

The School of Informatics and Computing Distinguished Colloquium Series



Edmund Clarke

FORE Systems University Professor of
Computer Science

**Carnegie Mellon
University**

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3:00-4:00 p.m.

Lindley Hall, Rm. 102

Model Checking and the Curse of Dimensionality

Abstract: The term "Curse of Dimensionality" was coined by the famous mathematician, Richard Bellman. He used the term to describe the exponential increase in volume associated with adding extra dimensions to an object in space. One implication of the Curse of Dimensionality is that methods for numerical solution of various optimization problems require vastly more computer time when the number of state variables involved increases. A similar phenomenon occurs in temporal logic model checking. Model checking is an automatic verification technique for concurrent systems that are finite state or have finite state abstractions. It has been used successfully to verify computer hardware and is beginning to be used to verify computer software as well. As the number of processes in the system increases, the number of global system states grows exponentially. This is called the state explosion problem. Much of the research in model checking over the past 30 years has involved developing techniques for dealing with this problem. In this talk I will describe some recent approaches to the state explosion problem using compositional reasoning, abstract interpretation, and statistical sampling techniques. I will give examples about how these techniques can be used to make model checking feasible for computer software and to understand molecular processes in systems biology.

Biography: **Edmund M. Clarke** received a B.A. degree in mathematics from the University of Virginia, Charlottesville, VA, in 1967, an M.A. degree in mathematics from Duke University, Durham NC, in 1968, and a Ph.D. degree in Computer Science from Cornell University, Ithaca NY, in 1976. After receiving his Ph.D., he taught in the Department of Computer Science, Duke University, for two years. In 1978 he moved to Harvard University, Cambridge, MA where he was an Assistant Professor of Computer Science in the Division of Applied Sciences. He left Harvard in 1982 to join the faculty in the Computer Science Department at Carnegie-Mellon University, Pittsburgh, PA. He was appointed Full Professor in 1989. In 1995 he became the first recipient of the **FORE Systems Professorship**, an endowed chair in the School of Computer Science. He was named a University Professor in 2008

Dr. Clarke's interests include software and hardware verification and automatic theorem proving. In his Ph.D. thesis he proved that certain programming language control structures did not have good Hoare style proof systems. In 1981 he and his Ph.D. student Allen Emerson first proposed the use of **Model Checking** as a verification technique for finite state concurrent systems. His research group pioneered the use of Model Checking for hardware verification. Symbolic Model Checking using BDDs was also developed by his group. This important technique was the subject of Kenneth McMillan's Ph.D. thesis, which received an ACM Doctoral Dissertation Award. In addition, his research group developed the first parallel resolution theorem prover (**Parthenon**) and the first theorem prover to be based on a symbolic computation system (**Analytica**).

Dr. Clarke has served on the editorial boards of Distributed Computing, Logic and Computation, and IEEE Transactions in Software Engineering. He is the former editor-in-chief of Formal Methods in Systems Design. He is on the organizing committee of Logic in Computer Science (LICS) and on the steering committee of Computer-Aided Verification (CAV). He received a **Technical Excellence Award** with Randy Bryant and Ken McMillan from the Semiconductor Research Corporation in 1995 for his work on formal verification techniques. He was a co-winner with Randy Bryant, Allen Emerson, and Kenneth McMillan of the **ACM Kanellakis Award** in 1998 for the development of Symbolic Model Checking. In 1999 he received an **Allen Newell Award for Excellence in Research** from the Carnegie Mellon Computer Science Department. In 2004 he received the **IEEE Harry H. Goode Memorial Award** for significant and pioneering contributions to formal verification of hardware and software systems, and for the profound impact these contributions have had on the electronics industry. He was elected to the **National Academy of Engineering** in 2005 for contributions to the formal verification of hardware and software correctness. He was a recipient with Allen Emerson and Joseph Sifakis of the 2007 **ACM Turing Award** for his role in developing **Model Checking** into a highly effective verification technology, widely adopted in the hardware and software industries. In 2008 he received the **CADE Herbrand Award** for Distinguished Contributions to Automated Reasoning in recognition of his role in the invention of Model Checking and his sustained leadership in the area for more than two decades. In 2011 he was elected to the **American Academy of Arts & Sciences** which includes distinguished leaders in the sciences, social sciences, the humanities, the arts, as well as business and public affairs. Dr. Clarke is a Fellow of the ACM and the IEEE, and a member of Sigma Xi and Phi Beta Kappa.



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