Knowledge Framework for Critical Infrastructure Dependency Analysis

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***Abstract*— The critical infrastructures protection landscape is a vast and varied pattern of independent, but interconnected infrastructure systems that are essential to the functioning of our modern society. The U.S. policy on critical infrastructure protection has been continually evolving since the Presidential Commission Report on Critical Infrastructure Protection was published in 1997. In response to these policies; federal, state, and local governments and research institutions have invested a substantial amount of time and effort to identify and analyze critical infrastructure structures, functions, and (inter)dependencies, in order better understand their vulnerabilities and their risk profiles. However to date, the ability to assess vulnerabilities, resiliency, and identify priorities for protective and support measures for interdependent critical infrastructure systems from an all hazards perspective still remains an open and difficult problem.**

In order to effectively address this challenging national need, a comprehensive knowledge discovery and decision support framework for critical infrastructure vulnerability and resiliency analysis is being developed to enhance understanding of the dependencies and interdependencies of these critical infrastructures. This All-Hazards Analysis Framework (AHA) and supporting research addresses the fundamental interdependent nature of critical infrastructure and focuses on bridging the gap between using anecdotal evidence (tribal knowledge) and high fidelity actuarial data. AHA provides three primary functions: 1) efficient methods to collect, ingest, and transform both structured and unstructured data relevant to critical infrastructure analysis, 2) dependency profiling for all hazard vulnerability and resiliency analysis, and 3) geospatially enable knowledge discovery and decision support for vulnerability, risk, and resiliency analyses.

Keywords—Dependency, Interdependency, Natural Language Processing, Critical Infrastructure, Knowledge Management, vulnerabilities

I. Extended Abstract

In order to effectively plan for, prepare for, mitigate against, respond to, and recovery from man-made and natural disasters significant national efforts have been undertaken to better understand the vulnerabilities, risks, and resiliency of critical infrastructure systems. These have included the development of advance modeling capabilities and robust assessment programs, as well as the creation of foundational infrastructure datasets. Where these efforts have significantly improved our understanding of critical infrastructure systems, there are limitations. There are three primary limitations that impact the efficacy of currently available methods and tools for critical infrastructure from an all hazards perspective. First, is the lack of a knowledge framework necessary to understand the vulnerability, hazard, and threat landscape from an integrated cyber/physical/interdependency perspective. Second, is the availability of actuarial data on the characteristics, operational state, and (inter)dependencies of critical infrastructure assets, facilities, and systems. Third, is the accessibility of knowledge discovery and decision support capabilities that results in actionable information across all critical infrastructure sectors for vulnerability, risk, and consequence based decision making.

To address this INL has developed an All-Hazards Analysis Knowledge Framework (AHA), which is hybrid data and expert driven fuzzy rule based model that enable the transformation and loading of existing data sources (e.g. geospatial, assessments, etc.) into dependency models. These types of models have the advantage of learning from data to provide highly accurate models and have the capability to adapt to new information via online learning. AHA is composed of three components 1) facility level dependency profiles, 2) dependency models, and 3) text analysis system (TAS). Dependency Profiles at the basic level are optimized facility level data models for infrastructure. They are adaptive to new attribution information and changing network topologies in order to support dependency analysis. The dependency models are linked dependency profiles of actual infrastructure. TAS incorporates natural language processing (NLP) and information extraction techniques to collect, ingest, and transform both structured and unstructured data relevant to critical infrastructure analysis, as well as population of the dependency models.

AHA directly supports the knowledge discovery and decision support function and provides analysts and decision makers a capability to quickly evaluate and understand critical dependencies and impacts of hazards on critical infrastructure. The AHA knowledge framework also provides an effective platform to inform other critical infrastructure modeling efforts. AHA has been integrated into an existing geospatial platform which provides the capability to leverage existing geospatial data and algorithms to optimize the investment and enhance our ability analyze critical infrastructures from a dependencies and interdependencies perspective.