Intermediate MPI (Message-Passing Interface)

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- Process 0 can copy the message into a buffer (internal to the library or user-specified) and return from the `MPI_Send` call.
- It can report failure.

An MPI implementation is allowed to use the first or second interpretation but is not required to use the second one.

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- **Use buffered sends**. We provide the buffering.
- **Use nonblocking communication**. This can often give the best performance, especially if we use it to overlap communication and computation.
- **Use synchronous sends**. MPI provides `MPI_Ssend`. Send doesn't return until the destination process starts receiving the message. However, this can have performance and scalability issues.

Send communication modes

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- Synchronous Mode - Send and receive can start before each other but can only complete together.
- Ready Mode - Send can only start if matching receive already reached, otherwise error. Use with care.

More on Send communication modes

- Each of the four modes can be applied to both blocking and nonblocking send routines.
- Only the standard mode is available for the blocking and nonblocking receive routines.
- Any type of send routine can be used with any type of receive routine.

Buffered Send

- Prototypes.

```
int MPI_BSend(void *buf, int count, MPI_Datatype datatype,
              int dest, int tag, MPI_Comm comm)

int MPI_Buffer_attach(void *buffer, int size)
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- MPI_Bsend allows the user to send messages without worrying about where they are buffered (because the user must have provided buffer space with MPI_Buffer_attach).
- The buffer size given should be the sum of the sizes of all outstanding Bsends that you intend to have, plus MPI_BSEND_OVERHEAD for each Bsend that will be done.
- MPI_Buffer_detach returns the buffer address and size so that nested libraries can replace and restore the buffer.

MPI Nonblocking routines

- Nonblocking send - MPI_Isend(...) - will return "immediately" even before source location is safe to be altered.
- Nonblocking receive - MPI_Irecv(...) - will return even there is no message to accept.

Nonblocking routine formats

MPI_Isend(buf,count,datatype,dest,tag,comm,request)

MPI_Irecv(buf,count,datatype,source,tag,comm, request)

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MPI_Wait(MPI_Request *request, MPI_Status *status)

int MPI_Waitall(int count, MPI_Request array_of_requests[], MPI_Status array_of_statuses[])

int MPI_Waitany(int count, MPI_Request array_of_requests[], int *index, MPI_Status *status)

MPI_Test(MPI_Request *request, int *flag, MPI_Status *status)

MPI_Isend example

```
MPI_Comm_rank(MPI_COMM_WORLD, &myrank); /* find rank */
if (myrank == 0) {
    int x;
    MPI_Isend(&x,1,MPI_INT, 1, msgtag, MPI_COMM_WORLD, req1);
    compute();
    MPI_Wait(req1, status);
} else if (myrank == 1) {
    int x;
    MPI_Recv(&x,1,MPI_INT,0,msgtag, MPI_COMM_WORLD, status);
}
```

Sending/Receiving structures (Part 1)

- We can send a structure by packing it as an array of bytes:

```
struct test {
    int n;
    double x[3], y[3];
};

if (pid == source) {
    struct test test1;
    MPI_Send(&test1, sizeof(struct test), MPI_BYTE, destination,
             tag, MPI_COMM_WORLD);
} else (pid == destination) {
    struct test test2;
    MPI_Recv(&test2, sizeof(struct test), MPI_BYTE, source, tag,
             MPI_COMM_WORLD, status);
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- However, this relies on the layout of the structure being the same on all nodes. It also obfuscates the code and introduces platform dependency so it is not a recommended practice for MPI programs.

Sending/Receiving structures (Part 2)

- We can send a structure by creating a custom MPI data type for the structure

```
struct test {
        int n;
        double x[3], y[3];
};
const int nitems = 3;
int blocklengths[3] = {1, 3, 3}; //lengths of i, x and y as #items
MPI_Datatype types[3] = {MPI_INT, MPI_DOUBLE, MPI_DOUBLE};
MPI_Aint offsets[3];
MPI_Datatype mpi_test_type;
offsets[0] = offsetof(struct test, n);
offsets[1] = offsetof(struct test, x);
offsets[2] = offsetof(struct test, y);
MPI_Type_create_struct(nitems, blocklengths, offsets, types,
                       &mpi_test_type);
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- Note that there is no way to send a structure that has variable length (because of pointers stored in it) in one message. We have to use two messages.