Research Task / Overview

• Cyber-physical systems are composed of diverse subsystems consisting of both physical and software components developed by different vendors.
• Stakeholders, such as DoD, have increasingly emphasized modular and open approaches to system development to improve interoperability, facilitate system evolution and technology insertion, and foster competition.
• With the advance of technology, the recognition of new consumer needs, and the detection of deficiencies in the current systems, can upgrades, replacements, or problem fixes happen quickly in a plug-and-play manner? In other words, is a cyber-physical system truly modular?

Data & Analysis

OpenWrt: A Linux operating system targeting embedded devices.
MdPnP: The medical device “Plug-and-Play” interoperability program advancing safe and secure interoperability to improve patient care.

1. Root Package View_(a.k.a. the development view).

2. Dependency Hierarchy (Sequential Task Allocation)

3. Organizational Modular Structure

4. Conceptual Structure

Goals & Objectives

• Examine the Criteria to Decompose a CPS into Modules
• Build a “Domain Concept Learner” to Identify Modularity Violations in Different Domains
• Build Decision Framework and Demonstrator

Methodology

1. Examine the Criteria to Decompose a CPS into Modules
   - Use three different criteria to decompose a large-scale, complex system into modules to represent different stakeholders concerns:
     o Package decomposition
     o Dependency hierarchy decomposition
     o Organizational structure decomposition
   - Investigate two different dimensions of relationship among modules:
     o The static structural dependencies
     o The co-change relationship

2. Build a “Domain Concept Learner” to Identify Modularity Violations in Different Domains
   - Use natural language processing (NLP) techniques to analyze project documentation and organize keywords into topics
   - Extract hardware related terms for use in co-change analysis
   - Identify relationships among topic groups to extract a semantic structure for the project

Future Research

• Short-term:
  o Cross reference learned domain concepts to modules.
  o Identify and measure modularity violations at different levels of decomposition for different stakeholders.
  o Build proof-of-concept demonstrator.

• Long-term:
  o Prioritize and visualize modularity violations for restructuring decision-making for stakeholders.
  o Provide in-depth interpretation of the root causes of modularity violations for restructuring insights.

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