SURFsara HPC Cloud Workshop

Design a Parallel Application

www.cloud.sara.nl → Tutorial-2014-06-11

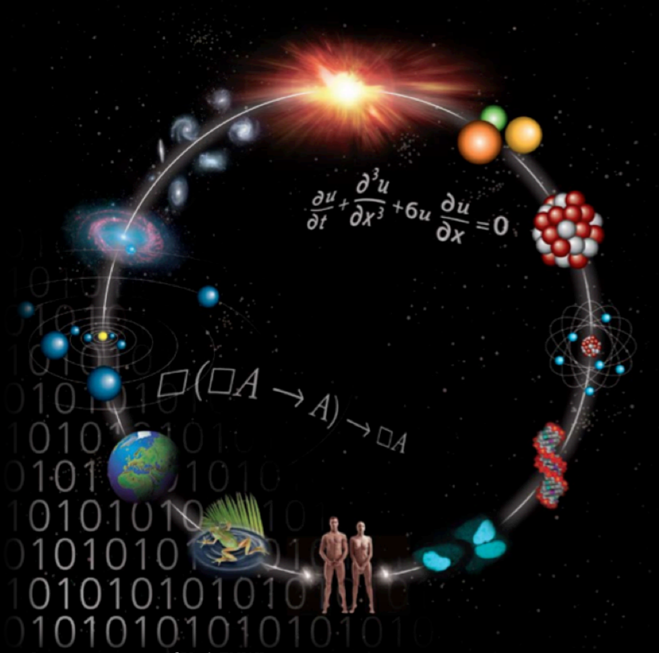
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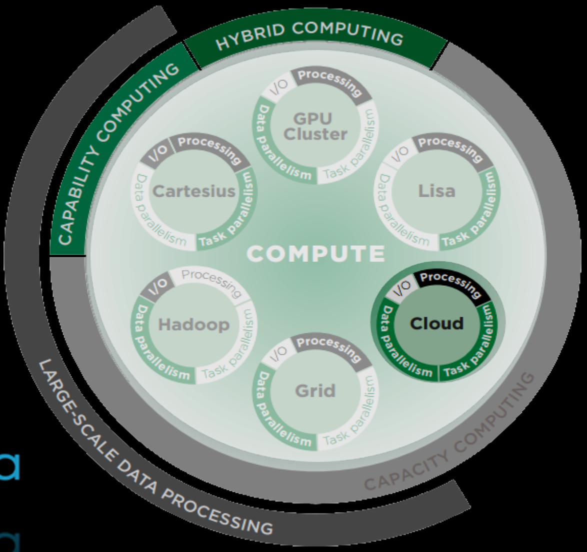
Image: courtesy of UvA FNWI


HYBRID COMPUTING

CAPABILITY COMPUTING

CAPACITY COMPUTING

LARGE-SCALE DATA PROCESSING

COMPUTE

GPU Cluster

Cartesius

Lisa

Hadoop

Cloud

Grid

VO

Processing

Data parallelism

Task parallelism

UvA HPC and Big Data Course June 2014
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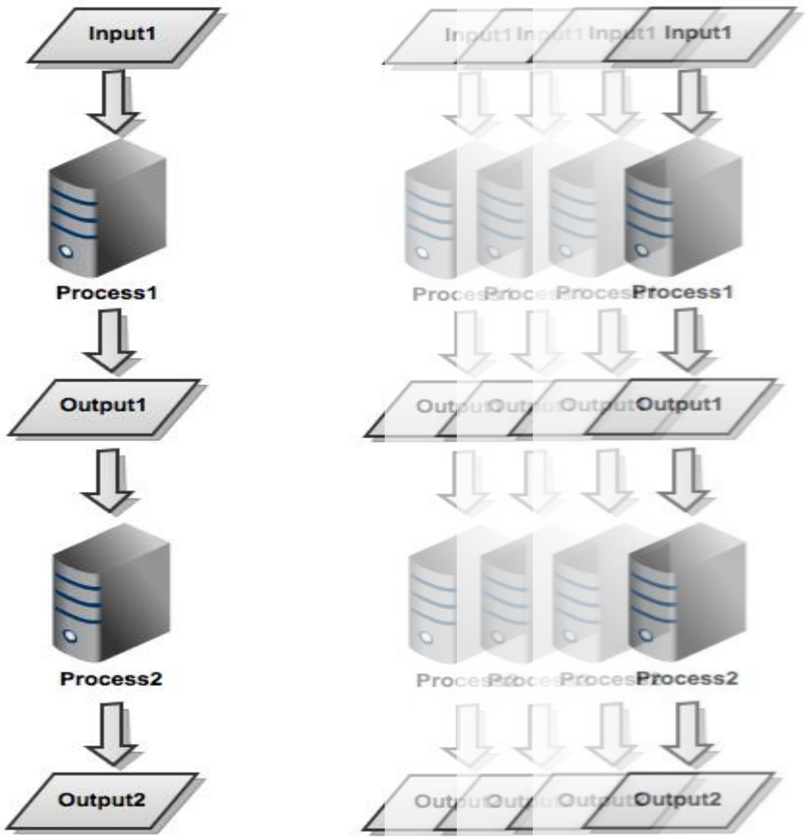
Agenda

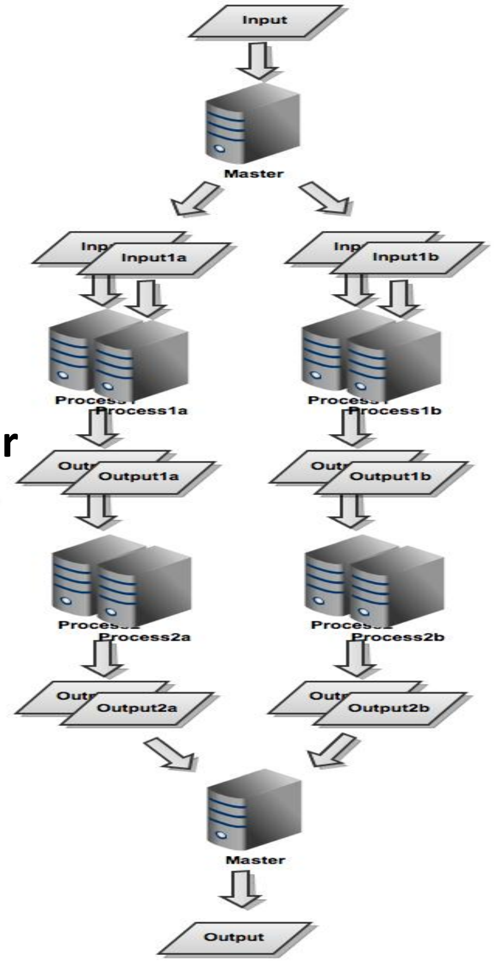
- ❑ **Think parallel**
- ❑ **Distributed vs. Parallel Computing**
  - Memory architectures
    - ✓ OpenMP & MPI
- ❑ **Designing Parallel applications**
  - Data & Functional parallelism
  - CPU time vs. Wall clock
  - Amdahl's Law
- ❑ **Hands-On: Tutorial 2014-06-11 MonkeySheet-Extras**
  - Calculation of an estimate of pi:
    - ✓ MPI
    - ✓ OpenMP (assignment)

Think parallel



Divide and conquer

Partitioning data/tasks

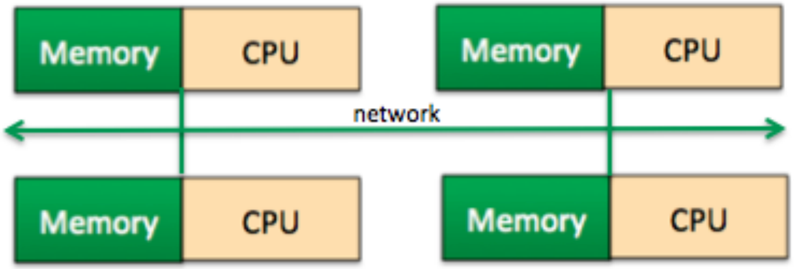


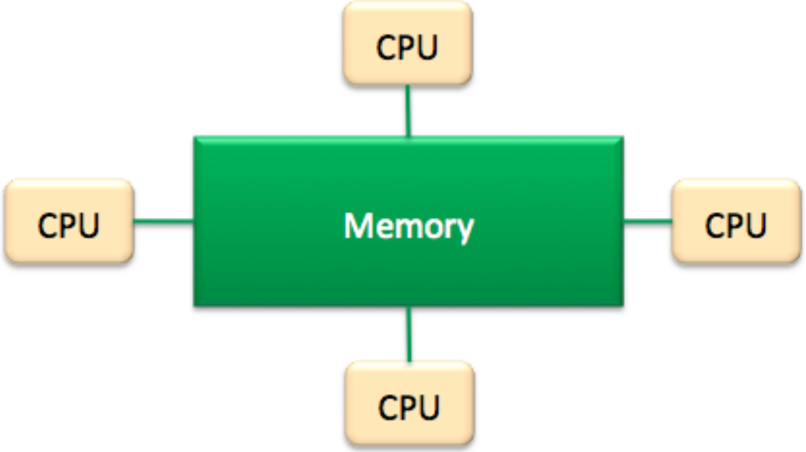
Distributed vs. Parallel systems

- ❑ **Distributed Computing**
  - Remote resources across multiple computers
  - Interconnected via network
  - Loosely coupled
- ❑ **Parallel systems**
  - Shared memory across multiple CPUs in a single computer
  - Fast data sharing
  - Tightly coupled

Memory architectures

- ❑ **Distributed memory systems**
  - Each CPU has its own memory
  - Message passing
  - eg. MPI:
    - ✓ Message Passing Interface
    - ✓ Communication overhead limits performance
- ❑ **Shared memory systems**
  - All CPUs access the same memory
  - Very fast
  - eg. OpenMP
    - ✓ Multicore programming
    - ✓ Fork/join threads





Designing parallel applications (1/2)

- ❑ **Which Design model to choose?**
  - Multiple threads in one core
  - Multiple cores in a single machine
  - Multiple single core interconnected machines
  - Multiple multicore interconnected machines

- ❑ **Parallelization method:**
  - Partitioning Tasks
  - Partitioning Data

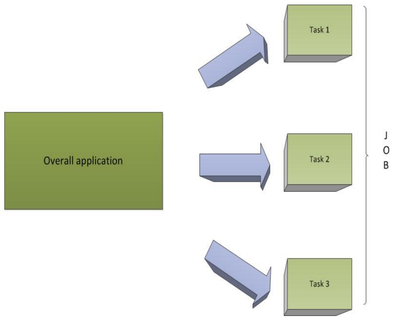
Designing parallel applications (2/2)

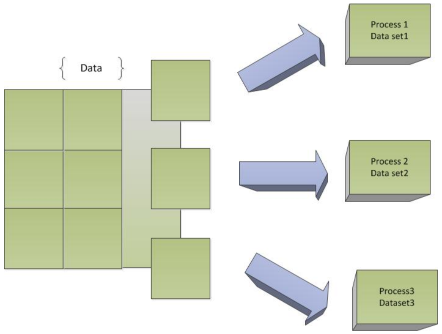
❑ **Rule of thumb:**

- place tasks that are able to execute concurrently on different processors: enhance concurrency
- place tasks that communicate frequently on the same processor: increase locality

❑ **Steps to simplify code parallelization:**

1. ***Partitioning***: decompose the problem into smaller tasks.
2. ***Communication***: overhead is smaller for shared memory systems than for distributed systems
3. ***Agglomeration & Mapping***: make realistic decisions & map the tasks among processing units





❑ **Granularity**

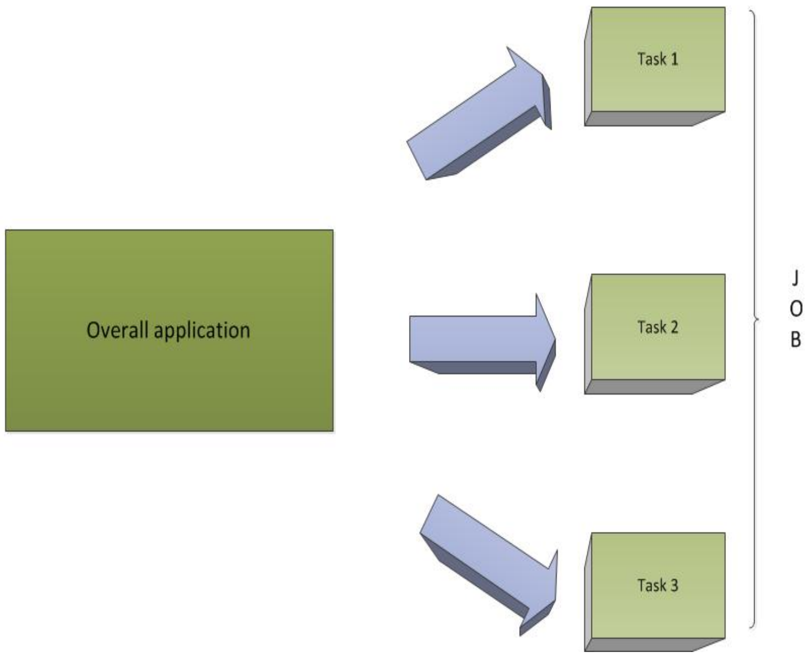
❑ **Optimization**

Check the time spent on message passing

Partitioning Tasks

Functional partitioning: a different task on the same (or different) data

Divide the application modules into small pieces (subtasks) and assign each to a separate processing element.



Useful for:

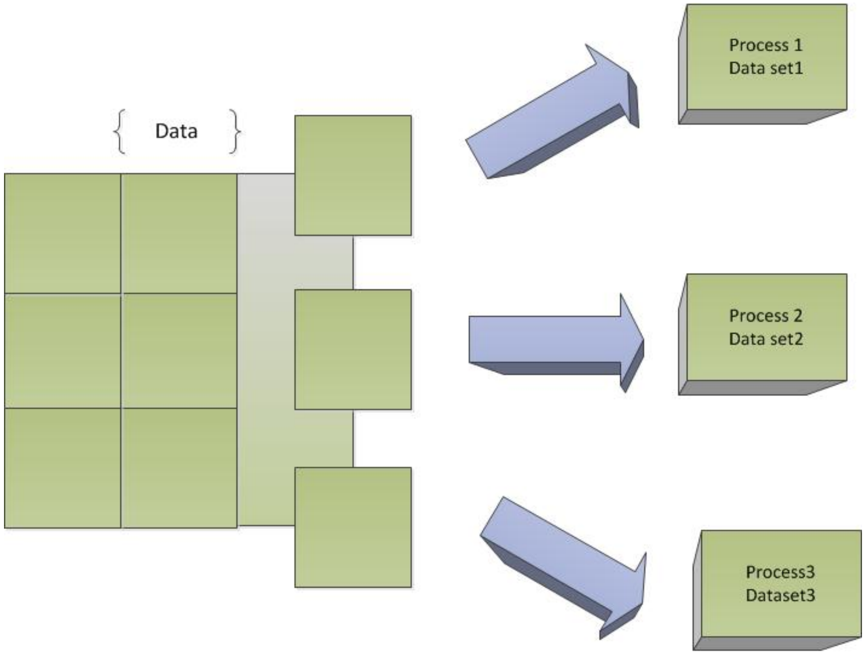
- reducing overall problem complexity

Drawbacks:

- dependencies between tasks, e.g. wait for intermediate results
- overlap of tasks may lead to shared data

Partitioning Data

- ❑ ***Data partitioning*** **: apply the same task on different data**
  - *Load balancing:* ensure that data blocks are roughly the same size to avoid threads waiting for a larger block of data to finish.



Useful for:

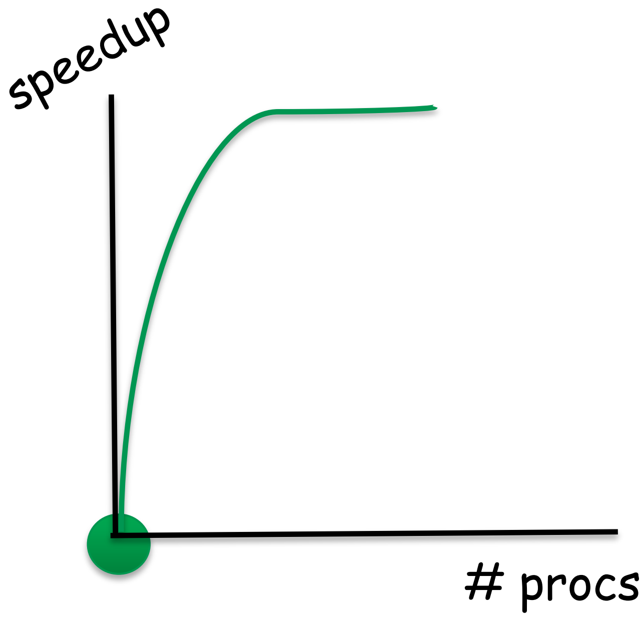
- large data sets
- independent data tasks

Drawbacks:

- The more tasks, the higher communication overhead!

Performance pick... Amdahl's law

- ❑ **Parts of a program can be parallelized**
- ❑ **Other parts *must* execute sequentially**
  - Amdahl's law:



CPU vs. Wall clock time

- ❑ **CPU Hour (CH):**

  the time that the processor is actively working on a certain task.

- ❑ **Wall-clock time:**

  the real time taken by a computer to complete a job.

- ❑ **The less wall clock time:**
  - ▪ the higher the degree of parallelization
  - ▪ the more CPU time a program will use

For programs executed sequentially, CPU time is close to wall-clock time. For programs executed in parallel, CPU time is the sum of all the CPUs taking part in the process.

Hands on - Calculation of an estimate of pi

- ❑ **MPI (Tutorial 2014-06-11 MonkeySheet-Extras)**
  - Start a virtual cluster with 1 CPU VMs and a Linux distribution
  - Install Open MPI
  - Observe the performance on:
    - ✓ the master machine only
    - ✓ the virtual cluster (multiple VMs)
- ❑ **OpenMP (assignment)**
  - Start a VM with 2 CPUs and a Linux distribution
  - Scale up to more CPUs
  - Observe the performance for:
    - ✓ serial calculation
    - ✓ OpenMP optimized implementations

Hands On

Support portal: https://www.cloud.sara.nl

Search: *Tutorial 2014-06-11 MonkeySheet-Extras*

Self-service portal: https://ui.cloud.sara.nl

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