Strategy and Challenges on Remote Diagnostics and Maintenance for Manufacturing Equipment

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SUMMARY & CONCLUSIONS

This position paper introduces the remote diagnostics and maintenance system in supporting globally integrated manufacturing activities. R&D strategy and challenges are discussed.

1. INTRODUCTION

The promise of a globalized integrated manufacturing is to make the remote factory a more effective laboratory, capable of realizing innovations through collaborative virtual manufacturing environments. Academe, in facing these new challenges, needs to redefine its research thinking to accommodate holistic research in a production environment-the factory as laboratory.

The development, implementation, and use of the national information infrastructure (NII) for manufacturing applications holds one critical key to sustained economic growth and manufacturing competitiveness. An advanced NII will enable manufacturers to transform and significantly improve all stages of manufacturing operations, from technology/market assessment and R&D to after-sales support and product disposal or reuse. Manufacturers will be able to use the NII to quickly and efficiently transfer data within and among operations; to effectively and sensibly transact business and collaborate with customers and partners; to rapidly and "virtually" prototype, simulate, and test products and processes; and to make easily and readily available the best manufacturing tools, knowledge bases, product information, and training materials regardless of location.

Manufacturing industries are facing serious structural problems brought about by their rapid development of overseas activities and manufacturing factories. Factories in different regions need to be coordinated through use of the state-of-the-art information technologies to insure consistent product quality. As a result, manufacturing activities could be integrated and monitored in many regions and countries. For example, the performance of a machine could be monitored and accessed from anywhere in the world. In addition, information on productivity, diagnostics, and training of manufacturing systems could be shared among different locations and partners. The development of a remote diagnostics and maintenance system (RDMS) would provide manufacturers and users with great flexibilities in conducting manufacturing activities. A remote intelligent reasoning agent serves a central intelligence unit for data acquisition, reasoning, remote diagnostics, tele-maintenance, and remote training system. The RDMS will support remote facilities to ensure the performance of manufacturing equipment, quality of operations, and productivity of the plant, in particular, for those facilities located in developing countries. In general, remote manufacturing systems with operational environment transmission capability should incorporate the following functions:

1.) Multi-sensor Integrated Monitoring and Control Systems: The display of information to operators in remote sites requires many different sensory output devices. The performance of machines should also be measured, monitored, and adjusted remotely. A "watchdog" agent might use neural computers to provide on-line composition and reasoning.

2.) Communications and Integration: The remote manufacturing system should encompass a multimedia information environment for information processing and transfer among geographically dispersed participants.

3.) Data Abstraction: The transmission of compressed data may require a physical model of the manufacturing process. As a result, only modifications of the model parameters, need be transmitted across the communication network.

4.) Knowledge Acquisition and Learning: Intelligent tools are required for acquisition and organization of data in manufacturing processes to
share with other manufacturing sites. In addition, the system should learn the behavior of users from different sites.

5.) Natural Language Translation: Tools are required for automated translation of texts into other languages. In the ideal case, the translation would be fully automated, highly accurate, stylistically perfect, applicable to many languages and many styles of text.

6.) Tele-Maintenance and Collaborative Diagnostics: Multimedia-based Tools are required to support remote users for maintenance assistance. Interactive and collaborative tools will enable the technical personnel to perform diagnostics from a remote distance.

2. GRAND CHALLENGES AND R&D STRATEGY

The manufacturing challenges for the industrial practices in the 21st century are: 1.) manufacturin solution, not just products and machines and build with confidence and guaranteed performance: industries are giving tighter specifications and are asking for manufacturers to be responsible for the manufacturing losses caused by the failure of the manufacturing equipment. For example, automobile makers are looking for machine tools with 100% reliability and predictive maintenance capabilities; 2.) re-configurable and re-cyclable: to meet the challenges of the mass customization and tighter environmental regulation.

To assure the production quality worldwide, technologies are needed to monitor the performance of manufacturing equipment in the remote facilities. The control of manufacturing machinery today is always done locally, for good reasons. Although one can imagine teleoperation, such as we might employ in unmanned space flights, such complete automation of manufacturing processes will probably be unjustifiable for some time to come. However, a lesser degree of control, which might be called process specification, will be essential to collaborative manufacturing. When someone who is not at the site of the equipment wants to ensure that what is produced meets requirements (which may not be fully known to those at the site of the equipment), he or she must be able to control process parameters. However, there is an inescapable tension between over-specifying, which would not grant sufficient freedom to the local operators to optimize their process, and under-specifying, which could leave too much ambiguity. This problem exists today between suppliers and producers, with much consequence for conflict; it will become a central issue in remote manufacturing.

To support the manufacturing globalization activities in a large scale, remote diagnostics and maintenance system technology needs to be formalized to define the underlying issues for remotely integrated manufacturing. Figure 1 shows the remote diagnostics and maintenance system and its key functions. The fundamental research issue which prevents us from resolving these problems is an inadequate understanding of most manufacturing processes. We simply do not know which process parameters are most important and which are insensitive. We lack the validated predictive models than could tell us what will happen when the process parameters take on specified values. Hence the problem is not simply one of designing a form that lists the available controls and requests values; it is one of creating sufficient understanding of each process to build an appropriately accurate predictive model. Once that is done, it will be relatively easy to standardize the communication interfaces. The research challenge, therefore, will be to construct models of manufacturing capability that can answer the questions posed remotely. In actual use, these models will be employed iteratively to home in on the control parameter values that can produce the desired results. These models, like all of the others, must be interoperable and responsive to agents so that the remote user does not always have to communicate with them through a human intermediary.

3. CONCLUSIONS

This position paper introduced the concept on remote diagnostics and maintenance manufacturing system methodology. In addition, research strategy in developing enabling technologies for supporting globally integrated manufacturing is addressed.

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