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**ABSTRACT:***From recent work in ENISA it is clear that UML, SDL and so on are not sufficient to model complex systems. Other methods exist and have been deployed in the resilience modelling activity at ENISA and it is suggested that MTS should extend their own methods guidance and recommendations to include such methods.*

The purpose of the present document is to show that ontology and taxonomy are tools that have potential to improve the clarity of standards. A taxonomy is a two-dimensional view of definition in the form of classifications and an ontology addresses the third, behavioural, dimension of the topic with a taxonomy at its core. In addition the paper requests that the role of metrics in giving meaning to any comparison of systems is addressed within the ontology and taxonomy schemes proposed in the present document.

The primary purpose of an ontology and its contained taxonomy is to use the results as the basis of definitions and processes in future work. The current approach to definition in most Standards Development Organisations (SDOs) is to separate definition from use and assume terms are always understood. For example the term **threat** is defined as "potential cause of an incident that may result in harm to a system or organization" but this approach doesn't put threat into context whereas using the approach of taxonomy and ontology introduces the additional contextual dimensions, in other words the additional concepts that a threat is enacted by a threat agent and leads to attack on the system objectives. Ultimately the intent is to use the ontology within standards that have to be followed for all network based resilience measures. This is not to state that ontologies are not used in development of standards or of networks although it is hard to find explicit use of the terms in existing standards. In practice it can be shown that many existing standards, particularly in the security domain, tend towards ontologies in their structure (but not in their terminology).

Before defining an ontology or a taxonomy it is essential to define what they are and why they are of benefit.

Where stakeholders, i.e. the people, organisations, and software systems, are required to communicate among themselves to achieve some specific objective they often misinterpret the same subject matter due to a desire or imperative to translate to their personal context. The misinterpretation leads to lack of a *shared understanding* that then leads to a number of unwanted consequences that include:

* *poor communication* between these people and within their organisations,
* difficulties when identifying requirements and defining a *specification* of an IT system,
* lack of *interoperability*, *reliability*, *re-use and sharing* capabilities, which lead to much *wasted effort* (in common terminology leading to endless cycles of *re-inventing the wheel*) because of different methods, sector specific terminology (jargon) and tools.

Without *shared understanding* acting as a *unifying framework* for the different viewpoints the problems that arise from misunderstanding will continue, and exaggerate conceptual and terminologicalconfusion. Ontology is the term used to refer to the science and methods of developing a shared understanding of some domain of interest which may be used as a unifying framework to solve the above problems. An ontology entails or embodies a set of concepts (e.g. entities, attributes, and processes),their definitions and their inter-relationships with respect to a givendomain. This is referred to as a conceptualisation andmay be *implicit* or *explicit,* depending on whether a subjective or objective analysis is undertaken*.* Note however that the aims of standardisation and of both ontologies and taxonomies is the same even if the practice is different. To this end a standard defines only the minimum requirements for a product or service that implements it to work safely and dependably with other products implementing the same (or associated) standards, i.e. if 2 mobile phones each implement the GSM standards they will be able to communicate with a standards compliant GSM base station and make calls to each other. The key matter than distinguishes those areas where taxonomy and ontology will give gain over conventional approaches to standardisation is where complex multi-factor environments are brought together to achieve new objectives. This is the case for resilience where conventional requirements for availability do not address resilience directly but address the more readily understood areas of reliability, maintainability and availability discretely rather than as they would by consideration using ontology: In combination.

The following quote taken from the Shared Re-usable Knowledge Bases (SRKB) electronic mailing list summarises what an ontology is and the various forms and contexts it arises in.

QUOTE: "Ontologies are agreements about shared conceptualizations. Shared conceptualizations include conceptual frameworks for modelling domain knowledge; content-specific protocols for communication among interoperating agents; and agreements about the representation of particular domain theories. In the knowledge sharing context, ontologies are specified in the form of definitions of representational vocabulary. A very simple case would be a type hierarchy, specifying classes and their subsumption relationships. Relational database schemata also serve as ontologies by specifying the relations that can exist in some shared database and the integrity constraints that must hold for them."

The domains or subject areas for use of ontologies is subdivided into the following categories:

* Communication:
* Ontologies enable shared understanding and communication "between people with different needs and viewpoints arising from their particular contexts".
* Interoperability:
* Many applications of ontologies address interoperability in which different users need to exchange data either in a practical deployment environment or in development between different software tools. A major theme for the use of ontologies in domains such as enterprise modelling and multiagent architectures is the creation of an integrating environment for different software tools.
* Systems engineering:
* Specification:
* In the specification of software systems, ontologies facilitate the process of identifying the requirements of the system and understanding the relationships among the components of the system among distributed teams of designers working in different domains and provide a declarative specification of a software system, which allows to reason about what the system is designed for, rather than how the system supports this functionality.
* Reliability:
* Ontologies enable the use of (semi-)automated consistency checking of the software system with respect to the declarative specification and can be used to make explicit the various assumptions made by different components of a software system, facilitating their integration.
* Reusability:
* Ontologies in order to be effective must also support reusability, so that the modules can be imported and exported among different software systems and are used to provide a framework for determining which aspects of an ontology are reusable between different domains and tasks. To be useful, these ontologies must be customisable through extension, both to the class of problems and the class of users, allowing the incorporation of new classes of constraints and the specialisation of concepts and constraints for a particular problem.



Figure 1: Uses for ontologies

Taxonomies have a close relationship to ontologies. Taxonomy is derived from 2 Greek words: taxis, meaning the arrangement or ordering of things; and, nomos meaning anything assigned a name, and the usage addressed by the thing. Taking an almost literal interpretation of this suggests that taxonomies give structure to the naming of things and this is clearly the approach used in biology and similar sciences. It has been suggested that there are three characteristics that define a taxonomy:

* A taxonomy is a form of classification scheme
* Classification schemes are designed to group related things together and to define the relationship these things have to each other.
* Taxonomies are semantic
* Taxonomies provide a vocabulary to describe knowledge and information assets. The vocabulary must be controlled to ensure that each entry in the taxonomy is unambiguous and to also ensure that alternate or less precise terms are excluded.
* A taxonomy is a kind of knowledge map
* A user of the taxonomy should immediately have a grasp of the overall structure of the knowledge domain covered by the taxonomy. The taxonomy should be comprehensive, predictable and easy to navigate.

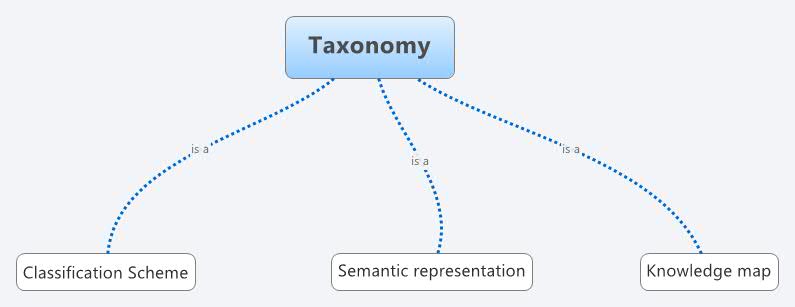


Figure 2: Visualisation of the definition of a taxonomy

# Proposal

To define a guide within MTS on the use of taxonomy and ontology in the development of standards.