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# CONCEPTUAL FRAMEWORK FOR CREATING CUSTOMIZED MODULAR CAPP SYSTEM

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***Abstract:*** *Information and communication technologies have a central role in the manufacturing system integration process. In this paper, a conceptual framework for the integration of available software applications is presented. Analysis of Croatian industrial enterprises is used to create a feasible computer aided process planning model. The suggested model uses the built-in ability of installed software for sharing information derived from processes with which they are connected. Information is then used for generating the optimal process plan for the current surroundings in the central CAPP module. Using the presented conceptual framework, modular CAPP solutions are created and customized to fit the needs of different manufacturing enterprises, taking into consideration the implementation costs and time.*

**Keywords:** – CAPP
– Module
– Integration
– Customized software solution

## 1. INTRODUCTION

Small and medium enterprises (SME) are the most dynamic part of the Croatian economy. In 2008, SMEs constituted 99.4% of the total number of enterprises and employed 64.3% of the total number of employees. They represent one of the most important drivers of overall economic development significantly contributing to an increase of production and exports [1]. Statistical indicators for usage of information and communication technologies in Croatian enterprises in the year 2008 show positive trends over the year 2007. This means that there is a high degree of integration of computer technology in businesses. For example, 98% of companies use computers and 97% of them have internet access [2]. However, usage of information, computing technologies and specific applications is related to the areas of communications, sales and financial operations. Usage of the same technologies for increasing productivity is not so highly represented as in industrial enterprises of the technologically more advanced countries. Analysis of statistical indicators, Figure 1, shows that small and medium sized enterprises which use and integrate computer aided systems within the existing computer system environment have improved business processes which are resulting in better business results. The biggest impact can be observed in the reorganization of the business and better use of resources [2].

Croatian micro industrial enterprises on the average employ less than 10 people and have up to 0,9 mil € worth in fixed assets. Medium industrial enterprises on the average employ less than 250 people and have up to 14 mil € worth in fixed assets. Considering the price of specialized integrated solutions, business surroundings and level of employed engineering resources, programming skills and knowledge, it can be assumed that the currently available solutions are not suitable for most enterprises in the SME group. These solutions usually require a high degree of engineering programming knowledge or presence of professional consultants.

In Croatian small and medium industrial enterprises, there is almost no trend of integrating available computer solutions into one integrated system.

The key component needed for computer integration of industrial enterprises is computer aided process planning, CAPP [3]. CAPP is often difficult to

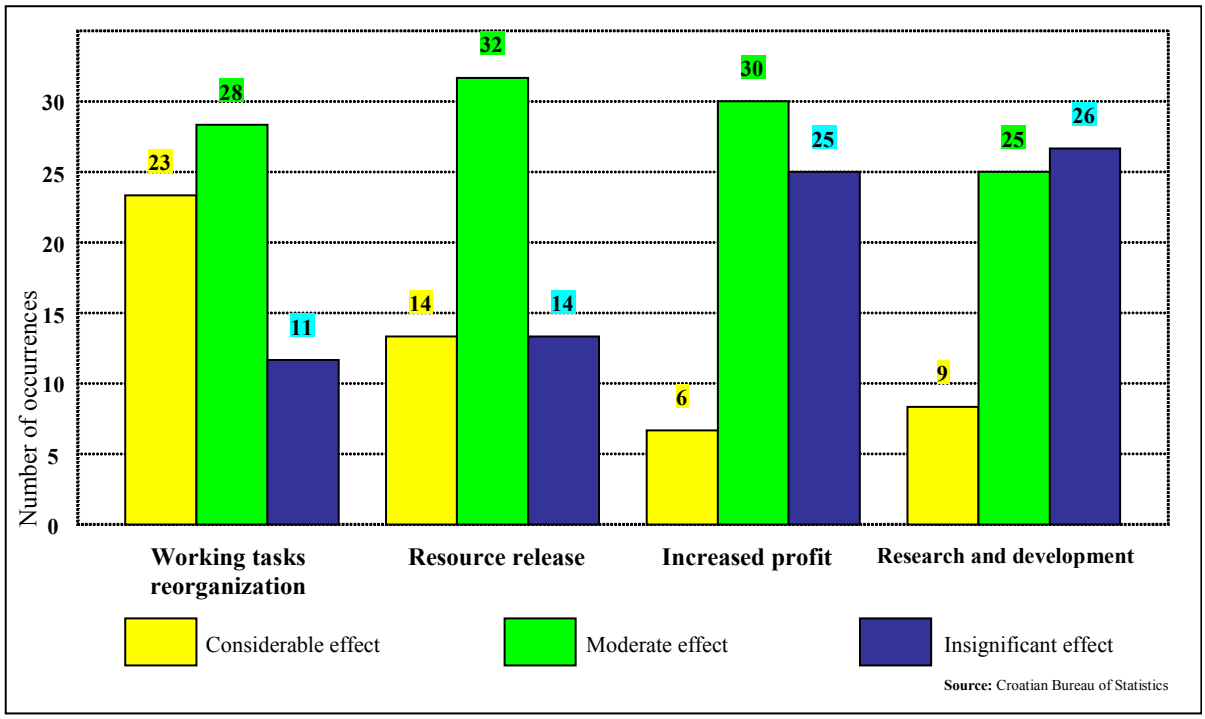


*Figure 1. Effects of ICT usage on enterprise productivity increase in year 2008*

integrate into existing enterprise information surroundings due to incompatibilities with CAD and CAM modules. The introduction of CAPP solution often requires acquiring specialized computer systems which generate costs through significant investments in software, hardware and consulting [4]. In introducing such systems, enterprises often agree to discard a part of knowledge and expertise, which are hard to integrate within the commercial solution and in the long run are irrecoverable. Currently accessible CAPP systems can still fully compensate for the technologist's knowledge and skills. The reason is in the complexity and dynamics of tasks and the diversity of factors and their impact on the decisions that the technologist must at a certain moment take. Innovations and technological improvements in the manufacturing system is an unavoidable part of the everyday tasks of the technologist. Introduction of a new technological solution and its proper implementation is a task which can't be left to a computer because the same computer is often part of this solution. A significant amount of scientific research currently concerns intelligent the CAPP system and CAD/CAM integration. CAPP is the key component for that integration, like the process planning representing the connection between design and manufacturing functions in an industrial enterprise.

## 2. CAPP – LITERATURE REVIEW

In the paper Computer Aided Process Planning, Houtzeel says that before the formalization of process planning, planning for manufacturing was trivial [5]. Note "Suitable for manufacturing" was entered on the technical drawing, and the drawing was sent to a foreman who would empirically define the "process plan". Such a process doesn't take into account the large number of technological parameters, which are indispensable factors for process planning optimization. Reviewing the current state of small and medium sized industrial enterprises in Croatia, where formal process planning is skipped, it appears that the above mentioned method is equal to the stated planning practice.

Because of the wide range of relevant scientific research in areas that include computer aided design process planning in the past two decades, it is very difficult to encompass all of it. However, some authors have made reviews of the research. Alting and Zhang [6], CAM-I [7] and Kiritsis [8] provide

detailed reviews of the scientific research of CAPP. Although [6 and 7] give an overview of research older than two decades, they cover the area of setting up grounds for the CAPP system and an overview of these works can give a good idea of the basic preconditions for setting up such systems. Kiritsis [8] gives an overview of research of the CAPP system based knowledge, and also classifies approaches for CAD-CAPP-CAM feature recognition. Eversheim and Schneewind [9] and ElMaraghy [10], based on the review of scientific research of CAPP, provide guidelines for future research. Guidelines given in these articles are still current.

In theory, there are two basic approaches in process planning: manual and computer aided approach. The manual process planning approach is based on the knowledge and skills of the technologist. Such knowledge and skills must be included in the autonomous CAPP system, and they include the following [11]:

- Ability to read technical documentation
- Knowledge of the properties of production materials,
- Knowledge of production processes,
- Knowledge of fastening and clamping devices,
- Ability to read the reference documentation,
- Knowledge about the impact of the cost of materials, tools and devices,
- Ability to calculate production and costs parameters,
- Knowledge of quality assurance procedures.

CAPP represents the connection between the design and manufacturing processes in industrial enterprises. It provides the necessary connection (information flow) between CAD models and manufacturing documentation. It uses the available information needed to create a process plan and generate supporting documentation. During the product and manufacturing system life cycle, CAPP moved by changing the status of influential factors and/or periodical audits of the process plan and providing the optimal solution for the current conditions.

The CAPP system was created to simplify and improve the technological planning process and to eliminate the shortcomings of manual process planning [12]. The evolution of CAPP systems follows the availability and number of implementations of computer systems in industrial enterprises. As can be seen in Figure 2 it starts with the manual technological process elaboration, continues with the introduction of the group technology concept, GT, it is simplified by the implementation of information storage systems and further developed to the CAPP approaches known as the variant approach and the generative approach.

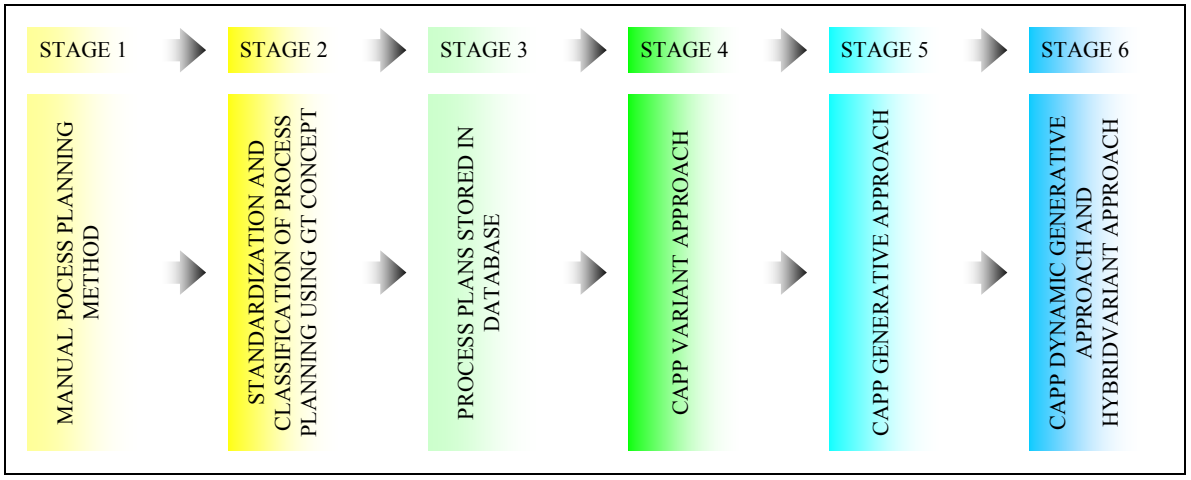


*Figure 2. Process planning and CAPP evolution*

Further development of the generative approach goes in the direction of dynamic generation of process plans [13], while the variant approach adopts some properties of the generative approach and becomes a hybrid of two [14]. Currently active scientific research reviews two basic approaches to computer aided process planning named the variant approach and the generative approach [15].

The variant approach uses the principles of the group technology concept and plans are generated using elaborated, generic plans for a family of products. The generic process plan is taken from the database and with minimal changes is adapted to a specific case [16].
Variant CAPP systems are very efficient but they have one big disadvantage for flexible manufacturing process planning. Variant CAPP are unable to generate a process plan for any product, but only for those products that belong to a particular family.
For a product that does not belong to a specific part family, it is necessary to develop a process plan from the beginning using the manual method. The new process plan can later be stored in a database and be used as a generic technological process for similar products.
The generative approach to computer aided process planning is based on the ability of the computers to independently, based on a set of rules and constraints that have already been given, generate and synthesize the technological process for any product. For this to be feasible, it is necessary to ensure that the computer system has the built-in procedure execution tasks of technological design, optimization algorithms, built-in knowledge and skills in database and decision-making algorithms. The main difference compared to the variant approach is self-generating process technology by the computer system. The generative approach does not use the referential technological process in order that a new technological improvement project could be carried out in relation to it, but over and over again, by using optimization algorithms to generate a unique technological process [16].
To survive in the current market surroundings, manufacturing systems have to generate lower costs with a small amount of production and small lots, shorter delivery times and they have to minimize downtime while the variety of products that they manufacture increases. By introducing the concept of reconfigurability, manufacturing systems are trying to move built in flexibility to dedicated manufacturing systems cost effectiveness. The basic concept upon which they rely is the group technology concept. Manufacturing system productivity is increased by grouping the overall production program into families of products that are suitable for manufacturing on the same system that has the feature of customized flexibility. It can be concluded that the hybrid variant approach is the logical solution for process planning of given manufacturing systems.

## 3. CONCEPTUAL FRAMEWORK

The concept of customized solution presented in this paper uses the built-in integration ability of individual applications to use information from one application within another application. The conceptual model belongs to a group of data integration models, DIM.
The suggested conceptual framework is based upon the hybrid variant CAPP approach.
A customized CAPP system is realized by linking CAD and CAM modules into an integrated whole using a customized or newly developed CAPP module that uses real-time, available expertise and skills of the technologist that are activated manually by entering them via a few simple user interfaces. That approach in application integration can be classified into groups of weak and medium strong connected applications. The usage of those applications in small and medium enterprises in Croatia has several important benefits:

- Application integration relies on a simple user interface,
- The integration is carried out using the black box method,
- Simple and intuitive upgrade is enabled,
- Ability to use applications separately (integration is defined by the user).

The specifics of individual production systems impose the need to use the general approach for setting up the computer applications integration concept. The steps of the suggested conceptual solution are given and explained in the following text.

### 3.1. Integration goals and application identification

Different systems use different applications for specifics in the manufacturing program, machines used, better connections with customers and suppliers, staff training in working with certain applications, costs, etc. Because the solutions are customized based on the available applications, it is clear that it is necessary to identify the applications that are included in the integration on the final result to be achieved. The above shows the first step of concept creation, thus determining the desired

results of integration and identification of available applications, Figure 3.

### 3.2. Application integrability

Some applications are relatively easy to connect, but for connecting others a middleware computer solution is created. The next step is to determine the concept of setting up the integration capabilities of individual applications. It is necessary to assess need and justify the introduction of the middleware solution. The current situation obtained by examining the small and medium-sized industrial enterprise systems in Croatia shows lack of applications integration. In such cases, there is a situation in which the introduction of any new application increases the required number of connections for its quality integration.

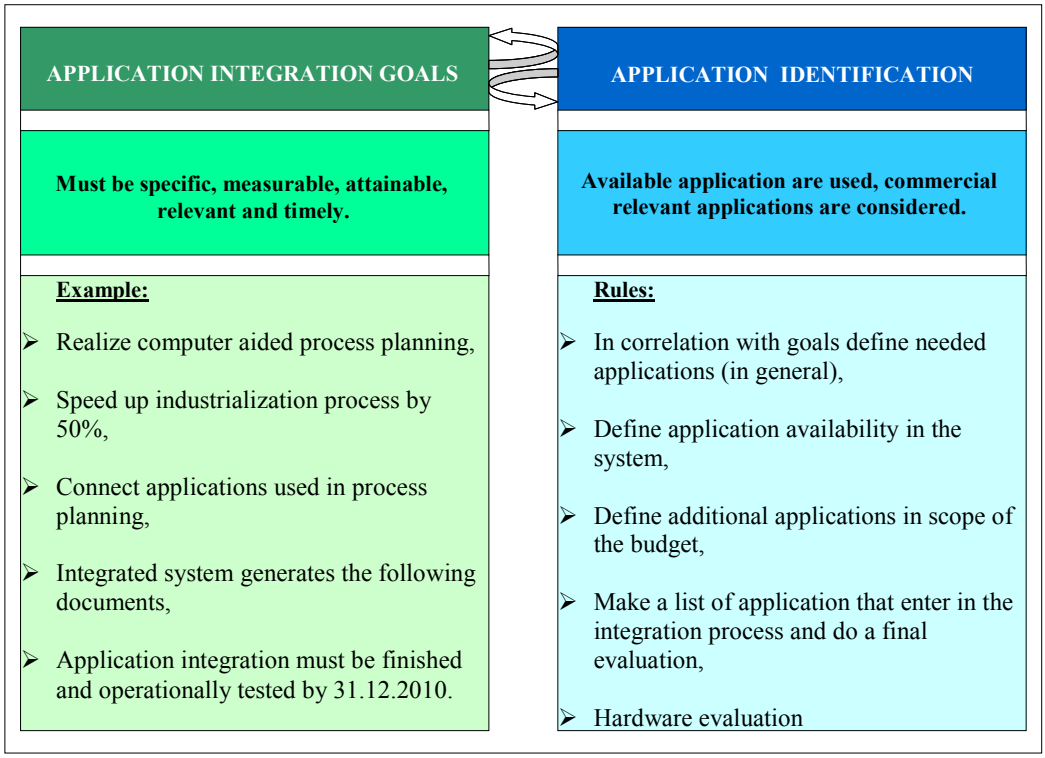


*Figure 3. First step – Application integrability*

### 3.3. Database integration

The simplest way to store experience and choice methods of execution of certain tasks of previously performed projects, templates, procedures, and information about the current state of the enterprise as well as influential surrounding factors is by using databases.

If in a computer system there is a database and analysis shows that it is the appropriate one for achieving the set integration goals, it is necessary to determine the activation mechanisms for usage of data in a customized central module. If there is no database, there is a need to determine the type of database that will meet the specific requirements based on goals of integration, user support and cost.

### 3.4. CAPP module creation

CAPP is the central module of the customized modular CAPP system. The CAPP module optimizes the process plan for the manufacturing of a product from optimal raw material type considering quality, costs and time constraints. Indirectly or directly, it creates information flow between processes connected with process planning; it collects, stores, guards, processes and delivers information important to process planning. Figure 4

shows the information flow through the CAPP module during raw material optimization.
Calculations are easily integrated into the CAPP module with technical calculation applications, while the calculating procedures and decision making can be integrated using a finite number of instructions.

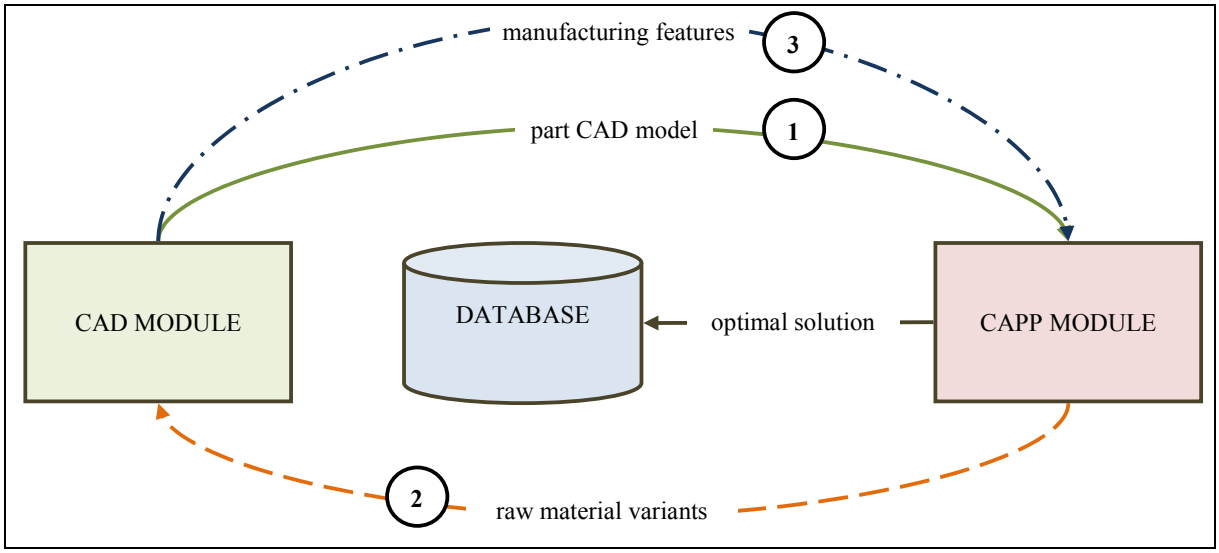


*Figure 4. CAPP module information flow*

### 3.5. User interface design

Knowledge and skills of the technologist in the suggested model are activated using user interfaces. Designing them directly affects the system and output information. They allow two-way communication between the user and the customized integrated CAPP system.
Design of user interfaces starts with efficiency analysis of available user interfaces from integrated modules, continues with user interface customization and finishes in the final integration with the system modules.

### 3.6. End user integration

Application integration is basically a project that an enterprise starts in order to improve efficiency of execution of the business processes. Business processes in the system include people who are in certain stages of the process directly involved in it, and it is therefore necessary to include them in the project of creating integrated solutions. Recognizing the benefits of using integrated computer modules by the end user will shorten the implementation phase of the concept in processes and will more quickly achieve the set of integration goals [17] and lead to positive developments in the execution of business processes using the suggested solutions.

Figure 5 shows the simple customized modular CAPP system creation process.

## 4. CONCLUSION

The conceptual framework presented in this article is to be used to solve complex and specific problems in Croatian industrial enterprises.
The paper attempts to set general policy or ideas on how application integration should be made regardless of the diversity of the individual industrial enterprise in which it is supposed to be carried out.
The concept was created using extracted characteristics from other enterprise information integration concepts.
The concept is limited to small and medium business systems in Croatia for several reasons:

- The idea derives from reviewing and real presence in those enterprises.
- Actual models designed on the basis of the proposed concept can be easily implemented in small and medium enterprises.

- The validity of the concept as well as the actual solutions that derive from it, is possible to confirm by insight into a number of small and medium-sized businesses and evaluation of improvements achieved through proposed concept application.

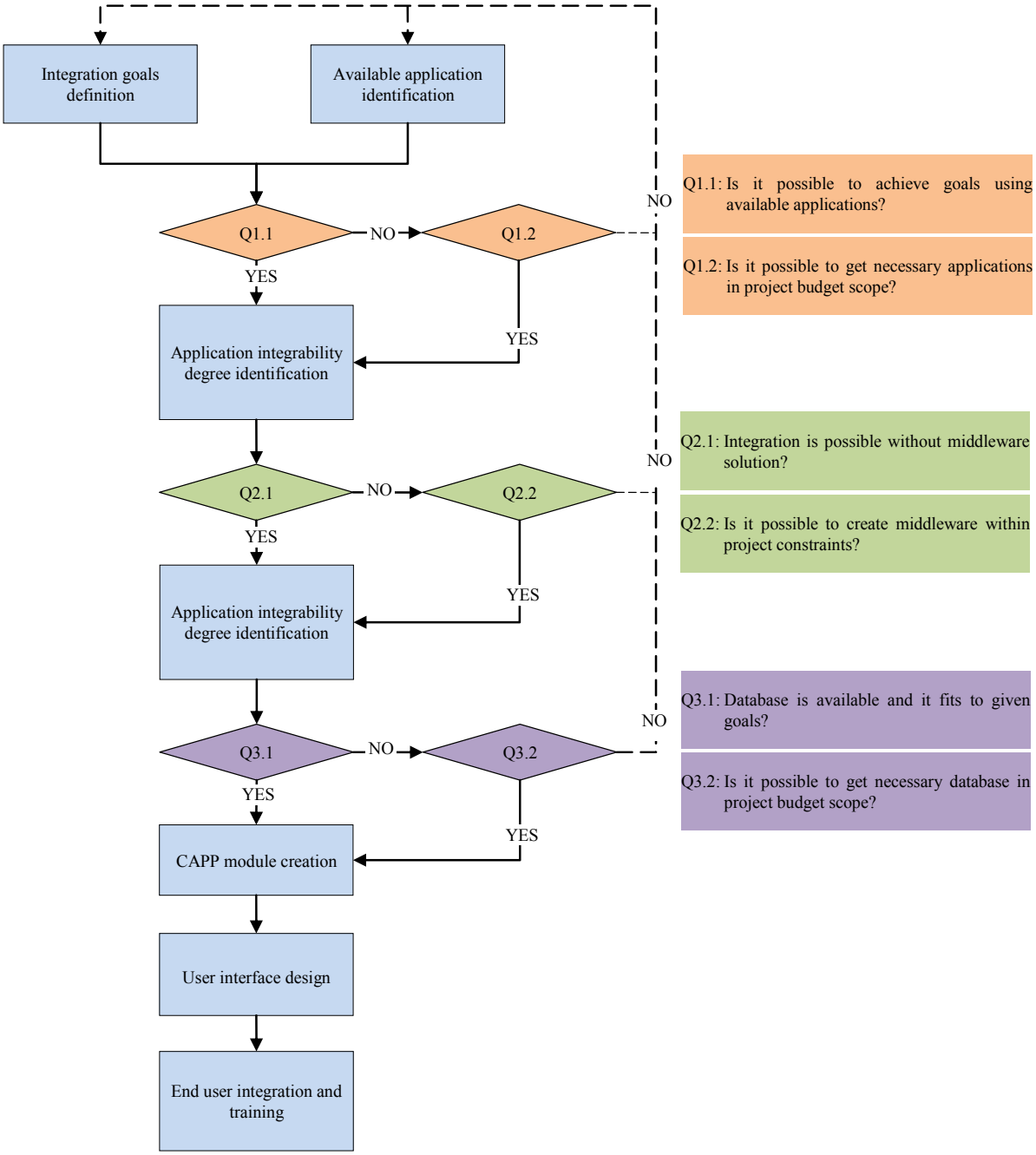


*Figure 5. Flow diagram of simple customized modular CAPP system creation process*

The models created on the basis of this concept represent customized solutions adapted to specific objectives and available computer applications and also they show the structure of the proposed concept under the given conditions.

The emphasis when determining the concept and customized model creation is on the business

processes. Application integration permanently removes limitations that prevent the smooth flow of information. With the creation of user interfaces, new standards for communication within the enterprise are set and communication is one of the four elements of information management in the business system.

With the newly created standard view, the enterprise presents the seriousness which is expressed with a high level of process documentation and simplicity of information within the processes included in the customized solution.

Although the application integration model presented in this paper was left at the information integration level, it leaves room for deeper application integration and ultimately in business processes in general. The adoption of the proposed concept enterprise can operate on four elements of information management. These elements include communication management, workflow management, document management and records management [18]. These elements are independent of the computer technology that realizes them, although commonly equated, which is erroneous.

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