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A polytope-based approach to measure the impact of events against critical infrastructures

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Abstract

This paper provides a method to calculate the impact of cyber attacks and security countermeasures in a multi-dimensional coordinate system. The method considers the simulation of services, attacks and countermeasures in at least one dimensional coordinate system, the projection of which originates geometrical instances (e.g., lines, squares, rectangles, hyper-cubes). Such instances are measured through geometrical operations (i.e., length, area, volume, hyper-volume), so that we determine the impact of complex attacks arriving on the system, as well as the impact of the implementation of single and/or multiple countermeasures selected to mitigate the effects of such detected attacks. As a result, we are able to measure the size of cyber events, which allows us to determine the mitigation level of the incidents, as well as, residual risks, and potential collateral damages. A case study of a critical infrastructure system is provided to show the applicability of the model.

Keywords: Geometrical Model, Polytope, Impact Measurement, Multiple Dimensions, Critical Infrastructures, SCADA

1. Introduction

Assessing the impact of cyber attacks and countermeasures is a very challenging process that requires identifying all vulnerable elements that interact with the target system. However, the risk of potential cyber attacks cannot be accurately described unless the consequences of such attacks are properly identified and quantified. Cyber attacks may cause direct impacts that include economic loss, reputation loss, legal exposure, regulation compliance loss, potentially social impact, and even infrastructure destruction.

Estimating the impact of current cyber attacks should consider two aspects. First, the impact of potential mitigation actions must be considered in the simulation and analysis of cyber attack impacts. Second, the estimation of such impacts must be analyzed with respect to time, geographic space and affected elements. For small organizations, this estimation can be straightforward, however, for critical infrastructures, it may pose a serious challenge. Therefore, it is of great importance to be able to quantify these impacts through the analysis of historical data or using simulation models that employ engineering, economic, or agent-based frameworks [1].

In this paper we propose a method to calculate the impact of cyber attacks and security countermeasures in a multi-dimensional coordinate system. The method considers ‘events’ and ‘services’ as inputs, and the impact of such events over the services as outputs. Events, e.g., attacks and

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