Firmware in the Data Center: Building a Modern Deployment Framework Using Unified Extensible Firmware Interface (UEFI) and Redfish REST APIs

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STTS001
Agenda

• Challenges of Firmware in the Data Center
• PXE and HTTP Boot
• UEFI Shell Scripting
• Data Center Manageability: Redfish and REST APIs
• Putting it all together: HP* ProLiant* Servers
• Summary and Q&A
Challenges of Firmware in the Data Center
Firmware Challenges in the Data Center

- Bare Metal Provisioning
- Deployment
- Firmware Updates
- Firmware Configuration
- Automation
- Security
- Scalability
- Ecosystem
The UEFI Solution

Bare Metal Provisioning
- Pre-Boot Networking
- IPv4, IPv6 TCP/UDP
- PXE, iSCSI, HTTP, FTP

Deployment
- Boot Device Selection
- Boot Order control
- OS install & recovery

Automation
- UEFI Shell
- Scripting language

Firmware Updates
- Firmware Management Protocol
- Capsule Updates

Firmware Configuration
- Human Interface Infrastructure (HII)
- Platform-To-Driver Config (CLP)
- REST Protocol

Scalability
- New Hardware abstraction with UEFI Protocols
- UEFI Driver model
- UEFI Device Path
The UEFI Solution

**Security**

- Secure Boot and Driver Signing
- Security technologies (OpenSSL*, RNG, etc...)
- Encrypted Disks and Key Management
- Interoperability with TCG standards

**Eco-system**

- Standards (UEFI Forum)
- Compliance: Self Certification Test (SCT), Linux* UEFI Validation (LUV)
- Open source code (EDK2 - [http://tianocore.org](http://tianocore.org))
- Ubiquitous vendor support (OEMs, ISVs, IHVs, OSVs)

**UEFI offers solutions to today's data center firmware challenges**
Data Center Manageability Interface Requirements

• **Use security best practices**
• **Support modern architectures**
  - Describe modern architectures (multi-node servers)
  - UEFI-aware (boot order selection, Secure Boot)
• **Scaling**
  - Scale-out servers usage model drastically different from traditional/enterprise servers
  - Management complexities grow exponentially
• **Interoperability for “OEM extensions”**

*Today’s Data Center Manageability Interfaces do not meet all of these needs*
PXE and HTTP Boot
PXE Boot Challenges

• Preboot eXecution Environment

• Security Issues
  - Only physical. No encryption or authentication.
  - Rouge DHCP servers, man-in-the-middle attacks

• Scaling issues
  - Circa 1998
  - TFTP timeouts / UDP packet loss
  - Download time = deployment time = $$$
  - Aggravated in density-optimized data centers

• OEMs and users workarounds
  - Chain-load 3rd party boot loaders (iPXE, mini-OS)

PXE is not keeping up with the modern data centers requirements
iPXE (http://ipxe.org)

• Open-source PXE client and bootloader
• Adds support of HTTP Boot, but currently:
  - Only works with Traditional BIOS
  - Only provides low-level SNP interface (no HTTP Boot) in UEFI
  - Users have to choose between HTTP Boot and UEFI Secure Boot

• iPXE UEFI vision
  • “Provide the same advanced features within the UEFI environment as are currently provided within the Traditional BIOS environment”
  - http://ipxe.org/efi/vision

Why not solve the PXE boot challenges natively in a standard way in UEFI?
Network Stack in UEFI v2.4

- IPv4 PXE
- IPv6 PXE
- Ping
- IfConfig
- Ping6
- IfConfig6
- DHCP4
- MTFTP4
- FTP4
- MTFTP6
- DHCP6
- IP4Config
- TCP4
- UDP4
- ARP
- IP4
- TCP6
- UDP6
- IP6
- IP6Config
- IPSec
- VLAN
- VLANConfig
- MNP
- SNP
- UNDI / NII
- EAP
Network Stack in UEFI v2.5

- Builds on top of UEFI 2.4
- DNS (IPv4 / IPv6)
- HTTP (IPv4 / IPv6)
- TLS (for HTTPs)
- HTTP Boot Wire Protocol
- Bluetooth® technology
- Wi-Fi®
UEFI Native HTTP Boot

HTTP Boot Wire Protocol

- Boot from a URL
- Target can be:
  1. EFI Network Boot Program (NBP)
  2. Shrink-wrapped ISO image
- URL pre-configured or auto-discovered (DHCP)

Addresses PXE issues

- HTTPs addresses security
- TCP reliability
- HTTP load balancing
HTTP Boot DHCP Discovery

- New HTTP Boot “Architectural Types” to distinguish from PXE
- Client sends DHCP Discover request
- DHCP Server responds with offer that includes the boot file URL
- Clients resolves URL server name from DNS
- Client downloads boot image from HTTP server using HTTP(s)
RAM Disk Standard

• UEFI 2.5 defined RAM Disk device path nodes
  - Standard access to a RAM Disk in UEFI
  - Supports Virtual Disk and Virtual CD (ISO image) in persistent or volatile memory

• ACPI 6.0 NVDIMM Firmware Interface Table (NFIT)
  - Describe the RAM Disks to the OS
  - Runtime access of the ISO boot image in memory

HTTP Boot is the emerging solution for modern data centers!

www.uefi.org
UEFI Shell Scripting
UEFI Shell

- UEFI Pre-boot command line interface (CLI)
  - Much like DOS* or Linux*/Unix* Shell environment
- Interactive prompt and scriptable
- Built-in commands
  - **Standard Commands:** File manipulations, driver management, device access, scripting control, system information, basic network operations
  - **Extensible:** OEMs can provide value-add commands
- Can be embedded as a boot option or bootable from storage
- Fully documented
  - Latest UEFI Shell Specification v2.1
UEFI Shell Standard Commands

**Scripting**
- echo, stall, set, shift, pause, parse, if / else / endif, for/endfor, reset, exit, cls
- **startup.nsh** auto-start script
- Parsable comma-separated output (-sfo)

**File Operations**
- dir cd, md, rd, mv, copy, del, type, edit, touch, attrib, setsize, comp, compress
- Read/Write files (FAT/FAT32)
- Console/file redirection and piping

**Debug and Test**
- **UEFI Drivers Debug**: load, unload, connect, disconnect, drivers, devices, devtree, dh, openinfo
- **System debug**: memmap, dmem, sbiosview, pci, dblk
Data Center Manageability: Redfish and REST APIs

- Firmware
- Configuration
- Scalability
- Security
Data Center Manageability Interface Requirements

- Use security best practices
- Support modern architectures
- Scaling
- Interoperability for “OEM extensions”

Today’s Data Center Manageability Interfaces do not meet all of these needs
What is Redfish?

• Architectural successor to previous manageability interfaces

• Industry Standard
  - DMTF* Scalable Platforms Management Forum (SPMF)
  - [www.dmtf.org/standards/redfish](http://www.dmtf.org/standards/redfish)
  - Specification, schema, mockup, whitepaper, FAQ, resource browser

• RESTful interface over HTTPs
  - JSON format
  - Secure (HTTPs)
  - Multi-node and aggregated rack-level servers capable
  - Schema-backed, human readable output
What is REST?

- **RE**presentational **S**tate **T**ransfer
- Scalable Software Architectural “style”
- Standardized operations (verbs)
  - HTTP GET, POST, PUT, and DELETE
  - Practical implementations add HTTP PATCH, HEAD
- Standardized operands (nouns)
  - Resources uniquely identified by URIs
- Stateless, atomic operations
  - No client/application context stored
What is JSON?

- Java Script Object Notation
- Lightweight data-interchange format
  - Easy for humans to read and edit
  - Easy for machines to parse and generate
- Much smaller grammar than XML
  - XML good for “documents”
  - JSON better for “data structures” used in programming languages
REST and JSON in WWW APIs

WWW Programmable APIs

- REST: 70%
- SOAP: 21%
- XML RPC: 3%
- Other: 1%
- JavaScript*: 5%

WWW APIs Data formats

- JSON: 54%
- XML: 46%

Source: http://www.programmableweb.com

REST and JSON: Simple Wins!
Redfish Data Model

- Root of service “/redfish/v1”
- Each resource has a type
  - Versioned schema
  - Meta-data
  - OEM extensions
- Collections to describe versatile server hardware architectures
  - Stand-alone
  - Multi-node
  - Rack-level aggregated
UEFI REST Protocol

- New in UEFI v2.5
- Standard pre-boot in-band access to a RESTful API, like Redfish
- Abstracts BMC-specific access methods (proprietary)
Putting it all together: HP* ProLiant* Servers
UEFI Deployment Solution on HP* ProLiant* Servers

• **UEFI Network Stack Extensions**
  - HTTP, FTP, DNS
  - “Boot from URL” to EFI file or ISO image
  - UEFI iSCSI Software Initiator

• **HP RESTful API**
  - Accessible in-band (from OS) or out-of-band (iLO4* HTTPS). Redfish conformance soon.
  - HP* OEM extensions including support for UEFI BIOS configuration

• **Embedded UEFI Shell**
  - Built into the system firmware
  - HP value-add commands for bare-metal deployment
  - Startup script loading from media or network location
UEFI Deployment Solution on HP* ProLiant* Servers

HP* ProLiant* Gen9 Servers with UEFI Network Deployment

HP Embedded UEFI Shell

RAM Disk
Tools & Scripts
UEFI Shell startup script

RAM Disk
RAM Disk

Boot ISO

Tools & Scripts

Deployment Assets
Boot ISO
UEFI Shell startup script

In-band RESTful API

Console and Virtual Media
(USB, Keyboard, Mouse)

Out-of-band RESTful API
(HTTPs)

HTTPs

HTTP

FTP

User Interface

Management Network

Management Clients
(Remote Console, RESTful tools, etc...)

API

iLO4*

Tools & Scripts

Management Network

UEFI network stack

LAN / WAN / Cloud

HTTP Server
HTTP Server
FTP Server

Management Clients
(Remote Console, RESTful tools, etc...)

Deployment Assets
Boot ISO
UEFI Shell startup script

Out-of-band RESTful API
(HTTPs)
Embedded UEFI Shell HP* Commands

• **HP* value-add commands for bare-metal deployment**

  • **ramdisk**: Provision memory disks and mount ISO files
  • **webclient** and **ftp**: Scriptable network download/upload
  • **restclient**: In-band client for the HP RESTful API
  • **sysconfig**: Configuration CLI (integrates with HP* RESTful API)
  • **secboot**: Secure Boot management (physical presence)
  • **boot**: Transition to OS/boot targets without rebooting
  • **sysinfo**: System hardware/firmware inventory
  • **fwupdate**: Firmware updates
  • **compress**: ZIP/UNZIP archives
  • **ifconfig**: UEFI network stack configuration
  • Commands to collect server service/troubleshooting logs
HP* RESTful API

• HP* RESTful API in iLO4*
  - Modern management API for HP ProLiant* and Moonshot servers
  - Comprehensive inventory and server configuration

• Integrated with UEFI
  - UEFI BIOS settings configuration
  - UEFI Boot Order and Secure Boot configuration
  - UEFI iSCSI Software Initiator configuration
HP* RESTful API Example: UEFI BIOS Settings

GET @ /rest/v1/systems/1/bios

- Get a list of all UEFI BIOS settings (name/values)
HP* RESTful API Example: Secure Boot

GET @ /rest/v1/systems/1/secureboot

- Enable/Disable Secure Boot
- Reset all Secure Boot variables to defaults
- Clear all keys (Setup Mode)

```json
{
    "Name": "SecureBoot",
    "ResetAllKeys": false,
    "ResetToDefaultKeys": false,
    "SecureBootCurrentState": false,
    "SecureBootEnable": false,
    "Type": "HpSecureBoot.0.9.5"
}
```
# Login to iLO
hprest login https://clientilo.domain.com -u username -p password

# Configure UEFI network settings (Use Auto and DHCP defaults)
hprest set PreBootNetwork=Auto --selector HpBios.
hprest set Dhcpv4=Enabled

# Configure UEFI Shell startup script from URL
hprest set UefiShellStartup=Enabled
hprest set UefiShellStartupLocation=NetworkLocation
hprest set UefiShellStartupUrl=http://192.168.1.1/deploy/startup.nsh

# Set one-time-boot to Embedded UEFI Shell
hprest set Boot/BootSourceOverrideEnabled=Once --selector ComputerSystem.
hprest set Boot/BootSourceOverrideTarget=UefiShell

# Save and reboot server
hprest commit --reboot=ON
Sample UEFI Shell Deployment Script (startup)

# Create FAT32 RAM Disk
ramdisk -c -s 512 -v MYRAMDISK -t F32
FS0:

# Download provisioning OS files from HTTP to RAM Disk
webclient -g http://repo.hp.com/deploy/efilinux.efi
webclient -g http://repo.hp.com/deploy/deploy.kernel
webclient -g http://repo.hp.com/deploy/deploy.ramdisk

# Start provisioning OS
efilinux.efi -f deploy.kernel initrd=deploy.ramdisk
Summary and Q&A
Summary and Next Steps

• UEFI 2.5 HTTP Boot bridges the gaps of network boot in the data center
• Redfish is emerging RESTful management API to address modern data center requirements
• HP* ProLiant* Servers showcase of a bare-metal UEFI deployment solution using HTTP Boot, Embedded UEFI Shell, and RESTful APIs

Next Steps:
• Adopt UEFI 2.5 implementations with HTTP Boot (now on open source)
• Adopt Redfish implementations in servers and management software
• Transition data centers to use HTTP Boot and Redfish REST APIs
Additional Sources of Information

• A PDF of this presentation is available from our Technical Session Catalog: www.intel.com/idfsessionsSF. This URL is also printed on the top of Session Agenda Pages in the Pocket Guide.

• More web based info:
  - UEFI Forum Learning Center: http://uefi.org/learning_center
  - UEFI 2.5 and ACPI 6.0 Specifications: http://www.uefi.org/specs/
  - Redfish Specification: http://www.dmtf.org/standards/redfish
  - UEFI on HP* ProLiant* Servers: http://hp.com/go/proliant/uefi
  - Open source UEFI EDK II Tianocore.org
  - HTTP Boot in the news
Other Technical Sessions

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✓ = DONE

See also:

- Technical Showcase Booths #763 (Redfish demo), #511 (Intel UEFI)
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Backup
JSON Grammar

Source: http://www.json.org