SOFTWARE FOR THE INTERACTIVE CONFIGURATION OF RP BASED PROCESS CHAINS

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Abstract

In product development, time is one of the most critical factors. By introducing Rapid Prototyping methods, development time can be reduced dramatically. But the required characteristics of the generated prototypes become more and more complex. As a result, a great variety of Rapid Prototyping devices and services have emerged on the market. The product developer may be highly satisfied with the wide range of new potentials, tools and methods but who will give him an orientation about the most suitable process chain to fulfil his demands? To solve this problem, a new software is being developed at the Fraunhofer Institute IPK in Berlin, the iViP-RPSelector.

In a first step, the software tracks a record of the demands to the prototype. These values can be inserted manually, but there is an interface as well connecting the RPSelector to CAD and PDM systems to obtain the design parameters without user interaction. The RPSelector then calculates a complete RP based process chain, which may comprise a layer wise creation, some post processing, a copying process and several finishing processes.

Design Loops

The design and production planning of technical products runs through several phases and each phase is repeatingly performed, using design reviews to allow a loop wise improvement of the product's design and functionality. Within these loops, depending on the maturity of the product, different technologies may be used to produce prototypes rapidly. Since the manufacturing of prototypes is divided into several steps, e.g. generative production, post processing, surface finish, multiplication by means of casting or moulding etc., these process chains have to be configured individually following the requirements.

Today, the configuration of process chains is a task that has to be performed thoroughly in order to obtain the best results in the prototype phase of a product development project. After having defined the requirements concerning all requested prototype characteristics, the product developer needs a partner to execute process selection and process planning interactively. Normally he will contact a 'Rapid Technologies' service bureau. This process can be considered as a brokerage between two or more partners. But when doing so, the product designer is not able to assess neither the selected solution nor the suitability of the promised result.

Software Support for RP manufacturing

Both processes, selection and brokerage of RP process chains, are subject to many error sources in daily business. Firstly, the designer may have omitted to communicate special parameters such as corrosive media that will destroy the surface of the planned prototype, or temperatures occurring during the tests. Secondly, the process planner may omit the influence of pre-processing or post processing steps. Finally, the service bureau may use sub optimal processes and material, being misinformed about the state of the art.

As a result, the requirements for the software are

- Taking into account the newest technological developments
- Checking the interoperability of individual process steps
- Calculating the impact of individual processes on the manufactured parts
- Make the user competent to assess technologies
- Offering an interface to the brokerage of manufacturing services
- Ability to introduce new processes and materials into the system
- Ability to introduce new rules for the computation of process chains
- Offer the possibility to moderate and control the procurement and logistics

The module has to be designed to assist both, the designer and the production service. It will enhance a much faster and more efficient design review loop. As a result, the quality and circle time of prototype manufacturing are improved significantly.

The software tool „iViP-RPSelector" and the corresponding "RPBroker" have been developed to meet the above described requirements. The development started by collecting the critical factors. This was done by analysing several existing projects in the industry. Existing shortcomings have been documented and converted into software abilities in order to eliminate those gaps.

An object-oriented approach was chosen. Hence all processes and materials could be described as objects having individual properties. As a first step a list of parameters describing the objects used, was exchanged between project partners. System development was then divided into two main tasks:

1. the organization of the database
2. the evaluation functionality

The technological evaluation of the previously defined requirements is based on an object model that describes typical process qualities. Input and output objects are defined for each individual manufacturing step. Input objects of a manufacturing step are e.g. the CAD data of the component or values for shrinkage of predecessor processes. Output objects are output files or the produced components (Fig. 1).

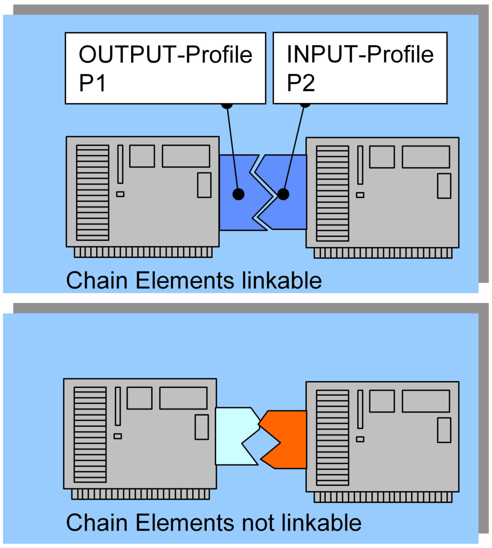

Figure 1: Linking individual process steps

A consistent description of process concatenation alternatives is the outcome. Material cost can be defined easily through a volume calculation of the workpiece. Machine working hours can be calculated approximately by computing the height and volume of the workpiece. Calculation deviations will originate in the workpiece position and amount of parts built, especially when estimating the cost of generative processes. So monetary aspects are reduced to 'technological' costs, that are material and a rough estimation of machine costs.

Evaluation of Requirements

In real life, certain fuzziness underlies the selection and configuration of manufacturing means. Imagine you request a set of four steel prototypes, allowing a delivery time of two weeks. A service bureau you contact is able to produce those four parts within three weeks. If you lower the requested surface quality, the period can be shortened to 16 days. But if you allow 4 weeks, they are able to produce 500 parts. A human being performs the evaluation on the base of his/her experience. The weight/importance is assigned to each requirement by communicating with the customer.

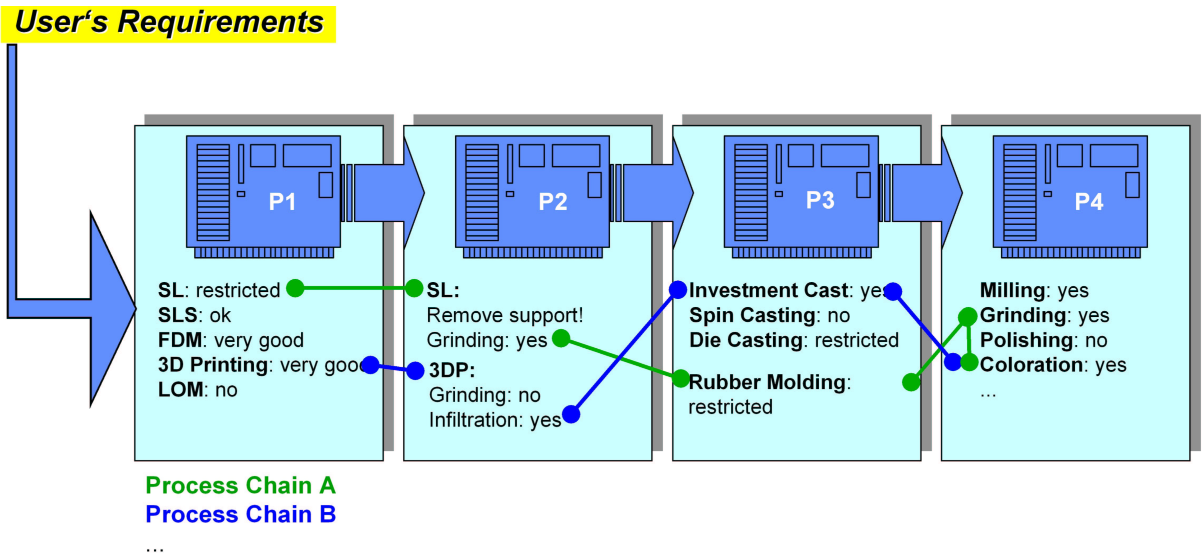

Figure 2: Concatenation of Process Elements

The requirements have to be weighted to enable the system to distinguish between important and less important requirements. The task of the evaluation algorithms is to find a manageable number of approximately ten best fitting manufacturing possibilities, taking into account the requirements and their priority (Fig. 2). The result is then presented to the customer. A reasoning module has been implemented which makes the selection transparent for the customer. For every criterion, the fulfilment degree of the requested characteristic is represented graphically. In the case of unsatisfactory selection results, the customer is able to identify those requirements that represent a weak point in the selection task.Process planning activities can be carried out more efficiently and more precisely based on the described process configuration. The limitations of each single process in the selected chain are listed and the system gives hints to support the machine operator. In addition to the pure technological process planning, the effects of the predecessor and consecutive technologies are considered.

If, for example, a milling process is planned as a following process to the generative production of a component in order to meet tolerances, the iViP-RPSelector adds a reminder to scale the relevant measures. As a result, a sufficient material removal by milling is guaranteed even in the most unfavourable case.

Available Software Architectures

The implementation of a PURE JAVA interface using a JDBC (JAVA Database-Connection)-bridge operating on SQL statements allows the access of database contents and the extraction of specified values regardless what type of database is used. The evaluation functionality is represented schematically in the following figures. Basically four consecutive process elements were defined (Fig. 3). A set of requirements is compared with the capa-bilities and limitations of every process element. The result is a pre-selection of adequate elements.

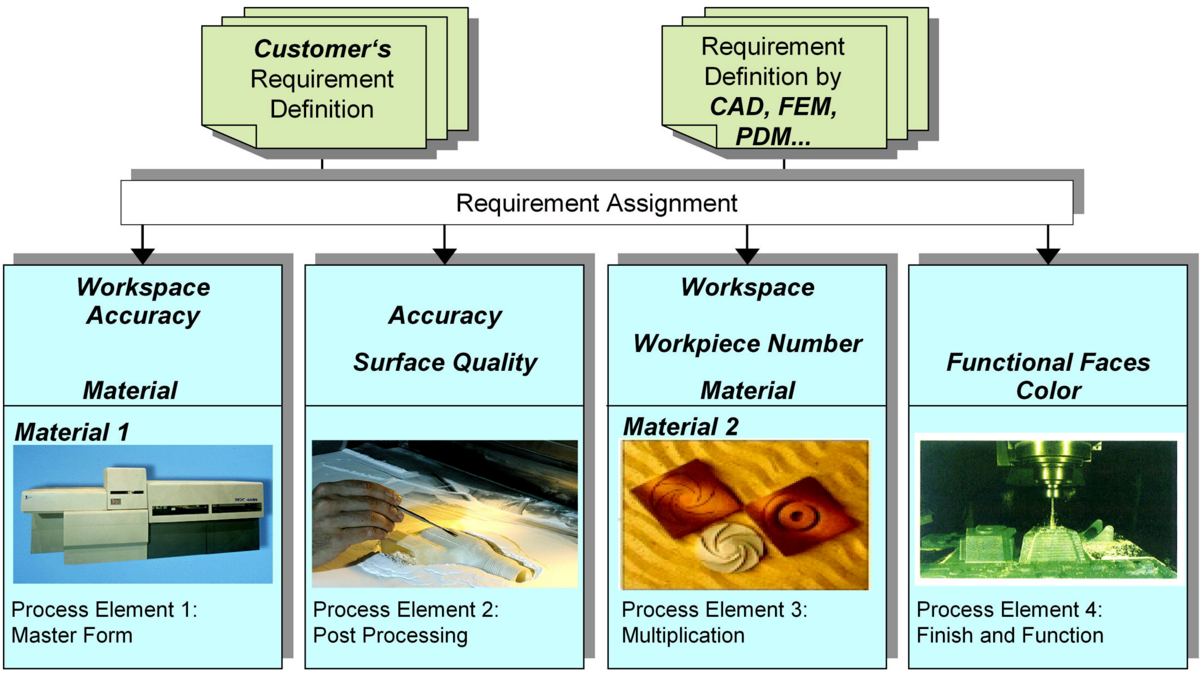

Figure 3: Configuration of process elements due to customer requirements

The planning software is designed to be used by product developers as well as service bureaus. It replaces neither the experience of the experts nor the process planning procedures available at the service bureau's site. The software forms an important bridge between the design and procurement activities on one hand and the subsequent component production on the other hand. The selection module can be used in multiple software environments:

1.1 Stand Alone Application

The selection module can easily be installed on a PC. The database is then stored locally. As a result, external access is not possible. Updating is done manually by inserting new processes or materials that are available at the user's site. Alternatively a complete installation of new versions of the software is necessary when the state of the art has changed.

1.2 Web Access

The selection can be performed by the installation of a web server and accessing it through the World Wide Web. Updates can be realised continuously by experts without end user's interaction. Individual changes of process and material limitations by the user are not available, because the only database is located on the web server.

1.3 Virtual Product Development

The software consists of multiple modules and hence can be integrated into a distributed software architecture like iViP. In this case, the iViP-RPSelector can communicate with other applications in order to retrieve relevant data such as workpiece size, material or prototype functionality. The results are sent to the module iViP-RPBroker, which supports the procurement and manufacturing workflow, following the selected process elements. The architecture of this complex software infrastructure is shown in Fig. 4.

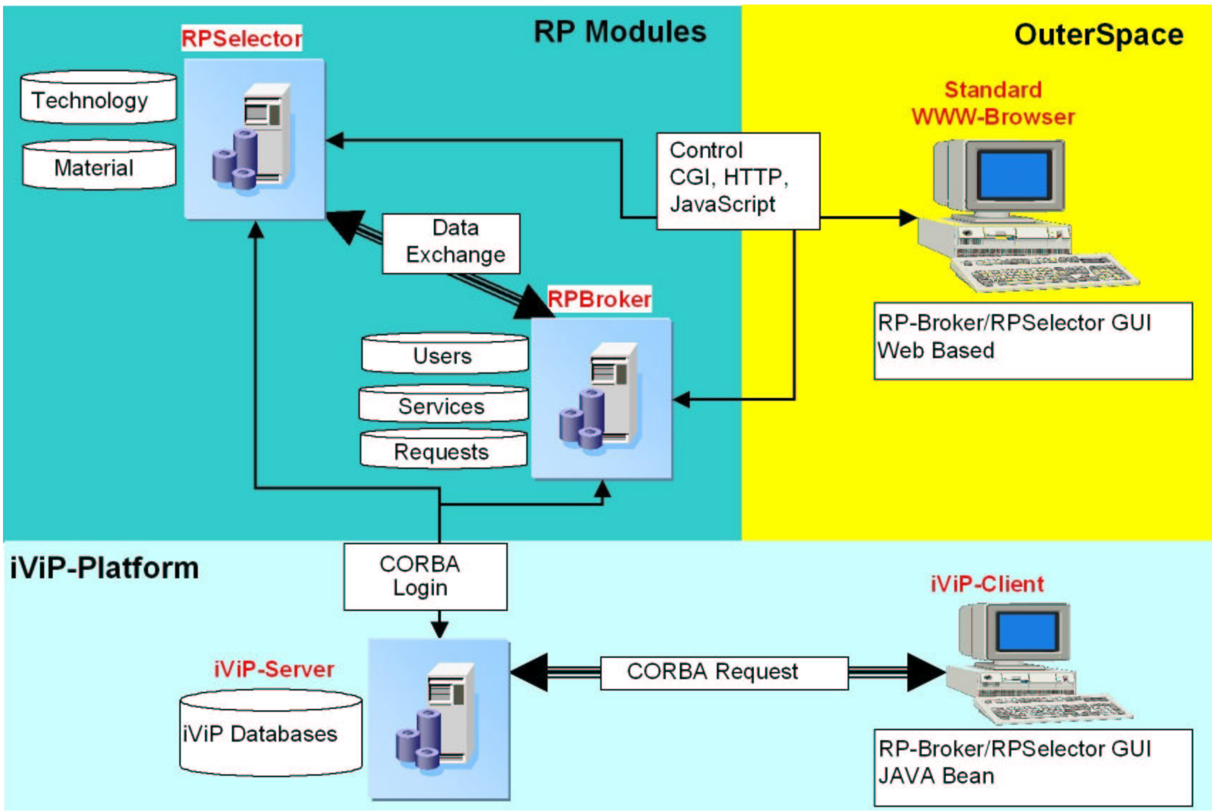

Figure 4: Software Architecture

Case Study

A ground connector bracket (Fig. 5) of an aircraft was used to show the applicability of the software modules.

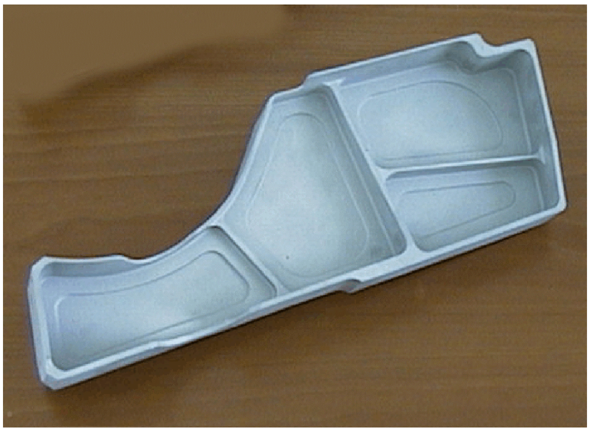

Figure 5: ground connector bracket

For the ground connector bracket, the basic requirements were:

Material characteristics:	aluminium like
Number of parts:	2
Surface Quality:	rough
Accuracy:	0.1 per 100 mm

In this case, the DTM steel 'Laserform' was selected because of its aluminium like characteristics. The only problem here was the specific weight of the part. This shortage of parameter definition was detected by the system and clearly stated.

The alternative presented by the software was generative manufacturing of solvable material and a subsequent employment of investment casting. This process chain requires a longer period, but creates optimal output. Additionally the user received information about shrinkage factors, process capabilities and restrictions. The selected processes, materials and annotations are then transmitted to the RPBroker software module, which accompanied the customer when procuring the corresponding services. The software gave hints regarding the difficulties when breaking out the parts. Several errors and misunderstandings could be eliminated when the complete set of data was transferred to the RPBroker, where procurement of RP services was performed.

Conclusion

It has been demonstrated that the selection of a single process may be an easy-to-perform task, but when a real world environment is considered, the construction of process chains is necessary. Assuming that each process element can be represented by 6 alternatives, the total amount of approximately 1300 process chains have to be tested, taking into account the individual linkage specification of each process and the overall efficiency of the resulting process chain.

Even if an expert could find the best configuration without software support, he/she will appreciate the capability of sorting out unemployable processes rapidly. Additionally, he/she will obtain preselection hints and immediate information about process limitations.

Acknowledgement

The described software was developed within the 'BMBF Leitprojekt' **iViP** and will be available as a product in early 2002. The author thanks Kai Loose and Stefan Ferstl, DaimlerChrysler AG; Thomas Lück, Bertrandt AG; Ralf Nachreiner, CIRP GmbH and Hans Peter Nicolai, TITAL GmbH.

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