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Pattern Driven Data Interoperability inSituation Awareness Systems: A Case ofthe Disaster Community in Uganda

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Abstract

The world is changing fast with increasing numbers of hazards that expose vast vulnerable communities to adverse impacts. The success of the integrated dis- aster management approach depends on the ability of multiple stakeholders to share information so that the right people can make the right decisions at the right time. However, disaster-related information managed by stakeholders is de- scribed in multiple schema, mark-up languages, with different vocabularies, and conceptualizations. The contribution of this study is that it proposes a bottom-up approach that uses patterns as a basis for addressing semantic interoperability barriers within multi-agency data in line with FAIR principles to support disaster risk situation awareness. Therefore, this study investigates how patterns can be used to address interoperability concerns in situation awareness systems for Dis- aster Risk Reduction.

We perform a meta-analysis of ontologies retrieved through a systematic literature review of articles in the domain to understand the reuse landscape of disaster vocabulary and best practices in line with FAIR recommendations. To study how interoperability barriers contribute to the identification of architectural patterns for disaster management systems in line with FAIR principles, we undertake an explanatory case study of the disaster management community in Uganda. To study how patterns can be used to organize knowledge in pattern-driven interoperable systems for disaster risk situation awareness, we perform a normative study using existing documents, interviews, focus group discussions and extreme designmethodology.

Results reveal that existing disaster management vocabularies have a very low adherence (19.54%) to FAIR recommendations and best practices. This implies that finding, accessing and reusing interoperable ontologies to organize disaster data is rather difficult because of non-existent domain repositories. While Ontology Design Patterns (ODPs) form an interdisciplinary vocabulary that fosters FAIRification through shared interoperability, their reuse in the disaster management domain is very low. Results also indicate high syntactic and technical interoperability maturity for data in the disaster community. On the contrary, there exist considerable semantic and legal interoperability barriers that hinder data integration and reuse. A mapping of the interoperability challenges in the disaster management community to solutions reveals a potential to reuse established patterns for managing data interoperability. We illustrate pattern reuse

through an interoperable architecture that integrates data for situation aware- ness during disaster management. To characterize disaster risk knowledge in the pattern-driven architecture, we elicit thirty-two (32) competency questions and identify ten (10) matching patterns for reuse from other contexts. Furthermore,we develop the Event classification and quality dependence description ODPs as emerging patterns for knowledge representation in the disaster domain. Accordingly, we present a modular, interoperable pattern-driven solution for drought risksituation awareness.

This study reveals that understanding trade-offs in FAIR principles and best practices is critical for design prioritization of interoperability architectures and APIs. The systematic approach to combining patterns in consideration of prevailing interoperability challenges is key to the composition of interoperable architectures forsituation awareness in disaster management. The use of the drought risk example provides a powerful use case for adopting a pattern-based approach to knowledge representation in the disaster domain.