STUDENT PAPER

Topic:
C2 Modeling and Simulation
C2/C4ISR Architecture

Scenario Based Modeling of C4ISR Architectures using Sequence Diagrams and Multi Level Petri Nets

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Abstract

Petri Nets are formal models of discrete event dynamical systems which are particularly useful for the analysis and modeling of concurrent and asynchronous processes. Because of their advantages in giving a graph theoretical representation of processes, and in providing a mathematical framework for analysis and evaluation they have been heavily utilized in modeling issues related to C4ISR [1][2].

Despite advantages posed by their graphical nature and the flexibility they provide in modeling most processes and systems, Petri Nets models are also not that easy to understand, build and communicate to others. Constructing correct Petri Nets and analyzing them is generally an expert issue. In addition to the above, some system interface features are hard to capture in the form of Petri Nets.

In the last couple of years scenario based techniques are becoming more and more popular in representing system behavior [5]. Sequence Diagrams (SD) provide an intuitive specification language for describing such scenarios. Just like Petri Nets the hierarchical composition of SDs make them very powerful in capturing parallel, sequential, and alternative scenarios. A disadvantage of SDs, however, is that they do not provide the flexibility to derive models for execution, and are not supported by analytical tools for analysis and evaluation.

In an effort to combine the advantages posed by SDs and Petri Nets, this paper proposes Scenario Based Architecture Modeling (SBAM) technique for elicitation, documentation and simulation based analysis of C4ISR systems. SBAM uses SDs as a semantic model to capture behavioral information from Subject Matter Experts, in the form of scenarios, and Multi Level Petri Nets for mathematical analysis of these scenarios. It is proposed that the accumulating nature of SBAM approach can be an opportunity to design models that would progressively mimic real-life cases regarding complex C4ISR related architectural issues [4].

The paper presents the SBAM approach along with a demonstration of an illustrative military case. The military case involves a set of tasks that are part of a territory defense mission over which a performance analysis is performed using SBAM. The mission employs a number of components from a component pool (i.e. missile launch workstation, control center, command center, intrusion detection center, weather database system, combat team) and represented by a number of scenarios. In most of the cases different scenarios utilize different functions provided by a certain component. A component that is used in one scenario may or may not be used in another one.

Once all such execution scenarios are elicited in the form of SDs, by employing the transformation used in [3] they are converted into a High Level Petri Net with multiple levels, where each level describes a certain scenario that is part of the mission of concern. A scenario sequencer allows the analyst to feed in scenarios, with a particular order so that they can be run in parallel and/or sequentially after each other. Throughout the runs, statistics such as average execution time of components, average execution times of scenarios, timeliness of component responses and other interactions among components are collected.
Reference:


