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# Introduction to High-Performance Computing

## **Exercise/2**

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# Agenda

- ✓ Exploit performance for matrix-matrix Multiplication
    - Fortran/C
  - ✓ Always check the results
  - ✓ Extract some Performance figure (in MFLOPs)
    - Change order of loops
    - Change size
    - With blocking
    - With unrolling
    - All together!!!!
  - ✓ Any available Compiler
  - ✓ Medium optimization level (-O2)
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# How to do

## ✓ Clone the repository

- `git clone https://github.com/gamati01/HPCLessons.git`

```
.
├── ESER1
│   ├── clean.sh
│   ├── compile.c.sh
│   ├── compile.fortran.sh
│   ├── EXERCISE1.pdf
│   ├── inc_precision.h
│   ├── mm.c
│   ├── mm.F90
│   ├── mod_tools.F90
│   └── README
├── LESSON1
│   ├── HPC-1.pdf
│   └── HPC-1-spoiler.pdf
└── README.md
```

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# Homework/1: Fill the table

Loop order	Size	Fortran	C
i, k, j	512*512		
j, k, i	512*512		
i, k, j	4096*4096		
j, k, i	4096*4096		

- ✓ Compiler used:
  - ✓ Compiler option used:
  - ✓ HW used:
-

## Homework/2: Fill the table

- ✓ Unrolling external loop

#unrolling	Size	Fortran	C
2	512*512		
4	512*512		
2	4096*4096		
4	4096*4096		

- ✓ Compiler used:
- ✓ Compiler option used:
- ✓ HW used:

## Homework/3: Fill the table

- ✓ Cache blocking: try a couple of blocking size...

#blocking	Size	Fortran	C
?	512*512		
?	512*512		
?	4096*4096		
?	4096*4096		

- ✓ Compiler used:
- ✓ Compiler option used:
- ✓ HW used:

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## Homework/4: Fill the table

- ✓ Put all together (blocking, unrolling,...)

#unrolling	#blocking	Size	Fortran	C
?	?	4096*4096		
?	?	8192*8192		

- ✓ Compiler used:
  - ✓ Compiler option used:
  - ✓ HW used:
-

# Homework/1

Loop order	Size	Fortran (MFLOPs)
i, k, j	512*512	221
j, k, i	512*512	6871
i, k, j	4096*4096	380
j, k, i	4096*4096	4170

- ✓ Compiler used: gcc, rel. 11.4.0
- ✓ Compiler option used: -O2
- ✓ HW used: AMD Ryzen 5 5625U



## Homework/2

Unrolling	Blocking	Fortran (Mflops)
-	-	5978
4*1*1	-	9626
-	64	10183
4*2*1	128	15623
4*4*1	128	17680

- ✓ Size=4096<sup>2</sup>
- ✓ Compiler used: gcc, rel. 11.4.0
- ✓ Compiler option used: -O3
- ✓ HW used: AMD Ryzen 5 5625U

# The code....

```
do jj = 1, n, step
do kk = 1, n, step
do ii = 1, n, step
  do j = jj, jj+step-1, 4
  do k = kk, kk+step-1, 4
  do i = ii, ii+step-1
    temp0 = a(i,k+0)
    temp1 = a(i,k+1)
    temp2 = a(i,k+2)
    temp3 = a(i,k+3)
    c(i,j+0)=c(i,j+0)+temp0*b(k+0,j+0)+temp1*b(k+1,j+0)+temp2*b(k+2,j+0)+temp3*b(k+3,j+0)
    c(i,j+1)=c(i,j+1)+temp0*b(k+0,j+1)+temp1*b(k+1,j+1)+temp2*b(k+2,j+1)+temp3*b(k+3,j+1)
    c(i,j+2)=c(i,j+2)+temp0*b(k+0,j+2)+temp1*b(k+1,j+2)+temp2*b(k+2,j+2)+temp3*b(k+3,j+2)
    c(i,j+3)=c(i,j+3)+temp0*b(k+0,j+3)+temp1*b(k+1,j+3)+temp2*b(k+2,j+3)+temp3*b(k+3,j+3)
  enddo
  enddo
  enddo
enddo
enddo      enddo
```