Parallel Computing - MPI

Message Passing Interface

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MPI - Program structure

```
#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();
}
```

Hope so you remember it...!!!

MPI - Message Passing Interface

MPI is built on ‘Routines’

The basic MPI Routines :-

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

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MPI - Communication

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Point to Point Comm^{n}

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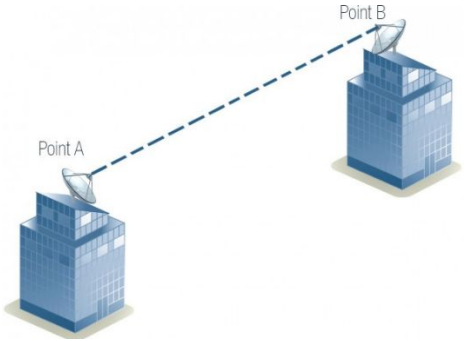

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Point to Point Comm^{n}

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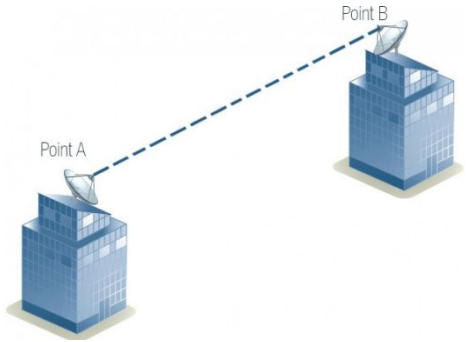

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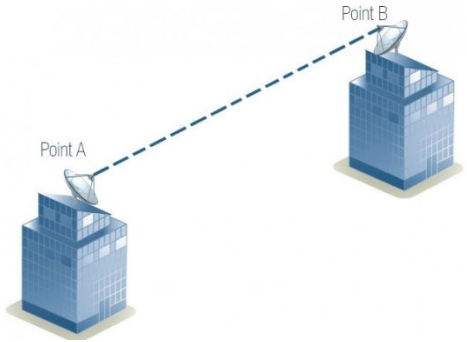

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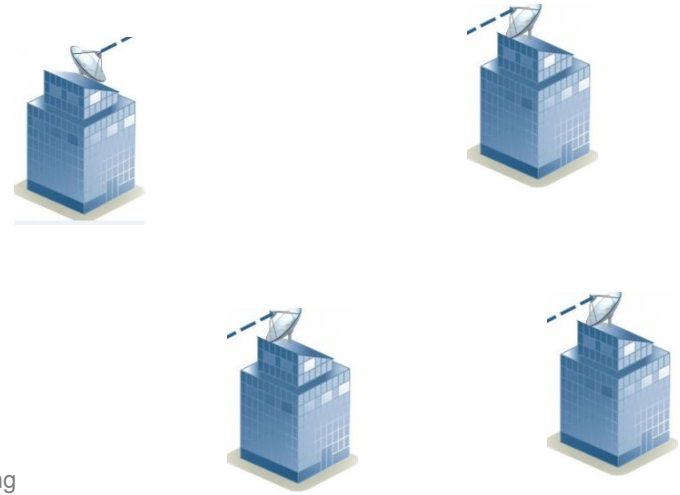

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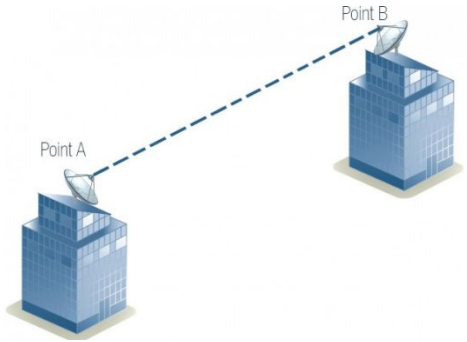

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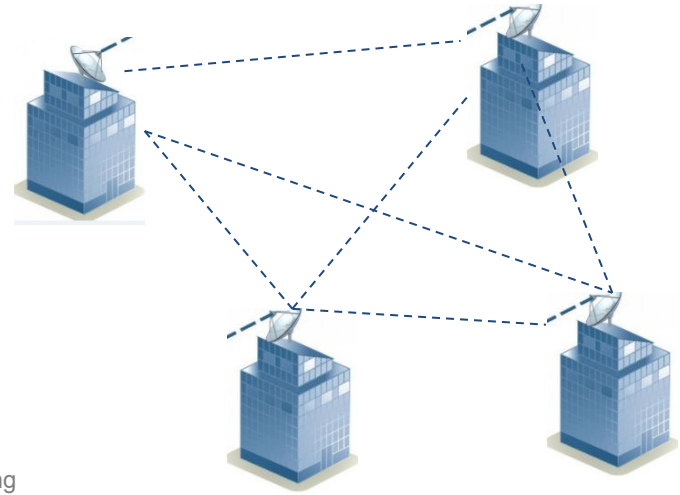

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...Do You Agree ?

Numerical Integration : Trapezoidal Rule

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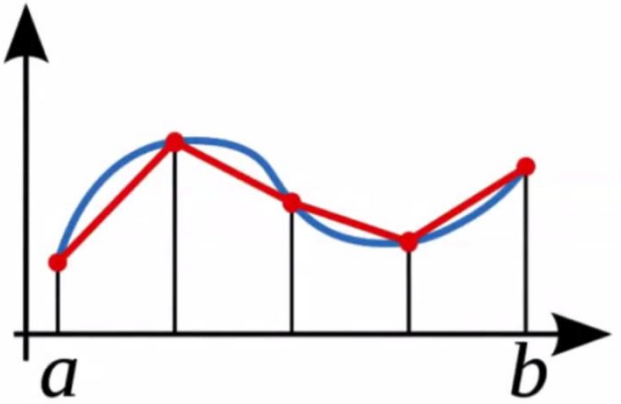

Numerical Integration : Trapezoidal Rule

Trapezoid rule for integrating $\int_a^b = f(x)dx$

with $h = (b - a)/n$ is

$f(x) \approx \frac{h}{2}(f(x_0) + f(x_n)) + h\sum_{i=1}^{n-1} f(x_i)$

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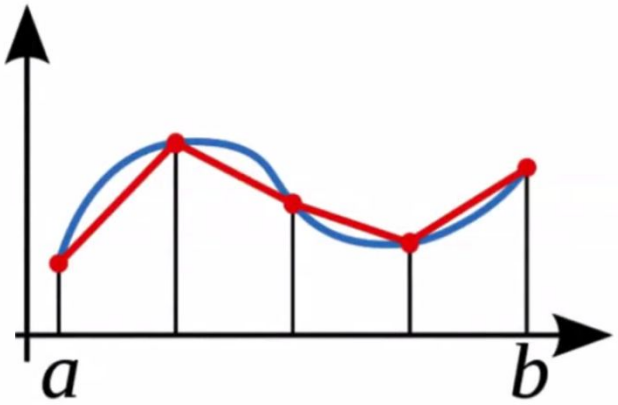

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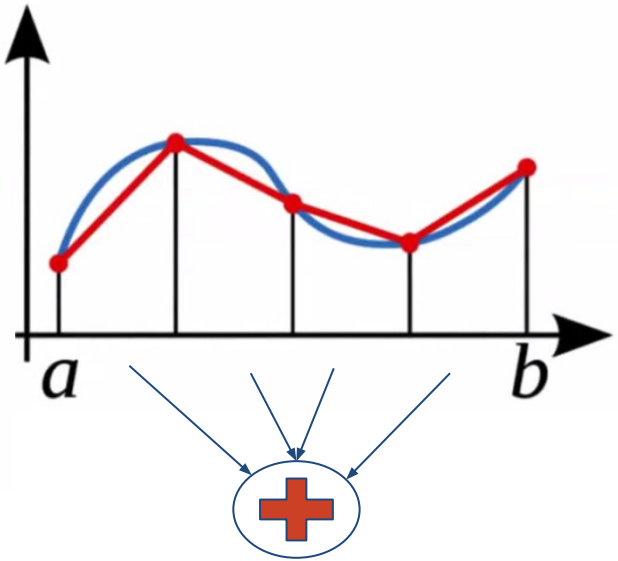

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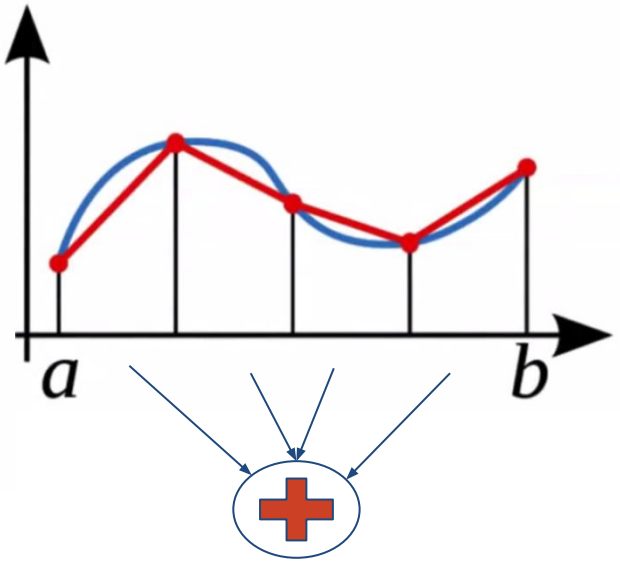

How do you achieve it Serially .. ?

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Function which we want to integrate

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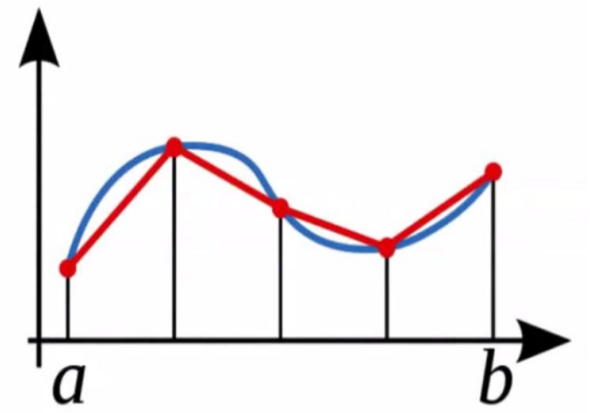

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        float integral, x ;
        int i ;
        integral = (f(a) + f(b)) / 2.0 ;
        x = a ;
        for (i=1; i<= n-1; i++)
            {
                x = x + h;
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        return integral*h ;
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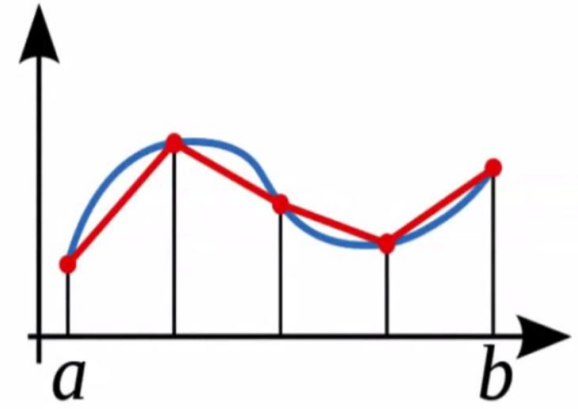

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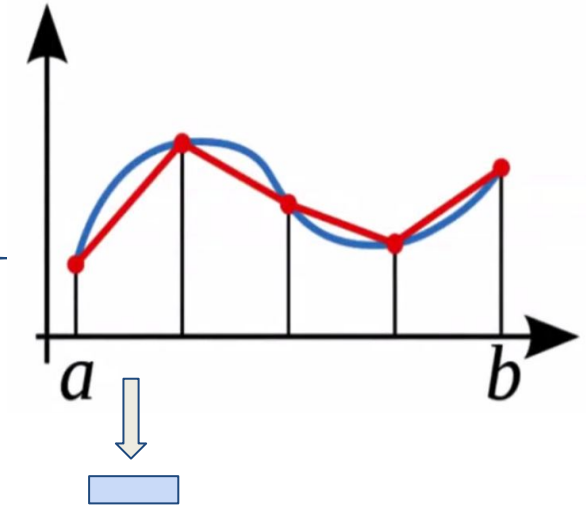

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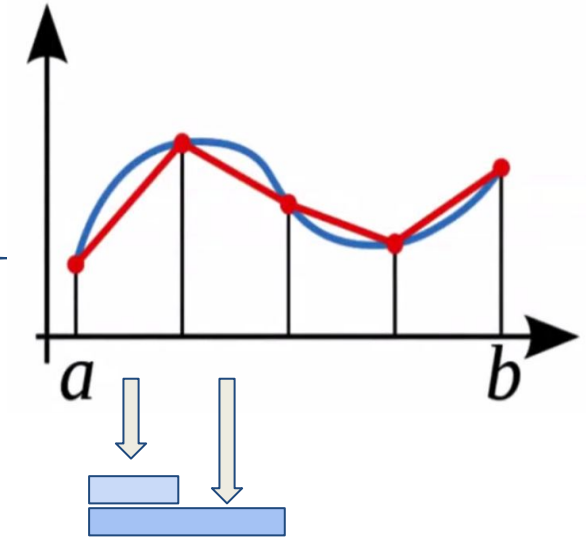

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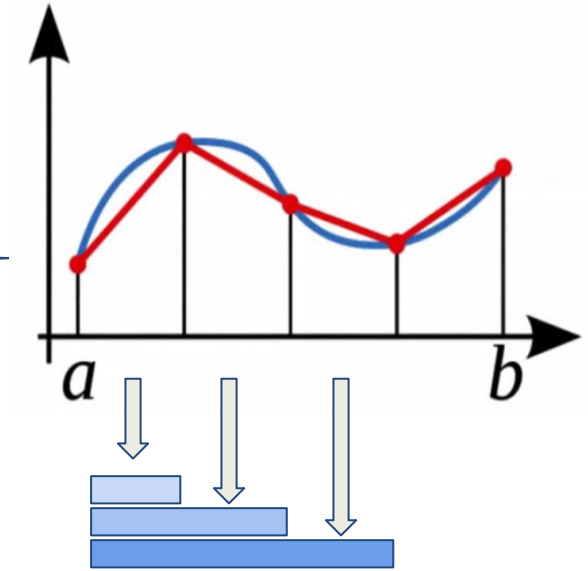

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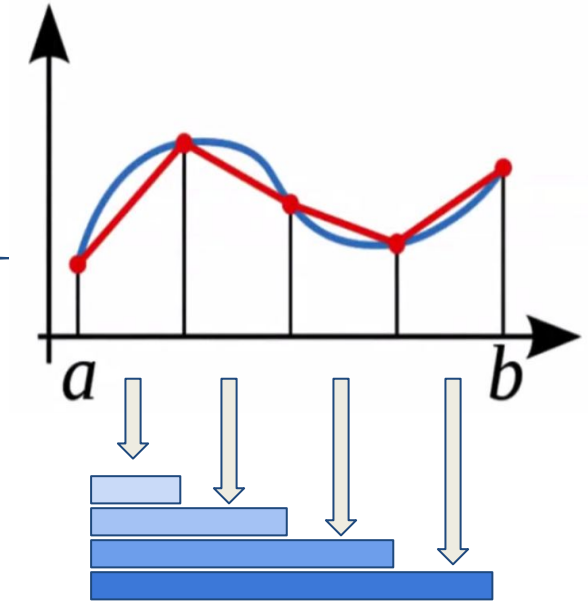

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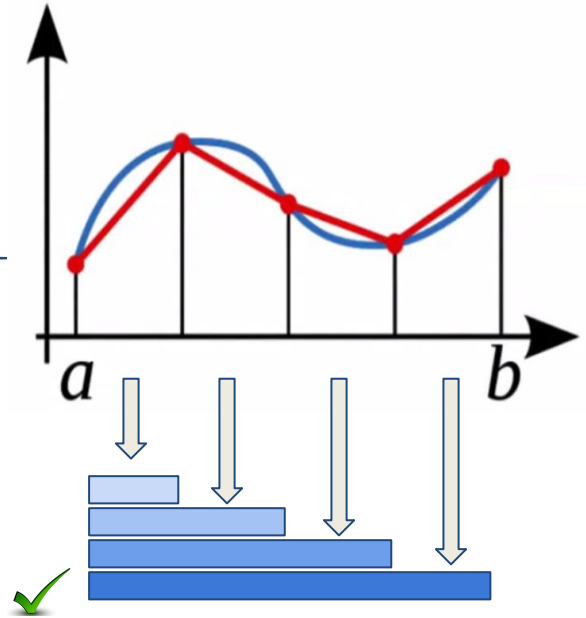
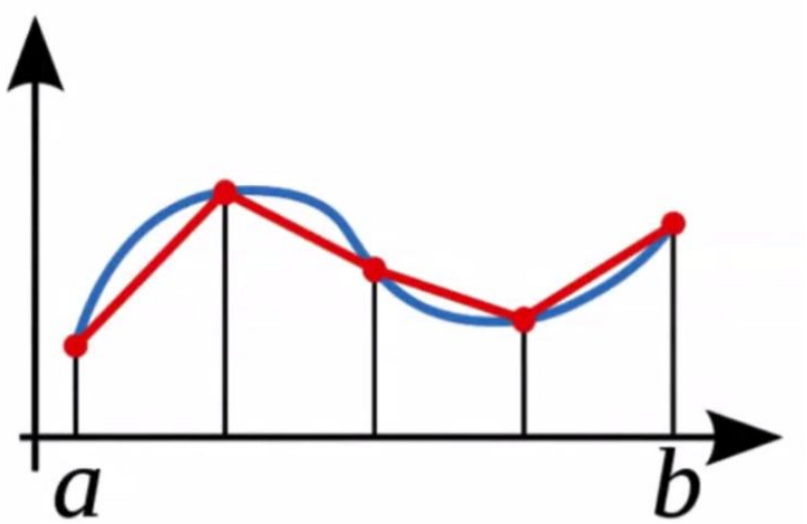


How we can do it Parallely .. ?

Trap Rule : Parallel Approach



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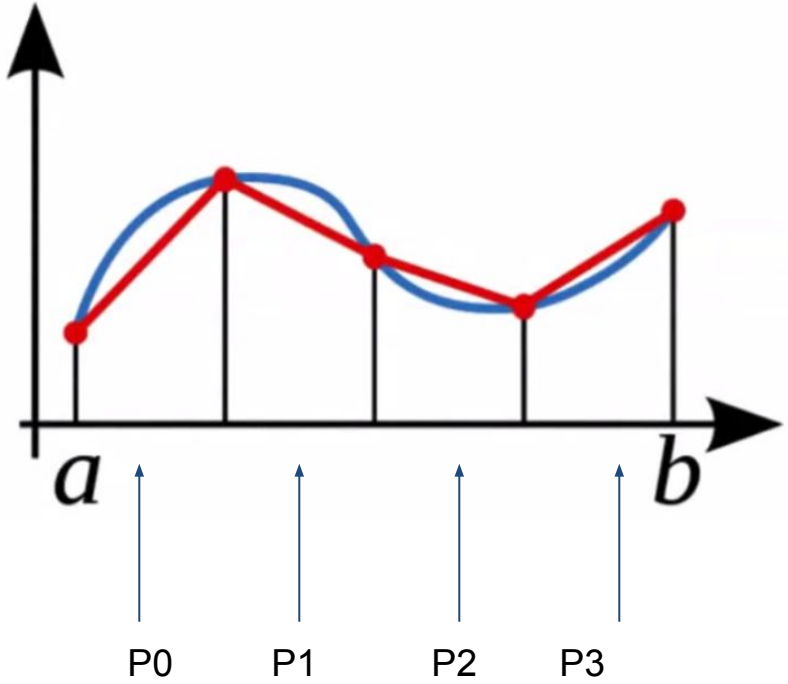

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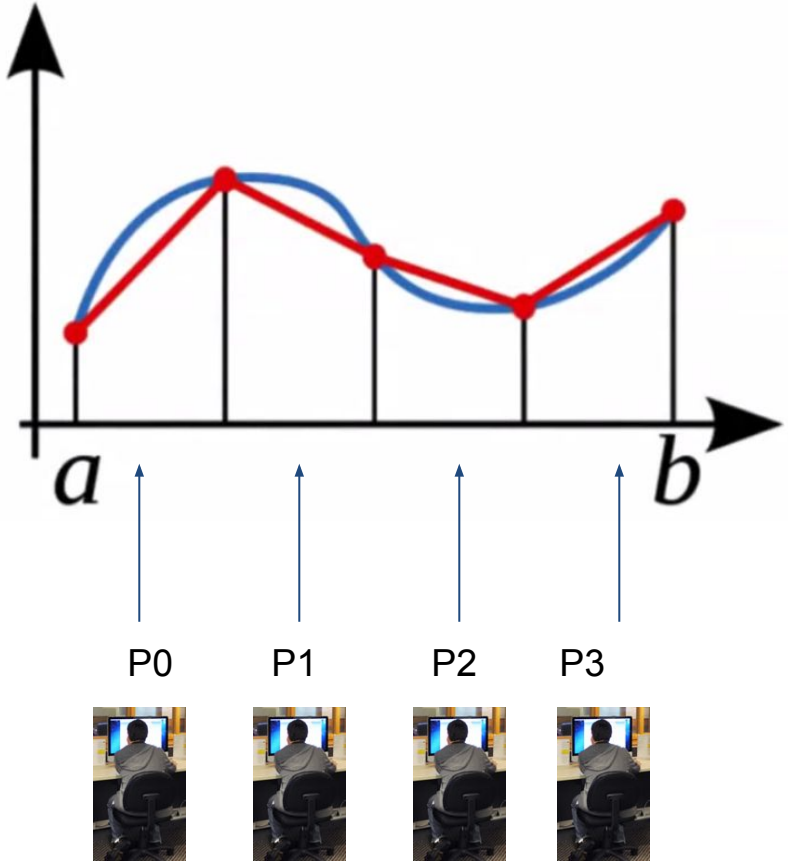

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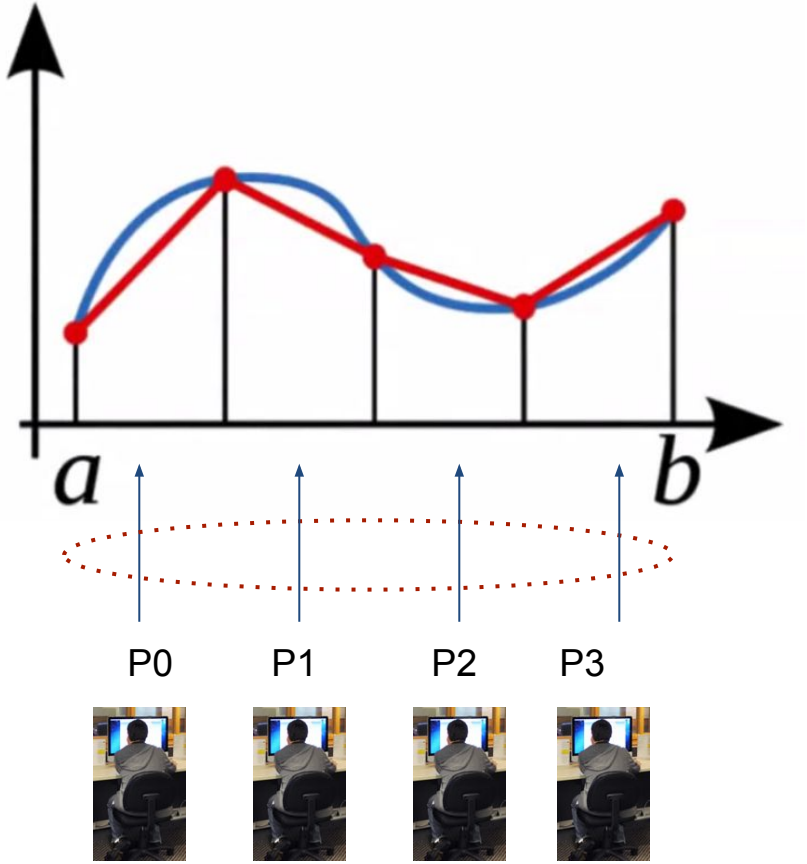

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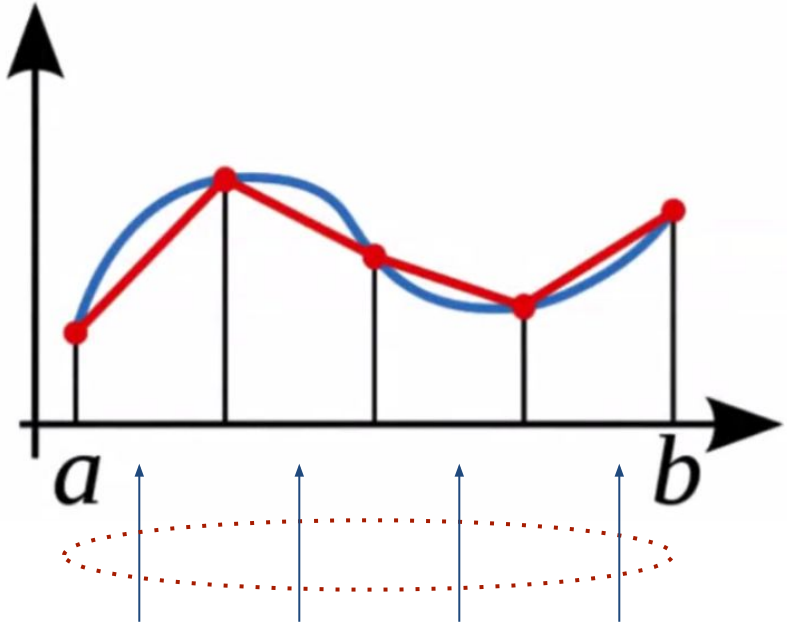

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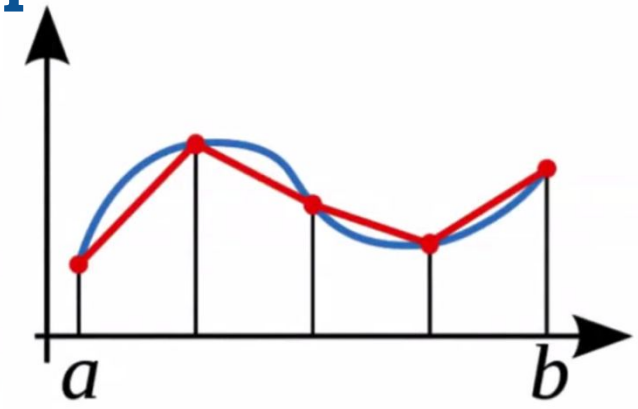

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Given p processes, each process can work on n/p intervals

Note: for simplicity will assume n/p is an integer

process	interval
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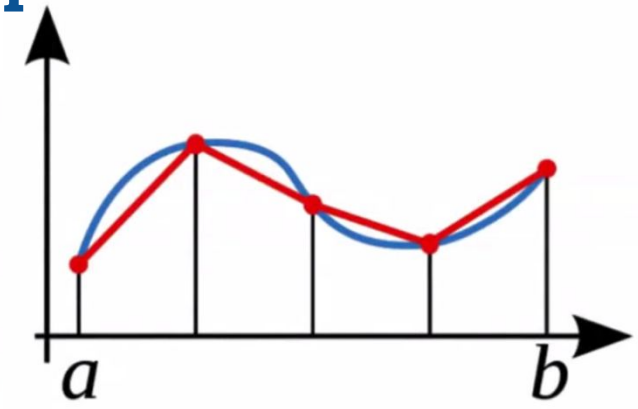

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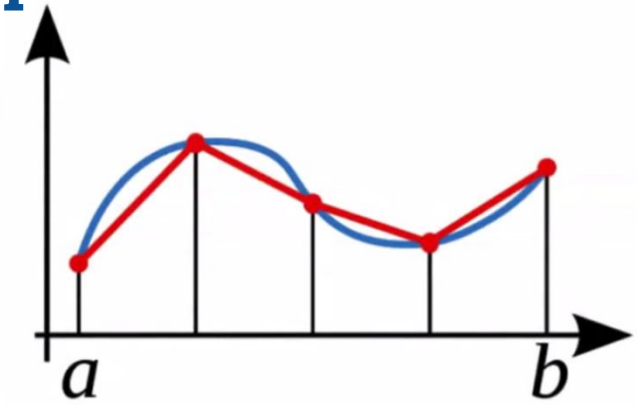

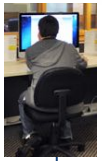

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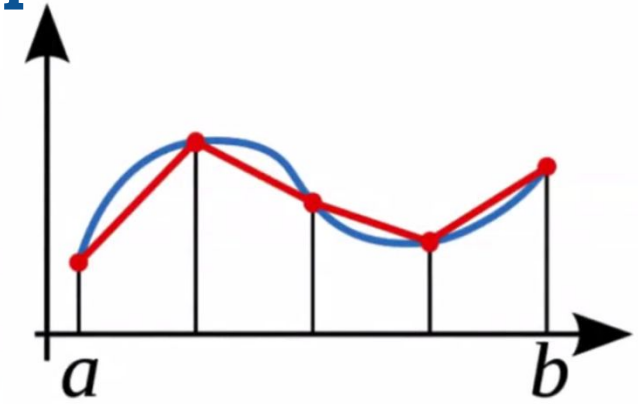

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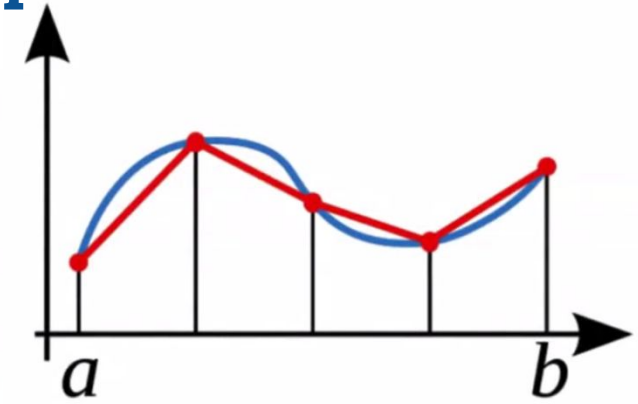

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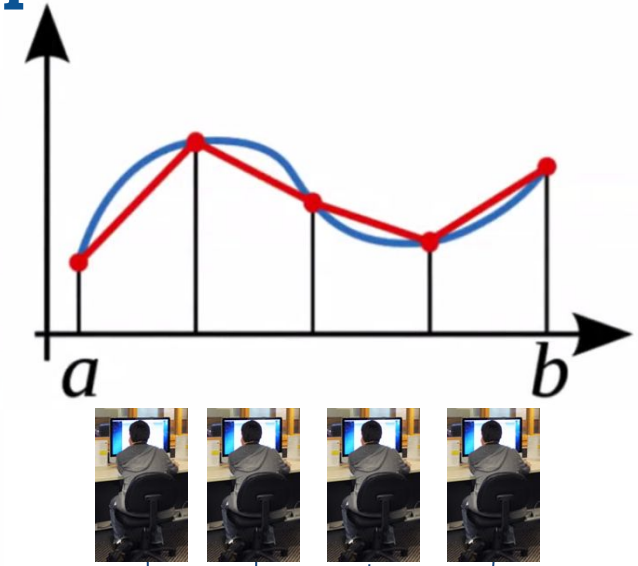

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#include <mpi.h>

void Get_data(int p, int my_rank, double* a_p, double* b_p, int* n_p);

double Trap(double local_a, double local_b, int local_n, double h);
                                                    /* Calculate local area  */

double f(double x);                                  /* function we're integrating */
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```
int main(int argc, char** argv)
 {
        int         my_rank;          /* My process rank           */
        int         p;                /* The number of processes   */
        double      a;                /* Left endpoint             */
        double      b;                /* Right endpoint            */
        int         n;                /* Number of trapezoids      */
        double      h;                /* Trapezoid base length     */
        double      local_a;          /* Left endpoint my process  */
        double      local_b;          /* Right endpoint my process */
        int         local_n;          /* Number of trapezoids for  */
      double        my_area;          /* Integral over my interval */
        double      total;            /* Total area                */
        int         source;           /* Process sending area      */
        int         dest = 0;         /* All messages go to 0      */
        int         tag = 0;
        MPI_Status  status;
```

```
MPI_Init(&argc, &argv);
 MPI_Comm_rank(MPI_COMM_WORLD, &my_rank);
 MPI_Comm_size(MPI_COMM_WORLD, &p);

 Get_data(p, my_rank, &a, &b, &n);

 h = (b-a)/n;                    /* h is the same for all processes */
 local_n = n/p;                  /* So is the number of trapezoids */

 local_a = a + my_rank*local_n*h;
 local_b = local_a + local_n*h;
 my_area = Trap(local_a, local_b, local_n, h);
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MPI_Comm_size(MPI_COMM_WORLD, &p);

Get_data(p, my_rank, &a, &b, &n);

h = (b-a)/n;                    /* h is the same for all processes */
local_n = n/p;                  /* So is the number of trapezoids */

local_a = a + my_rank*local_n*h;
local_b = local_a + local_n*h;
my_area = Trap(local_a, local_b, local_n, h);
```

Environment Management Routines

```
MPI_Init(&argc, &argv);
MPI_Comm_rank(MPI_COMM_WORLD, &my_rank);
MPI_Comm_size(MPI_COMM_WORLD, &p);

Get_data(p, my_rank, &a, &b, &n);

h = (b-a)/n;                    /* h is the same for all processes */
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my_area = Trap(local_a, local_b, local_n, h);
```

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MPI_Comm_rank(MPI_COMM_WORLD, &my_rank);
MPI_Comm_size(MPI_COMM_WORLD, &p);

Get_data(p, my_rank, &a, &b, &n);

h = (b-a)/n;                    /* h is the same for all processes */
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 MPI_Comm_rank(MPI_COMM_WORLD, &my_rank);
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 Get_data(p, my_rank, &a, &b, &n);

 h = (b-a)/n;                    /* h is the same for all processes */
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 Get_data(p, my_rank, &a, &b, &n);

 h = (b-a)/n;                    /* h is the same for all processes */
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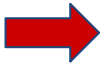
 local_a = a + my_rank*local_n*h;
 local_b = local_a + local_n*h;
 my_area = Trap(local_a, local_b, local_n, h);
```

```
MPI_Init(&argc, &argv);
 MPI_Comm_rank(MPI_COMM_WORLD, &my_rank);
 MPI_Comm_size(MPI_COMM_WORLD, &p);

 Get_data(p, my_rank, &a, &b, &n);

 h = (b-a)/n;                    /* h is the same for all processes */
 local_n = n/p;                  /* So is the number of trapezoids */

 local_a = a + my_rank*local_n*h;
 local_b = local_a + local_n*h;
 my_area = Trap(local_a, local_b, local_n, h);
```



```
MPI_Init(&argc, &argv);
 MPI_Comm_rank(MPI_COMM_WORLD, &my_rank);
 MPI_Comm_size(MPI_COMM_WORLD, &p);

 Get_data(p, my_rank, &a, &b, &n);

 h = (b-a)/n;                    /* h is the same for all processes */
 local_n = n/p;                  /* So is the number of trapezoids */

 local_a = a + my_rank*local_n*h;
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 my_area = Trap(local_a, local_b, local_n, h);
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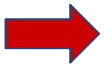

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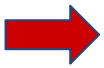
 MPI_Comm_rank(MPI_COMM_WORLD, &my_rank);
 MPI_Comm_size(MPI_COMM_WORLD, &p);

 Get_data(p, my_rank, &a, &b, &n);

 h = (b-a)/n;                    /* h is the same for all processes */
 local_n = n/p;                  /* So is the number of trapezoids */

 local_a = a + my_rank*local_n*h;
 local_b = local_a + local_n*h;
 my_area = Trap(local_a, local_b, local_n, h);
```



```
 if (my_rank == 0)
{
      total = my_area;
      for (source = 1; source < p; source++)
      {
            MPI_Recv(&my_area, 1, MPI_DOUBLE, source, tag, MPI_COMM_WORLD, &status);
            total = total + my_area;
      }
} else
       {
            MPI_Send(&my_area, 1, MPI_DOUBLE, dest,  tag, MPI_COMM_WORLD);
       }
```

```
if (my_rank == 0)
{
    total = my_area;
    for (source = 1; source < p; source++)
    {
        MPI_Recv(&my_area, 1, MPI_DOUBLE, source, tag, MPI_COMM_WORLD, &status);
        total = total + my_area;
    }
} else
    {
        MPI_Send(&my_area, 1, MPI_DOUBLE, dest,  tag, MPI_COMM_WORLD);
    }
```

```
 if (my_rank == 0)
{
     total = my_area;
     for (source = 1; source < p; source++)
     {
          MPI_Recv(&my_area, 1, MPI_DOUBLE, source, tag, MPI_COMM_WORLD, &status);
          total = total + my_area;
     }
} else
      {
          MPI_Send(&my_area, 1, MPI_DOUBLE, dest,  tag, MPI_COMM_WORLD);
      }
```

```
 if (my_rank == 0)
{
      total = my_area;
      for (source = 1; source < p; source++)
      {
          MPI_Recv(&my_area, 1, MPI_DOUBLE, source, tag, MPI_COMM_WORLD, &status);
          total = total + my_area;
      }
} else
      {
          MPI_Send(&my_area, 1, MPI_DOUBLE, dest,  tag, MPI_COMM_WORLD);
      }
```

```
        if (my_rank == 0)
        {
            printf("With n = %d trapezoids, our estimate\n", n);
            printf("of the area from %f to %f = %.15f\n", a, b, total);
         }

        MPI_Finalize();

       return 0;
}

       /* END of MAIN */
```

```
    if (my_rank == 0)
    {
        printf("With n = %d trapezoids, our estimate\n", n);
        printf("of the area from %f to %f = %.15f\n", a, b, total);
     }

     MPI_Finalize();

    return 0;
}

    /* END of MAIN */
```

```
        if (my_rank == 0)
        {
            printf("With n = %d trapezoids, our estimate\n", n);
            printf("of the area from %f to %f = %.15f\n", a, b, total);
        }

        MPI_Finalize();

        return 0;
}

        /* END of MAIN */
```

Releases the MPI resources

```
void Get_data(int p, int my_rank, double* a_p, double* b_p, int* n_p)
{
          int        q;
          MPI_Status status;
          if (my_rank == 0)
        {
             printf("Enter a, b, and n\n");
             scanf("%lf %lf %d", a_p, b_p, n_p);
                    for (q = 1; q < p; q++) {
                    MPI_Send(a_p, 1, MPI_DOUBLE, q, 0, MPI_COMM_WORLD);
                    MPI_Send(b_p, 1, MPI_DOUBLE, q, 0, MPI_COMM_WORLD);
                    MPI_Send(n_p, 1, MPI_INT, q, 0, MPI_COMM_WORLD);
                    }
          } else
       {
             MPI_Recv(a_p, 1, MPI_DOUBLE, 0, 0, MPI_COMM_WORLD, &status);
             MPI_Recv(b_p, 1, MPI_DOUBLE, 0, 0, MPI_COMM_WORLD, &status);
             MPI_Recv(n_p, 1, MPI_INT, 0, 0, MPI_COMM_WORLD, &status);
          }
}
```

```
void Get_data(int p, int my_rank, double* a_p, double* b_p, int* n_p)
{
        int         q;
        MPI_Status status;
        if (my_rank == 0)
       {
            printf("Enter a, b, and n\n");
            scanf("%lf %lf %d", a_p, b_p, n_p);
                    for (q = 1; q < p; q++) {
                    MPI_Send(a_p, 1, MPI_DOUBLE, q, 0, MPI_COMM_WORLD);
                    MPI_Send(b_p, 1, MPI_DOUBLE, q, 0, MPI_COMM_WORLD);
                    MPI_Send(n_p, 1, MPI_INT, q, 0, MPI_COMM_WORLD);
                    }
        } else
      {
            MPI_Recv(a_p, 1, MPI_DOUBLE, 0, 0, MPI_COMM_WORLD, &status);
            MPI_Recv(b_p, 1, MPI_DOUBLE, 0, 0, MPI_COMM_WORLD, &status);
            MPI_Recv(n_p, 1, MPI_INT, 0, 0, MPI_COMM_WORLD, &status);
        }
}
```

```
void Get_data(int p, int my_rank, double* a_p, double* b_p, int* n_p)
{
        int       q;
        MPI_Status status;
        if (my_rank == 0)
       {
            printf("Enter a, b, and n\n");
            scanf("%lf %lf %d", a_p, b_p, n_p);
                    for (q = 1; q < p; q++) {
                    MPI_Send(a_p, 1, MPI_DOUBLE, q, 0, MPI_COMM_WORLD);
                    MPI_Send(b_p, 1, MPI_DOUBLE, q, 0, MPI_COMM_WORLD);
                    MPI_Send(n_p, 1, MPI_INT, q, 0, MPI_COMM_WORLD);
                    }
        } else
      {
            MPI_Recv(a_p, 1, MPI_DOUBLE, 0, 0, MPI_COMM_WORLD, &status);
            MPI_Recv(b_p, 1, MPI_DOUBLE, 0, 0, MPI_COMM_WORLD, &status);
            MPI_Recv(n_p, 1, MPI_INT, 0, 0, MPI_COMM_WORLD, &status);
        }
}
```

```
void Get_data(int p, int my_rank, double* a_p, double* b_p, int* n_p)
{
          int        q;
          MPI_Status status;
          if (my_rank == 0)
        {
            printf("Enter a, b, and n\n");
            scanf("%lf %lf %d", a_p, b_p, n_p);
                    for (q = 1; q < p; q++) {
                    MPI_Send(a_p, 1, MPI_DOUBLE, q, 0, MPI_COMM_WORLD);
                    MPI_Send(b_p, 1, MPI_DOUBLE, q, 0, MPI_COMM_WORLD);
                    MPI_Send(n_p, 1, MPI_INT, q, 0, MPI_COMM_WORLD);
                    }
          } else
        {
            MPI_Recv(a_p, 1, MPI_DOUBLE, 0, 0, MPI_COMM_WORLD, &status);
            MPI_Recv(b_p, 1, MPI_DOUBLE, 0, 0, MPI_COMM_WORLD, &status);
            MPI_Recv(n_p, 1, MPI_INT, 0, 0, MPI_COMM_WORLD, &status);
          }
}
```

```
double Trap(double  local_a, double  local_b , int  local_n , double  h )
        {
            double my_area;                    /* Store my result in my_area  */
            double x;
            int i;
            my_area = (f(local_a) + f(local_b))/2.0;
            x = local_a;
            for (i = 1; i <= local_n-1; i++)
            {
                  x = local_a + i*h;
                  my_area = my_area + f(x);
            }
            my_area = my_area*h;
            return my_area;
        }
```

```
double f(double x)
 {
     double return_val;

     return_val = x*x + 1.0;

     return return_val;
}


   /* END of Program */
```

Recap :

Recap :

- **Serial and Parallel Approach -**

Recap :

- Serial and Parallel Approach -
- MPI_Comm_rank(...)

Recap :

- Serial and Parallel Approach -
- MPI_Comm_rank(...)
- MPI_Comm_size(...)

Recap :

- Serial and Parallel Approach -
- MPI_Comm_rank(...)
- MPI_Comm_size(...)
- Point to point communication

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- Serial and Parallel Approach -
- MPI_Comm_rank(...)
- MPI_Comm_size(...)
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- MPI_Send(...)
- MPI_Recv(...)
- Blocking and Non-blocking Point to Point communication - Cases !

Recap :

- Serial and Parallel Approach -
- MPI_Comm_rank(...)
- MPI_Comm_size(...)
- Point to point communication
- MPI_Send(...)
- MPI_Recv(...)
- Blocking and Non-blocking Point to Point communication - Cases !
- ..... Trapezoidal Rule Example

References :

[1] Barker, Brandon. "Message passing interface (mpi)." *Workshop: High Performance Computing on Stampede*. Vol. 262. 2015.

[2] Yuan, Chung-Tsz, and Shenjian Chen. "Message Passing Interface (MPI)." (1996).

[3] https://computing.llnl.gov/tutorials/mpi/


Thank
You

MPI_Comm_rank(.....)

MPI_Comm_rank(.....)

Syntax :

MPI_Comm_rank (MPI_Comm communicator , int * rank) ;

MPI_Comm_rank(.....)

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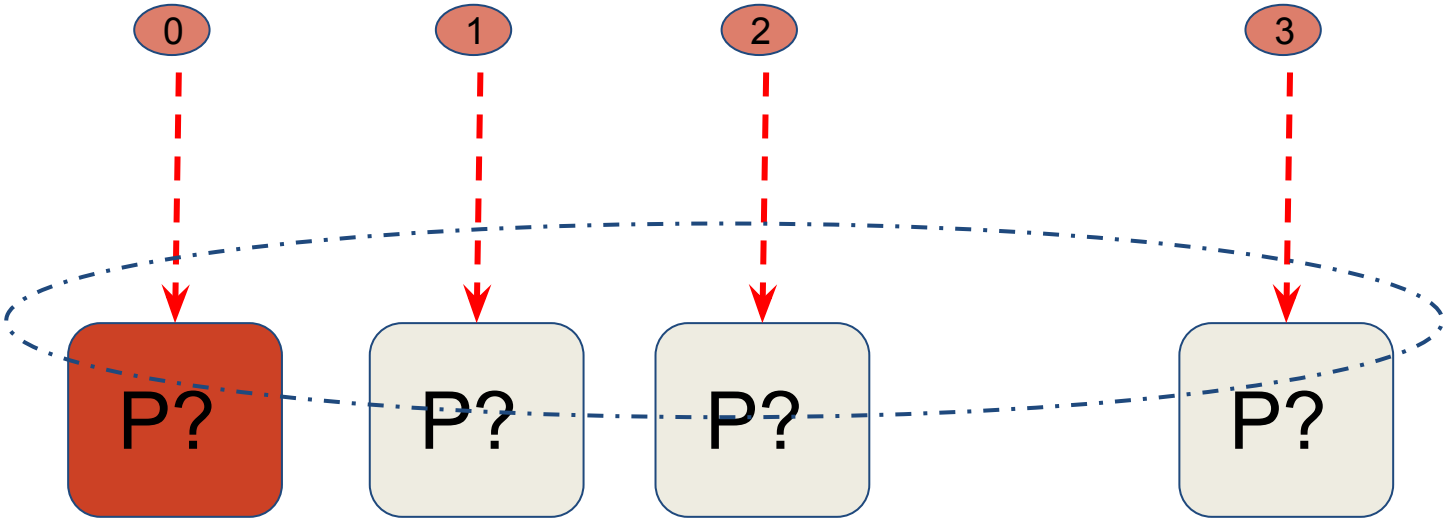

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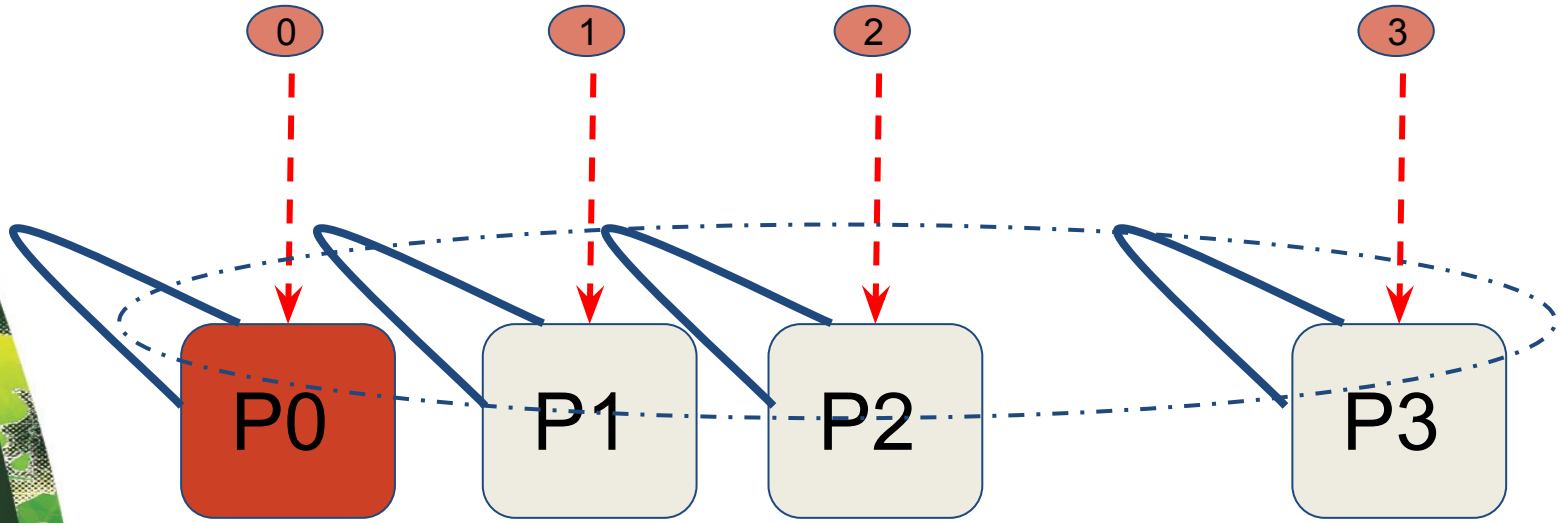

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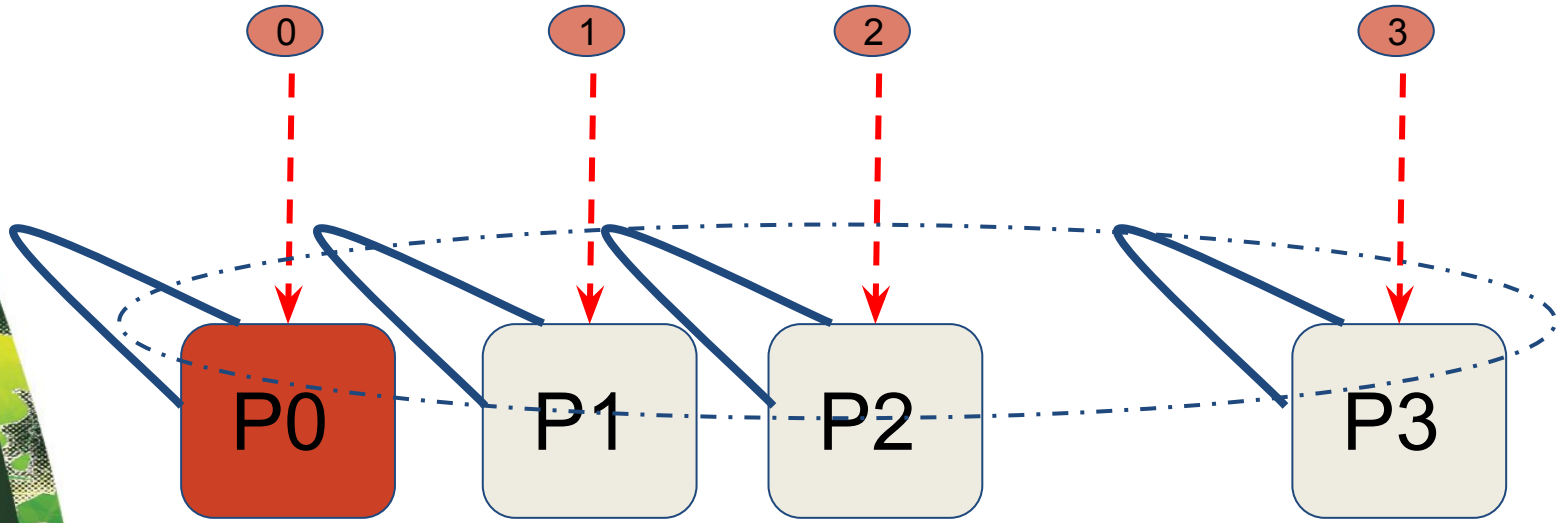

MPI_Comm_size(.....)

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Syntax :

MPI_Comm_size (MPI_Comm communicator , int * size) ;

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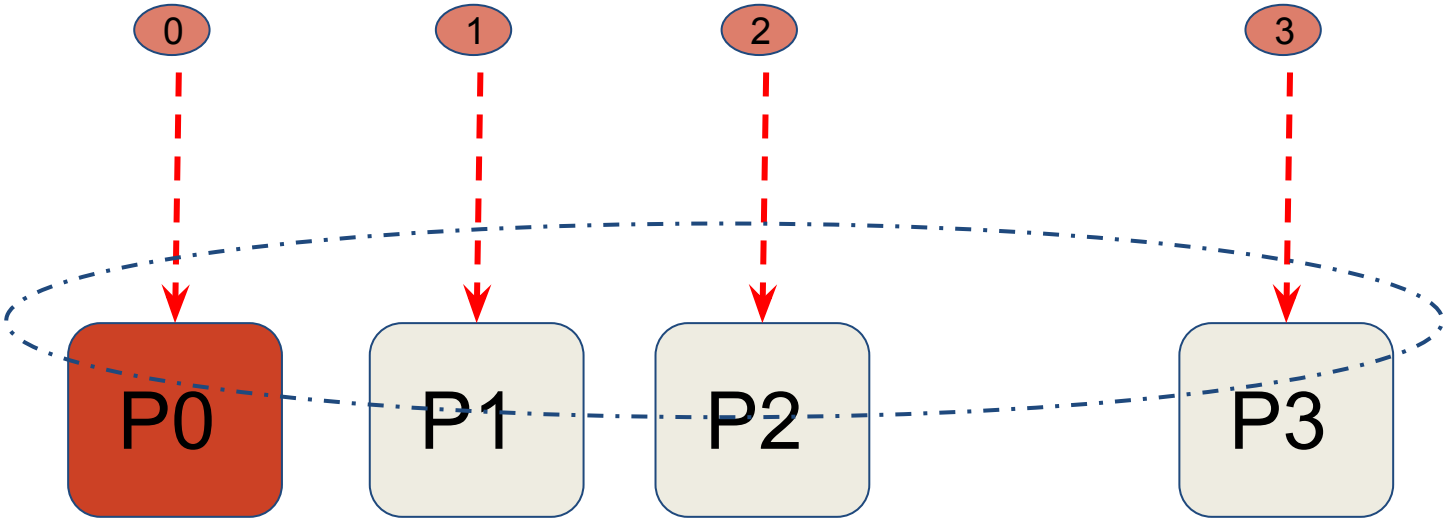

MPI_Comm_size(.....)

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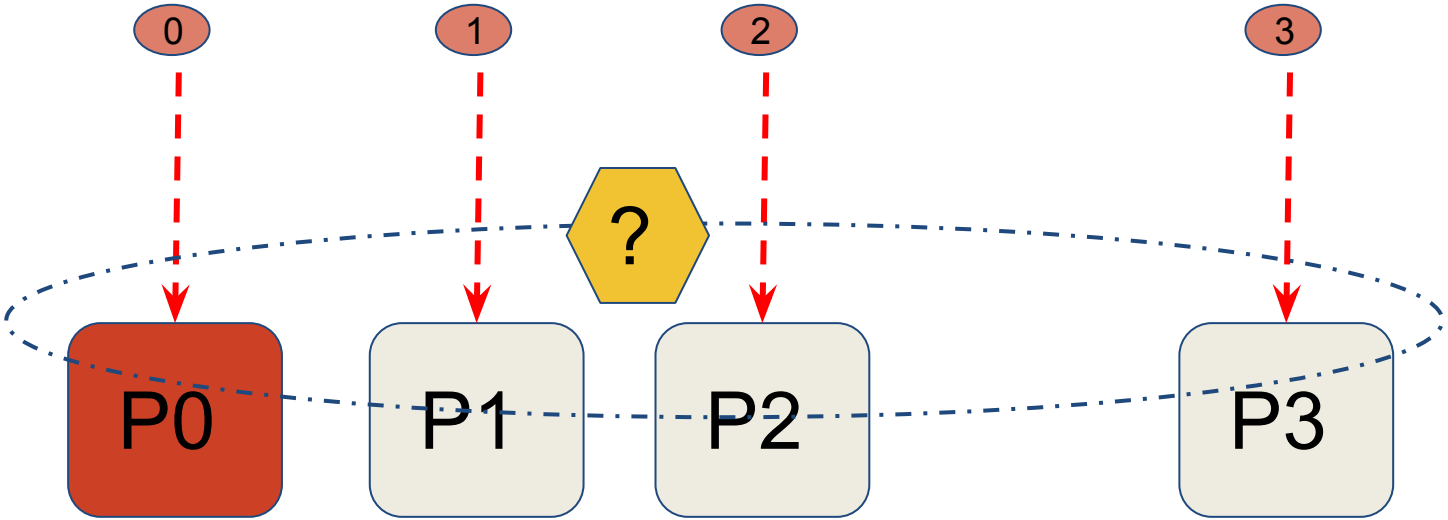

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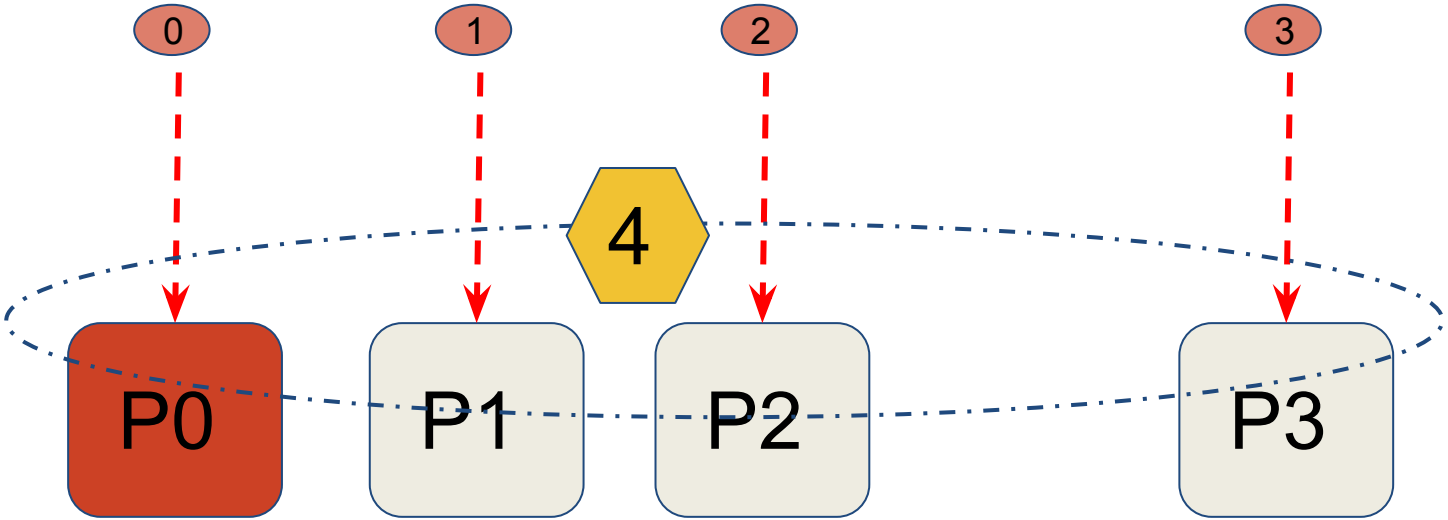

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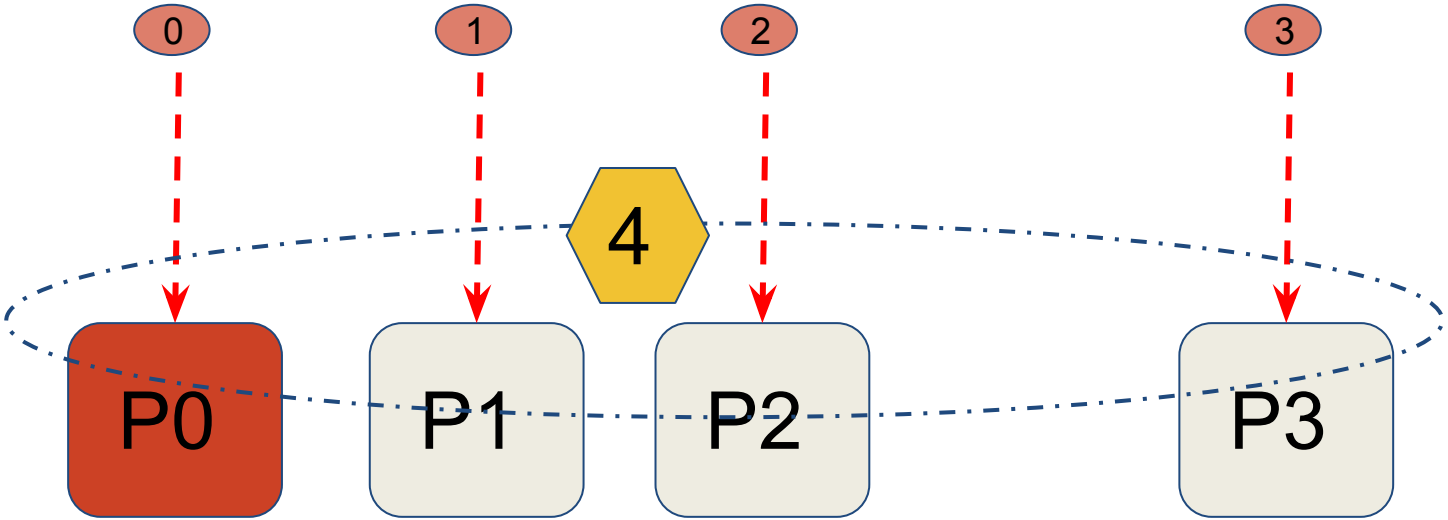

MPI_Send(.....)

MPI_Send(.....)

Syntax :

MPI_Send (void* msg_buffer , Int msg_size, MPI_Datatype msg_type,
Int destination, Int tag , MPI_Comm communicator) ;

MPI_Send(.....)

Syntax :

1 2 3

MPI_Send (void* msg_buffer , Int msg_size, MPI_Datatype msg_type,
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4 5 6

MPI_Send(.....)

Syntax :

1 2 3

MPI_Send (void* msg_buffer , Int msg_size, MPI_Datatype msg_type,
Int destination, Int tag , MPI_Comm communicator) ;

4 5 6

1 Address of Message buffer

MPI_Send(.....)

Syntax :

1 2 3

MPI_Send (void* msg_buffer , Int msg_size, MPI_Datatype msg_type,
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4 5 6

1. Address of Message buffer
2. Message size

MPI_Send(.....)

Syntax :

1 2 3

MPI_Send (void* msg_buffer , Int msg_size, MPI_Datatype msg_type,
Int destination, Int tag , MPI_Comm communicator) ;

4 5 6

1. Address of Message buffer
2. Message size
3. Data Type

MPI_Send(.....)

Syntax :

1 2 3

MPI_Send (void* msg_buffer , Int msg_size, MPI_Datatype msg_type,
Int destination, Int tag , MPI_Comm communicator) ;

4 5 6

1. Address of Message buffer
2. Message size
3. Data Type
4. Destination process rank

MPI_Send(.....)

Syntax :

1 2 3

MPI_Send (void* msg_buffer , Int msg_size, MPI_Datatype msg_type,
Int destination, Int tag , MPI_Comm communicator) ;

4 5 6

1. Address of Message buffer
2. Message size
3. Data Type
4. Destination process rank
5. Tag - Message Identifier/..

MPI_Send(.....)

Syntax :

1 2 3

MPI_Send (void* msg_buffer , Int msg_size, MPI_Datatype msg_type,
Int destination, Int tag , MPI_Comm communicator) ;

4 5 6

1. Address of Message buffer
2. Message size
3. Data Type
4. Destination process rank
5. Tag - Message Identifier/..
6. Communicator

MPI_Send(.....)

Syntax :

1 2 3

MPI_Send (void* msg_buffer , Int msg_size, MPI_Datatype msg_type,
Int destination, Int tag , MPI_Comm communicator) ;

4 5 6

MPI_Send(.....)

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1 2 3

MPI_Send(.....)

Syntax :

1 2 3

MPI_Send (void* msg_buffer , Int msg_size, MPI_Datatype msg_type,
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4 5 6

Tell us information about message

1 2 3

MPI_Send(.....)

Syntax :

1 2 3

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Int destination, Int tag , MPI_Comm communicator) ;

4 5 6

Tell us information about message

1 2 3 4 5 6

MPI_Send(.....)

Syntax :

1 2 3

MPI_Send (void* msg_buffer , Int msg_size, MPI_Datatype msg_type,
Int destination, Int tag , MPI_Comm communicator) ;

4 5 6

Tell us information about message

Tell us, where and How to send a message

1 2 3 4 5 6

MPI_Recv(.....)

MPI_Recv(.....)

Syntax :

```
MPI_Recv (void*  msg_buffer , Int  buf_size, MPI_Datatype  buf_type,
          Int source,  Int  tag , MPI_Comm  communicator, MPI_Status* );
```

MPI_Recv(.....)

Syntax :

1 2 3

MPI_Recv (void* msg_buffer , Int buf_size, MPI_Datatype buf_type,
Int source, Int tag , MPI_Comm communicator, MPI_Status*);

4 5 6 7

MPI_Recv(.....)

Syntax :

1 2 3

```
MPI_Recv (void*  msg_buffer , Int  buf_size, MPI_Datatype  buf_type,
          Int source,  Int  tag , MPI_Comm  communicator, MPI_Status* );
```

4 5 6 7

1. Address of Message buffer
2. Buffer size
3. Data Type

MPI_Recv(.....)

Syntax :

1 2 3

```
MPI_Recv (void*  msg_buffer , Int  buf_size, MPI_Datatype  buf_type,
          Int source,  Int  tag , MPI_Comm  communicator, MPI_Status* );
```

4 5 6 7

1. Address of Message buffer
2. Buffer size
3. Data Type
4. Source process rank
5. Tag - Message Identifier/..
6. Communicator

MPI_Recv(.....)

Syntax :

1 2 3

```
MPI_Recv (void*  msg_buffer , Int  buf_size, MPI_Datatype  buf_type,
          Int source,  Int  tag , MPI_Comm  communicator, MPI_Status* );
```

4 5 6 7

1. Address of Message buffer
2. Buffer size
3. Data Type
4. Source process rank
5. Tag - Message Identifier/..
6. Communicator
7. Status of Received message

Successful transmission of Message..

- MPI_Send (void* msg_buffer , Int msg_size, MPI_Datatype msg_type,
  Int destination, Int tag , MPI_Comm communicator) ;

- MPI_Recv (void* msg_buffer , Int buf_size, MPI_Datatype buf_type,
  Int source, Int tag , MPI_Comm communicator, MPI_Status*);

Successful transmission of Message..

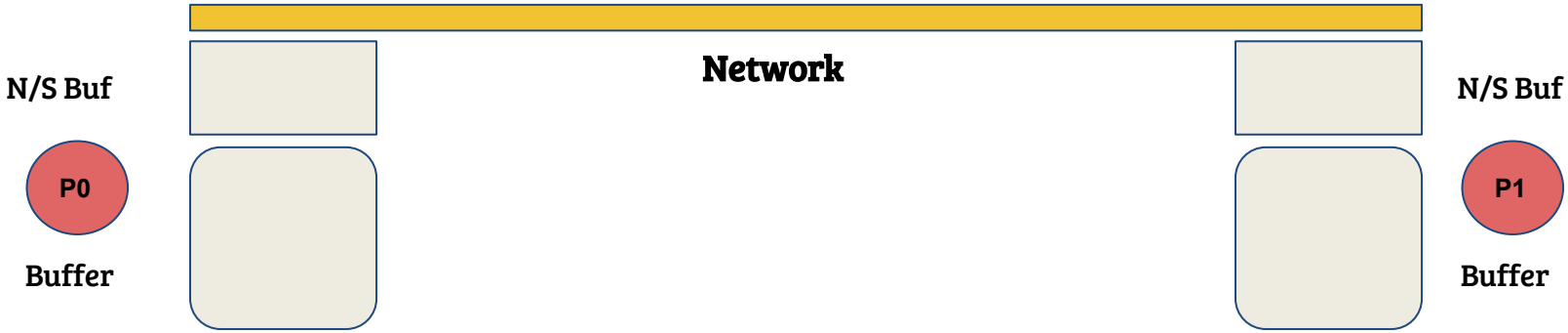
- MPI_Send (void* msg_buffer , Int msg_size, MPI_Datatype msg_type,
  Int destination, Int tag , MPI_Comm communicator) ;

- MPI_Recv (void* msg_buffer , Int buf_size, MPI_Datatype buf_type,
  Int source, Int tag , MPI_Comm communicator, MPI_Status*);

recv_comm = send_comm
recv_tag = send_tag
dest = Destination process rank
Src = Source process rank

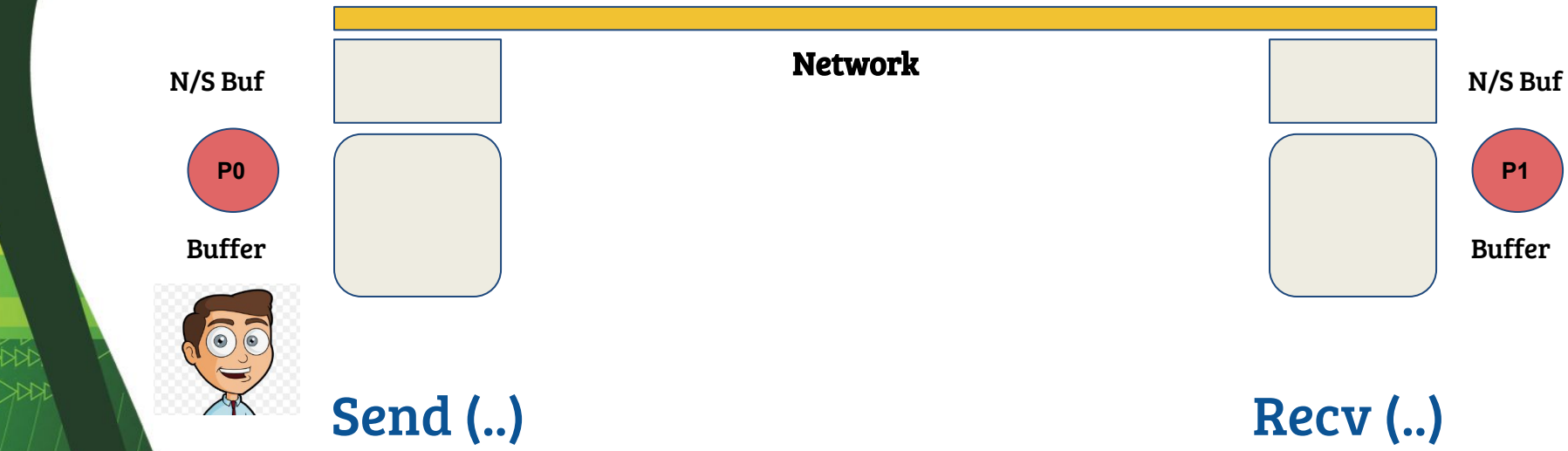
How message is transferred … ?

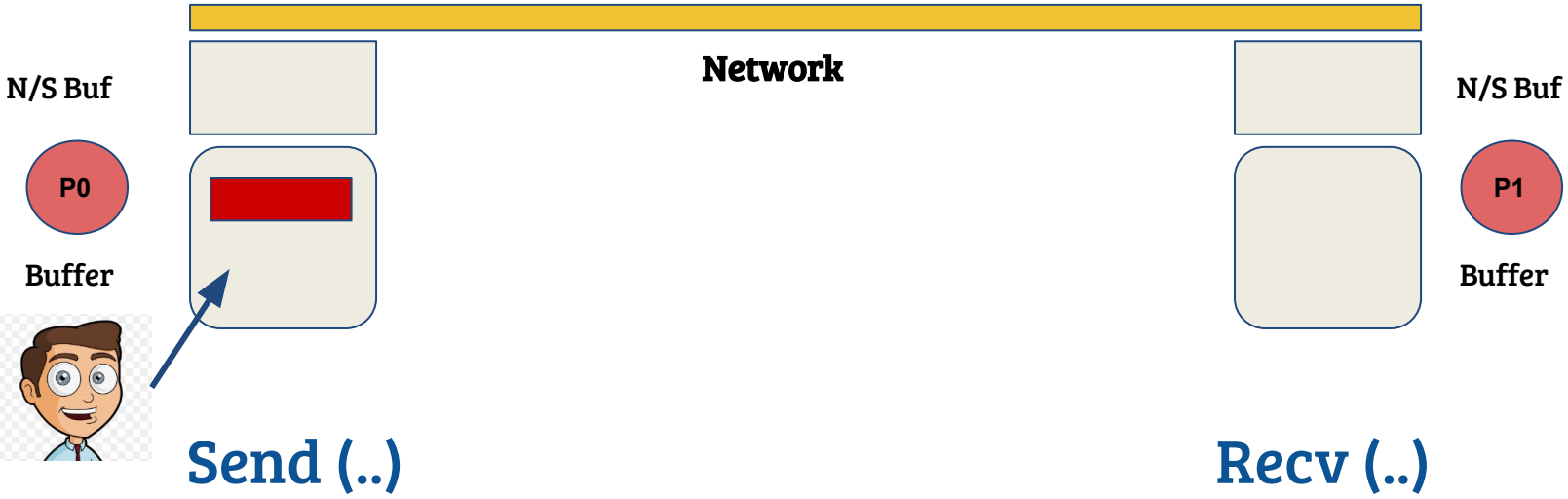
… Different cases !

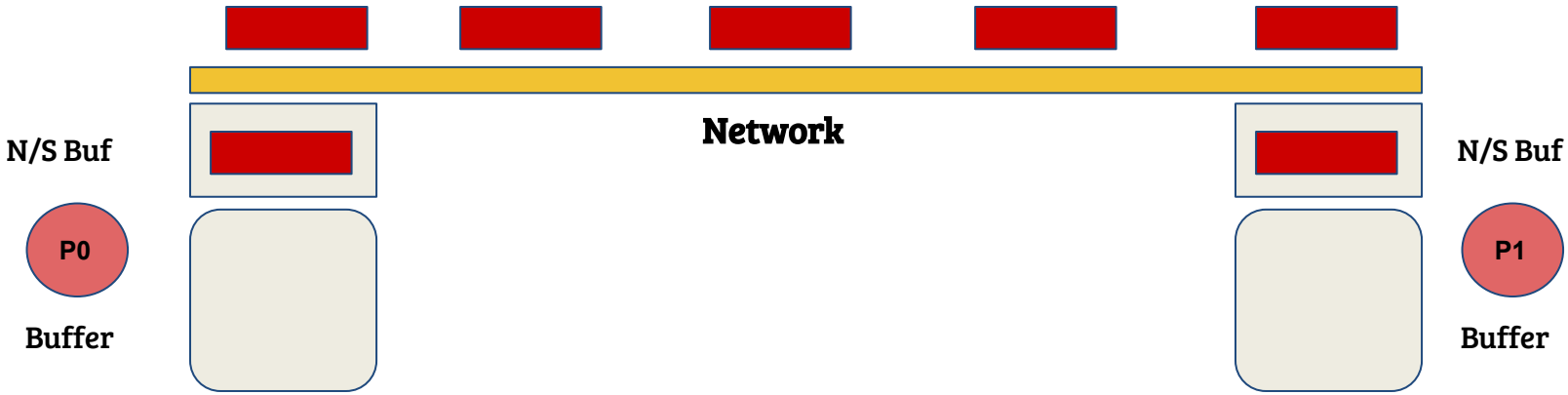


Send (..)

Recv (..)

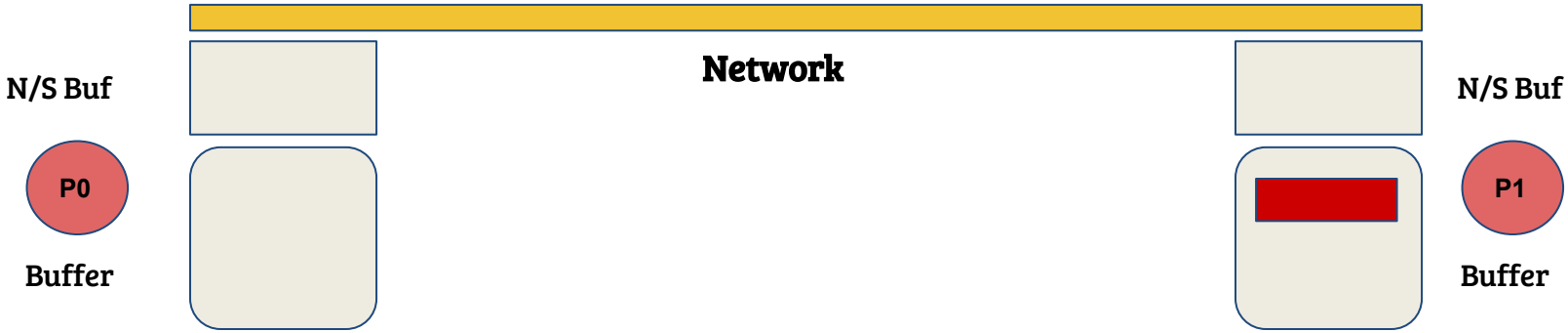

Network
N/S Buf
P0
Buffer
N/S Buf
P1
Buffer
Send (..)
Recv (..)


Network
N/S Buf
P0
Buffer
N/S Buf
P1
Buffer
Send (..)
Recv (..)



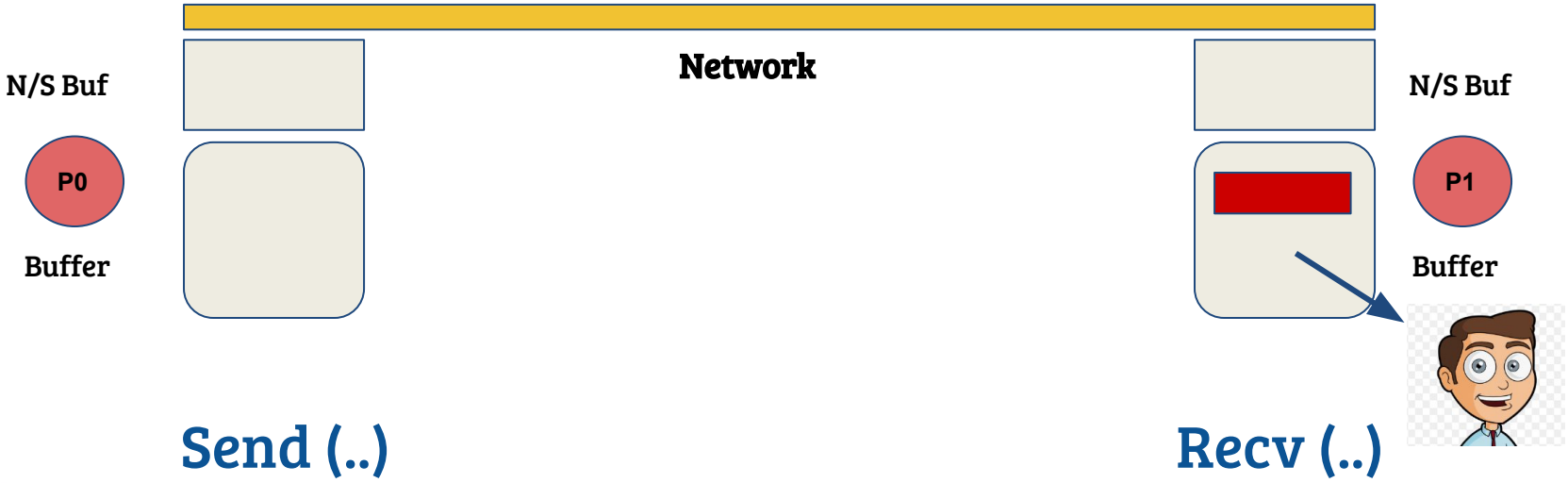
Send (..)

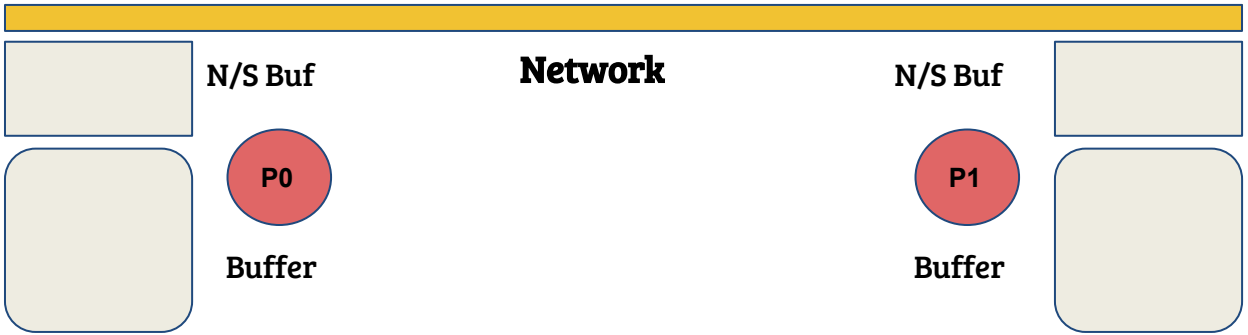
Recv (..)



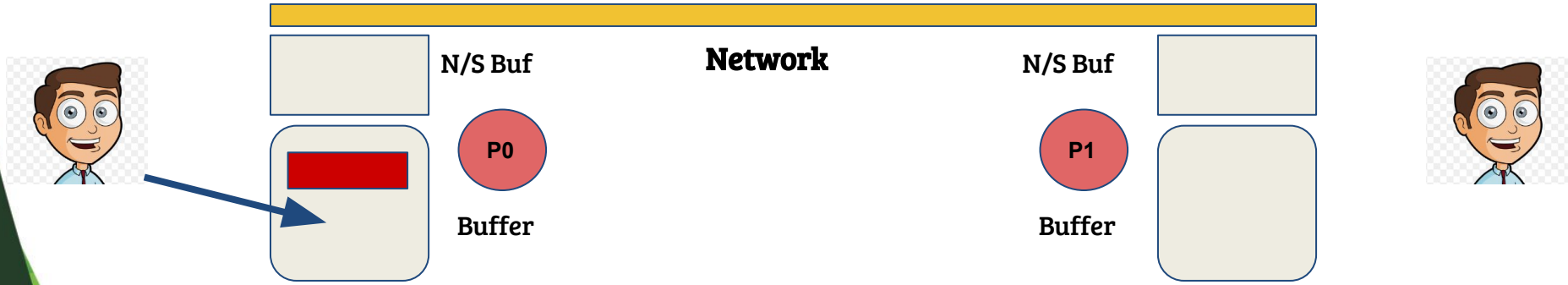
Send (..)

Recv (..)

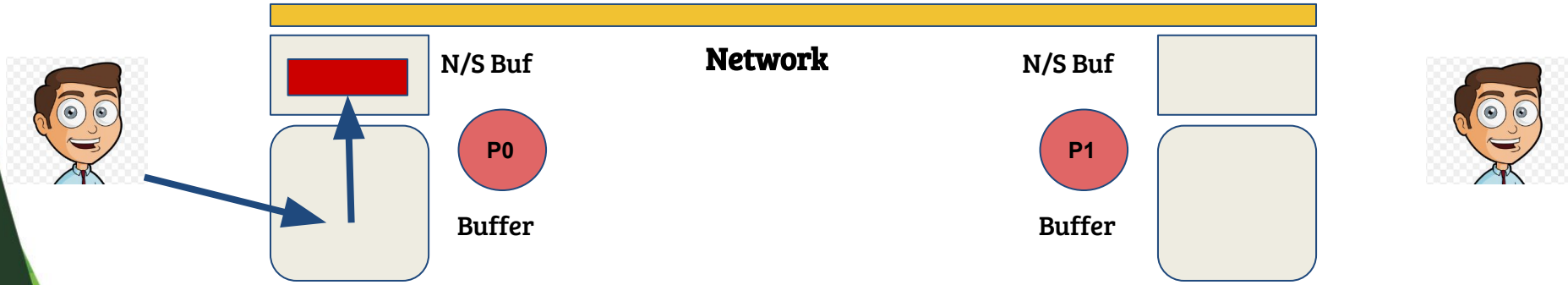

Network
N/S Buf
P0
Buffer
N/S Buf
P1
Buffer
Send (..)
Recv (..)



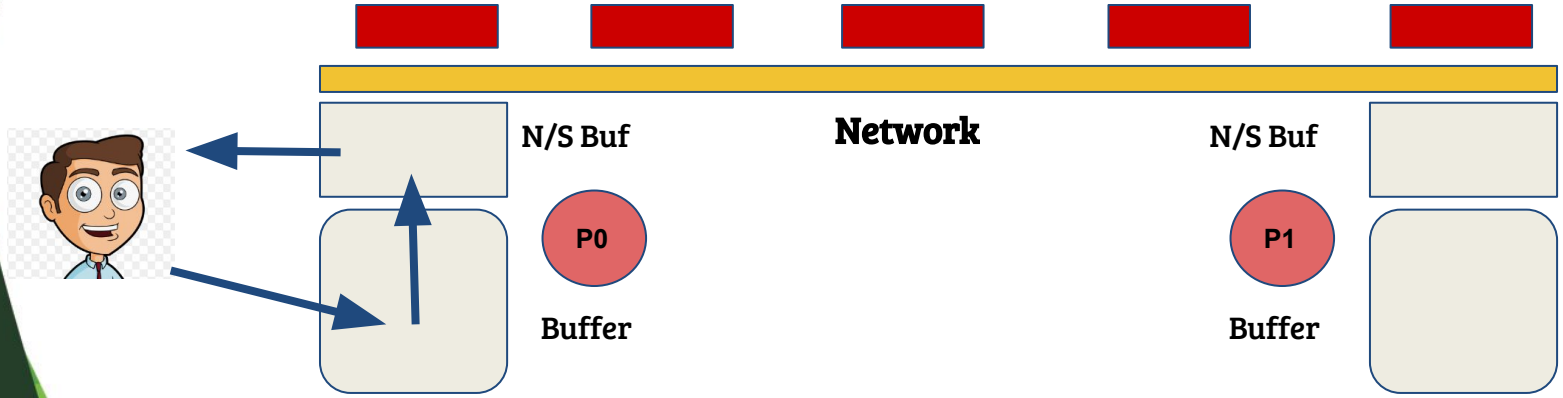
Case 1 : Blocking - Point to Point Communication



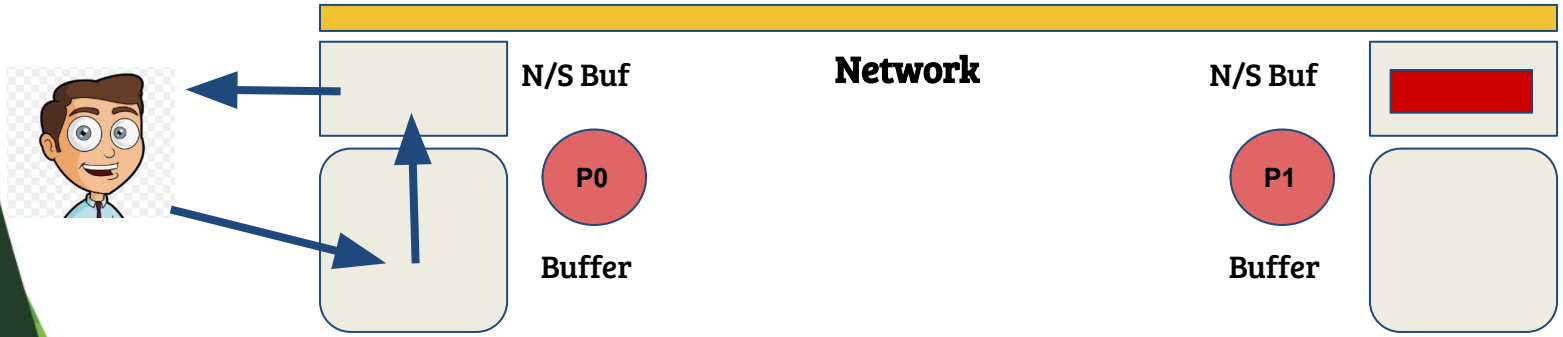
Case 1 : Blocking - Point to Point Communication



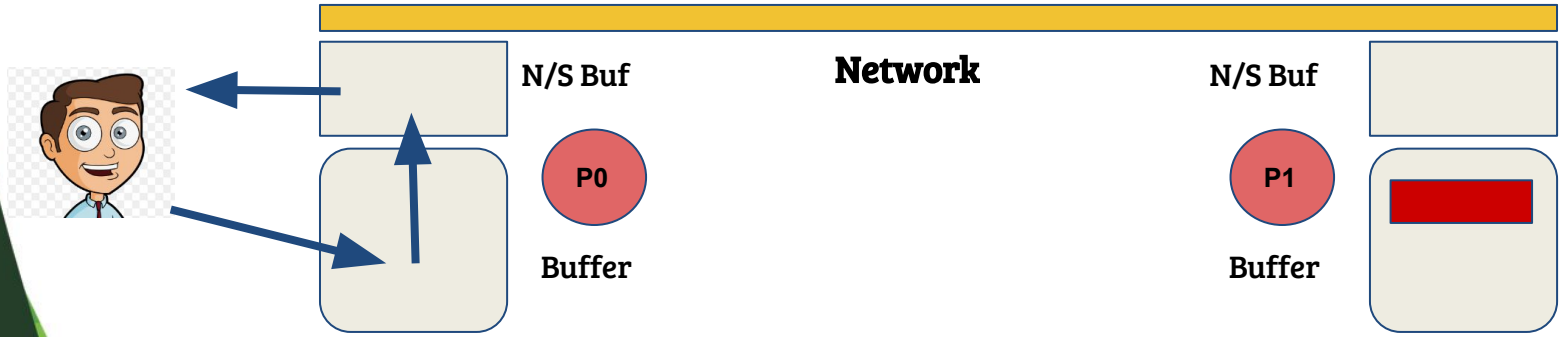
Case 1 : Blocking - Point to Point Communication



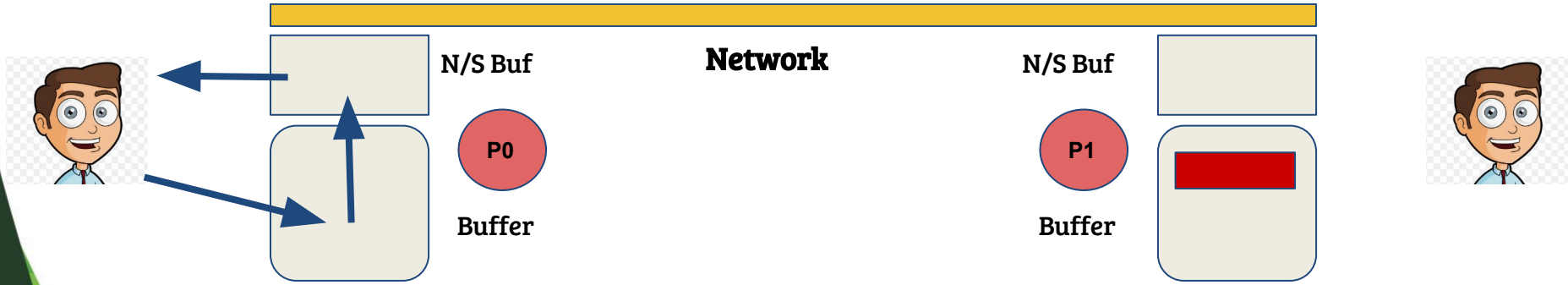
Case 1 : Blocking - Point to Point Communication



Case 1 : Blocking - Point to Point Communication

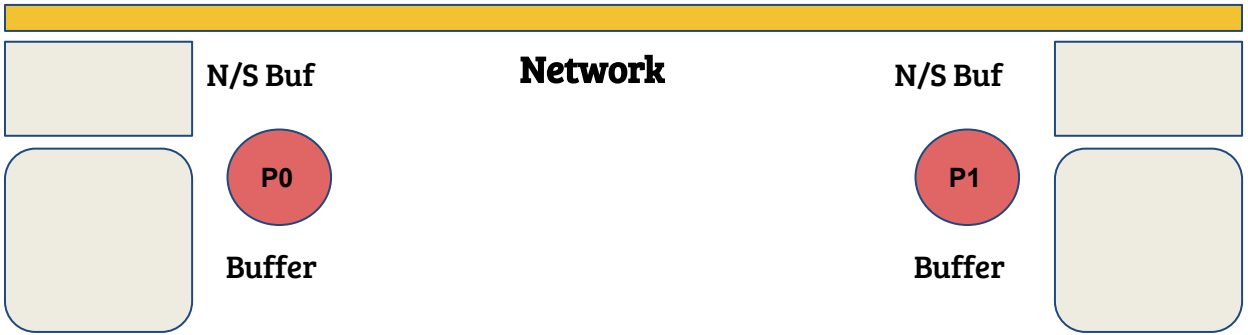


Case 1 : Blocking - Point to Point Communication

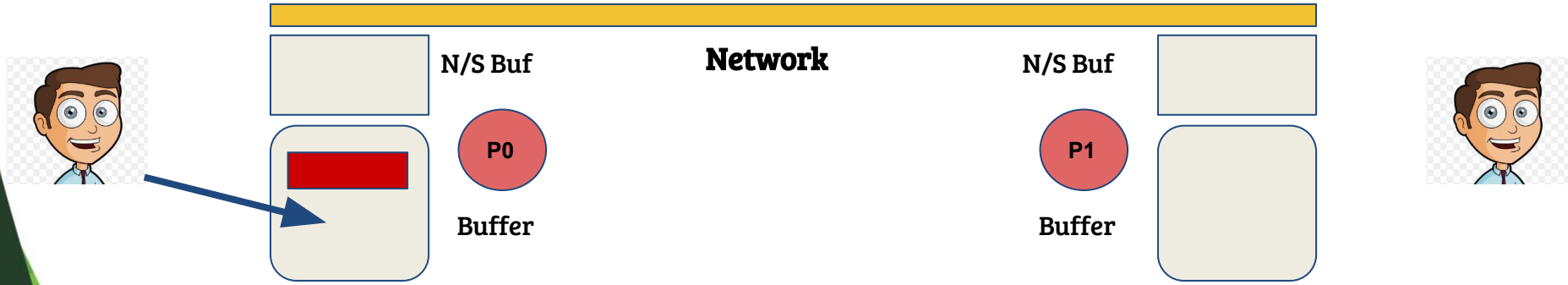


Case 1 : Blocking - Point to Point Communication

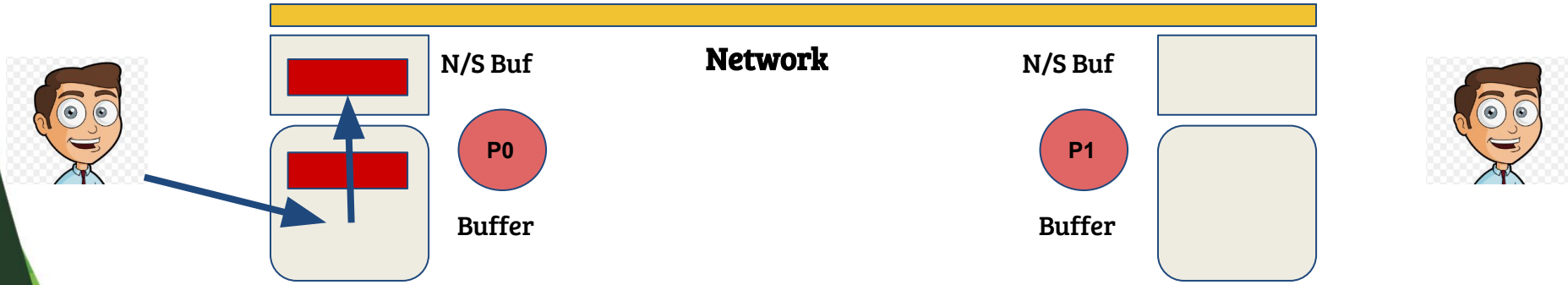
- MPI_Send (void* msg_buffer , Int msg_size, MPI_Datatype msg_type, Int destination, Int tag , MPI_Comm communicator) ;
- MPI_Recv (void* msg_buffer , Int buf_size, MPI_Datatype buf_type, Int source, Int tag , MPI_Comm communicator, MPI_Status*);



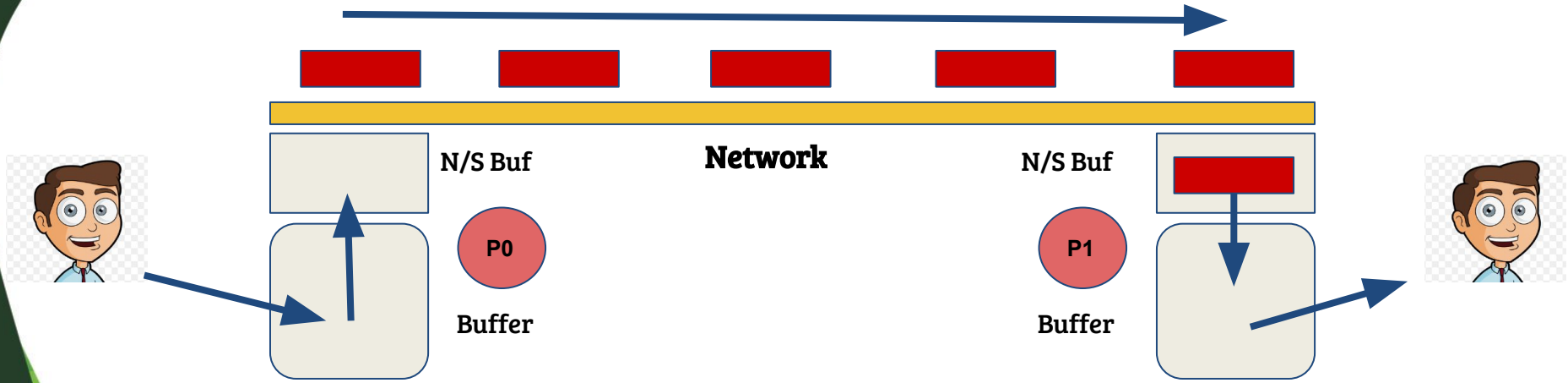
Case 2 : Synchronous Blocking - Point to Point Communication



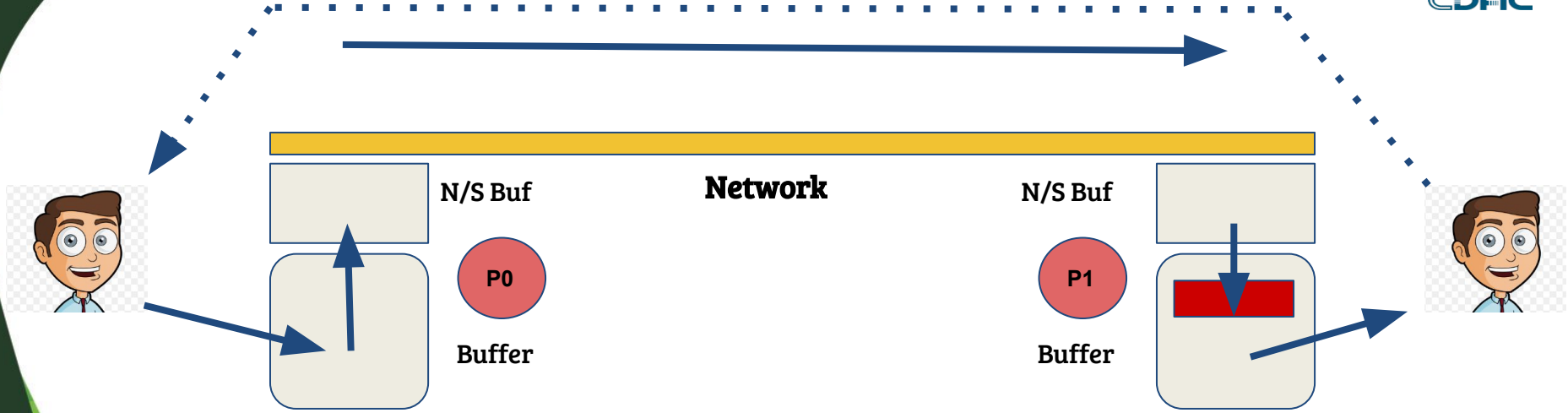
Case 2 : Synchronous Blocking - Point to Point Communication



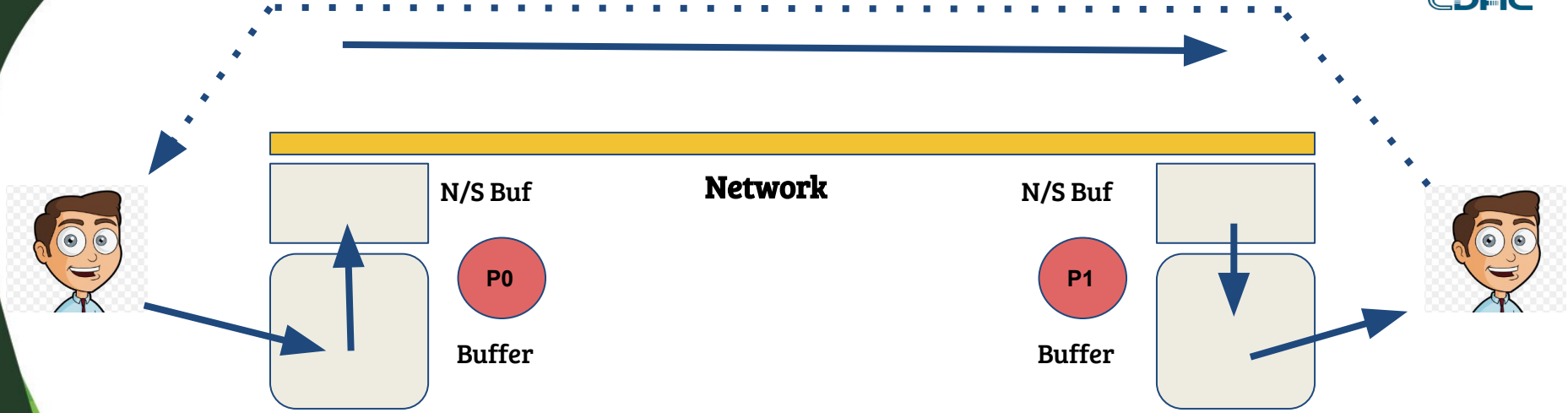
Case 2 : Synchronous Blocking - Point to Point Communication



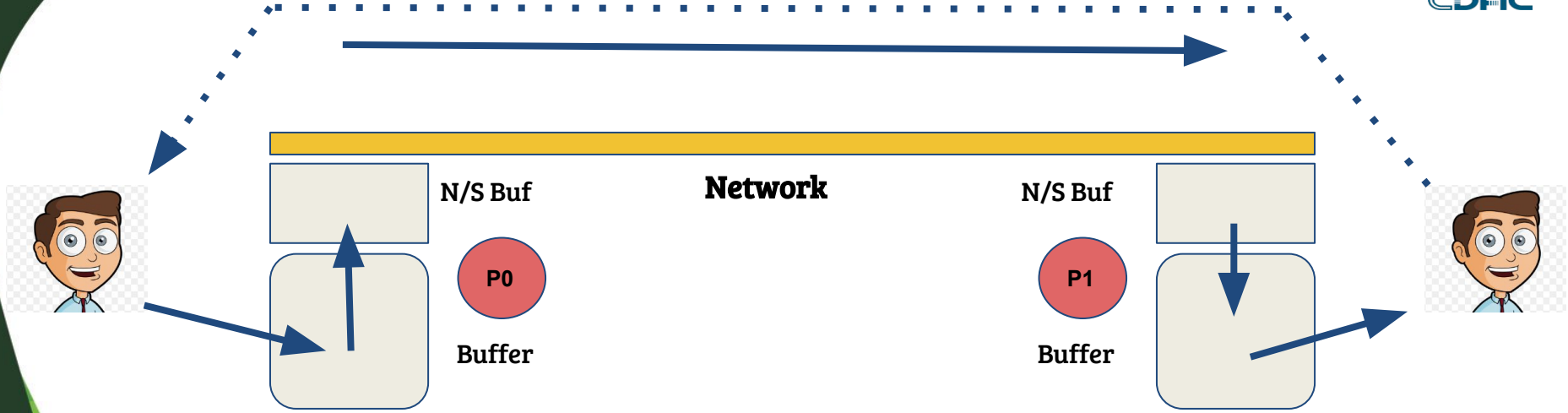
Case 2 : Synchronous Blocking - Point to Point Communication



Case 2 : Synchronous Blocking - Point to Point Communication

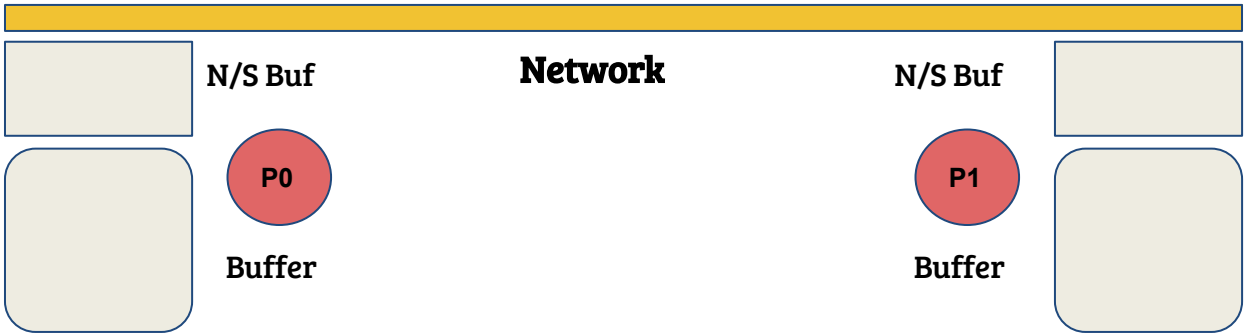


Case 2 : Synchronous Blocking - Point to Point Communication

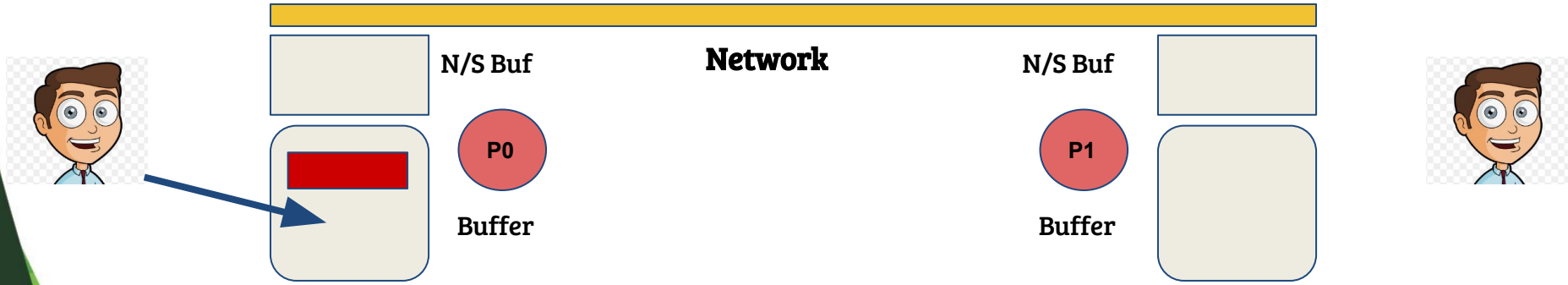


Case 2 : Synchronous Blocking - Point to Point Communication

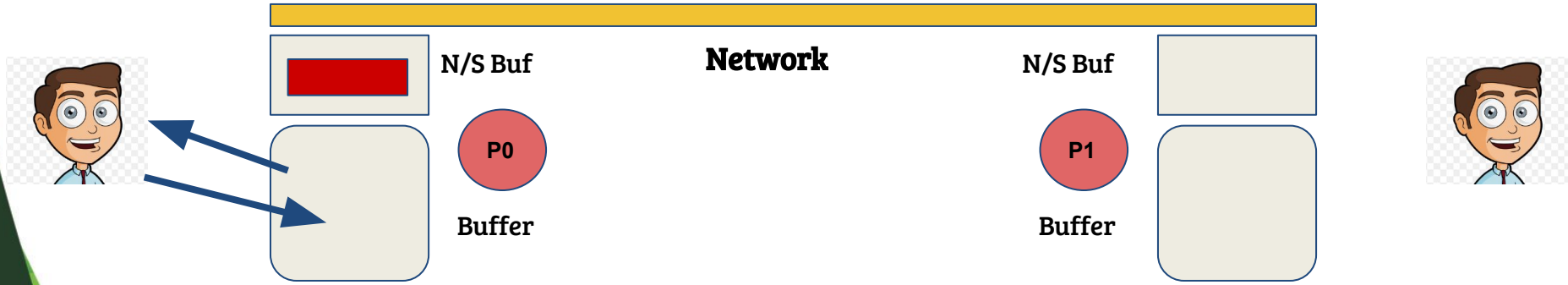
MPI_Ssend (void* msg_buffer , Int msg_size, MPI_Datatype msg_type, Int destination, Int tag , MPI_Comm communicator) ;



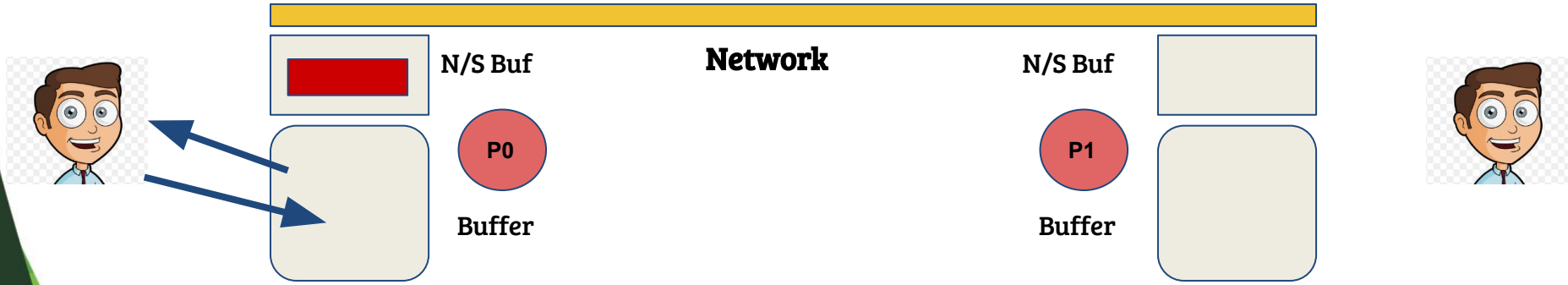
★ Case 3 : Non Blocking - Point to Point Communication



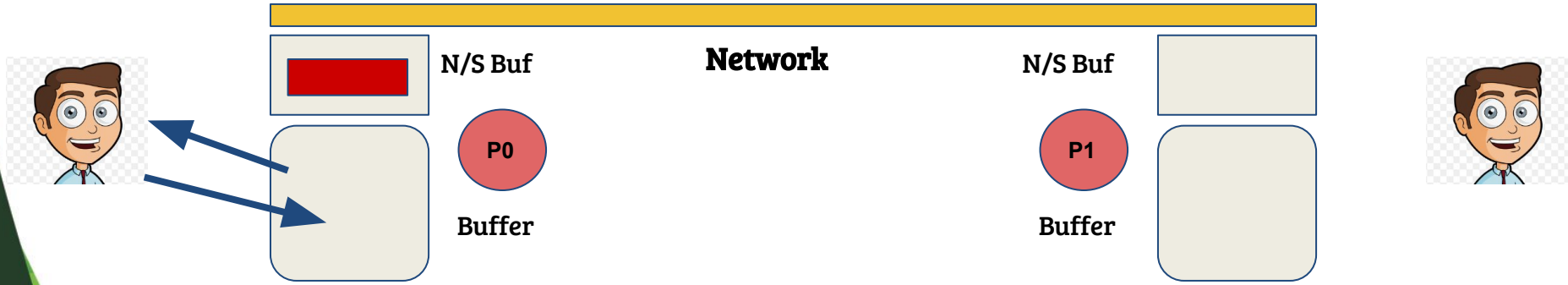
★ Case 3 : Non Blocking - Point to Point Communication



★ Case 3 : Non Blocking - Point to Point Communication

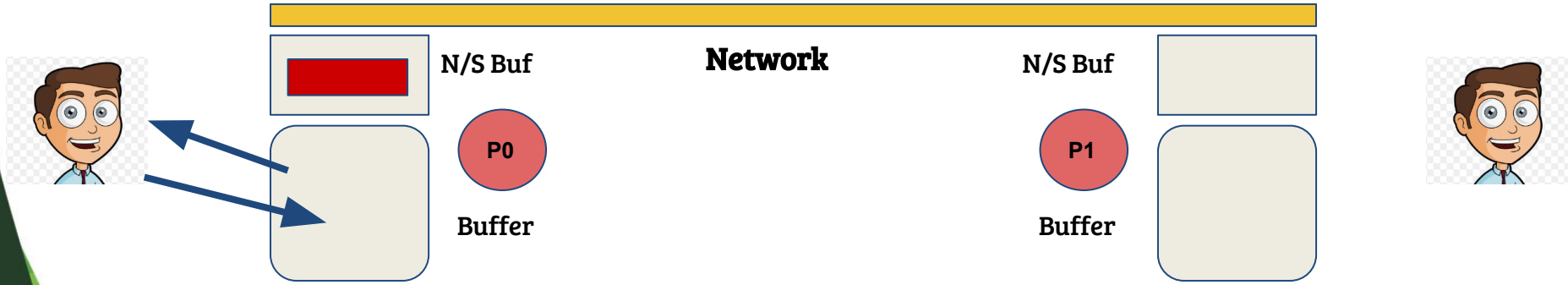


★ Case 3 : Non Blocking - Point to Point Communication

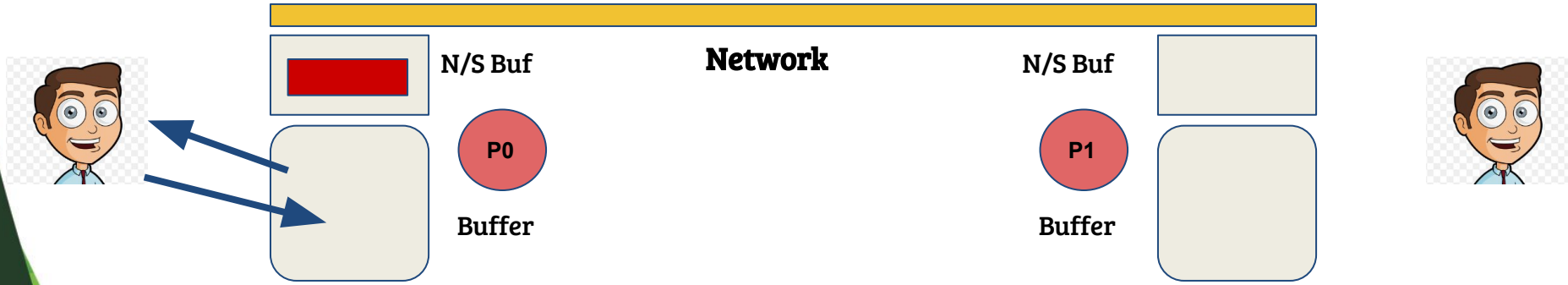


Case 3 : Non Blocking - Point to Point Communication

MPI_Isend (void* msg_buffer , Int msg_size, MPI_Datatype msg_type,
Int destination, Int tag , MPI_Comm communicator, req *) ;

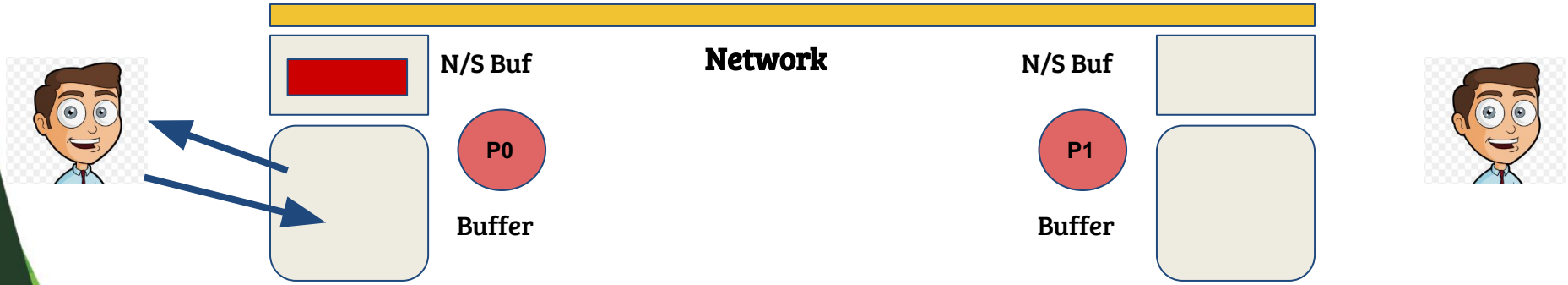


★ Case 3 : Non Blocking - Point to Point Communication



Case 3 : Non Blocking - Point to Point Communication

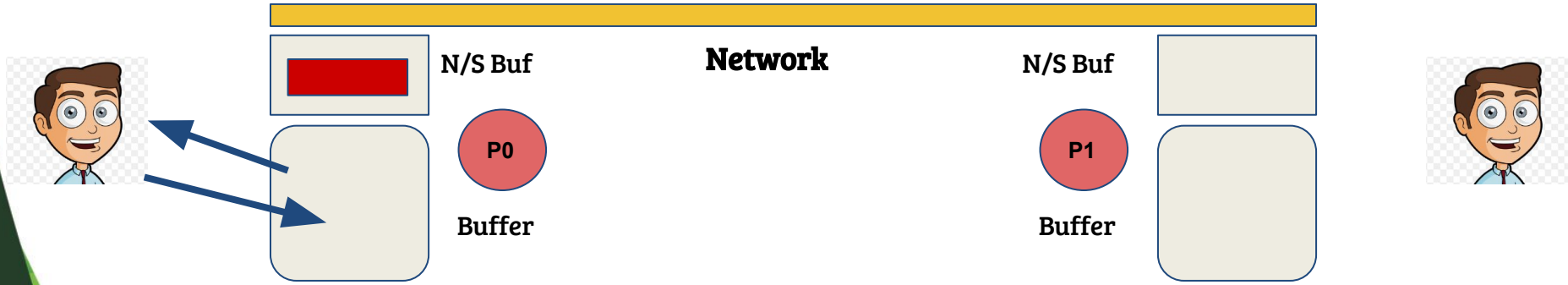
- How we will know, whether that message has been transferred or not ?



Case 3 : Non Blocking - Point to Point Communication

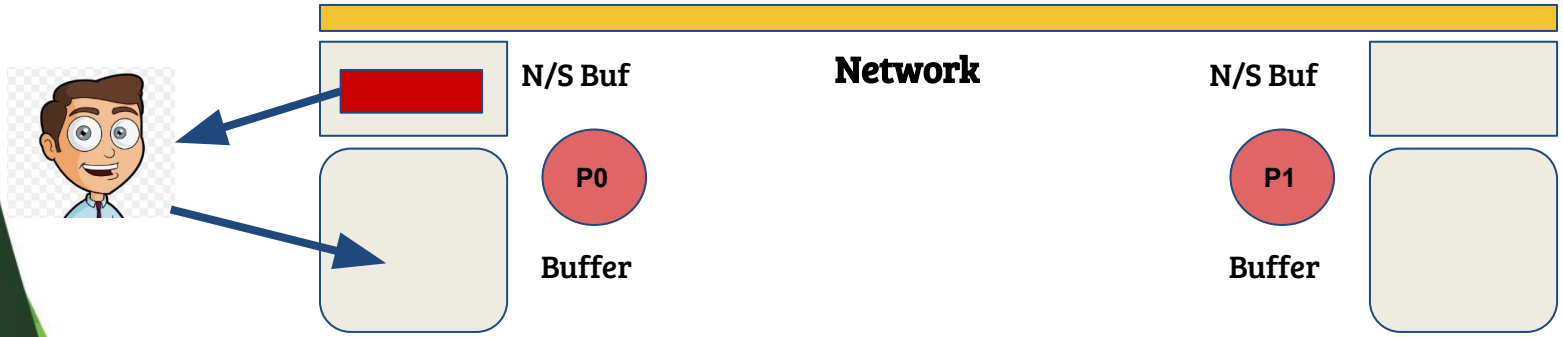
How we will know, whether that message has been transferred or not ?

MPI_Test(MPI_Request *req, int *flag, MPI_Status *status) ;



Case 3 : Non Blocking - Point to Point Communication

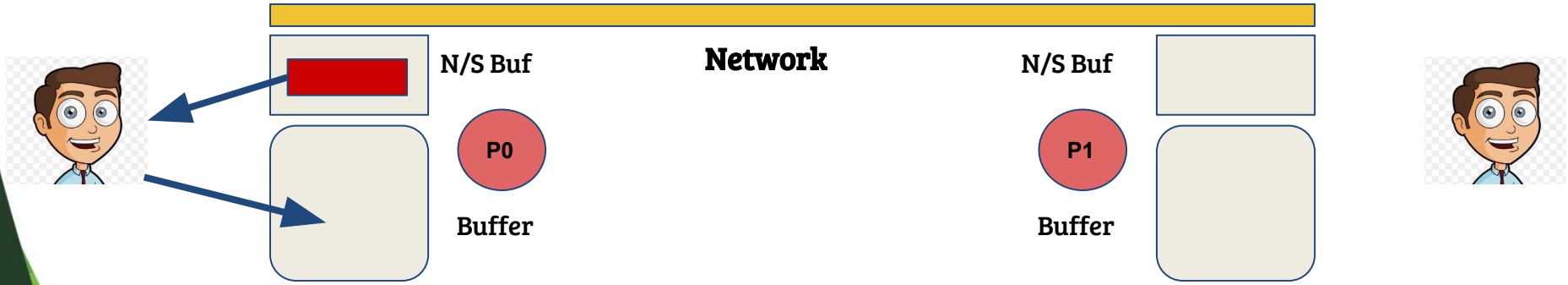
- Data may be in buffer till next message arrive ..!



Case 3 : Non Blocking - Point to Point Communication

Data may be in buffer till next message arrive ..!

MPI_Wait(MPI_Request *request, MPI_Status *status)

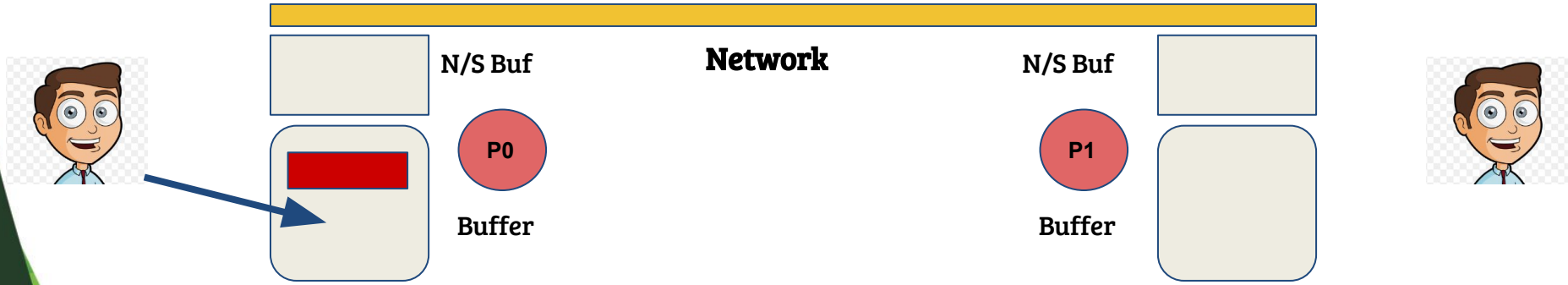


Case 3 : Non Blocking - Point to Point Communication

Data may be in buffer till next message arrive ..!

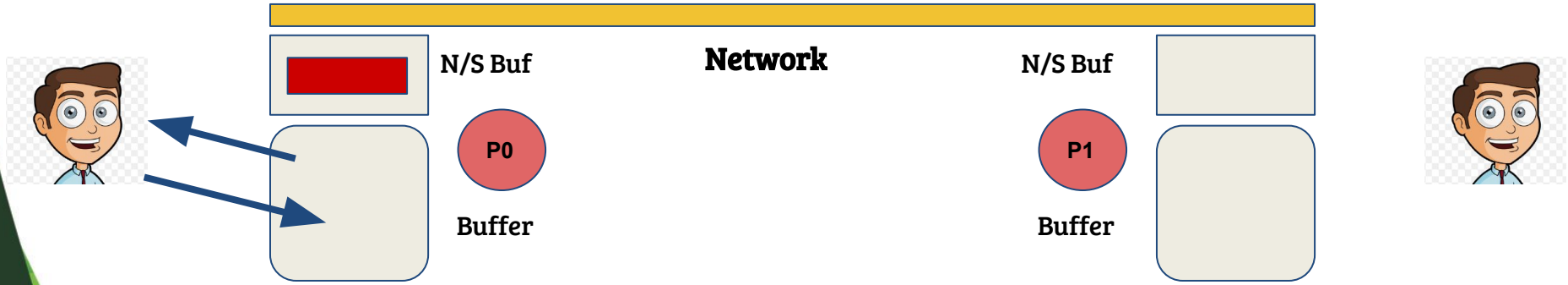
Block and Wait till operation get finish..

MPI_Wait(MPI_Request *request, MPI_Status *status)



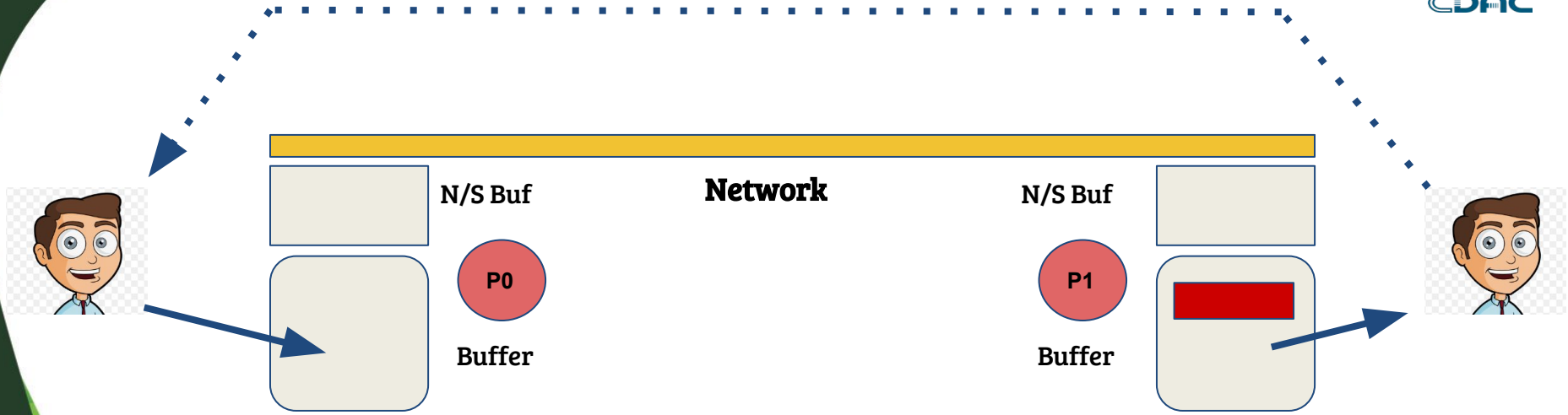
Case 4 : Synchronous Non Blocking - Point to Point Communication

MPI_Issend (void* msg_buffer , Int msg_size, MPI_Datatype msg_type, Int destination, Int tag , MPI_Comm communicator, req *) ;



Case 4 : Synchronous Non Blocking - Point to Point Communication

MPI_Issend (void* msg_buffer , Int msg_size, MPI_Datatype msg_type,
Int destination, Int tag , MPI_Comm communicator, req *) ;



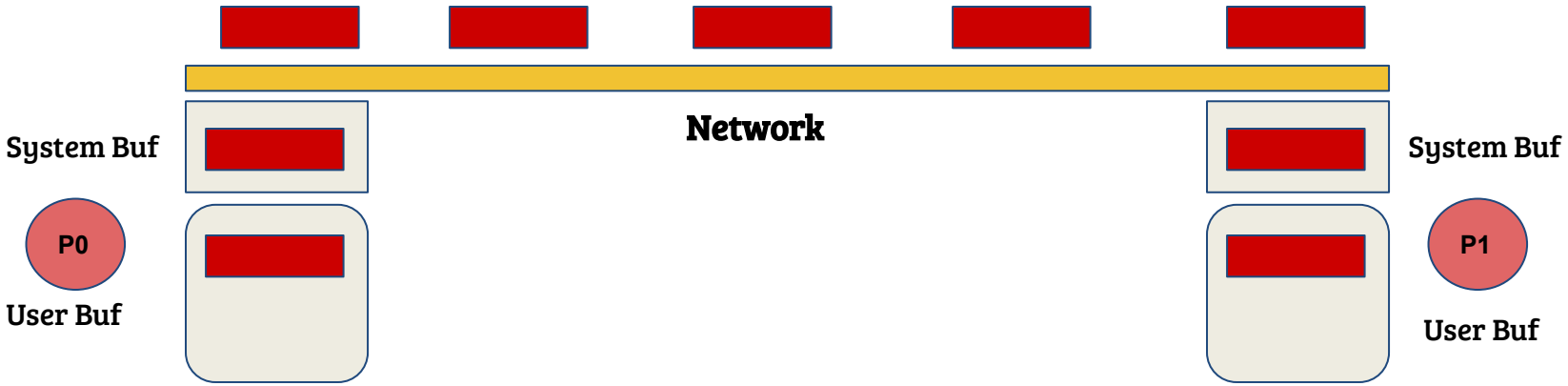
Case 4 : Synchronous Non Blocking - Point to Point Communication

- Similar to Non-Blocking except MPI_Wait(....) and MPI_Test(....)
  Completes their operation when destination process receive the message

❖ Got it ?

❖ Got it ?

❖ Got it ?



Send (..)

Recv (..)

❑ Point to Point Communication Routines

Non - Blocking point to point communication :

Asynchronous communication

- MPI_Isend (&buf,count,datatype,dest,tag,comm,&request**)**
- MPI_Irecv (&buf,count,datatype,source,tag,comm,&request)
- MPI_Issend (&buf,count,datatype,dest,tag,comm,&request)
  - Synchronous non-blocking send.

- Check for Asynchronous Transfer :
  - **MPI_Test(MPI_Request *request, int *flag, MPI_Status * status)**
    - **Flag**:
      - if **flag == 0**, the send/receive operation is **not yet complete**
      - if **flag != 0**, the send/receive operation is **complete** and the variable **status** contains information about the messag
    - **status**: contains information about the message (use the information **only** if **flag != 0**

Collective Communication Routines

- Used for performing operation on all processes simultaneously
- Approx -- 16

MPI_Reduce (

```
void*           input_data ,
void*           output_data ,
Int             count  ,
MPI_Datatype    datatype ,
MPI_Op          operator ,
Int             dest_process,
MPI_Comm        comm
) ;
```

MPI_MAX
MPI_MIN
MPI_SUM
MPI_PROD
MPI_LAND
:
:
:

Ex : MPI_Reduce(&local_int, &total_int, 1, MPI_DOUBLE, MPI_SUM, 0, MPI_COMM_WORLD) ;

MPI_Allreduce (

```
void*           input_data ,
void*           output_data ,
Int             count  ,
MPI_Datatype    datatype ,
MPI_Op          operator ,

MPI_Comm        comm
) ;
```

Ex : MPI_Allreduce(&local_int, &total_int, 1, MPI_DOUBLE, MPI_SUM, MPI_COMM_WORLD) ;

Collective Communication Routines

MPI_Bcast (

void*	data ,
Int	count ,
MPI_Datatype	datatype ,
Int	source_process ,
MPI_Comm	comm

) ;

Eg : MPI_Bcast(a, 1, MPI_DOUBLE, 0, MPI_COMM_WORLD) ;

MPI_Scatter (

void*	send_buffer ,
Int	send_count ,
MPI_Datatype	send_datatype ,
void*	recv_buffer ,
Int	recv_count ,
MPI_Datatype	recv_datatype ,
Int	source_process ,
MPI_Comm	comm

) ;

Eg : MPI_Scatter (a, local_n, MPI_DOUBLE, local_a, local_n, MPI_DOUBLE, 0, comm) ;

Collective Communication Routines

- MPI_Gather (

```
        void*           send_buffer ,
        Int             send_count ,
        MPI_Datatype    send_datatype ,
        void*           recv_buffer  ,
        Int             recv_count ,
        MPI_Datatype    recv_datatype ,
        Int             destination_process ,
        MPI_Comm        comm
        ) ;
```

Eg : MPI_Gather (local_b, local_n, MPI_DOUBLE, b, local_n, MPI_DOUBLE, 0, comm) ;

- MPI_Allgather (

```
        void*           send_buffer ,
        Int             send_count ,
        MPI_Datatype    send_datatype ,
        void*           recv_buffer  ,
        Int             recv_count ,
        MPI_Datatype    recv_datatype ,

        MPI_Comm        comm
        ) ;
```

Eg : MPI_Allgather (local_b, local_n, MPI_DOUBLE, b, local_n, MPI_DOUBLE, comm) ;