TrenchBoot and GRUB –
A Quick Introduction

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Meet the Presenter

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Agenda

• TrenchBoot – What is it?
• TrenchBoot and UEFI Secure Boot
• TrenchBoot and GRUB – Why?
• GRUB - Current State and Challenges
• Questions?
• Documentation

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TrenchBoot

• TrenchBoot is a cross-community integration project focused on launch integrity
  • This means there is no “one thing” that is TrenchBoot
  • The name was a play off of dealing with the muddy mess of trying to find a way to unify boot integrity
  • The purpose is to develop a common, unified approach to building trust in the platform through launch integrity
  • And to work with existing Open Source ecosystem to integrate the approach into their respective projects
    • The intention here is to have a unified Dynamic Launch approach between Xen, KVM, Linux, BSD(s), and potentially proprietary kernels
Motivation

• The idea for TrenchBoot originated in 2014 dealing with the limitations of using tboot to launch Xen for the OpenXT project
  • Access to the TXT TPM event log is blocked
  • Conflict over access to the UEFI boot services
  • Can only measure Multiboot modules that were loaded into memory by the bootloader
  • Supports only one attestation action: predetermined the PCR manifest verification
  • Only supports the Intel TXT, no love for AMD’s Secure Startup and other architectures and platforms
Motivation – Continuation

• Launch integrity is the foundation for platform security
  • It deserves the attention needed to get it right and well integrated with Open Source
• In the past Dynamic Launch was under utilized
  • It can in fact be initiated many times between power-on and power-off
  • Each Dynamic Launch is an opportunity to establish the current integrity of the platform
Secure Launch for Linux

- TrenchBoot Secure Launch for Linux provides for different strategies to build trust in the platform
- First Launch – Establishing hardware rooted integrity during platform boot
- Runtime Launch – Establishing hardware rooted integrity during platform runtime, e.g.
  - Secure Launch a kernel upgrade
  - Secure Launch Integrity Kernel for runtime verification
    - Integrity verification before executing a privileged operation
    - Re-establishing platform state after sleep or hibernate
  - Secure Launch Update/Shutdown kernel
    - Reviewing platform state before platform reboot/shutdown
    - Checking integrity before persisting state to disk
Who Contributes to TrenchBoot?

- CITRIX
- Intel
- apertus solutions
- ORACLE
- 3M DEB
**Terminology**

Mapping concepts to TCG specification and vendor terms

<table>
<thead>
<tr>
<th>Description</th>
<th>TCG</th>
<th>Intel TXT</th>
<th>AMD-V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process of starting a software environment at an arbitrary time in the runtime of a system</td>
<td>Dynamic Launch (DL)</td>
<td>Late Launch</td>
<td>Secure Startup</td>
</tr>
<tr>
<td>Platform dependent event that triggers the DL</td>
<td>DL Event</td>
<td>GETSEC[SENTER]</td>
<td>SKINIT</td>
</tr>
<tr>
<td>Performs initial configuration actions that are platform specific before invoking DL Event</td>
<td>D-RTM Configuration Environment (DCE) Preamble</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Core Root of Trust for the DL environment that is initiated by a DL event and represented by the initial measurement</td>
<td>D-CRTM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Software/firmware that executes from the instantiation of the DL Event to the transfer of control to the DLME</td>
<td>D-RTM Configuration Environment (DCE)</td>
<td>Authenticated Code Module (ACM)</td>
<td>Secure Loader (SL)</td>
</tr>
<tr>
<td>Software executed after the DCE instantiated TCB is established</td>
<td>Dynamically Launched Measured Environment (DLME)</td>
<td>Measured Launch Environment (MLE)</td>
<td>Security Kernel (SK)</td>
</tr>
</tbody>
</table>
UEFI Secure Boot Trust

- The CRTM is not measured until during PEI
  - Therefore SEC and PEI must be trusted
  - CRTM is of SEC and PEI, thus it is self referential
  - Relies on integrity of Boot Flash
  - Relies on TPM to protect measurements
- The DXE phase enforces UEFI secure boot verification
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Dynamic Launch Trust

- DCE Preamble may be a bootloader or an executing OS
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- On Intel there is also an additional authentication protocol between the DCE and CPU
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The Control of a Dynamic Launch

- Provides a very controlled and protected startup
  - The CPU obtains Locality 4 on the TPM and clears DRTM PCRs (17-22)
  - All CPU interrupts (NMI, SMI, INIT, etc) are disabled
  - The CPU protects the DCE from DMA access
    - Intel uses Cache as RAM (CRAM)
    - AMD uses Device Exclusion Vector (DEV)
  - The DCE is measured by the CPU and stored in PCR 17 of the TPM before execution
    - On Intel the ACM is authenticated before measurement
    - On AMD the Secure Loader is owner provided
  - The DCE ensures the DLME is DMA protected, measures, and then executes
- The result is a very high integrity assertion of the DLME
  - Removes boot firmware from the TCB with the exception being the SMI Handler
Basic Flow of First Launch – Intel TXT

Diagram:
- SL
- ACM
- TPM
- vmlinux
- Setup
- Piggy
- Initrd (u-root)
- Header
- Kernel
- Target OS
- DLME

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The GRUB History

• The project was initiated by Erich Boleyn in 1995
• It was an attempt to boot the GNU Hurd with the University of Utah’s Mach 4 microkernel
• One of the outcomes of this efforts was the Multiboot Specification made by Erich Boleyn and Brian Ford
• Erich tried to implement the Multiboot Specification in FreeBSD boot loader but quickly realized that it was easier to write own bootloader from scratch
• This way the GRUB was born
• In 1999, Gordon Matzigkeit and Yoshinori K. Okuji adopted GRUB as an official GNU package
The GRUB History – Continuation

• Over the next few years, GRUB was extended to meet many needs
• However, it quickly became clear that its design was not keeping up with the extensions being made to it
• Around 2002, Yoshinori K. Okuji started work on PUPA (Preliminary Universal Programming Architecture for GNU GRUB), aiming to rewrite the core of GRUB
• The project PUPA was later renamed to GRUB2 and the original version of GRUB was renamed to GRUB Legacy
• The GRUB Legacy last release (0.97) was made in 2005
• Major GNU/Linux distributions migrated to GRUB2 between 2007 and 2009

Based on https://www.gnu.org/software/grub/manual/grub/grub.html#History
The GRUB – Why is it the Bootloader of Choice?

• The GRUB is the most common boot loader in deployment thus making it the choice initial boot loader to make capable of being a DCE Preamble for DL
• The GRUB is the most feature rich reach bootloader in the wild:
  • It supports at least 24 variants of targets (architectures) including ARM, x86, IA64, MIPS, POWER, RISC-V, SPARC64 and platforms like e.g. UEFI
  • It supports many filesystems including btrfs, ext2, ext3, ext4, F2FS, FAT, HFS, JFS, ReiserFS, SquashFS, romfs, NTFS, XFS, ZFS, LUKS, LUKS2
  • It has many security and crypto features embedded including UEFI Secure Boot via shim_lock and TPM support
  • It can start directly from ROM (coreboot)
  • It supports network boot
  • It has minimal shell capabilities which allow scripting
  • And many more...
The GRUB and UEFI

• The GRUB works on all architectures which are capable of running UEFI
• Most UEFI features are supported by the GRUB
• The GRUB supports the UEFI Secure Boot via shim
• The GRUB supports measurements using the UEFI TPM calls
• The GRUB can load many different OSes which even sometimes do not support the UEFI at all
• The GRUB presents the unified interface to the user regardless of architecture and firmware
• The GRUB supports basic scripting which is very useful for automation
• The GRUB community is pretty active
The GRUB – Current Challenges

• We want to unify the UEFI Linux boot protocol for all targets
• ...and later for other OSes
• The GRUB has some long standing network boot problems on UEFI platforms due to issues with the SNP driver
• The project struggles with a shortage of reviewers from firmware and OSes side
Questions?
Documentation

• https://trustedcomputinggroup.org/wp-content/uploads/TCG_D-RTM_Architecture_v1-0_Published_06172013.pdf
• https://github.com/TrenchBoot/
• https://www.gnu.org/software/grub/
• https://lists.gnu.org/mailman/listinfo/grub-devel/
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For more information on UEFI Forum and UEFI Specifications, visit http://www.uefi.org

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