THE GOLDILOCKS NODE: GETTING THE RAM JUST RIGHT

Collaboration between Kove, Argonne, Illinois Institute of Technology, University of Reading

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WOULDN’T IT BE NICE…

- If a facility could have
  - exactly the right combination of resources
  - put them together exactly the way each application needed them; and
  - upgrade each resource completely independent of the others?

- We already do it with disk (SAN)…

- Why not RAM?
  - We replace nodes to get newer CPUs, but throw away perfectly good RAM.
  - We build “big memory nodes” which are either poorly utilized or have a queue a mile deep.
Rethinking the Use of RAM

- **RAM Area Network (RAN)**
  - Put minimal RAM on the compute node (32GB-64GB)
  - Put a pool of RAM on the network
  - Allocate additional RAM when and where it is needed
    - Allow the RAM pool to be **persistent** as a cherry on top.
  - Early results suggest this could be a killer app for some applications (Deep learning)
    - Small GPU memory and computation time allow latency hiding.
  - *This topic will be the focus of the talk today*

- **Alternative uses:** RAM can be considered as **persistent storage**
  - e.g. when streaming visualization data through GPUs.
  - Fast additional storage tier or independent storage location
    - Should people care where data is stored?
  - Temporary storage for IO reordering to improve disk IO performance.
  - *We consider these aspects and more in the collaboration (out of scope for slides)*
RAM AREA NETWORK TO THE RESCUE

▪ Advantages
  – Reduction in aggregate resources and therefore CAPEX and OPEX
  – No more “this node has unused RAM and that one is out”
  – No need for heterogeneous clusters (big memory nodes)
    • Maximum size limited by the motherboard
    • What if that still isn’t big enough?
  – Another alternative in the “deep memory hierarchy”
  – Changes in facility needs for RAM can by trivially and dynamically addressed
  – Decouple the purchases

▪ Disadvantages
  – Performance, particularly latency and jitter
  – Some apps/algorithms would need to be rewritten
  – Some will simply not be amenable to it
  – Power, maybe: More data movement vs. less aggregate offset each other
SOUNDS GOOD. HOW DO WE DO THAT?

- Management interface that allows dynamic allocation of memory "volumes"

- Usage alternatives
  - Xmem kernel driver
    - Transparent access
      No changes to the application.
    - Accomplished by intercepting `malloc()` and `mmap()` calls.
    - Native QEMU/KVM integration starting in RHEL 7.5
    - Can also be used as a block device
  - Explicit memory management
    - Needs modification of the application
    - C, Java, and memkind interfaces
Partners in the Collaboration

- Argonne Leadership Computing Facility (long-term collaboration with Kove)
  - *William (Bill) Allcock*: Prototyping of novel approaches for applications and systems
  - ALCF provides the development environment that includes XPD memory appliances

- Kove – small Chicago Tech Company
  - Produce the XPD memory appliances and software
  - Virtualization and got support into RHEL driver

- University of Reading
  - *Dr. Julian Kunkel* - Kove MPI-IO driver, cost modeling, monitoring

- Illinois Institute of Technology
  - *Dr. Zhiling Lan*
    - Multi-objective scheduling (how do we balance nodes, RAM, burst buffer, etc.)
    - Use of RAN in Machine Learning and Deep Learning applications.
  - *Dr. Xian-He Sun* – Memory performance modeling and optimization

- Your name here?  We are very interested in expanding the collaboration.