A Year with the New Initiative in Embedded Systems and Global Security Engineering

by:
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During 2007, the IEEE and the University of New Hampshire have embarked on a new initiative in Embedded Systems and Global Security Engineering -- highlighted by:
1) The Critical Infrastructure Dependability Laboratory, headquartered in Kingsbury Hall at the University of New Hampshire in Durham
2) The growing acceptance of the role of microelectronics embedded in our critical infrastructure and other mission critical systems that enable the “Western Lifestyle”
3) The IEEE Global Education for Microelectronic Systems Initiative -- to foster the process to design and implement these mission-critical embedded systems
4) A new engineering discipline of Global Security Engineering – complete with its own International Workshops and its own peer-reviewed archival journal of record
5) The IEEE Repository for the building blocks and environment for design and implementation of the mission-critical embedded systems

In what space that I have left – I will summarize the key developments that transpired in 2007, in a basically chronological fashion, illustrated by a number of representative photographs. While the antecedents of our initiative go back a few years and include consultation with other IEEE and outside IEEE leaders, the New Hampshire Section Executive Committee, and by extension all the members, provided – mission-critical support for the nascent initiative.

I begin with a brief preamble. Two specific events in the past seven years knocked us out of the complacency that followed the end of the Cold War. President Clinton tramping through snowy New Hampshire, before the 1992 Presidential Primary told us, “It’s the Economy – Stupid!” The next near decade was highlighted by a telecommunications technology explosion {aka the “Dot-Com Boom”}. The events of September 11, 2001 shattered the illusion of our physical isolation from global turbulence. In August 2005, Hurricane Katrina’s flooding returned New Orleans to its founding in 1718. Katrina and the earlier blackouts exposed the thin veneer of our technological infrastructure that separated the modern “Western Lifestyle” from the pre-Industrial Revolution society.

In 2006 despite a proliferation of university courses, books, conferences, and workshops, the implementation of Security on a Global Scale and insuring the dependability of our Critical Infrastructure seemed ad hoc and lacking in a conceptual framework to guide the marshaling of technical resources. Was there a lesson in recent technical history that could be applied to developing systems for Global Security and Critical Infrastructure?
In the 1970’s breakthroughs in materials and microelectronics manufacturing processes posed a vexing challenge. It was getting very easy to make lots of transistors {e.g. Moore’s Law} but it was becoming harder and harder to organize and interconnect them into a functioning chip. The “Mead-Conway-triggered” microelectronic revolution {1978} separated logical design from physical fabrication. The consequences were first the development of automated tools and a formal design process. Once the curriculum was in place to permit the training of the cadre of microelectronic engineers; the application of the design methodology and tools led to the creation of the microelectronic - centric “Western Lifestyle.” For forty years, the annual Design Automation Conference has been witness to thousands that turned to billions {transistors on a chip} and microseconds gave way to picoseconds {gate delays}. Professor Andrzej Rucinski of UNH has been teaching CMOS VLSI for more than two decades and his Design Automation Laboratory had focused on developing tools and procedures for testing and insuring microelectronics reliability.

In late 2006, the stage was set for the new initiative in Global Security and Embedded Systems. Specifically this new discipline is focused on providing a secure and dependable infrastructure to permit global commerce.
1) Microelectronics embedded in the fabric of our critical infrastructure forms a “global nervous system,” people goods and information to freely move globally.
2) Microelectronics has benefited from and fostered the development of design, testing and verification tools to successfully manage the complexity of today’s multi-core processors with billions of transistors.
3) Dependable critical infrastructure requires dependable microelectronic “nerve cells” and their interconnections
4) Professor Rucinski seemed to be the ideal leader for the new initiative – with his background that links the successful aspects of the microelectronics industry with the requirements for secure global commerce and mission critical embedded systems.

In early March 2007, Andrzej Rucinski and I addressed the New Hampshire Section about a proposed University of New Hampshire Pilot Center for education in dependable microelectronics design – we received the support of the Executive Committee.
In May discussions with Professor Don Bouldin of University of Tennessee (the “father of MOSIS”), during the IEEE Boston Section sponsored Spring Lectures on “FPGAs and Programmable Systems On a Chip” we modified the approach to focus on the creation of a Steering Committee that would be linked to the Design Automation Technical Committee. The role of the Steering Committee, to be chaired by Prof. Rucinski for the IEEE Global education for Microelectronic Systems Initiative (I-GEMS) is to guide the development of the new curriculum and the Repository. We also began to define what we were then calling the “Design for Globalization” that later became refocused on the challenge of “Designing and Implementing Embedded Systems for Mission Critical Applications.”
Fig. 2. Dr. Henk Spannenburg, Associate Affili ate Professor lectures about reconfigurable processors during the IEEE Boston Section Lecture Series, organized by UNH, “FPGA and Programmable Systems On a Chip,” Woburn, MA, in May. Inset -- Prof. Don Bouldin {Center} discusses FPGA technology with two UNH Ph.D. students during a visit to the basement laboratory of one of the students in May.
In June 2007 at the Microelectronics Systems Education Conference in San Diego, these basic concepts were “alpha tested” to the attendees. A number of suggestions were incorporated in the revised concepts that were again “alpha tested” at the Embedded Systems Conference in Boston in September. Along the way, we attracted the support of CMP-Media {publisher of EE Times}, a major media, and engineering forum publisher. In particular, a CMP-Media element known as TechOnline and its associated Virtualabs looked to provide an infrastructure to test the essence of the Repository Concept.
Fig. 4. Prof. Rucinski’s keynote address about the evolution in the state-of-the-art and the state-of-the-practice in microelectronics design at the Microelectronics Systems Education Conference in San Diego in early June. We recruited members for the I-GEMS Steering Committee and also proposed the functions of the Repository and got some useful feedback in San Diego. Upper Inset -- a lunch after the conference where I-GEMS was discussed {Prof. Don Bouldin in L foreground, Kochanski {l-center}, Rucinski {r-center}}. Lower Inset – Kochanski discusses the UNH poster that explained details about our concepts {note the Design for Globalization figure} with some attendees.
Fig. 5. Prof. Rucinski taking a break during the Embedded Systems Conference in Boston, in September -- where we presented the concepts to CMP-Media TechOnline and received their support to develop the prototype Repository to be hosted at their facility in Waltham, MA.
Fig. 6. Ted Kochanski, touring the TechOnline Virtulab facility in Waltham, MA with the development stage of a Virtualab being demonstrated by Rob Seiber, Engineer in Charge:
A) Rob Sieber Demonstrating VirtuaLab GUI
B) VirtuaLab under development
C) VirtuaLab installed and on-line with host
D) Blade Servers for Techonline
E) TPK inspecting redundant Cisco Networking gear used to connect to the Internet
Fig. 7. The New Kingsbury Hall (funded in part by BAE Systems) Home of the Department of Electrical and Computer Engineering and CIDLab & Dr. Henk Spannenburg, Associate Affiliate Professor, and Technical Director for CIDLab-USA, opening the doors to the lab formally in October. CIDLab is now being outfitted with a high performance computing cluster and will be in use for a graduate seminar for the Spring Semester.

In November, 2007 we advanced to “alpha-plus test” or early “beta test” with a presentation and semi-live demonstration at the annual meeting and tutorial of the Design Automation Technical Committee held at the International Conference on Computer Aided Design in San Jose.
Fig. 8. Left -- Dr. Juan-Antonio Carballo, Chair Design Automation Technical Committee and Member of the Steering Committee of I-GEMS, introducing the ICCAD Tutorial Program of the Annual Meeting of the Design Automation Technical Committee in November in San Jose.

R-- Ted Kochanski Presenting the Tutorial “Design for Globalization as implemented through the IEEE Global Education for Microelectronics Systems {I-GEMS}.” We organized the Tutorial that featured presentations by MathWorks on Model Based Design and TechOnline as well as the UNH presentation.

The Department of Electrical Engineering of the University of New Hampshire has created three courses for the Spring Semester that are focused on Embedded Systems and dependable Microelectronics and Security at both the undergraduate {e.g. ECE-668 “Fundamentals of Computer Engineering“} and the graduate level {e.g. ECE-993 “Embedded Systems Engineering: System-on-a-Chip (PSoC) Design“ and ECE-998 “Mission-Critical FPGA-based Embedded Systems“}. The undergraduates will be learning through the aid of the “hands-on” class project “Take Me Out to the Ball Game,” focused on sports venue security. At the graduate level, two courses focus on designing and implementing mission critical embedded systems and will be developing key elements of the Repository including implementing BOLBO in Simulink and populating our new computing cluster.
For the practicing engineer – we have organized for the IEEE Boston Section a spring Lecture series on “Mission-Critical FPGA-based Embedded Systems” offering hand-on access to FPGA high level development tools {Simulink, ModelSim} and another “beta test” of the Repository Concept.

Fig. 9. Prof. Rucinski introducing “Embedded Systems Engineering at UNH in a public session in December. Lower Inset UNH Students presenting Internet connected prototypes of the GNAT {Global Network Academic Test} a node for a large-scale distributed embedded system designed using the Design for Globalization approach. This is essentially the first concrete developments to come out of the new Embedded Systems curriculum. Upper Inset – general discussion between students and other participants during a break for Pizza. The session ended earlier than planned due to the rapidly falling snow that disrupted a lot of our commutes home.

During the past the twelve months we also have been developing a proposal for a “Special Issue of the Proceedings of the IEEE” that will be focused on Global Security Engineering as a new scientific discipline. In addition to the journal that could become the template for an archival Transactions in Global Security Engineering, we have been engaged in planning with a number of European colleagues for a series of Workshops to be associated with US and overseas internationally accepted conferences associated with aspects of Global Security, and /or Microelectronics and Embedded Systems.
As we review the progress made over the past 12 months, we can look back on period of exploring concepts that seem to have finally coalesced around the Repository and associated curriculum development on the Microelectronics side and the Series of Workshops focused on Global Security Engineering and Microelectronics Embedded in Critical Infrastructure. Looking forward through 2008, we anticipate the first of the workshops to be held in Waltham, MA in conjunction with and immediately following the 2008 IEEE Conference on Technologies for Homeland Security in may 2008. The Second Workshop will be in the form of Special Structured Sessions and a Panel Discussion as part of the 1rst International IEEE Conference on Information Technology to be held in Gdansk Poland in May.

In summary, over the past twelve months we have pursued an initiative focused on embedded systems and in particular the design and implementation of dependable embedded systems for Global Security and Critical Infrastructure and other mission critical applications. Electrical and Computer Engineering is a career, profession and business that is founded fundamentally on continued change in some cases faster than can be imagined and with consequences unforeseeable at the point of initiation. Who could have realized the combined impact of the trillions of transistors that followed that first chunk of germanium and some gold foil at Bell Labs just sixty years ago?

Finally, we look forward to keeping you appraised of the next twelve months of evolution of our initiative of the growth of CIDLab and the initial implementation of the Repository and the impact of the Workshops. Microelectronics now forms an essential element of every aspect of our increasingly globally based and interdependent modern lifestyle. To continue to lead economically, the US must lead in insuring the design and implementation of dependable critical embedded systems on a global scale.