

Welcome to the course

PARALLEL PROGRAMMING IN R



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Prerequisites

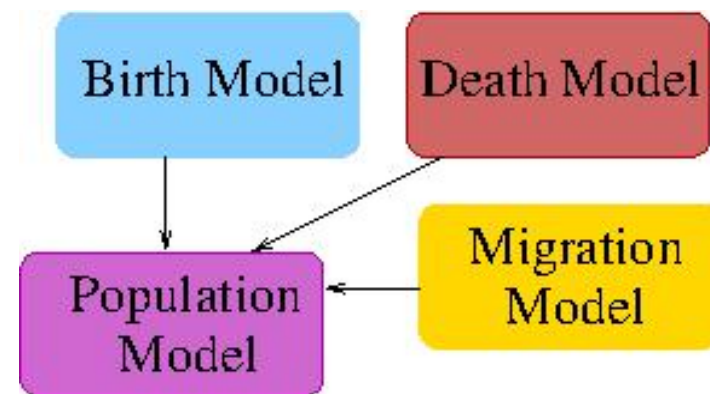
- Writing Efficient R code
- Optimized sequential code
- Benchmark your code

Overview

1. Methods of parallel programming & supporting R packages
2. The `parallel` core package in detail
3. Packages `foreach` and `future.apply`
4. Random numbers & reproducibility and final example

Splitting computation problems for parallel processing

I. By Tasks



II. By Data



1	8	13	12
14	11	2	7
4	5	16	9
15	10	3	6

Summary of partitioning

1. **By Task:** Apply different tasks to the same or different data.
2. **By Data:** The same task is performed on different data.

Example (splitting by data):

$$1 + 2 + 3 + \dots + 100$$

```
sum(1:25) + sum(26:50) + sum(51:75) + sum(76:100)
```

Embarrassingly parallel applications

Many such independent tasks = embarrassingly parallel

E.g., many statistical simulations of the structure (in pseudo-code):

```
initialize.rng()  
for (it in 1:N) result[it] <- myfunc(...)  
process(result, ...)
```

Let's practice!
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Models of parallel computing

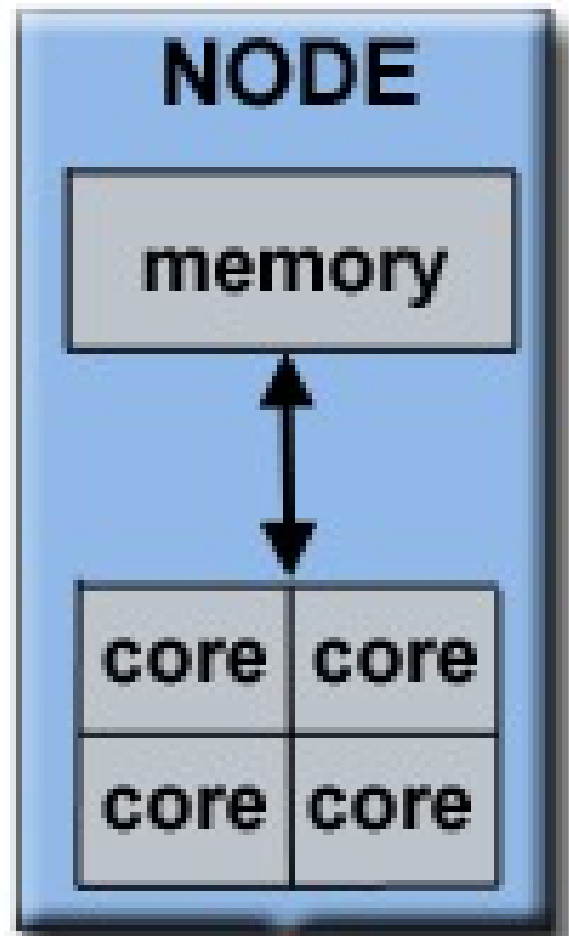
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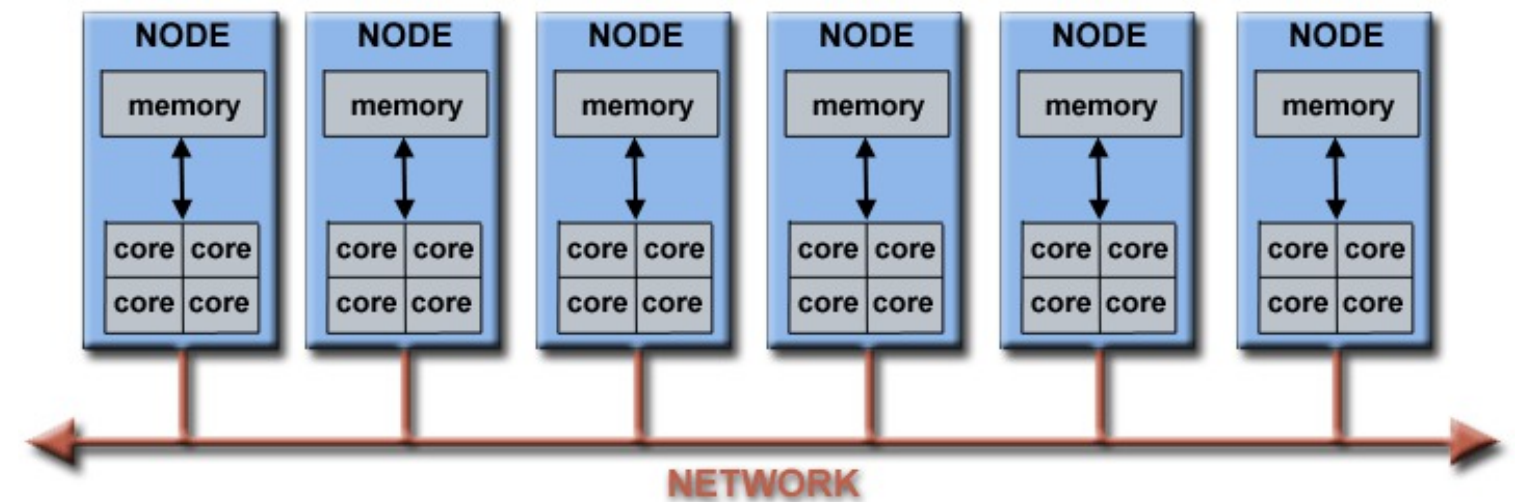
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Hardware - Central processing unit (CPU)

I. **Multi-processor** (CPU, core) computer

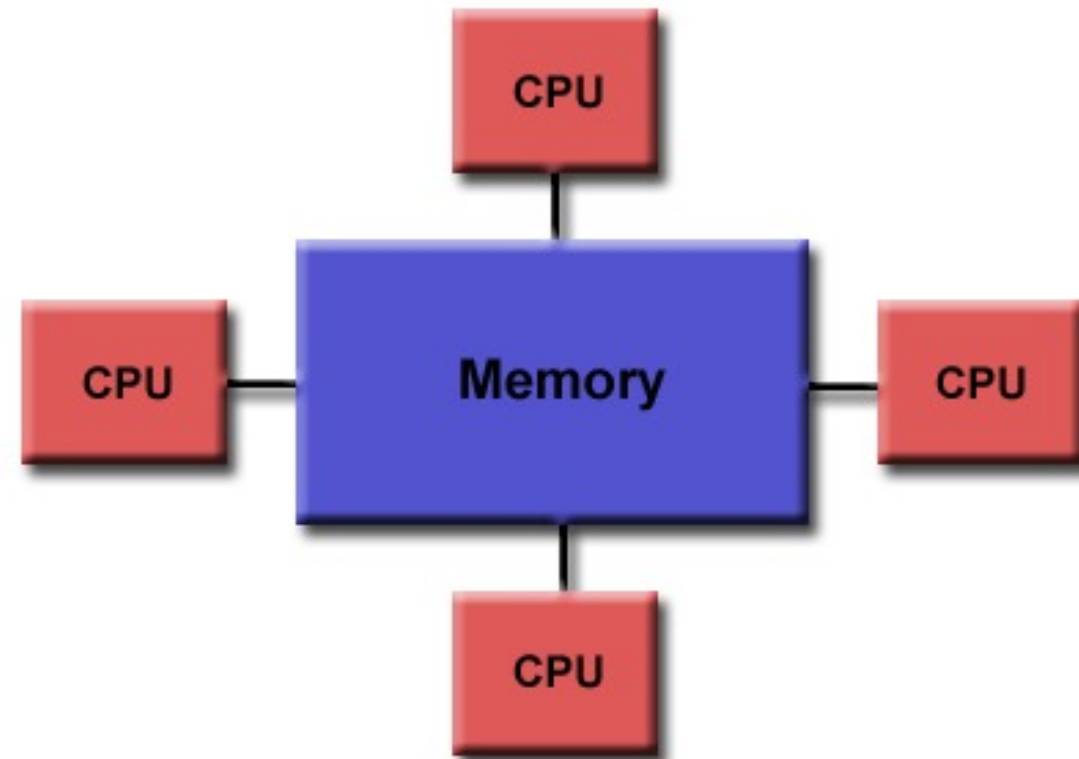


II. **Cluster** of single- or multi-processors computers



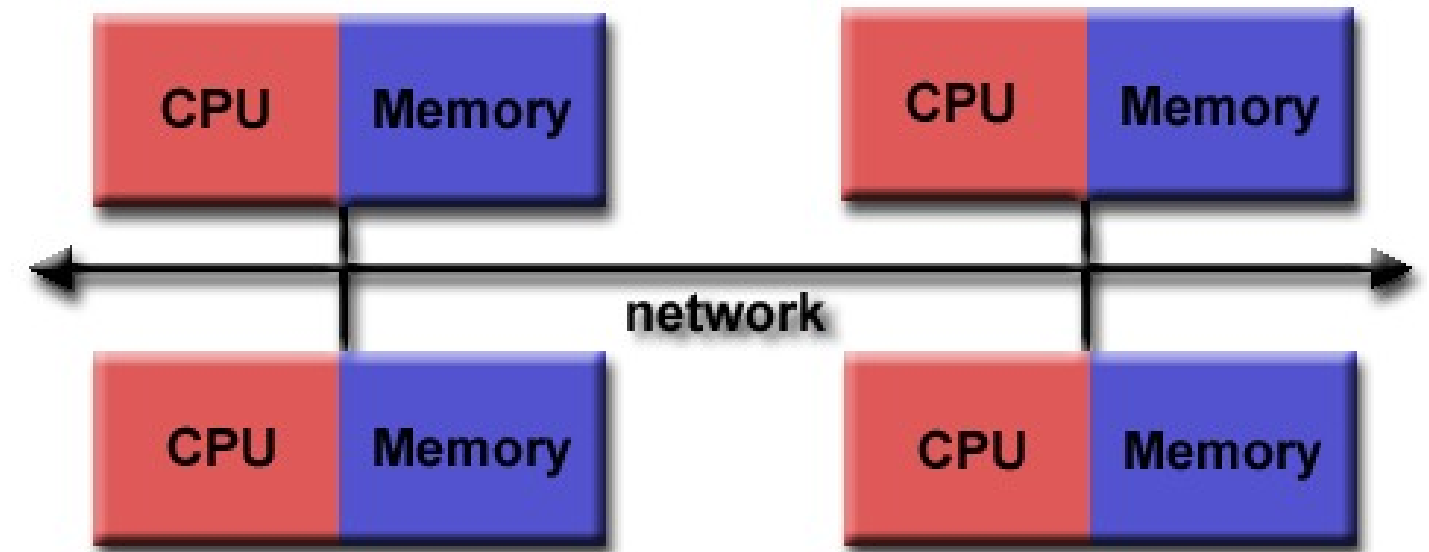
Hardware - Memory

- Shared memory



- Shared memory software
- Message-passing software

- Distributed memory



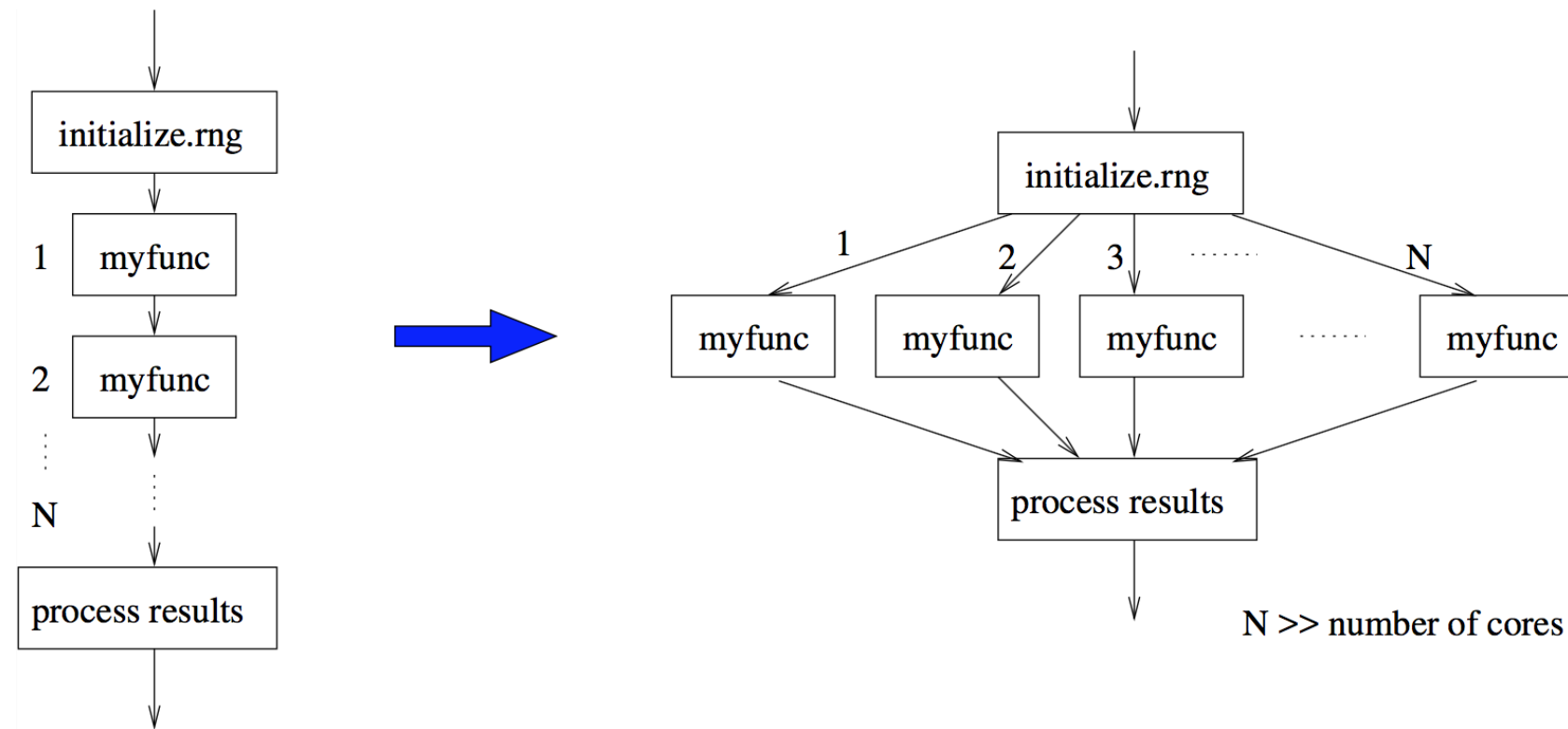
- Message-passing software

Programming paradigms

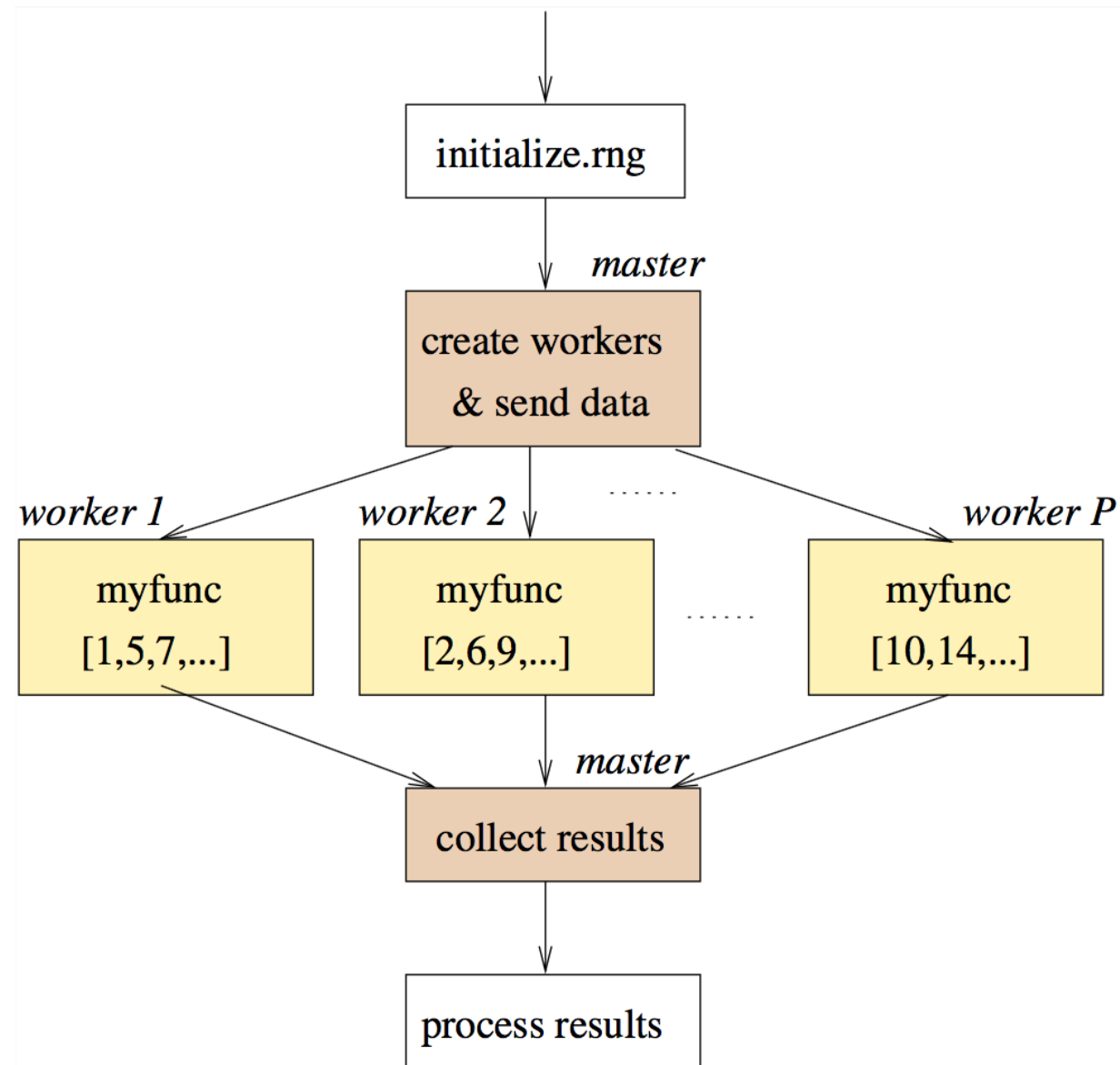
- Master-worker model
- Map-reduce paradigm
 - applications for distributed data
 - Hadoop, Spark
 - **Scalable Data Processing in R**

Master-worker model (1)

```
initialize.rng()  
for (it in 1:N) result[it] <- myfunc(...)  
process(result, ...)
```



Master-worker model (2)



Let's practice!
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R packages for parallel computing

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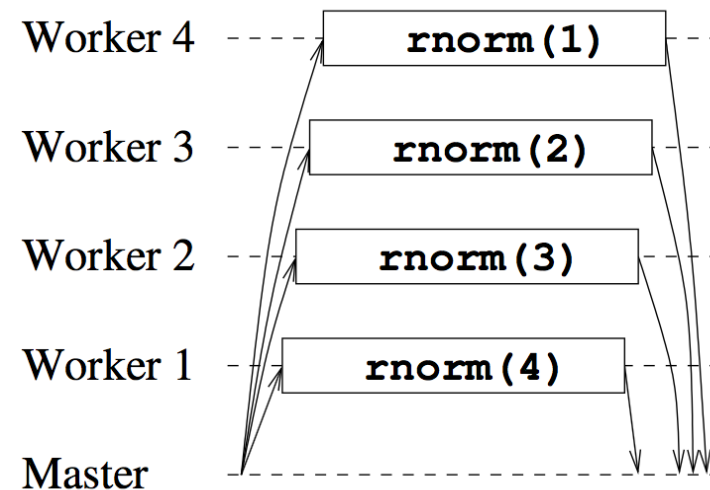
R packages

- Core package: `parallel`
- Parallel support for big data:
 - `sparklyr` , `iotools`
 - `pbdR`
- Embarrassingly parallel, master-worker model:
 - `foreach` , `future.apply`
 - `snow` , `snowFT` , `snowfall`
 - `future`

Package parallel

```
library(parallel)
ncores <- detectCores(logical = FALSE)
cl <- makeCluster(ncores)
clusterApply(cl, x = ncores:1, fun = rnorm)
stopCluster(cl)
```

`ncores = 4` \rightarrow `x = c(4, 3, 2, 1)`



Let's practice!
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