ENABLING FAM ACCESS IN CHAPEL

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AGENDA

- Fabric-Attached Memory (FAM) – Context
- Why Chapel?
- FAM access from Chapel
  - FAM Distributed Arrays – Design
- Status and Next Steps
**FABRIC-ATTACHED (PERSISTENT) MEMORY**

- Converging memory and storage
  - Resource disaggregation leads to high capacity shared memory pool
  - Local volatile memory provides lower latency, high performance tier
- Distributed heterogeneous compute resources
  - High-speed interconnect
  - Operating system instance per compute node
- Fabric Attached Memory is
  - Large – enabling workloads with large data sets
  - Shared – enabling communication across compute nodes through FAM
  - Persistent – enabling faster checkpointing and access to persistent data
Our Goal:
Enable FAM access through multiple programming languages to make FAM available for a variety of workloads.

FAM enablement in Chapel, because Chapel is:
- written for HPC
- scalable: Designed to be as scalable as MPI & OpenMP parallel computing
- fast: performance competes with or beats C/C++
- portable: runs on laptops, clusters, the cloud, and HPC systems
- Programmable: Designed with programmer productivity in mind
- open source: hosted on GitHub, permissively licensed

Guiding Philosophy
- Access FAM-resident data with minimal language changes
- Abstraction of FAM access from the application
Chapel simplifies parallel programming through elegant support for:

- **Distributed Arrays**
  - An important aspect of large-scale programming on HPC clusters
  - Chapel distributes the elements of the array across nodes, and so the tasks associated with the elements
  - Array distributions provide a “global view” as if it was a local array

Ref: [https://chapel-lang.org/](https://chapel-lang.org/)
FAM ACCESS FROM CHAPEL

Proposed Solution

- New distribution module - Array resides on FAM
- Use OpenFAM library for the accessing FAM
- Provides support for named array allocation in the application
- Supports implicit parallelism through domain partitioning

![Figure 1: Chapel Components](image)
FAM DISTRIBUTED ARRAYS - DESIGN

High Level Design:

• FAM distribution module converts high level array operations into FAM-specific accesses underneath
• Complete array is allocated on FAM by the locale creating the array
• Each locale is then assigned a partition upon which to operate
• Array operations executed in parallel by target nodes
  • Example: forall, reduce or scan are divided into multiple tasks based on the partitioning, and executed in parallel by the target nodes.
FAM DISTRIBUTED ARRAYS - STATUS
Enable longer-term vision

Current Status:
Initial Implementation of
- Array allocation, Array lookup, Array Destroy
- Random indexed access
- Iteration (serial and parallel loops with zippering)
- Bulk transfers
- Reduce and scan
- Array slicing and re-indexing

Design ensures that:
- Applications can allocate and reuse arrays located on FAM
- Our solution honors Chapel’s programming philosophy, e.g., programmer productivity
- Management of FAM data allocation and accesses are abstracted away from the application
- Semantics of a FAM array is as close to that of existing Chapel distributions as possible

Examples of FAM access from Chapel
BULK TRANSFER RESULTS

Preliminary results with bulk transfer
- 25 GiB array copied from FAM to a DRAM distributed array using the bulk transfer operation
- Array directly copied from the application using OpenFAM APIs
- With bulk transfer
  - Throughput increases as the number of locales increase due to task parallelism with FAM distributed array
- Without bulk transfer
  - Throughput drops as the number of locales is increased as a result of the communication overhead between locales with application copy

Configuration:
- Chapel 1.25
- 40 Xeon Gold 6248 cores (80 hyper threaded cores) with 128 GB memory running RHEL 8.3
- Infiniband cluster interconnected using 12.5 GB/s link fat-tree
- One of the nodes used as memory server
FAM ACCESS FROM CHAPEL – LOOKING AHEAD

- Next Steps:
  - Characterize performance of FAM distributed arrays
  - Evaluate FAM distributed arrays usage in workloads like Arkouda
  - Integrate with Chapel mainline code
  - Evaluate other proposals for enabling FAM access in Chapel
    - Enabling FAM as a Chapel object class
    - Present FAM as a sub-locale
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REFERENCES


THANK YOU
FABRIC-ATTACHED (DISAGGREGATED) MEMORY IN CONTEXT

Shared nothing

Shared something

Shared everything
**OPENFAM**

**Purpose:**
- Develop an API and reference implementation to enable programmers to easily program FAM.

**Challenges**
- API should be “natural” to HPC programmers.
- Usable across scale-up machines, existing scale-out clusters, and emerging FAM architectures.

**More detail available from**

Open source reference implementation: [https://github.com/OpenFAM](https://github.com/OpenFAM)

**Status:**
- Reference implementation is available
  - Omnipath and Infiniband clusters
- Currently we are
  - Optimizing the implementation
  - Adapting it for slingshot