Engineering of Computer Based Systems (ECBS), Panel Introduction

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Computer-based systems affect virtually everything we do. Computer-based systems (CBS) are those for which behavior is, to a substantial degree, determined or controlled by computers. Such systems include telephone and communication, airline reservation, electronic banking and commerce, process control and computer integrated manufacturing, avionics and aerospace, transportation (automotive, train, ship, traffic), medical instruments, microprocessor controlled domestic equipment, and a wide variety of military applications. These applications involve (a) large systems of information and knowledge, (b) distributed and possibly embedded computer and communication components, (c) humans, (d) organizations and (e) system and organization environments.

Computer-based systems tend to be complex, often consisting of many networked, geographically distributed subsystems, and each subsystem may itself be a multi-computer system. A CBS is software, hardware, and frequently communication intensive, and its functional, performance, and reliability requirements mandate tightly integrated information processing and physical behavior. The integration of information technologies dramatically increases the interactions among physical components and processes, generates complex dynamics, and creates component interdependencies unknown in earlier systems. Although development processes for the individual components exist, they remain largely fragmented.

We need a system-level interdisciplinary specialty that addresses the qualities of computer-based systems and the challenges in engineering them. Such inter-disciplinary engineering specialties have long existed for other domains such as aeronautical, marine, and chemical engineering but not for CBS. We need a specialty in the Engineering of Computer-Based Systems because our dependence on these systems has made us vulnerable. As never before, we need our computing systems to be dependable, but systems are becoming more and more complex. Interdisciplinary development is necessary, and we need systems engineering to coordinate the whole.

In a complex system, we cannot understand the system by studying the individual elements in isolation. The interaction of the parts affects functionality, performance, reliability, availability, safety and security. A system level discipline is needed to allocate requirements, develop the overall architecture, synthesize the component designs, and integrate and test the system. Systems are not only complex in and of themselves, but they operate in complex environments, frequently involving both humans and physical components. To design such a system, engineers must thoroughly understand complex application domain scenarios and technology, possible tradeoffs in system design, the interaction between the system and the domain, and the realization of the heterogeneous system elements.

Poorly engineered computer-based systems have killed people, delayed openings of major installations, and caused huge financial loss. The examples are many but some of the well known ones in recent years are as follows: A United States congressional investigation asked why production of a new Federal air traffic control system accrued costs of over 5 billion dollars without producing useful results. In Europe, the crash of the maiden flight of the Ariane 5 launcher focused attention on the significant problems in the systems engineering of computer-based systems. In the private sector, the delayed delivery of a baggage conveyor system at Denver airport postponed the airport opening. A poorly designed radiation therapy machine, the Therac-25, was responsible for six deaths. Other examples abound. The cost of project failures is too large. We have to gain control over the engineering of complex computer-based systems upon which our society is becoming highly dependent.

Let us support research, education, and standards that improve our system engineering capability. We need to address the wide variety of technological and non-technological issues involved in acquiring, supplying, designing, developing, producing, utilizing, and maintaining systems in which significant portions of system behavior is computer controlled. In recognition of this need, the IEEE Computer Society established the Technical Committee on the Engineering of Computer-Based Systems (www.computer.org/tab/tclist/tcecbs.htm). In November 2001, the Computer Society published a special theme issue of IEEE Computer on ECBS [1].

References: 1. S. White, B. Melhart, and H. Lawson, Guest Editors, Theme Issue on Systems Engineering, *IEEE Computer*, 34, 11 (Nov. 2001).

Proceedings of the 26 th Annual International Computer Software and Applications Conference (COMPSAC'02)
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