Installation procedure for the GreenWaves Technologies GAP processor development environment :

I started by installing a Ubuntu 20.04 virtual machine from osboxes.org. I then update the local package lists from the software repositories :

```
osboxes@osboxes:~$ sudo apt-get update
```

I've installed the necessary dependencies :

```
osboxes@osboxes:~$ sudo apt-get install -y    autoconf    automake    bison    build-essential
    libsdl2-dev      libsdl2-ttf-dev      libsndfile1-dev    graphicsmagick-libmagick-dev-compat

    cmake    curl    doxygen    flex    git    gtkwave    libftdi-dev    libftdi1    libjpeg-dev
libtool    libusb-1.0-0-dev    pkg-config    python3-pip    rsync    scons    texinfo    wget
```

As recommended, I have defined python3 as the default:

```
osboxes@osboxes:~$ sudo update-alternatives --install /usr/bin/python python /usr/bin/python3 10
update-alternatives: using /usr/bin/python3 to provide /usr/bin/python (python) in auto mode
```

Then I cloned the repository containing the toolchain:

```
osboxes@osboxes:~$ git clone https://github.com/GreenWaves-Technologies/gap_riscv_toolchain_ubuntu.git
Cloning into 'gap_riscv_toolchain_ubuntu'...
remote: Enumerating objects: 3841, done.
remote: Counting objects: 100% (332/332), done.
remote: Compressing objects: 100% (185/185), done.
remote: Total 3841 (delta 116), reused 292 (delta 95), pack-reused 3509
Receiving objects: 100% (3841/3841), 432.07 MiB | 2.32 MiB/s, done.
Resolving deltas: 100% (1960/1960), done.
Updating files: 100% (3418/3418), done.
```

And I installed it:

```
osboxes@osboxes:~$ cd gap_riscv_toolchain_ubuntu/
osboxes@osboxes:~/gap_riscv_toolchain_ubuntu$ ./install.sh
```

Then I cloned the SDK repository :

```
osboxes@osboxes:~/gap_riscv_toolchain_ubuntu$ git clone https://github.com/GreenWaves-Technologie
s/gap_sdk.git
```

And I've defined the target as GAPUINO_V3 :

```
osboxes@osboxes:~/gap_riscv_toolchain_ubuntu/gap_sdk$ source sourceme.sh
Select the target :
        1 - GAPOC_B_SPI_V2
        2 - GAPOC_B_V2
        3 - GAPUINO_V3
        4 - GAPUINO_V3_SPI
3
The target board you have chosen is : gapuino, GAP8_V3.
```

I then installed all the python dependencies for the SDK and for the documentation:

```
osboxes@osboxes:~/gap_riscv_toolchain_ubuntu/gap_sdk$ pip install -r requirements.txt
```

```
osboxes@osboxes:~/gap_riscv_toolchain_ubuntu/gap_sdk$ pip install -r doc/requirements.txt
```

I then installed the entire SDK with the "make all" command.

I then tried to build the html page for the documentation but an error appeared indicating that sphinx-build could not be found :

```
osboxes@osboxes:~/gap_riscv_toolchain_ubuntu/gap_sdk/doc$ make html
/bin/sh: 1: sphinx-build: not found
make: *** [Makefile:20: html] Error 127
```

I tried to install it via pip install but it already existed :

```
osboxes@osboxes:~/gap_riscv_toolchain_ubuntu/gap_sdk/doc$ pip install sphinx
Requirement already satisfied: sphinx in /home/osboxes/.local/lib/python3.8/site-packages (7.0.1)
Requirement already satisfied: sphinxcontrib-devhelp in /home/osboxes/.local/lib/python3.8/site-packages (from sphinx) (1.0.2)
Requirement already satisfied: Pygments>=2.13 in /home/osboxes/.local/lib/python3.8/site-packages (from sphinx) (2.15.1)
Requirement already satisfied: babel>=2.9 in /home/osboxes/.local/lib/python3.8/site-packages (from sphinx) (2.12.1)
Requirement already satisfied: importlib-metadata>=4.8; python_version < "3.10" in /home/osboxes/.local/lib/python3.8/site-packages (from sphinx) (6.6.0)
Requirement already satisfied: Jinja2>=3.0 in /home/osboxes/.local/lib/python3.8/site-packages (from sphinx) (3.1.2)
Requirement already satisfied: sphinxcontrib-serializinghtml>=1.1.5 in /home/osboxes/.local/lib/python3.8/site-packages (from sphinx) (1.1.5)
Requirement already satisfied: sphinxcontrib-jsmath in /home/osboxes/.local/lib/python3.8/site-packages (from sphinx) (1.0.1)
Requirement already satisfied: packaging>=21.0 in /home/osboxes/.local/lib/python3.8/site-packages (from sphinx) (23.1)
Requirement already satisfied: imagesize>=1.3 in /home/osboxes/.local/lib/python3.8/site-packages (from sphinx) (1.4.1)
Requirement already satisfied: docutils<0.21,>=0.18.1 in /home/osboxes/.local/lib/python3.8/site-packages (from sphinx) (0.20.1)
Requirement already satisfied: snowballstemmer>=2.0 in /home/osboxes/.local/lib/python3.8/site-packages (from sphinx) (2.2.0)
Requirement already satisfied: alabaster<0.8,>=0.7 in /home/osboxes/.local/lib/python3.8/site-packages (from sphinx) (0.7.13)
Requirement already satisfied: sphinxcontrib-htmlhelp>=2.0.0 in /home/osboxes/.local/lib/python3.8/site-packages (from sphinx) (2.0.1)
Requirement already satisfied: sphinxcontrib-applehelp in /home/osboxes/.local/lib/python3.8/site-packages (from sphinx) (1.0.4)
Requirement already satisfied: sphinxcontrib-qthelp in /home/osboxes/.local/lib/python3.8/site-packages (from sphinx) (1.0.3)
Requirement already satisfied: requests>=2.25.0 in /home/osboxes/.local/lib/python3.8/site-packages (from sphinx) (2.31.0)
Requirement already satisfied: pytz>=2015.7; python_version < "3.9" in /usr/lib/python3/dist-packages (from babel>=2.9->sphinx) (2019.3)
Requirement already satisfied: zipp>=0.5 in /home/osboxes/.local/lib/python3.8/site-packages (from importlib-metadata>=4.8; python_version < "3.10"->sphinx) (3.15.0)
Requirement already satisfied: MarkupSafe>=2.0 in /home/osboxes/.local/lib/python3.8/site-packages (from Jinja2>=3.0->sphinx) (2.1.3)
Requirement already satisfied: charset-normalizer<4,>=2 in /home/osboxes/.local/lib/python3.8/site-packages (from requests>=2.25.0->sphinx) (3.1.0)
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/lib/python3/dist-packages (from requests>=2.25.0->sphinx) (1.25.8)
Requirement already satisfied: idna<4,>=2.5 in /usr/lib/python3/dist-packages (from requests>=2.25.0->sphinx) (2.8)
Requirement already satisfied: certifi>=2017.4.17 in /usr/lib/python3/dist-packages (from requests>=2.25.0->sphinx) (2019.11.28)
```

And I was indeed able to find sphinx-build in the right place:

```
osboxes@osboxes:~/gap_riscv_toolchain_ubuntu/gap_sdk/doc$ ls /home/osboxes/.local/bin/sphinx-build
/home/osboxes/.local/bin/sphinx-build
```
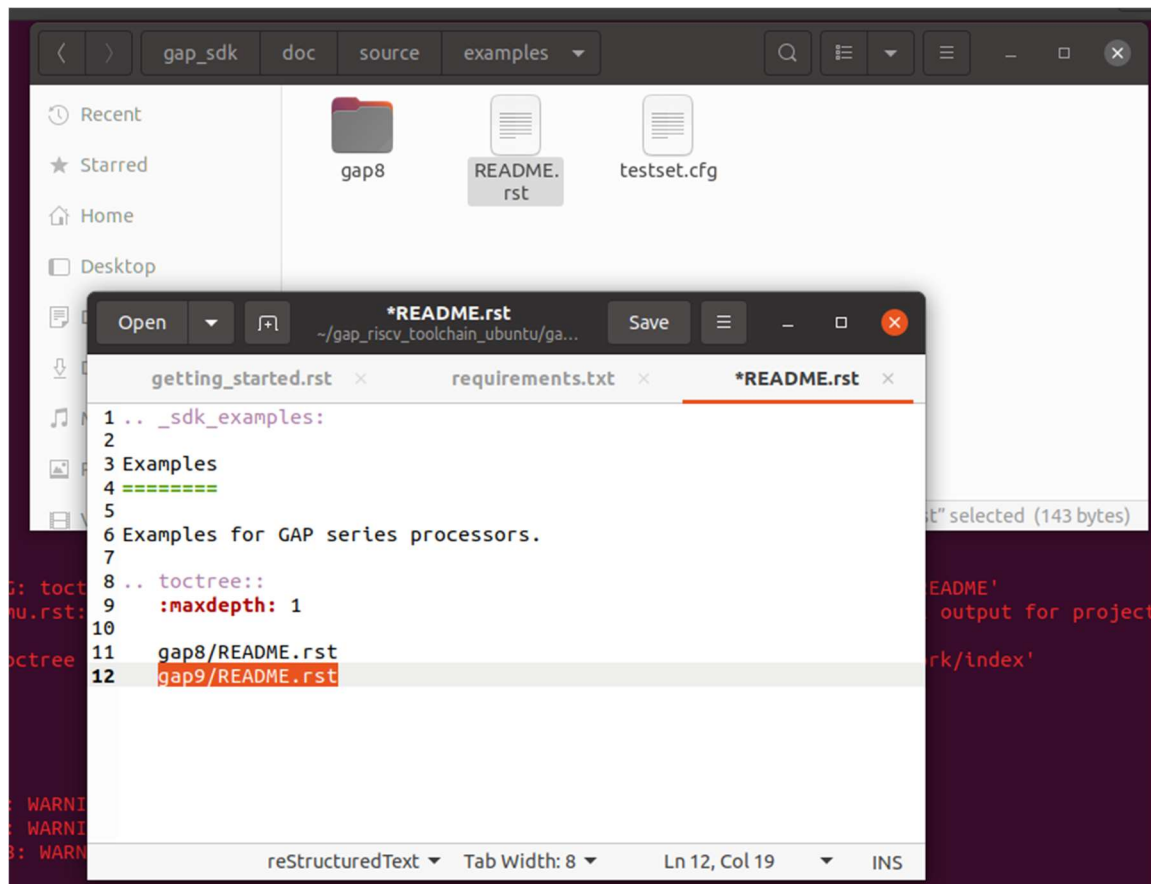
So I added the path to the system directory and ran the make command again :

```
osboxes@osboxes:~/gap_riscv_toolchain_ubuntu/gap_sdk/doc$ export PATH="/home/osboxes/.local/bin:$PATH"
osboxes@osboxes:~/gap_riscv_toolchain_ubuntu/gap_sdk/doc$ make html
Running Sphinx v7.0.1
@DOXYGEN_PROJECT_NAME@ gap_sdk
@DOXYGEN_OUTPUT_DIR@ _build
@DOXYGEN_XML_DIR@ xml_gap_sdk
@DOXYGEN_INPUT_DIRS@ ../rtos/pmsis/api/include/pmsis/drivers/ \
../rtos/pmsis/api/include/pmsis/rtos/ \
../rtos/pmsis/api/include/pmsis/cluster/ \
```

But errors appeared indicating that files could not be found:

```
finished...
building [mo]: targets for 0 po files that are out of date
writing output...
building [html]: targets for 166 source files that are out of date
updating environment: [new config] 166 added, 0 changed, 0 removed
reading sources... [100%] source/tools/nntool/nntool_api/reference
/home/osboxes/gap_riscv_toolchain_ubuntu/gap_sdk/doc/source/examples/README.rst:8: WARNING: toctree contains reference to nonexisting document 'source/examples/gap9/README'
/home/osboxes/gap_riscv_toolchain_ubuntu/gap_sdk/doc/source/reference/pmsis_api/drivers/pmu.rst:32: WARNING: doxygengroup: Cannot find group "GAP9_PMU" in doxygen xml output for project "gap9" from direc
tory: _build/xml_gap9
/home/osboxes/gap_riscv_toolchain_ubuntu/gap_sdk/doc/source/tools/index.rst:6: WARNING: toctree contains reference to nonexisting document 'source/tools/audio-framework/index'
looking for now-outdated files... none found
pickling environment... done
checking consistency... done
preparing documents... done
writing output... [100%] source/tools/nntool/nntool_api/reference
/home/osboxes/gap_riscv_toolchain_ubuntu/gap_sdk/doc/source/guides/low_power_modes.rst:41: WARNING: undefined label: 'example_power_idle_mode'
/home/osboxes/gap_riscv_toolchain_ubuntu/gap_sdk/doc/source/guides/low_power_modes.rst:86: WARNING: undefined label: 'example_power_deep_sleep'
/home/osboxes/gap_riscv_toolchain_ubuntu/gap_sdk/doc/source/guides/low_power_modes.rst:108: WARNING: undefined label: 'example_power_deep_sleep'
generating indices... genindex py-modindex done
writing additional pages... search done
copying images... [100%] source/tools/docs/profiler/windows/images/image_25.png
copying static files... done
copying extra files... done
dumping search index in English (code: en)... done
dumping object inventory... done
build finished with problems, 6 warnings.
make: *** [Makefile:20: html] Error 1
```
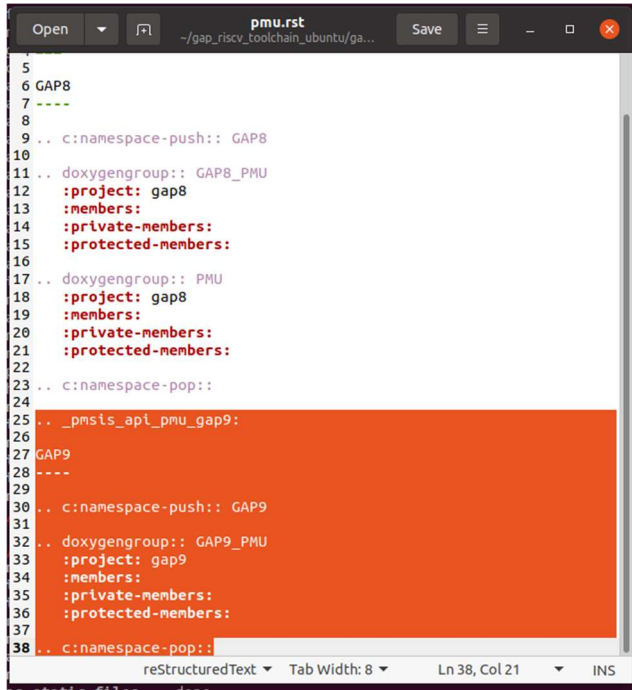
In the example folder there was no gap9 folder, so I deleted the associated dependency in readme.rst as I would only need gap8.

The compilation removes the error and I do the same with the following problems:
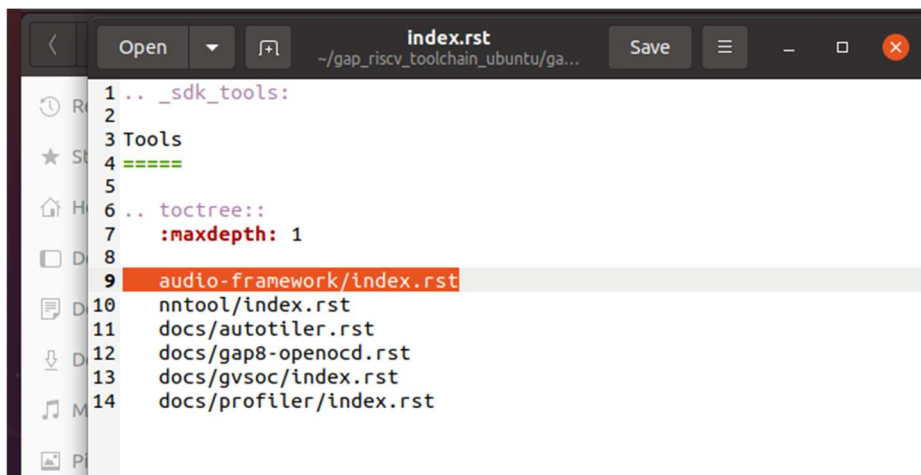
I am therefore deleting the link to gap9 in orange:
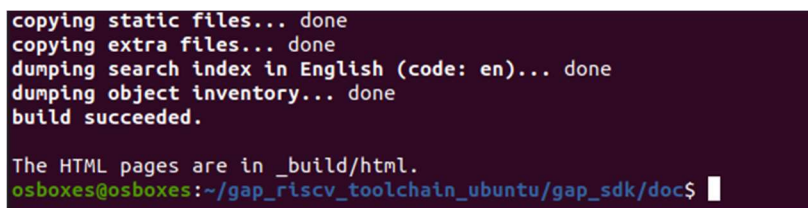
And I'm also removing the dependency on the Audio Framework since I won't need it and it won't compile properly.

Everything is compiled and we can continue :

Running the Hello world Example:

Now I'll run a first example displaying hello world on each of cores of the virtual processor:

```
osboxes@osboxes:~/gap_riscv_toolchain_ubuntu/gap_sdk/examples/gap8/basic/helloworld$ make c
lean all run platform=gvsoc
```

Everything compiles and the code works :

```
        *** PMSIS HelloWorld ***

Entering main controller
[32 0] Hello World!
Perf : 3417 cycles Timer : 9447 cycles
Cluster master core entry
[0 7] Hello World!
[0 1] Hello World!
[0 2] Hello World!
[0 3] Hello World!
[0 4] Hello World!
[0 5] Hello World!
[0 6] Hello World!
[0 0] Hello World!
Cluster master core exit
osboxes@osboxes:~/gap_riscv_toolchain_ub
```

I then created a bash script containing the make command.

```
osboxes@osboxes:~/gap_riscv_toolchain_ubuntu/gap_sdk/examples/gap8/basic/helloworld$ touch launch.sh
```

```
Open    ▼    [+|        launch.sh        Save    ≡    _    □    ✕
                  ~/gap_riscv_toolchain_ubuntu/ga...
1 #!/bin/bash
2
3 # Clean, build and run the code
4 make clean all run platform=gvsoc
```

I give the executions rights and run the script, it works.

```
osboxes@osboxes:~/gap_riscv_toolchain_ubuntu/gap_sdk/examples/gap8/basic/helloworld$ chmod +x launch.sh
osboxes@osboxes:~/gap_riscv_toolchain_ubuntu/gap_sdk/examples/gap8/basic/helloworld$ ./launch.sh
```

```
        *** PMSIS HelloWorld ***

Entering main controller
[32 0] Hello World!
Perf : 3417 cycles Timer : 9447 cycles
Cluster master core entry
[0 7] Hello World!
[0 1] Hello World!
[0 2] Hello World!
[0 3] Hello World!
[0 4] Hello World!
[0 5] Hello World!
[0 6] Hello World!
[0 0] Hello World!
Cluster master core exit
Test success !
```
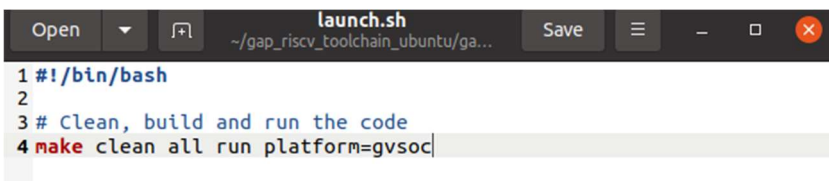
Running the matrix algorithm without the convolution:

Using the cluster_dma example as a starting point, I was able to design an algorithm taking 2 matrices stored in memory L2 as input, these 2 matrices are sent to memory L1 and the 8-core cluster is responsible for multithreading the sum of the 2 matrices which it then stores in matrix 1 and the multiplication of the 2 matrices which is stored in matrix 2. The set is then returned to memory L2 and enters a verification stage in which the program checks that the cluster's calculations have been carried out correctly and returns an error if an element of the matrix does not have the correct result. The cluster is perfectly functional for matrices ranging from 8x8 to 96x96. Beyond 96x96, errors appear indicating poor cluster calculation, probably due to memory errors.

```
osboxes@osboxes:~/gap_riscv_toolchain_ubuntu/gap_sdk/examples/gap8/basic/cluster/cluster_dma_raph$ ./launch.sh -s 8

Size selected : 8


        *** PMSIS Cluster DMA Test ***

Entering main controller
Sending task.
Cluster master core entry
Core 0 requesting DMA transfer from l2_in_matrice1 to l1_buffer_matrice1.
Core 0 : Transfer done.
Core 0 requesting DMA transfer from l2_in_matrice2 to l1_buffer_matrice2.
Core 0 : Transfer done.
Core 0 requesting DMA transfer from l1_buffer_matrice1 to l2_out_matrice1.
Core 0 : Transfer done.
Core 0 requesting DMA transfer from l1_buffer_matrice2 to l2_out_matrice2.
Core 0 : Transfer done.
Cluster master core exit
Close cluster after end of computation.
Matrix Summed :
2 3 4 5 1 2 3 4
5 1 2 3 4 5 1 2
3 4 5 1 2 3 4 5
1 2 3 4 5 1 2 3
4 5 1 2 3 4 5 1
2 3 4 5 1 2 3 4
5 1 2 3 4 5 1 2
3 4 5 1 2 3 4 5

Matrix multiplied :
16 16 16 16 16 16 16 16
15 15 15 15 15 15 15 15
19 19 19 19 19 19 19 19
13 13 13 13 13 13 13 13
17 17 17 17 17 17 17 17
16 16 16 16 16 16 16 16
15 15 15 15 15 15 15 15
19 19 19 19 19 19 19 19

Cluster DMA done with 0 error(s) !
```

```
Size selected : 64


        *** PMSIS Cluster DMA Test ***

Entering main controller
Sending task.
Cluster master core entry
Core 0 requesting DMA transfer from l2_in_matrice1 to l1_buffer_matrice1.
Core 0 : Transfer done.
Core 0 requesting DMA transfer from l2_in_matrice2 to l1_buffer_matrice2.
Core 0 : Transfer done.
Core 0 requesting DMA transfer from l1_buffer_matrice1 to l2_out_matrice1.
Core 0 : Transfer done.
Core 0 requesting DMA transfer from l1_buffer_matrice2 to l2_out_matrice2.
Core 0 : Transfer done.
Cluster master core exit
Close cluster after end of computation.
Matrix Summed :
2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5
1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4
5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3
4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2
3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1
2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5
1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4
5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3
4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2
3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1
```

The bash script takes as an argument the size in width of the desired matrix via the command "./launch.sh -s 96" if no value is entered, the default value is 64.

```bash
1 #!/bin/bash
2
3 # Default value
4 SIZEMATRIX=64
5
6 while getopts ":s:" opt; do
7   case $opt in
8     s)
9       SIZEMATRIX=$OPTARG
10      ;;
11    \?)
12      echo "Invalid option: -$OPTARG" >&2
13      exit 1
14      ;;
15   esac
16 done
17
18 # Clean and build the project
19 make clean all run platform=gvsoc VALUE=$SIZEMATRIX
20
```

The makefile retrieves this value via a "value" variable and links it in the .c file, which becomes usable via the SIZEOFMATRIX variable.

```makefile
1 # User Test
2 #----------------------------------
3
4 VALUE = "64"
5
6 APP             = test
7 APP_SRCS       += test_cluster_dma.c
8 APP_INC        +=
9 APP_CFLAGS     += -D SIZEOFMATRIX=$(VALUE)
10
11 ifeq ($(ASYNC), 1)
12 APP_CFLAGS     += -DASYNC
13 endif
14
15 include $(GAP_SDK_HOME)/utils/rules/pmsis_rules.mk
16
```

```
/* Program Entry. */
int main()
{
    printf("\n\nSize selected : %i\n", SIZEOFMATRIX);
    size=SIZEOFMATRIX;

    printf("\n\n\t *** PMSIS Cluster DMA Test ***\n\n");
    return pmsis_kickoff((void *) test_cluster_dma);
}
```

Running the matrix algorithm with the convolution:

The convolution of the matrix poses more difficulty, in fact I'm not sure that the results are calculated correctly, I've tried to adapt a function from the internet, the programme works but the results are probably incorrect. Also the convolution filter is made up of unsigned integers but it contains negative values (unsigned short filter[9] = {-1, -2, -1, 0, 0, 0, 1, 2, 1}) so there's probably an error here. The code accepts matrices between 8x8 and 32x32, beyond this value a memory error appears.

```
Matrix multiplied :
16 16 16 16 16 16 16 16
15 15 15 15 15 15 15 15
19 19 19 19 19 19 19 19
13 13 13 13 13 13 13 13
17 17 17 17 17 17 17 17
16 16 16 16 16 16 16 16
15 15 15 15 15 15 15 15
19 19 19 19 19 19 19 19

Matrix convolution :
0 0 25508 7168 1 0 33796 0
5 12 12 12 12 12 12 7175
4 65528 65528 65528 65528 65528 65528 7168
3 65528 65528 65528 65528 65528 65528 0
0 12 12 12 12 12 12 7168
0 65528 65528 65528 65528 65528 65528 6912
4 12 12 12 12 12 12 7168
0 0 19 0 23395 7168 17854 7168

Cluster DMA done with 0 error(s) !
```