ABB Industrial ^{IT} Platform supports Bayesian Networks

The ABB Industrial ^{IT} platform is an automation and information platform that integrates diverse standardization of global processes and has a greater return on process assets. ABB is utilizing the advanced Hugin tool from Hugin Expert A/S for decision support.

The increasing complexity of industrial processes and the struggle for cost reduction and higher profitability requires automated systems for processes diagnosis in plant operation and maintenance. As the systems complexity increases, condition monitoring and diagnosis turned to be very demanding task for the process operators, which are facing an overflow of data and extensive search for unexpected faults, connected with working overload and stress. Simultaneously, the need to consider technical, economical, and time constraints on production efficiency and quality requires permanent condition monitoring and adaptation of the production and service processes. ABB has with its customers from process industries, collaborated with Hugin Expert A/S on a R&D project (started in 2000) targeting the development of a methodology for root cause analysis (RCA) and decision support on process operation.

Company Background
ABB is a leader in power and automation technologies that enable utility and industry customers to improve performance while lowering environmental impact. The ABB Group of companies operates in around 100 countries and employs around 133,000 people.

The customers in process industries have been partnering with ABB to meet a number of automation challenges and develop in collaboration a number of advanced methods in measurement, automatic control, diagnostics and modeling. All of which empowered into the real plant operation by the ABB's Industrial ^{IT} platform.

Motivation and employed techniques
In order to determine the origin of a process disturbance or fault, a need for a quick and flexible guidance tool for decision support at higher automation level has emerged. This includes analysis of process conditions and advice on cost-efficient actions.

The technology of probabilistic graphical models, such as Bayesian networks and influence diagrams, has turned out to be the right choice out of several alternatives, when high diagnostics capabilities, explanation of conclusions for transparency in reasoning, and trustworthy decision support are expected by the users (process engineers, operators and maintenance crew).

Due to the existence of a number of first level diagnostic tools, the aim has been to provide decision support on process operation. The framework of Bayesian networks has been found to be an efficient and flexible tool in overall-level process operation analysis, since not all conditions are measurable or computable in real-time, and the combinatorial reasoning procedure is subject to uncertainties.

RCA system integration - Verification with real plant data
The development of the methodology incorporated the following system requirements and modeling issues:

- Root Cause Analysis of industrial processes with adaptation to process operation/grade changes, aging and wear;
- Reusable system design for various process applications;
- Reusable modeling of repetitive structures, e.g. sensors, control loops, assets such as pumps and valves.
- Risk assessment of disturbances by analysis of signals' level-trend, adaptive to changes in process operation mode;
- Ease of communication and explanations of conclusions at different process levels.

These modeling and system requirements are all met by the developed methodology. This is further supported by the integration of the methodology and the Hugin Tool into the ABB Industrial [IT] platform. This integration allows efficient data exchange with all available IT-applications, e.g. distributed control systems, diagnosis of sensors and control loops, physical models computations. Thus, the infrastructure for applying this methodology in different domains is ready for immediate use, i.e. any new application of Bayesian networks is automatically integrated on the ABB Industrial [IT] platform.

The first prototype of the root cause analysis system was tested by ABB with real process data during 2002. Monitoring and root cause analysis of the digester operating conditions in a pulp plant as been selected as the real world application for testing purposes.
The application development has been closely related with the integration of the methodology into the Industrial [IT] platform. ABB has managed the reuse issues through a generic approach including object-oriented Bayesian networks modeling (reflecting the process hierarchy) supported by the Hugin Tool. As a consequence, when all modeling related conventions are followed for new developed BN-applications, they would be automatically integrated into the Industrial [IT] platform and thus information data exchange issues are resolved from the very beginning.

Hugin Technology
ABB has integrated the Hugin Decision Engine into the Industrial [IT] platform. The Hugin Decision Engine proved to be the fastest, most efficient, and most reliable inference engine in comparison with software of competing tools providers. Moreover, ABB partnered with Hugin on modeling and methodological issues. The collaboration benefit for ABB has been in the Bayesian expertise of Hugin.

Benefits, Results and Consequences
The resulting RCA-system is providing the process operators with information on condition overview and advice on the most efficient sequence of corrective actions. In addition, the advantages for process industries include seamless integration of all relevant information sources on the Industrial [IT] platform with the result of automated and early assessment of abnormal conditions with flexible diagnosis and advice.

The methodology and associated tools are subject of five separate patent applications.

The future activities involve integration of the functionalities providing advice on the suitable time for maintenance activities under technical constraints and order deadline in process scheduling, as well as simulation of the impact of intended corrective actions on the process efficiency. This allows taking a pro-active (instead of reactive) troubleshooting, which increases the process performance, availability and output, avoids potential process breakdowns and cuts both operation downtime and maintenance cost.

Expectations
According to the judgment of ABB and Hugin, we expect that the Bayesian technology is the future technology for intelligent process analysis and that the developed methodology will provide a powerful complement to system control in process industries. These expectations and proof of the system potential are supported by the successful verification and validation tests with real plant data.

ABB has chosen to partner with Hugin, since besides being the leading provider of software, Hugin, provides its customers with consultancy, training, and fast, efficient, and effective technical support. The developed methodology for root cause analysis is an illustration of the successful ABB-Hugin collaboration.

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