UEFI Secure Boot in Linux*

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STTS002
Agenda

• Problem Statement
• What is UEFI Secure Boot
• Introduction to Machine Owner Key
• Secure Boot in SUSE Linux
• Demo
Problem Statement
Secure Boot Problem

• Malware moving more into the platform
• UEFI extensibility can be exploited by unauthorized parties
• Attacks increasingly targeting the platform firmware
  – Black Hat 2007, 2009, 2013, CanSecWest 2013...
• Need to balance UEFI code loading controls and maintain platform owner and user choice
• For platform integrity and user flexibility:
  – Maintain ability to have several operating systems on the platform
  – Provide platform owner a choice for software
What is UEFI Secure Boot?
UEFI Secure Boot

1. Enroll
   - PEI FV
     - Authenticated Variables
       - PK
       - KEK
     - db
     - dbx
   - Variable
   - DXE FV
     - Image Verify

2A. Signed Image Discover
   - Certificate + SignInfo
   - OpRom.efi

2B. Signature Verification
   - Certificate + SignInfo
   - OsLoader.efi

2C. Signed Image Load
   - Certificate + SignInfo

3. Post ship update DB
   - Update DB

Cloud
The full solution

Intel® Device Protection Technology with Boot Guard – Secure Boot Policy Enforcement

End to end platform integrity
Secure Boot Challenges for Linux*

• Dual OS deployment challenge
  – Users can disable UEFI Secure Boot to install Linux* but this isn’t the best deployment plan
  – Users must have an option to install Linux alongside an OS, even when UEFI Secure Boot is enabled

• Linux can benefit from UEFI Secure Boot, if...
  – Customers can install Linux without disabling the feature
  – Platform owner can set security policy and customize system

• Different roles interact with UEFI Secure Boot
  – Kernel hacker – disable or enroll own keys w/firmware screens
  – Consumer – just want it to work, seamless boot of live images
  – Managed IT machine – IT is the ‘owner.’ Control end user actions.

Linux distributions have several options to implement secure boot
Introduction to Machine Owner Key
Machine Owner Key (MOK)

• To support UEFI Secure Boot in Linux*, there are two challenges to overcome
  – Coexist with other operating systems
  – Avoid the potential General Public License (GPL) copyright issues caused by the UEFI image signature

• MOK gives back the key management control to users or security admin
SUSE Solution

MOK comprised of 4 parts

**shim**
- **grub2, kernel, and kernel drivers**
  - A BSD licensed preloader of the OS loader (grub2) signed with the db key
  - All involved components are signed

**MOKList**
- **MOK database** - The key database implemented in a UEFI nvram variable, MOKList

**MokManager**
- The UEFI program to manipulate the MOK database

**mokutil**
- The Linux* utility program to issue requests to MokManager
MOK Database

- The MOK database is used as a boot service non-volatile variable
- UEFI Boot Service non-volatile variables are immune from threats from OS
- MOKList is not the db and does not need to be controlled by KEK

<table>
<thead>
<tr>
<th></th>
<th>Boot Service</th>
<th>Runtime Service</th>
<th>Authenticated</th>
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<tbody>
<tr>
<td>UEFI - Read</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>UEFI - Write</td>
<td>Yes</td>
<td>Yes</td>
<td>Restricted</td>
</tr>
<tr>
<td>OS - Read</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>OS - Write</td>
<td>No</td>
<td>Yes</td>
<td>Restricted</td>
</tr>
</tbody>
</table>

**MOKList is not accessible at OS runtime**
UEFI Secure Boot With MOK

shim is loaded before other UEFI images
Multi-boot with MOK

Load the UEFI image as long as it is trusted
Enroll A New MOK Key

1. Request
   - Reboot

2. Detect
   - RT Var
   - MOKNew
     - User
     - Password Hash

3. Verify
   - MokManager

4. Enroll
   - BS Var
   - MOKList

5. Reboot
   - Custom boot path
Multisigned shim

Either the UEFI CA key or SUSE key will let the shim boot with UEFI secure boot.
Linux* Driver Verification

• All kernel drivers have to be signed with the SUSE key
• Linux* kernel verifies drivers with the built-in SUSE key or MOK keys
• SUSE will NOT sign any binary driver that is incompatible with GPLv2
• The user is free to enroll the key for the third party binary driver
• SUSE's Partner Linux Driver Program (PLDP) - simplifies MOK implementation

Users can get their 3rd party drivers included in the secure boot with MOK
Third Party Driver Verification

Boot Service

- shim

Runtime

- kernel

- $3^{rd}$ Party Driver
  - User Signature

- MOKList
  - User
  - BS Var

- MOKListRT
  - User
  - RT Var

copy

verify
SUSE Summary and Call to Action

• UEFI Secure Boot no longer an issue to the Linux* World
• With MOK, users select the keys they trust
• Linux systems benefit from MOK to ensure the integrity of the drivers

Call to action:
• Use MOK in your Linux deployments
• Put SUSE key in UEFI database to test multi-signed shim
• Utilize SUSE's Partner Linux Driver Program for delivering kernel drivers compatible with SUSE Linux Enterprise and Secure Boot
  – https://www.suse.com/partners/linux-driver-program/
Summary

• Attacks against the platform will most likely continue
• Deploy UEFI Secure Boot to address pre-OS malware
• Design a robust platform implementation
• Avoid ‘restricted boot’ & continue to enable platform owner choice of UEFI Secure Booted code
• Emergent tools for choice include multi-signed images, the Shim Loader, and Machine Owner Key
• Machine Owner Key provides practical solution for implementing key management
Updates from Linux* Distributions

• Ubuntu* 12.10 – 64-bit version of Ubuntu 12.10 shipped with Shim to support secure boot
• Fedora* 19 – included Shim with MOK (Machine Owned Key) functionality
• OpenSUSE* 12.3 release supports MOK manager and multisigned Shim loader
• SUSE SLES 11 SP3* - included multisigned Shim with MOK functionality and runtime Mokutil
• Linux Foundation Secure Boot System Released
• UEFI Technology Adopted by Linux Community†


Linux distro implementation with MOK 3rd party manager signing list implemented already
Additional Sources of Information

PDF of this presentation is available from our Technical Session Catalog: www.intel.com/idfsessionsSF. The URL is on top of Session Agenda Pages in Pocket Guide.

Visit the Unified EFI Forum for the latest specifications.

The EDK II project is hosted at http://tianocore.org.

Latest updates to SUSE* UEFI secure boot:
OpenSUSE tools UEFI:

http://download.opensuse.org/repositories/home:/jejb1:/UEFI/
http://build.opensuse.org/project/show/home:jejb1:UEFI

Related Articles/Whitepapers at tianocore.org:
• “A Tour Beyond BIOS into UEFI Secure Boot”
• Images with Multiple Signatures
## Other Sessions at IDF
**Wednesday, Sept 11, Moscone Room 2008**

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<th>ID</th>
<th>Title</th>
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<tr>
<td>STTS001</td>
<td>Creating UEFI Solutions Optimized for Mobile Devices</td>
<td>11:00</td>
</tr>
<tr>
<td>STTS002</td>
<td>UEFI Secure Boot in Linux*</td>
<td>13:00</td>
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<tr>
<td>STTS003</td>
<td>Using UEFI for Secure Firmware Update of Expansion Cards</td>
<td>14:15</td>
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<td>STTS004</td>
<td>Predicting Performance of Hadoop* and Data Center Clusters with Intel® CoFluent™ Studio</td>
<td>15:45</td>
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<tr>
<td>STTS005</td>
<td>Accelerating Software Development on Next Generation Intel® Architecture Microservers and Tablets with Wind River Simics*</td>
<td>17:00</td>
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See also
Technical Showcase Booths 408, 409, 410
“Intel® Device Protection Technology with Boot Guard - Secure Boot Policy Enforcement, booth #318”

✔️ = Done
Software Developers: Network & Have Fun!

Don’t miss out on some great IDF networking and social activities hosted by Intel Software & Services Group (SSG):

- **Day 1, Tuesday, Sept 10th, 7pm-10:30pm**
  - **Software Developer Networking Party**
    - Pick up your Software VIP lanyard at the Software and Services Pavilion Info Counter to get party access!

- **Day 2, Wednesday, Sept 11**
  - **SSG Inspiration Through Innovation Hour**
    - Location: Showcase Networking Plaza, 11am-12pm & 5pm-6pm
    - SSG/guests discuss how innovation has inspired their products
  - **Doug Fisher (Intel VP, GM SSG) Meet & Greet**
    - Software & Services Pavilion, 5-7pm

- Watch out for SSG Mobile lunch food and dessert carts outside Moscone throughout the conference
- Visit SSG Pavilion Showcase for great demos and games!
Additional Linux Resources

IDF 2012 – Developing UEFI Support for Linux*

For more information on Ubuntu* ...
Secure Boot Tools - git://kernel.ubuntu.com/jk/sbsigntool
https://github.com/vathpela/pesign

Summary of secure bootloaders
http://www.rodsbooks.com/efi-bootloaders/secureboot.html

Matthew Garrett http://mjg59.dreamwidth.org/
Shim https://github.com/mjg59/
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Winners will be announced by email

Sweepstakes rules are available at the Help Desk on Level 2
All sessions evaluations must be submitted by Friday, September 13 at 5pm
Q&A
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Backup
Authenticated Variables

**Authenticated Variables (AT):**
Small signed named data containers
- Managed, protected by the system BIOS
- Read by BIOS, OS.
- Modified by BIOS, OS only if signature verifies (or local user on Intel® Architecture platforms)

**Signed PE/COFF executables**
- Op ROMs
- Boot loaders
- Applications

**Authenticode signing format**

**PK: Platform Key:** AT containing OEM’s keys.
Party who can edit the KEK via s/w

**KEK: Key Exchange Key:** List of certificates of owners allowed to update white list (db), black list (dbx)

**db: Authorization Database:** AT containing authorized certs / hashes

**dbx: Exclusion Database:** AT containing excluded certs / hashes
The Full Solution

Signed Firmware Update 800-147

OS Secure Boot

UEFI Secure Boot

HDD

OS

Secure Boot

UEFI

OS Driver

OS Driver

OS Kernel

UEFI OS Loaders (SecondStageLoader.elf)

UEFI OROM

UEFI App

UEFI App

UEFI Driver

UEFI Driver

UEFI Driver

UEFI Boot Loaders

OSLoader1.elf

OSLoader2.elf

OSLoader3.elf

UEFI DXE Core / Dispatcher

Silicon initialization (SEC/PEI)

Hardware

I/O

Memory

Network

Graphics

End to end platform integrity