Web-based Rapid Contracting, Prototyping and Custom Manufacturing

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Introduction

Proposed is a project which would link students, designers, and small companies to automated shops and manufacturing facilities via the Internet. Using a web page maintained by an independent entity, designers could submit designs using a custom-made java application which would funnel DXF data to special automated woodworking and metalworking shops. The shops would quickly process the requests, and send the finished pieces directly to the designer.

Background

MOSIS PROJECT: In the 1970's electrical engineer Lynn Conway headed a research group at Xerox which began a collaboration with another team at Caltech to search for improved, simplified methods for VLSI (microprocessor "chips") system design. In the late 70's Conway realized the need for large-scale experimentation to further generate, test, and validate the methods. The design and manufacture of microchips is an expensive endeavor, which very few companies can afford. Independent designers, students, and smaller companies were all but cut out of the process due to high cost. Conway began using novel methods within a systematic, rapidly expanding set of interactions with many universities throughout the United States. Conway set up a system whereby students could do design projects along with their studies, and actually manufacture prototypes of the microchips. Using seed funding, online manufacturing facilities were set up where students and independent designers could send microchip designs via ARPAnet (the predecessor of the Internet) and have prototypes of the designs manufactured economically. The project became known as the MOSIS Project, which has become a thriving vital link in microchip design processes throughout the United States.

AUTOMATED CONSTRUCTION: In early 1996, architect A. Scott Howe conducted a research project under Conway, which attempted to derive design principles for automated construction techniques. Using the Internet and an industrial robot, Howe successfully constructed and disassembled a model building from Denmark and Japan using an ordinary telephone line and a portable laptop computer. An employee of Kajima Corporation of Tokyo, Japan, Howe has been interested in computer-based building design, and the eventual construction of the buildings via automated means. Kajima and several other Japanese construction firms have developed automated construction systems independently of each other which have actually been employed in the construction of highrise buildings.

COMPUTER-AIDED MANUFACTURING: Donald Geister has worked with computer-aided manufacturing facilities. Geister has been instrumental in the acquisition of computing and automated manufacturing equipment for the establishment of CAD/CAM facilities at the University of Michigan. He is currently working on several projects which attempt to open numerical controlled prototyping facilities to schools and Internet audiences. Geister is currently developing a project in collaboration with the University of Utah for setting up domestic prototyping and manufacturing facilities for remote use by foreign designers. Geister has immediate access to hundreds of potential designers as users of a web-based system.

Project Description

Recently Conway and Howe have been involved with research topics which involve remote control and communications over the Internet. Coming from two different fields, a refreshing perspective of techniques and methods have given birth to the idea of setting up a service which would connect designers and manufacturing facilities via the Internet, similar to the way the MOSIS Project functions with microchip design processes. The idea is to base the service on a purely object-oriented approach, where designers would submit designs to the web page, and a web page cgi would search for an appropriate manufacturing service. To the designer, the manufacturing process would be completely transparent; designs would be submitted, and a few days later finished pieces would arrive at their doorstep. To the manufacturer the design process would also be completely transparent; having received design data from the web page service, the processed materials would be sent to a specified address, or to the next

manufacturing facility for further processing. Designers would pay for services through the entity which maintains the web page and manufacturers would bill the entity for services done.

The eventual goal of such a system would be to provide economical access of manufacturing processes to students, independent designers, and companies. Sophisticated manufacturing processes could become wide open to anyone with access to the Internet, including the hobbyist and handyman. Libraries of finished components could be developed which already have their manufacturing processes worked out, which anyone could freely use, or custom artifacts could be devised based on the manufacturing processes available on the service.

It is hoped that seed funding could offset initial costs for pilot programs which would establish the utilization of the web service as an economically viable alternative to designers. It is also hoped that the web service could be presented in such a way as to gain popularity on the Internet in order to have enough momentum to continue beyond the seed funding. The project will proceed in three phases:

PHASE I: (In progress) 120 CAD/CAM students in the University of Michigan ME250 course will be linked with local automated woodworking and metalworking shops via the Internet. Student's designs will be piped to the manufacturer, and the finished results will be delivered to the students. Don Geister has estimated the needs for the ME250 course to be around $2000. Additional funds may be required for programming and software (developed in-house or acquired off-the-shelf). It is hoped that this phase of the project will be funded and operated by the Millenium Project of the University of Michigan. The Millenium Project is a major entity devoted to investigating future applications of education and partnership with business and community.

Preparations:

1) Initially a simple automated server can be established which takes e-mail with DXF file attachments and pipes files off to the appropriate manufacturer. Mr. Howe has some of the expertise needed to implement such a system, but additional java-knowledgeable programmers would need to be recruited fairly soon.

2) A web page with controlled access can be established which contains a simple java draw application. Students would be able to draw to a grid cut lines on a virtual sheet of material, or upload a DXF file prepared elsewhere. The web page would submit the DXF file along with information on the designer's address to the manufacturer / fabricator. Some of the web page development can be done by Mr. Howe. Again, additional programming help may be necessary.

PHASE II: The web page would be opened for public access, including the hobbyist and handyman as well as students, designers, and companies. This phase of the project would be funded and operated jointly by the University of Michigan and a private company, perhaps established especially for this purpose.

Preparations:

1) The web page design would be honed down and perfected, including certified encryption and sophisticated drawing program.

2) Contract with shipping services for delivery from manufacturers to anywhere in the world. Following the object-oriented approach, perhaps a neutral location can be established where manufacturers can deliver the finished pieces, which can then be shipped off to the designer.

3) Automated fee and rate calculation based on requested service and appropriate manufacturer. The fee estimation would be directly related to number of cuts, holes, etcetera and would be fed back to the designer before official submittal.

4) Enlist more manufacturers.

5) Potential for remote cameras and queue feedback from manufacturer to web page.

PHASE Ⅲ: Sophisticated ready-designed parametric component libraries could be made available which have all their manufacturing processes worked out. A user could choose and order a component, and have it delivered to their doorstep a few days later. This would be facilitated by a barcode system which keeps track of parts and fabrications as they are passed from manufacturer to manufacturer until the finished product is complete. Also, the possiblity of sophisticated custom artifact manufacturing can also be incorporated in the system.

Preparations:

1) Development of a more sophisticated web interface, using a modeling program instead of a draw program. The modeler would be able to generate tool paths and include expert systems which determine manufacturing sequences.

2) Establishment of a bar code system for keeping track of parts and fabrications.

3) Enlist more sophisticated manufacturers, such as machine shops and automated factories.

4) Design kit-of-parts libraries with all components pre-designed. All fabrications and manufacturing processes would be pre-planned and established.

5) Development of expert systems which analyze compound assemblies of the ready-made components, such as buildings or automobiles. Expert systems could include structural analysis, finite element analysis, thermal analysis, daylighting analysis, etcetera.

Conclusion

Eventual goals of this system could include web access to fully automated manufacturing and construction systems by common users of the Internet. Eventually it could be conceivable that with the help of expert systems an elementary school student could design a sophisticated artifact, such as an automobile, and have it manufactured automatically. While this is an extreme case which could not be achievable in the near future, it illustrates the possiblities that web-based manufacturing systems could eventually embrace. Initially, since the project is based on object-oriented theory, none of the processes need be automated in themselves, as long as the interface between the designer and manufacturer is kept transparent and conveniently accessible. Starting with simple prototypes produced by students should provide suitable material for feasiblity studies.

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