Chapter 1

TLM: AN OVERVIEW AND BRIEF HISTORY

Frank Ghenassia and Alain Clouard
STMicroelectronics, France

Abstract: The trend of “the smaller the better” in semiconductor industry pictures a bright future for System-on-Chip (SoC). The full exploitation of new silicon capabilities, however, is limited by the tremendous SoC design complexity to be addressed within very short project schedule. This limiting factor has pushed the need for altering the classic SoC design flow into prominence. A novel SoC design flow starting from a higher abstraction level than RTL, i.e. System-to-RTL design flow, has surfaced as a real need in advanced SoC design teams. After a decade of attempts to define a useful intermediate abstraction between SoC paper specification and synthesizable RTL, the SystemC C++ open-source class library has finally emerged as the right vehicle to explore the adequate level of abstraction. Transaction Level Modeling (TLM), a methodology based upon such abstraction, has proven revolutionary values in bringing software and hardware teams together using the unique reference model; resulting in dramatic reduction of time-to-market and improvement of SoC design quality.

Key words: system-on-chip; integrated circuit; SoC bottleneck; system-to-RTL design flow; transaction level modeling; TLM; abstraction level; SystemC; OSCI.

1. SYSTEM-ON-CHIP

1.1 The Smaller The Better

An electronic system is a blend of hardware and software components intended for performing a set of functions. These functions have to be delivered to target users at a satisfactory level of performance.

The integrated circuit (IC) or chip is a semiconductor wafer comprising millions of interconnected transistors as well as passive components such as resistors and capacitors. ICs can function as any individual or combined...
parts of an electronic system, for instance, microprocessors, memories, amplifiers, or oscillators. In general, ICs are classified into three categories according to their intended purposes: analog, digital, and mixed-signal.

Through the tiny size of a few square millimeters, integrated circuits have dramatically improved the overall system performance compared to those circuits assembled at board level. High speed, low power consumption, and reduced fabrication cost are among the most remarkable benefits brought by ICs.

In 1965, Gordon Moore predicted that the number of transistors incorporated in an IC would increase twofold every year. This was really an amazing prediction proved to be more accurate than Moore had believed. Since the past few decades, the scale of IC integration has been soaring high. It started from Small Scale Integration (SSI) with around 100 transistors per IC in 1960s, up to Very Large Scale Integration (VLSI) accommodating more than 10000 transistors per IC in 1980s. There is no sign that such tendency would ever cease. In recent years, the integration scale has only slightly slowed down to a factor of two for every eighteen months. This very interesting observation has later been adopted by the Semiconductor Industry Association (SIA) as the famous Moore’s Law to determine IC complexity growth.

Nowadays, ICs could hardly be removed from daily life since they are extensively used in consumer electronic products, telecommunication, data processing, computing, automotive merchandises, multimedia, aerospace, industry and so forth. This invention has really made great changes in our modern life style. Integrated circuits are, for this reason, widely acclaimed as one of the most important inventions in the last century.

The outburst of IC complexity, as predicted by Moore’s Law, is driving the current semiconductor industry to challenge another cutting edge revolution: System-on-Chip (SoC). With the capacity of integrating more and more transistors in a chip, the principle of “the smaller the better” seems steadily realistic and promising.

System-on-Chip is the concept of conceiving and integrating distinct electronic components on a single chip to form an entire electronic system. This concept is feasible thanks to the very exceptional manufacturing advances that bring IC nanotechnology to fruition.

SoC is typically used in a small yet complex consumer electronic product such as hand-phone or digital camera. The fundamental building blocks of SoC are intellectual property (IP) cores, which are reusable hardware blocks designed to perform a particular task of a given component. An IP core could either be a programmable component like processor; or a hardware entity with fixed behavior like memory, input/output peripheral, radio-