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Do we need Rack-Scale Coordination?

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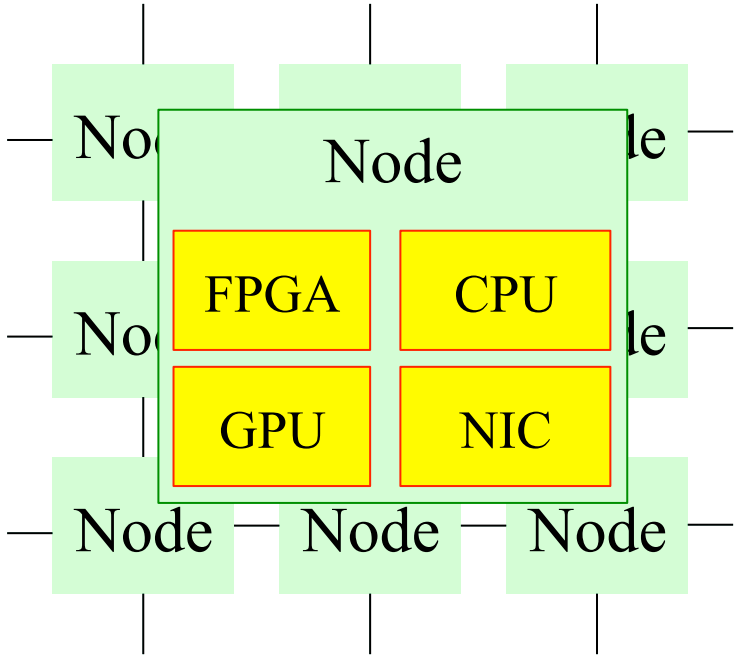
Rack-Scale Computers (RSC)

(or *Datacenter-in-a-Box* systems)

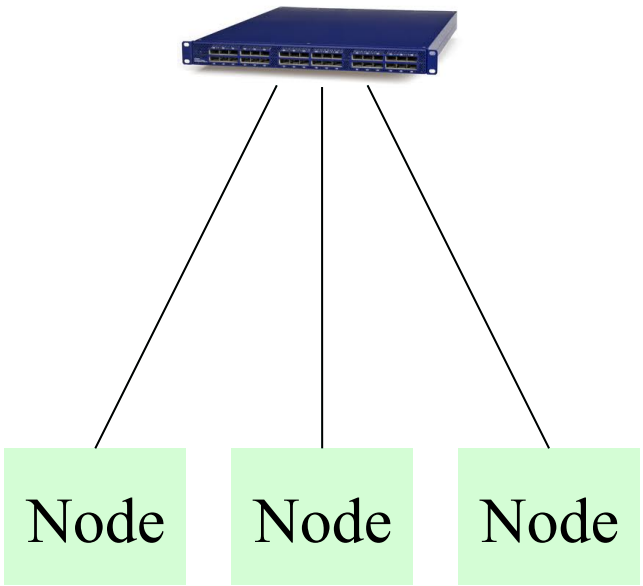
- Tightly integrated rack (in a single box)
- Very fast node interconnection
- Special-purpose components
- *"Uncommon"* network topologies



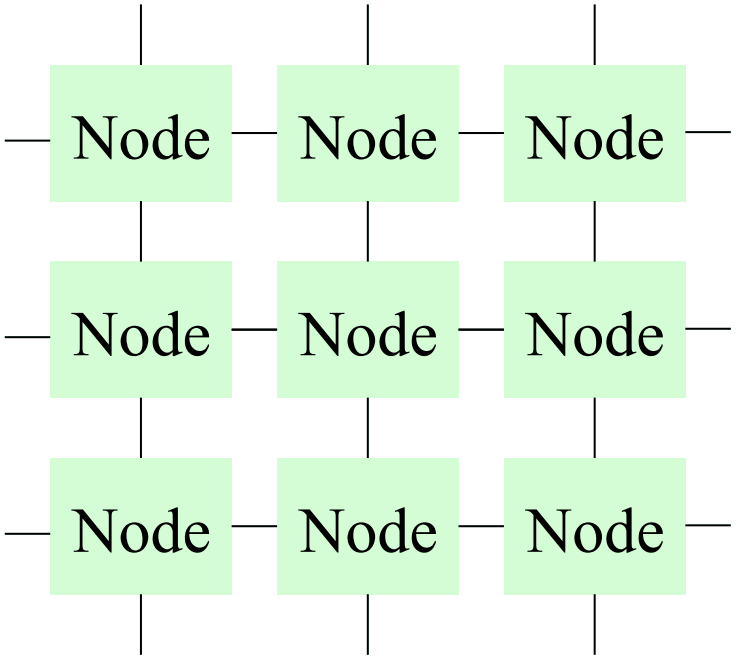
Rack-Scale Computers (RSC)

(or *Datacenter-in-a-Box* systems)

“Traditional” Model



“Torus” Model



Do they need coordination?

- Leader election
- Locks
- Barriers
- Atomic counters
- Augmented Queues

  …
- Configuration management

Out of the box Alternatives

- Shared memory algorithms
- Multi-kernel coordination
- Datacenter coordination

Single-machine Coordination

- **Shared-memory algorithms**
  - Classical shared memory locking algorithms exist since the 70s (Lamport's Bakery, etc.)
  - Algorithms require some consistency on the shared memory
    - Total Store Ordering (TSO – weaker than sequential consistency)
    - The best know result requires a **constant number** of remote memory references and memory barriers [PODC'13]
- **Multi-kernel Solution**
  - A service (deployed on a core) that provides all the coordination primitives that applications need
    - E.g., Barrelfish supports a service like Zookeeper [APSys'12]
- Both solutions do not tolerate faults

Datacenter Coordination

- Coordination services:

System	Data Model	Sync. Primitive	Wait-free
Boxwood [44]	Key-Value store	Locks	No
Chubby [17]	(Small) File system	Locks	No
Sinfonia [6]	Key-Value store	Microtransactions	Yes
DepSpace [14]	Tuple space	cas/replace ops	Yes
ZooKeeper [31]	Hierar. of data nodes	Sequencers	Yes
etcd [3]	Hierar. of data nodes	Sequen./Atomic ops	Yes
LogCabin [5]	Hierar. of data nodes	Conditions	Yes

  - dependable (limited) storage
  - synchronization power
  - client failure detection

So…

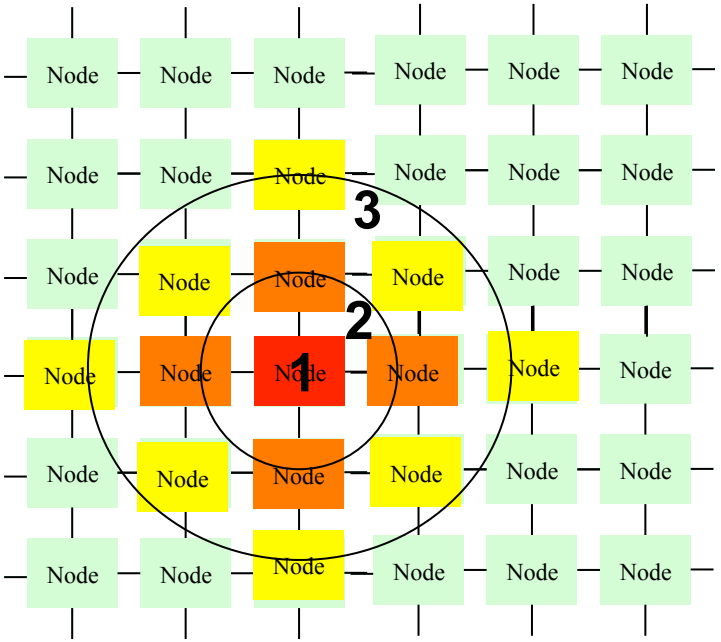
- A RSC has multiple fault domains, so **fault tolerance** is needed
  - Coordination services are our best bet
- **Durability** may or may not be needed
  - Strictly required for configuration management
- **Extensibility** for improved performance
  - See the *"Extensible Distributed Coordination"* paper/talk on EuroSys'15

Traditional Network

- The coordination service is implemented as usual, i.e., *"just deploy Zookeeper on your RSC"*
  - A bunch of replicas ensure the service is fault tolerant
  - Durability techniques ensure full crash recovery
- Possible improvements:
  - More efficient replication algorithms
    - DARE [HPDC'15] proposes RAFT-like RDMA-based state machine replication with 12 microsec latency (1kB write)
      - 35x faster than ZK in the same network
  - Faster durability mechanisms (e.g., NVRAM)

Torus Network

- Coordination scope
  - L0: local CPU
  - L1: CPU + other local computing devices
  - L2: all nodes reachable in one hop
  - L3: all nodes reachable in two hops
  - …
  - LN: all nodes reachable in N-1 hops
- This may lead to the development of new quorum systems and fault-tolerant algorithms



Questions… questions…

- The RSC software stack requires general coordination support. The question is:
  - *Do we need anything specific or it is just a matter of deploying what we already have?*
- Other questions:
  - *Can specialized hardware (FPGA) help?*
  - *Can we assume/implement reliable failure detection?*
  - *Efficiency or predictability?*
  - *What about data-centric coordination?*

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More Questions?