Tutorial Proposal INDICON 2014

- **Title:** Reliable Real Time Embedded Systems

- **Abstract**
Real-time embedded applications span a wide range of mission critical domains like automotive and flight control, nuclear plant monitoring, robotics, medical instrumentation, etc. In addition to satisfying timing constraints, these systems must ensure functional correctness in the presence of permanent and transient faults. Further, due to the amount of embedded software and complex hardware that is involved in real time embedded systems, it is not possible to guarantee error operations under all possible input cases. In the proposed tutorial we would focus on issues and solutions that are involved in development of Reliable Time Embedded Systems.

- **Objectives and motivation**
  - *Objectives*

    - Study of techniques for fault tolerant design of Real Time Embedded Systems
    - Study of techniques for verifying correct functional and timing behaviors of the applications in Real Time Embedded Systems.

  - *Motivations*:
    - The major parameters that provide reliability to Real Time Embedded Systems are fault tolerance and, verification and testing.

- **Timeliness and intended audience**
  With the advent of extremely powerful but portable hardware computing platforms, large size on-chip memory, small LED/LCD displays, lithium ion batteries etc. most of the systems are being developed as embedded system applications. It is claimed that in the next decade almost all systems will be implemented as embedded applications and would contain real-time features. There will be a greater demand for safe, dependable, and certifiable embedded real-time systems.

    Intended Audience:
    - Academia: Senior PG students, Research Scholars and Faculty Members of Computer Science, Electronics and Electrical Engineering Disciplines.
    - Industry: Researchers and Developers working in the area of Embedded Application Design, CAD tools for Embedded System, Embedded System verification, testing etc.

- **Prior history of the tutorial presentation and number of past attendees, if applicable**
  - Dr. Santosh Biswas delivered a tutorial on "Mixed Signal VLSI Testing" in INDICON 2004 (along with Prof. Amit Patra and Prof. Siddhartha Mukhopadhyay, IIT Kharapur). Attendees: 50 (Approx)

  - Dr. Santosh Biswas delivered a tutorial on "Embedded System Testing" in Embedded System Workshop held at St. Anthony's College, Shillong 2011. Attendees 100 (Approx)

- **Detailed outline of the tutorial**
  Real time embedded system comprises wide range of multi-disciplinary topics. In the proposed tutorial we will cover some import issues in design and verification of Real time embedded systems that ensures reliability.
  Broadly, the tutorial will have three parts.

  - *Introduction to Scheduling of real time concurrent applications in embedded system platform:*
    In most real-time systems design, the task / application scheduler is a major architectural component responsible for ensuring proper processing of all tasks having timeliness constraints on their execution response. In the presence of several concurrent activities running on a processor, the real-time scheduler has to ensure that each activity completes within its deadline. The first part of this tutorial will deal with a few important trade-offs (schedulability, run-time overheads, etc) involved in scheduling independent as well as precedence constrained real-time tasks on uni-processor and multiprocessor systems. Also, we will discuss several optimal multiprocessor scheduling strategies like Pfair, ERfair, DP-Fair, Run etc., highlight their strength and weaknesses. This part of the talk concludes by presenting scheduling strategies that attempts satisfy non-functional requirements like low run-time overheads, limited power budgets, handling transient overloads etc.

  - *Fault-tolerant Scheduling of real time applications in embedded system platform:*
    After presenting the basics of scheduling, which is one of the most vital component of real time embedded system design, in the second part of the tutorial we would present the strategies required for making the schedules fault-tolerant. Such fault tolerant scheduling techniques guarantee satisfaction of deadlines even under permanent or transient failures in processors or software, a desirable requirement for improving reliability. A brief overview of processor fault models and fault tolerant structures that are used will be presented in the beginning. In the next part, schemes for fault tolerant scheduling considering transient faults will be covered. This will also include handling of software failures. Faults can be periodic or aperiodic in nature. Handling of permanent hardware faults, that requires multiprocessor environment in order to be fault tolerant, will also be presented. Use of voltage scaling for fault tolerance will be described next. At the end, a few current challenges will be discussed.

  - *Verification of real time embedded systems*
    Verification and test have been intensively studied and understood for hardware systems and software programs separately. However, real time embedded systems not only consist of hardware components, a large portion is realized by firmware and programs. There are lots of issues and challenges if verification is to be performed on systems involving hardware-software co-designs e.g., different platforms of describing the hardware and software designs, interfaces of hardware-software etc. In the third part of the tutorial we will discuss the challenges involved in verification of embedded systems and various evolving techniques to handle them.

- **Short biography of the instructor(s)**

  - **Dr. Arijit Mondal (Asst. Professor. IIT Patna)** received B.Tech. (2001) in Electrical Engineering, M.S. (2004) and PhD (2010) in Computer Science and Engineering, all from the Indian Institute of Technology (IIT) Kharagpur, India. He worked for Berkeley Design Automation (now Mentor Graphics) as Senior Member of Technical Staff for around three years and then briefly worked for Cadence Design System. Since November 2012, Arijit is with the Department of Computer Science and Engineering at IIT Patna, India where he is working as Assistant Professor. His research interests include embedded control systems, CAD for VLSI and fault-tolerant systems.

  - **Dr. Arnab Sarkar (Asst. Professor. IIT Guwahati)** received the B.Sc. degree in Computer Science in 2000 and B.Tech degree in Information Technology in 2003 from University of Calcutta, Kolkata, India. He received the M.S. (2006) and PhD (as a Microsoft Research PhD Fellow; 2012) degrees from the Computer Science and Engineering department at the Indian Institute of Technology (IIT) Kharagpur, India. After submitting his PhD, he worked briefly as a Visiting Scientist with the Advanced Computing and Micro-electronics Unit (ACMU), Indian Statistical Institute (ISI), Kolkata, India, before joining Samsung India Software Operations (SISO), Bangalore where he worked for one year as a Chief Engineer with the Android Platforms Group. Since November 2012, Arnab is with the Department of Computer Science and Engineering at IIT Guwahati, India, where he is working as an Assistant Professor. Arnab's current research interests include Real-time scheduling on multiprocessors, Design space exploration methodologies for embedded systems, Radio resource allocation in wireless systems (like LTE) and Algorithms.

  - **Dr. Santosh Biswas (Associate. Professor. IIT Guwahati)** completed BTech in Computer Science and Engineering from NIT Durgapur in the year 2001. Following that he received the degree of MS (by Research) and PhD from IIT Kharagpur in the year 2004 and 2008, respectively. After that he is working as a faculty member in the department of Computer Science and Engineering, IIT Guwahati for six years, where he is currently an associate professor. His research interests are VLSI testing, Embedded Systems, Fault Tolerance and Network Security. Dr. Biswas has revived several awards namely, Rashtriya Shiksha Gaurav Award 2014 (CGER, New Delhi), IEI young engineer award 2013-14, Microsoft outstanding young faculty award 2008-09, Infineon India Best Master's Thesis sward 2014 etc.

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