Energy-Adaptive Scheduling of Imprecise Computation Tasks for QoS Optimization in Real-Time MPSoC Systems

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10.7 Adaptive and Resilient Cyber-Physical Systems

Date: Thursday, March 30, 2017

Time: 11:00 - 12:30

Location / Room: 3B

Chair:

Rolf Ernst, TU Braunschweig, DE, Contact Rolf Ernst

Co-Chair:

Paul PoP, Technical University of Denmark, DK, Contact Paul Pop

The session contains four regular papers and four IP papers addressing different aspects of adaptivity and resilience for Cyber-Physical Systems. The topic of the first paper is distributed architectures for deep neural networks executing on a set of mobile nodes. The second paper considers scheduling of imprecise computation tasks on MPSoC systems taking the uncertainty of harvested energy into account. The final two papers both considers resilience of CPS. The first presents a scheme for preventing GPS-based hijacking of drones and the last considers how to avoid adversaries from learning what is printed using a 3D printer. The four IP papers considers control and scheduling co-design, contract-based design, medical CPS, utility-driven data transmission strategies for CPS.

Time	Label	Presentation Title Authors
11:00	10.7.1	**MODNN: LOCAL DISTRIBUTED MOBILE COMPUTING SYSTEM FOR DEEP NEURAL NETWORK** (Paper/SoftConf ID: 402) **Speaker**: Yiran Chen, University of Pittsburgh, US **Authors**: Jiachen Mao[1], Xiang Chen[2], Kent W. Nixon[1], Christopher Krieger[3] and Yiran Chen[1] [1]University of Pittsburgh, US; [2]George Mason University, US; [3]University of Maryland, Baltimore County, US ***Abstract*** *Although Deep Neural Networks (DNN) are ubiquitously utilized in many applications, it is generally difficult to deploy DNNs on resource-constrained devices, e.g., mobile platforms. Some existing attempts mainly focus on client-server computing paradigm or DNN model compression, which require either infrastructure supports or special training phases, respectively. In this work, we propose MoDNN - a local distributed mobile computing system for DNN applications. MoDNN can partition DNN models onto several mobile devices to accelerate DNN computations by alleviating device-level computing cost and memory usage. Two model partition schemes are also designed to minimize non-parallel data delivery time, including both wakeup time and transmission time. Experimental results show that when the number of worker nodes increases from 2 to 4, MoDNN can accelerate the DNN computation by 2.17-4.28×. Besides the parallelled execution, the performance speedup also partially comes from the significant reduction of the data delivery time, e.g., 30.02% w.r.t. conventional 2D-grids partition.*
11:30	10.7.2	**ENERGY-ADAPTIVE SCHEDULING OF IMPRECISE COMPUTATION TASKS FOR QOS OPTIMIZATION IN REAL-TIME MPSOC SYSTEMS** (Paper/SoftConf ID: 491) **Speaker**: Tongquan Wei, East China Normal University, CN **Authors**: Junlong Zhou[1], Jianming Yan[1], Tongquan Wei[1], Mingsong Chen[1] and X, Sharon Hu[2] [1]East China Normal University, CN; [2]University of Notre Dame, US ***Abstract*** *The key issue of renewable generations such as solar and wind in energy harvesting system is the uncertainty of energy availability. The characteristic of imprecise computation that accepts an approximate result when energy is limited and executes more computations yielding better results if more energy is available, can be exploited to intelligently handle the uncertainty. In this paper, we first propose a task allocation scheme that adaptively assigns real-time imprecise computation tasks to individual processors considering uncertainties in renewable energy sources. The proposed task allocation scheme enhances energy efficiency by minimizing system energy consumption followed by adapting the execution of imprecise computation tasks to the*

Time	Label	Presentation Title Authors

energy availability. We then present a QoS-aware task scheduling scheme that determines the optional execution cycles of tasks allocated to processors. The proposed task scheduling scheme maximizes system QoS under the energy budget constraint.

12:00 10.7.3 **FIX THE LEAK! AN INFORMATION LEAKAGE AWARE SECURED CYBER-PHYSICAL MANUFACTURING SYSTEM** (Paper/SoftConf ID: 875)

Speaker:

Mohammad Al Faruque, UCI, US

Authors:

Sujit Rokka Chhetri[1], Sina Faezi[1] and Mohammad Al Faruque[2]

[1]University of California, Irvine, US; [2]University of California Irvine, US

Abstract

Cyber-physical additive manufacturing systems consists of tight integration of cyber and physical domains. This results in new cross-domain vulnerabilities that poses unique security challenges. One of the challenges is preventing confidentiality breach due to physical-to-cyber domain attacks, where attackers can analyze various analog emissions from the side-channels to steal the cyber-domain information. This information theft is based on the idea that an attacker can accurately estimate the relation between the analog emissions (acoustics, power, electromagnetic emissions, etc.,) and the cyber-domain data (such as G-code). To obstruct this estimation process, it is crucial to quantize the relation between the analog emissions and the cyber-data, and use it as a metric to generate computer aided manufacturing tools, such as slicing and tool-path generation algorithms, that are aware of these information leakage through the side-channels. In this paper, we present a novel methodology that uses mutual information as a metric to quantize the information leakage from the side-channels, and demonstrates how various design variables (such as object orientation, nozzle velocity, etc.,) can be used in an optimization algorithm to minimize the information leakage. Our methodology integrates this leakage aware algorithms to the state-of-the-art slicing and tool-path generation algorithms and achieves 24.76% average drop in the information leakage through acoustic side-channel. To the best of our knowledge, this is the first work that demonstrates the idea of generating information leakage aware computer aided manufacturing tools for protecting the confidentiality of the manufacturing system.

12:15 10.7.4 **EFFICIENT DRONE HIJACKING DETECTION USING ONBOARD MOTION SENSORS** (Paper/SoftConf ID: 187)

Speaker:

Zhiwei Feng, Northeastern University, China, CN

Authors:

Zhiwei Feng[1], Nan Guan[2], Mingsong Lv[1], Weichen Liu[3], Qingxu Deng[1], Xue Liu[4] and Wang Yi[1]

[1]Northeastern University, CN; [2]Hong Kong Polytechnic University, HK; [3]Chongqing University, CN; [4]McGill University, CA

Abstract

The fast growth of civil drones raises significant security challenges. A legitimate drone may be hijacked by GPS spoofing for illegal activities, such as terrorist attacks. The target of this paper is to develop techniques to let drones detect whether they have been hijacked using onboard motion sensors (accelerometers and gyroscopes). Ideally, the linear acceleration and angular velocity measured by motion sensors can be used to estimate the position of a drone, which can be compared with the position reported by GPS to detect whether the drone has been hijacked. However, the position estimation by motion sensors is very inaccurate due to the significant error accumulation over time. In this paper, we propose a novel method to detect hijacking based on motion sensors measurements and GPS, which overcomes the accumulative error problem. The computational complexity of our method is very low, and thus is suitable to be implemented in the micro-controllers of drones. Experiments with a quad-rotor drone are conducted to show the effectiveness of the proposed method.

12:30 IP5-3, 813 **ANOMALIES IN SCHEDULING CONTROL APPLICATIONS AND DESIGN COMPLEXITY**

Speaker:

Amir Aminifar, Swiss Federal Institute of Technology in Lausanne, CH

Authors:

Amir Aminifar[1] and Enrico Bini[2]

[1]Swiss Federal Institute of Technology in Lausanne (EPFL), CH; [2]University of Turin, IT

Abstract

Today, many control applications in cyber-physical systems are implemented on shared platforms. Such resource sharing may lead to complex timing behaviors and, in turn, instability of control applications. This paper highlights a number of anomalies demonstrating complex timing behaviors caused as a result of resource sharing. Such anomalous scenarios, then, lead to a dramatic increase in design complexity, if not properly considered. Here, we demonstrate that these anomalies are, in fact, very improbable. Therefore, design methodologies for these systems should mainly be devised and tuned towards the majority of cases, as opposed to anomalies, but should also be able to handle such anomalous scenarios.

12:31 IP5-4, 843 **CONTRACT-BASED INTEGRATION OF AUTOMOTIVE CONTROL SOFTWARE**

Speaker:

Tobias Sehnke, IAV GmbH, DE

Time	Label	Presentation Title Authors

Tobias Sehnke[1], Matthias Schultalbers[2] and Rolf Ernst[3]

[1]Control Engineering Excellence Cluster of IAV GmbH, DE; [2]Gasoline Engines, IAV GmbH, DE; [3]Inst. of Comput. & Network Eng, Tech. Univ. Braunschweig, DE

Abstract

The functionalities of automotive control are distributed over a large number of independently developed components that are interconnected by complex data dependencies. During integration it is critical to ensure the functional correctness of each component, due to the safety-critical nature of the automotive system. Thus existing integration processes ensure that interfaces are syntactically correct. Still in many cases communicated signals are semantically incompatible. This results in complicated errors that are hard to detect and fix. Moreover, existing component languages do not provide applicable means for the description and control of correspondent requirements. In this paper we present a novel methodology for an automated identification of integration errors in automotive control software. The key aspect of our approach are contracts, which are used to disclose domain level requirements. These contracts are then checked during integration supported by existing tools. A case study involving an existing engine control software shows the applicability of our approach by detecting a significant number of formerly unknown integration errors.

12:32 IP5-5, 736 **MODELING AND INTEGRATING PHYSICAL ENVIRONMENT ASSUMPTIONS IN MEDICAL CYBER-PHYSICAL SYSTEM DESIGN**

Speaker:

Chunhui Guo, Illinois Institute of Technology, US

Authors:

Zhicheng Fu[1], Chunhui Guo[1], Shangping Ren[1], Yu Jiang[2] and Lui Sha[3]

[1]Illinois Institute of Technology, US; [2]Tsinghua University, CN; [3]University of Illinois at Urbana-Champaign, US

Abstract

Implicit physical environment assumptions made by safety critical cyber-physical systems, such as medical cyber- physical systems (M-CPS), can lead to catastrophes. Several recent U.S. Food and Drug Administration (FDA) medical device recalls are due to implicit physical environment assumptions. In this paper, we develop a mathematical assumption model and composition rules that allow M-CPS engineers to explicitly and precisely specify assumptions about the physical environment in which the designed M-CPS operates. Algorithms are developed to integrate the mathematical assumption model with system model so that the safety of the system can be not only validated by both medical and engineering professionals but also formally verified by existing formal verification tools. We use an FDA recalled medical ventilator scenario as a case study to show how the mathematical assumption model and its integration in M-CPS design may improve the safety of the ventilator and M-CPS in general.

12:33 IP5-6, 535 **A UTILITY-DRIVEN DATA TRANSMISSION OPTIMIZATION STRATEGY IN LARGE SCALE CYBER-PHYSICAL SYSTEMS**

Speaker:

Bei Yu, The Chinese University of Hong Kong, HK

Authors:

Soumi Chattopadhyay[1], Ansuman Banerjee[1] and Bei Yu[2]

[1]Indian Statistical Institute, IN; [2]The Chinese University of Hong Kong, HK

Abstract

In this paper, we examine the problem of data dissemination and optimization in the context of a large scale distributed cyber-physical system (CPS), and propose a novel rule-based mechanism for effective observation collection and transmission. Our work rests on the idea that all observations on all parameters are not required at all times, and thereby, selective data transmission can reduce sensor workload significantly. Experiments show the efficacy of our proposal.

12:30 End of session

Lunch Break in Garden Foyer

Keynote Lecture session 11.0 in "Garden Foyer" 1320 - 1350

Lunch Break in the Garden Foyer

On all conference days (Tuesday to Thursday), a buffet lunch will be offered in the Garden Foyer, in front of the session rooms. Kindly note that this is restricted to conference delegates possessing a lunch voucher only. When entering the lunch break area, delegates will be asked to present the corresponding lunch voucher of the day. Once the lunch area is being left, re-entrance is not allowed for the respective lunch.