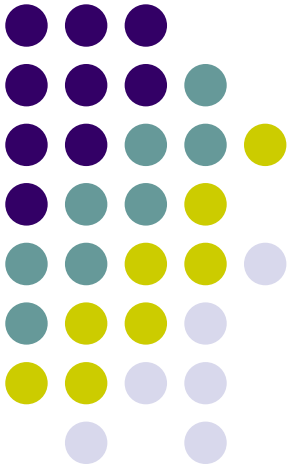
2017 Practical Parallel Computing (実践的並列コンピューティング) No. 2

Parallel Programming Models



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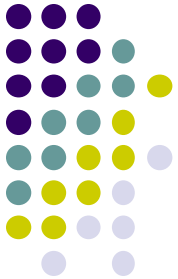
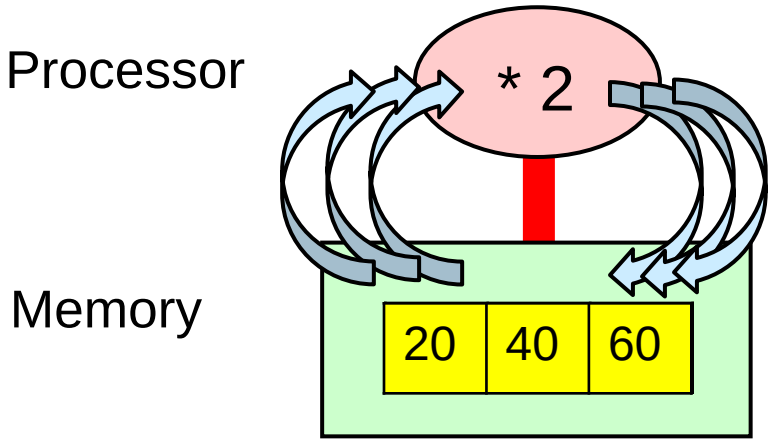
Computation on Computer Architecture



- Computation (Software) = Algorithm + Data
- Architecture (Hardware) = Processor + Memory

Note: This is so simplified discussion

Computer Architecture



Computation Example

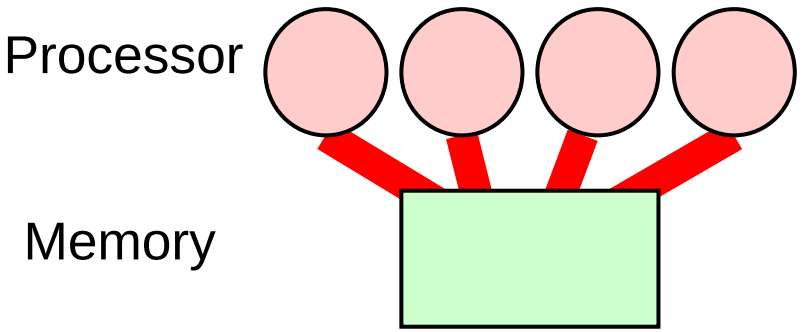
```
int a[3] = {10, 20, 30};
int i;

for (i = 0; i < 3; i++) {
   a[i] = a[i] *2;
}
```

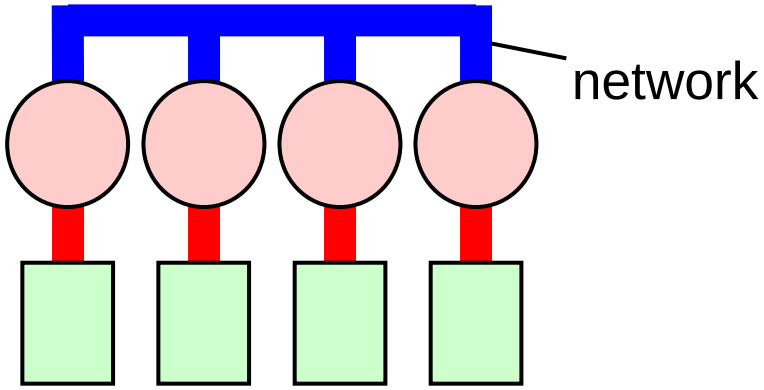
What is Parallel Architecture?

- Parallel architecture has MULTIPLE components
- Two basic types:

Shared memory parallel architecture



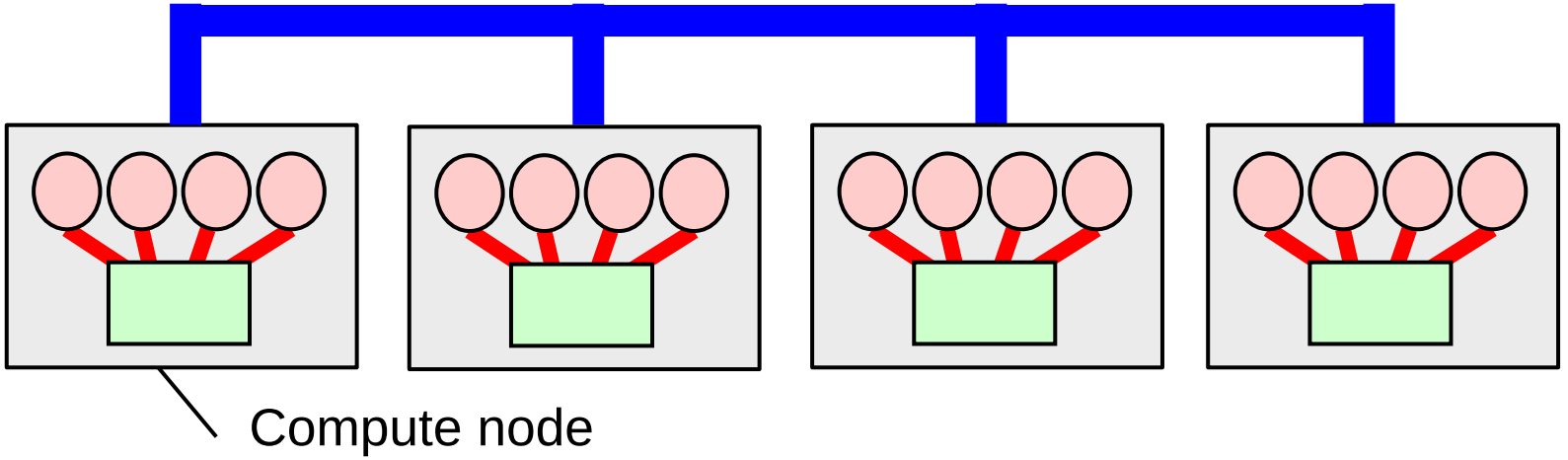
Distributed memory parallel architecture



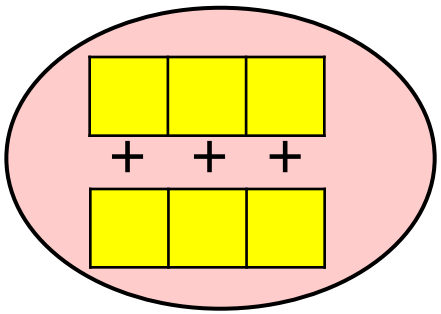
- Different programming methods are used for different architecture

Modern SCs use Both!

Modern SCs are combination of “shared” and “distributed”
“shared memory” in a node
“distributed memory” among nodes, connected by network

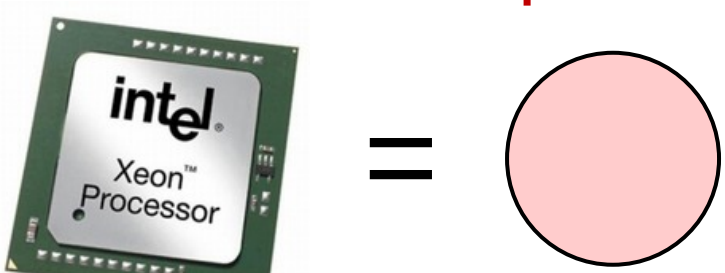


※ Moreover, each processor (core) may have *SIMD parallelism* , such as SSE, AVX…
A processor (core) can do several computations at once
SIMD is out of scope of this class



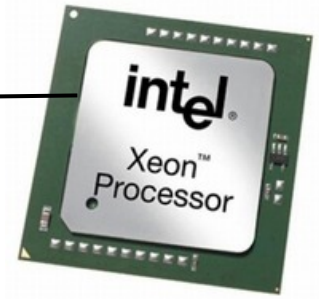
(Confusing) Terminology

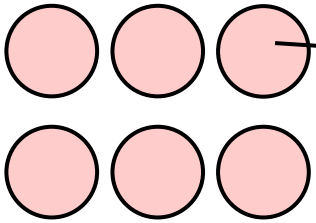
- In old days, definition of "processor" was simple



- Around 2000 or later, "multicore processor" became popular

A processor package



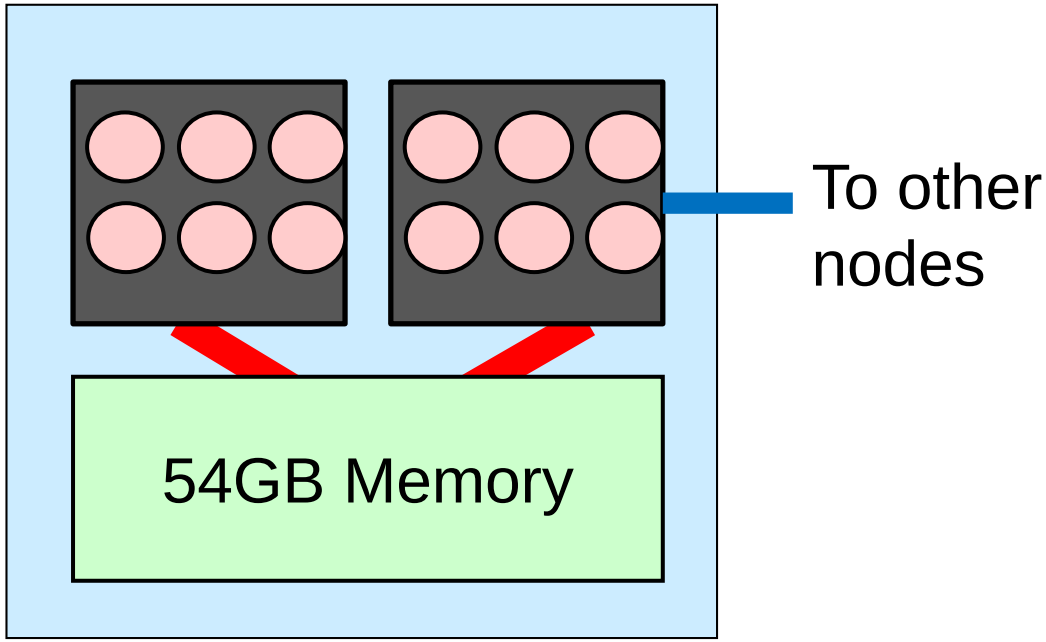


A processor core

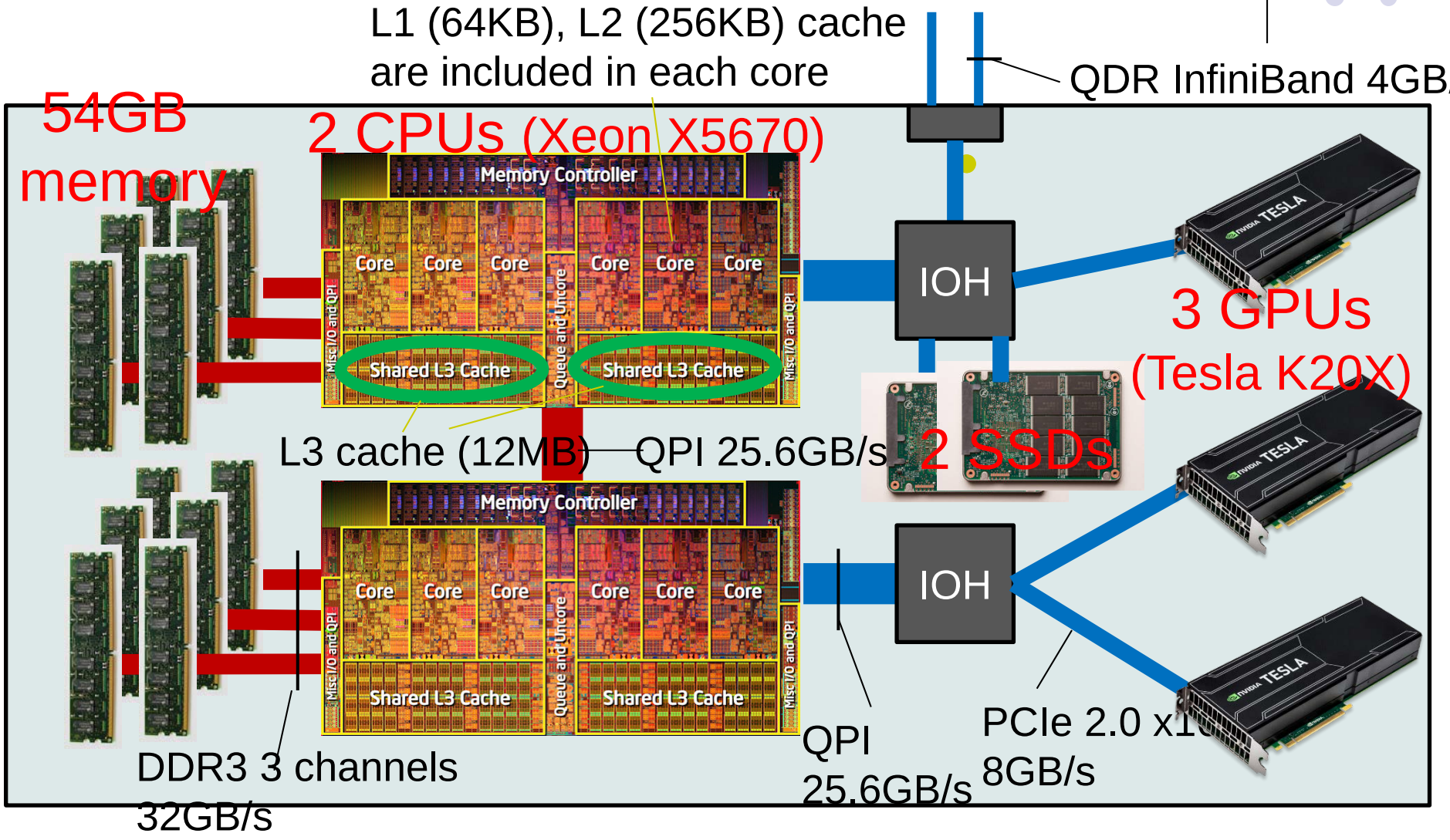
※ *Hyperthreading* makes discussion more complex, but skipped

TSUBAME2 Node

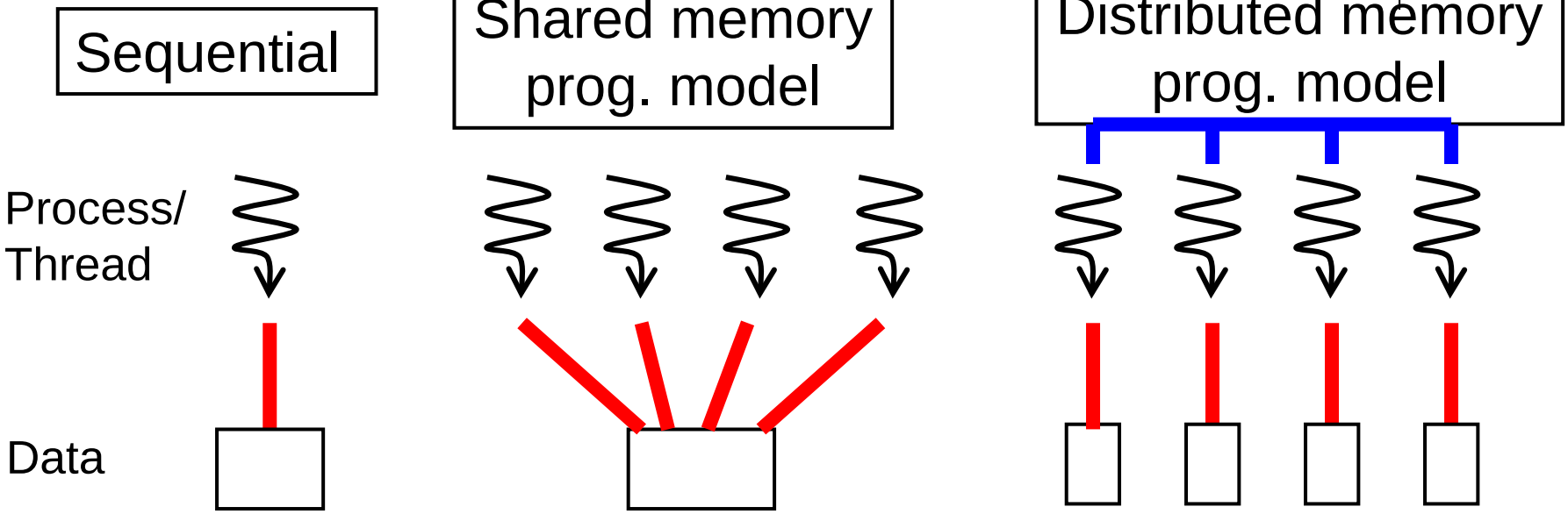
- 2 processor packages × 6 cores
  - 12 cores share memory



TSUBAME2 Node in More Detail



Classification of Parallel Programming Models

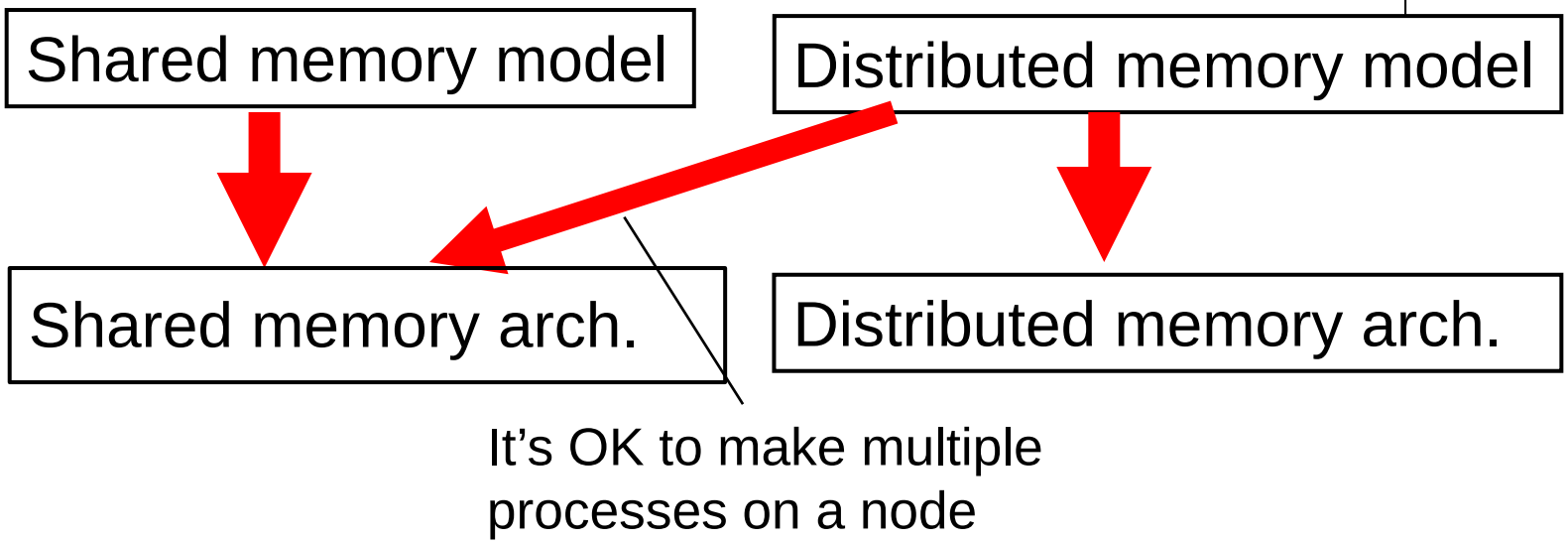


Programming without parallelsim

Threads have access to shared data
- OpenMP
- pthread
- Java thread…

Need communication among processes
- MPI
- socket
- Hadoop, Spark…

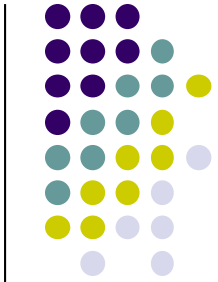
Programming Models on Architecture



When considering architecture,

- Shared memory model can use only cores in a single node (up to 12 cores on TSUBAME2)
- Distributed memory model supports large scale parallelism (>1,000 cores on TSUBAME2)

In This Course



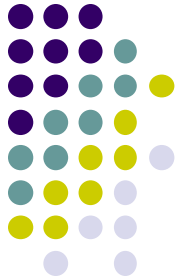
Part1: Shared Memory Parallel Programming with OpenMP

Part2: Distributed Memory Parallel Programming with MPI

Part3: GPU Programming with CUDA

- Uses knowledge both of shared/distributed

TSUBAME Account



- Students of this course will become members of "t2g-ppcomp" TSUBAME group
  - Use t2sub command with "-W grouplist=t2g-ppcomp"

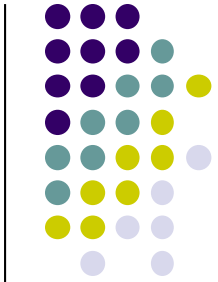
Please do the following by Apr 20 (earlier is better)

- Please make your account on TSUBAME2
  - Tokyo Tech Portal (portal.titech.ac.jp) → TSUBAME2 Portal
- Please send an e-mail to ppcomp@el.gsic.titech.ac.jp

Subject: TSUBAME2 ppcomp account
To: ppcomp@el.gsic.titech.ac.jp

Lab name
Department name
School year
Name
Your TSUBAME account name

Next Class: Introduction to OpenMP



- Shared memory parallel programming API
- Extensions to C/C++, Fortran
- Includes directives& library functions
  - Directives:#pragma omp ~~

```
   int s = 0;
   int i;
#pragma omp parallel for
  for (i = 0; i < 100; i++)
   {
        a[i] = b[i]+c[i];
  }
```