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Run Time Systems R&D with the Qthreads Multithreading Library

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Qthreads Philosophy

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- Qthreads as a vehicle for run time system research
  - Co-design efforts with architecture and applications
  - Modular for flexibility and extensibility
    - Interfaces to OpenMP, Kokkos, Chapel, <your language here>
    - Different schedulers, e.g., work stealing, hierarchical
- Crowded space of run time system solutions
  - Don't claim to have the best, but strive to improve
  - Still many unsolved problems
    - Want to gain understanding
    - Seek collaboration

Qthreads Overview

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- Programmer exposes application parallelism as massive numbers of lightweight tasks (qthreads)
  - Problem-centric rather than processor-centric decomposition enhances productivity, transparent scaling
  - Both loop-based and task-based parallelism supported
  - Full/empty bit primitives for powerful, lightweight synchronization (emulates Tera/Cray MTA/XMT behavior)
  - C API with no special compiler support required
- Dynamic run time system manages the scheduling of tasks for locality and performance
  - Heavyweight worker pthreads execute the tasks
  - Worker pthreads pinned to underlying hardware

Qthreads Capabilities

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- Locality-aware load balancing of tasks to support NUMA and complex cache hierarchies
  - Locality domain with work queue shared among worker threads that share cache and memory
  - Work stealing between locality domains for global load balancing
- Lightweight task context switching
- Ported to x86, Phi, PPC, Sparc, Tilera

Qthreads Run Time View of Locality

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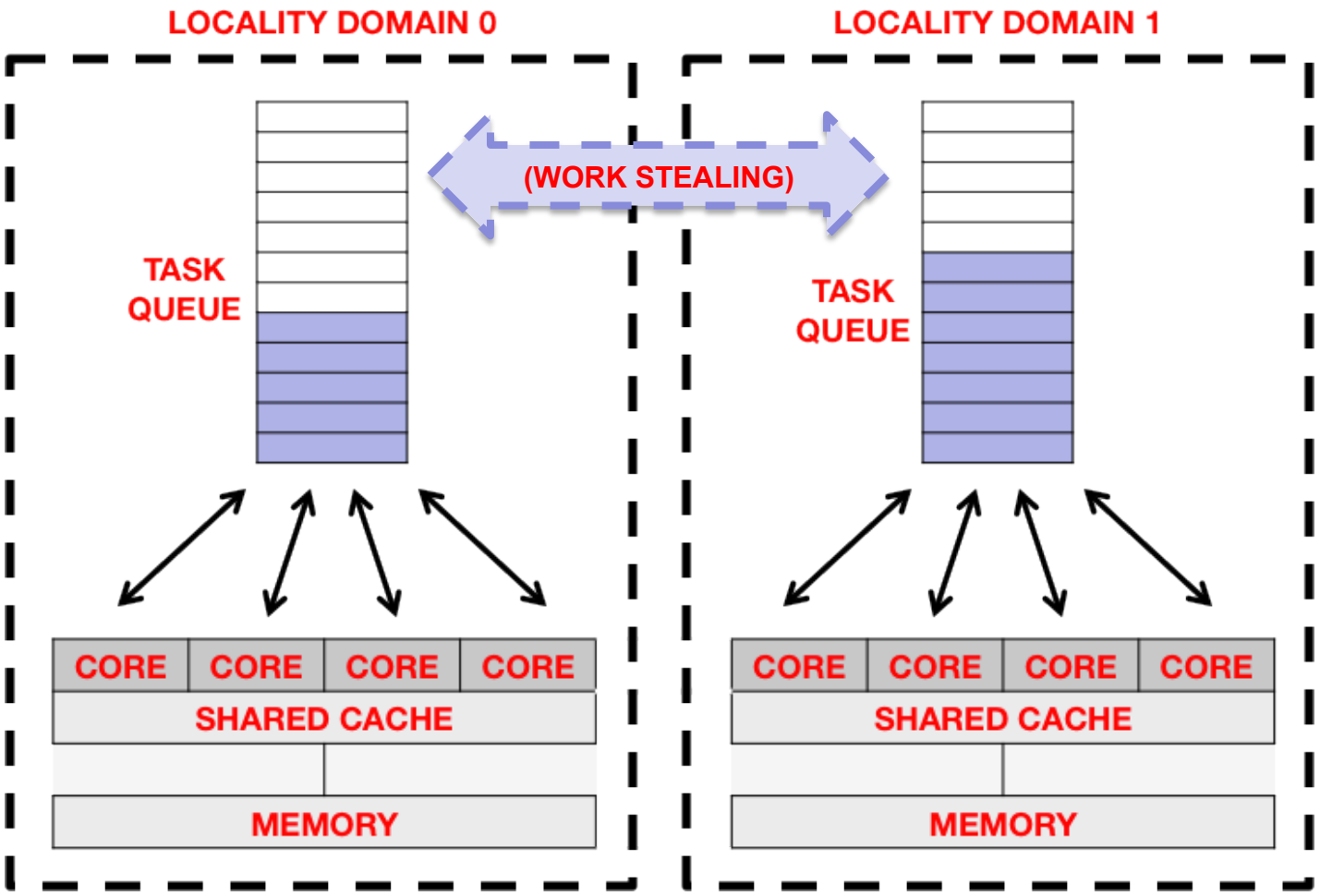

X-over-Qthreads

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- Qthreads as run time for **X**
  - Allows execution of **X** codes without porting to Qthreads API
  - Leverage existing front-ends
  - Enables experimentation with potential new OpenMP features
- **X** = OpenMP (ROSE, Intel)
- **X** = Chapel
- **X** = Kokkos
- And supports composition for MPI+**X**

A Unified Runtime Example

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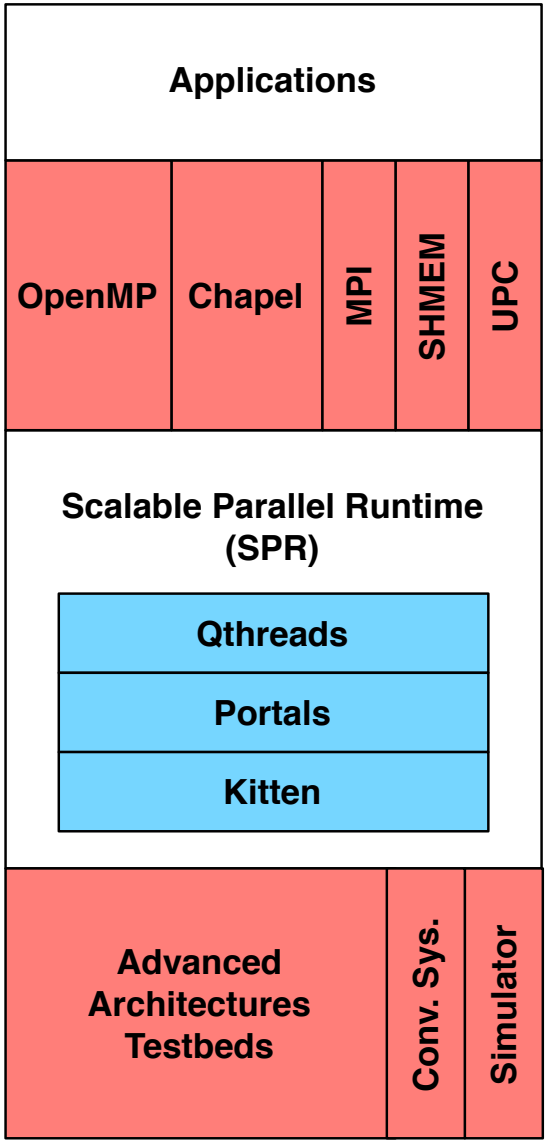
- **Qthreads: Lightweight threading interface**
  - Scalable, lightweight scheduling on NUMA platforms
  - Supports a variety of synchronization mechanisms, including full/empty bits and atomic operations
  - Potential for direct hardware mapping
- **Portals 4: Lightweight communication interface**
  - Semantics for supporting both one-sided and tagged message passing
  - Small set of primitives, allows offload from main CPU
  - Supports direct hardware mapping
- **Kitten: Lightweight OS kernel**
  - Builds on lessons from ASCI Red, Cplant, Red Storm
  - Utilizes scalable parts of Linux environment
  - Primarily supports direct hardware mapping



Available Online

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Qthreads

More info: http://www.cs.sandia.gov/qthreads/

Source: https://code.google.com/p/qthreads/