

Using Secure Coprocessors

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Abstract

How do we build distributed systems that are secure? Cryptographic techniques can be used to secure the communications between physically separated systems, but this is not enough: we must be able to guarantee the privacy of the cryptographic keys and the integrity of the cryptographic functions, in addition to the integrity of the security kernel and access control databases we have on the machines. Physical security is a central assumption upon which secure distributed systems are built; without this foundation even the best cryptosystem or the most secure kernel will crumble. In this thesis, I address the distributed security problem by proposing the addition of a small, physically secure hardware module, a *secure coprocessor*, to standard workstations and PCs. My central axiom is that secure coprocessors are able to maintain the privacy of the data they process.

This thesis attacks the distributed security problem from multiple sides. First, I analyze the security properties of existing system components, both at the hardware and software level. Second, I demonstrate how physical security requirements may be isolated to the secure coprocessor, and showed how security properties may be bootstrapped using cryptographic techniques from this central nucleus of security within a combined hardware/software architecture. Such isolation has practical advantages: the nucleus of security-relevant modules provide additional separation of concern between functional requirements and security requirement, and the security modules are more centralized and their properties more easily scrutinized. Third, I demonstrate the feasibility of the secure coprocessor approach, and report on my implementation of this combined architecture on top of prototype hardware. Fourth, I design, analyze, implement, and measure performance of cryptographic protocols with super-exponential security for zero-knowledge authentication and key exchange. These protocols are suitable for use in security critical environments. Last, I show how secure coprocessors may be used in a fault-tolerant manner while still maintaining their strong privacy guarantees.

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