DiPOSH: a modular testbed and OpenSHMEM implementation

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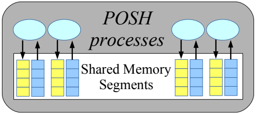
Roadmap

Implementing OpenSHMEM in POSH

POSH runs multiple OpenSHMEM processes



Shared heap is **symmetric**

- POSH creates a shared memory segment for each process
- Just locate objects at the **same offset** in the shared segments

Communication routines are datatype-specific

- `shmem_int_put`, `shmem_char_put`, `shmem_float_put`..

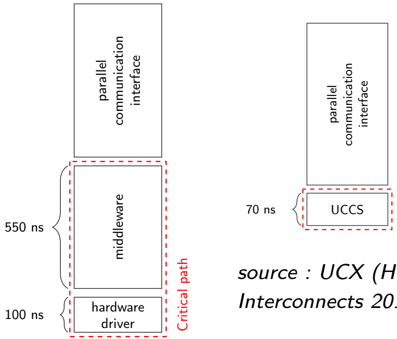
$->$ Use **C++ templates**

- Implement `shmem_<T>_put` and let the compiler do the job

Global static data is symmetric

- In practice :
  - In the BSS segment of the executable if not initialized at compile-time
  - Int the data segment if they are
- Workaround : parse the code and **replace them** by SHMEM allocations just after the initialization of the library

Thin layers



source : UCX (HOT Interconnects 2017)

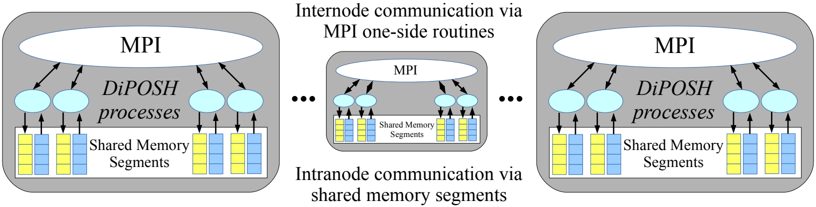
Software overhead

- Achieve low network latency
- Waste no time going through the software stack !

Take advantage of the **simple OpenSHMEM interface**

- Implement data movements in a few instructions
- Avoid additional copies, branches
- ... while being portable

DiPOSH Architecture



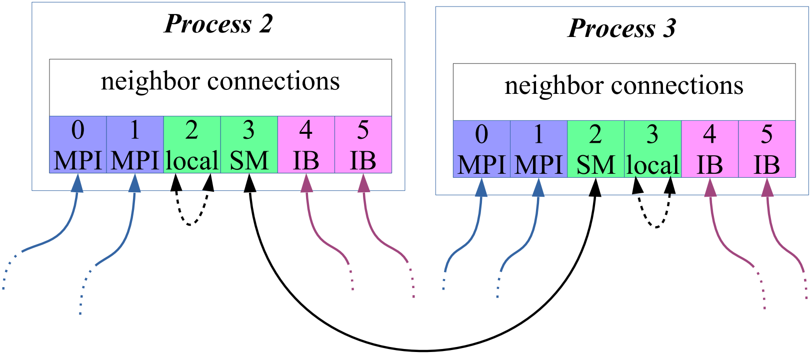
Shared heaps : cornerstone

- One shared heap per process
- Processes on the same node communicate through this heap
  - Segment of shared memory
  - Copy into/from the segment
- Inter-node communications : network
  - Buffers read from/written into this shared memory segment

Run-time environment

- In charge with starting the OpenSHMEM processes, sharing their communication information...
- Any distributed overlay network (currently supported : MPI and PadicoTM)

Network Portability



Currently supported :

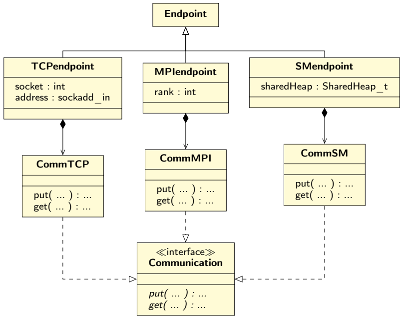
- MPI, TCP, shared memory, KNEM
  - Under testing : Knem and NewMadeleine
- Want to see yours in this list ? Contact us !

Software composition for network portability

The API calls network-specific routines

- Each network driver must implement an **interface**
- ... plus some network-specific methods

→ composition over inheritance



At start-up time, processes discovers how they can communicate with the other ones

- "*Plug*" the right object into the neighbor's local communication gate
  - `Endpoint` (polymorphism)
- Calling `neighbor[rank]->put(....)` will call the appropriate low-level communication routine
  - `Communication` interface

Multi-library programming

DiPOSH lets you **use other parallel programming interfaces**

- For example, MPI
- Possible with DiSPOH's MPI run-time environment

→ Take advantage of **both programming models**

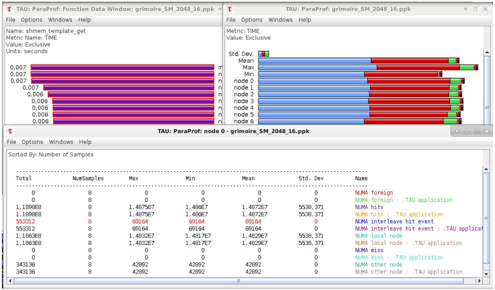
- *e.g.*, mix MPI's two-sided semantics and OpenSHMEM's blocking one-sided semantics

```
start_pes( 0 );
rank = shmem_my_pe();
value = (int*)shmalloc( sizeof( int ) );
/* do stuff */
if( 0 == rank )
    shmem_int_put( value, &result, 1, 1 );
MPI_Barrier( MPI_COMM_WORLD );
/* do stuff */
if( 0 == rank )
    MPI_Send( &number, 1, MPI_INT, 1, 0, MPI_COMM_WORLD );
if( 1 == rank )
    MPI_Recv( &number, 1, MPI_INT, 0, 0, MPI_COMM_WORLD, &stat );
```

Low-level profiling

TAU already supports OpenSHMEM

- Low-level profiling information
- Tune application using communication optimization



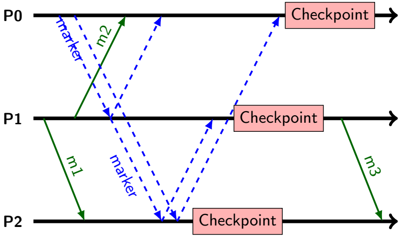
Low-level profiling information

- Usual function calls
  - `MPI_Init()` in red
  - `shmem_*_get` in purple
- Information about the NUMA communications.

Fault tolerance : Chandy & Lamport's algorithm (1985)

Idea : circulate a marker

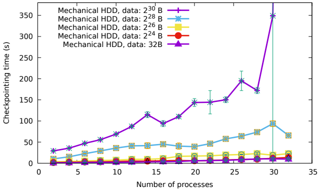
- Initiate the checkpoint wave by **sending a first marker**
- Once a process receives the marker :
  - **Flush** the communication channels
  - Take a **local snapshot**
  - **Send the maker** to all the other processes
- Checkpoint wave done (locally) after reception of all the other processes' markers.



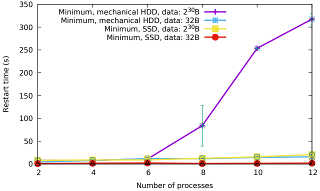
Adaptation : `get()` might cross the marker !

Fault tolerance performance

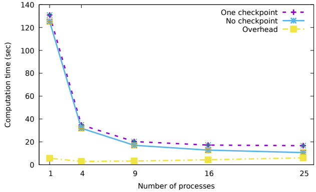
- Checkpointing time scalability on a mechanical HDD with various memory footprints.



- Restart time : SSD and mechanical HDD.



- Scalability of 30 multiplications of two square matrices of size 2048×2048, with and without a checkpoint during the computation. Mechanical HDD.



Checkpoint storage is *critical*

Open perspectives

Network portability (cf [Coti & Malony, PPAM 2019])

- Support other networks
- At various levels : UCX, NewMadeleine... vs InfiniBand
- Support other run-time environments

Use as a **testbed** for distributed algorithms over **one-sided communications**

- Fault tolerance (cf [Butelle & Coti, HPCS 2018])
- Collective communications

OS support

- Shared heap : binding ? Bound to the process it belongs to ? Moving with communications ?

Fault tolerance

- Scalability, other algorithms

... still under development !