# Simics Cheatsheet

## 1 Simics Usage (command line)

### Glossary & Documentation

| | |
|---|---|
| *Simics Base* | `simics` executable + the set of supporting shared libraries (DLLs) + tools |
| *simulation* | running of code (target) on a model/platform (target) with advancement of time |
| *host* | a computer where simulation runs |
| *target* | a simulated code running in its isolated memory region, e.g. Linux or Windows guest |
| *platform* | a complete runnable model: full set-up of devices with CPU or with at least a clock provider |
| *package* | a set of devices, oftentimes constituting 1 platform, distributed as a whole in an archive and unpacked into 1 directory |
| *[Simics] Script* | simple Unix-shell-like language (a wrapper over Python) used for connecting devices and command line automation |
| *Simics User's Guide* | documentation on **Simics** usage — both command line and Eclipse |

Below **$** stands for Unix shell prompt, **>** for **Simics** prompt. *Big_italic* text means user-supplied arguments for commands/functions.

### Getting help

```
# Get help on some command:
> help instantiate-components
# Finding sections of documentation mentioning it:
> apropos instantiate-components
```

### Set up a workspace with platform package

```
$ path/to/simics-base/bin/project-setup .
$ bin/addon-manager -c # remove default package associations
# allow scripts & shared libraries be found:
$ bin/addon-manager -s /path/to/platform-package
$ bin/addon-manager -s /path/to/additional/package
```

### Start up

```
$ ./simics targets/platf/platf.simics
```

Shell command line arguments ⟶ **Simics** command line correspondence:

```
$ ./simics start.simics
```

⟶

```
$ ./simics
> run-command-file start.simics
```

```
$ ./simics script.py
```

⟶

```
$ ./simics
> run-python-file script.py
```

```
$ ./simics -e '$config_variable1=value; $config_var2=value' start.simics
# ⚠ NOT ./simics start.simics -e $varibables ...
```

⟶

```
$ ./simics
> $config_variable=value
> $config_var2=value
> run-command-file start.simics
```

### Environment & Packages

```
> version # list of installed packages
$ ./simics -v # the same
> pwd # current directory where simics is running
> list-directories # where Simics searches files
```

To debug chain of called auxiliary scripts `include`s:

```
$ ./simics -script-trace targets/platf/platf.simics
```

### Commands for running simulation

```
> c[ontinue]
> r[un] 100 cycles # or 10 steps or 0.1 seconds
> ptime [-all] # to show target's time
```

### Printing device structure

To find devices by name/class or interface name:

```
> list-objects -all name # searches also for the class
> list-objects -all substr = mem # object names containing mem
> list-objects -all iface = my_interface # by interface name
```

To examine device structure (**Simics** *components* and *devices*) of a given component *myPlatform*:

```
# 1-level representation: immediate children myPlatform:
> list-objects namespace = myPlatform
# multi-level one: all children of myPlatform with all hierarchy:
> list-objects namespace = myPlatform -tree
```

To find all objects with the same class as given device:

```
> platf.myDevice->classname
my_class
> list-objects -all my_class
> list-objects -all class = my_class
```

### Registers

```
# print all registers:
> print-device-regs platf.myDevice
# print fields of register myRegister:
> print-device-reg-info platf.myDevice.myBank.myRegister
```

### Writing/reading with side effects

```
> write-device-reg
    platf.myDev.bank.myBank.myGrp.myReg 0x1
# (Register groups like myGrp may be omitted in devices)
> read-device-reg platf.myDev.bank.myBank.myGrp.myReg
```

### Writing/reading **without** side effects (aka set/get)

It's done through attributes:

```
# To set to value 0x1
platf.myDev->myBank_myGrp_myReg = 0x1
# To get the value:
platf.myDev->myBank_myGrp_myReg
```

### Connects — attributes that point to other devices

```
# to set connect attribute:
> platf.myDevice->myConnect = "platf.anotherDevice"
# to zero connect attribute:
> platf.myDevice->myConnect = FALSE # obvious ;-)
```

### Device information: static

```
# To find info about class/module/package for your device:
> help platf.myDev
  Class myClass
  Provided By
    myModule (from myPackage)
  # ...then documentation about the device is printed.
# To list all classes provided by a module:
> list-classes -m myModule
# Configuration information
> platf.myDev.info
```

### Device information: dynamic

```
# Runtime information:
> platf.myDev.status
# pretty-print device attributes with values:
> list-attributes platf.myDev
# to search all attributes/registers containing mem:
list-attributes platf.myDevice substr = mem
```

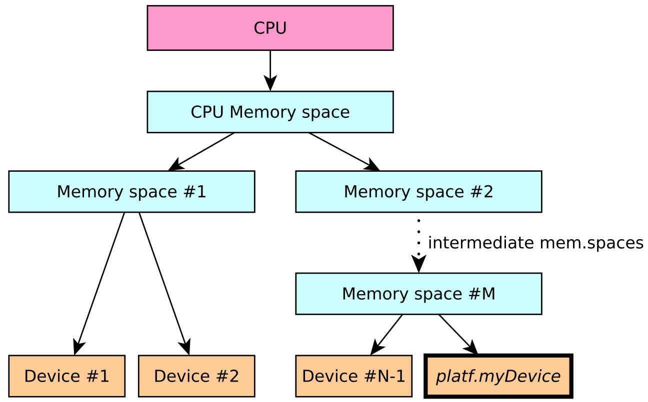
### Debugger commands

To use **Simics** to debug target:

```
dis[assemble] # show assembler commands at current address
# Break points:
break address
break-hap Core-Magic-Instruction
```

### Memory spaces

All target software runs on CPU and can access devices only through hierarchy of memory spaces:




```
# To find memory spaces the device is mapped in:
> devs platf.myDevice
```

### Examining current state

| | |
|---|---|
| pselect | show currently running CPU |
| memory-map | print all mapped devices |
| pregs | print all CPU registers |
| probe-address *addr* | path to target *addr* |

#### x86-specific and platform-specific commands

| | |
|---|---|
| memory-trace *addr* | path to target *addr* |
| pregs | to know x86 mode (16/32/64-bit), 1st line |
| reset-button-press | to reboot the target |
| power-button-press | to press power button |

#### Moving files target ⟷ host

```
> start-simicsfs-server
```

```
target$ mkdir a
target$ simicsfs-client a
```

#### Saving info

Save logs from current point

```
> start-command-line-capture filename
```

Save simics variables to file

```
> start-command-line-capture filename
> list-variables
> stop-command-line-capture
```

#### Check points

| | |
|---|---|
| write-configuration *"checkpoint_name"* | — save checkpoint |
| read-configuration *"checkpoint_name"* | — restore it back |

#### Miscellaneous

```
# To dump network packages (for analysis with Wireshark):
> pcap-dump link=ethernet_switch0 filename=myFile
```

```
# Treat all input as Python code
> python-mode
> > > Enter your code
```

## 2 Simics DML 1.4 Programming & C/DML API

#### Glossary & Documentation

| | |
|---|---|
| *DML* | Device Modelling Language is a wrapper over C for writing (fast) devices. Its compiler is included into **Simics** Base. |
| **device** | any **Simics** class for modelling real devices. Different **Simics** devices communicate via *interfaces*. |
| *Model Builder User's Guide* | overview of **Simics**/DML programming |
| *DML 1.4 Reference Manual* | language specification |
| *API Reference Manual* | API function list for DML & C, describes ownership rules |
| *model writers* | those who write **Simics** devices |
| *users* | those who use **Simics** devices: device driver writers, firmware/UEFI writers, validators/testers, etc |

#### Getting help

```
# Print explanation of C/Python/DML API functions:
> api-help SIM_add_configuration
```

#### Create stub device

```
$ bin/project-setup --device example-dev
$ ls modules/example-dev
test/ example-dev.dml Makefile module_load.py
```

The header of *example-dev*.dml is then:

```
dml 1.4;               // Obligatory .dml header
device example_dev;    // Class name.
                       // Note: - changed to underscore _
```

#### Create stub interface with Python wrapper

```
$ bin/project-setup --interface sample
$ ls modules/sample-interface
Makefile sample-interface.dml sample-interface.h
```

Python support is enabled by `IFACE_FILES` in the Makefile. The generated C **struct** name is *`sample_interface_t`*.

#### Arithmetics

RHS is int64, LHS truncates

Assignments are equivalent to casts and hence can truncate:

```
local uint8 x = 0xffff // results in x == 0xff
```

All aritmetic operators like +, ∗ convert its operands to int64:

```
local uint16 i = 0x7fff; local int8 j = 2; // let us sum them:
                 calculates as int64 → 0x8001
local int16 x =  i+j;
                        truncates to int16
// finally results in x == 1
```

Comparisons act as uint64 or int64: ==, <, <=

Comparisons on only uint64 act as proper uint64, however in comparisons int64 vs. uint64 the operands are converted to int64!

```
local uint64 u;
u = -1;    // equivalent to u = cast(-1, uint64) = 2^64 − 1, all ones
u == -1    // FALSE! Equivalent to int64(u) == int64(-1),
           // where upper bit is cropped: int64(u) == (2^63 − 1).
u == cast(-1, uint64) // true. As comparison is b/w two uint64
u > -1     // true, but unlike C! it's int64(u) > int64(-1): 2^63 − 1 > 1
```

#### Syntax

Statements

```
// Printing through log statements:
log log-type, level, groups: "format-string", arg1, ..., argN;
                default 1   default 0 (no group)
// (The "format-string" is the same as in C, see 'man 3 printf')
```

| *log-level* | usage rule |
|---|---|
| 1 | most important messages (for both users and model writers), typically `error` |
| 2 | crucial events for boards/devices, e.g. their resets |
| 3 | any other messages (for users) |
| 4 | internal device debug messages (for model writers) |

| *log-type* | usage rule |
|---|---|
| `info` | informational message |
| `spec_viol` | specification violation by target software (for users) |
| `unimpl` | attempt to use not implemented functionality (for users) |
| `error` | internal device error (for model writers). ⚠ There is a limit (default 10_000) after which simulation stops! |
| `critical` | like `spec_viol` or error, but ⚠ stops simulation |

```
// Dynamic allocation (like malloc() in C):
local type * x = new type;
// e.g. for int array:
local int * x = new int[100];
delete x; // Deallocation like free() in C
// Raising/catching exceptions:
try {
    throw; // YES, no data can be carried by exception
} catch {
    ...
}
```

#### Expressions

```
sizeof value // : int — get byte size of the value
sizeoftype type // : int — get byte size of the type
x[10:8] // Get bits 10—8 of integer x:
x[8] // Get bit 8 of integer x:
```

#### Types

**uint1**...**uint64** and **int1**...**int64**.

#### Methods

They are called *methods*, not functions, because they accept **implicit** 1st argument — object (current device), like C++ methods.

```
method name(inputType1 arg1) -> (outputType1, outputType2)
{
    ...
    local outputType1 var1 = ...; local outputType2 var2 = ...;
    return (var1,var2);
}
// calling this method:
local inputType1 val = ...;
local outputType1 x; local outputType2 y;
(x, y) = name(val);
```

#### Bitfields

```
bitfields 32 {
    uint3 upper_bits @ [31:29];
    ...
}
```

#### Object declarations

```
objectType objectName {
    method methodName {
        ...
    }
}
register regName @ offset is (template1, ...);
// @ offset is a syntax for "param offset = offset;"
```

## Module variables and other data objects

| DML construct | check-pointed | fields | address-mapped | arbitrary data |
|---|---|---|---|---|
| **session** | - | - | - | + |
| **saved** | + | - | - | - |
| attribute | + | - | - | + |
| unmapped register | + | + | - | - |
| [normal] register | + | + | + | - |

## Interfaces

Definition in `.dml`:

```
extern typedef struct {
    method name(conf_object_t *obj, type_1 value_1)
        -> out_type;
} sample_interface_t;
```

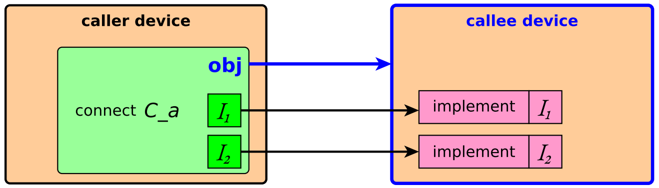
Obligatory definition in C `.h` file **for using the interface from Python**:

```
SIM_INTERFACE(sample) { // essentially 'typedef struct' also
    out_type (*name)(conf_object_t *obj, type_1 value_1);
}
#define SAMPLE_INTERFACE "sample"     // necessary!
```

Then it is called **without** `obj`: just `name(value_1)`.

## Explaining `connect`s and `implement`s

- `connect`s are for **out**bound calls
- `implement`s are for **in**bound calls




| | unnamed (whole-device) | named (wrapped in attribute) |
|---|---|---|
| `connect` | - | connect C_a { ❶<br>  interface $I_1$ { ❷<br>    ...<br>  }<br>  interface $I_2$ { ❷<br>    ...<br>  }<br>}<br>connect C_b { ❶<br>  interface $I_2$ { ❷<br>    ... |
| `implement` | implement $I_1$ {<br>  ...<br>}<br>implement $I_2$ {<br>  ...<br>}<br>(as in picture above) | port $P_A$ {<br>  implement $I_1$ {<br>    ...<br>  }<br>  implement $I_2$ {<br>    ... *variant 1* ...<br>  }<br>}<br>port $P_B$ {<br>  implement $I_2$ {<br>    ... *variant 2* ... |

To make the whole `connect` required:

❶
```
param configuration = "required";
// other variants: "optional" (default), "pseudo", "none"
```

❷ Individual interfaces are already **required** by default, to make them optional:

```
param required = false;
```

⚠ `implement {}` does NOT check that all (or any!) methods of an interface are really provided, defaulting to **NULL**.

## Calling device code from Python

If *device* `implement`s interface $iface_1$ then its methouds can be invoked from **Simics** command line via Python:

```
@conf.platf.device.iface.iface_1.method_1(argument_1, ...)
```

## Debugging with Gdb

To debug simics and its modules itself:

**Terminal #1:**

```
# Recompile your module with debugging support:
$ make clobber-my-module
$ make D=1 my-module
$ ./simics
> pid
12345
```

**Terminal #2:**

```
$ bin/gdb
>>> attach 12345
>>> br file.dml:100     # set break point on line 100 of file.dml
>>> continue
```

**Back to terminal #1:**

```
> run-command-file targets/platf/platf.simics
```

## Using gdb for debugging target

```
load-module gdb-remote
new-gdb-remote 50000     # open port 50000
```

## Attribute values

`attr_value_t` is a C union that can hold one of a few predefined types. Attributes values are allocated/packed by: `attr_value_t x = SIM_make_attr_T(cType val)`, and extracted by: `cType val = SIM_attr_T(x)`, where *T* and *cType* can be:

| *T* | type spec | *cType* — DML/C type |
|---|---|---|
| uint64, int64 | i | **uint64**, **int64** |
| boolean | b | **bool** |
| floating | f | **double** |
| string | s | **char*** |
| object | o | **conf_object_t** |
| list | $[x_1 ... x_n]$ | fixed-width tuple with $n$ elements of types $x_1$, ..., $x_n$ |
| list | $[x*]$ | arbitrary-width array of $x$ |
| list | $[x+]$ | non-empty arbitrary-width array of $x$ |
| list | $[x\{m:n\}]$ | array of $x$ with $m \le size \le n$ |
| list | $[x\{n\}]$ | fixed-width tuple with $n$ elements of $x$ |
| dict | D | array of **attr_dict_pair_t** |
| data | d | **uint8*** |
| nil | n | **void** or $x$***** |
| invalid | | (none, used for indicating errors) |

List items are accessed by `SIM_attr_list_item`. Type specs can be OR'ed as $x_1|x_2$. Type spec is used in `param type = "..."`. For first 4 types there are predefined DML templates `uint64_attr`, `int64_attr`, `bool_attr`, `double_attr`.

## Attribute initialization

| Execution stage | SIM_object_is_configured(obj) | SIM_is_restoring_state() |
|---|---|---|
| Create object at 1st platform init | - | - |
| Load checkpoint | - | + |
| Load micro-checkpoint (reverse execution) | + | + |
| Manual attribute assignment (hot plug from **Simics** command line) | + | - |

## Standard register templates

### Compile-time statements & conditional compilation

```
param p1 = 10; // Non-overridable parameter
param p2 default "value"; // Overridable parameter
template myTemplate {
    param p3; // undefined value — must be given on myTemplate instantiation
    ...
}
// Compile-time if
#if (p1 == 20) {
    ...
} #else #if {
    ...
} #else {
    ...
}
// Compile-time ternary operator #? #:
param mode = p1 == 20 #? "equal 20" #: "not equal 20";
// Represent value of parameter as string
param p1_str = stringify(p1); // results in "10"
```

### Hash tables

```
import "simics/util/hashtab.dml";
...
local ht_str_table_t tab; // str — string (aka const char*) keys.
ht_init_str_table(&tab, /*keys_owned*/ true);
local double *value = new double; *value = 10.0;
ht_insert_str(&table, "key", cast(value, void *));
local double *get_back = cast(ht_lookup_str(&tab, "key"), double*);
assert *get_back == 10.0;
```

There are also tables for `int` keys or general (`common`) keys.

### The secret of DML

Many "internal" features like registers and even connects are actually normal templates for objects (`is object;`) in plain DML defined in `1.4/dml-builtins.dml` and thus they can be expanded.

### C API

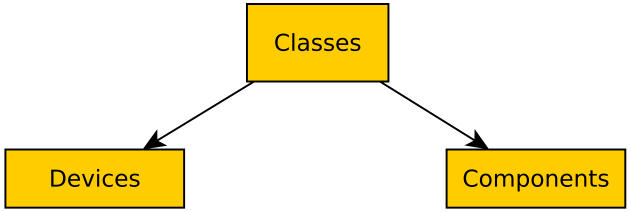
It's possible to do most things in C, e.g. create device by `SIM_create_object`, though normally it's done from Python components.

## 3 Simics configuration and build system

### Glossary & Documentation

*Python* — this language is used for connecting devices together (writing components), for writing some (slow) devices, for unit-testing

*Component* — a special **Simics** class that forms a namespace tree and (typically) in its nodes contains instances of device classses. Components implement required `component` interface and optional `component_connector` interface.




### Creating devices dynamically

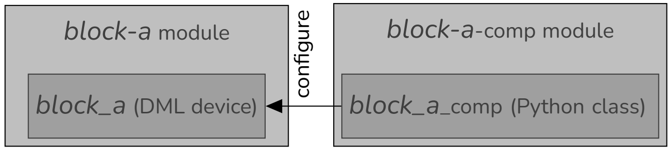
```
> create-myDevice-comp "system.mydev"
> connect system.mydev system.other.connect
> instantiate-components
```

### Modules/Components/Classes

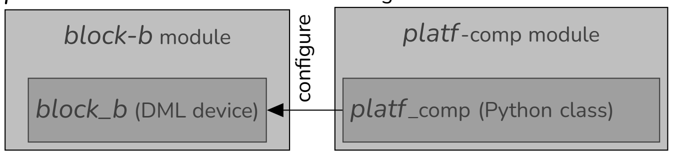
A **Simics** module includes classes, there are 2 types of them:

- devices, typically written in DML
- *components*, typically written in Python

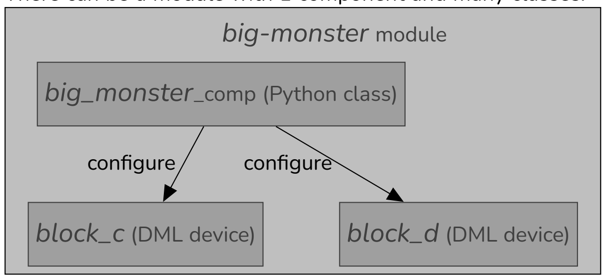
A typical layout with 1-to-1 device-component correspondence:




In simplest case there are no components for a device, so its platform *platf* will have to instantiate and configure the device:




There can be a module with 1 component and many classes:




### Connecting devices

- from Script:

  platf.$device_1$->$connect_1$ = platf.$device_2$

- from Python:

  conf.platf.$device_1$.$connect_1$ = conf.platf.$device_2$

### Components vs functions

Components/connectors are used:

- when there is a need to unite big number of devices to prevent pollution of the surrounding namespace
- when this is a separate device that can be used across different packages independently

⚠ Do not confuse: *Connectors* connect *component* objects, while *connects* (+implements) connect *device* objects. `connect` command acts on connectors only!

### Structure and initialization order

A typical structure of component class code:

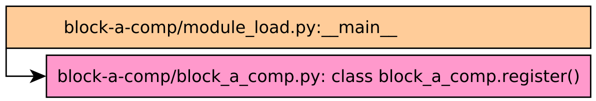
```
class block_a_comp(StandardComponent):
    @classmethod
    def register(cls):
        ...
    def __init__(self):
        ...
    def setup(self):
        ...
    def add_objects(self):
        ...
    class attribute_name(ConfigAttribute):
        def _initialize(self):
            ...
        def _finalize(self):
            ...
    class component_connector(Interface):
        def get_connect_data(self, block_a_connector):
            ...
        def connect(self, block_a_connector, data_from_b):
            ...
    ...
    class component(StandardComponent.component):
        ...
```

Let us examine initialization of modules ⟶ components ⟶ devices for this sample program:

```
❶ load-module block-a-comp
❷ load-module block-b-comp
❸ create-block-a-comp "block_a_component"
❹ create-block-b-comp "block_b_component"
❺ connect block_a_component.eth0 block_b_component.eth0
❻ instantiate-components
```

The corresponding break down of functions that are normally `simics-defined` or `user-defined`.

❶




❷ The same for `block_b_comp`

❸ Note that `add_objects` adds normally pre-configured objects:

create object block_a_comp

block_a_comp.__init__(self)

block_a_comp._initialize(self)

- for earch block_a_comp attribute
  - attribute_name._initialize(self)

block_a_comp._finalize(self)

- for each block_a_comp attribute
  - attribute_name._finalize(self)

block_a_comp.setup(self)

- user-supplied function like add_objects(self)
  - call self.add_pre_obj("block_a_device", "block_a")

**4** The same for block_b_comp & block_b

**5**

block_a_comp.get_connect_data(self, block_a_connector)
... return data_from_a

block_b_comp.get_connect_data(self, block_b_connector)
... return data_from_b

Note get_connect_data is basically just a switch/case statement that chooses which data (object references, port names, etc) to pass to connect function call below.

**6a**

block_b_comp.class component_connector(Interface).connect(
self, block_b_connector, data_from_a)

- set connects of block_b DML device:
  block_b_component.block_b_device = data_from_a["field"]

block_a_comp.class component_connector(Interface).connect(
self, block_a_connector, data_from_b)

- set connects of block_a DML device:
  block_a_component.block_a_device = data_from_b["field"]

block_a_comp.component.pre_instantiate(self)
block_b_comp.component.pre_instantiate(self)

**6b** Pre-configuration phase ends and finally instantiate-components begins to configure real DML objects:

block_a: call init() on all attributes with `init` template applied.
block_a: call device method init()

block_b: call init() on all attributes with `init` template applied.
block_b: call device method init()

block_a: call set() for all connects/attributes

block_b: call set() for all connects/attributes

block_a: call device method post_init()

block_b: call device method post_init()

After that phase self.get_slot("name") returns real, already configured, device objects.

**6c** Rarely some additional tweaks are required on configured objects:

block_a_comp.component.post_instantiate(self)

block_b_comp.component.post_instantiate(self)