MobiSec 2009

Open Trusted Computing

an overview

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during 2007-2009, as part of part of the Open Trusted Computing project, http://www.opentc.net

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In the beginning (2004) ... 

- Trusted Computing was controversial, so much so ...
  - “Will lock down computers of end users”
  - “Will lock customers into specific OSs and software”
  - “TC’s purpose is to enforce DRM on consumer machines”
  - “TC considered harmful for Open Source Software”

- ... that academia typically did not dare to touch it.
  - No R&D ecosystem, in particular in Europe
  - No fact base to address Fear, Uncertainty & Doubt
  - No experimental implementations

But underlying problems are real and need investigation!
Problem Statement: IT is an Actor. But whose script does it follow?

Current Situation
- IT can change a YES into a NO
- IT can distort expressions of will and intentions and we have no indication mechanisms for this
- We can’t qualify the technical risk of subverted end platforms from the user’s authorization

Future scenario
- Attest platform’s “fitness for purpose”
- Use it as admission criterion for network or transactions
- Allows for multiple purposes, roles, and identities
OpenTC Motivations: Technology that’s useful

- **Exploit** existing capabilities of Virtualization and Trusted Computing technologies beyond proprietary solutions, in a collaborative/cross industry solution
- **EC** wanted to ensure that the Trusted Computing value proposition was also delivered in an OSS setting
- **Counter** critical response of OSS spectrum to TC
- **Extend** corporate options (IBM, HP, Novell/SuSE)
  - Support corporate strategies: TC in managed infrastructures
- **Extend** market (Infineon, AMD)
  - Wider deployment of Hardware (TPMs, CPUs)
OpenTC: Working Hypotheses

- Trust requires transparency (actual degree tbd.)
  - Inherent advantage of Open Source (can be inspected)?
  - Inherent problem of proprietary hardware and software?

- Flexible Trusted Computing is possible
  - Avoid platform lockdown and consumer lock-in
  - Core idea: Trusted Virtual Platforms

- Trusted Computing and Open Source are compatible
  - Technically, legally, and philosophically
OpenTC: Project Goals

- Produce a security enhanced OS base
  - Integrating TC and Virtualization technologies
  - Based on Open Source components
- Management framework and protocol software
  - For trusted virtualized systems
- Application prototypes / use examples

- Some of the challenges in building such a system:
  - Robust and secure virtualization layer isolation
  - Trusted sharing of hardware I/O devices
  - Manageability and attestability
### OpenTC partners (EU Integrated Project, FP6)

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OpenTC Main Phases

• Phase 1
  – Working together
  – Integrating existing technologies and understanding their potential
  – Client measurements for backend services
  – UC: Privacy Enhanced Electronic Transactions (secure browsing)

• Phase 2
  – Architecture (e.g. disaggregation of VMM, graphics), measurement framework, richer interaction models, validation and verification
  – UC: CC@Home (separating environments for work and private use)

• Phase 3
  – Server side virtualization, using virtual networking and Trusted Virtual Domains concept for customer separation
  – UC: Virtual Data Center
Chain of Trust
Manageable and attestable virtualization layer

- Integrity Measurement Architecture
- Enabling remote attestation of invariant security properties implemented in the trusted virtualization layer
Trusted Computing and virtualization

• Trusted virtualization
  – Use of virtualization for security on PC class platforms
    • Ideally a possible replacement for the traditional security kernels
  – Combined use of virtualization and Trusted Computing

• Used to build general purpose security frameworks
  – Suitable for many broad application scenarios
  – Ideally comprising all application purposes

• Taken into account at least in some R&D projects
  – OpenTC (Open Trusted Computing)
  – EMSCB (European Multilateral Security Computing Base)
**Trusted Computing and virtualization (2)**

- **Key points**
  - Much more than TCG-aware OSes and applications
  - TPM used as hardware root of trust
    - many features/services implemented in software
  - Virtualization used to achieve memory isolation
  - Security services running in small virtual machines (compartments)
    - Secure GUI, Secure Storage, Virtual TPMs, ...
    - They can be measured (trusted)
      - Together the Virtual Machine Monitor (VMM) they form the Trusted Computing Base (TCB)
  - Also user security critical applications can be isolated in different virtual machines (compartments) and measured
  - Communications between compartments is subject to flow control policies enforced by VMM
Comprehensive security framework

- Secure services (VM control and communication, secure storage, secure UI)
- TC-based application (appliance)
- Conventional OS (single VM)
- Conventional OS (single VM)

Virtual Machine Monitor

Trusted platform (conventional HW + TPM)
1st - Private Electronic Transactions (PET)

- Trusted Service Domain (\textit{dom0})
  - Client Proxy

- Trusted Application (\textit{domT})
  - Trusted Browser

- Generic OS (\textit{domU})
  - Untrusted Application

- Bank Operator

- Trusted Virtualisation Layer

- Boot Loader

- TPM

- Hardware (CPU, BIOS)

- Policy Enforcement Proxy

- Bank Application Server

- Internet
PET: Trusted Browser

- Trusted Service Domain (dom0)
  - Client Proxy
  - CM
- Trusted Application (domT)
  - Trusted Browser
- Generic OS (domU)
  - Untrusted Application

- Trusted Virtualisation Layer
- Boot Loader
- TPM
  - Good Value 1
  - Good Value 2
  - Good Value 3
  - Good Value 4
- Hardware (CPU, BIOS)

- Bank Operator
- Policy Enforcement Proxy
- Bank Application Server
- Internet
PET: Standard Browser
CC@H: high-level architecture

Corporate OS (domC)
(Xen) (L4)
Trusted Applications

Multimedia Player (domVLC)
VLC player

Corporate Server
Corporate Service
TVD Master
TVD policy

Trusted Virtualisation Layer

Hardware (CPU, BIOS)

TPM

Secure GUI (domG)
Compartiment Manager (L4)

Trusted Service Domain (dom0)
Compartiment Manager (Xen)
vSwitch
TVD Proxy

VM GUI (Xen)

Good Value
Good Value 3

Good Value 1
Good Value 2
Good Value 3

vNIC

Corporate Data

multimedia content

Good Value

Boot Loader

www.opentc.net
June 4th, 2009
CC@H: Trusted Access to the Corporate Service
CC@H: OpenTC taskbar

- Control icon
  - only known to the legitimate user
    - not provided with the distribution
  - sealed (i.e. encrypted) against a “good” system configuration
    - if unsealing fails at boot time, this means that the system configuration changed
CC@H: Corporate Compartment with standard VPN software
CC@H: Corporate Compartment with OpenTC VPN bound to integrity

TC Open Trusted Computing

opensUSE™
3rd - Virtual Data Centers (VDC)
Trusted Virtual Domain concept

- to implement the access to the corporate network we built upon the TVD concept
  - pushed by IBM research labs (T.J. Watson, Zurich)
- (one possible) definition for Trusted Virtual Domain (TVD)
  - group of virtual resources subject to a (security) policy
    - the resources belonging to a TVD can be logically isolated from the resources belonging to other TVDs
      - resources belonging to the same TVD can run on different physical platforms
        » they can be interconnected through a trusted network
      - resources belonging to different TVDs can run side-by-side on the same physical platform
A1, C1, D1 and E2 belong to TVD blue
A2, B1, D2, D3 and E1 belong to TVD red
VDC: Data Center Physical Layout

VDC Computing Node
- DomU
- DomU
- vSwitch

VDC Management Node
- Image Repository
- TVD Master
- Dom0
- vSwitch
- IPsec

Remote TVD Management Client
- L4Linux
- Mgmt Console
- L4/Fiasco

VDC LAN

Internet

Legend:
- trusted hard- and software
- VDC TVD / storage TVD
- Internet + INET TVD
- VMs + interfaces of red TVD
- multiplexed TVDs (VLAN)
- multiplexed TVDs (IPsec)
- VMs + interfaces of blue TVD
OpenTC: Mobile and Embedded Systems

- Investigation on the use of Trusted Computing technologies and virtualization on mobile and embedded devices
  - a thorough examination of the TCG and OMTP standards
  - definition and security analysis of several use cases that are relevant for mobile scenarios
  - the development and analysis of the Secure Wallet use case as an example scenario
  - the port of basic microkernel-based operating system components from other OpenTC WPs (in particular: the L4 microkernel, L4 environment, L4Linux)
  - the port of the TPM emulator and its modification to use security features of the mobile hardware
OpenTC: other relevant aspects

- Architecture for accelerated 3D graphics in VMs via Gallium stack
  - Xen3D
- Standardization effort
  - Trusted Computing Group
  - Java community
- Validation, Verification and Testing
  - White and Black-box testing
    - TSS
  - Static analysis and code review
    - Virtualization layer (Xen and L4)
  - Work on Protection Profile and Trust methodology/metrics
Conclusion

Thanks for the attention!

Any question?
CC@H: network configuration and interfaces
CC@H: guest domain and sealed virtual disk

measurement

unseal decryption key

successful?

OK

set decryption key

Domain0 (privileged domain)

domU. cfg

DOMU-ro.img

domU. sealed

DOMU-rw.img

Guest domain (domU)

/ 

Linux

Kernel

dm-crypt

Virtualisation Layer (Xen)

Physical disk

Hardware (CPU, BIOS)

Linux

Kernel

AUFS

sda1

sda2
CC@H: Trusted Channel via proxies for TVD pre-admission phase

CC@H client (configuration#1)

CC@H server (configuration#2)
CC@H: setup of TVD network (VPN)

CC@H client (configuration#1)

- Domain0 (privileged domain)
  - openvpn
  - TVD proxy
  - CM

- Linux Kernel
  - xenbr0
  - peth0
  - vif0.0
  - vpnbr8
  - tap0
  - vifX.0

- Corporate compartment domU (ID X)
  - Linux Kernel
    - 10.0.0.1

- Virtualisation Layer (Xen)

- Hardware (CPU, BIOS)

- TVD network (VPN)

CC@H server (configuration#2)

- Domain0 (privileged domain)
  - openvpn

- Linux Kernel
  - xenbr0
  - peth0
  - vif0.0
  - vifX.0

- Corporate compartment domS (ID Y)
  - Linux Kernel
    - 10.0.0.2
  - z_vpn
    - br0
    - tap0
    - vif0.0
    - vifY.0
    - vifY.1

- Virtualisation Layer (Xen)

- Hardware (CPU, BIOS)

- Web server
  - TVD master
  - Corp service

- 172.31.254.4
  - eth1

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CC@H: some facts about the prototype

- **linux distribution**
  - commercial grade openSUSE 10.3

- **building the prototype**
  - harmonisation of the building tools
    - all source code compiles with the latest GCC/G++
    - OpenTC components packaged as RPMs
      - using the public SUSE build server
  - OpenTC prototype generated using SUSE KIWI imaging system
    - developed KIWI templates and wrapping scripts
    - CC@H completely generated “from scratch” in about 1.5 hour
• first rough support for measuring persistent root file system
  – for dom0 and other guest domains (RO and RW layers)
  – currently working on a Hierarchical Integrity Measurement (HIM) architecture
• integrated Xen/L4 prototype
  – for all domains the same root file system image can be started with both Xen and L4
• support for MS Windows XP (Xen only, HD installation only)
CC@H: which are the used components?

- VMMs (or hypervisors)
  - XEN hypervisor, L4 Fiasco µ-kernel
- boot loaders
  - Trusted GRUB (S-CRTM)
  - OSLO for TPM 1.2 and AMD CPUs (D-CRTM)
- GUI
  - proof of concept of unified secure GUI running under Xen
  - real secure GUI for L4
- security services
  - compartment manager and sealed storage
  - secure virtual network: TVD components
  - TC proxy for remote attestation
- VLC multimedia player (video and audio in a VM)
CC@H: everything is open source!

- OpenTC CC@H Proof of Concept prototype
  - live CD released in mid July 2008:
    

    - all software components are open source (GPL, CPL)

    - the packages are automatically created/updated using the SUSE public build server
      https://build.opensuse.org/

    - the source and binary package can be downloaded from (choose openSUSE 10.3)
      http://download.opensuse.org/repositories/security:/OpenTC
CC@H: stay tuned (www.opentc.net)!

- OpenTC CC@H Proof of Concept prototype
  - KIWI templates and scripts will be released in fall 2008
    • to build your own instance for hard disk installation
    • to re-build the live CD with updated components
    • to play with it (modify for your own purposes)
  - future versions of CC@H in fall 2008 or spring 2009 (also VDC)
- to be informed when templates and future versions will be released
  - check our web site
    http://www.opentc.net
  - subscribe to the OpenTC newsletter
    http://www.opentc.net/index.php?option=com_forme&fid=4
- please send us your feedback about CC@H prototype
VDC: Data Center infrastructure services

Graphics courtesy of K. Eriksson, IBM
VDC: TVD Management Console
The Open-TC project is co-financed by the EC.

If you need further information, please visit our website www.opentc.net or contact the coordinator:

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