Managing Conflicting Interests in Socio-technical Energy Systems – How to Identify and Mitigate Intra-actor Interests as Risk Factors

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Abstract. Global networks like energy grids, transportation networks or financial IT-infrastructure are crucial for the wealth of modern societies. Reliable and resilient control of these infrastructures thus has gained much attention in the last years. Typical approaches to ensure stable operation of these infrastructures follow two contradictory paradigms, i.e. complexity reducing and complexity increasing measures. Whereas the first are supposed to encapsulate interdependencies and decision-making processes and typically reduce transparency as a side-effect, the latter strengthen the role of the human actor in these systems by increasing transparency to allow for well-informed decision-making.

In this paper, we will discuss these two paradigms and show why intra-actor conflicts arise from adding both complexity and reducing transparency at the same time. We will outline a research agenda to model the effect of these conflicts using the example of energy systems and current transparency-enhancing technologies like e.g. distributed ledger technology.

Keywords: smart grids, socio-technical energy systems, intra-actor conflicts

1 Summary

Global networks like energy grids, transportation networks or financial IT-infrastructure are crucial for the wealth of modern societies. Reliable and resilient control of these infrastructures thus has gained much attendance in the last years [1]. Typical approaches to ensure stable operation of these infrastructures follow two contradictory paradigms:

Complexity reducing measures are supposed to encapsulate interdependencies and decision-making processes. With energy systems being complex cyber-physical systems and setting up a critical infrastructure of modern societies, dependencies and effects of decisions can only hardly be evaluated [2]. Thus, modern ICT systems try to hide relevant information in such a way that decisions are supported best while reducing potential non-relevant interdependencies. These measures typically reduce transparency as a side-effect.

Two technologies largely support the trend to transparency and complexity reduction:

- **Machine Learning:** The availability of data has largely supported the role of machine learning and other data-driven AI-based technologies like neural networks. Supported by affordable multi-core computing hardware, automated learning has taken the role of expert systems without providing additional methods for interpretability [3]
- **Autonomous agent-based systems:** Autonomous systems, often based on software agents and multi-agent systems, pave the way to a decentralized and adaptive control of both processes and systems [4]. Given the high degree of interconnectedness of technical systems as e.g. used in IoT (Internet-of-Things)-applications, decentralized decisions of technical components reduce the overall understandability and global interpretability of decisions.

Complexity increasing measures on the other hand, strengthen the role of the human actor in these systems by increasing transparency to allow for well-informed decision-making. In energy systems, this is of crucial importance, as security, stability and robustness of the system operation largely depends on (human) decision processes. Therefore, these decision processes should be supported by giving transparent access to all relevant data. Many trends in current technologies support the trend to complexity increase and transparency, e.g. distributed transaction systems: especially distributed concepts like distributed ledger realizations, allow to track either contract-relevant or even safety-critical processes. By adding data access concepts well-known from cryptography, even privacy-relevant or safety-critical data can be stored in a cooperative and secure manner, thus allowing to give access to relevant human actors for decision processes [5].

In this paper, we will discuss these two paradigms and show why intra-actor conflicts arise from adding both complexity and reducing transparency at the same time. We will outline a research agenda to model the effect of these conflicts using the example of energy systems, autonomous control systems and current transparency-enhancing technologies like e.g. distributed ledger technology. We will focus on the role of the human actor in this system and the effects of possible **intra-actor conflicts**: Human actors base their decisions on information regarding the effects of possible actions (and alternatives). Consequently, increasing / reducing transparency will lead to different decisions: Adding automated process steps encapsulates these and enhances system controllability, but reduces interpretability. As a consequence, decision processes may be encumbered. Adding transparency on the other hand will lead to a more complex decision setup. Thus, a dynamic, customizable trade-off is needed in the IT-enhanced control of cyber-physical systems like energy systems. Up to now, no engineering process has been presented to support the development of this kind of systems.

The research agenda presented in this work addresses current approaches and open issues regarding an abstract model of decision conflicts, a dynamic model to evaluate the effect of transparency changes during runtime, and metrics to evaluate degrees of autonomy and transparency, using the context of energy systems.

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