Simultaneously designing and testing both software and SoC designs before silicon is an enticing goal to reduce the time and cost of building embedded devices. The earlier that applications can run on a reliable representation of the SoC, the better. Merging the software and SoC paths before silicon saves time and money and creates a virtuous cycle that gets the embedded product to market faster.

This paper describes a new pre-silicon continuum for concurrent SoC and software development and verification for safety and security critical systems, composed of a safety-certified RTOS and advanced C/C++ development tools that continuously support SoC verification from the earliest functional simulator (virtual prototype with Arm Fast Models) through RTL emulation and FPGA prototype stages on the path to first silicon. The continuous convergence brings more safety, security and verified reliability while establishing a more mature software infrastructure for lead customers and partners at the time of first silicon.

Safety and Security Considerations for Software

The most effective approach to developing a safe and secure system begins with decomposing the system into separate components. Each component is analyzed for its size, complexity, resource needs, and safety and security requirements. The components that will be certified for safety or security must be designed to be very small, simple, and isolated from other components in the system. In turn, these components will be much simpler to test and certify. Non-critical components, on the hand, may be large and complex, as they will not need to be certified. Proper separation of the safety or security-critical components from the non-critical components is critical. Without this isolation, the system design can be compromised. A Separation Kernel guarantees resource isolation between application-level programs, allowing a system architect to separate critical device drivers and applications from applications that may be less safe or secure. Additionally, a Separation Kernel provides the isolation required to safely and securely run guest operating systems alongside critical real-time applications.

Cost of Software Bugs

Studies have shown that the relative cost to fix an error highly depends on the phase in which it is found. Compared to the requirements phase, the cost can be 3-6 times as high in the design phase, 10 times in the coding phase, 10-40 times in the testing phase, and 40-1000 times in the operational phase.

Chain of Trust in a Typical Software Stack

Security is multi-faceted and must address more than just architectural design. Functions such as secure software boot, key storage and infrastructure, software update systems, and cryptography for data at rest and in transit are critical parts of a safe and secure system. Figure 3 shows how the chain of trust is built across the software stack from boot loader, through operating systems, device drivers, middleware and user applications.

Fault Campaign Management Execution and Analysis

From a central cockpit, the flow of campaigns is controlled, campaign sessions and steps are executed. The result of fault session is collected from actual execution in dynamic engines like simulation and emulation, and accumulated, illustrating to the user the various attributes like classification of a detection.

Cost of Hardware Bugs

Studies have shown that the relative cost to fix an error highly depends on the phase in which it is found. Compared to the requirements phase, the cost can be 3-6 times as high in the design phase, 10 times in the coding phase, 10-40 times in the testing phase, and 40-1000 times in the operational phase.

Software and Security Aware Pre-silicon Concurrent Software Development and Verification

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Shift Left with Early Hardware-Software Integration

Early in the design flow, virtual prototypes at the transaction level can execute the same software that later is loaded on the board using register accurate descriptions in SystemC. At the register transfer level (RTL), simulation, emulation and prototyping provide different trade-offs between execution performance, debug insight, accuracy and bring-up time (i.e. the time to when the execution model runs functionality correctly). Simulation and emulation are initially focused on hardware verification, with prototyping focused on software development. Once chips are back from production, software development can proceed on the actual silicon.

Results

An Arm-based virtual platform using a Cadence Virtual System Platform based on Xcelium SystemC simulation was developed. The virtual platform is executing an OS – in this case Linux – for early software bring-up. The virtual platform is connected to the Green Hills Multi IDE and debugger for software development.