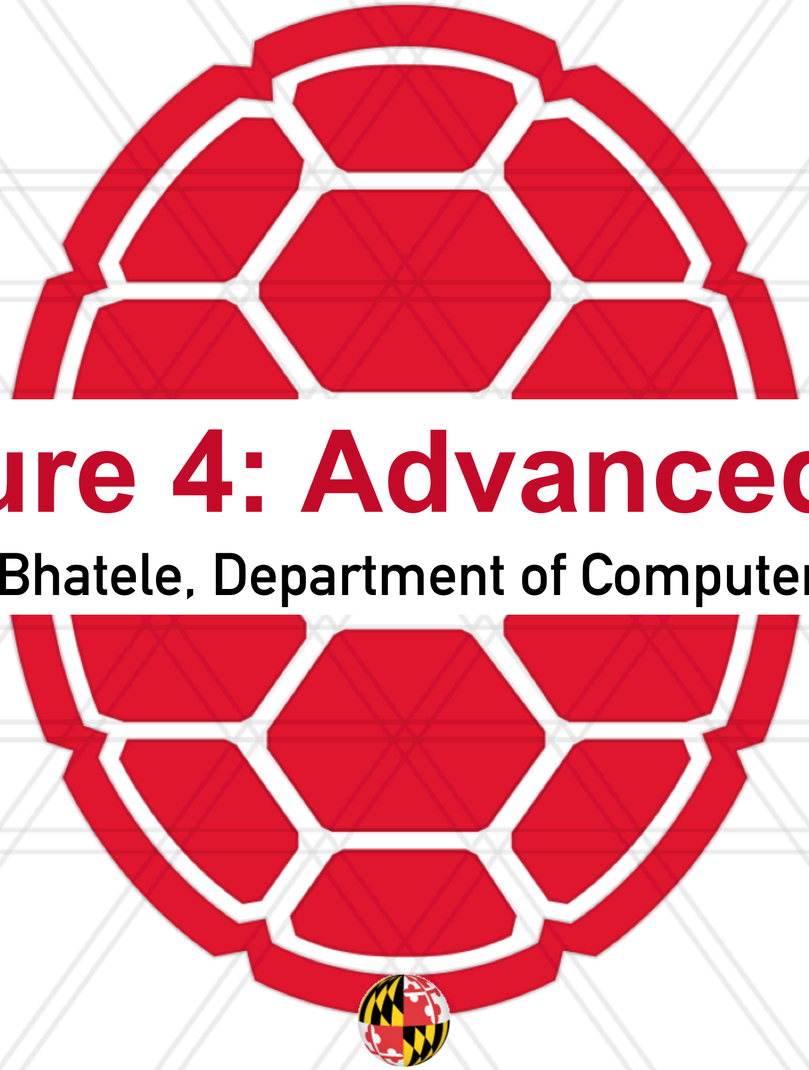
High Performance Computing Systems (CMSC714)



Lecture 4: Advanced MPI

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Announcements

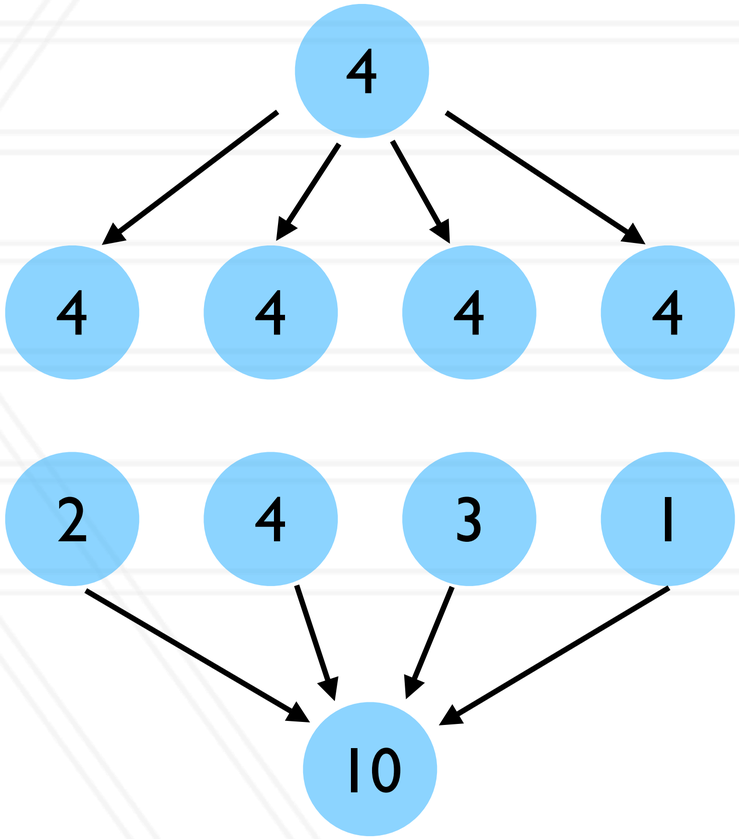
- Starting next week, there will be paper reading assignments
- Assignment 1 on MPI will be out on September 9 and due on September 23

Summary of last lecture

- Parallel architectures and programming models
- Message passing and MPI
- Basic MPI routines:
  - MPI_Init, MPI_Finalize
  - MPI_Comm_rank, MPI_Comm_size
  - MPI_Send, MPI_Recv
- Delivery order: only guaranteed between a pair of processes

Collective operations

- `int MPI_Barrier( MPI_Comm comm)`
  - Blocks until all processes in the communicator have reached this routine
- `int MPI_Bcast( void *buffer, int count, MPI_Datatype datatype, int root, MPI_Comm comm )`
  - Send data from root to all processes
- `int MPI_Reduce( const void *sendbuf, void *recvbuf, int count, MPI_Datatype datatype, MPI_Op op, int root, MPI_Comm comm )`
  - Reduce data from all processes to the root



Collective operations

- `int MPI_Scatter( const void *sendbuf, int sendcount, MPI_Datatype sendtype, void *recvbuf, int recvcount, MPI_Datatype recvtype, int root, MPI_Comm comm)`
  - Send data from root to all processes
- `int MPI_Gather( const void *sendbuf, int sendcount, MPI_Datatype sendtype, void *recvbuf, int recvcount, MPI_Datatype recvtype, int root, MPI_Comm comm)`
  - Gather data from all processes to the root
- MPI_Scan

Calculate the value of $\pi = \int_0^1 \frac{4}{1+x^2}$

```
int main(int argc, char *argv[])
{
    ...

    n = 10000;

    h   = 1.0 / (double) n;
    sum = 0.0;

    for (i = 1; i <= n; i += 1) {
        x = h * ((double)i - 0.5);
        sum += (4.0 / (1.0 + x * x));
    }
    pi = h * sum;

    ...
}
```

Calculate the value of $\pi = \int_0^1 \frac{4}{1+x^2}$

```
int main(int argc, char *argv[])
{
    ...

    n = 10000;
    MPI_Bcast(&n, 1, MPI_INT, 0, MPI_COMM_WORLD);

    h   = 1.0 / (double) n;
    sum = 0.0;

    for (i = myrank + 1; i <= n; i += numranks) {
        x = h * ((double)i - 0.5);
        sum += (4.0 / (1.0 + x * x));
    }
    pi = h * sum;

    MPI_Reduce(&pi, &globalpi, 1, MPI_DOUBLE, MPI_SUM, 0, MPI_COMM_WORLD);

    ...
}
```

MPI communicators

- Communicator is a group or set of processes numbered 0, … , n-1
- Every program starts with MPI_COMM_WORLD
- Several MPI routines to create sub-communicators
  - MPI_Comm_split
  - MPI_Cart_create
  - MPI_Group_incl

Non-blocking point-to-point calls

- MPI_Isend and MPI_Irecv
- Two parts:
  - post the operation
  - Wait for results: need to call MPI_Wait or MPI_Test
- Can help with overlapping computation with communication

Other MPI Calls

- MPI_Wtime
- MPI profiling interface: PMPI_*

Questions?

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