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# COMP2129

# Assignment 3

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Due: 6:00pm Friday, 22 May 2015

*This assignment is worth 10% of your final assessment*

## Task description

In this assignment we will implement a matrix computation engine that is able to construct matrices and perform matrix computations in the C programming language. The aim is to use a variety of parallel programming, code optimisation and algorithmic techniques to achieve peak performance.

You have been provided with some well documented scaffold code. Your task is to implement the incomplete functions and then analyse the running time of the operations under various inputs with an aim to make each operation run as fast as possible. Most of the matrix operations can be improved by using parallelisation, more efficient algorithms and code optimisation techniques. It is up to you to determine whether you will focus on tuning certain operations that are dramatically slower than the others, or to focus on each operation equally. Make sure to cache matrices and results where possible.

You are encouraged to ask questions on [ed](#) using the assignments category. As with any assignment, make sure that your work is your own, and you do not share your code or solutions with other students.

## Working on your assignment

You can work on this assignment on your own computer or the lab machines. Students can also take advantage of the online code editor on [ed](#). Simply navigate to the assignment page and you are able to run, edit and submit code from within your browser. We recommend that you use Safari or Chrome.

It is important that you continually back up your assignment files onto your own machine, flash drives, external hard drives and cloud storage providers. You are encouraged to submit your assignment while you are in the process of completing it. By submitting you will obtain some feedback of your progress.

## Academic declaration

By submitting this assignment you declare the following:

*I declare that I have read and understood the University of Sydney Academic Dishonesty and Plagiarism in Coursework Policy, and except where specifically acknowledged, the work contained in this assignment or project is my own work, and has not been copied from other sources or been previously submitted for award or assessment.*

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*I realise that I may be asked to identify those portions of the work contributed by me and required to demonstrate my knowledge of the relevant material by answering oral questions or by undertaking supplementary work, either written or in the laboratory, in order to arrive at the final assessment mark.*

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## Implementation details

Your task is to implement a matrix computation engine based on the included scaffold code. You can assume only valid input will be tested. All matrices will be square and have the same dimensions between  $1 \leq \text{order} \leq 10000$ . All matrix rows, columns and elements will be indexed from 1. Matrix elements range from 0 up to the maximum value of `uint32_t`. We expect some operations to cause unsigned integer overflows, this behaviour is well defined and those results will wrap around from 0.

Your program must be contained in `matrix.c` and `matrix.h` and produce no errors when built and run on the lab machines and [ed](#) with the following command:

```
$ clang -O1 -std=gnull -Wall -pthread main.c matrix.c -o matrix
```

Your program output must match the exact output format shown by the prototype and on [ed](#). You are encouraged to submit your assignment while you are working on it, so you can obtain some feedback.

## Commands

```
> HELP
BYE
HELP

SET <key> = identity
SET <key> = random <seed>
SET <key> = uniform <value>
SET <key> = sequence <start> <step>

SET <key> = cloned <matrix>
SET <key> = reversed <matrix>
SET <key> = transposed <matrix>

SET <key> = matrix#add <matrix a> <matrix b>
SET <key> = matrix#mul <matrix a> <matrix b>
SET <key> = matrix#pow <matrix> <exponent>
SET <key> = scalar#add <matrix> <scalar>
SET <key> = scalar#mul <matrix> <scalar>

SHOW <key>
SHOW <key> row <number>
SHOW <key> column <number>
SHOW <key> element <row> <column>

COMPUTE sum <key>
COMPUTE trace <key>
COMPUTE minimum <key>
COMPUTE maximum <key>
COMPUTE frequency <key> <value>

> BYE
bye
```

## Examples

```
> SET a = identity
ok

> SHOW a
1 0
0 1

> SET b = random 1
ok

> SHOW b
41 18467
6334 26500

> SET c = random 2
ok

> SHOW c
45 29216
24198 17795

> SET d = uniform 0
ok

> SHOW d
0 0
0 0

> SET e = uniform 1
ok

> SHOW e
1 1
1 1

> SET f = sequence 1 1
ok

> SHOW f
1 2
3 4

> SET g = sequence 1 2
ok

> SHOW g
1 3
5 7
```

```
> SET a = identity
ok

> SHOW a
1 0
0 1

> SET b = sequence 1 1
ok

> SHOW b
1 2
3 4

> SET c = scalar#add a 1
ok

> SHOW c
2 1
1 2

> SET d = scalar#add b 4
ok

> SHOW d
5 6
7 8

> SET d = scalar#mul a 1

> SHOW d
1 0
0 1

> SET e = scalar#mul c 2
ok

> SHOW e
4 2
2 4

> SET f = scalar#mul e 2
ok

> SHOW f
8 4
4 8
```

```
> SET a = identity
ok

> SET b = uniform 4
ok

> SET c = sequence 1 1
ok

> SHOW c
1 2
3 4

> SET d = matrix#add b c
ok

> SHOW d
5 6
7 8

> SET e = matrix#mul c a
ok

> SHOW e
1 2
3 4

> SET f = matrix#mul c d
ok

> SHOW f
19 22
43 50

> SET g = matrix#pow c 0
ok

> SHOW h
1 0
0 1

> SET i = matrix#pow c 4
ok

> SHOW i
199 290
435 634
```

```
> SET a = identity
ok

> SHOW a
1 0
0 1

> SET b = uniform 4
ok

> SHOW b
4 4
4 4

> COMPUTE sum a
2

> COMPUTE sum b
16

> COMPUTE trace a
2

> COMPUTE trace b
8

> COMPUTE minimum a
0

> COMPUTE minimum b
4

> COMPUTE maximum a
1

> COMPUTE maximum b
4

> COMPUTE frequency a 1
2

> COMPUTE frequency a 2
0
```

## Running the prototype

We have provided you with a prototype implementation of matrix computation engine that is accessible from the lab machines and undergraduate servers by running:

```
$ /labcommon/comp2129/bin/matrix
```

We suggest that you experiment with the prototype implementation, and also run and compare your own test cases against it. Your program must match the output of the prototype for all valid input.

## Writing your own testcases

We have provided you with some test cases but these do not test all the functionality described in the assignment. It is important that you thoroughly test your code by writing your own test cases.

You should place all of your test cases in the `tests/` directory. Ensure that each test case has the `.in` input file along with a corresponding `.out` output file. We recommend that the names of your test cases are descriptive so that you know what each is testing, e.g. `sum.in` and `trace.in`

## Submission details

You must submit your code in the assignment page on [ed](#). To submit, simply place your code into the code editor, click the run button to check your program works and then click the submit button.

You are encouraged to submit multiple times, but only your last submission will be marked.

## Marking

In this assignment correctness and performance are equally weighted. However, your submission will only be eligible for the performance component if it passes all of the correctness test cases.

**5 marks** are assigned based on automatic tests for the *correctness* of your program.

This component will use our own hidden test cases that cover every aspect of the specification.

To pass test cases your solution must produce the correct output within the imposed time limit.

**5 marks** are assigned based on the *performance* of your code relative to other students.

This component is tested on a separate machine in a consistent manner. The fastest submission will receive 5 marks, with successively slower solutions receiving lower marks. Any student who is faster than our basic parallel reference implementation will receive at least 2.5 marks.

Your program will be marked automatically, so make sure that you carefully follow the assignment specifications. Your program must match the exact output of the prototype and the test cases on [ed](#).

**Warning:** Any attempts to deceive or disrupt the marking system will result in an immediate zero for the entire assignment. Negative marks can be assigned if you do not properly follow the assignment specification, or your code is unnecessarily or deliberately obfuscated.