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Part VI: Cyber Physical Systems

Preface

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Cyber-physical systems (CPS) engineering aims to create system of systems using the vast information network infrastructure, computational algorithms and physical components to elevate to new heights the capability, adaptability, scalability, resiliency, safety, security and usability aspects of their precursor embedded systems. Progress in computational power, system simulation frameworks, parallel and distributed computation, smart and adaptive algorithms, wireless sensor networks, multi agent systems, global online and real-time connectivity for information exchange collectively facilitate creation of such systems with unparalleled potential. Highly anticipated benefits are projected to entail revolutionary advances in utility, precision, coordination, efficiency, augmentation of human capabilities, operational effectiveness in high-risk environments of such systems. The diverse sectors that are poised to benefit include transportation, energy, healthcare, manufacturing, automation, and agriculture. The promise of CPS is revolutionary in the way it is likely to transform the human existence and experience.

There are many obstacles towards making the CPS dream a reality. Creation of a CPS requires collaborative work of engineers from different domains such as computer, electrical, mechanical, chemical, civil, manufacturing and bio-medical engineering at levels that are far comprehensive and deeper than anything up to this point in the history of human intellectual productivity. The design and development tools and platforms used by these diverse set of engineers were not conceived originally to interface and interact with tools from other domains. Overcoming this hurdle is necessary to enable collaborative and cooperative engineering activity to materialize towards creating a CPS. The lack of mature science and technology to support systems engineering of reliable and robust CPS is another major obstacle as stated in the US NSF Cyber-Physical System Program Solicitation (NSF 14-542). Shortcomings of existing analysis tools to predict the consequences of small perturbations for an electric power grid, which may be considered as a prototype CPS, at regional or national scale, are real current impediments. The sheer complexity of a CPS poses another challenge since it is likely to require distributed and parallel approaches for modeling and simulation. Multi agent systems provide a good starting point and frame of reference to address the complexity aspect. Secure, reliable and failsafe operation of a CPS is of paramount importance at an impending era of cyber wars since attacks are likely to have profound implications for the survival of industries, sectors and eventually nations themselves.

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The Cyber-Physical Systems track as part of the 2014 Complex Adaptive Systems Conference offers 11 papers addressing fault-tolerance, security, complexity multi agent systems, and computational paradigm aspects of CPS engineering.

In line with the significance of the reliable, fault-tolerant and fail-safe operation for a CPS, three papers discuss various aspects related to these considerations. In "A Study of the Effect of Basic Network Characteristics on System-of-Systems Failure Propagation" by Adler and Dagli, researchers try to understand how the failure propagation is affected by initial failure size, grid node density and grid interdependency radius. Toy in his study entitled "Self-Managed Networks with Fault Management Hierarchy" proposes the concept of a self-managed network that can identify autonomously network configuration problems and repair them. This study addresses important issues towards realization of robust systems with self-diagnosis and repair facilities. Mirchandani in his paper "Cloud Computing as a Debug Tool" proposes migrating complex software testing platforms to the cloud to minimize the cost of maintaining multiple instances of such systems within the same organization.

Security and privacy are two critical aspects of computing which are subject to intense investigation by researchers. These same concerns are no less applicable for a CPS given the substantial computing component of such systems. Five papers in the CPS track address authentication, encryption for data confidentiality and privacy aspect of computing as they also would be applicable for a CPS. In "Graphical Challenge Questions for Secure and Usable Authentication" by Ullah et al. authors propose a hybrid approach combining picture and text for user authentication for online environments towards improving usability and security of the system. Griffin in his paper "Telebiometric Authentication Objects" describes a method for achieving strong, low-cost multi-factor authentication on the Internet-of-Things that is conceived to be convenient for people to use. Safier and Moskowitz demonstrate the application of the random matrix theory to detection of network traffic anomalies in the form of anomalous correlations between origin-destination flows in their study entitled "Network Traffic Anomalies, Natural Language Processing, and Random Matrix Theory." Data confidentiality in cloud is addressed by Rizvi et al. in "A Trusted Third-Party (TTP) Based Encryption Scheme for Ensuring Data Confidentiality in Cloud Environment." Authors propose an encryption scheme by combining both symmetric and asymmetric cryptographic algorithms which appear to provide strong data confidentiality while preserving secret key encryption functionalities. In "Applying Moving Average Filtering for Non-interactive Differential Privacy Settings", authors Mivule and Turner conclude that the signal processing technique of filtering might have an effect of reducing excessive noise associated with the application of differential data. They propose using the moving average filtering model for non-interactive differential privacy settings. Overall, authors claim that the utility of the differentially privatized data is increased through their proposed technique.

Multi agent systems as decentralized, distributed and parallel architectures offer valuable insight into similar essential characteristics of CPS. In their study entitled "A Multi-Agent System Model for Company Selection Process in an Ontology-based Virtual Enterprise," Sadigh et al. report that simulated multi-agent virtual enterprise (VE) formations can be used in real time as a VE information system deals with highly dynamic flow form heterogeneous data sources. They propose ontology based virtual enterprise model in order to manage and store dynamic VE information in a database. Simulation of very large scale wireless sensor networks can be extremely costly if not done at the proper level and detail. Serpen and Gao in their study entitled "Empirical Model Development for Message Delay and Drop in Wireless Sensor Networks" propose an abstraction model to reduce the complexity of simulating such large scale wireless sensor networks. Finally, Hart in this study "Towards a Compiler for a Polychronous Wavefront Computer: Programming by Optimization" investigates issues associated with the polychronous wavefront computation and reports the results of testing the ability of particle swarm optimization algorithms to select arrangements capable of encoding simple mathematical functions.

I believe that readers will greatly benefit from the rich set of perspectives offered by these eleven papers towards understanding and developing engineering solutions for complex Cyber Physical Systems of today.