

Highly Dependable SCADA Systems

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Recognizing that today's competitive global economy requires continued advances in manufacturing technology to achieve and maintain cost advantages, and the fact that while the overall quality index of the U.S. GDP has been improving, the quality index of the manufacturing production has been on decline since early 2000, the President's Office recently issued an Executive Order Encouraging Innovation in Manufacturing that would enable U.S. to maintain its leadership in the manufacturing sector. Critical to meeting this challenge is the quality of information that can be extracted from the distributed sensor measurements. Thus sensor and network reliability has a direct impact on process yields, throughput, and product performance. For example, based on our experience, several high-value thin-film processes involve manufacturing systems that are dynamic and while reliable and accurate sensor measurements are very critical due to the very low tolerance margins they are typically exposed to harsh chemical and thermal environments making them highly susceptible to failures. Thus faulty sensors need to be identified in real time to ensure that the manufacturing process does not continue with incorrect process settings, and the sensing process should be reconfigured so that the process control can continue with accurate information.

Furthermore, it is well known that the nation's grid is aging and getting congested, and this has led to several blackouts and brownouts in the country. Therefore, there is an urgent need to optimize the utilization of the country's generation and transmission and distribution system by developing fault tolerant SCADA architectures to enable 'fault-tolerant' grid networks. A good portion of the R&D conducted at Electric Power research Institute (EPRI) is focused on improving the reliability, security and safety of country's electric grid. In fact, the DOE has commissioned a new research program called "GRID 2030" to improve the country's grid network.

Similarly, recent world events have created unprecedented urgency in creating effective fault-tolerant wireless networks in which sensors and modules can be integrated in minimal time for surveillance and monitoring environmental and hazardous conditions for quick decision-making.

Thus the most important challenges that need to be addressed include development of a comprehensive framework for fault tolerant SCADA systems that enables incorporation of strategies for dependability as an integral part of the design process of the system as opposed to an "add-on" component, support plug-and-play capability of sensors, and fault tolerance consisting of hierarchical fault diagnosis and reconfiguration within the real-time constraint. Moreover, the systems that use SCADA are dynamic and they undergo various types of unforeseen changes and upsets. Thus there is a tremendous need to incorporate highly flexible computing platforms that can effectively meet these challenges. The field-programmable gate arrays (FPGAs) are ideally suited for such applications since they have adequate processing power, they are highly adaptable, poses inherent redundancy that could be utilized for fault tolerance, and they are cheaply available.

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Addressing these challenges effectively will create several research needs in the information technology areas. These will include:

- Define the architecture and framework based on current and future needs, 1-2 years;
- Development of basic strategies for incorporating hierarchical fault diagnosis and reconfiguration at component and system levels, 2 years;
- Feasibility of incorporating reliability and safety as the members of the IEEE 1451 family of standards together with plug-and-play capability, 3 years;
- Aptness of FPGAs for SCADA; and
- Feasibility of exploiting temporal and physical redundancy of FPGAs and other devices for fault tolerance, 2 years.

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