ExaNoDe Programming Environment to Exploit ARM, UNIMEM and FPGAs

Babis Chalios
Barcelona Supercomputing Center
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The UNIMEM architecture
T5.1: High-level Architecture of 64-bit DP

- Coherence Island 0
- Xilinx board
- multicore

- Coherence Island 1
- Coherence Island N-1
- Coherence Island N

- Processors
- Peripherals
- Coherent Interconnect

- Central Router
- Interconnect

- Xilinx KCU105 board
UNIMEM: Remote Coherent Memory Accesses

Coherence Island 1

Juno Board
A72
A53

Xilinx KCU105
Ultra scale

4x PCIe

SFP+
10Gbps

Coherence Island 2

Juno Board
A72
A53

Xilinx KCU105
Ultra scale

4x PCIe

SFP+
10Gbps

Xilinx KCU105
Ultra scale

10x10Gbps

✓ Global Partitioned Address Space
✓ Coherent Accesses
ExaNode communication libraries
**MPI over UNIMEM Design**

- **Our approach**
  - MPI
  - CH4
  - OFI
  - Collectives
  - UNIMEM provider

- **Our approach**
  - **MPICH**
    - With its derivatives, default MPI in 9/10 top in TOP500
  - **CH4**
    - Non-scalable structures restricted to non-scalable nets
    - Full communication semantics provided to networks
    - Shared memory improvement
    - Latency improvements
  - **OFI / libfabric**
    - Designed to minimize mismatch between apps/libraries & comm. HW
  - **Work in Progress**
    - Performance improvements using better RDMA support in UNIMEM

**Throughput**

- socket
- unimem
GPI (Global Address Space Programming Interface): asynchronous communication library and programming model
- GPI combines the advantage of a global address space with the accumulated performance of separated memory subsystems
- GPI aims to initiate a paradigm shift from bulk-synchronous two-sided communication patterns towards an asynchronous communication and execution model
- GPI delivers the highest communication performance and scalability on all RDMA-Networks available today
GPI-2 for ExaNode/UNIMEM

- Within the ExaNode project most of the GPI Modules were ported to UNIMEM
- Different performance limitations were reported when using RDMA in UNIMEM
- GPI-2/GASPI developments are currently supported on an UNIMEM Emulation Framework (UniEF) as well as on Socket over UNIMEM
- Early performance characteristics of UNIMEM-Sockets are available (see below)

Performance results of two Trenz-Prototype-Boards@Forth connected via UNIMEM
ExaNode programming models
**OmpSs for distributed memory systems**

- **Task-based parallel programming model**
  - Parallelism defined through task constructs
  - Synchronization between tasks using data dependencies

- **Single global virtual address space abstraction**
  - No need for explicit memory transfers
  - Programmer focuses in algorithm and parallelism design

- **Runtime support for physically distributed memory systems**
  - The run-time system is responsible for memory transfers across cluster nodes
  - Scheduling based on locality and load-balancing
  - Opportunities for run-time optimizations for irregular parallelism.
OmpSs for distributed memory systems

- **Current status**
  - Support of distributed arrays
  - Scheduling based on locality of task data
  - Communication layer independent of underlying library
    - Current implementation based on MPI
  - Release of beta version by the end of the month

- **Work in progress**
  - Performance profiling based on kernels and mini-apps
  - Improvements on scheduling policies

- **Future work**
  - Integration with UNIMEM-capable MPI
  - Implement support for offloading tasks to FPGAs using OpenCL
OpenStream on UNIMEM

- **Task data-flow programming model**
  - Express task-dependent parallelism
  - Implicit privatization of data
  - Runtime has full control over data management

- **Uniform, shared memory abstraction is preserved for programmers**
  - No need to explicit data placement or transfer
  - No need to customize parallelization to the topology of the system

- **Dynamic work and data management**
  - Load balancing through work-stealing
  - Data locality optimized by work-pushing
  - Communication mapped to UNIMEM RDMA and overlapped with computation
Thank you!

European Exascale Processor & Memory Node Design

www.exanode.eu