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INTEGRATION OF PROCESS PLANNING FOR DISTRIBUTED MANUFACTURING IN VIRTUAL ENVIRONMENT

Saša ĆUKOVIĆ[1], Milan ERIĆ[2], Goran DEVEDŽIĆ[3], Vanja LUKOVIĆ[4], Ionuţ GHIONEA[5]

Abstract: *Production process planning in real or virtual environment refers to the choice of parameters and sequencing of certain manufacturing processes with the aim to obtain the required product features with greater productivity, reduced production costs, shorter development time etc. Therefore, innovative systems for virtual process planning, based on intelligent agents, greatly improve adaptation to dynamic changes and uncertain disturbances in the production process and environment. Achieving these objectives in distributed production environment, to a large extent, is obtained through Internet and modern Web and VR technologies. This paper presents new concepts of process planning integration in virtual manufacturing enterprises.*

Key words: *integrated and distributed CAPP, virtual environment, Web and Virtual CAPP, CAPP agents, XML, STEP-NC standards.*

1. INTRODUCTION

Development teams and production facilities are often geographically dislocated. Hence, there is a need for distribution of construction and production activities in a virtual environment, where all these activities correspond to a real development and production process [1 and 2]. The development phases of a new production and ICT infrastructures, PLM and virtual systems, creates conditions for virtual enterprises and organizations diversification at global scale (Fig. 1) [3]. Also, many modern software solutions and tools enable reliable exchange, management, control and integration of information and business documents in a distributed virtual environment.

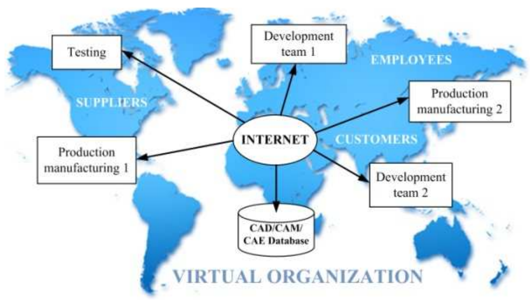

Fig. 1. Internet based virtual organization.

[1] PhD Student, Faculty of Mechanical Engineering Kragujevac, University of Kragujevac, Department of Production Engineering, Sestre Janjić 6, Kragujevac, Serbia, *E-mail: cukovic@kg.ac.rs,*
[2] PhD, Professor, Faculty of Mechanical Engineering Kragujevac, University of Kragujevac, Department of Production Engineering, Sestre Janjić 6, Kragujevac, Serbia, *E-mail: ericm@kg.ac.rs,*
[3] Professor, Faculty of Mechanical Engineering Kragujevac, University of Kragujevac, Department of Production Engineering, Sestre Janjić 6, Kragujevac, Serbia, *E-mail: devedzic@kg.ac.rs,*
[4] PhD Stud., Technical Faculty Čačak, University of Kragujevac, Svetog Save 65, Čačak, Serbia, E-mail: *vanja@bluenet.rs,*
[5] PhD Lecturer, University POLITEHNICA of Bucharest, Department of Machine Manufacturing Technology, Bucharest, Romania. *E-mail: ionut76@hotmail.com.*

Unlike traditional, centralized and/or hierarchical systems for process planning, modern virtual systems based on intelligent agents, represent physical manufacturing resources, include distributed planning in dynamic environments and provide algorithms for appropriate optimization of all activities. Each agent has the capability for local decisions making and collaboration with other agents. Main features of these software entities are: autonomy, responsibility, adaptability, openness, cooperation with other agents, distributed decision making and possibility for distributed control [4, 5, and 6].

Web-based CAPP systems are based on server/client architecture and essentially consist modules based on web browser to visualize process objects, remote service calls for process planning optimization, as well as a virtual display of all optimization results. In addition to these actions, some modules perform search and management services for virtual process planning via Internet. Specific modules are designed for storing and saving 3D data of manufacturing equipment, cutting tools and costs in the unique database. This paper presents current CAPP systems and new Web based concept for process planning integration.

2. LITERATURE REVIEW

Traditional computer aided process planning systems (CAPP) and approaches for process plan generation are developed for specific operations and these systems were inflexible for dynamic operating conditions [7]. There are several approaches for CAPP systems:

- Generative CAPP systems,
- Variant CAPP systems,
- AI (Artificial Intelligence) based on CAPP systems,
- Hybrid CAPP systems.

New developed systems based on Java, JNI and XML technology have modules which can exist in different geographic locations and operating systems, therefore there are created conditions for process planning distribution in the virtual environment. Existing systems for computer aided design (CAD), process planning (CAPP) and resources databases are integrated into system and in a 3I-PP system (Integrated Process Planning) for integrative planning based on object-oriented representation of knowledge. Virtual model of processing is generated and implemented through: geometric model, kinematic model and 3D animation.

CyberCut is a multiagent system for rapid product design and processing of parts through a global network. An essential part of this system is a module for automated process plan generation.

AAPP system (Adaptive Agent-based Process Planning) is also one of the advanced CAPP systems.

MASSYVE (Multiagent Agile Manufacturing Scheduling System for Virtual Enterprises) is a prototype system for manufacturing operations planning in the virtual environment using intelligent agents.

Multiagent system IntaPS (Integrated Agent-Based Process Planning and Production Control) is suitable for decentralized production process planning (rough and detailed planning) and for improving existing logistic method. Two layer architecture (workshop level - planning and monitoring, and the level of CNC controllers - operate planning) is suitable for separating and processing of generic and specific data. Among the most important techniques of the process planning, based on geometric modeling, are the processes planning based on CAD features (Feature Based Process Planning) (Fig. 2), processes planning based on volume 3D model geometry (Solid Model Based Process Planning), interactive planning processes etc.

VWS (Virtual Work System) system uses functional blocks for process planning in distributed environment. The concept of functional blocks is described in IEC 61 499 specifications or IEC standard for distributed industrial processes and control systems [8].

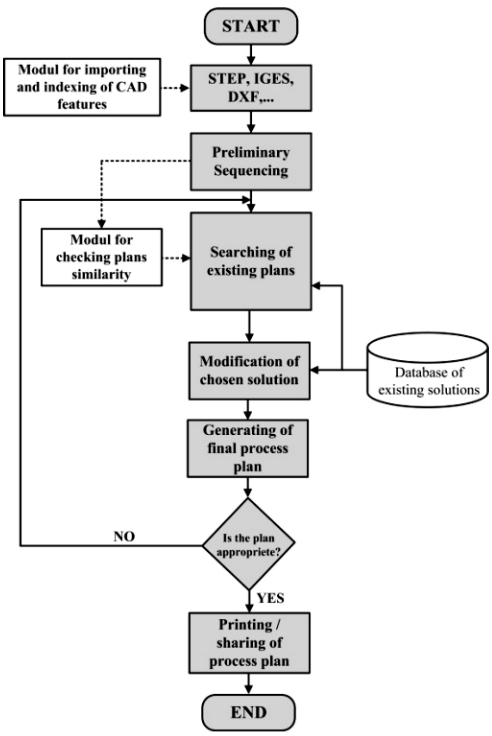

Fig. 2. Feature based process planning.

3. VIRTUAL PROCESS PLANNING

Concept of virtual design and manufacturing, as well as the virtual teams, enable development of new Internet/Intranet/Extranet-based services and virtual networks, e.g. VLAN (Virtual Local Area Network). These systems focus not only on local planning of individual units or functions, but also planning of global coordination and cooperation between various stages of planning and production (Fig. 3) [9].

According to one indicative definition, the virtual manufacturing and production systems are those systems which functionality and performance are independent from the physical distance between elements of system. This includes simulation of real processes and activities in the 3D environment using methods for designing and implementing digital processing in virtual environment. Realization of process in virtual environment includes plans to generate virtual prototype (3D model).

Virtual manufacturing process consists in series of virtual manufacturing operations and procedures. Using virtual networks, integration of all planning activities and process plan distribution are enabled [10]. More recently, the methods for CAPP system development can be generally classified into two groups:

- Techniques of planning process based on geometric modeling,
- Methods of object-oriented planning process.

Techniques based on artificial intelligence such as genetic algorithms, neural networks, Petri nets and fuzzy logic are used for development and implementation of CAPP systems.

Expert systems are decreasingly used because of inflexibility, difficulty in knowledge acquiring and application is more difficult for new industrial purposes. Particularly interesting are systems that generate process plans based on existing plans from a database using CBR (Case-Based Reasoning) and similar techniques of artificial intelligence (AI-based CAPP systems) and adapt them to current production requirements.

By using this system to a great extent, advantages of generative and variant process planning is combined with possibility of generating more alternative solutions.

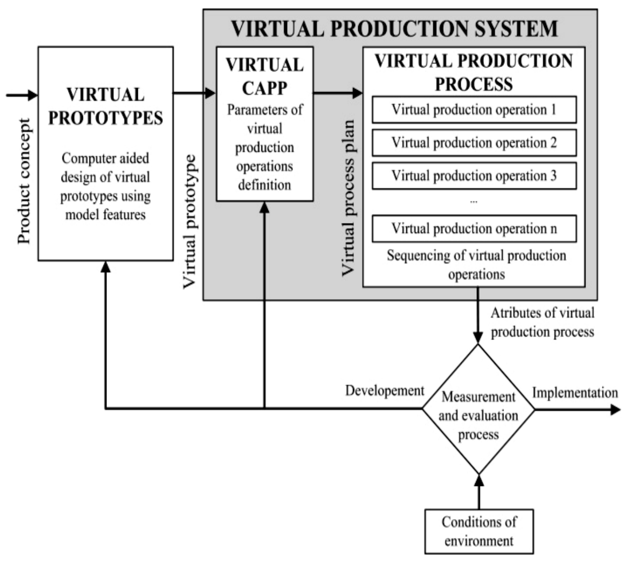

Fig. 3. Process planning in virtual production system.

Despite of all efforts, most available CAPP systems had significant ineffectiveness, in terms of centralized architecture and off-line data processing, which preclude adaptive and decision-making in advance. In addition to these, emergence of "bottleneck" in production often causes CAPP to be incompatible with CAD and CAM systems [11 and 12].

3.1. XML and virtual CAPP systems

Many modern software solutions enable reliable exchange, management, control and integration of information and business documents in distributed virtual environment. Most popular are EDM (Engineering Data Management), PDM (Product Data Management), PIM (Product Information Management), TDM (Technical Data Management), e-BOP (Electronic Bill of Processes).

All of these systems services will document management (DM - Document Management), such as the BOM (Bill of Materials), BOR (Bill of Resources), BOP (Bill of Processes), CAX files, instructions, etc.

In particular, most developed systems manage electronic documents in specific formats for exchange through a direct communication link without human intervention [7].

Model features representation, amends parameters and relationships and access to the history of model to a large extent is completed by combining XML and VRML format (Fig. 4). In the context of geometric model forms and patterns, XML is basically composed of the following items:

- Identifiers (part_id, feature_id and face_id),
- Model forms and constraints of assembly (coincidence, concentricity, etc.),
- The color and material,
- Type of model features and parameters,
- The relationship between model features (Boolean operation or local operation of model features),
- Attributes of surfaces,
- VRML representation.

Browsing of existing XML plans from a database and display information about geometry and technology also is being done at user level. Management of XML, XML DTD (Data Type Definition) and XML schemas is realised on user level, thus the most appropriate framework for implementation of these modules is a set of Web browsers.

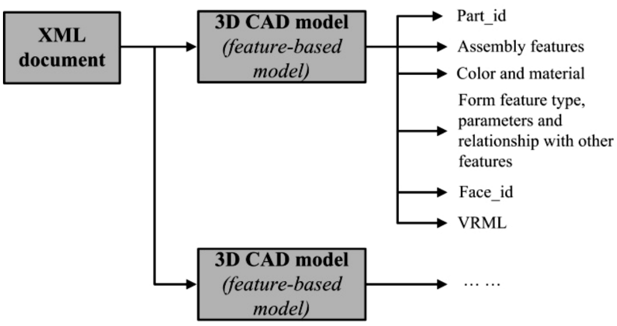

Fig. 4. Structure of XML document – CAD model representation.

3.2. Web based virtual environment architecture

Most Web-based systems were developed in the context of e-manufacturing and integrating activities of designing, collaboration, generative planning and production. A new form of organizational structure includes work in the virtual network environment and it is supported by new information and communication technologies for remote integration and distributed manufacturing processes [13].

The conditions for production integration and cooperation at global level are created by development of Internet/Intranet technology (Fig. 5).

Unlike the variant, generative CAPP systems are systems of the highest levels of automation [14]. Technological manufacturing process is based on adequate input information about workpiece, using built-in logic for decision-making, formulas and technological algorithms.

It is designed to operate autonomously and generate solutions without direct influence and intervention of engineers. Hybrid CAPP systems are used to generate alternative process plans.

By using techniques to transfer messages and information, teleoperation can be done using CGI (Common Gateway Interface) and Java client using generic HTTP server.

In addition to Web-based systems that accept different CAD information, special modules for Web-based support product manufacturing are designed. On-line visualization is provided by GUI architecture with support of two servers:

- VRML servlet-based server and is used to generate 3D geometric models,
- JATLite (Java Agent Template Lite) server for collaborative modeling using intelligent agents [15].

Authorized users can access these servers by entering a unique username and password.

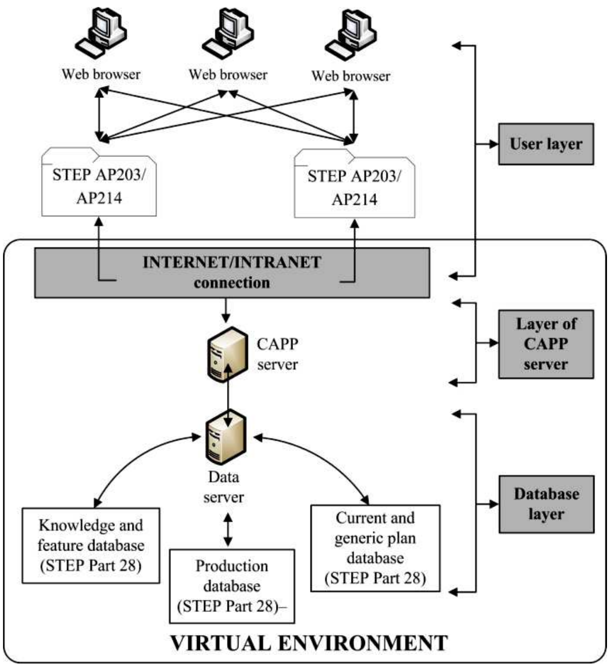

Fig. 5. Web based integration system for process planning in virtual environment.

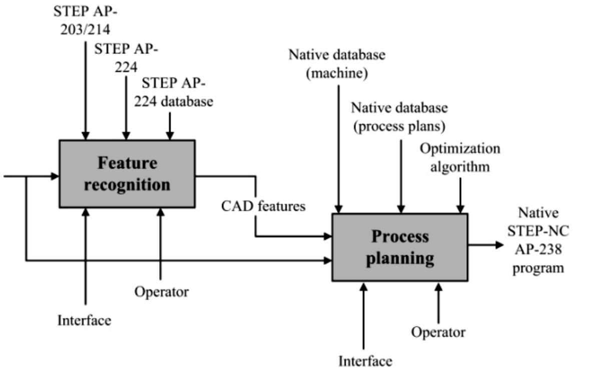

Fig. 6. IDEF0 diagram of CAPP server: Integration, MODEL I.

There are two models for planning optimization and integration at the CAPP server, as follows:

- Integration model (Model I),
- Interface model (Model II).

One of the first tasks of both models is the model features recognition and automatic workpiece model decomposition (ISO 10 303, AP-203, AP-224) to the level of geometric and technological primitives. This way of reasoning is highly intuitive and consistent with conventional thinking [16].

Integration model involves generating new native plan based on existing product information from native database (Fig. 6). CAPP server interface model also generates generic and native plan.

Main function modules for process planning (MODEL I) is joining manufacturing resources to model features recognized by CAD feature recognition. Control of planning process involves application of ISO 10303 AP-238 (STEP-NC AIM) standards, optimization algorithms and production database of native resources. Resource database of production are compatible with the ISO 14649-111 (tools for milling) and ISO 14649-121 (tools for turning) standards. Information about production resources is in the form of XML STEP-28 standard and link between CAPP server and native resources is achieved via Internet. The existing manufacturing resources (machines and tools) are assigned with recognized model features and thus, process planning module generates native program (STEP-NC AP 238). In this case, generated native plan can be immediately implemented at the workshop level.

In Model II, the optimization mechanism is separated from planning process and represents special module. Namely, output from planning module is generic plan ("what to do") but for the generation of native plan ("how to do") a STEP-NC adapter is used. Due to characteristics of flexibility and portability, Model II can be fully implemented for collaborative and distributed production in virtual environment.

4. CONCLUSIONS

The ddevelopment and using of new information technology in order to achieve strategic advantage, reduce costs and improve service levels, is one of the prerequisites for successful business. Conditions of modern production systems have been developed for integrative distribution planning in a virtual environment and consist of several dependent or independent modules to generate geometry, feature model recognition, process and equipment selection, cost estimation, sequencing, etc. Although the initial introduction of Web and VR approaches require large investments, the overall effects are significant.

Solutions that are generated largely eliminate technologists' subjectivity, simulate the real process and depend on knowledge embedded in the appropriate database.

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