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GUEST EDITORIAL

COMPLEX SYSTEMS WITH APPLICATIONS

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The advance of technology has enabled design and implementation of larger and more complex systems. This has brought new system engineering perspectives in terms of architecting and manufacturing “meta-systems” with a formal definition called “System of Systems” (SoS). SoS is a set of different systems so connected or related as to produce results unachievable by the individual systems alone. The methodology for defining, abstracting, modeling, and analyzing SoS problems is typically referred to as System of Systems Engineering (SoSE). SoS typically exhibit the behaviors of complex systems. But not all complex problems fall in the realm of SoS. Current research into effective approaches to SoS problems mainly includes: establishment of an effective frame of reference, study of designing architecture, study of various modeling, simulation, and analysis techniques, etc. It can be expected that the development and application of SoS engineering will provide important scientific and technological support for such fields as national air, auto transportation, space exploration, health care, design of the Internet, software integration, and energy management.

In this issue, 7 papers on complex systems with applications are selected through a peer view process. These papers are mainly concerned about the problems in complex systems, especially the problems in SoSE. These papers present recent new theoretical and practical developments in systems integration, distributed virtual simulation, risk management of SoS, enterprise systems engineering, wildfire monitoring using SoS, and energy management system.

There are four papers on SoSE. Ireland attempted to define complexity more clearly and to analyze the implications of this definition for SoSE. Research directions in SoS were examined and areas that have been relatively neglected were also identified. These include the definition of complexity, the application of power laws and Paretian statistics, innovation occurring at the edge of chaos, chaordic behavior, scale laws, fractals, self-organized criticality, tiny initiating events, adaptive cycles, systemic and cascading risk, attractor cages and fitness landscapes. The use of systems thinking and the concept of system context were examined. Appropriate economic models were also briefly discussed. Cinar et al. reviewed a multi-probe scanning probe microscopy system in terms the characteristics of SoSE, such as interoperability, integration of each individual system to achieve complex tasks. A detailed "back end" data exchange architecture and interfaces were presented to show how interoperability and exchange of data can be provided between "heterogonous" system components. Moreover, the new functionalities brought by multiple system interactions were provided as novel applications in the SoSE. Kinder et al. discussed the approaches required for risk management of 'traditional' (single) systems and SoS and identified key differences between them. It was argued that a quantitative approach is essential for effective SoS which utilizes risk management, due to the inherent complexity of this process and that this can only be achieved through the implementation of appropriate models. A model-based approach was outlined, which utilizes a central Bayesian belief network to represent risks and contributing factors. Gomez et al. developed a team reformation strategy for the SoS to determine the wildfire size. Monitoring and determining a wildfire size are very difficult tasks. Number of stakeholders affected makes it possible to analyze it as a SoS. The benefits of developing a collaborative collection of systems as the solution were discussed. Agent based modelling was used to show interactions of each of the systems including system network configuration. Team reformation strategy for determining the wildfire size was studied.

There are three papers on complex systems. Dickerson et al. presented a demonstration of a service oriented virtual environment for complex system analysis. Distributed virtual simulation is increasingly in demand within the automotive industry. A distributed and networked approach to system level design and simulation stands to benefit from a unifying relational oriented modeling and simulation framework. In their work, they demonstrated an analysis of the vehicle as a complex system through the combination of a relational framework, high level syntax and semantics for representing models and distributed simulation. Their work promises to provide a rigorous, traceable and agile approach to conceptual vehicle design and analysis. Drury et al. presented a conceptual causal model of enterprise systems engineering (ESE) impact on systems acquisition success. The model takes the form of a directed acyclic graph and its major components consist of collaboration support, ESE technique application, system characteristics, and organizational characteristics. They converted this conceptual model to a computational model using the proposed Descriptive to Executable SIMulation (DESIM) modeling method. They obtained data based on subject matter experts' (SMEs') mental models so that they could determine the degree to which SMEs agreed with the model's components and relationships. Roiné et al. developed a microgrid energy management system using fuzzy logic control. The energy management and the modelisation of a microgrid system were studied. The energy resources models for a solar panel and a wind turbine were developed. The electricity consumption was simulated via a residential load. The control approach used was fuzzy logic that considers the evolution of prices during the day, the energy demand, the production and time. The model and the control were assembled to estimate the power flow evolution during the day and how this management could be improved. Finally the results obtained were shown and analyzed.

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