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ENGINEERING INFORMATION INFRASTRUCTURE FOR PRODUCT LIFECYCLE MANAGMENT

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Abstract: For proper management of total product life cycle, it is fundamentally important to systematize design and engineering information about product systems. For example, maintenance operation could be more efficiently performed, if appropriate parts design information is available at the maintenance site. Such information shall be available as an information infrastructure for various kinds of engineering operations, and it should be easily accessible during the whole product life cycle, such as transportation, marketing, usage, repair/upgrade, take-back and recycling/disposal. Different from the traditional engineering database, life cycle support information has several characteristic requirements, such as flexible extensibility, distributed architecture, multiple viewpoints, long-time archiving, and product usage information, etc. Basic approaches for managing engineering information infrastructure are investigated, and various information contents and associated life cycle applications are discussed.

Key words: Engineering Information Infrastructure, Product Life Cycle Management, Digital Engineering

1. INTRODUCTION

Due to the very severe competition in global market and rapid technological progresses, manufacturing industry is now facing fundamental changes and renovation of its operations and organizations. There are several keywords which characterize such new trends of manufacturing:

- very short time-to market,
- quick and drastic changeability,
- customer-pull production instead of manufacturer-push,
- service production instead of product production, etc.

By thorough adoption of such trends, it becomes possible to achieve highly efficient manufacturing and large reduction of various kinds of losses for time, cost, human and physical resources.

Based on the above consideration, a vision for future manufacturing is summarized as shown in Figure 1. According to very strong social demands and constraints, environmental consideration should direct manufacturing activities into more resource-saving and environmentally benign manners. At the same time manufacturing industry must be competitive to survive in very severe global market, as discussed above. Information technology is clearly an enabler to accommodate both requirements, and to lead to a new manufacturing paradigm: from product manufacturing to function or service manufacturing.

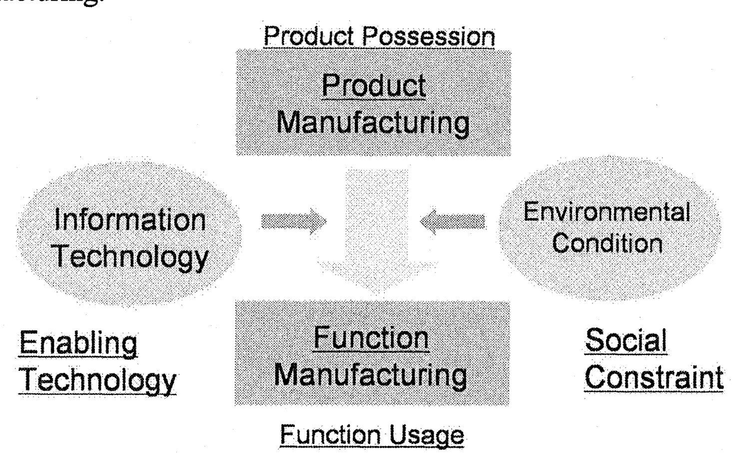

Figure 1. Vision for Future Manufacturing.

In such new manufacturing paradigm, where service providing plays an important role, it is essential to realize an engineering information infrastructure, which is shared by all stakeholders of manufacturing, such as manufactures, users, society, etc. Engineering information infrastructure should contain all aspects of product and production related information, and, as a ubiquitous information environment, can be utilized for optimally efficient usage of products. Therefore, design of information infrastructure systems for manufacturing is one of the most keen issues for future manufacturing.

In this paper, characteristics of future manufacturing are briefly discussed. As a core technology for future manufacturing, life cycle management and modeling are explained. And some examples of practical approaches for engineering information infrastructure are shown.

2. FUTURE VISION FOR MANUFACTURING

There are many issues for realizing competitive and environmentally benign manufacturing for the future:

- how to achieve drastic reduction of lead time to market,
- how to achieve agile changeability under rapid technology progresses and market fluctuations,
- how to achieve efficient negotiation and collaboration activities in global environment,
- how to efficiently generate and reuse intelligent resources,
- how to achieve comprehensive automation based on mature technology,
- how to achieve quick-response production through customer-pull processes,
- how to increase value-addition by mass-customization or tailor-made production,
- how to adapt to and to maintain variety of product usage, etc.

For solving all such issues, engineering information infrastructure for product life cycle is mandatory. Particularly it is important to support information sharing in the early planning stages of manufacturing and after-sales/service stages, as shown in Figure 2.

It is also important to install appropriate mechanisms for total life cycle management of engineering knowledge based on information technology based infrastructure, as shown in Figure 3. For competitiveness of manufacturing, it is essential to create new innovative knowledge, but at the same tine, it is important to systematize such innovative knowledge. Innovative knowledge gradually becomes mature, and it is important to manage such mature knowledge and to reuse it for efficient manufacturing. For such life cycle management of knowledge, engineering information infrastructure plays a very essential role. Here are some critical issues for knowledge management:

- early and lossless capturing of knowledge,
- flexible knowledge sharing,
- transparency for knowledge evolution,
- re-usability of knowledge, etc.

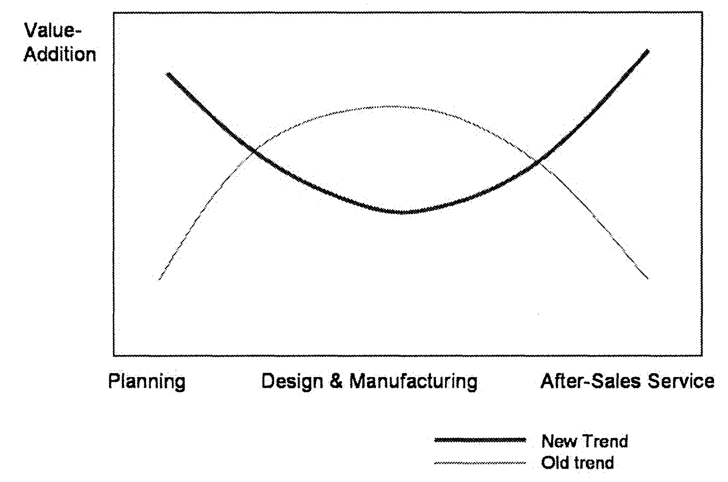

Figure 2. Value-Additive Processes in Manufacturing.

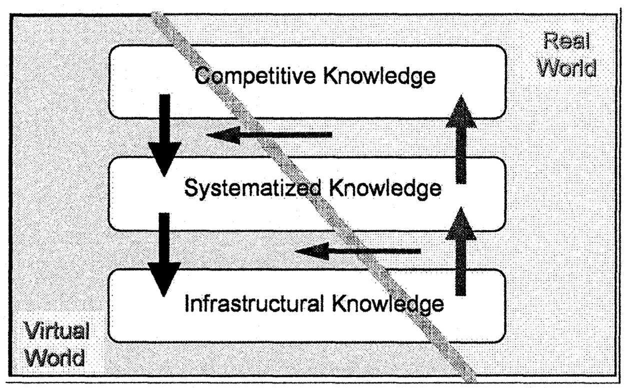

Figure 3. Life Cycle Management of Engineering Knowledge.

Those issues need to be fully investigated for engineering information infrastructure.

Based on such information infrastructure, various kinds of manufacturing activities can be loosely integrated or federated, and new service oriented manufacturing can be organized, as shown in Figure 4. There are different kinds of "Factories" with different focuses on life cycle stages. "Service Factory" provides services to end customers, "Inverse Factory" accepts used products for reuse/recycling, and "Automated Factory" produces mature goods for daily life. "Innovation Factory" offers new knowledge and technology to other Factories. Based on comprehensive information infrastructure, various kinds of new manufacturing activities can be easily visualized.

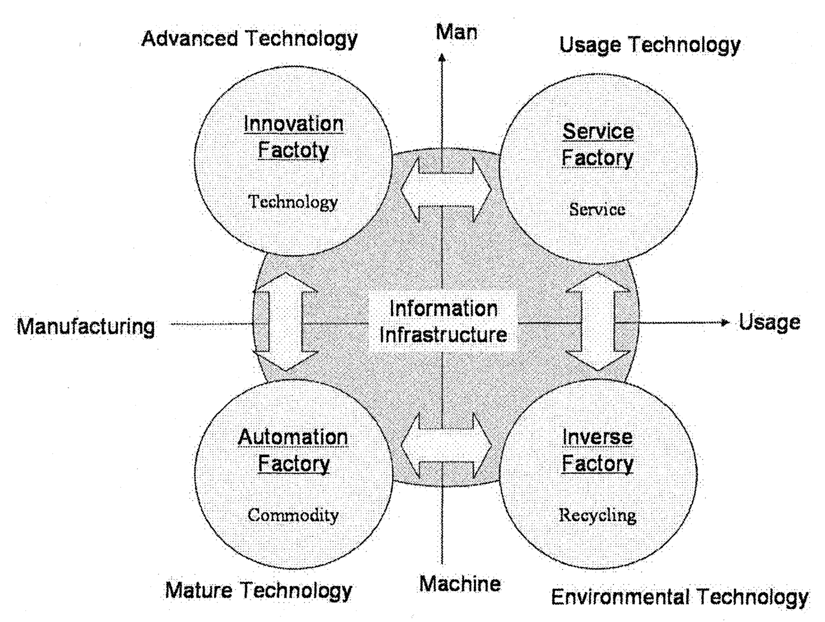

Figure 4. New Manufacturing based on Information Infrastructure.

3. LIFE CYCLE MANAGEMENT AND MODELLING

In total life cycle of products, product usage phase is becoming more and more important. As shown in Figure 5, product usage phase includes many activities, such as repair, upgrade, refurbishment, etc. It can be said as another kind of manufacturing or extension of traditional manufacturing. It is a crucial issue how to rationalize such new manufacturing activity for environmentally conscious manufacturing.

In practice, products are not used as designers plan, and many inefficiencies happen, such as:

- unexpected early disposal of products,
- non-use or idle products in users' hands,
- long-term use of old inefficient products, etc.

All those are primarily due to the lack of communication and common understanding between users and manufacturers. Therefore it is important to set up common information infrastructure, and to integrate product life cycle design and management activities with product design activity, as shown in Figure 6.

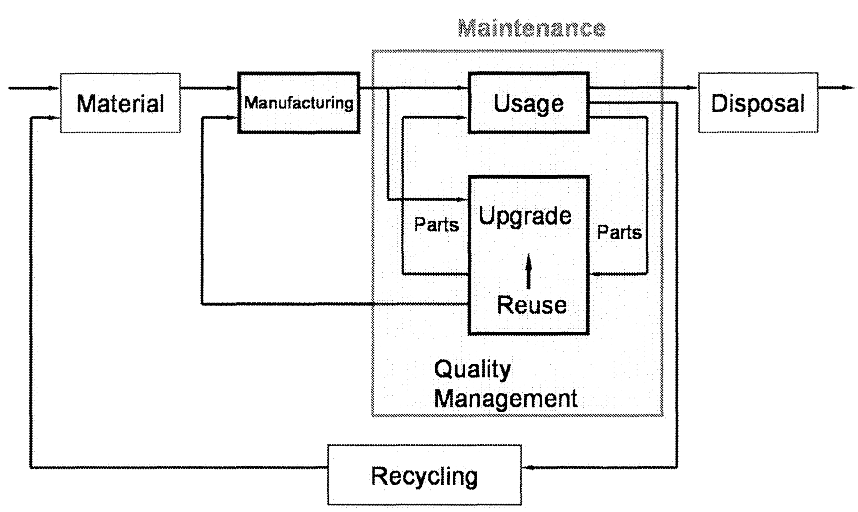

Figure 5. Total Product Life Cycle Management.

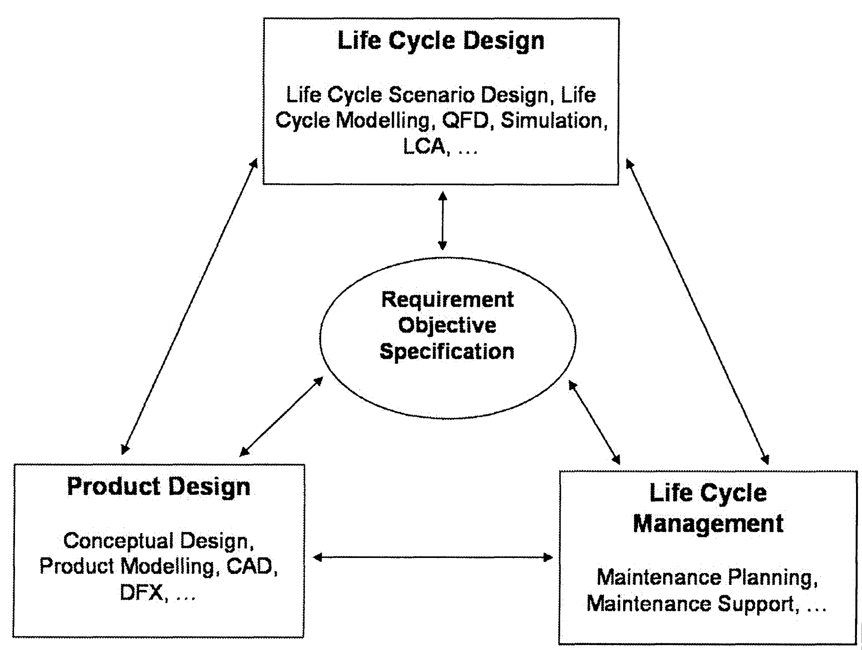

Figure 6. Product Life Cycle Design.

For proper life cycle management, product life cycle modelling is important, which includes modelling of product deterioration during usage[1]. Based on deterioration simulation, life cycle design and management can be rationalized based on computer supported technology. An approach to deteriorated behaviour simulation is shown in Figure 7.

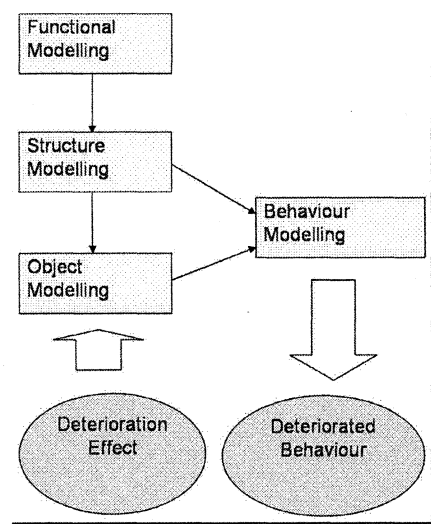

Figure 7. Modelling of Deteriorated Behaviour.

An example of total life cycle modelling for elevator maintenance planning is shown in Figure 8[2]. A core of this model is Failure Model of Elevator and Monitoring Unit for elevator operations.
Much of such model information comes from elevator design activity, and it is clearly important to share engineering information among various stages of product life cycle.

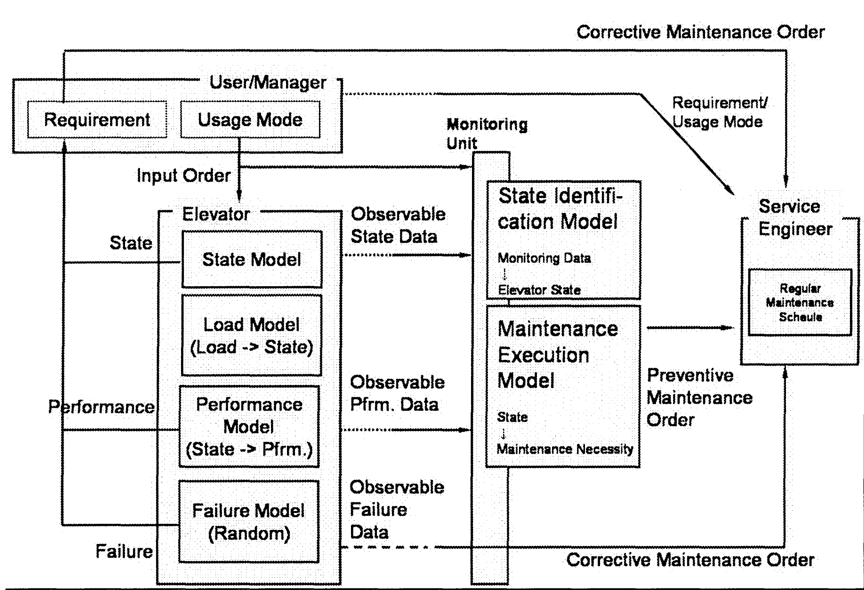

Figure 8. Life Cycle Modelling for Elevator Maintenance.

4. ENGINEEREING INFORMATION INFRASTRUCTURE

After many years of research and development about computer aided technology for product development, such as CAD/CAM/CAE, engineering databases and PDM, it is now feasible to consider the total integrated support of product creation processes by computer. As a basis for such comprehensive support, total life cycle modelling is important, from product planning, through product creation, production preparation, usage support and down to reuse/recycling/disposal. Such whole life cycle modelling is summarized in Figure 9, where some modelling is well developed in relation with product and process engineering, whereas some other modelling is still in primitive stage, such as deterioration modelling, reliability modelling, functional modelling, etc.

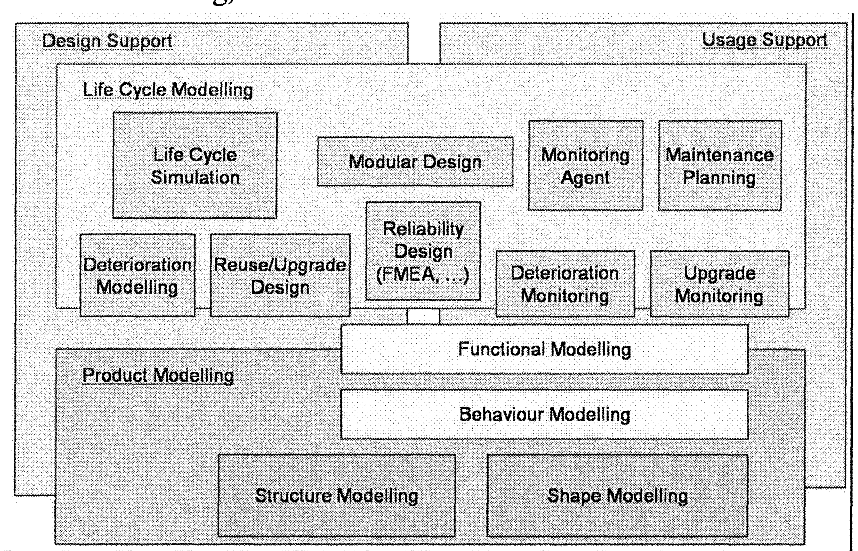

Figure 9. Total Product Life Cycle Modelling.

For construction of engineering information infrastructure for representing total life cycle models, the following points shall be noted:

- Hierarchical systematization of related engineering knowledge is necessary. As a basis of generic information infrastructure, basic engineering concepts shall be systematically organized.
- Modelling framework shall be flexible enough to enable loose and evolutional federation of various kinds of modelling information.

For modelling framework, there are many critical issues remaining:

- how to integrate or federate various kinds of models, such as shape, engineering constraints, product configurations, etc.,

- how to manage modelling processes in dynamically evolutional and collaborative environment,
- how to systematize information infrastructure based on generic primitive models, etc.

The above issues are theoretically very complicated and difficult. However there are many practical development activities for coping with these issues. One recent example is iViP development supported by German government[3]. A similar approach is pursued in Japanese project[4], and is shown in Figure 10. Here a common information bus is constructed, and available information resources can be connected to this bus via a generic wrapper mechanism.

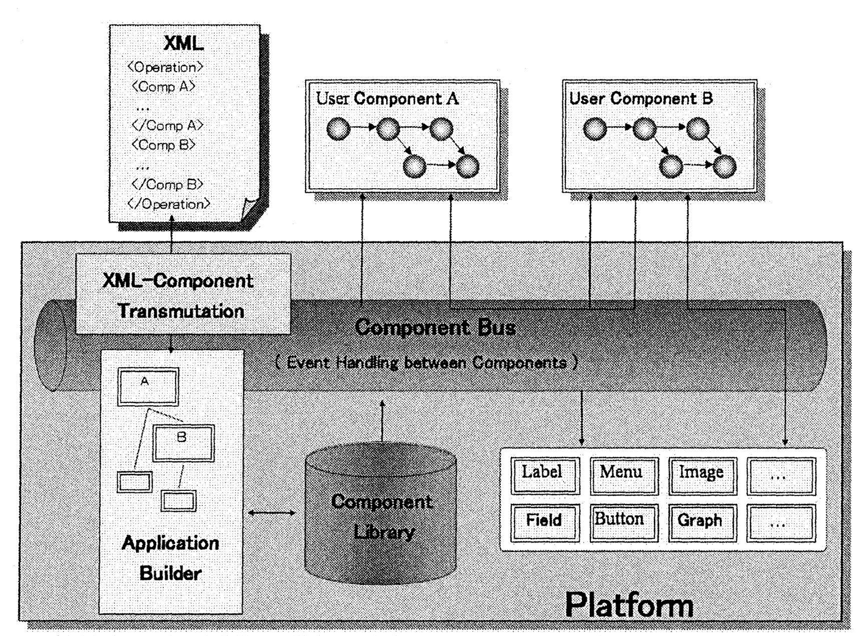

Figure 10. Software Integration Platform for Engineering.

5. CONCLUSION

Future manufacturing could be more competitive and environmentally benign due to change of paradigm from products to services. This paradigm change can be realized by intimate information sharing among all stakeholders of manufacturing based on engineering information infrastructure. Engineering information infrastructure facilitates rationalized life cycle management of products, particularly at the product usage phase.

In recent years, such life cycle management becomes popular, and practical implementation is emerging under the concept of PLM (Product Lifecycle Management). However there are still many open issues for powerful implementation of engineering information infrastructure, for example:

- consistent modelling of engineering semantics throughout the total product life cycle,
- various information modelling standards for federating multiple models,
- light-weighted frameworks for information representation and management.

In the future, engineering information infrastructure will be merged in the social information infrastructure, and will become fundamental industrial backbone for advanced countries.

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