NSF EAGER: Cybermanufacturing

Enabling Production as a Service

PROJECT OBJECTIVE

This project proposes a web-based Production as a Service (PaaS) framework that increases the effective utilization of existing geo-distributed manufacturing facilities by connecting them with new product developers.

MOTIVATION AND CHALLENGE

Manufacturing of new products is usually preceded by a convoluted process requiring product developers to query, and subsequently negotiate, production quotes with various manufacturers. This process often takes a lot of time. Moreover, product developers are usually constrained to approach the limited number of manufacturers in their network. At the same time, there exist manufacturers with underutilized machinery. Currently, there is no framework extensive enough to incorporate several geo-distributed manufacturers to produce new products in small batch sizes. There are service oriented architectures (SOA) proposed in the literature to address this problem, but usually, they lack the required abstractions to model the design requirements and the manufacturer capabilities. Another major concern associated with SOA is the preservation of intellectual property (IP) which is vital for a new product.

BENEFITS

- ✓ Equip mid/small manufacturers to compete for new customers.
- ✓ Facilitate prototyping & product customization by leveraging under-utilized capital equipment & labor.
- ✓ Enable small companies to produce mid-size lots.
- ✓ Optimize system performance for the requested manufacturing services.
- ✓ Framework design and logic can extend to other industries such as hospital logistics.

OVERVIEW OF THE WORK

The proposed PaaS framework is based on the principles of Service Oriented Architecture. PaaS aims to increase utilization of existing geo-distributed manufacturing facilities by connecting them with product developers who have small batch custom manufacturing needs. Key functionalities of PaaS include:

- Preserving IP with the use of abstracted product data instead of a detailed technical drawing of the product.
- APIs for new production request, quotation query, and optimization stages.
- A comprehensive optimization capability to optimize the collected production quotes and evaluate feasible solutions, where multiple manufacturers are utilized in parallel for faster production cycles, based on the given cost, time, quality, batch constraints, and precedence parameters.

PROJECT DESCRIPTION

PaaS framework aims to present feasible manufacturing options to new product developers with small batch manufacturing needs. The framework has a front end for communicating with the customers and suppliers to gather required information for production. The basic architecture of the framework is shown in Fig. 1.

(1) Customer logs on to the system and submits a RFQ with the abstracted product data,
(2) Database finds capable manufacturers and forwards the customer request,
(3) Manufacturers submit production quotes to the framework and the quotes collected from the manufacturers are optimized,
(4) Proposed manufacturing schemes are presented to the customer.

The framework architecture does not require direct communication of the customer and the manufacturers until the production decision of the customer.

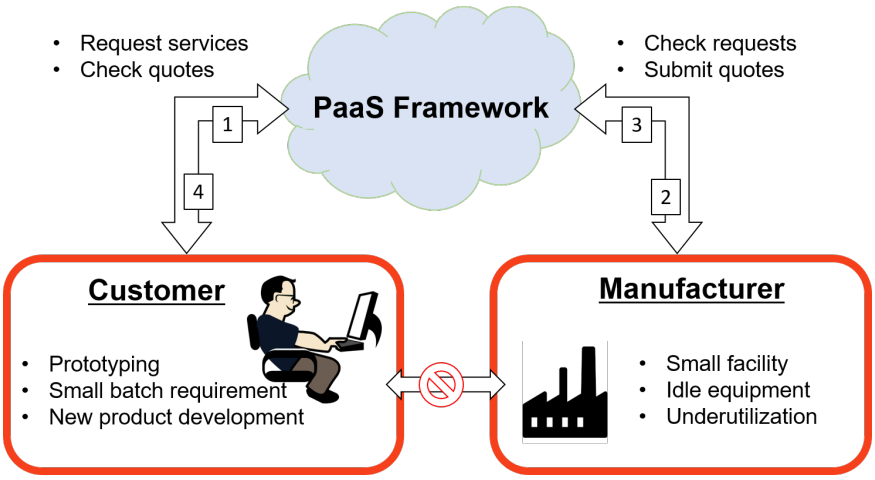

Fig. 1. The information flow through the proposed PaaS framework.

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Fig. 2 illustrates the APIs and their interactions with different components of the framework. The user (customer, product developer) makes a production request through the RFQ interface. Required design specifications, tolerances, and precedence constraints are entered at this stage; however, detailed technical data about the design is not required. Production Quote API analyzes and encodes the RFQ information into a predefined abstracted form, to ensure preservation of user's IP throughout the quotation stage. As the manufacturers with required capabilities are identified, manufacturer surveys (MFS) are sent to respective manufacturers and their responses are processed by the Analysis API to generate optimization quotes, which are used by the optimization algorithm in the Decision API to evaluate feasible production schemes for the user's request. Analysis API also assigns quality indices to the production quotes according to the user specified tolerances and the manufacturer responses.

Decision API uses user defined linear weights in the fitness function to evaluate the optimal solution in terms of cost, time, and quality of the submitted quotes. Optimization algorithm presents the evaluated feasible (optimal, sub-optimal) results to the user through the visualization interface. User may choose to change the preference on the weights of the optimization and inputs new weights through the visualization interface and the Decision API re-evaluates the optimal solutions. As the user chooses to use one of the presented production schemes, the manufacturers are notified and the full technical design is disclosed to the manufacturers to initiate the manufacturing of the product.

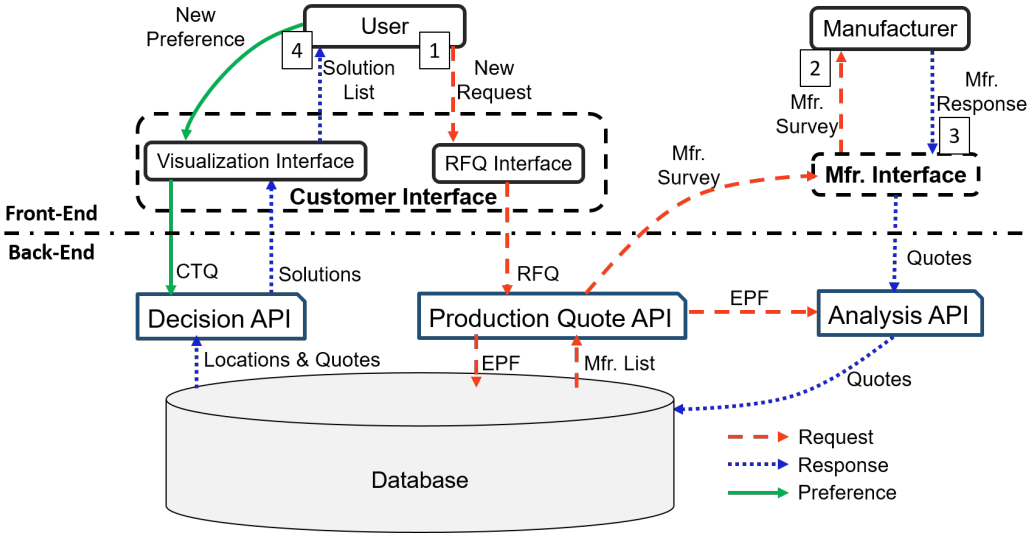

Fig. 2. APIs of PaaS.
(EPF: Encoded Product Features, RFQ: Request for Quotation)

CURRENT STATUS

- APIs for the framework designed
- Data structures to abstract production request defined
- Optimization algorithm to find optimal production schemes developed
- Feature extraction logic, and batch splitting algorithms are developed.
- Working implementation of the framework implemented.

FUTURE MILESTONES

- Incorporating scheduling in the optimization algorithm for multi-part products.
- Simulation of the framework with enhanced capabilities.
- Development of cognitive technologies for plant-level planning and scheduling.

DELIVERABLES

- ✓ A Production as a Service framework design in terms of its constituting APIs and their respective functionalities.
- ✓ Framework demonstration on a small real dataset and a larger simulated dataset.
- ✓ Identification of future research needs for realizing the framework on a large scale.

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