

Parallel Computing - MPI

Message Passing Interface - Introduction



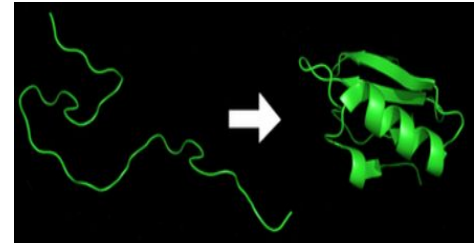
Mr. Om Jadhav
Senior Technical Officer
HPC - Tech, CDAC Pune
(omjadhav@cdac.in)

Agenda

- Why Parallel Computing ?
- Why we need ever-increasing Performance ?
- Parallel programming Architectures/Model ..
- MPI - Message Passing Interface
 - What is MPI ?, Need and Evolution of MPI.
 - MPI program - Compile and Execution
 - MPI Program Structure
 - MPI Routines
 -

Why we need Ever-Increasing Performance ?

- Accurate medical imaging
- Fast and accurate web searches
- Realistic computer games, Entertainment
- Climate modeling
- Protein folding
- Artificial Intelligence
- Energy research
- Data analysis
-

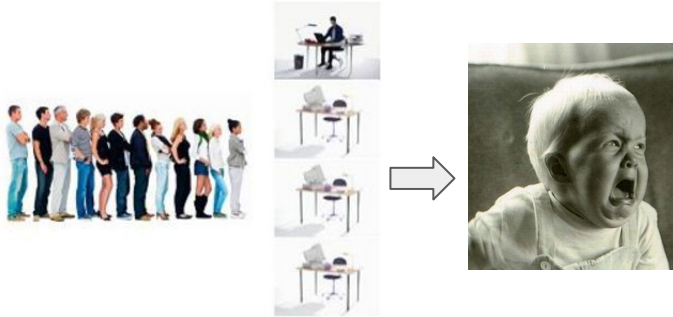


Why Parallel Computing ?

- Aren't single processor systems fast enough ?

Why Parallel Computing ?

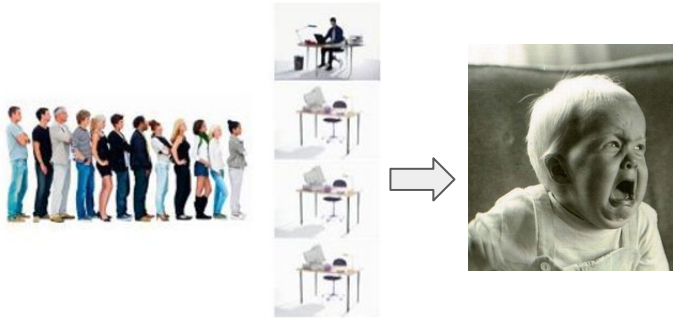
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Serial Computing

Why Parallel Computing ?

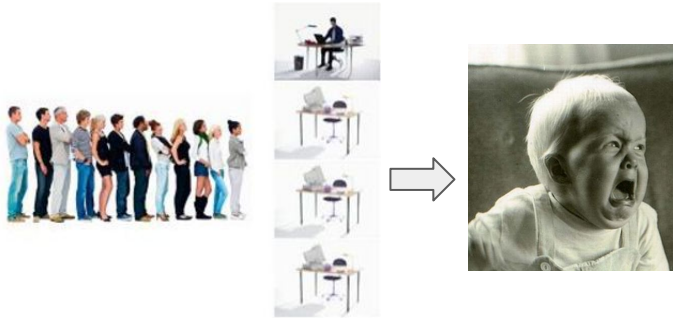
- Aren't single processor systems fast enough ?
- Why to build parallel systems ? Why build systems with multiple processors ?



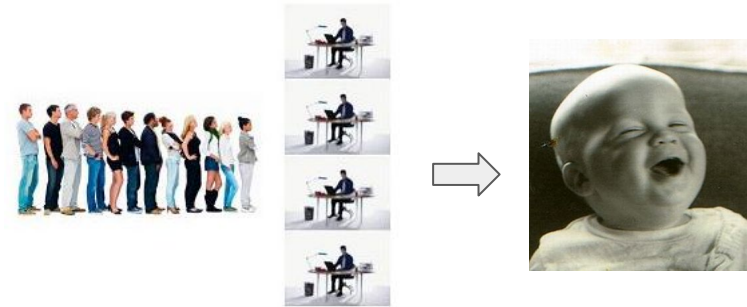
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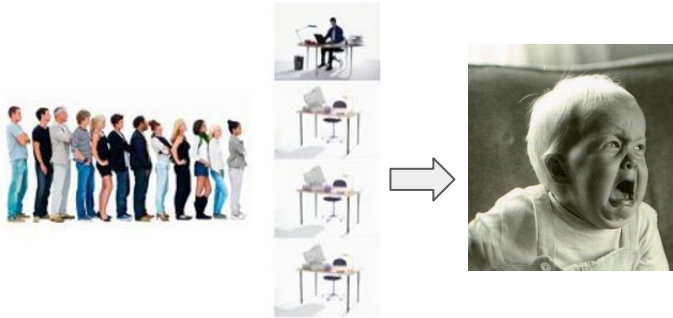
Serial Computing



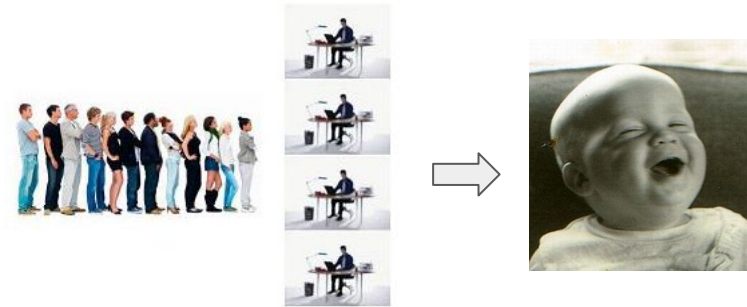
Parallel Computing

Why Parallel Computing ?

- Aren't single processor systems fast enough ?
- Why to build parallel systems ? Why build systems with multiple processors ?
- Why can't we write programs that will automatically convert serial programs to parallel programs ?



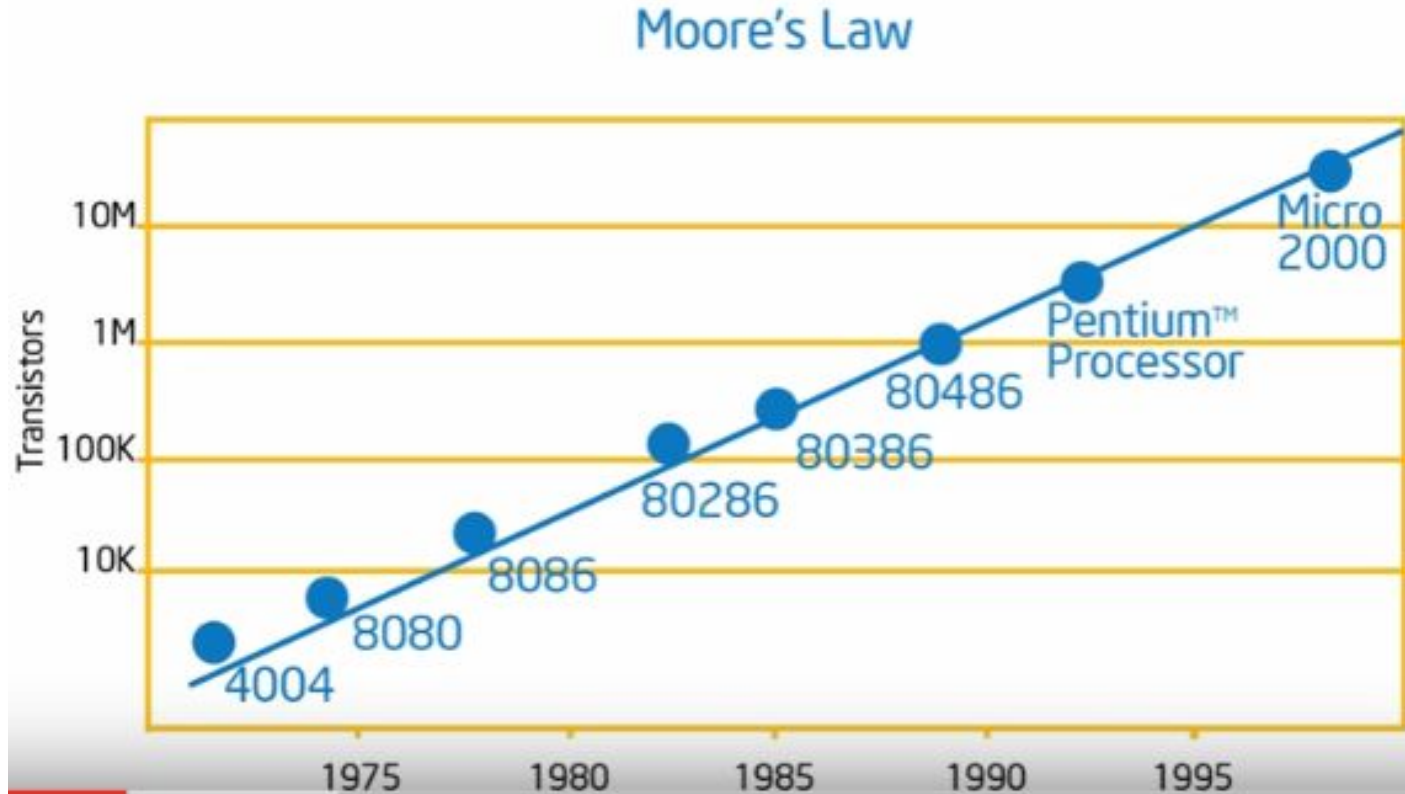
Serial Computing



Parallel Computing

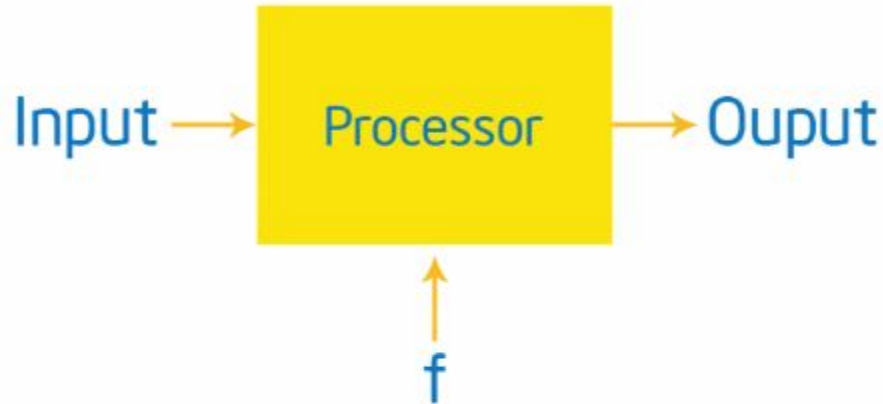
What Moore's Law tells.. ?

What Moore's Law tells.. ?



Uniprocessor ?

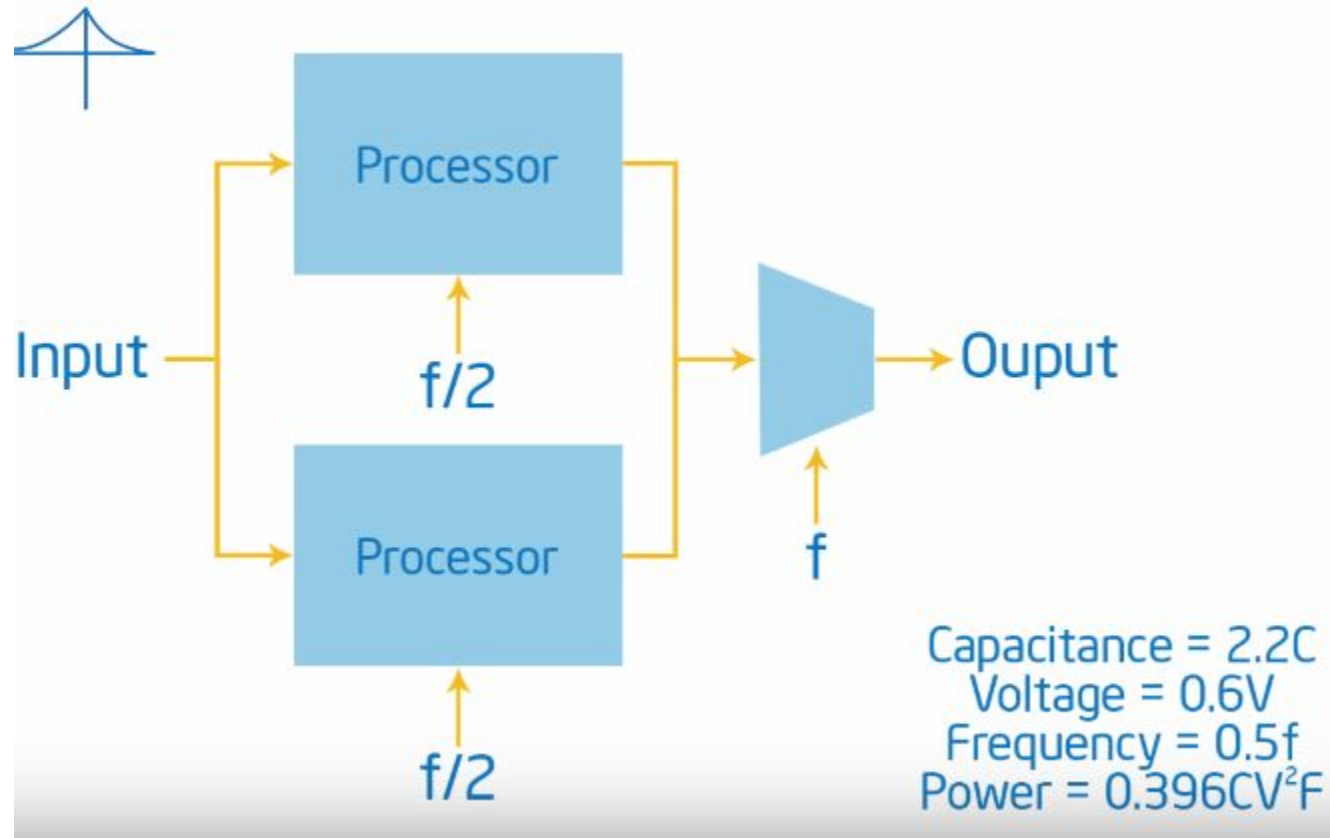
Uniprocessor ?



Capacitance = C
Voltage = V
Frequency = f
Power = CV^2f

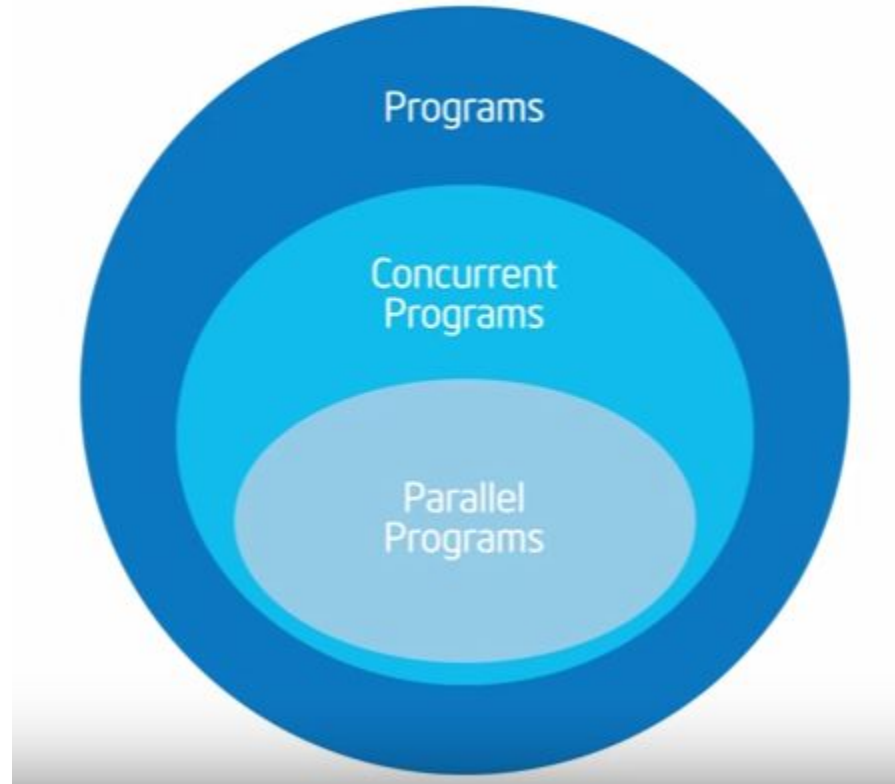
Parallel Architecture ?

Parallel Architecture ?



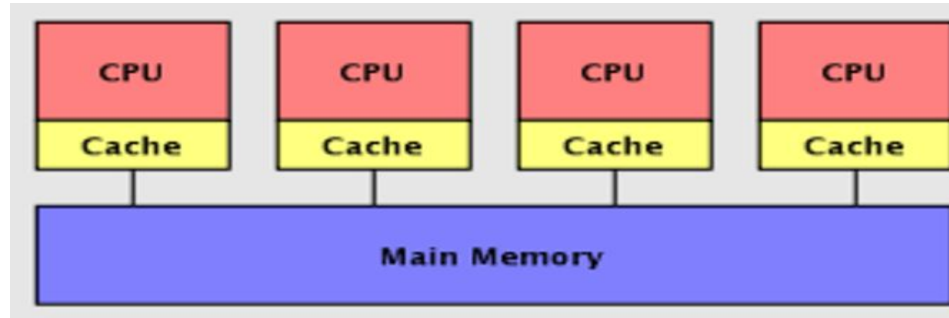
Parallel program

Parallel program



Parallel Programming Models..

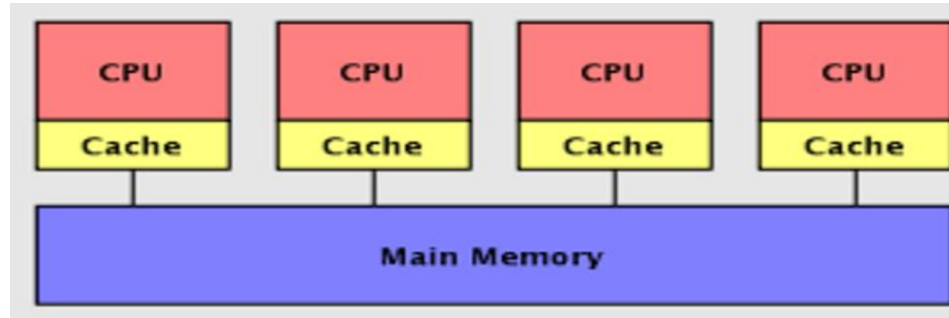
❑ Shared-memory Model



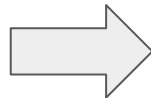
- UMA - Uniform Memory Access
- NUMA - Non-Uniform Memory Access

Parallel Programming Models..

❑ Shared-memory Model



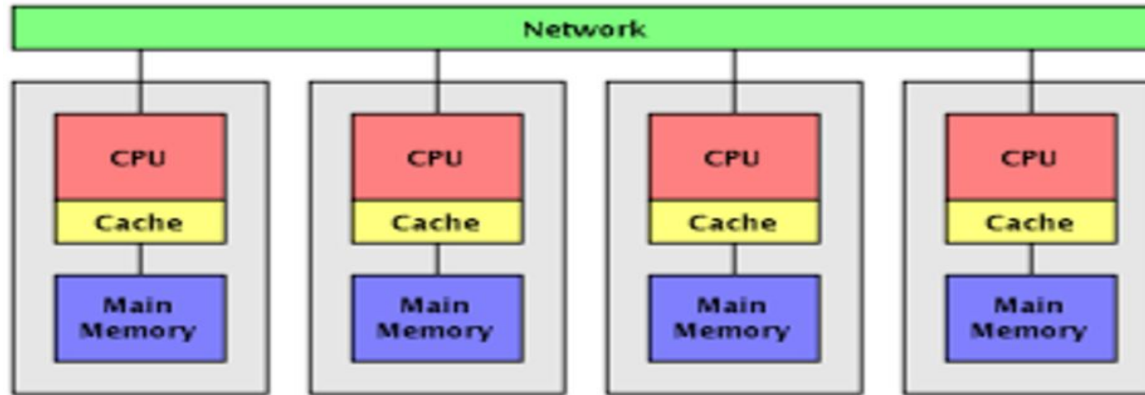
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❖ openMP
❖ Pthreads ...

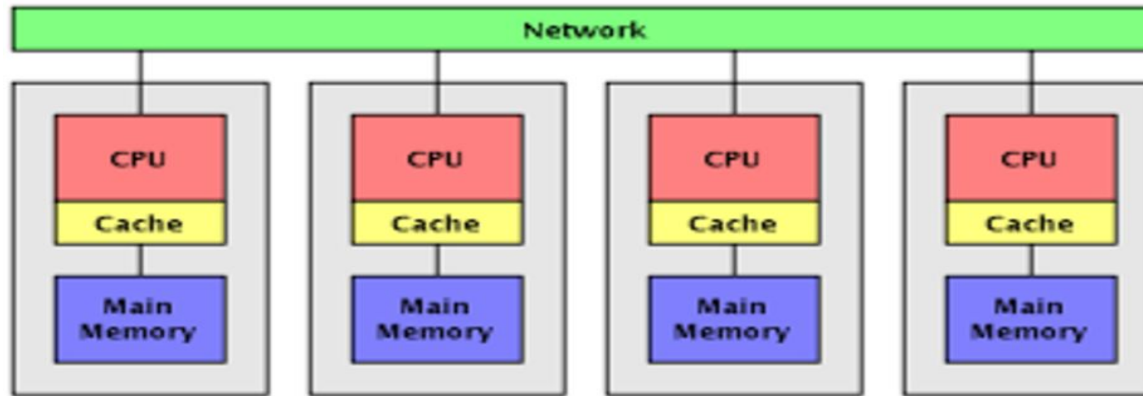
Parallel Programming Models..

❑ Distributed-memory Model



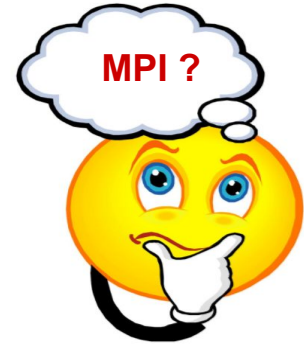
Parallel Programming Models..

❑ Distributed-memory Model



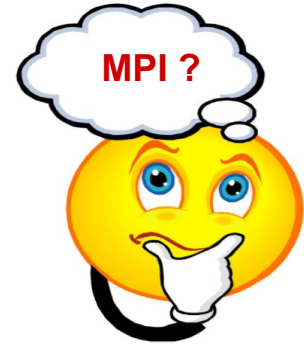
❖ MPI - Message Passing Interface

MPI - Message Passing Interface



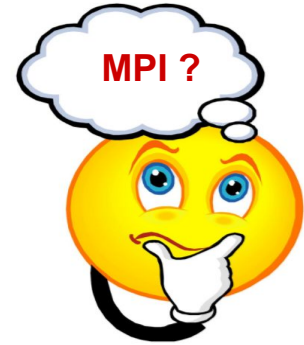
MPI - Message Passing Interface

- The Message Passing Interface Standard (MPI) is a message passing library standard based on the consensus of the MPI Forum



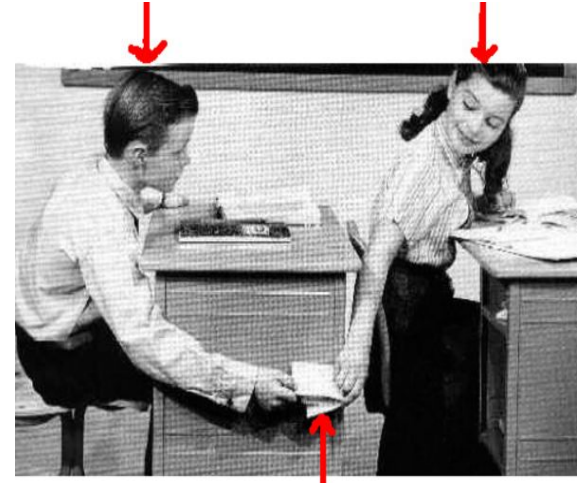
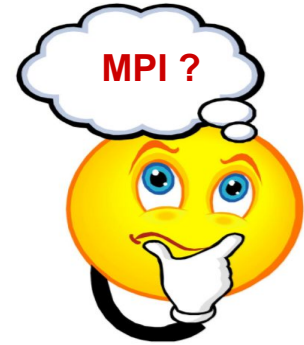
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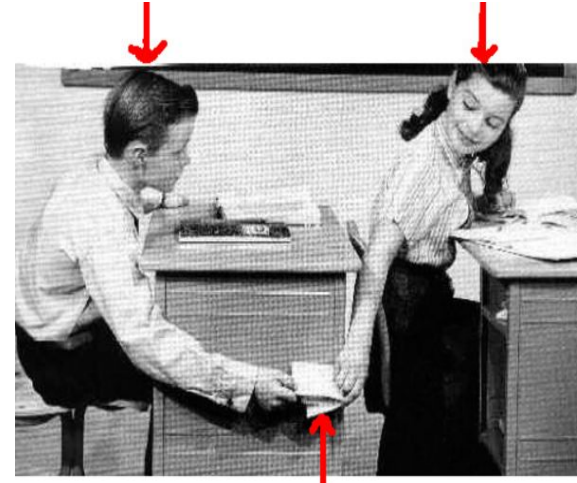
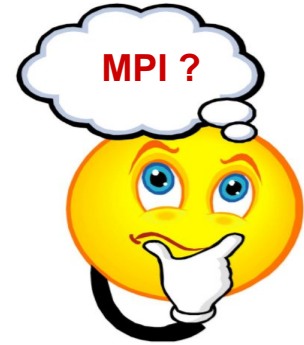
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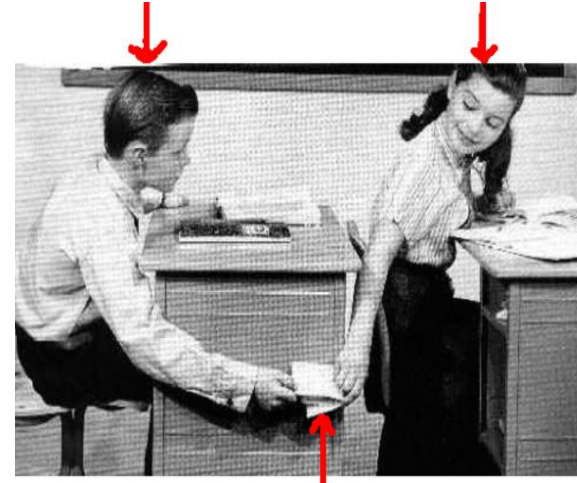
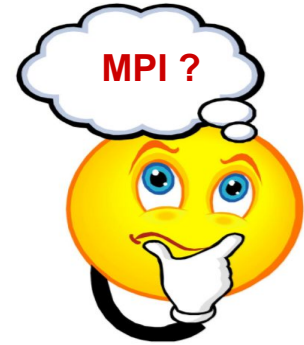
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- In MPI a Message is passed from one process to another process
- MPI is based on Routines.
- MPI is not an IEEE or ISO standard, but has in fact, become the "industry standard" for writing message passing programs on HPC platforms.



MPI - Development

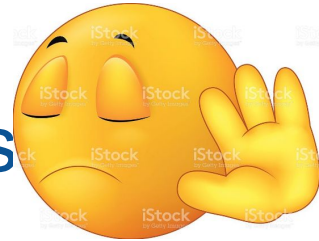
- The MPI standard has gone through a number of revisions, with the most recent version being MPI-3.x
 - MPI-3.1 - Jun 2015
 - MPI-3.0 - Sep 2012 Standard was approved
 - MPI-2.2 - Sep 2009
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Wait....

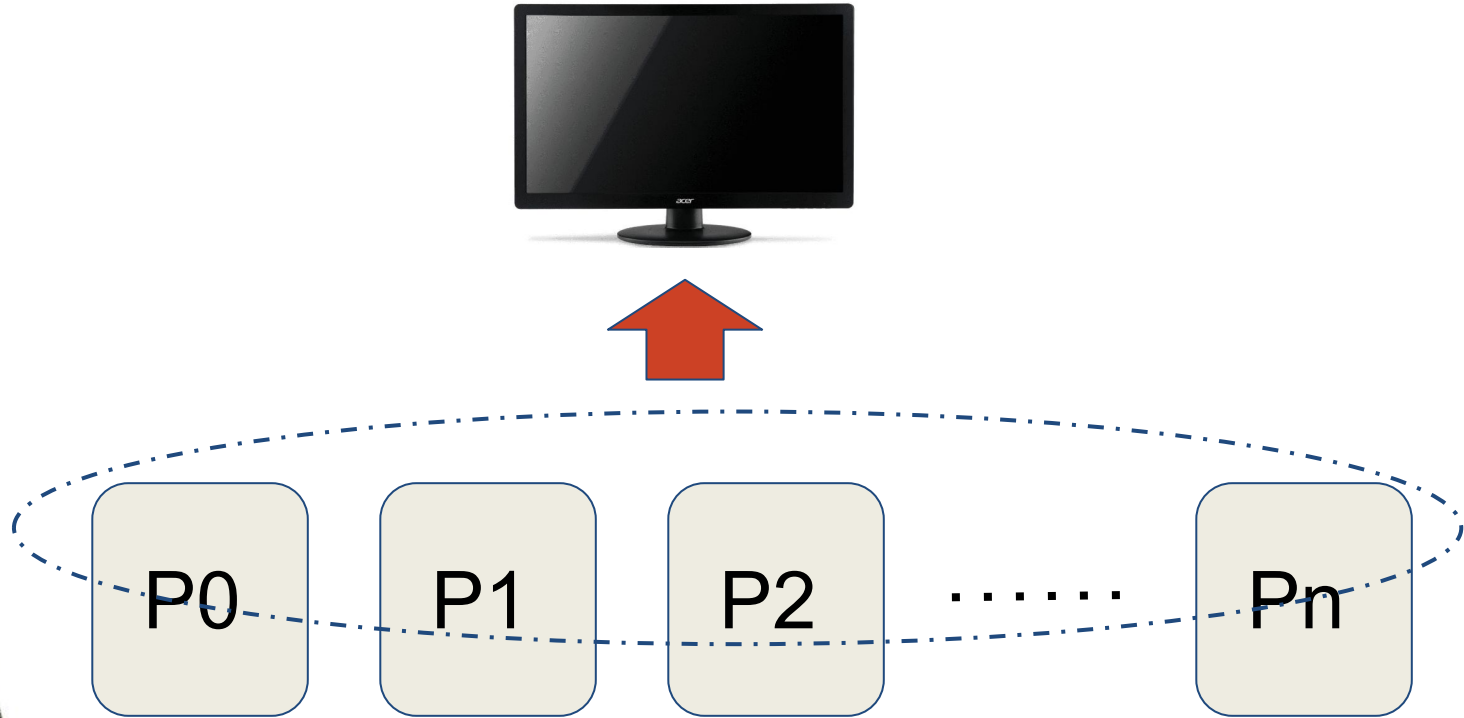
..Answer me first



- ❖ What is Process ?
- ❖ Is MPI a new programming Language ..?

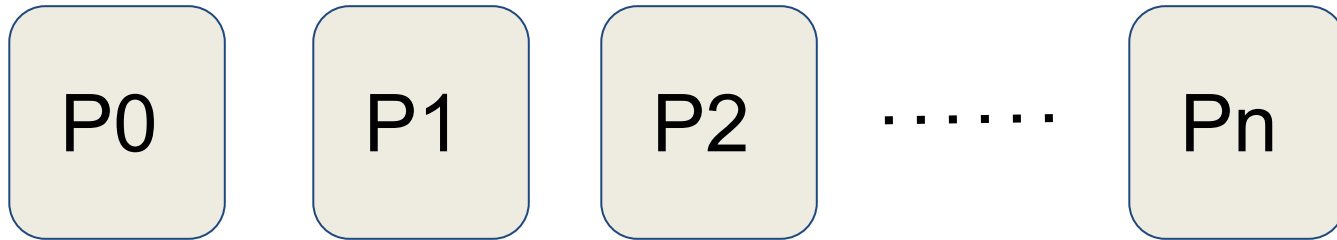


The Goal ..?

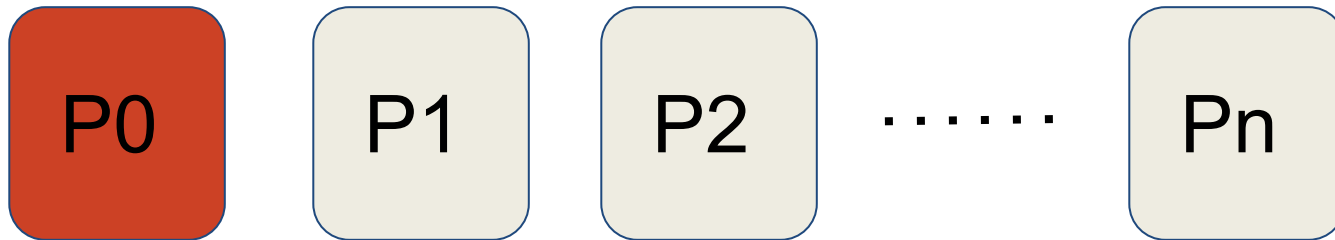


How to Achieve it ..?

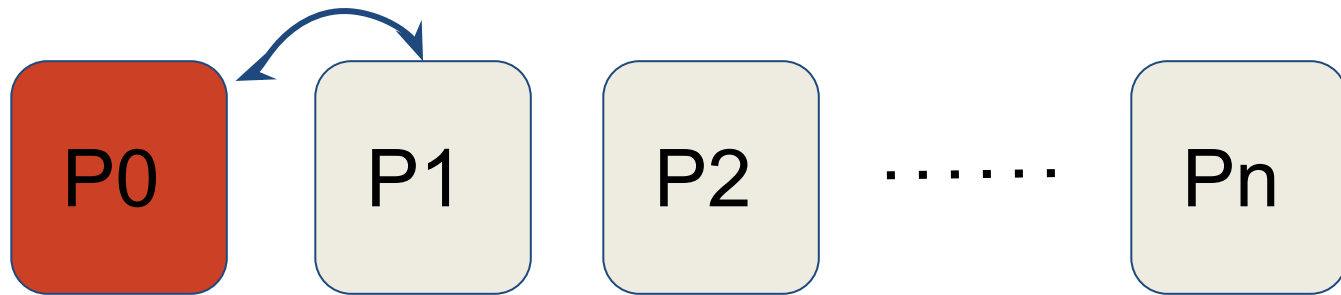
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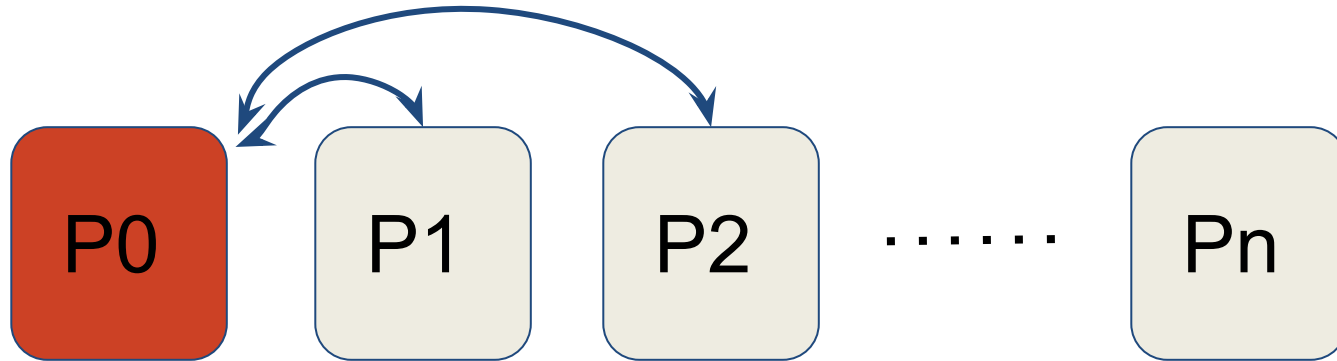
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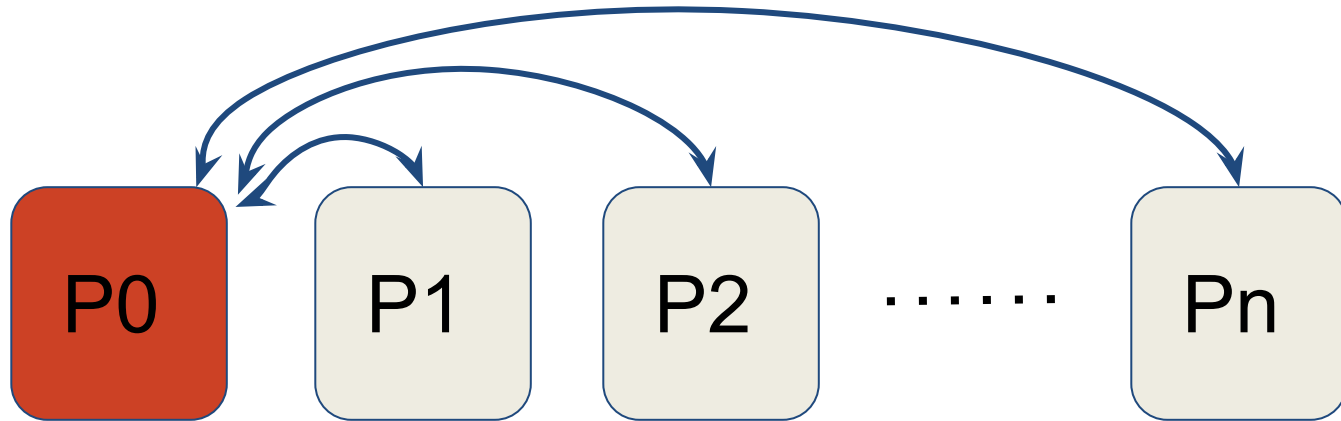
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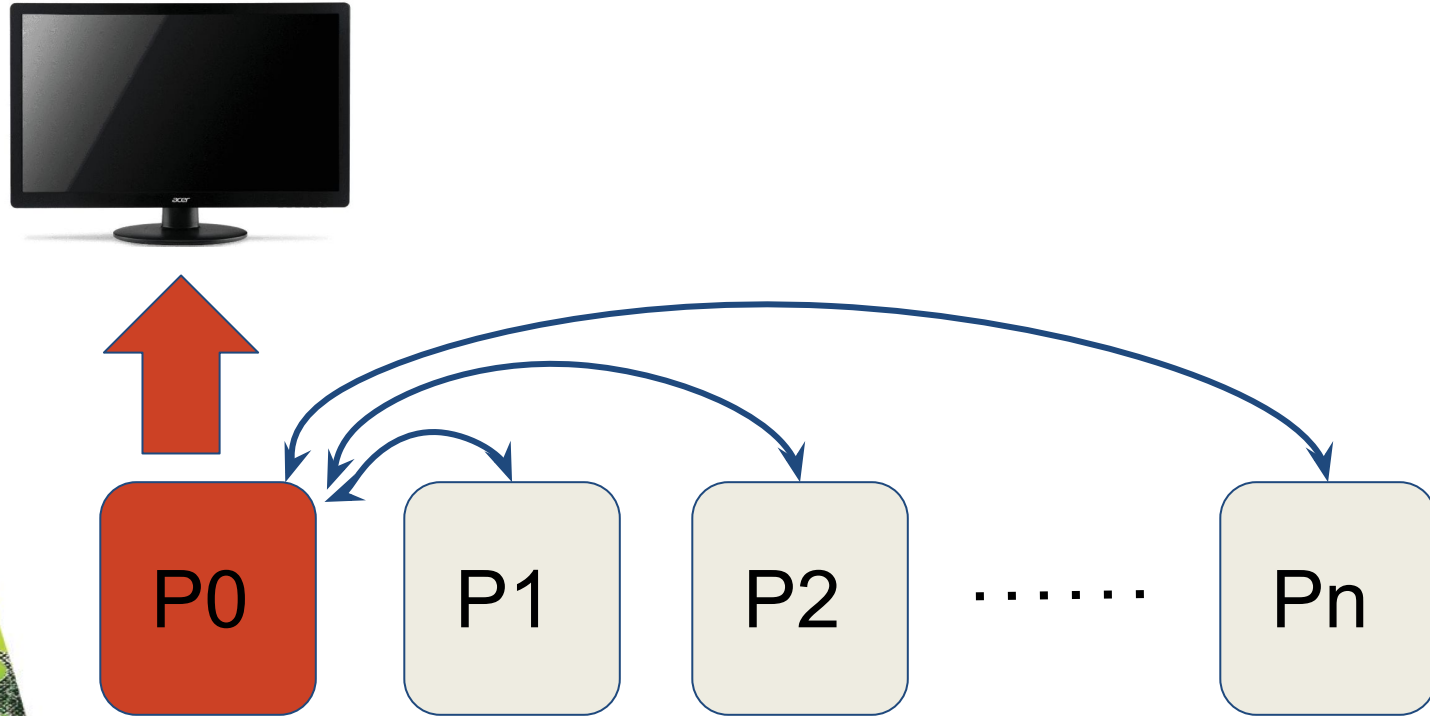
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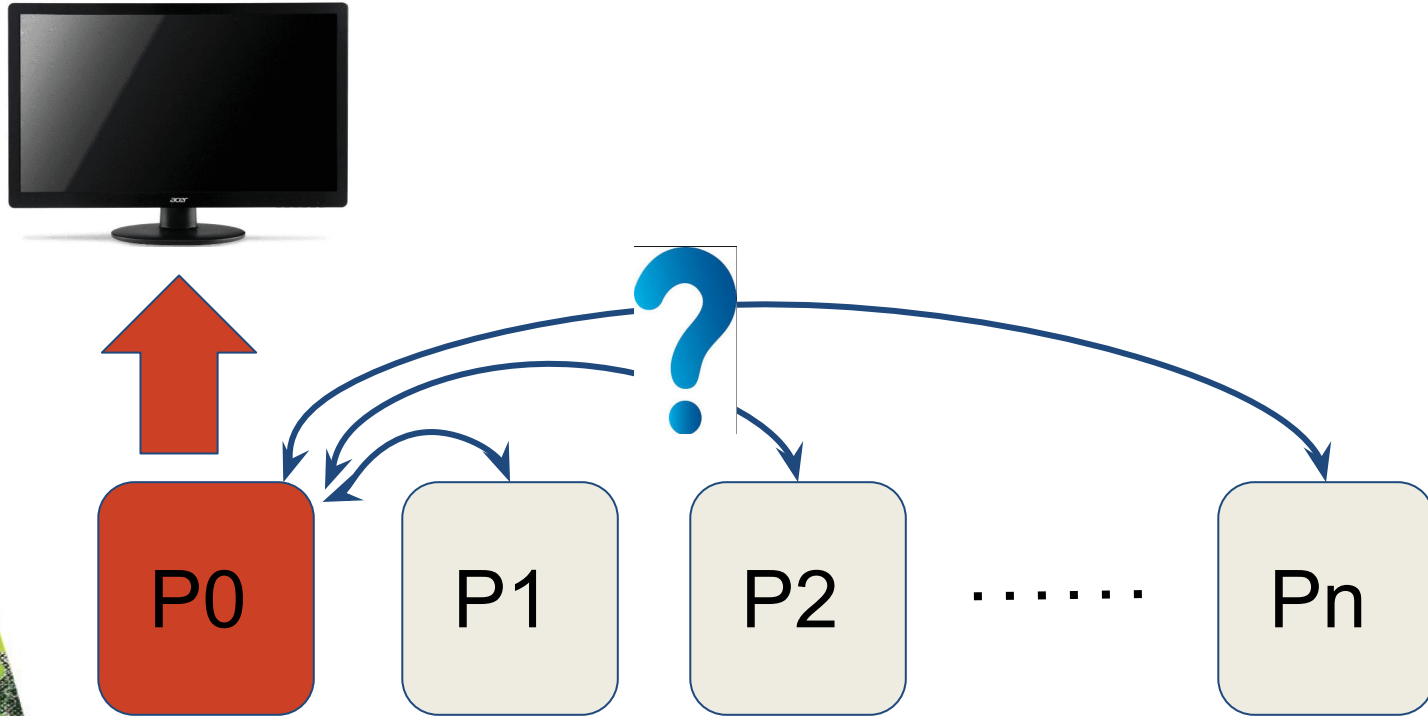
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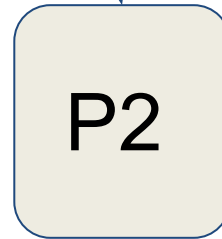
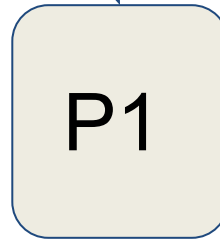
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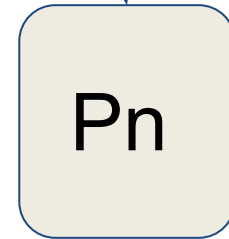
How ..?



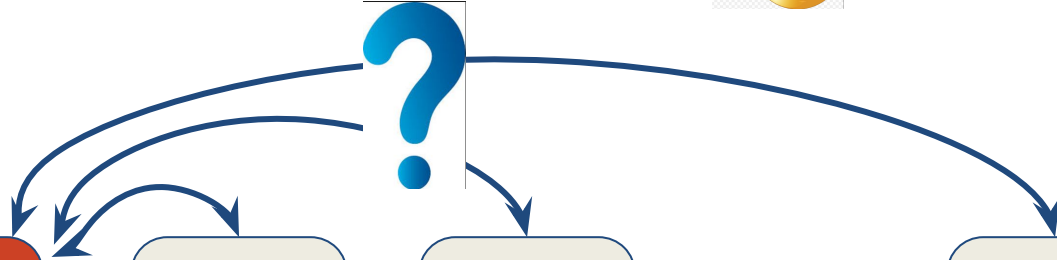
How ..?



.....

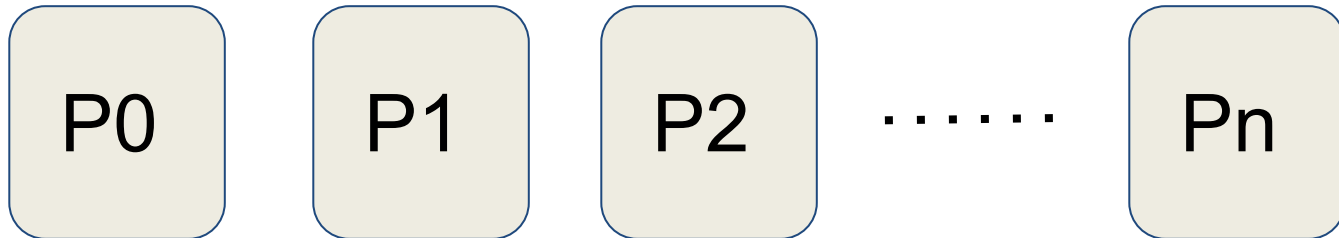


MPI



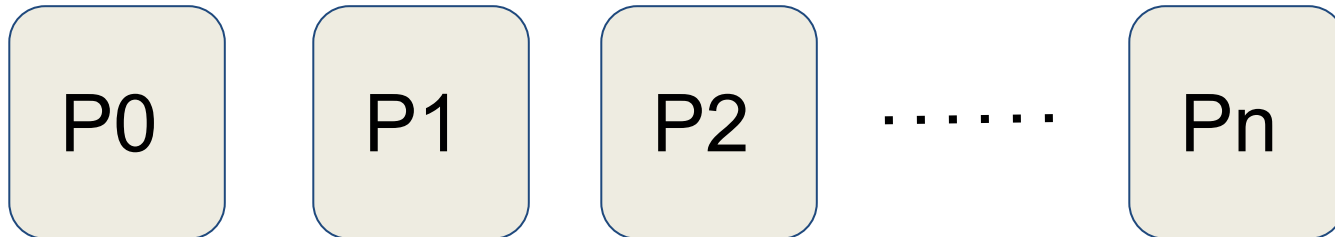
How MPI Works ..?

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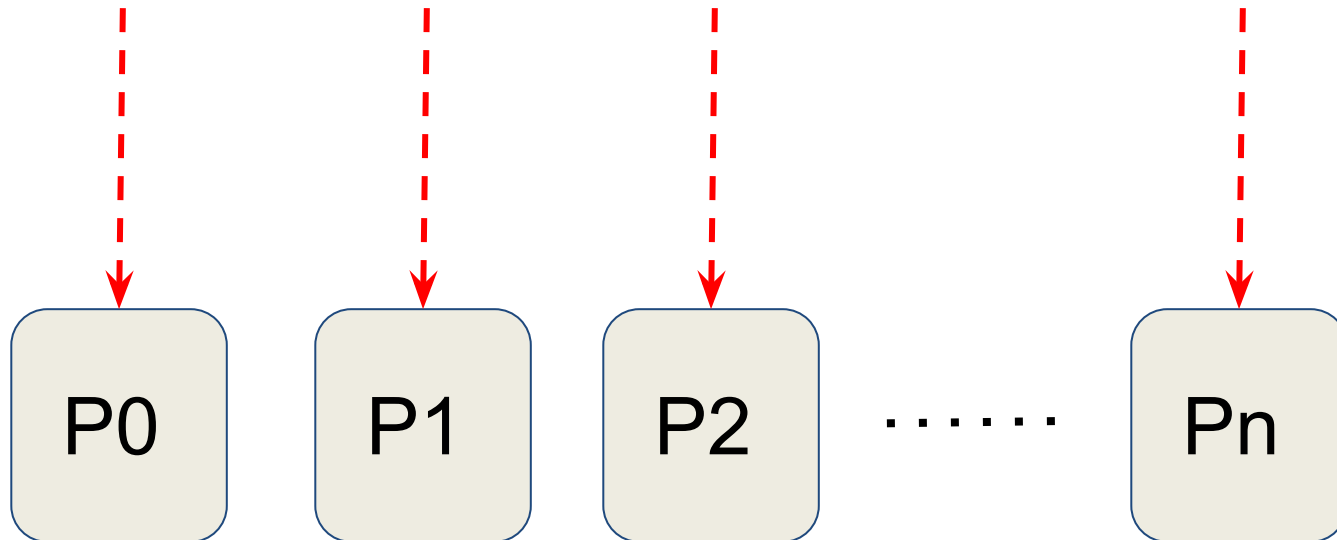
How MPI Works ..?

- ❖ Creates Instances of same program on Every Processor involved..!



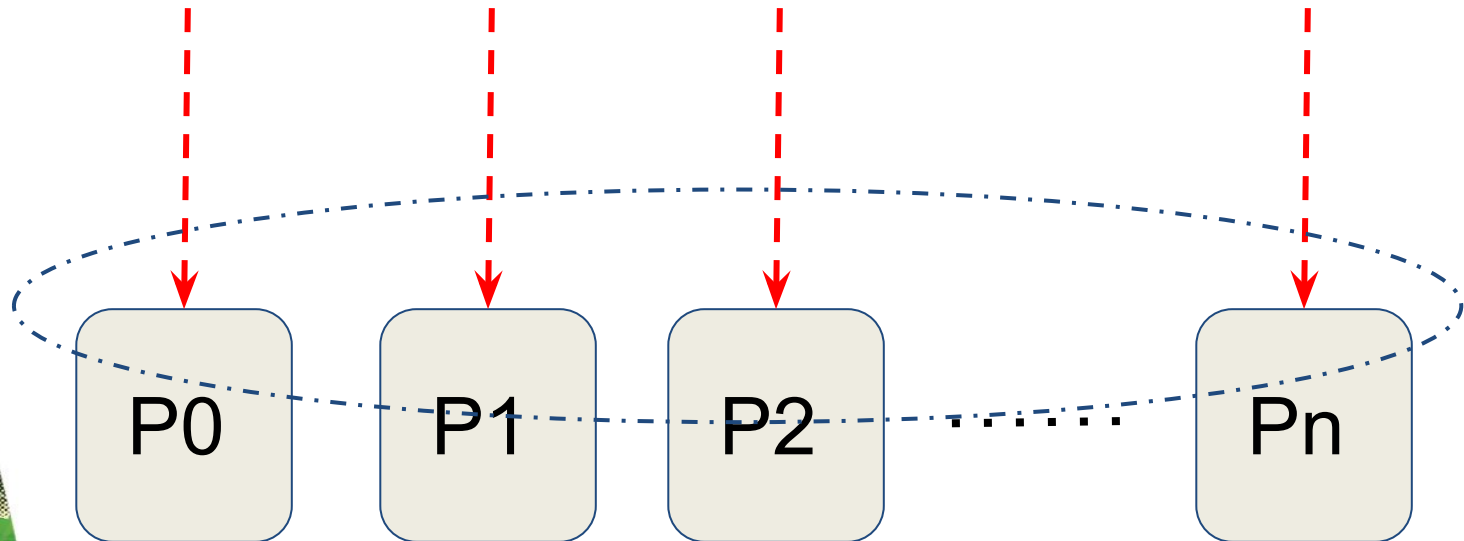
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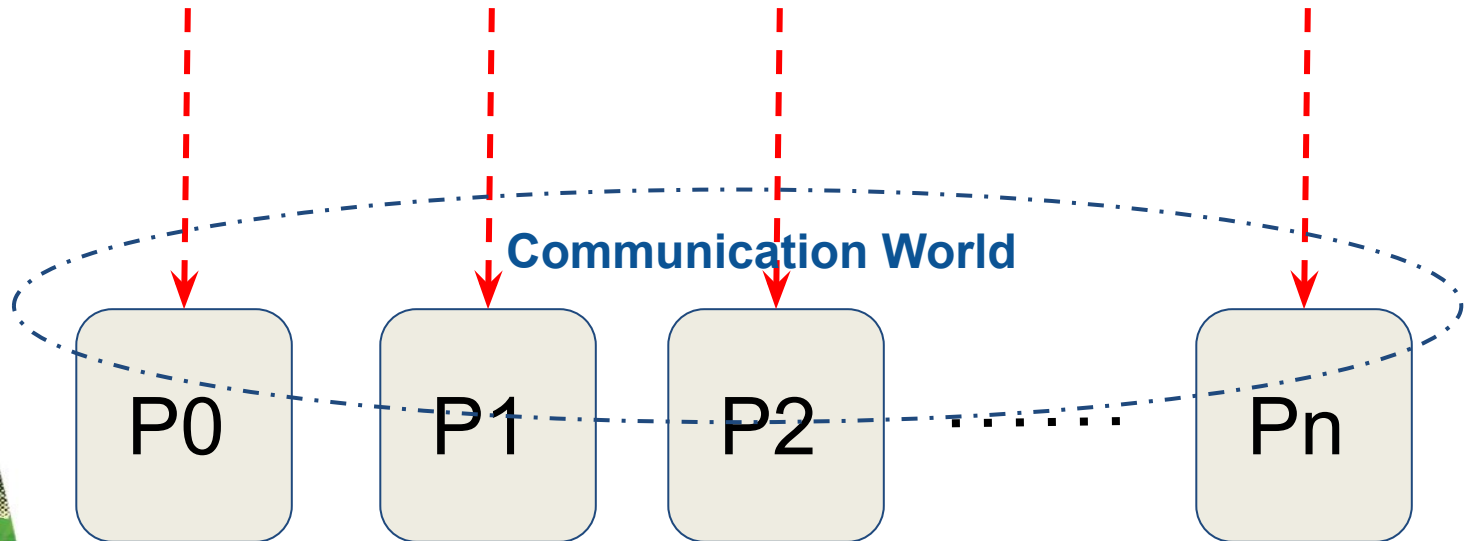
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How MPI Works ..?

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❖ Got it ?

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❖ Got it ?



❖ Let's try to understand with example...

❖ Got it ?



❖ Let's try to understand with example...



Welcome to the World of Parallel Computing ...!

```
#include<stdio.h>
#include<string.h>
#include<mpi.h>
#define MASTER 0
Int main(void)
{
    char greeting[MAX_STRING];
    int  comm_sz ;
    int  my_rank ;

    MPI_Init(NULL, NULL);
    MPI_Comm_size(MPI_COMM_WORLD, &comm_sz);
    MPI_Comm_rank(MPI_COMM_WORLD, &my_rank);
```

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#include<mpi.h>
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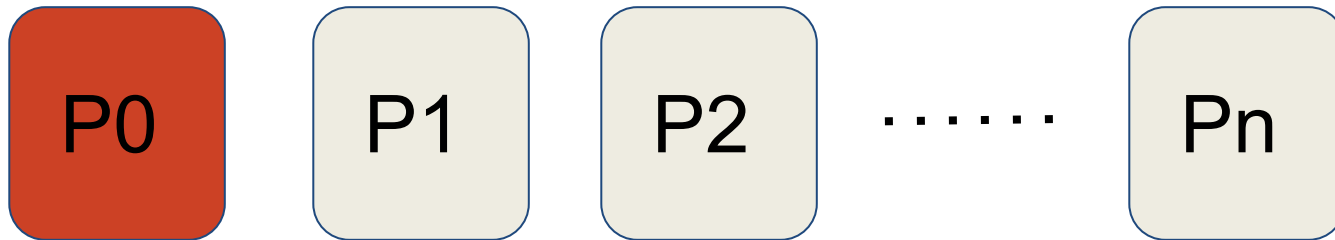
```
→ MPI_Comm_rank(MPI_COMM_WORLD, &my_rank);
```

```
if(my_rank != MASTER)
{
    sprintf(greeting, "Welcome to the world of Parallel Computing. I am Process no %d out of %d", my_rank, comm_sz);
    MPI_Send(greeting, strlen(greeting)+1, MPI_CHAR, 0, 0, MPI_COMM_WORLD) ;
}
```

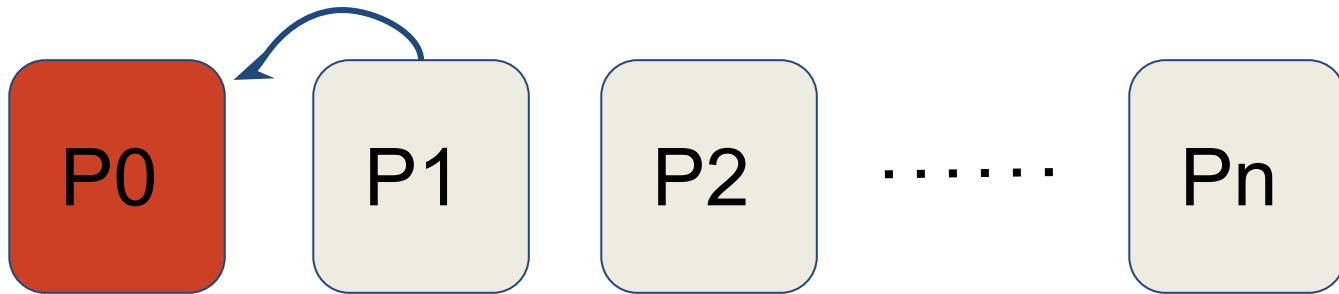


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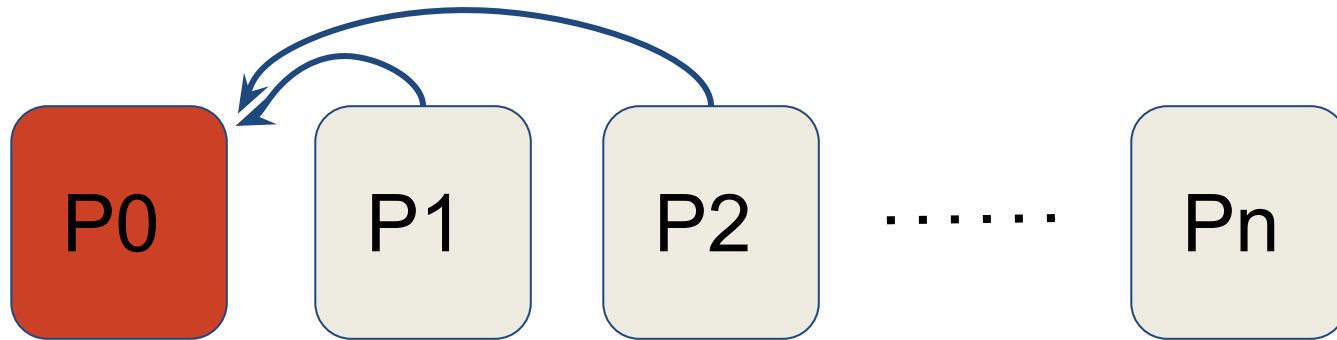
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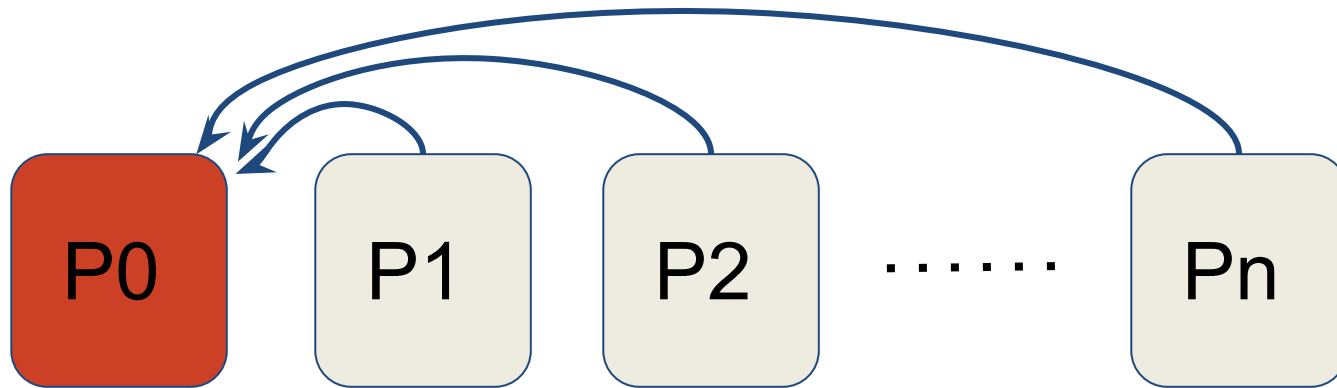
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}
```



```
else
```

```
{
```

```
    printf( "Welcome to the world of Parallel Computing. I am Process no %d out of %d", my_rank, comm_sz) ;
```

```
    for(int q=1; q < comm_sz; q++)
```

```
    {
```

```
        MPI_Recv(greeting, MAX_STRING, MPI_CHAR, q, 0, MPI_COMM_WORLD, MPI_STATUS_IGNORE) ;
```

```
        printf("%s \n", greeting) ;
```

```
    }
```

```
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```
MPI_Finalize();
```

```
return 0;
```

```
}/* END */
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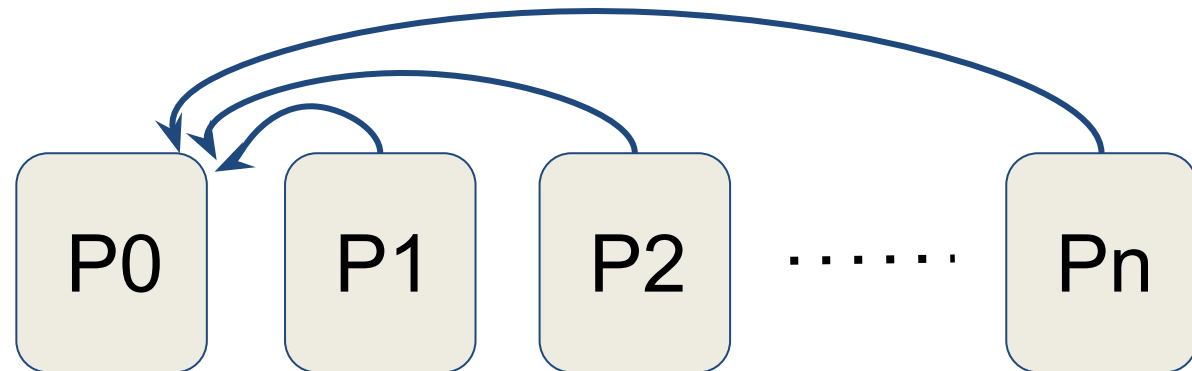
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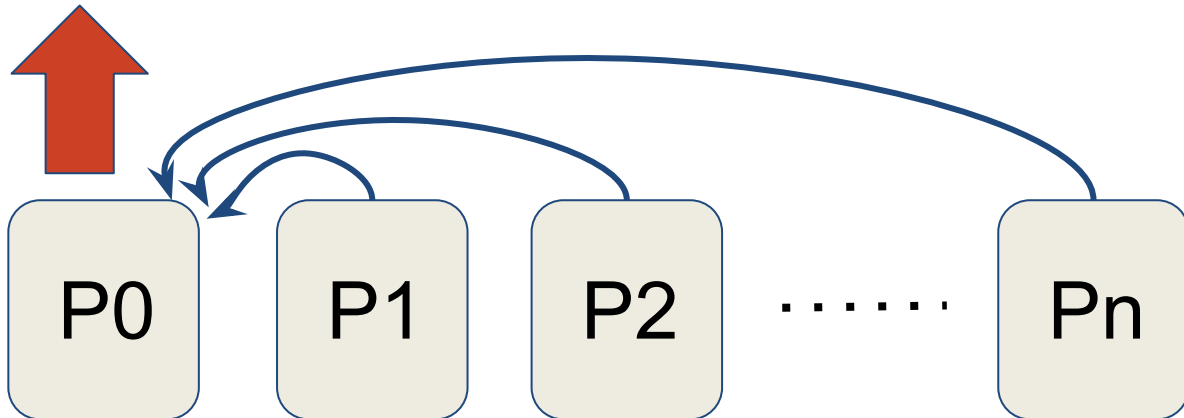
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        printf("%s \n", greeting);
```

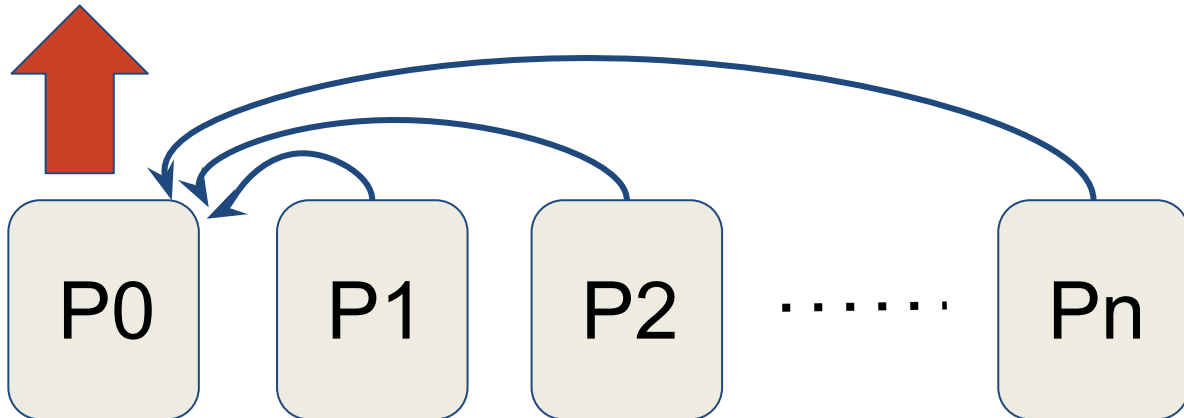
```
    }
```

```
}
```

```
→ MPI_Finalize();
```

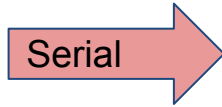
```
    return 0;
```

```
}/* END */
```



❖ How to compile and run it ?

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Serial

- \$ gcc -o test test_serial.c
- \$./test

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Serial

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➤ $ gcc -o test test_serial.c  
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Parallel

❖ How to compile and run it ?

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Parallel

- \$ mpicc -o mpi_test mpi_test.c
- \$ mpirun -np n ./mpi_test

❖ Output ..

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❖ Output ..

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➤ $ mpirun -np 4 ./mpi_test
```



Welcome to the world of Parallel Computing. I am Process no 0 out of 4
Welcome to the world of Parallel Computing. I am Process no 1 out of 4
Welcome to the world of Parallel Computing. I am Process no 3 out of 4
Welcome to the world of Parallel Computing. I am Process no 2 out of 4

❖ Got it ?





Got it ?

-np 4



❖ Got it ?



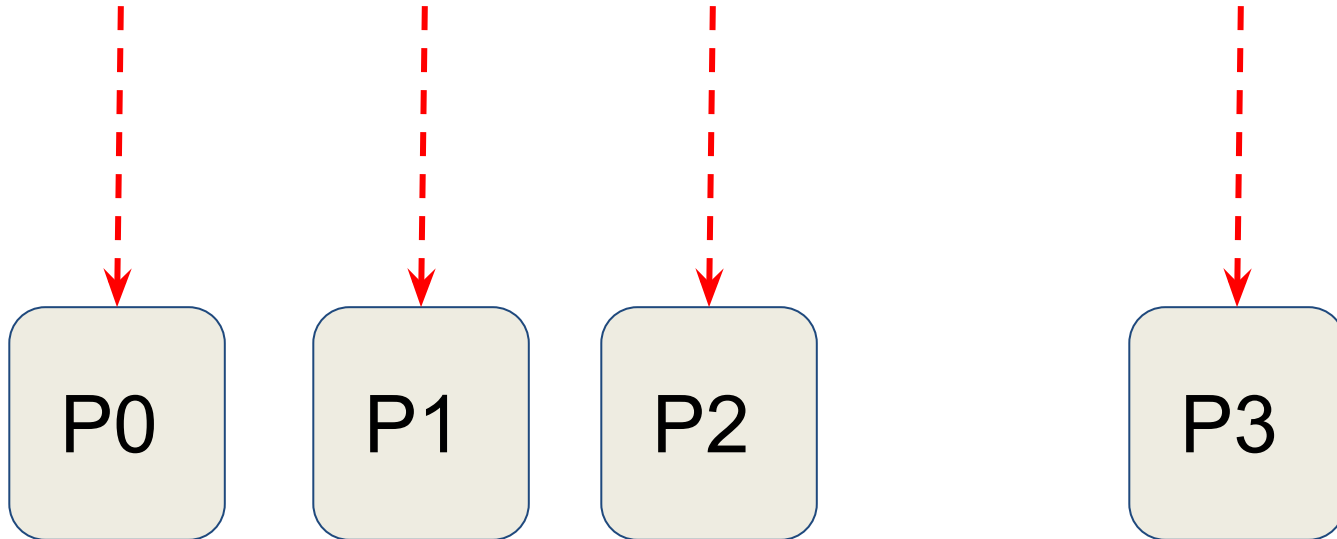
P0

P1

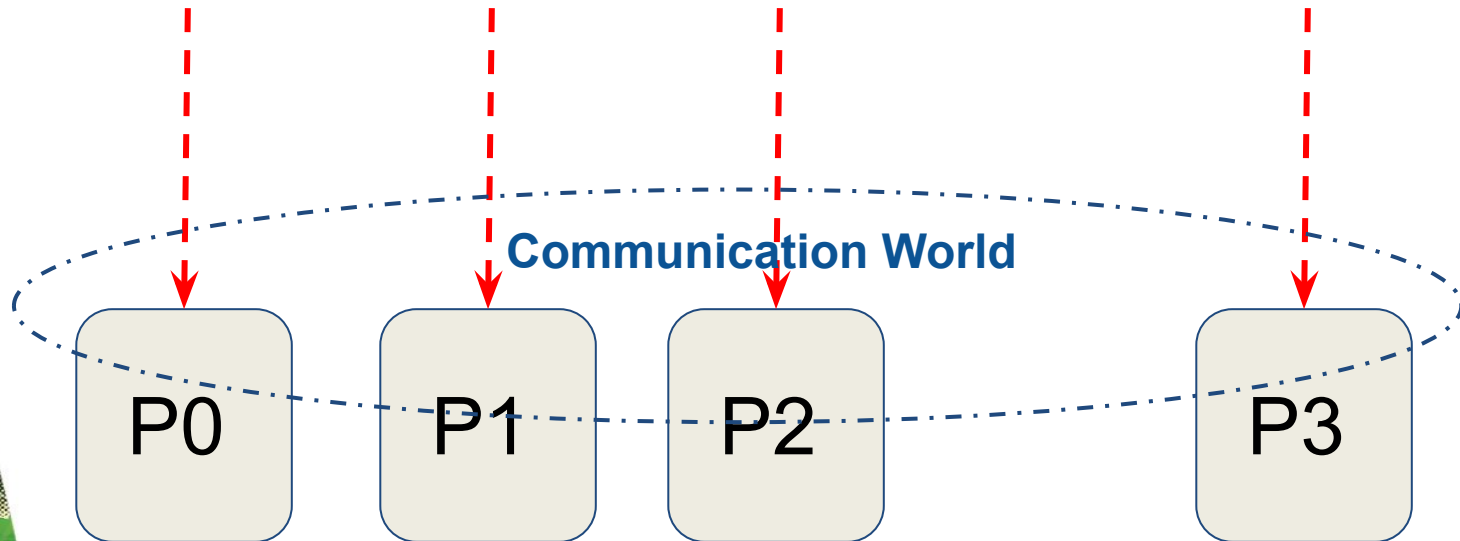
P2

P3

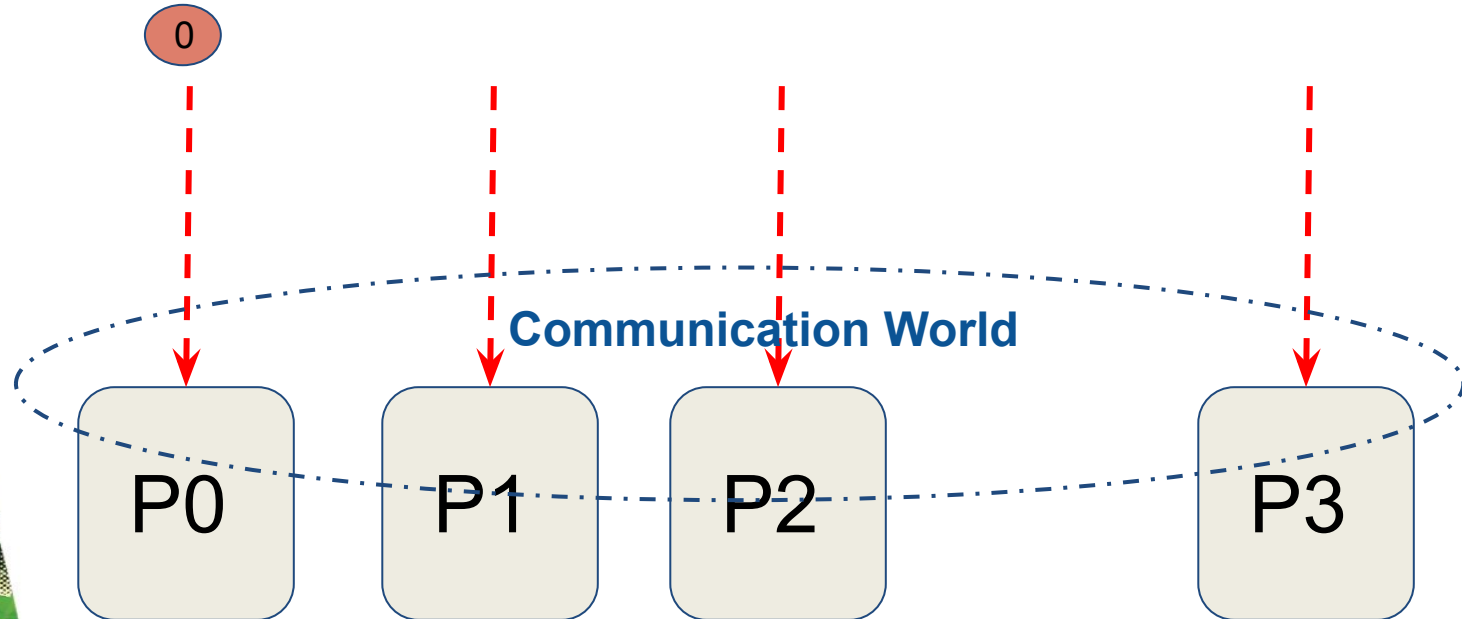
❖ Got it ?



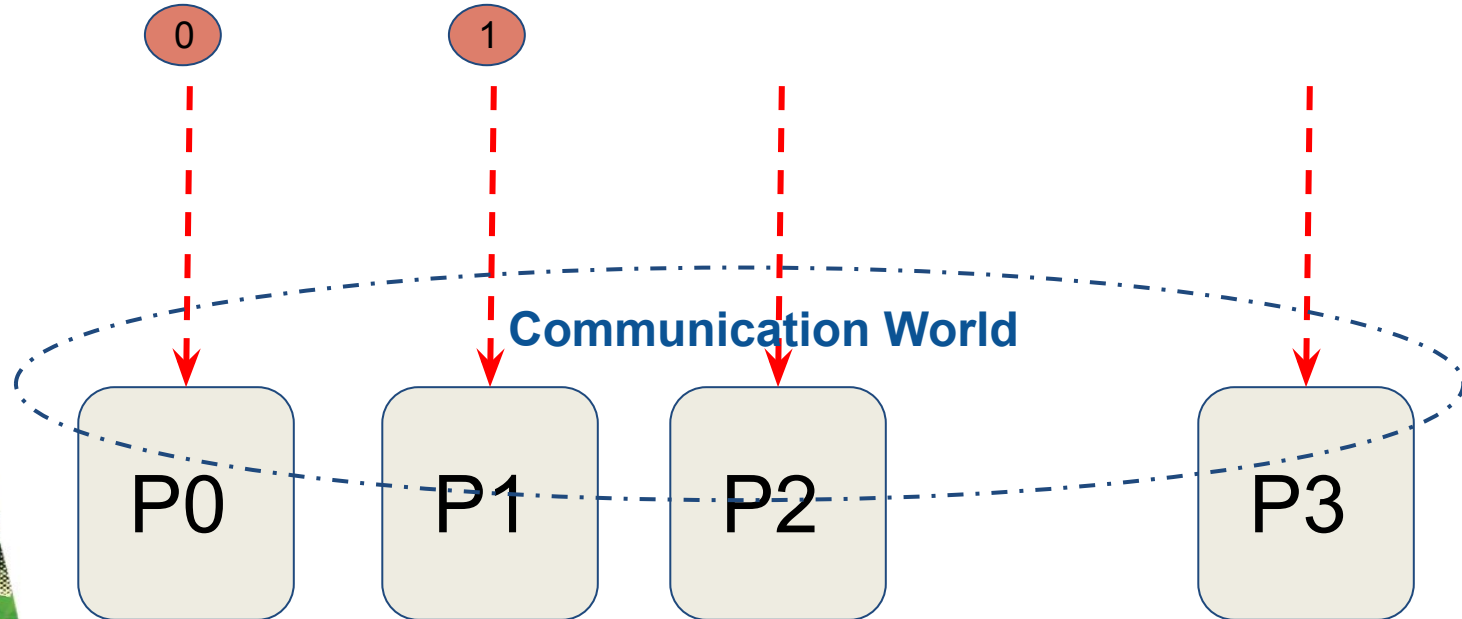
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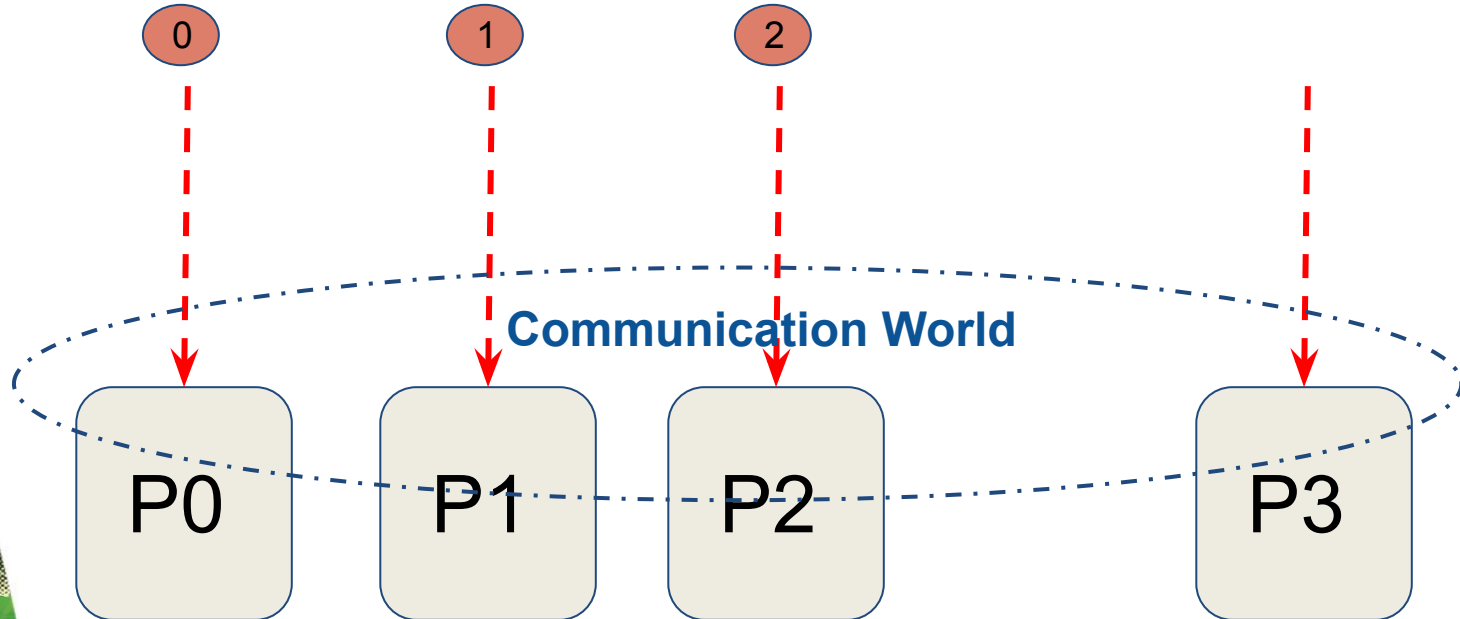
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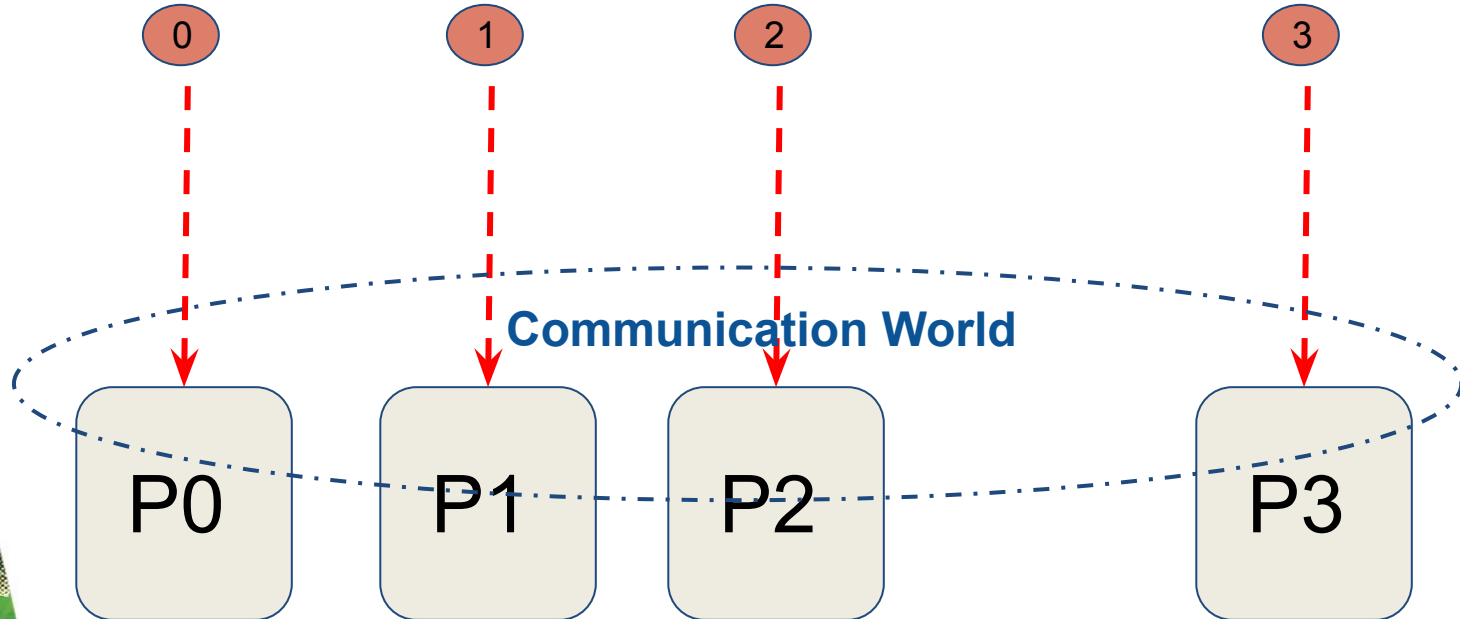
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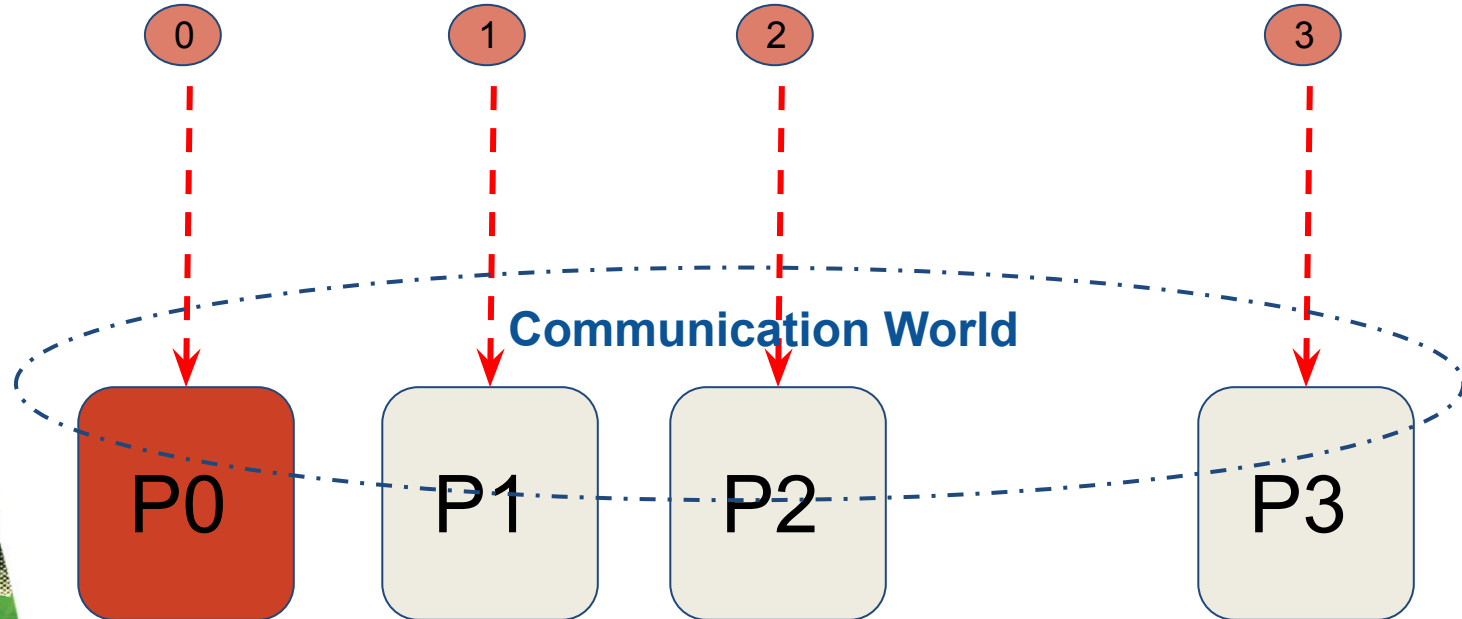
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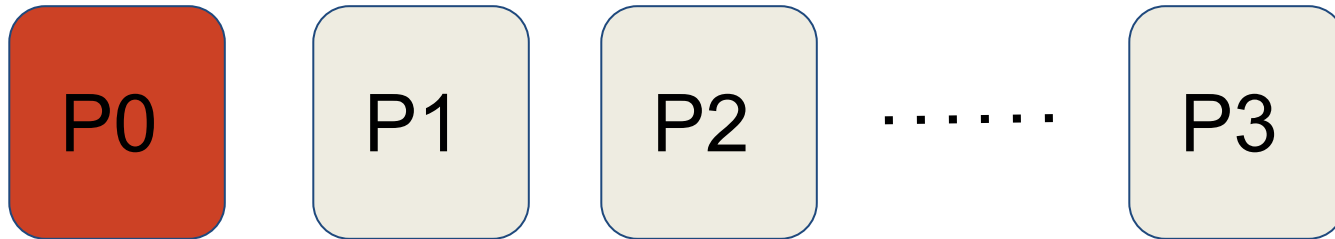
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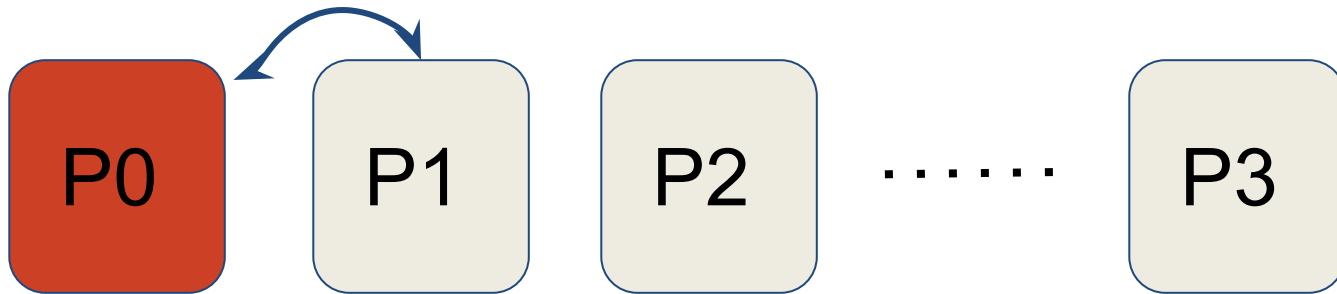
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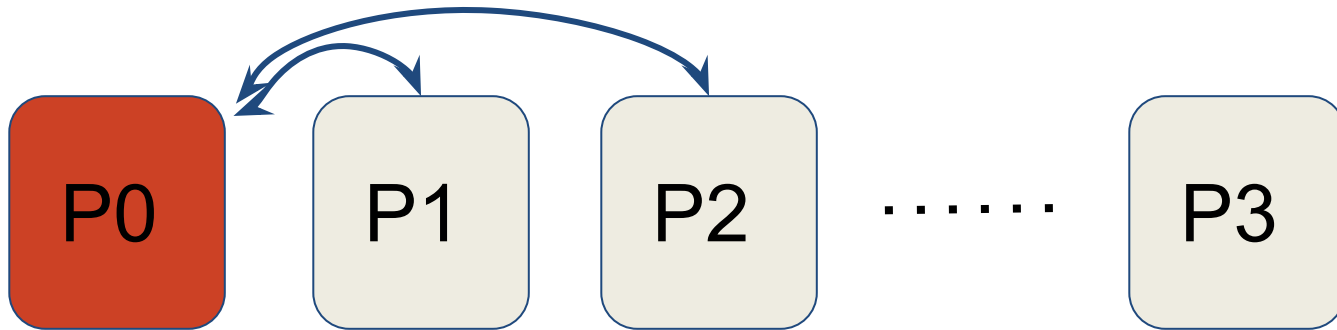
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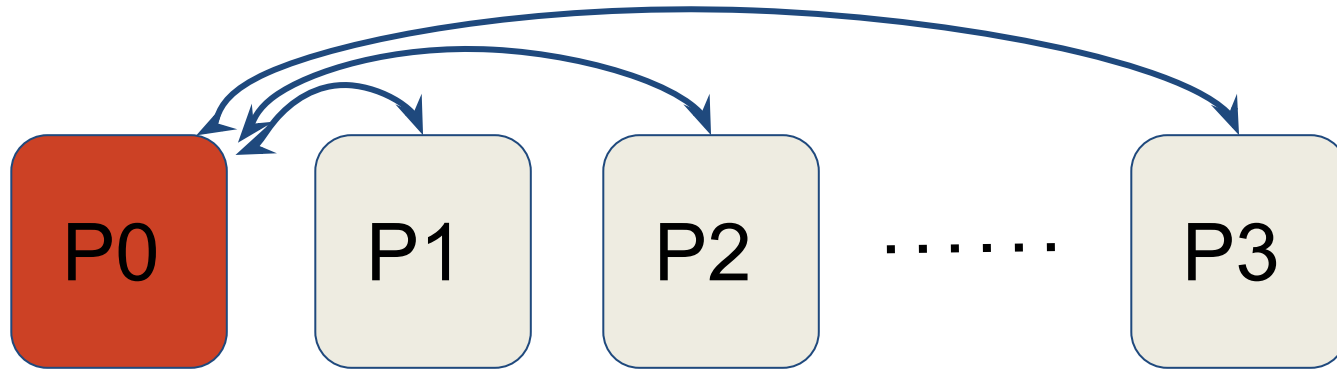
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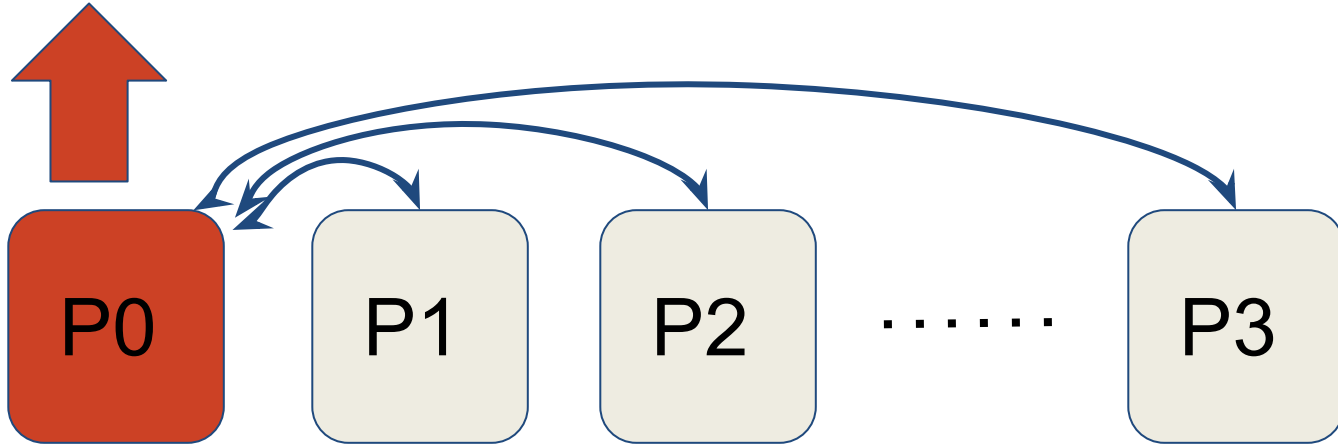
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MPI - Message Passing Interface

MPI is built on 'Routines'

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The basic MPI Routines :-

- ☐ MPI_Init () ;
- ☐ MPI_Comm_rank () ;
- ☐ MPI_Comm_size () ;
- ☐ MPI_Send () ;
- ☐ MPI_Recv () ;
- ☐ MPI_Finalize () ;

- ☐ -----

MPI - Program structure

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```
#include <mpi.h>

main( int argc, char** argv )
{
    MPI_Init( &argc, &argv );

    /* main part of the program */

    /*
    Use MPI function call depend on your data
    partitioning and the parallelization
    architecture
    */

    MPI_Finalize();
}
```

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Hope so you got it...!!!

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Hope so you got it...!!!



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