (an order of a particular type and the number of labels, the printing priority, the printer status) pass from the internet via the perceptor, the Ixv interface, the workstation and the CNC controller to the printing-process implementation device. The processing of orders is done from the information network via the perceptor, execution and inference modules, the Iyv interface, the workstation and the controller.

Data on the marking labels pass from the internet via the perceptor, the Ixv interface, the workstation and the CNC controller to the process-implementation device.

3.2.2 VWS structure

The label printing VWS represents the label printing EWS in the IT world (in the information network). Agent definitions [6] do not anticipate an extensive user interface between the EWS and its corresponding VWS, so the interface is defined on the level between the EWS and VWS (Figure 5). From the content point of view, there are two types of interfaces on this intermediate level:
- sensors (Sxp, Syp) allow monitoring of the printing process and they fill the D&K database via the mapping element (Figure 6)
- interfaces (Ixv and Iyv) transfer to the subject the relevant data about the agent operation and data on tasks that should be processed by the EWS.

All information in electronic form (orders, activities for obtaining the job, label data-recipes, etc.) is received by the VWS agent via the perceptor. The perceptor is, therefore, the entity that takes the relevant data from the network for the EWS represented by it on the network.

Zaznavanje vse prejete informacije pošlje naprej v element izvajanja, ki jih obdela. Osebek ima možnost vpogleda v še neobdelane podatke skozi vmesnik Ixv.

Rezultati obdelave elementa izvajanja razširjajo:
- po posledicah nazaj na mrežo (sporočila v fazah pridobivanja poslov, obvestila o delovanju ODS,
- v bazo podatkov in znanj (sl. 5).
- skozi vmesnik Iyv k informacijsko podprti usposobljeni osebi.

Mehanizem sklepanja z uporabo baze podatkov in znanj ter sprotnih podatkov izvajanja postopka svetuje pri sprejemanju odločitev.

V kraju Izlake so trenutno uvedena štiri mesta tiskanja in uvedenih pet mest naročanja (štiri mesta s prenosno strojno opremo in eno stalno mesto naročanja).

VDS za medsebojno komunikacijo uporabljajo inter/intra-omrežno (Wide Area Network - WAN / Local Area Network - LAN) infrastrukturo (sl. 6).

The perceptor forwards the data obtained to the executing element that processes them. The subject may take a look at the unprocessed data using the Ixv interface.

The results of the executing element processing are sent:
- back to the network via the effector (messages in job-gaining phases, notices on EWS operation),
- to the Data&Knowledge database (D&K, Fig. 5),
- through the Iyv interface to the IT-supported competent subject.

The inference mechanism supports decision-making using the D&K database and the online processing of data.

At the Izlake location there are currently four printing places and five ordering places (four places with mobile hardware and one stationary ordering place).

An internet/intranet infrastructure (Wide Area Network (WAN) / Local Area Network (LAN)) is used for the communication between VWSs (Fig. 6).

4 RAZPRAVA

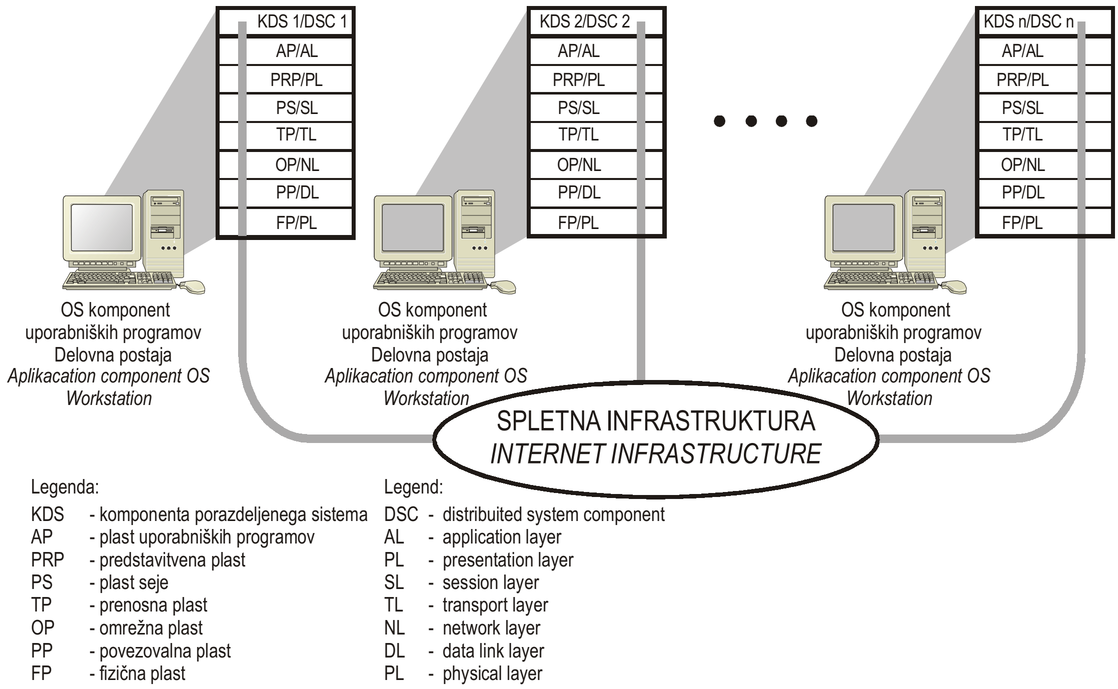
4.1 Orodja za izdelavo dejavnika

Pomembno vlogo pri gradnji dejavnih struktur v industrijskem okolju ima izbira delovnega

4 DISCUSSION

4.1 Agent building tools

When building agent structures in an industrial environment, the selection of the work and programming



Sl. 6. *Intra- in internetna infrastruktura*
Fig. 6. *Intranet / internet infrastructure*

in programskega okolja. Le to mora zadostiti naslednjim pogojem:
- stabilnosti delovanja,
- funkcionalni učinkovitosti,
- hitrosti in prilagodljivosti in
- ustrezni ceni.

Izbira med objektno usmerjenimi programskimi orodji je velika. Glavna merila pri izbiri orodij so a) zmožnosti razvojnega okolja (učinek razhroščevanja, pomoč pri pisanju kode, moč programskega jezika, preprostost programskega jezika), b) kakovost izhodne kode ter c) namen razvitih programskih enot.

Gibanje na ravni operacijskih sistemov se danes nagiba predvsem v korist Microsoftovih izdelkov družine Windows. Vse opaznejši pa postaja tudi operacijski sistem Linux, ki je plod razvoja računalniških zanesenjakov po vsem svetu in je prav zaradi tega skoraj brezplačen. V poslovnem svetu in v svetovnem spletu (WWW) so še vedno močno zastopani tudi opravilni sistemi družine Unix.

Še pred kratkim je bila Java glavni prevajalnik za izdelavo porazdeljenih uporab. Danes Javi predstavljajo alternativo objektno usmerjena orodja Visual Studio, C++ Builder, Delphi/Kylix in .NET, ki omogočajo pisanje programov na vseh ravneh programiranja (od gonilnika do povsem vizualno usmerjene uporabe). Odločitev o izbiri orodja ni preprosta, saj ima vsako orodje v primerjavi z drugimi na eni strani prednosti, na drugi strani pa tudi pomanjkljivosti.

4.2 Delovno okolje

Izbira delovnega okolja je vezana na izbiro predmetnega komunikacijskega modela. Med dvema glavnima alternativama, DCOM/COM+/.NET in CORBA dajemo prednost prvi alternativi. Razlogi so naslednji:
- jasna je strategija nadaljnjega razvoja,
- zrelost tehnologije in uvajanja,
- preprostost upravljanja in stabilnost delovanja,
- funkcionalnost, ki zadošča zahtevam po informacijski mreži porazdeljenih struktur ter
- cenovna ugodnost.

Tehnologija DCOM/COM+/.NET pomeni ključno tehnologijo sistemov Windows NT/200x in je že v osnovi vgrajena v opravilni sistem največjega proizvajalca tovrstnih izdelkov, Microsofta. Ta tehnologija je bila v preteklih letih predmet intenzivnega

environment is of crucial importance. The programming environment has to fulfill the following requirements:
- stable operation,
- functional efficiency,
- speed and adaptability,
- suitable cost.

There are several object-oriented programming tools available. The main criteria when selecting the tools are: a) the capacities of development environment (debugging efficiency, help at code generation, power of programming language, simplicity of programming language), b) the quality of the produced executable code, and c) the destination of the programming-entities developed.

At the operating system level the current trend is towards Microsoft Windows products. On the other hand, there is an ever-increasing use of the Linux operating system, which has been developed by a large number of computer enthusiasts from all over the world and for this reason it is almost free of charge. In the business environment and in the world wide web there are still many Unix-compatible operating systems.

Until recently, Java was the main compiler for the development of distributed applications. Today, there are several alternatives - object-oriented tools of Visual Studio, C++ Builder, Delphi/Kylix and .NET - which allow for the development of programs on all programming levels (from device driver to completely visually-oriented application). The selection of a particular tool is not a simple task, because each tool has some advantages and drawbacks in comparison with others.

4.2 Operating environment

The selection of operating environment depends on the selection of the object communication model. There are two main alternatives: DCOM/COM+/.NET and CORBA; we prefer the first one for the following reasons:
- clear strategy of further development,
- maturity of the technology and its implementation,
- simple management and stable operation,
- functionality that satisfies the requirements of the structures distributed over the information network,
- competitive price.

DCOM/COM+/.NET technology is the key element of Windows NT/200x systems, and it is already incorporated in Microsoft operating systems. This technology has been under intensive development in recent years and it reached its mature razvoja in je dobila zrelo podobo v operacijskem sistemu Windows 2000. Čeprav je CORBA starejša in ima trenutno več uporabnikov, so napovedi strokovnjakov skupine Gartner Group bolj v prid tehnologiji COM+/.NET, ki nadgrajuje tehnologijo DCOM. Prav zaradi te tehnologije predvidevajo tudi prevladujočo vlogo sistemov Windows 200x v okoljih strežniških sistemov. Z drugimi besedami, Microsoft po utrditvi položaja v namiznem računalništvu utrjuje svojo prevlado tudi v strežniških sistemih.

state in the Windows 2000 operating system. CORBA is older and currently has more users. However, Gartner Group expert predictions favor COM+/.NET technology, which is an upgrade of DCOM technology. Just because of this technology, the dominant role of Windows 200x systems in server environments is foreseen. In other words, after establishing its main role in desktop computing, Microsoft is now strengthening its dominance in server environments, too.

4.3 Obremenitveno preverjanje porazdeljenega sistema

Obremenitveno preverjanje določi (overi) razmerje med ceno in postopkovno močjo sistema. Pri radodarnem dodajanju zmogljivosti (postopkovna moč, obseg spomina, prepustnost podatkovnih poti) se cena sistema hitro nedopustno poveča. Varčevanje pri ceni sistema (počasne povezave, skromnejše delovne postaje in skromnejši strežniki) pa povzroči, da s svojimi minulimi izkušnjami (nezadovoljstvo naročnikov) ne moremo pridobiti novih naročil kljub dobri zasnovi in uvajanju programskih rešitev. Zato je protokolirano obremenitveno preverjanje nujen del porazdeljenega informacijskega projekta.

4.3 Load verification of distributed system

Load verification determines (verifies) the relation between price and system processing power. With a generous addition of features (processor speed, RAM and disk size, data flow throughput), the system price increases very rapidly. If we over-economize the system price (slow connections, cheap workstations and weak servers), then because of our past references (unsatisfied clients) we cannot obtain new orders, in spite of good design and the implementation of programming solutions. Therefore, the load verification (using the proper protocol) is an essential part of a distributed IT project.

5 SKLEPI

Nov postopek reševanja označevanja izdelkov, temelječ na vzorcu ZPPS, ima naslednje lastnosti:

- Sistem je modularno grajen in odprt za vse spremembe v prihodnosti. Predvidene spremembe omogoča modularna gradnja sistema, izvedbo nenačrtovanih sprememb pa omogočajo vgrajeni posplošeni uporabniški vmesniki.
- Upravljanje ter vzdrževanje sistema sta nezahtevna.
- Razmeroma nezahtevno je programsko uvajanje novih VDS in novih funkcij ODS.
- Uvajanje sistema v dejanskem proizvodnem okolju ne zahteva sprememb varnostnih nastavitev v informacijskem okolju.
- Neodvisnost od nadrejenih informacijskih sistemov hčerinskih podjetij in
- relativizacija oziroma nepomembnost fizičnih razdalj za delovanje informacijskega sistema tiskanja.

Rešitev je uvedena v proizvodnem okolju podjetja ETI d.d. Izlake na treh lokacijah, in sicer v Izlakah, Trbovljah in Kamniku.

5 CONCLUSIONS

A new approach to product labeling, based on the CAMS paradigm, has the following characteristics:

- the system has been built from modules and it is open to changes in the future; it will be possible to make anticipated changes because of the modular system design, while generalized user interfaces will enable the realization of unplanned changes,
- the system is not difficult to manage and maintain,
- program implementation of new VWSs and new EWS functions is relatively easy,
- system implementation in a real manufacturing environment does not require changes of security settings in the information environment,
- independence from parent information systems in subsidiary companies,
- physical distance is not relevant for the operation of the printing information system.

This solution has been implemented in the distributed manufacturing environment of the ETI d.d. company, at the locations Izlake, Trbovlje and Kamnik (all places are in Slovenia).

Predstavljena izvedbena struktura VDS je preverjena v rešitvi porazdeljenega označevanja izdelkov z n mest naročanja označb in z m mest izdelave označb. Razviti in preverjeni so delovni moduli VDS (rokovnik, razlage meta-kode označevanja izdelkov, komunikacija s pristojno osebo, podatkovna baza označevanja, moduli odločanja v predvidenih okoliščinah). Celotna mreža VDS je preverjena delovno in obremenitveno.

The presented VWS structure has been verified in the solution of distributed product labeling; there are n places of label ordering and m places of label printing. Functional VWS modules have been developed and verified (organizer, product labeling meta-code interpreters, communication with competent persons, labeling database, decision modules in predictable circumstances). The whole VWS network has been verified in terms of functions and load.

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