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Modelling and Evaluating Non-functional aspects of Integrated Protection and Control Systems

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The later years of development within information and communication technologies (ICT) have enabled power system control to make greater use of new types of sensors, communication systems, and distributed computer platforms. Traditionally centralized SCADA/EMS solutions with local protection systems are merging into integrated protection and control systems utilizing for example wide area measurements [1]. In such control system architectures, functionality needed for control and protection of the power system can be located at any platform within the distributed ICT platform. An example of this development is for instance the use of autonomous systems and intelligent agents for power system control and operation [2]. Another development is loosely coupled system architectures built on Service Oriented Architectures for power system operation and control exemplified in [3] and discussed in [4]. An obvious concern raised when implementation of such systems for power system control and operation is discussed is the non-functional aspects of the systems measured in terms of their performance, dependability, safety and level of security. Although these ICT based control technologies appear to offer possibilities of improved power system operation and control, they of course cannot be implemented if the overall security and safety requirements on the power system cannot be met.

To some extent such concerns can be addressed by traditional modelling and evaluation techniques within the specialized fields, such as communication system performance. For example in [5] modelling and simulation is used to evaluate the effect on the communication systems performance on a set of special protection schemes utilizing measurements from remote locations. However, the analysis is limited to that of communication system performance, while other issues such as information security, interoperability and dependability are, understandably, not addressed. This is not surprising as methods that combine assessment of several of non-functional aspects, is a relatively unexplored field. At the same time, when implementing systems for power system control and operation, all non-functional aspects need to be considered in conjunction. If only one of the factors is addressed, it is possible that the resulting system architecture is optimized only towards that aspect while lacking in others.

To address this challenge, we present a method for modelling and evaluation of integrated protection and control systems that includes a wider range of non-functional aspects and offers supports for decision making in design of such systems. The method is based on the use of a formalism termed *Extended Influence Diagrams* [6] that is used to represent the relation between the attributes that constitute the non-functional aspects in question. For instance, at a high-level of abstraction the constituent attributes of performance are latency and throughput. The factors represented in the EIDs are all theoretically grounded and empirically established within the research community. The representation of the factors in EIDs further allows the evaluation of their inter-dependence using Bayesian logic. Based on the factors and their relation as described in the EID, modelling semantics for control system components that include these attributes are defined. By creating models of the intended system using these semantics, an engineer can evaluate the effect on the non-functional aspects under study from the design decisions taken.

By breaking down the non-functional aspects in their constituent attributes and capturing the causal relation between them in Extended Influence Diagrams, it is possible to include theory from several related fields of study thereby allowing study of a wider range of non-functional aspects concurrently. In Figure 1 a simplified example of an Extended Influence Diagram is shown, indicating the causal relation between a number of system attributes and three top-level non-functional aspects.

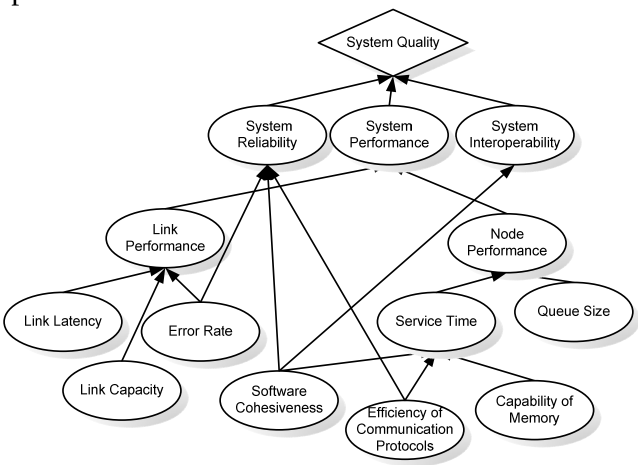

Figure 1 An Influence Diagram that shows the causal relation between system attributes and three top-level non-functional aspects, reliability, performance and interoperability.

The modelling semantics that is created includes the identified system attributes. This ensures in turn that the models of the control systems that are created contain all the necessary information that must be included for analysis of the important non-functional aspects. Finally, this allows for a rigorous evaluation of the causal effect on the non-functional aspects of the system that different design decisions impose.

In the paper the modelling and evaluation method is described in detail and its application to typical control system architecture is presented and discussed. The paper also discusses the relation between the proposed approach and similar approaches based on creating system architectures.

References

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