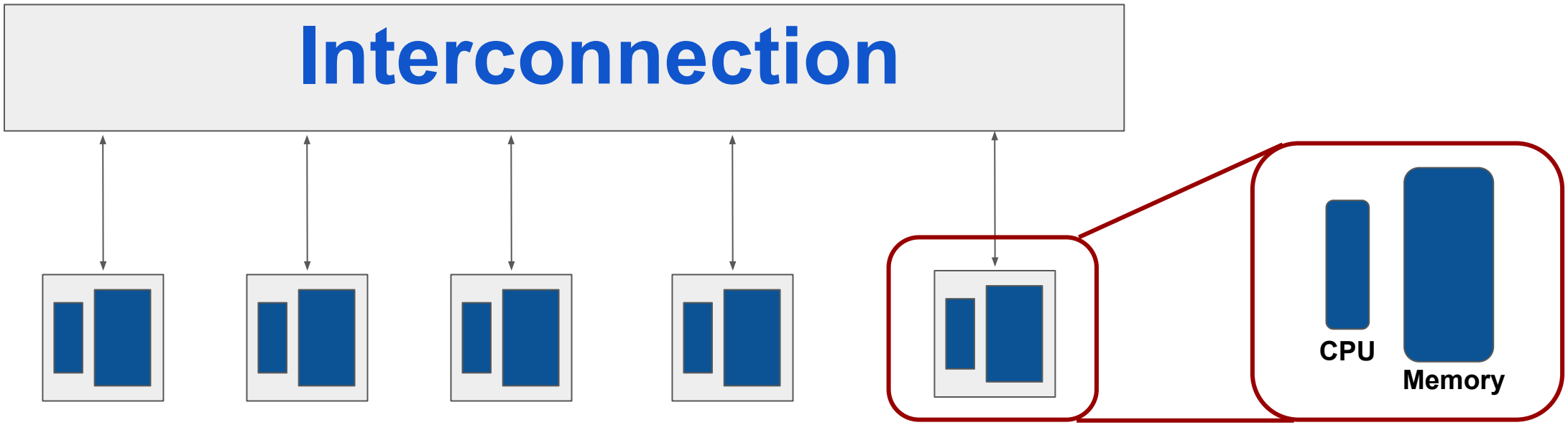
LogP: Towards a Realistic Model of Parallel Computation

1. Parallel Machine Models

What are they?

- Generalization of a parallel system, simulating its behavior.
- Use of some of their properties. Some may not be considered in order to have a practical model.



1. Parallel Machine Models

Why have them?

- Basis for the design and analysis of algorithms that can be implemented effectively on a wide variety of parallel machines.
- Better understanding of the system without having to worry about too specific and not important operations.

What is a good model?

Simple and realistic: simple to facilitate understanding and programming, and realistic to ensure that programs developed for the model execute with reasonable efficiency on real computers.

2. Old Models and their issues

- **PRAM**

  >Most popular model.

  >Assumes **infinite bandwidth**, **zero latency** and **zero overhead**.

  >Too simple to observe practical situations, as bottlenecks in the network.

- **BSP**

  >Assumes a special hardware to synchronize all processors.

  >Sometimes, messages between the machines already received cannot be used until a new cycle(superstep) comes in.

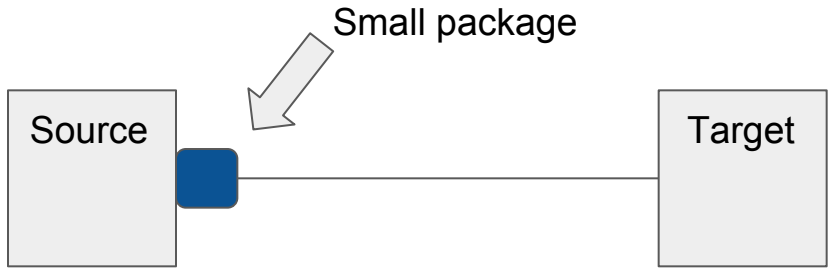
3. Introduction to LogP

- “Model of parallel computation for design and analysis of fast portable parallel algorithms”
    - LogP: towards a realistic model of parallel computation (1993)

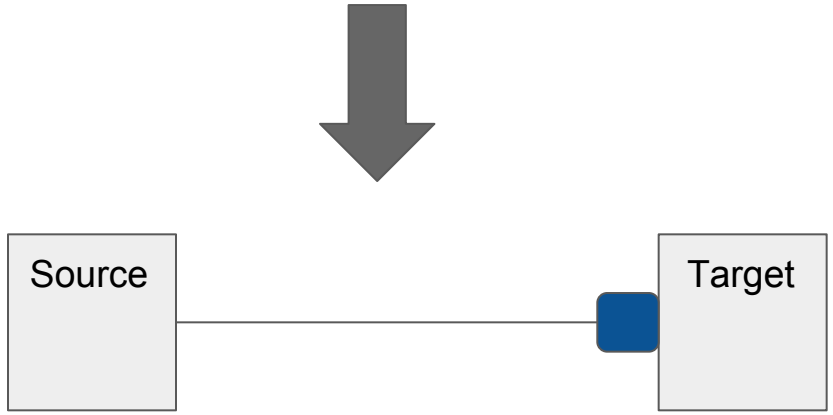
- Realistic model

- Good balance of variables, with simplicity and detailing.

4. Latency and processors



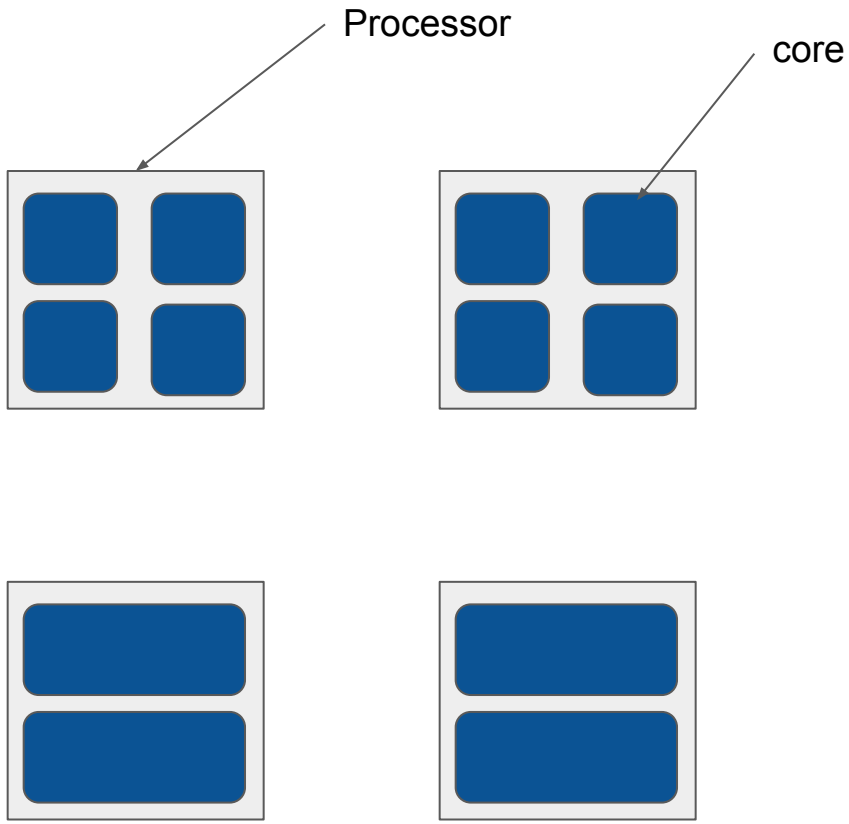
initialTime = 0 cycles of the processor.



finalTime = 4 cycles of the processor.

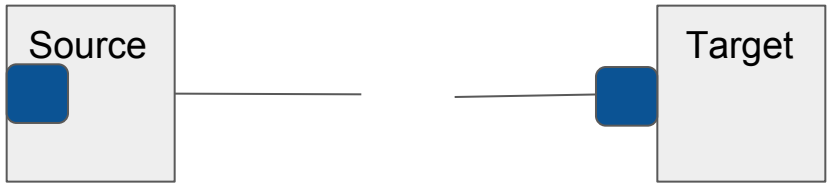
Latency = finalTime - initialTime

L = 4 cycles of the processor

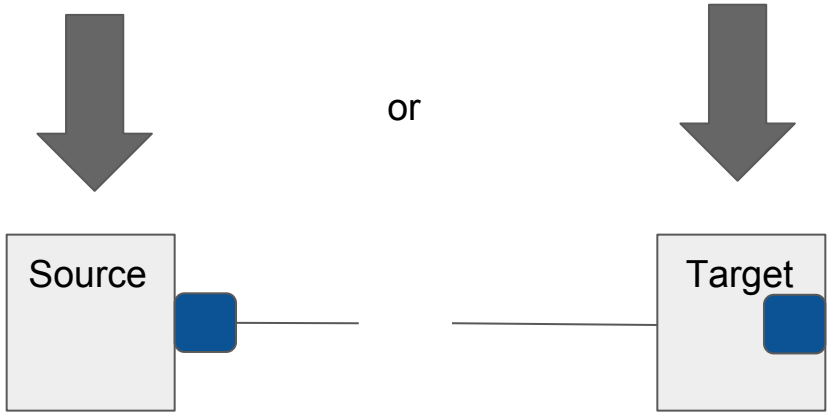


p = 4

5. Overhead and gap



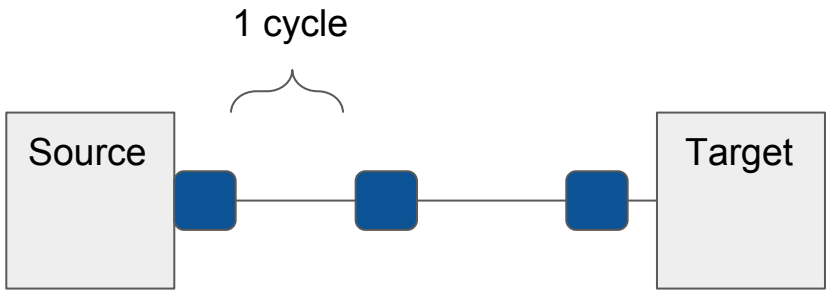
initialTime = 0 cycles of the processor.



finalTime = 2 cycles of the processor.

overhead = # of cycles the processor is engaged in **transmit or receive** a message.

o = 2 cycles of the processor



gap = minimal interval between messages transmission.

g = 1.

6. Discussion of parameters

- Ignore some parameters depending to the situation

- When is it better to do the work alone and when to distribute it?

7. Algorithm example

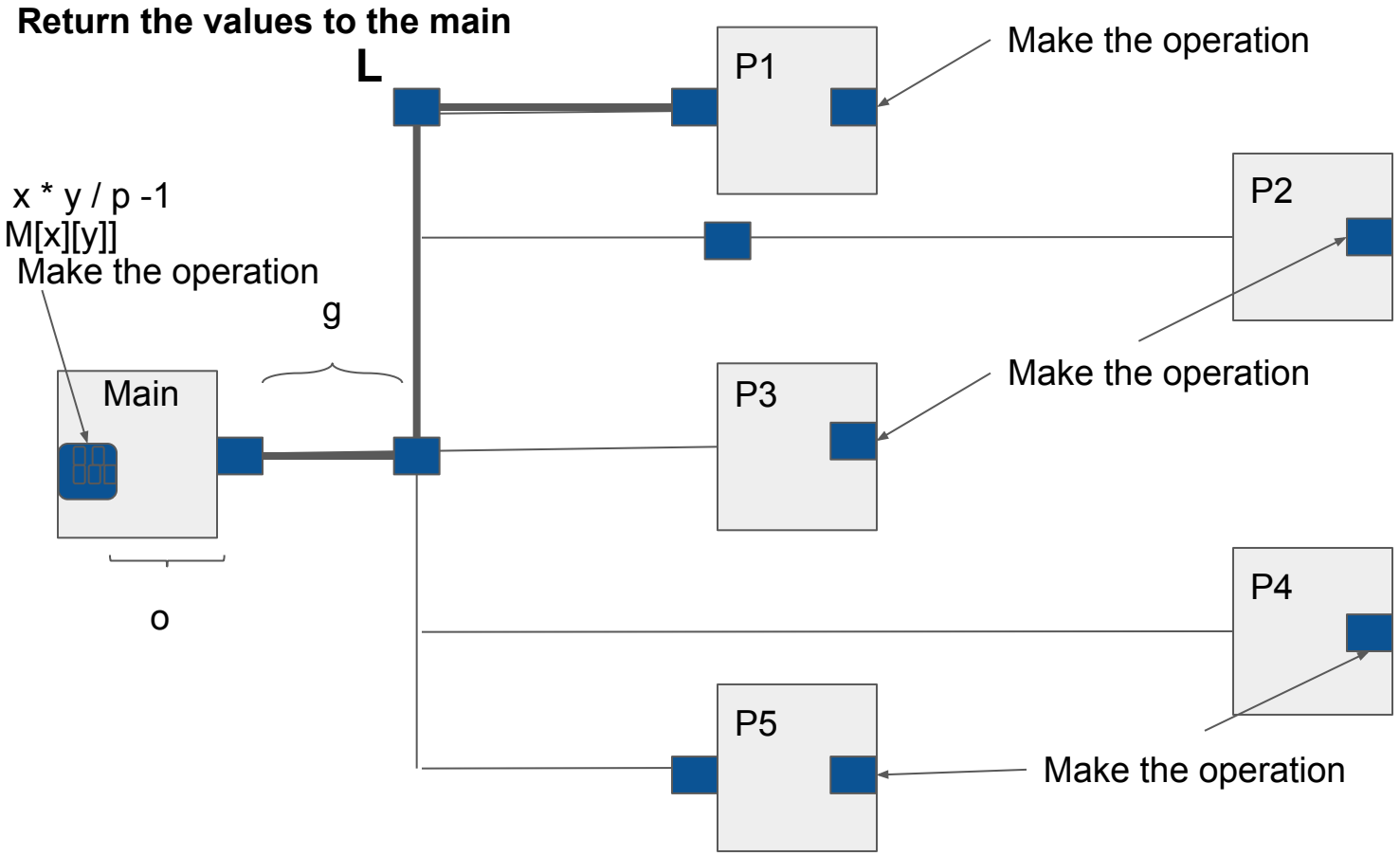
- Sum all the elements of a matrix
- Divide the work through the processors.
- Execute the final operation in the main processor
- $2L + 4o + 2*(p-2)g$
- $O(L+o+p*g)$

8. Algorithm example

- Sum all the elements of a matrix

M[x][y] =

4	3	6	1	9
8	7	5	3	6
7	9	5	8	6
-3	7	-5	1	4
0	9	8	2	2



T = 0

T = o

T = o + g

T = o + 2g

T = L + o + 3g

T = L + o + 4g

T = L + 2o + 4g

T = 2L + 4o + 8g

9. Applying to real machines

Considering a message with M bits long and T the number of cycles to complete the communication

1. **Send overhead**
2. **Transmission** through a network
   w = channel width
3. Time for the **last bit cross the network**
   H = number of hops
   r = delay through each intermediate node
4. **Receive overhead**

9. Applying to real machines

$$T(M,H) = Tsnd + \lceil M/H \rceil + Hr + Trcv$$

Machine	Network	Cycle ns	w bits	Tsnd + Trcv cycles	r cycles	avg. H (1024 Proc.)	T(M=160) (1024 Proc.)
nCUBE/2	Hypercube	25	1	6400	40	5	6760
CM-5	Fattree	25	4	3600	8	9.3	3714
Dash	Torus	30	16	30	2	6.8	53
J-Machine	3d Mesh	31	8	16	2	12.1	60
Monsoon	Butterfly	20	16	10	2	5	30

10. Advantages vs disadvantages

Disadvantages

- Long messages doesn’t have special treatment
- Processor cache is not considered
- Not ideal for all the cases(infrequently communications)

Advantages

- Realistic model for algorithm analysis
- Can detect network bottlenecks

11. Summary

The LogP model tries to represent the parallel machines in a realistic and simple way having a small number of parameters: latency(L), overhead(o), bandwidth(g) and the number of processors(P).

Contributions

- Analysis of performance and execution of present algorithms
- Stimulate the development of new parallel algorithms

12. Bibliography

Foster, Ian. (1995). *A Parallel Machine Model*. Retrieved from https://www.mcs.anl.gov/~itf/dbpp/text/node8.html

Culler, David; Karp, Richard; Patterson, David; Sahay, Abhijit; Schauser, Klaus Erik; Santos, Eunice; Subramonian, Ramesh; Von Eicken, Thorsten. (July 1993). *LogP: Towards a realistic model of parallel computation*.