CHIPSEC

Platform Security Assessment Framework

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Contents

1 Description

CHIPSEC is a framework for analyzing security of PC platforms including hardware, system firmware including BIOS/UEFI and the configuration of platform components. It allows creating security test suite, security assessment tools for various low level components and interfaces as well as forensic capabilities for firmware.

CHIPSEC can run on any of these environments:

1. Windows (client and server)
2. Linux
3. UEFI Shell

2 Installation

CHIPSEC supports Windows, Linux, and UEFI shell. Circumstances surrounding the target platform may change which of these environments is most appropriate. When running CHIPSEC as part of a corporate IT management infrastructure, Windows may be preferred. However, sometimes it may be preferable to assess the platform security without interfering with the normal operating system. In these instances, CHIPSEC may be run from a bootable USB thumb drive - either a Live Linux image or a UEFI shell.

2.1 Windows Installation

Supports the following client versions:

- Windows 8 x86 and AMD64
- Windows 7 x86 and AMD64
- Windows XP (support discontinued)

Supports the following server versions:

- Windows Server 2012 x86 and AMD64
- Windows Server 2008 x86 and AMD64

1. Install Python (http://www.python.org/download/)

   - Tested on 2.7.x and Python 2.6.x

   - E.g. Python 2.7.6 (http://www.python.org/download/releases/2.7.6/)

2. Install additional packages for installed Python release (in any order)

   - (REQUIRED) pywin32: for Windows API support (http://sourceforge.net/projects/pywin32/)

   - (OPTIONAL) WConio : if you need colored console output
(http://newcenturycomputers.net/projects/wconio.html)

   - (OPTIONAL) py2exe : if you need to build chipsec executables (http://www.py2exe.org/)

   Note: packages have to match Python platform (e.g. AMD64 package on Python AMD64)

3. Turn off kernel driver signature checks

Windows 8 64-bit (with Secure Boot enabled) / Windows Server 2012 64-bit (with Secure Boot enabled):

- In CMD shell: shutdown /r /t 0 /o
- Navigate: Troubleshooting > Advanced Settings > Startup Options > Reboot
- After reset choose F7 "Disable driver signature checks"

OR

- Disable Secure Boot in the BIOS setup screen then disable driver signature checks as in Windows 8 with Secure Boot disabled

Windows 7 64-bit (AMD64) / Windows Server 2008 64-bit (AMD64) / Windows 8 (with Secure Boot disabled) / Windows Server 2012 (with Secure Boot disabled)):

- Boot in Test mode (allows self-signed certificates)

  * Start CMD.EXE as Adminstrator

```
* BcdEdit /set TESTSIGNING ON
```

  * Reboot

  If doesn't work, run these additional commands:

```
* BcdEdit /set noIntegrityChecks ON
* BcdEdit /set loadoptions DDISABLE_INTEGRITY_CHECKS
```

OR

- Press F8 when booting Windows and choose "No driver signatures enforcement" option to turn off driver signature checks at all

4. N otes on loading chipsec kernel driver:

- On Windows 7, launch CMD.EXE as Administrator
- CHIPSEC will attempt to automatically register and start its service (load driver) or call existing if it's already started.

- (OPTIONAL) You can manually register and start the service/driver. Follow below instructions before running CHIPSEC, then run it with "--exists" command-line option. CHIPSEC will not attempt to start the driver but will call already running driver.

* To start the service (in cmd.exe)

```
        sc create chipsec binpath=<PATH_TO_CHIPSEC_SYS> type= kernel
DisplayName="Chipsec driver"

        sc start chipsec
```

* Then to stop/delete service:

```
        sc stop chipsec

        sc delete chipsec
```

2.2 UEFI Shell

A zipped image of a USB stick that has been prepared according to the below instructions is available in `__install__/UEFI/duet.img.zip`. A USB stick, imaged from this file, can be used after CHIPSEC is copied to it.

2.2.1 Building bootable USB thumb drive with UEFI Shell

If you don't have bootable USB thumb drive with UEFI Shell yet, you need to build it:

1. Download UDK from Tianocore http://sourceforge.net/apps/mediawiki/tianocore/index.php?title=UDK2010 (Tested with UDK2010.SR1)

2. Follow instructions in `DuetPkg/ReadMe.txt` to create a bootable USB thumb drive with UEFI Shell (DUET)

2.2.2 Installing CHIPSEC on bootable thumb drive with UEFI shell

1. Extract contents of __install__/UEFI/chipsec_uefi_x64.zip to the DUET USB drive

   - This will create /efi/Tools directory with Python.efi and /efi/StdLib with subdirectories

2. Copy contents of CHIPSEC (source/tool) to the DUET USB drive

The contents of your thumb drive should look like follows:

```
\
        EFI\
                Boot\
                        Boot64.efi
                StdLib\
                        Python.27\
                                [lots of python files and directories]
                Tools\
                        Python.efi
        Chipsec\
                Source\
```

3. Reboot to the USB drive (this will load UEFI shell)

4. Run CHIPSEC in UEFI shell

```
fs0:

cd source/tool

python chipsec_main.py (or python chipsec_util.py)
```

2.2.3 Extending CHIPSEC functionality for UEFI

You don't need to read this section if you don't plan on extending native UEFI functionality for CHIPSEC. Native functions accessing HW resources are built directly into Python UEFI port in built-in edk2 module.

If you want to add more native functionality to Python UEFI port for chipsec, you'll need to re-build Python for UEFI:

1. Check out AppPkg with Python 2.7.2 port for UEFI from SVN

  http://edk2.svn.sourceforge.net/svnroot/edk2/trunk/edk2

  - You'll also need to check out StdLib and StdLibPrivateInternalFiles packages from SVN

  - Alternatively download latest EADK (EDK II Application Development Kit) from

    http://sourceforge.net/apps/mediawiki/tianocore/index.php?title=EDKII_EADK

EADK includes AppPkg/StdLib/StdLibPrivateInternalFiles. Unfortunately, EADK Alpha 2 doesn't have Python 2.7.2 port so you'll need to check it out SVN

2. Add functionality to Python port for UEFI

- Python 2.7.2 port for UEFI is in <UDK>\AppPkg\Applications\Python

- All chipsec related functions are in <UDK>\AppPkg\Applications\Python\Efi\edk2module.c "#ifdef CHIPSEC"

Asm functions are in <UDK>\AppPkg\Applications\Python\Efi\cpu.asm

- e.g. <UDK> is C:\UDK2010.SR1

- Add cpu.asm under the Efi section in PythonCore.inf

3. Build <UDK>/AppPkg with Python

- Read instructions in <UDK>\AppPkg\ReadMe.txt and <UDK>\AppPkg\Applications\Python\PythonReadMe.txt

- Binaries of AppPkg and Python will be in <UDK>\Build\AppPkg\DEBUG_MYTOOLS\X64\

4. Create directories and copy Python files on DUET USB drive

- Do not use Python binaries from python_uefi.7z, copy newly generated

- Read instructions in <UDK>\AppPkg\Applications\Python\PythonReadMe.txt

2.3 Linux Installation

Tested on:

- Linux 3.2.6 x32 (Mint/Ubuntu)
- Linux 2.6.32 x32 (Ubuntu)
- Fedora 20 LXDE 64bit

2.3.1 Creating a Live Linux image with CHIPSEC:

1. Download things you will need

a. Download chipsec

b. liveusb-creator: https://fedorahosted.org/liveusb-creator/

c. desired Linux image (e.g. 64bit Fedora 20 LXDE)

2. Use liveusb-creator to image a USB stick with the desired linux image. Include as much persistent storage as possible.

3. Reboot to USB

4. Update and install necessary packages

```
#> yum install kernel kernel-devel python python-devel gcc
```

5. Copy chipsec to the USB stick

Installing CHIPSEC:

6. Build Linux driver for CHIPSEC

```
cd source/drivers/linux

make
```

7. Load CHIPSEC driver in running system

```
cd source/drivers/linux

(Optional) chmod 755 run.sh

sudo ./run.sh or sudo make install
```

8. Run CHIPSEC

```
cd source/tool

sudo python chipsec_main.py (or sudo python chipsec_util.py)
```

9. Remove CHIPSEC driver after using

```
sudo make uninstall
```

3 Usage

CHIPSEC should be launched as Administrator/root.

- In command shell, run chipsec_main.py

```
# python chipsec_main.py --help
```

```
USAGE: chipsec_main.py [options]
OPTIONS:
-m --module             specify module to run (example: -m common.bios)
-a --module_args        additional module arguments, format is 'arg0,arg1..'
-v --verbose            verbose mode
-l --log                output to log file

ADVANCED OPTIONS:
-p --platform           explicitly specify platform code. Should be among the
supported platforms:
                        [ SNB | IVB | JKT | BYT | IVT | HSW ]
-n --no_driver          chipsec won't need kernel mode functions so don't load chipsec
driver
-i --ignore_platform    run chipsec even if the platform is not recognized
-e --exists             chipsec service has already been manually installed and
started (driver loaded).
-x --xml                specify filename for xml output (JUnit style).
-t --moduletype         run tests of a specific type (tag).
   --list_tags          list all the available options for -t,--moduletype
-I --import             specify additional path to load modules from.

  Use "--no-driver" command-line option if the module you are executing does not
require loading kernel mode driver
  Chipsec won't load/unload the driver and won't try to access existing driver

  Use "--exists" command-line option if you manually installed and start chipsec
driver (see "install_readme" file).
  Otherwise chipsec will automatically attempt to create and start its service (load
driver)or open existing service if it's already started
```

- you can also use CHIPSEC to access various hardware resources:

```
# python chipsec_util.py help
```

3.1 Using CHIPSEC as a Python Package

The directory should contain the file `setup.py`. Install CHIPSEC into your system's site-packages directory:

```
# python setup.py install
```

3.2 Compiling CHIPSEC Executables on Windows

Directories "bin/<platform>" should already contain compiled CHIPSEC binaries:

```
  "chipsec_main.exe", "chipsec_util.exe"
- To run all security tests run "chipsec_main.exe" from "bin"
directory:
  # chipsec_main.exe
- To access hardware resources run "chipsec_util.exe" from "bin"
directory:
  # chipsec_util.exe
```

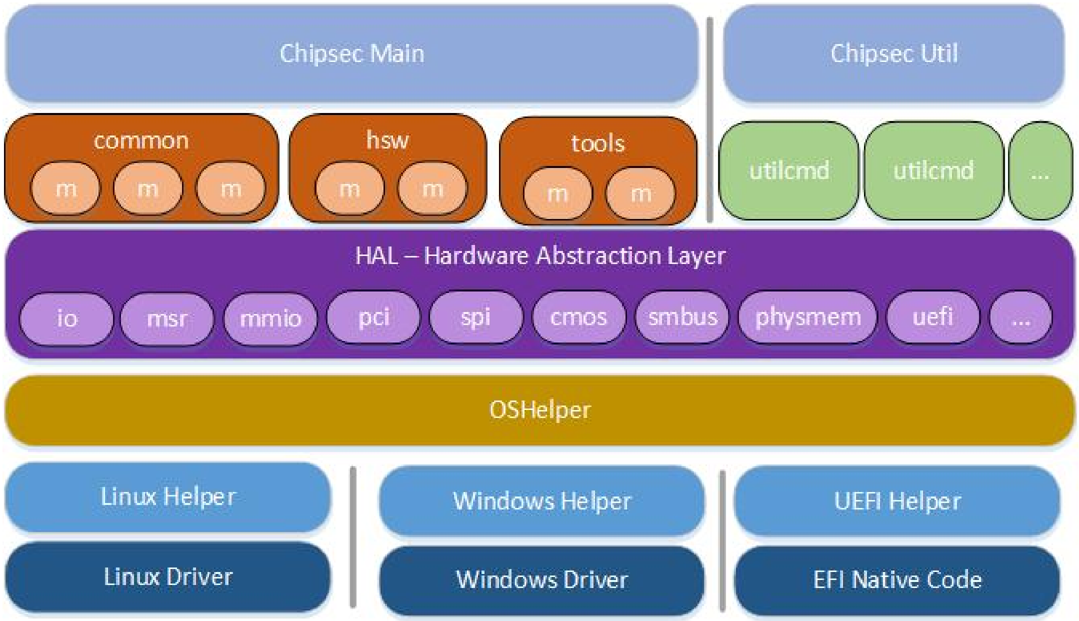
If directory "bin" doesn't exist, then you can compile CHIPSEC executables:

- Install "py2exe" package from http://www.py2exe.org
- From the build directory run "build_exe_<platform>.py" as follows:

```
  # python build_exe_<platform>.py py2exe
```

- chipsec_main.exe, chipsec_util.exe executables and required libraries will be created in "bin/<platform>" directory

4 CHIPSEC Components and Structure



4.1 Core components

```
chipsec_main.py                  - main application logic and
automation functions
chipsec_util.py                  - utility functions (access to
various hardware resources)
chipsec/chipset.py              - chipset detection
chipsec/logger.py               - logging functions
chipsec/file.py                 - reading from/writing to files
chipsec/module_common.py        - common include file for modules
chipsec/helper/oshelper.py      - OS helper: wrapper around platform
specific code that invokes kernel driver
chipsec/helper/xmlout.py        - support for JUnit compatible XML
output (-x command-line option)
```

4.2 HW Abstraction Layer (HAL)

```
chipsec/hal/                    - components responsible for access
to hardware (Hardware Abstraction Layer):

chipsec/hal/pci.py              - Access to PCIe config space
chipsec/hal/pcidb.py            - Database of PCIe vendor and device
IDs
chipsec/hal/physmem.py          - Access to physical memory
chipsec/hal/msr.py              - Access to CPU resources (for each
CPU thread): Model Specific Registers (MSR), IDT/GDT
chipsec/hal/mmio.py             - Access to MMIO (Memory Mapped IO)
BARs and Memory-Mapped PCI Configuration Space (MMCFG)
chipsec/hal/spi.py              - Access to SPI Flash parts
```

```
chipsec/hal/ucode.py              - Microcode update specific
functionality (for each CPU thread)
chipsec/hal/io.py                 - Access to Port I/O Space
chipsec/hal/smbus.py              - Access to SMBus Controller in the
PCH
chipsec/hal/uefi.py               - Main UEFI component using platform
specific and common UEFI functionality
chipsec/hal/uefi_common.py        - Common UEFI functionality (EFI
variables, db/dbx decode, etc.)
chipsec/hal/uefi_platform.py      - Platform specific UEFI
functionality (parsing platform specific EFI NVRAM, capsules, etc.)
chipsec/hal/interrupts.py         - CPU Interrupts specific functions
(SMI, NMI)
chipsec/hal/cmos.py               - CMOS memory specific functions
(dump, read/write)
chipsec/hal/cpuid.py              - CPUID information
chipsec/hal/spi_descriptor.py     - SPI Flash Descriptor binary
parsing functionality
```

4.3 OS/Environment Helpers

```
chipsec/helper/win/               - Windows helper
chipsec/helper/linux/             - Linux helper
chipsec/helper/efi/               - UEFI/EFI shell helper
```

4.4 Platform Configuration

```
chipsec/cfg/                      - platform specific configuration
includes

chipsec/cfg/common.py             - common configuration
chipsec/cfg/<platform>.py         - configuration for a specific
<platform>
```

4.5 CHIPSEC utility command-line scripts

```
chipsec/utilcmd/                  - command-line extensions for
chipsec_util.py

chipsec/utilcmd/<command>_cmd.py  - implements "chipsec_util
<command>" command-line extension
```

4.6 CHIPSEC modules (security tests, tools)

```
chipsec/modules/                            - modules including tests
or tools (that's where most of the chipsec functionality is)

chipsec/modules/common/                     - modules common to all
platforms
```

```
chipsec/modules/<platform_code>/            - modules specific to
<platform_code> platform

chipsec/modules/tools/                      - security tools based on
CHIPSEC framework (fuzzers, etc.)
```

4.7 Auxiliary components

```
bist.cmd                                    - built-in self test for
various basic HW functionality to make sure it's not broken
setup.py                                    - setup script to install
CHIPSEC as a package
```

4.8 Executable build scripts

```
<CHIPSEC_ROOT>/build/build_exe_*.py         - make files to build
Windows executables
```

5 CHIPSEC Extension Modules and API

In the most basic sense, a platform module is just a python script with a top-level function called check_all(). These modules are stored under the chipsec installation directory in a subdirectory "modules". The "modules" directory contains one subdirectory for each chipset that chipsec supports. Internally the chipsec application uses the concept of a module name, which is a string of the form:

```
common.bios_wp
```

This means module `common.bios_wp` is a python script called `bios_wp.py` that is stored at <ROOT_DIR>\chipsec\modules\common\.

5.1 Existing Modules

Each published module can be mapped to a publication that details the issue being checked. The mapping is provided below.

Chipsec Module	Publication
Modules/common/ bios_ts.py	"BIOS Boot Hijacking and VMware Vulnerabilities Digging" - Sun Bing
Modules/common/ bios_kbrd_buffer.py	DEFCON 16: "Bypassing Pre-boot Authentication Passwords by Instrumenting the BIOS Keyboard Buffer" – Jonathan Brossard
Modules/common/ bios_wp.py	Black Hat USA 2013 "BIOS Security" – MITRE (Kovah, Butterworth, Kallenberg) NoSuchCon 2013 "BIOS Chronomancy: Fixing the Static Root of Trust for Measurement" – MITRE (Kovah, Butterworth, Kallenberg)
	Parsing of SPI descriptor access permissions is implemented in "ich_descriptors_tool" which is part of open source flashrom.
Modules/common/ smm.py	CanSecWest 2006 "Security Issues Related to Pentium System Management Mode" – Duflot
Modules/common/ smrr.py	"Attacking SMM Memory via Intel CPU Cache Poisoning" – ITL (Rutkowska, Wojtczuk) "Getting into the SMRAM: SMM Reloaded" – Duflot, Levillain, Morin, Grumelard
Modules/common/ spi_lock.py	FLOCKDN is in flashrom and MITRE's Copernicus
Modules/common/secure boot/keys.py	UEFI 2.4 spec
Modules/common/secure boot/variables.py	UEFI 2.4 spec

5.2 Writing Your Own Modules (security modules)

Implement a function called `run()` in your module.

- Use other chipsec components for support
- See 'CHIPSEC Components/API' section

Copy your module into the `chipsec/modules/` directory structure

- Modules specific to certain chipset should be in `chipsec/modules/<chipset_code>` directory
- Modules common to all supported chipsets should be in `chipsec/modules/common` directory

If a new chipset needs to be added:

- Create directory for the new chipset in `chipsec/modules`
- Create empty `__init__.py` in new directory
- Modify `chipsec/chipset.py` to include detection for the chipset you are adding

5.3 Using CHIPSEC in a Python Shell

The chipsec.app component can also be run from a python interactive shell or used in other python scripts. The chipsec.app module contains application logic in the form of a set of python functions for this purpose:

`run_module('module_path')`
Immediately calls module.check_all() and returns. Does not affect internal loaded modules list.

`load_module('module_path')`
Loads a module into the internal module list for batch processing

`unload_module('module_path')`
Unloads a module from the internal module list

`load_my_modules()`
Loads all modules from "modules\common" and (if the current chipset is recognized) `modules\<chipset_code>` into an internal list for batch processing.

`un_loaded_modules()`
Calls the check_all() function from every module in the internal loaded modules list

`clear_loaded_modules()`
Empties the internal loaded module list

`run_all_checks()`

Calls `load_my_modules()` followed by `run_loaded_modules()`. This function executes all existing security checks for a given chipset/platform. Calling this function in Python shell is equivalent to executing standalone `chipsec_main.py` or `chipsec_main.exe`.

```
Example:
>>> import chipsec_main
>>> chipsec_main._cs.init(True) # if chipsec driver is not running
>>> chipsec_main.load_module('chipsec/modules/common/bios_wp.py')
>>> chipsec_main.run_loaded_modules()
```

6 CHIPSEC Utilities

CHIPSEC utilities provide the capability for manual testing and direct hardware access.

WARNING: DIRECT HARDWARE ACCESS PROVIDED BY THESE UTILITIS COULD MAKE YOUR SYSTEM UNBOOTABLE. MAKE SURE YOU KNOW WHAT YOU ARE DOING!

NOTE: All numeric values are in hex.

6.1 Accessing and Parsing the Contents of SPI Flash

CHIPSEC includes functionality for reading and writing the SPI flash. When an image file is created from reading the

SPI flash, this image can be parsed to reveal sections, files, variables, etc.

6.1.1 Accessing SPI Flash

The spi utility command provides access to read, write, and erase the SPI flash.

```
chipsec_util spi info|dump|read|write|erase [flash_address] [length]
[file]
```

Examples:

```
chipsec_util spi info

chipsec_util spi dump rom.bin

chipsec_util spi read 0x700000 0x100000 bios.bin

chipsec_util spi write 0x0 flash_descriptor.bin

chipsec_util spi erase 0x7FFFF0
```

WARNING: Particular care must be taken when using the spi write and spi erase functions. These could make your system unbootable.

A basic forensic operation might be to dump the entire SPI flash to a file. This is accomplished as follows:

```
# python chipsec_util.py spi dump rom.bin
```

The file `rom.bin` will contain the full binary of the SPI flash. It can then be parsed using the decode util command below.

6.1.2 Parsing the SPI Flash

CHIPSEC can parse an image file containing data from the SPI flash (such as the result of `chipsec_util spi dump`). This can be critical in forensic analysis.

`chipsec_util decode <rom> [fw_type]`

`<fw_type>` should be in `[ evsa | nvar | uefi | vss | vss_new ]`

Examples:

`chipsec_util decode spi.bin vss`

This will create multiple log files, binaries, and directories that correspond to the sections, firmware volumes, files, variables, etc. stored in the SPI flash.

NOTE: It may be necessary to try various options for fw_type in order to correctly parse NVRAM variables. Currently, CHIPSEC does not autodetect the correct format. If the nvram directory does not appear and the list of nvram variables is empty, try again with another type.

6.2 Accessing Memory Mapped PCI Configuration Space

The `mmcfg` command allows direct access to memory mapped config space.

`chipsec_util mmcfg <bus> <device> <function> <offset> <width> [value]`

Examples:

```
chipsec_util mmcfg 0 0 0 0x88 4

chipsec_util mmcfg 0 0 0 0x88 byte 0x1A

chipsec_util mmcfg 0 0x1F 0 0xDC 1 0x1

chipsec_util mmcfg 0 0 0 0x98 dword 0x004E0040
```

6.3 Accessing PCI Configuration Space

The `pci` command can enumerate PCI devices and allow direct access to them by bus/device/function.

```
chipsec_util pci enumerate

chipsec_util pci <bus> <device> <function> <offset> <width> [value]
```

Examples:

```
chipsec_util pci enumerate

chipsec_util pci 0 0 0 0x88 4

chipsec_util pci 0 0 0 0x88 byte 0x1A

chipsec_util pci 0 0x1F 0 0xDC 1 0x1

chipsec_util pci 0 0 0 0x98 dword 0x004E0040
```

6.4 UEFI Variable Access

The uefi command provides access to UEFI variables, both on the live system and in a SPI flash image file.

```
chipsec_util uefi var-list

chipsec_util uefi var-read|var-write <name> <GUID> <efi_variable_file>

chipsec_util uefi nvram[-auth] <fw_type> [rom_file]
```

<fw_type> should be in [evsa | nvar | uefi | vss | vss_new]

```
chipsec_util uefi keys <keyvar_file>
```

<keyvar_file> should be one of the following EFI variables

[SecureBoot | SetupMode | CustomMode | PK | KEK | db | dbx]

Examples:

```
chipsec_util uefi var-list

chipsec_util uefi var-read db D719B2CB-3D3A-4596-A3BC-DAD00E67656F db.bin

chipsec_util uefi var-write db D719B2CB-3D3A-4596-A3BC-DAD00E67656F db.bin

chipsec_util uefi nvram vss bios.rom

chipsec_util uefi nvram-auth vss

chipsec_util uefi decode uefi.bin fwtype

chipsec_util uefi keys db.bin
```

6.5 Access to I/O Port Space

The `io` command allows direct access to read and write I/O port space.

```
chipsec_util io <io_port> <width> [value]
```

Examples:

```
chipsec_util io 0x61 1
chipsec_util io 0x430 byte 0x0
```

6.6 Access to MSRs

The `msr` command allows direct access to read and write MSRs.

```
chipsec_util msr <msr> [eax] [edx] [cpu_id]
```

Examples:

```
chipsec_util msr 0x3A
chipsec_util msr 0x8B 0x0 0x0 0
```

6.7 Access to Physical Memory

The `mem` command provides direct access to read and write physical memory.

```
chipsec_util mem <phys_addr_hi> <phys_addr_lo> <length> [value]
```

Examples:

```
chipsec_util mem 0x0 0x41E 0x20
chipsec_util mem 0x0 0xA0000 4 0x9090CCCC
chipsec_util mem 0x0 0xFED40000 0x4
```

6.8 Access Operating System IDT and GDT

The `idt` and `gdt` commands print the IDT and GDT, respectively.

```
chipsec_util idt|gdt|ldt [cpu_id]
```

Examples:

```
chipsec_util idt 0
chipsec_util gdt
```