A Semantic Mediation Framework for Architecting Federated Ubiquitous Systems

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Agenda

- Introduction
- Problem statement and research objective
- Semantic Interoperability in SoSE
- Semantic Mediation Framework
- Conclusion
Introduction

Definition: A Federation of Systems (FOS) is a coalition of partners with decentralized power and authority and potentially differing perspectives on situations\(^1\) (also called a virtual SoS).

Scenario: A federation of ubiquitous context-aware systems
- Heterogeneous
- Autonomous
- Geographically dispersed
- No central authority

Semantic Interoperability: Ability of systems to exchange information meaningfully.

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Research Overview

- **Problem Statement:** The lack of a central authority in a federation of systems makes interoperability a difficult task requiring tedious manual work, significant time and human involvement in capability discovery.

- **Research question:** Does the use of semantic web principles and technologies enable partial or full automation of system capabilities discovery, selection, and composition between heterogeneous, autonomous and geographically dispersed systems?
Purpose of the presentation

- Identify the areas where Semantic Interoperability tools and techniques can help the system engineers in dealing with interoperability challenges in federations of systems.
- Present a conceptual semantic mediation framework for integrating autonomous and heterogeneous ubiquitous systems.
Challenges with capability discovery in FoS

Service-oriented SoS engineering approach

- Lack of a central authority or a centrally agreed purpose in FoS
- Systems that have never come together will do so at runtime
- Significant time and human involvement in capability discovery
Research Objective

Explore the use of Semantic Interoperability tools and techniques to orchestrate the system engineering activities related to:

1. rigorously publishing constituent system capabilities during the design stage of the “federated” system engineering lifecycle, and
2. automating capability discovery, selection, and composition at runtime.

Semantic Interoperability is achieved when:

- capability exchange partners have a common understanding of the meaning of the shared capabilities -> semantic description
- capability exchanges adhere to the shared understanding -> semantic mediation
- capabilities are exchanged without misinterpretation -> semantic discovery

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Semantic Interoperability in SoSE

Enables system architects to:

- Semantically describe the information and the capabilities of their systems in a machine readable format (called Ontology) in order to be shared with other constituent systems of the federation.
  - Main Technologies: URIs, RDF, OWL, Semantic Web Services, Ontology Repositories (Knowledgebase)

- Semantically define how the terms in their descriptions relate to the terms of a mutually agreed domain description (called Upper Ontology) in order to be understood by other constituent systems of the federation.
  - Main Technologies: RDF, OWL, Rules

- Manually or programmatically discover descriptions, and therefore information and capabilities, published by other constituent systems of the federation.
  - Main Technologies: Semantic Web Browsers, Search Engines, Query Languages (SPARQL), Reasoners, Semantically Enabled SOA
Our Proposed Conceptual Framework

Semantic Description

Semantic Discovery

Realized Using:
- WSMO
- WSML
- WSMX
Towards a dynamically changing architecture

- The federation of systems would form a dynamically changing architecture.
- This architecture would continuously evolve as additional systems, subsystems and components join (or leave) the federation.
- Solution synthesis would be performed at runtime and it will be aided by semantic reasoning.
Conclusion

- Semantic mediation techniques help the orchestration of the system engineering activities related to:
  - publishing semantic descriptions of constituent system capabilities during the design stage of the “federated” system engineering lifecycle, and
  - automating the discovery, selection, and composition of (semantically described) capabilities at runtime.

- The proposed semantic mediation framework:
  - allows system architects to select their own data formats and service implementations for their systems, while still being able to use capabilities offered by other systems, and
  - facilitates the seamless integration of capabilities published in a federation of ubiquitous systems.