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# Model informacijskega vmesnika med enotami prilagodljivega obdelovalnega sistema

# A Model of Informational Interface between Flexible Manufacturing System Units

JOŽE BALIČ - IVO PAHOLE

*Obratovanje prilagodljivih obdelovalnih sistemov (POS) je odvisno od ustreznega delovanja nadzorno upravljalnega sistema. Nadzorno upravljalni modul lahko kakovostno deluje le takrat, ko je komunikacija med enotami POS in nadzorno-upravljalnega modula kakovostno in pravilno zasnovana. Prispevek opisuje model, kako lahko pregledno sestavimo tok informacij od izvora do centralnega dela, kjer izdelamo krmilne informacije. Nadalje je prikazano tudi usmerjanje informacij k pravemu naslovniku v POS.*

Ključne besede: sistemi obdelovalni prilagodljivi, informacije krmilne, krmiljenje numerično, vmesniki, modeli informacijski

*One of factors important for operation of flexible manufacturing systems (FMS) is trouble-free functioning of the monitoring-operating system. The monitoring-operating module can function trouble-free, if the communication between the units of the FMS and the monitoring-operating module is well and correctly conceived. The paper describes how to model in a clear way the information flow from the source to the central part where the control information is made. Further the orientation of information to the correct addressee in the FMS is presented.*

Keywords: flexible manufacturing systems, control information, numerical control, interface, informational models

## 0 UVOD

Pri vodenju prilagodljivih obdelovalnih sistemov (POS) je bistvenega pomena povezava med posameznimi enotami. V današnjem času imamo običajno opravka z velikim številom med seboj različnih informacij. Vsaka posamezna enota POS ne potrebuje celotnega spektra informacij o določenem stanju oziroma spremembi stanja. Velika količina informacij za določeno enoto pomeni tudi zahtevnejšo, kakovostnejšo povezavo NNK (neposredno numerično krmiljenje), ki jo med delovanjem tudi zaseda. Posredno je zato potreben tudi večji in zmogljivejši računalnik, ki vzdržuje povezavo NNK. Povprečno se pojavljajo dogodki v POS vsake tri sekunde [1], [3]. Prevelika količina informacij na posamezni enoti POS privede velikokrat do težjega razumevanja zahtev.

## 1 ZASTAVLJENA NALOGA

Opraviti želimo natančno analizo stanj za vse enote POS ter izdelavo in postavitev tega modela, definirati krmilne informacije in vse podinformacije, ki so aktualne za posamezne enote, izdelati model inteligentnega vmesnika za razporejanje informacij po posameznih enotah. Pod pojmom razporejanje informacij je mišljena določitev le tistih potrebnih informacij, ki jih potrebuje posamezna enota POS v

## 0 INTRODUCTION

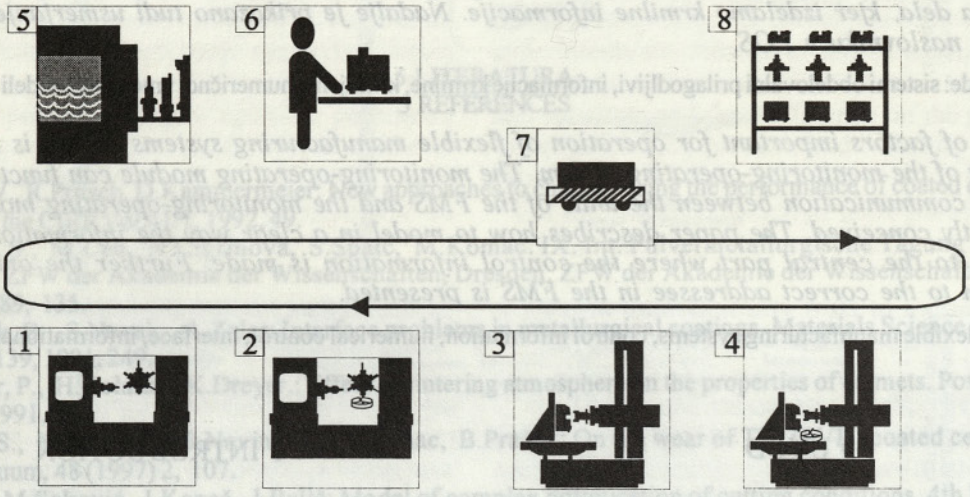
For the operating of flexible manufacturing systems (FMS) the communication between the individual units is of vital importance. Today we have usually to deal with a great number of mutually different bits of information. However, each individual unit of the FMS does not need the entire spectrum of information on a certain state or change of state. A great quantity of the information for a particular unit involves more demanding/higher quality DNC (Direct Numerical Control) connection which it occupies during functioning. Indirectly, to this end a larger and more capable computer is necessary to maintain the DNC connection. On the average, the events in the FMS occur every 3 seconds [1] and [3]. Too large a quantity of information on the individual unit of FMS often leads to more difficult understanding of the requirements.

## 1 SCOPE OF TASK

It is our intention to perform an accurate analysis of states for all units of the FMS, making and setting of the units, making of a model of an intelligent interface for sorting out - arranging of information for individual units. The term arranging of information means the determination of that information only which is required by the individual FMS unit in some changed state of any FMS unit.

dani spremembi stanja katerekoli enote POS. Teorija celotne zastavljene naloge se preiz-kuša delno na resnično postavljenem POS, delno pa z metodami simuliranj v laboratoriju na Fakulteti za strojništvo v Mariboru. Računalniška izvedba je v fazi dodelave in preizkušanja le za določen segment, v nadaljnjem delu pa bo v okviru projekta IPROS v celoti izvedena [9]. Slika 1 prikazuje model POS, ki je skoraj v celoti izveden na Fakulteti za strojništvo v Mariboru. Model je sestavljen iz enot, ki so karakteristične za kovinsko predelovalno industrijo v našem industrijskem bazenu. V POS so avtomatizirane le tiste funkcije, ki se dovolj pogosto pojavljajo. Reševanje konfliktnih, nepredvidljivih situacij je prepuščeno operaterjem.

he theory of the entire task set is tested partly on a real set FMS and partly by simulation methods in the laboratory of the Faculty of Mechanical Engineering in Maribor. The computer application is at the stage of completing and testing for a certain segment only; in further work it will be executed completely [9] in the frame of the project IPROS. Figure 1 shows a FMS model which has been almost completely built at the Faculty of Mechanical Engineering in Maribor. The model consists of units characteristic of the metal processing industry in the Maribor industrial region. In the FMS only those functions are automated which occur often enough. Solving of conflicting, unforeseeable situations is left to the operators.




Sl. 1. *Model prilagodljivega obdelovalnega sistema*
1, 2 - numerično krmiljena stružnica, 3, 4 - numerično krmiljen vrtalno-frezalni stroj,
5 - pralni stroj, 6 - vpenjanje - izpenjanje, 7 - samovozni voziček, 8 - vmesno skladišče

Fig. 1. *Model of flexible machining system*
1,2 - NC-lathe, 3 ,4 - NC- milling machine, 5 - washing machine,
6 - part clamping, 7 - automated guided vehicle, 8 - buffer storage

## 2 ZAZNAVANJE DOGODKOV V POS

Za vsak stroj ali kakšno drugo enoto, ki jo postavimo v POS, moramo natančno definirati zahteve, ki jih mora ta enota oziroma stroj, kot element POS, izpolnjevati. Ko kupujemo nov stroj, so to navadno dodatne zahteve za določen stroj [6]. V primeru, ko vključujemo v POS sedanje stroje, moramo dograditi ustrezne elemente, (npr. vmesnike NNK v krmiljih itn.), ki omogočajo dodatno zahtevane aktivnosti v POS. Vsako enoto, ki je sestavni del sistema, moramo torej jemati kot sklenjeno celoto. Za vsak tak del pa moramo potem seveda natančno opredeliti vstopne in izstopne informacije. Delo znotraj sklenjenih celot nato prevzamejo interna krmilja ali eno samo krmilje, kar je odvisno od načina izvedbe. Na sliki 2 je shematsko prikazano, kakšne so navedene trditve. V osnovi lahko opišemo stanje [7] vsake enote POS z dvema osnovnima stanjema:

## 2 FOLLOWING OF EVENTS IN FMS

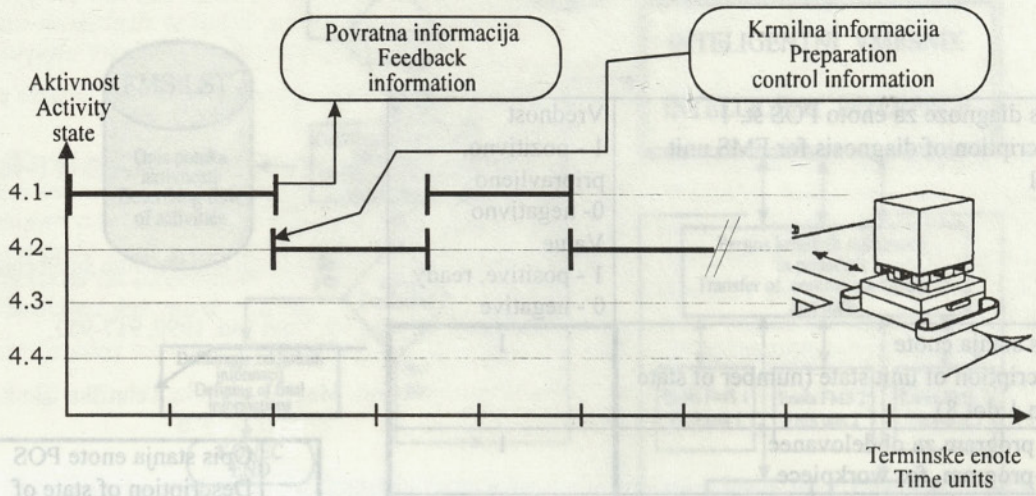
For each machine or some other unit set in the FMS it is necessary to specify the requirements which the unit or machine - as FMS components - has to fulfill. In case a new machine is purchased, these are usually additional requirements for certain machine [6]. When existing machines are incorporated in the FMS it is necessary to add appropriate components (e.g. DNC - cards in controls etc.) which assure the activities additionally required in the FMS. Each unit which is an integral part of the system must be considered to be a separate unit in the FMS. Afterwards, for all such parts it is necessary to specify the input and output information. Operating within such units is then undertaken by internal controls or one control component depending on the type of design. Figure 2 shows diagrammatically how the a.m. assertions look. Basically, the state of any FMS unit can be described by two basic states [7]:

- stanje obratovanja,
- stanje, ko ne obratuje .

Taka razdelitev sicer natančno določi stanje elementa, vendar bistveno pregrobo. Zato je treba opredeliti tudi podstanja vsake enote: 1 - obratovanje; 2 - programiranje, vnos; 3 - nastavljanje, opremljanje; 4 - stanje pripravljenosti; 5 - vzdrževanje; 6 - motnje; 7 - okvare, zastoji; 8 - posvet, nepredviden poseg v stroj.

- state during operation,
- state out of operation.

Such distribution accurately defines the state of the component but too roughly. Therefore it is necessary also to define the sub-states of each unit: 1 - operation; 2 - programming, reading-in; 3 - setting, equipping; 4 - state of readiness; 5 - maintenance; 6 - troubles; 7 - defects, stoppages; 8 - consulting, unforeseen interference with the machine.




Sl. 2. *Prikaz vstopnih in izstopnih informacij enot POS*
1 - delovanje - vožnja, 2 - stanje pripravljenosti, 3 - vzdrževanje, 4 - okvare

Fig. 2. *Representation of input and output information of FMS units*
1 - operation - travel, 2 - state of readiness, 3 - maintenance, 4 - defects

## 3 DEJANSKA REŠITEV PROBLEMA

Na sliki 4 je skupni diagram poteka za celoten programski paket za vodenje POS. Paket je sestavljen iz naslednjih programskih enot - modulov:

- simulacijski modul, ki daje možnost polnjenja datoteke, dobljene iz paketov CAPP (računalniško podprto načrtovanje in vodenje proizvodnje) in PPC (neposredno krmiljenje proizvodnje), in je nujen pripomoček v fazi testiranja programskega sistema,
- modul za komunikacijo, za prenos podatkov med krmilji enot obdelovalnega sistema in vodilnim računalnikom.

Uporabljen je sistem za prenos in spremljanje proizvodnih in strojnih podatkov podjetja DLOG,

- glavni modul za izdelavo krmilnih informacij.

Pri izdelavi in testiranju samega vmesnika so uporabljena standardna programska orodja na računalniških sistemih VAX in osebnih računalnikih, delno pa tudi postopki objektnega programiranja in dogodkovno usmerjenega programiranja.V analitičnem delu se za določitev spektra podatkov uporablja metoda razstavitve. Delo se v dejanskem

## 3 ACTUAL SOLUTION OF THE PROBLEM

Figure 4 shows a joint diagram of the progress of a complete programme package for operating the FMS. The package consists of the following programme units - modules:

-simulation module which ensures filling of the datafile obtained from CAPP (Computer Aided Proces Planing) and PPC (Process Planing and Control) package and which is an urgently necessary device at the stage of testing of the programme system,

-communication module for transfer of data between FMS unit controls and leading computer.

The DLOG system for transfer and follow up of production and mechanical data are used,

- main module for preparing control information.

For formatting and testing of the interface itself, the conventional programming tools on VAX computer system and personal computers are used and partly also the procedures of object programming and event-oriented programming.In the analytical part the method of decomposition is used for determining the data spectrum. The work at the actual

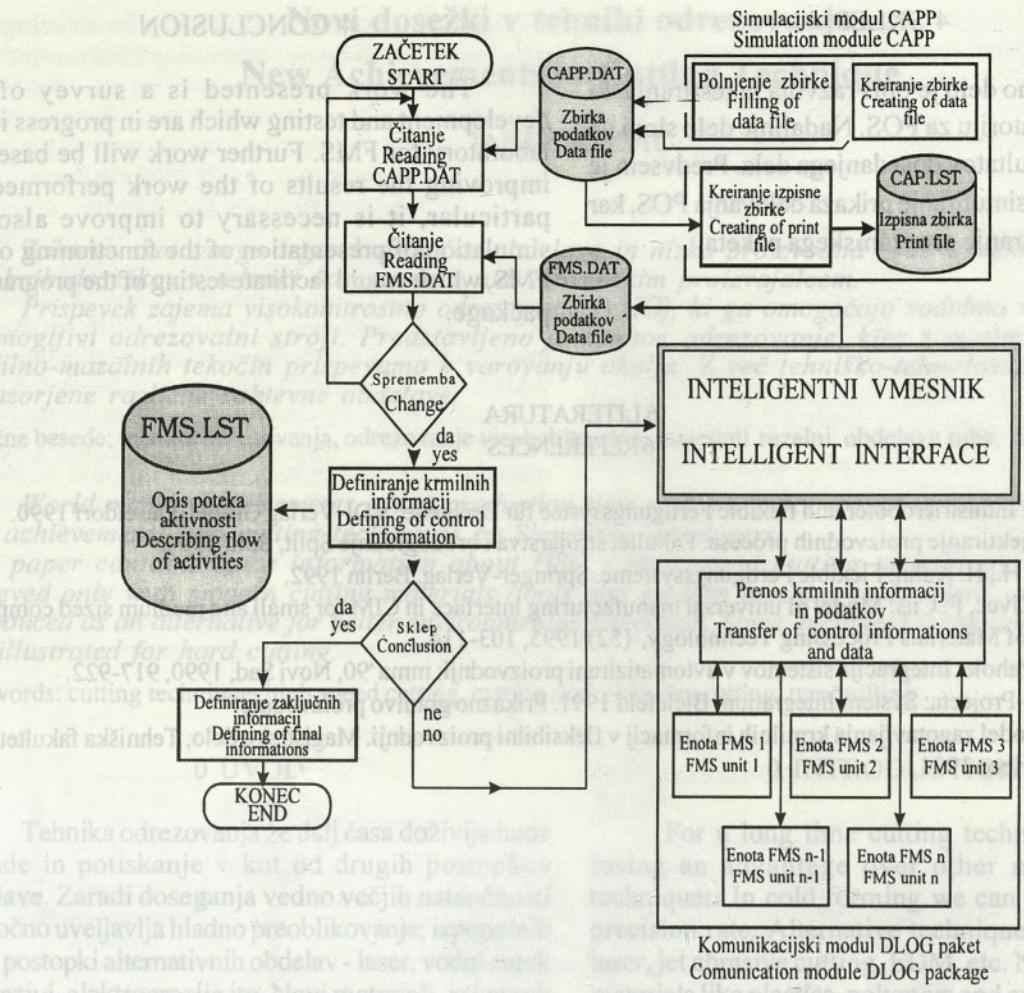
izvajalnem nivoju ujema s projektom IPROS [4], ki poteka v laboratoriju LAOP. POS je sestavljen iz enot, ki so značilne za kovinsko-predelovalno industrijo v našem industrijskem bazenu. Ker pomeni izdelava samega informacijskega vmesnika sorazmerno zapleteno in obsežno delo, se za zdaj obdeluje le področje ravnanja z orodji za odrezovalne stroje. Slika 4 prikazuje model, kako deluje informacijski vmesnik z uporabo pretočne matrike.

implementation level agrees with the project IPROS [4] which is being executed in the laboratory LAOP. The FMS consists of units characteristic of the metal processing industry in the Maribor industrial region. Since making of the information interface itself represents relatively complex and comprehensive work, for the time being only the area of tool handling for cutting machines is dealt with. Figure 4 indicates a model showing how the information interface operates by the use of flow a matrix.

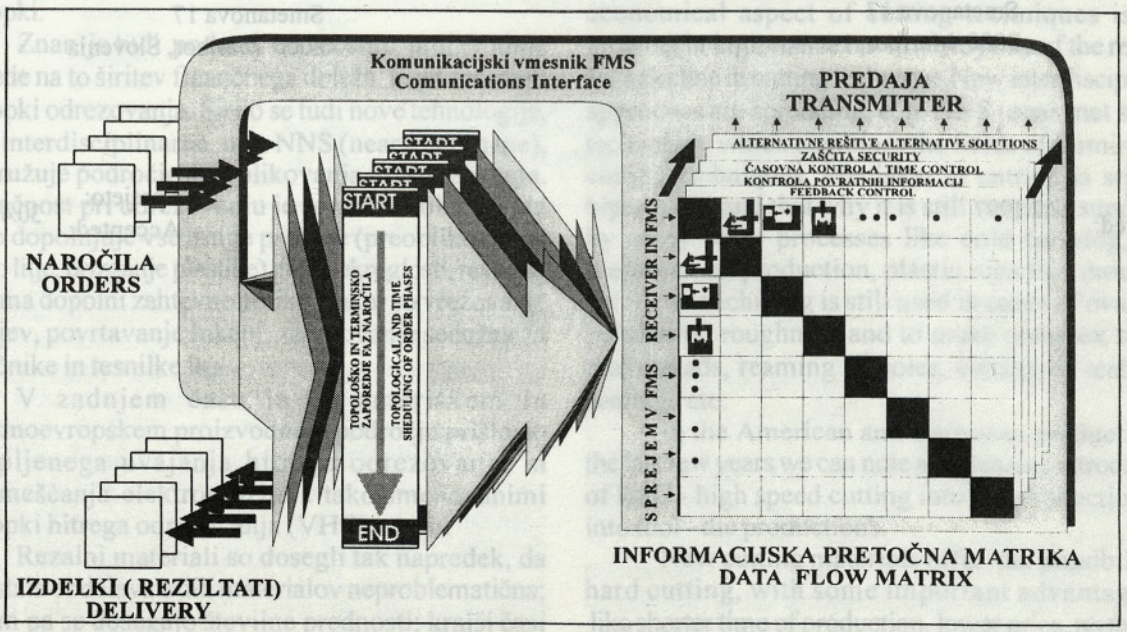
| | Opis diagnoze za enoto POS št. 1<br>Description of diagnosis for FMS unit No.1 | Vrednost<br>1 - pozitivno, pripravljeno<br>0- negativno<br>Value<br>1 - positive, ready<br>0 - negative |
|---|---|---|
| 1 | Opis stanja enote<br>Description of unit state (number of state from 1 dot 8) | 1 |
| 2 | NK program za obdelovanec<br>NC-program, for workpiece | 1 |
| 3 | Paleta obdelovancev, tip palete<br>Pallet for work pieces, type of pallet | 1 |
| 4 | Paleta z orodjem<br>Pallet for tools (drum with bars, if the bars on tool drum are correct) | 1 |
| 5 | Orodni adapterji v skladišču<br>Tool adapters in tool magazine | 1 |
| 6 | Prijemala manipulatorja za polnjenje<br>Gripping arms of filling manipulator | 1 |
| 7 | Prijemala manipulatorja za praznjenje<br>Gripping arms of emptying manipulator | 1 |
| 8 | Nastavitev konjička<br>Adjustment of tailstock | 1 |
| 9 | Opremljenost s pravilnim vpenjalom<br>Correct clamping head | 1 |
| 10 | Pravilne vpenjalne čeljusti<br>Correct jaws | 1 |
| 11 | Pripravljenost stružnih orodij<br>Readiness of turning tools | 1 |
| 12 | Pripravljenost gnanih stružilno-frezalnih orodij<br>Readiness of driven drilling - milling tools | 0 |
| 13 | Pripravljenost merilnih in nadzornih priprav za obdelovanec<br>Readiness of measuring, checking devices for workpiece | 1 |

| | Opis stanja enote POS<br>Description of state of FMS unit |
|---|---|
| 1 | Delovanje<br>Operations |
| 2 | Programiranje, vnos<br>Programming, reading in |
| 3 | Nastavljanje, opremljanje<br>Setting, preparation |
| 4 | Pripravljenost<br>Readiness |
| 5 | Vzdrževanje<br>Maintenance |
| 6 | Motnje<br>Troubles |
| 7 | Okvare<br>Defects |
| 8 | Drugo<br>Other |

Sl. 3. *Primer opisnega vektorja za enoto POS*
Fig. 3. *Example of description of FMS unit by describing vector*




Sl. 4. *Diagram poteka programskega paketa za vodenje POS*
Fig. 4. *Diagram of progress of programme package for operating of the FMS*




Sl. 5. *Informacijski vmesnik za selektiranje informacij v POS*
Fig. 5. *Information interface for selecting information in FMS*

## 4 SKLEP

Prikazano delo je opis razvoja in testiranja, ki poteka v laboratoriju za POS. Nadaljnje delo sloni na izboljšanju rezultatov dosedanjega dela. Predvsem je treba izboljšati simuliranje prikaza delovanja POS, kar bi olajšalo testiranje programskega paketa.

## 4 CONCLUSION

The work presented is a survey of the development and testing which are in progress in the laboratory for FMS. Further work will be based on improving the results of the work performed. In particular, it is necessary to improve also the simulation of presentation of the functioning of the FMS, which would facilitate testing of the programme package.

## 6 LITERATURA
## 6 REFERENCES

[1] Katalinić, B.: Industrieroboter und flexible Fertigungssystee für Drehteile. VDI-Verlag GmbH, Düseldorf 1990.
[2] Veža, I.: Projektiranje proizvodnih procesa. Fakultet strojarstva i brodogradnje Split, Split 1994.
[3] Templmeier, H., H. Kuhn: Flexible Fertigungssysteme. Springer-Verlag, Berlin 1992.
[4] Balič, J., Z. Živec, F. Čuš: Model of universal manufacturing interface in CIM for small and medium sized companies. Journal of Materials Processing Technology, (52) 1995, 103-114.
[5] Živec, Z., I. Pahole: Integracija sistemov v avtomatizirani proizvodnji; mma '90, Novi Sad, 1990, 917-922.
[6] Gildemeister-Projecta: System Integration, Bielefeld 1991. Prikazno gradivo proizvodnje.
[7] Pahole, I.: Model zagotavljanja krmilnih informacij v fleksibilni proizvodnji. Magistrsko delo, Tehniška fakulteta, Maribor, Maribor 1991.

Naslov avtorjev: dr. Jože Balič, dipl. inž.
mag. Ivo Pahole, dipl. inž.
Univerza v Mariboru
Fakulteta za strojništvo
Smetanova 17
2000 Maribor

Authors' Address: Dr. Jože Balič, Dipl. Ing.
Mag. Ivo Pahole, Dipl. Ing.
University of Maribor
Faculty of Mechanical Engineering
Smetanova 17
2000 Maribor, Slovenia

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