One-sided Communication with MPI-2

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Acknowledgements

This course is based on the "One-sided" chapter of the MPI-2 tutorial on the MPIDC 2000:

MPI-2: Extensions to the Message Passing Interface

MISSISSIPPI STATE UNIVERSITY [1]
HIGH PERFORMANCE COMPUTING LAB
NSF ENGINEERING RESEARCH CENTER

HLRS [2]

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Synchronization Taxonomy

Message Passing:
  explicit transfer, implicit synchronization,
  implicit cache operations

Access to other processes' memory:

- **1-sided**
  explicit transfer, explicit synchronization,
  implicit cache operations (problem!)
- Shared Memory
  implicit transfer, explicit synchronization,
  implicit cache operations
- shmem interface
  explicit transfer, explicit synchronization,
  explicit cache operations

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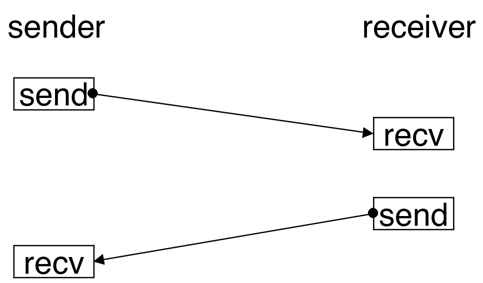
Cooperative Communication

- MPI-1 supports cooperative or 2-sided communication
- Both sender and receiver processes must participate in the communication



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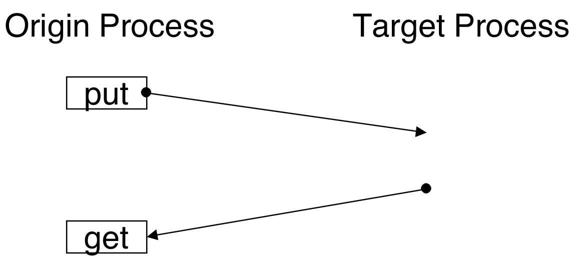
One-sided Communication

- Communication parameters for both the sender and receiver are specified by one process (origin)
- User must impose correct ordering of memory accesses



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One-sided Operations

- Initialization
  - MPI_ALLOC_MEM, MPI_FREE_MEM
  - MPI_WIN_CREATE, MPI_WIN_FREE
- Remote Memory Access (RMA, nonblocking)
  - MPI_PUT
  - MPI_GET
  - MPI_ACCUMULATE
- Synchronization
  - MPI_WIN_FENCE (like a barrier)
  - MPI_WIN_POST / MPI_WIN_START / MPI_WIN_COMPLETE / MPI_WIN_WAIT
  - MPI_WIN_LOCK / MPI_WIN_UNLOCK

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Window Creation

- Specifies the region in memory (already allocated) that can be accessed by remote processes
- Collective call over all processes in the intracommunicator
- Returns an opaque object of type `MPI_Win` which can be used to perform the remote memory access (RMA) operations

MPI_WIN_CREATE(base_address, win_size, disp_unit, info, comm, *win*)

MPI_Put

- Performs an operation equivalent to a send by the origin process and a matching receive by the target process
- The origin process specifies the arguments for both the origin and target process
- The target buffer is at address target_addr = win_base + target_disp * disp_unit

MPI_PUT(origin_address, origin_count, origin_datatype,
target_rank, *target*_disp, target_count,
target_datatype, win)

Heterogeneous platforms: Use only basic datatypes or derived datatypes without byte-length displacements!

MPI_Get

- Similar to the put operation, except that data is transferred from the target memory to the origin process
- To complete the transfer a synchronization call must be made on the window involved
- The local buffer should not be accessed until the synchronization call is completed

```
MPI_GET( origin_address, origin_count, origin_datatype,
         target_rank, target_disp, target_count,
         target_datatype, win)
```

Heterogeneous platforms: Use only basic datatypes or derived datatypes without byte-length displacements!

MPI_Accumulate

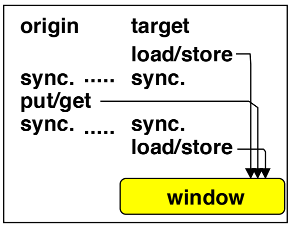
- Accumulates the contents of the origin buffer to the target area specified using the predefined operation op
- User-defined operations cannot be used
- Accumulate is atomic: many accumulates can be done by many origins to one target
  -> [*may be very expensive*]

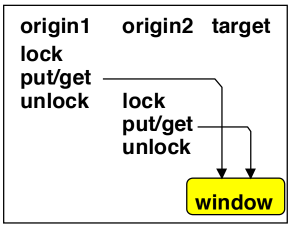
```
MPI_ACCUMULATE(origin_address, origin_count,
         origin_datatype, target_rank, target_disp,
         target_count, target_datatype, op, win)
```

Heterogeneous platforms: Use only basic datatypes or derived datatypes without byte-length displacements!

Synchronization Calls

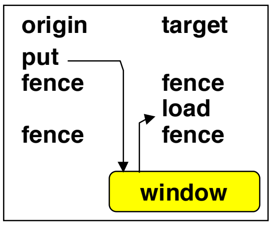
- Active target communication
  - communication paradigm similar to message passing model
  - target process participates only in the synchronization
  - fence or post-start-complete-wait
- Passive target communication
  - communication paradigm closer to shared memory model
  - only the origin process is involved in the communication
  - lock/unlock





MPI_Win_fence

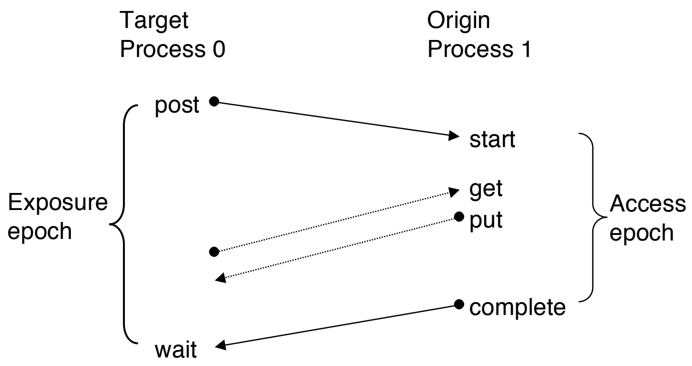
- Synchronizes RMA operations on specified window
- Collective over the window
- Like a barrier
- Should be used before and after calls to put, get, and accumulate
- The `assert` argument is used to provide optimization hints to the implementation
- Used for active target communication



MPI_WIN_FENCE(assert, win)

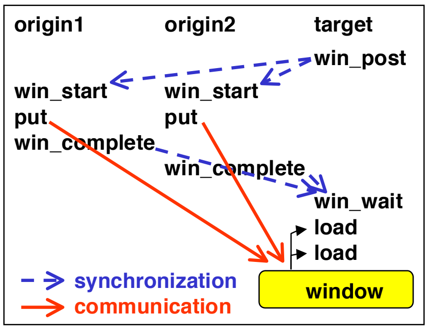
Start/Complete and Post/Wait, I.

- Used for active target communication with weak synchronization



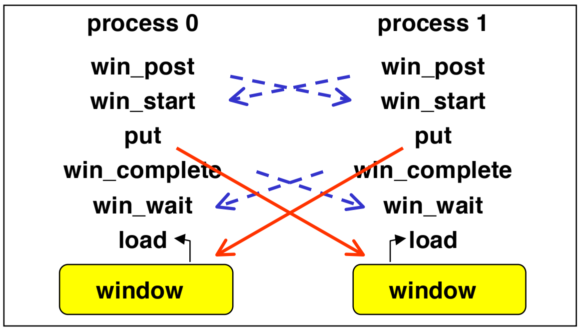
Start/Complete and Post/Wait, II.

- RMA (put, get, accumulate) are finished
  - locally after win_complete
  - at the target after win_wait
- local buffer must not be reused before RMA call locally finished
- communication partners must be known
- no atomicity for overlapping “puts”
- assertions may improve efficiency --> give all information you have



Start/Complete and Post/Wait, III.

- symmetric communication possible,
  only win_start and win_wait may block



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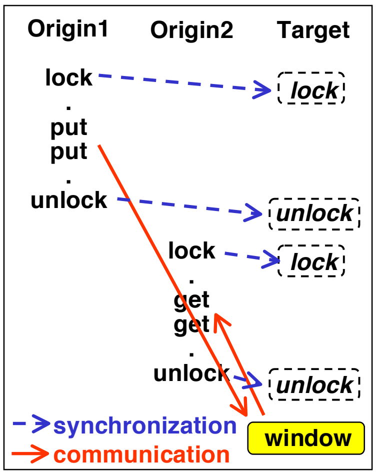
Lock/Unlock

- Does not guarantee a sequence
- agent may be necessary on systems without (virtual) shared memory
- Portable programs can use lock calls to windows in memory allocated **only** by **`MPI_ALLOC_MEM`**
- RMA completed after **`UNLOCK`** at both origin and target



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MPI_ALLOC_MEM

MPI_ALLOC_MEM (size, info, *baseptr*)

MPI_FREE_MEM (base)

```
REAL A
POINTER (P, A(100))   ! no memory is allocated
INTEGER (KIND=MPI_ADDRESS_KIND) Size
INTEGER Lng_real, Win, IERR
CALL MPI_TYPE_EXTENT(MPI_REAL, Lng_real, IERR)
Size = 100*Lng_real
CALL MPI_ALLOC_MEM(Size, MPI_INFO_NULL, P, IERR)
CALL MPI_WIN_CREATE(A, Size, Lng_real,
         MPI_INFO_NULL, MPI_COMM_WORLD, Win, IERR)
...
CALL MPI_WIN_FREE(Win, IERR)
CALL MPI_FREE_MEM(A, IERR)
```


Fortran Problems with 1-Sided

Source of Process 1	Source of Process 2	Executed in Process 2
bbbb = 777	buff = 999	register_A := 999
call MPI_WIN_FENCE	call MPI_WIN_FENCE	
call MPI_PUT(bbbb into buff of process 2)		stop application thread
		buff := 777 in PUT handler
		continue application thread
call MPI_WIN_FENCE	call MPI_WIN_FENCE	
	ccc = buff	ccc := register_A

- Fortran register optimization
- Result ccc=999, but expected ccc=777
- How to avoid: (see MPI-2, Chap. 6.7.3)
  - window memory declared in COMMON blocks
    i.e. MPI_ALLOC_MEM cannot be used
  - declare window memory as VOLATILE
    (non-standard, disables compiler optimization)
  - Calling MPI_Address(buff, idummy_addr, ierror) after 2nd FENCE in process 2

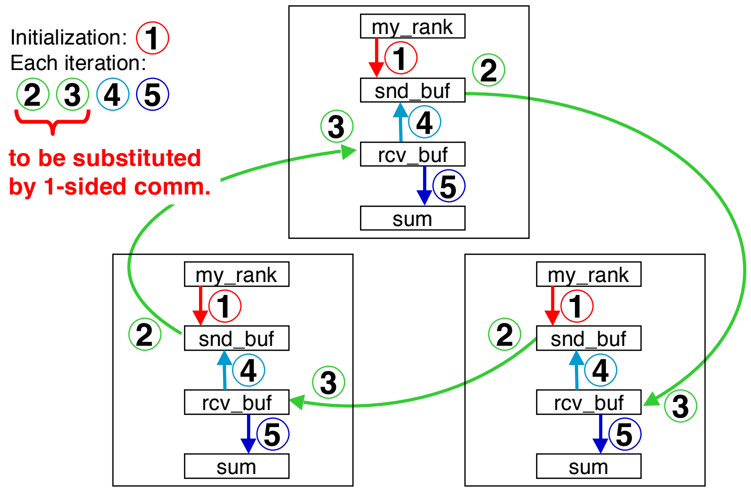
One-sided: Summary

- Three one-sided communication primitives provided
  - put / get / ccumulate
- Several synchronization options supported
  - fence / post-start-complete-wait / lock-unlock
- User must ensure that there are no conflicting accesses
- For better performance **assertions** should be used with fence/start/post operations

MPI–One-sided Exercise 1: Ring communication with fence

- Copy to your local directory:
  cp ~/MPI/course/**C**/1sided/ring.c **my_1sided_exa1.c**
  cp ~/MPI/course/**F**/1sided/ring.f **my_1sided_exa1.f**
- Tasks:
  - Substitute the non-blocking communication by one-sided communication. Two choices:
    - **either rcv_buf = window**
      - MPI_Win_fence - the rcv_buf can be used to receive data
      - MPI_Put - to write the content of the local variable snd_buf into the remote window (rcv_buf)
      - MPI_Win_fence - the one-sided communication is finished, rcv_buf is filled
    - **or snd_buf = window**
      - MPI_Win_fence - the snd_buf is filled
      - MPI_Get - to read the content of the remote window (snd_buf) into the local variable rcv_buf
      - MPI_Win_fence - the one-sided communication is finished, rcv_buf is filled
  - Compile and run your `my_1sided_exa1.c / .f`

ring.c / .f: Rotating information around a ring



MPI–One-sided Exercise 1: additional hints

- MPI_Win_create:
  - base = reference to your rcv_buf or snd_buf variable
  - disp_unit = number of bytes of one int / integer, because this is the datatype of the buffer (=window)
  - size = same number of bytes, because buffer size = 1 value
  - size and disp_unit have different internal representations, therefore:
    - **C:** **MPI_Win_create(&rcv_buf, sizeof(int), (MPI_Aint) sizeof(int), MPI_INFO_NULL, ..., &win);**
    - **Fortran:**

```
INTEGER disp_unit
INTEGER (KIND=MPI_ADDRESS_KIND) size
CALL MPI_TYPE_EXTENT(MPI_INTEGER, disp_unit, ierror)
size = disp_unit * 1
CALL MPI_WIN_CREATE(rcv_buf, size, disp_unit, MPI_INFO_NULL, ..., ierror)
```

- see MPI-2, page 110

MPI–One-sided Exercise 1: additional hints

- MPI_Put or MPI_Get:
  - target_disp
    - **C:** **MPI_Put(&snd_buf, 1, MPI_INT, right, (MPI_Aint) 0, 1, MPI_INT, win);**
    - **Fortran:** **INTEGER (KIND=MPI_ADDRESS_KIND) target_disp**
      target_disp = 0
      CALL MPI_GET(snd_buf, 1, MPI_INTEGER, right, target_disp, 1,
      MPI_INTEGER, win, ierror)
- see MPI-2, page 116

MPI–One-sided Exercise 2: Post-start-complete-wait

- Use your result of exercise 1 or copy to your local directory:
  cp ~/MPI/course/**C**/1sided/ring_1sided.c **my_1sided_exa2.c**
  cp ~/MPI/course/**F**/1sided/ring_1sided.f **my_1sided_exa2.f**
- Tasks:
  - Substitute the two calls to MPI_Win_fence
    by calls to MPI_Win_post / _start / _complete / _wait
  - Use to group mechanism to address the neighbors:
    - **MPI_COMM_GROUP(comm, *group*)**
    - **MPI_GROUP_INCL(group, n, ranks, *newgroup*)**
    - **MPI_COMM_CREATE(comm, group, *newcomm*)**
      - do not forget **ierror** with Fortran!
      - Fortran: integer comm, group, newgroup, newcomm, n, ranks(...)
      - C: MPI_Comm comm, newcomm; MPI_Group group, newgroup; int n, ranks[...];
  - Compile and run your `my_1sided_exa2.c / .f`