

SUnCPS: A Taxonomy of Security-related Uncertainty in Cyber-Physical Systems*

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Abstract. Cyber-Physical Systems (CPS) are driving the fourth industrial revolution. In CPS, uncertainty is inherent that may cause security issue either directly or indirectly. To understand security together with uncertainty, we propose SUnCPS, a taxonomy of security-related uncertainty in the context of CPS. SUnCPS can provide a structured representation of security-related uncertainty in CPS as the basis for different (early) security engineering activities for CPS such as security risk analysis and management, vulnerability/attack analysis, and security testing for CPS.

1 Summary

Cyber-Physical Systems (CPS) such as smart grids, unmanned vehicles, smart healthcare systems are transforming our world. For the critical CPS like smart grids, security must be ensured. Learning from the security issues of information systems in the past, the security of critical CPS must not come as an afterthought while engineering such complex systems [1]. Besides, uncertainty is inherent in CPS and must be tackled [2], preferably together with security. We have created a taxonomy of security-related uncertainty (SUn) in CPS (SUnCPS) by 1) inheriting the literature of cyber security and system theory wherever applicable for CPS [3], and 2) synthesizing the possible security issues of CPS in different CPS application domains.

A SUn consists of at least one CauseGroup, and a corresponding number of EffectGroup(s). Each CauseGroup consists of at least one SUnTrigger, and a corresponding number of SUnConflict. Each SUnConflict specifies the CPS element (ConflictElement) that being conflicted with the Action done by the SUnTrigger. Each SUnConflict also specifies the Influence (Change) caused by the conflict. Each EffectGroup consists of at least one SUnEffect of the corresponding CauseGroup. CauseGroup and EffectGroup can together specify how a SUn is propagated inside the cyber parts, or physical parts, or crossing between cyber-physical parts of a CPS.

We have used SUnCPS to specify different security-related uncertainty instances in smart grids and water treatment systems. Based on SUnCPS, we have been working on an approach of Security-related Uncertainty Model-Based Testing for CPS.

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References

1. Nguyen, P.H., S. Ali, and T. Yue, *Model-based security engineering for cyber-physical systems: A systematic mapping study*. Information and Software Technology, 2017. **83**: p. 116-135.
2. Zhang, M. and Selic, B. and Ali, Shaukat and Yue, Tao and Okariz, Oscar and Norgren, Roland, *Understanding uncertainty in cyber-physical systems: A conceptual model*, in *European Conference on Modelling Foundations and Applications*. 2016.
3. Yampolskiy, M., et al. *Taxonomy for description of cross-domain attacks on CPS*. 2013. ACM.