ELECTRICAL ENGINEERING

Network Analysis and Management for

Cyber-Physical Systems and Their Applications

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Dissertation under the direction of Professor Gabor Karsai

Cyber-Physical Systems (CPS) are becoming increasingly more distributed in nature.  These distributed systems interact closely with the physical world and require the use of communications channels between the hardware nodes of the system as well as to external systems.  Since such systems are generally remotely deployed and managed, applications deployed onto the systems must be analyzed and verified before deployment to ensure that the system can provide the application's required services and that the application will not degrade the system's overall functionality.  As these systems become more distributed in nature, they rely more heavily on the network for communications, cooperation, and coordination, so the network utilization and resources are becoming larger factors in the analysis and performance of the systems.  To facilitate the development of these systems, we created analysis techniques for accurately and precisely predicting run-time application network performance and resource utilization from design-time models of the system and its applications. To validate this work, we developed network traffic production and measurement code and used run-time network emulation to enforce the system network characteristics.  Using these experimental results, we compared the accuracy and precision of our predictive techniques with state of the art analysis techniques. Furthermore, we integrated our modeling semantics into a communications middleware to measure the data production of each application and compared it against the application's network resource requirement profile.  By comparing the stated resource requirements to the application's actual resource utilization, we could detect deviations and take mitigation actions.  Using this measurement and detection, we showed how denial of service (DoS) and distributed DoS (DDoS) attacks could be mitigated.

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Gabor Karsai, Ph.D.