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Use of Trusted Software Modules for High Integrity Data Display

by

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This report provides summary of the interface, mechanisms and semantics for high integrity display of information in a secure computer system, based on the use of a high assurance separation kernel and trusted software modules in both the application domain and the trusted software domain.

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SecureCore
Trustworthy Commodity Computation and Communication

Technical Report: NPS-CS-08-012

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Abstract

This report provides summary of the interface, mechanisms and semantics for high integrity display of information in a secure computer system, based on the use of a high assurance separation kernel and trusted software modules in both the application domain and the trusted software domain.

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This document describes an on-going research effort of the SecureCore project.[4] The intended audience is the SecureCore research team whose members are familiar with the SP hardware [5] and SecureCore software architecture [1].

Introduction

High assurance computer systems provide a trusted path for users to securely interact with the trusted computing base (TCB), including a keyboard for user input and a display device for the TCB to output information to the user. The TCB may also provide interfaces for other programs to write to an attached display device such that there is high assurance that data written to the device is displayed to the user without modification. Usually this assurance is established through the program's direct access to a securely designed interface, along with the ability of the TCB to protect itself.

Despite these capabilities, there is no guarantee that high integrity information is written to the screen by untrusted applications supported by untrusted operating systems. During emergencies, there may be a need for applications, which do not have direct access to the TCB interface, to write to the screen with high assurance that the data is displayed to the user. The SP trusted software module (TSM) provides a context for high integrity code execution in the application domain, but requires support for a trusted display. This document describes an architecture that supports a high integrity conduit between an application-level TSM and a high integrity display. Before describing the design of this capability, this report briefly reviews the SecureCore architecture, including the management of devices and communication channels.

SecureCore Overview

In the SecureCore security architecture, a *trusted software module* (TSM) hosted by an untrusted commercial operating system may communicate with a remote *central authority* (the Authority) through a channel that is encrypted with the SP [5] hardware-based *Device Root Key* (DRK). [6] Using a mechanism described in this paper, the TSM can communicate directly with the TCB – the Trusted Management Layer (TML) – ensuring that data from the TSM is displayed to the user, without potential interference by the commercial OS.

The TML is composed of the Least Privilege Separation Kernel (LPSK) [7][9] and the Secure Core Security Services (SCSS) layer. The TML provides a processing environment in which a separate OS in each partition can manage its own applications without interference from other partitions. In this environment there are three types of partitions: trusted, emergency, and normal.

The TML provides a high integrity display mechanism that is available to both applications hosted by untrusted operating systems in untrusted partitions and applications hosted by the SecureCore Operating System (SCOS) in the trusted partition. This mechanism ensures that information can be displayed to the user with high integrity, without requiring the user to explicitly change the *focus* (see below) of the system to the trusted partition. The TML manages small, high integrity display areas such that critical messages from different applications can be seen simultaneously by the user. The limited screen area allocated for these critical messages as well as the simple mechanisms required in high assurance TCB development result in the requirement that each message must be short and non-graphical.

Management of Devices and Communication Channels

The TML provides synchronous and asynchronous device I/O interfaces and services. Device management is characterized in three ways. First, certain devices may be virtualized by the TML. In this case, the TML presents the OSes with a virtual hardware device, such that undesirable interference between partitions is prevented, while the client operating systems and SCOS may simultaneously share the services of the actual underlying device.

Second, a device may be assigned solely to a particular partition. For example, memory-mapped devices may be used so that they interact with processes through dedicated memory regions. Here device management is vectored by the LPSK to the client OS for its exclusive use.

Finally, the SCSS supports focus management by allowing a particular partition temporary exclusive use of a device until the user, via the TPA, chooses to associate the device with a different partition. The keyboard, mouse, and screen require focus management. While keyboard and mouse input is vectored to the selected partition, all partitions continue to update their screen buffers. The system supports configurations with tiled windowing, so that output from partitions with sensitivity levels dominated by the user's current session level can be simultaneously displayed. For partitions that write to the display at a level higher than the current session level, the SCSS will maintain their screen output until the user establishes a session at a high enough level. Thus, instead of having to shut down activity at a particular session level to make the device available at a different level, e.g. [2][3], all partitions can continue to execute according to the predefined schedule.

The TML divides the physical display screen into two regions. One region is reserved by the TML as a high-integrity display area, for example, for critical system messages. The other region is available to partition applications, as normal.

Each exported device has two labels associated with it: a read-class and a write class. [8] A device where both labels are equal is a single-level device; a device for which the two labels are different is a multilevel device. For single-level devices, the SCSS exports an interface for administrative change of the device level during runtime, thereafter restricting access to the device to that security level. A multilevel device may be assigned to an untrusted partition by the SCSS, which then labels all of its I/O at the level of the partition. Finally, a multilevel device can be used by a trusted application, which is trusted to apply the right labels to its data.

The secure attention key (SAK), which is currently a keystroke sequence, allows users to invoke the Trusted Path Application (TPA). The LPSK services the SAK interrupt and passes control to the SCSS, which manages the focus change to the Trusted Path Application in the trusted partition.

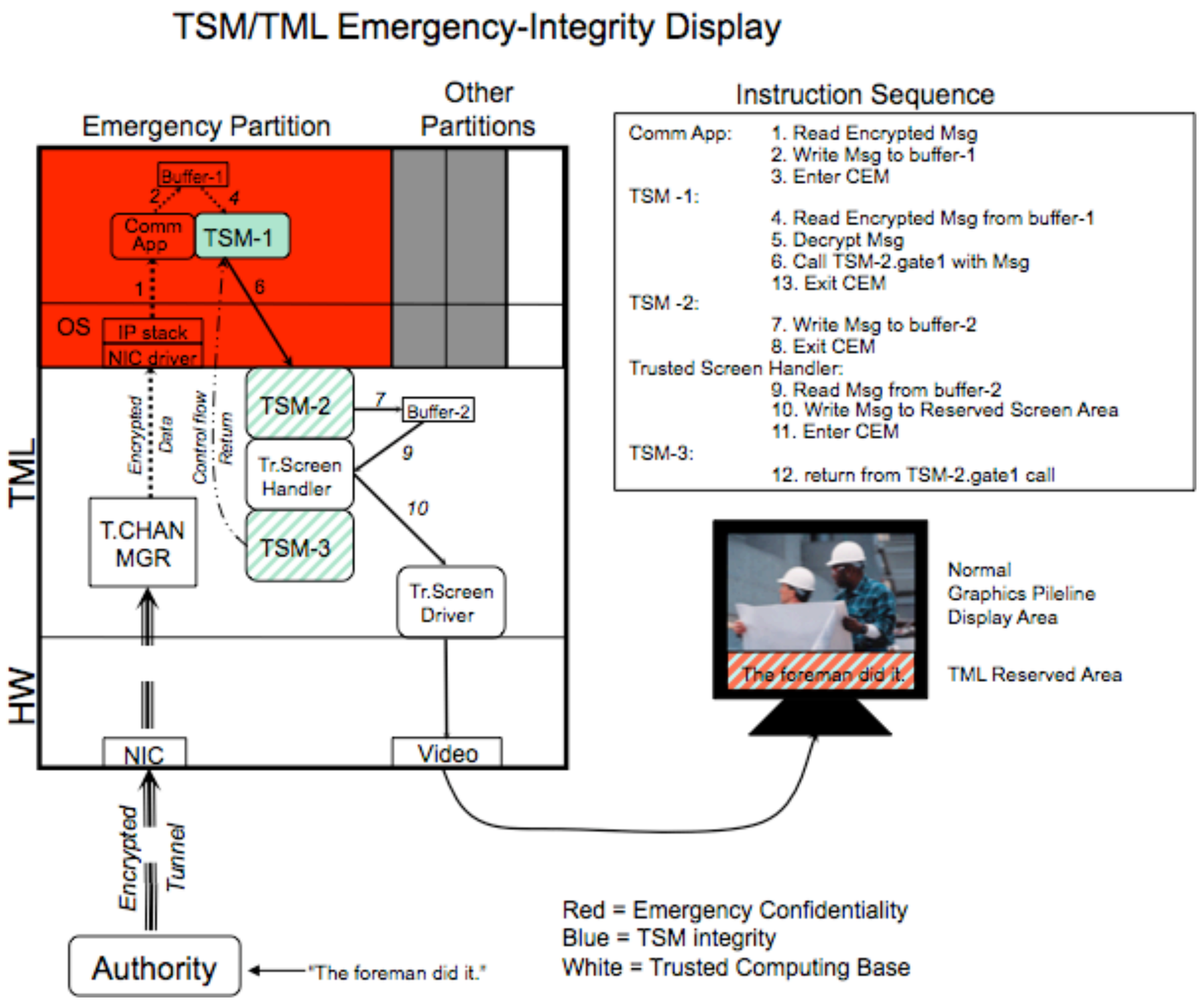
The SCSS is responsible for establishing trusted communication channels between the device and the central authority or trusted third parties. It detects and verifies emergency signals from the central authority, restricts or allows access to the emergency partition accordingly, and raises or lowers alarms to other programs within the device, as configured to do so.

Partitions may host network-capable client operating systems. The TML multiplexes communications among its partitions and to external nodes while ensuring enforcement of the system's information flow policy. It associates implicit or explicit labels with information as needed. It also provides support for the establishment of secure communication channels, e.g. VPNs, with external nodes. For example, since network communication protocols are bidirectional, in a partition-to-partition communication channel, both partitions must be the same sensitivity level.

High Integrity Display of Data

The Trusted Application Display mechanism allows an application TSM or the TPA to send data directly to a reserved region of the display device. Figure 1 illustrates how this would be organized in an untrusted partition, in this case, the Emergency Partition.

In the case of the TSM, the text for display may be encrypted, e.g., if it has come from the Authority. Figure 1 shows this information stored in *buffer 1*.The TSM decrypts the data using SP-protected keys, and then stores the clear text in SP-protected memory using SP Secure_Store instructions, to prevent other applications from viewing or modifying it. The application TSM then invokes a TML TSM module, through a TML call gate. The TML TSM reads the clear text using SP Secure_Load and then uses regular store instructions to write the data to a TML buffer (*buffer 2*). The TML TSM then exits CEM mode and invokes the TML's Trusted Screen Handler, which sends the data to the Trusted Screen Driver for display in the restricted display region, labeling the data as appropriate. Finally, the TML TSM code re-enters CEM mode and returns execution control to the application-TSM, with a return value or similar mechanism indicating the success or failure of the display operation. As the data traverses through different software components, its integrity is protected by SP hardware mechanisms and the TML.



Comm App:	1. Read Encrypted Msg
	2. Write Msg to buffer-1
	3. Enter CEM
TSM -1:	
	4. Read Encrypted Msg from buffer-1
	5. Decrypt Msg
	6. Call TSM-2.gate1 with Msg
	13. Exit CEM
TSM -2:	
	7. Write Msg to buffer-2
	8. Exit CEM
Trusted Screen Handler:	
	9. Read Msg from buffer-2
	10. Write Msg to Reserved Screen Area
	11. Enter CEM
TSM-3:	
	12. return from TSM-2.gate1 call

Figure 1. Trusted Application Display

Summary

This report presents a high level design of a trusted display capability that utilizes both hardware and software protection mechanisms to preserve data integrity. This capability affords users a high level of confidence that the data seen on the display device has not been tampered with by untrusted programs executing in the application domain.

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