Building Fault-Tolerant Consistency Protocols for an Adaptive Grid Data-Sharing Service

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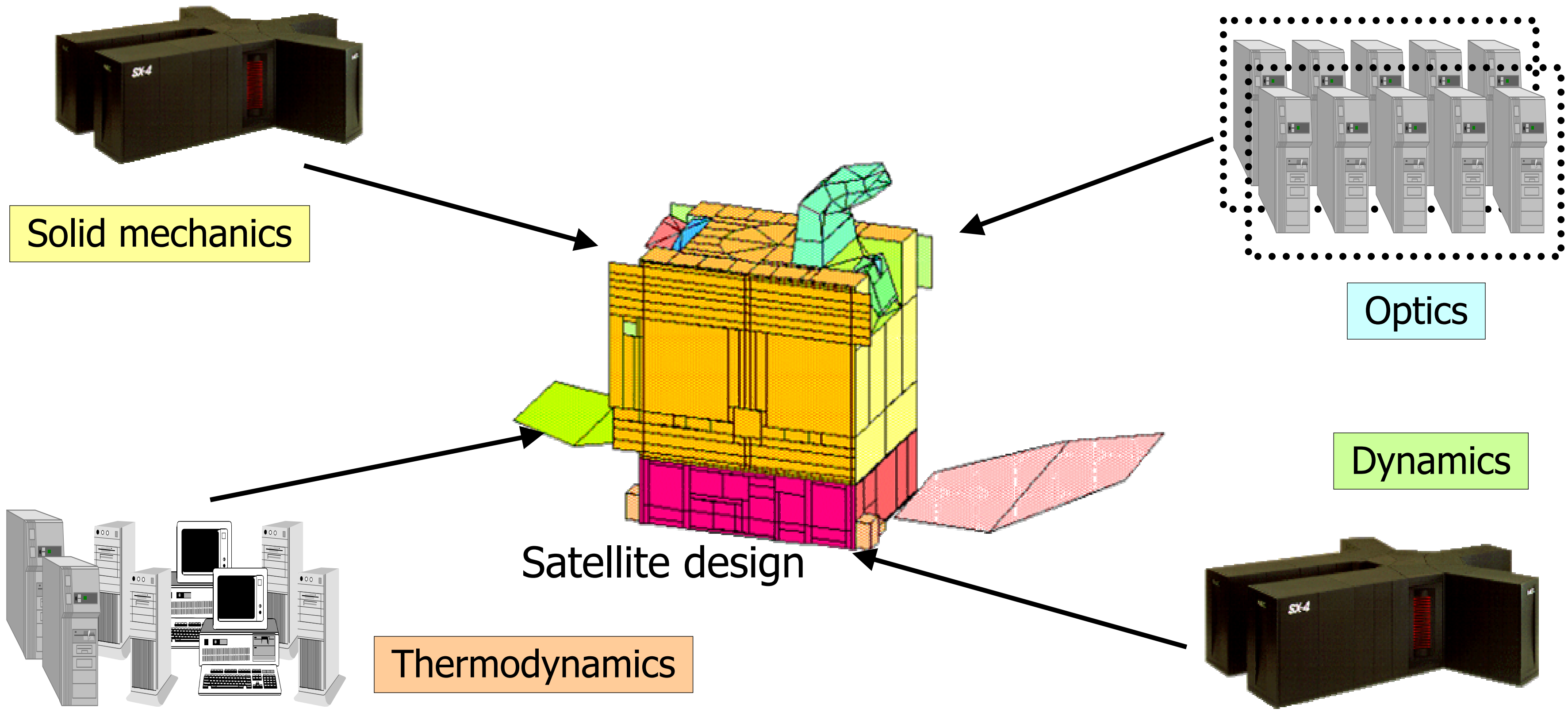
Context: Grid Computing

- Target architecture: cluster federations (e.g. GRID 5000)
- Target applications: distributed numerical simulations (e.g code coupling)
- Problem: the right approach for data sharing?

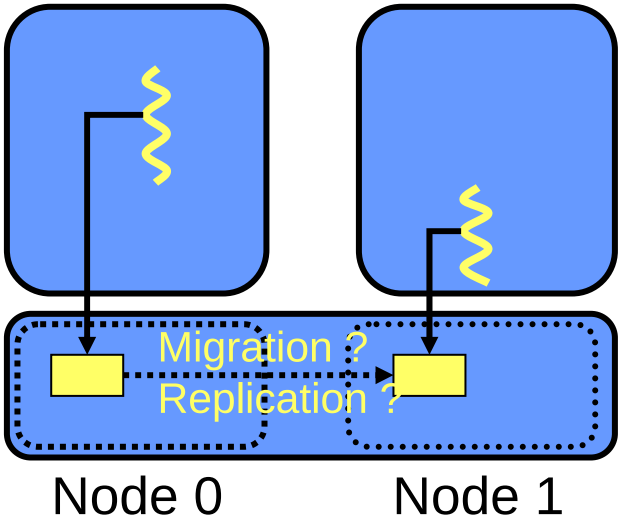


Current Approaches: Explicit Data Management

- Explicit data localization and transfer
  - GridFTP [ANL], MPICH-G2 [ANL]
    - Security, parallel transfer
  - Internet Backplane Protocol [UTK]
- Limitations
  - Application complexity at large-scale
  - No consistency guarantees for replicated data

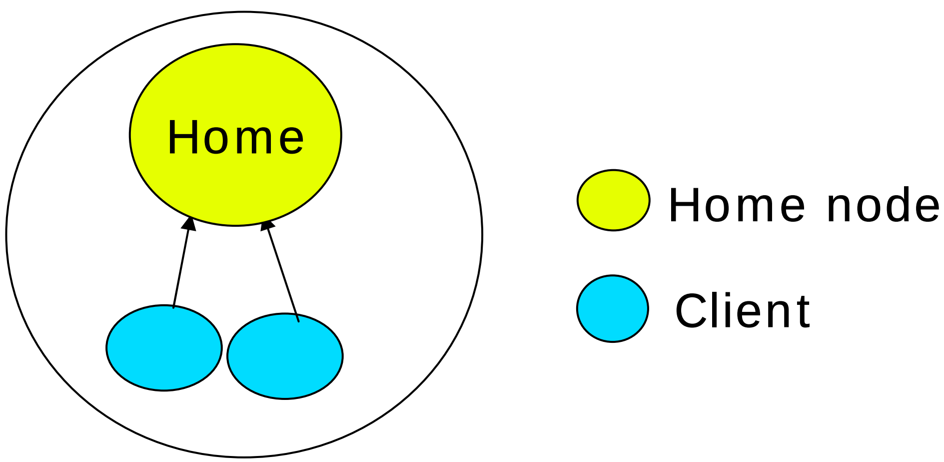
Handling Consistency: Distributed Shared Memory Systems

- Features:
  - Uniform access to data via a global identifier
  - Transparent data localization and transfer
  - Consistency models and protocols
- But:
  - Small-scale, static architectures
- Challenge on a grid architecture:
  - Integrate new hypotheses !
    - Scalability
    - Dynamic nature
    - Fault tolerance

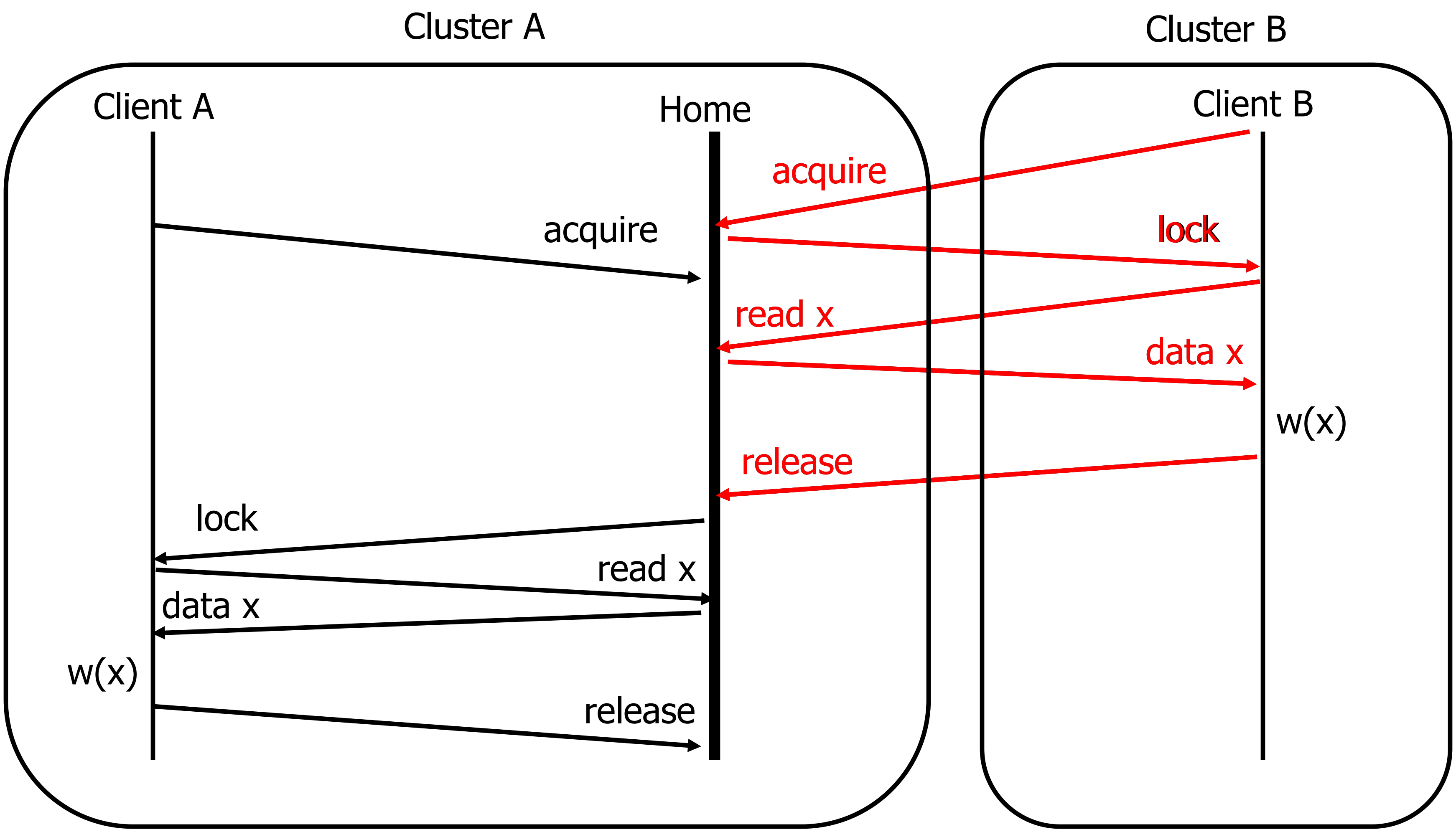


Case Study: Building a Fault-Tolerant Consistency Protocol

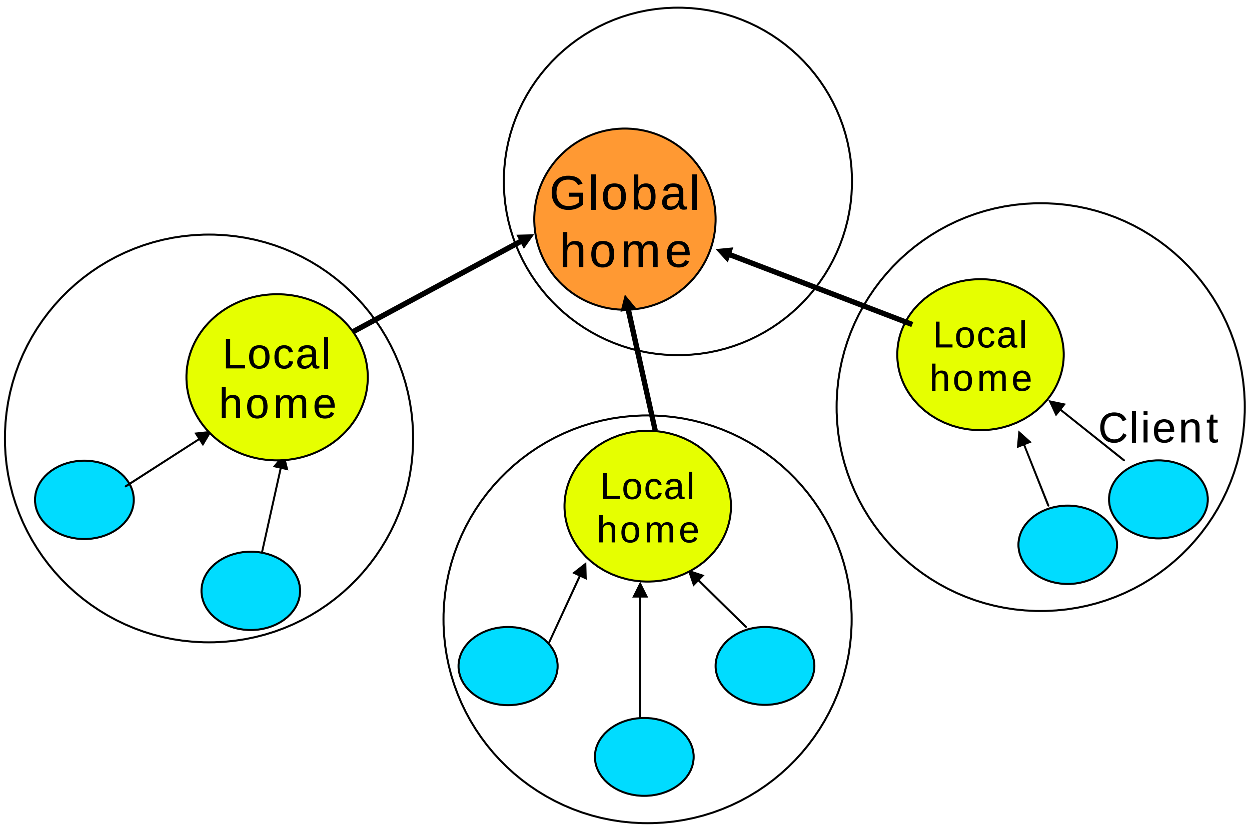
- Starting point: a home-based protocol for entry consistency
  - Relaxed consistency model
    - Explicit association of data to locks
    - MRSW: Multiple Reader Single Writer
      - acquire(L)
      - acquireRead(L)
  - Implemented by a home-based protocol



Home Based Protocol

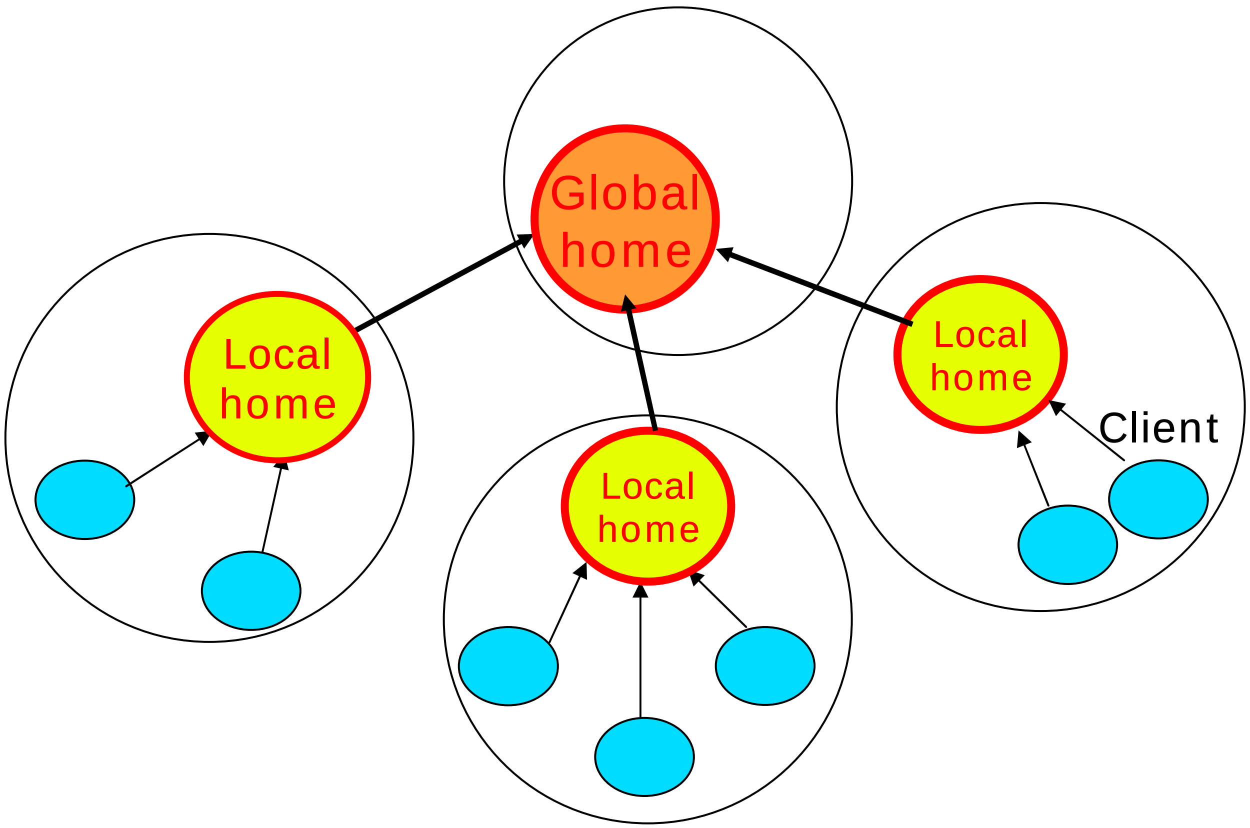


Going Large Scale: a Hierarchical Consistency Protocol



- Inspired by CLRC[LIP6, Paris] and H2BRC[IRISA, Rennes]

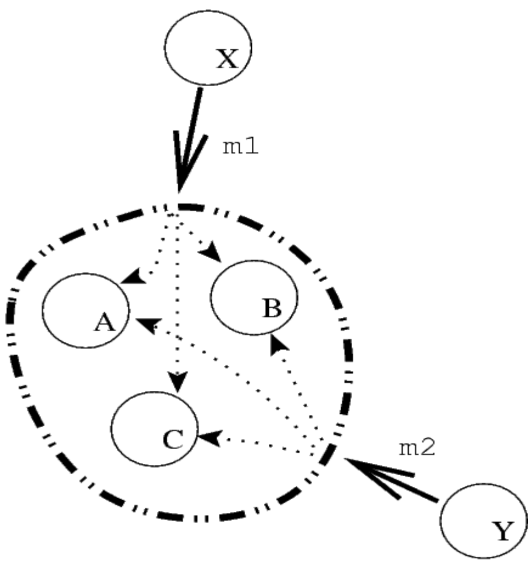
Problem: Critical Entities May Crash

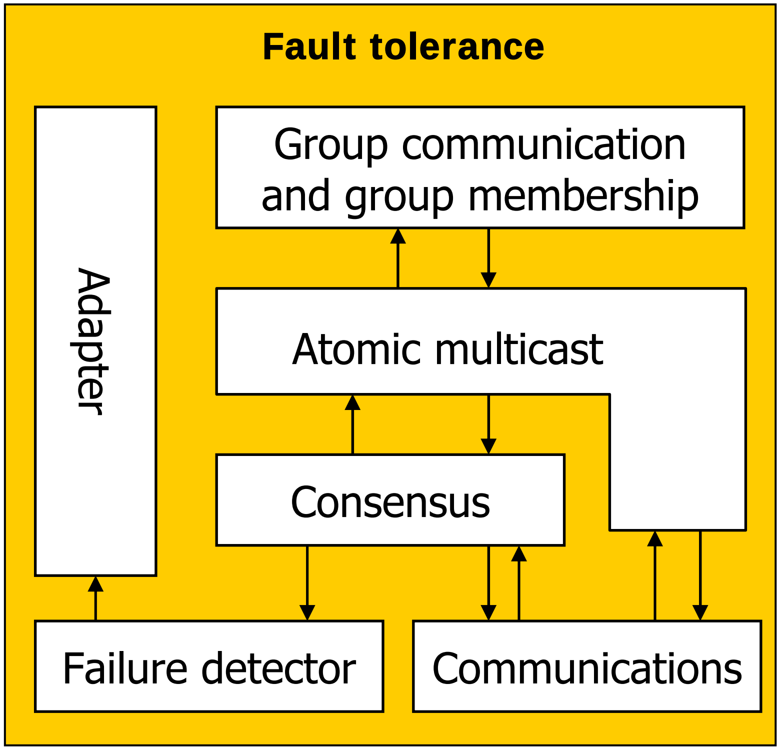


- How to support *home* crashes on a grid infrastructure ?

Idea: Use Fault-Tolerant Components

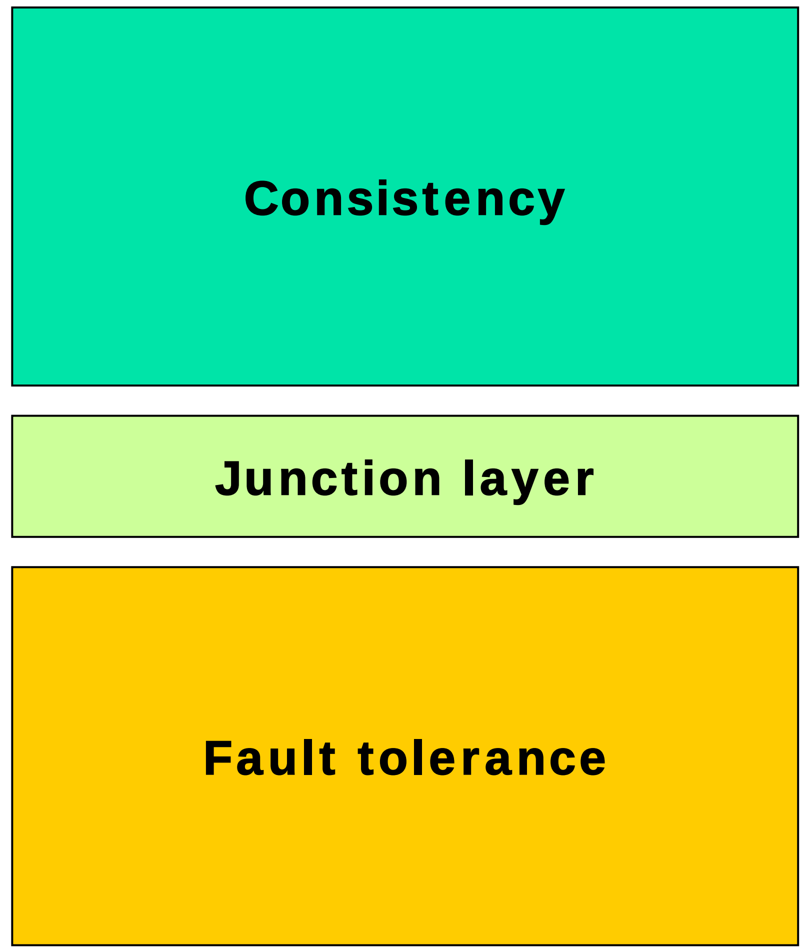
- Replicate critical entities on a group of nodes
- Group of nodes managed using the *group membership* abstraction
- Rely on *atomic multicast*
- Example architecture: A. Schiper[EPFL]





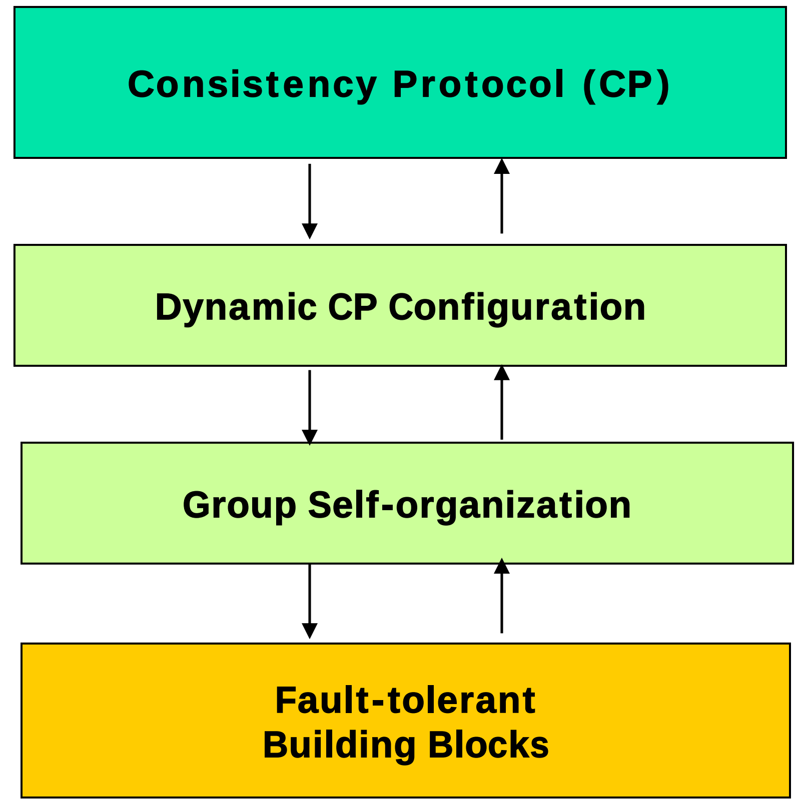
Approach: Decoupled Design

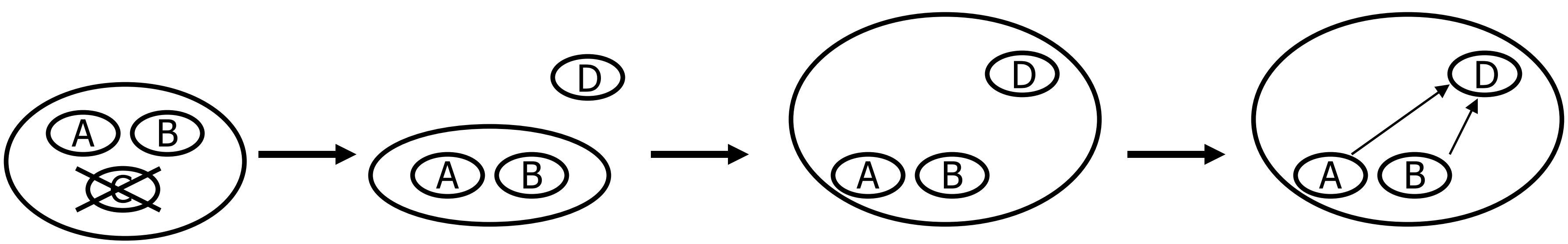
- Consistency protocol layer and fault-tolerance layer are separated
- Interaction defined by a junction layer



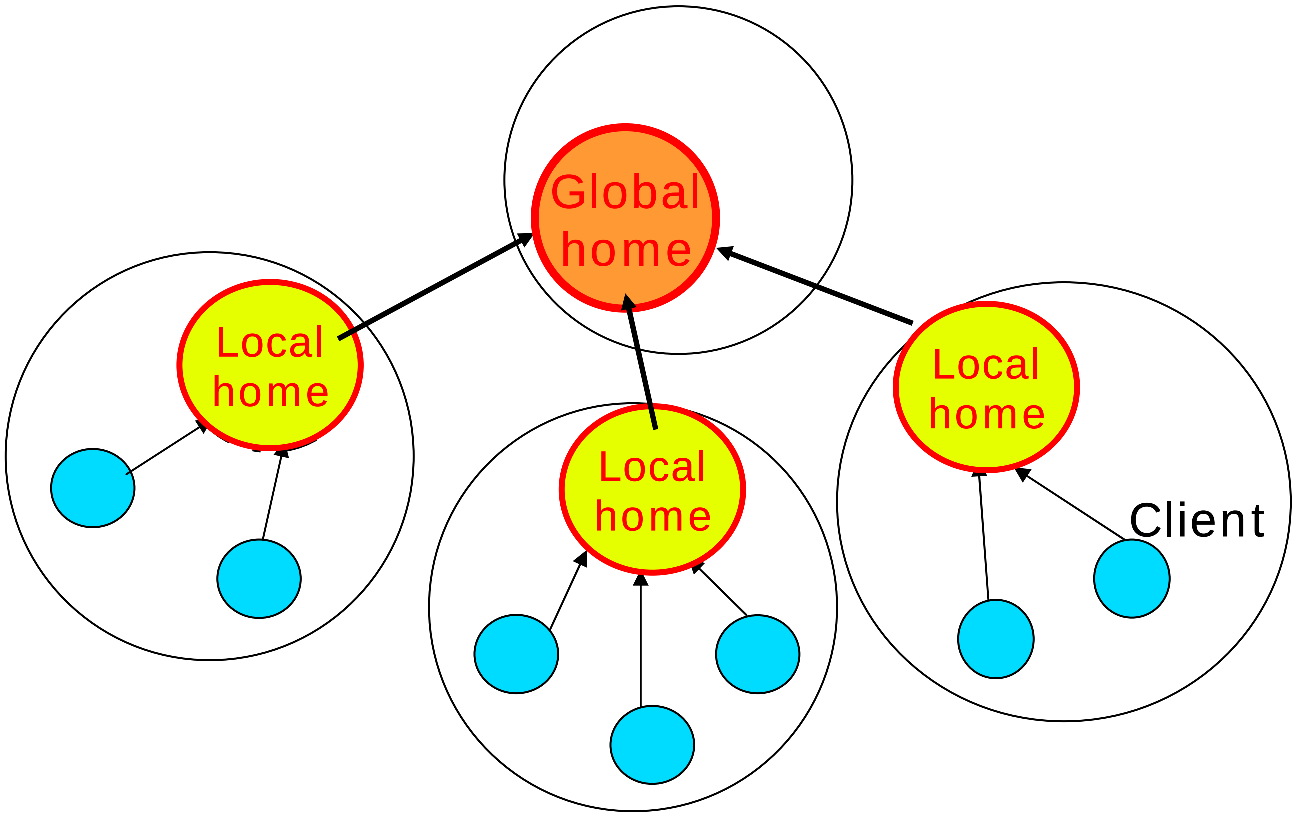
Consistency/Fault-Tolerance Interaction

- Critical consistency protocol entities implemented as fault-tolerant node groups
- Group management using traditional group membership and group communication protocols
- Junction layer handles
  - Group self-organization
  - Configuration of new group members





Replicate Critical Entities Using Fault-Tolerant Components



- Rely on replication techniques and group communication protocols used in fault-tolerant distributed systems

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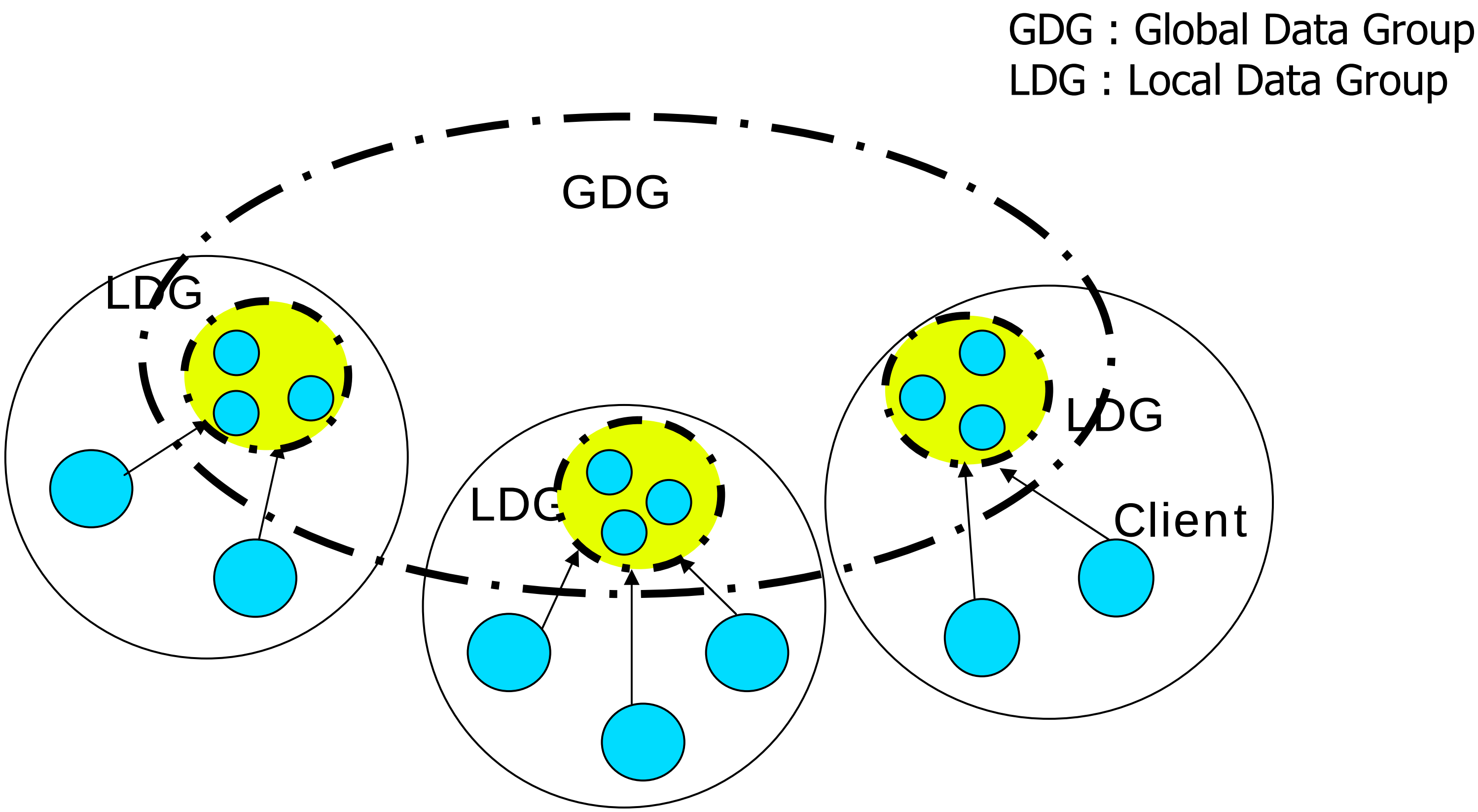

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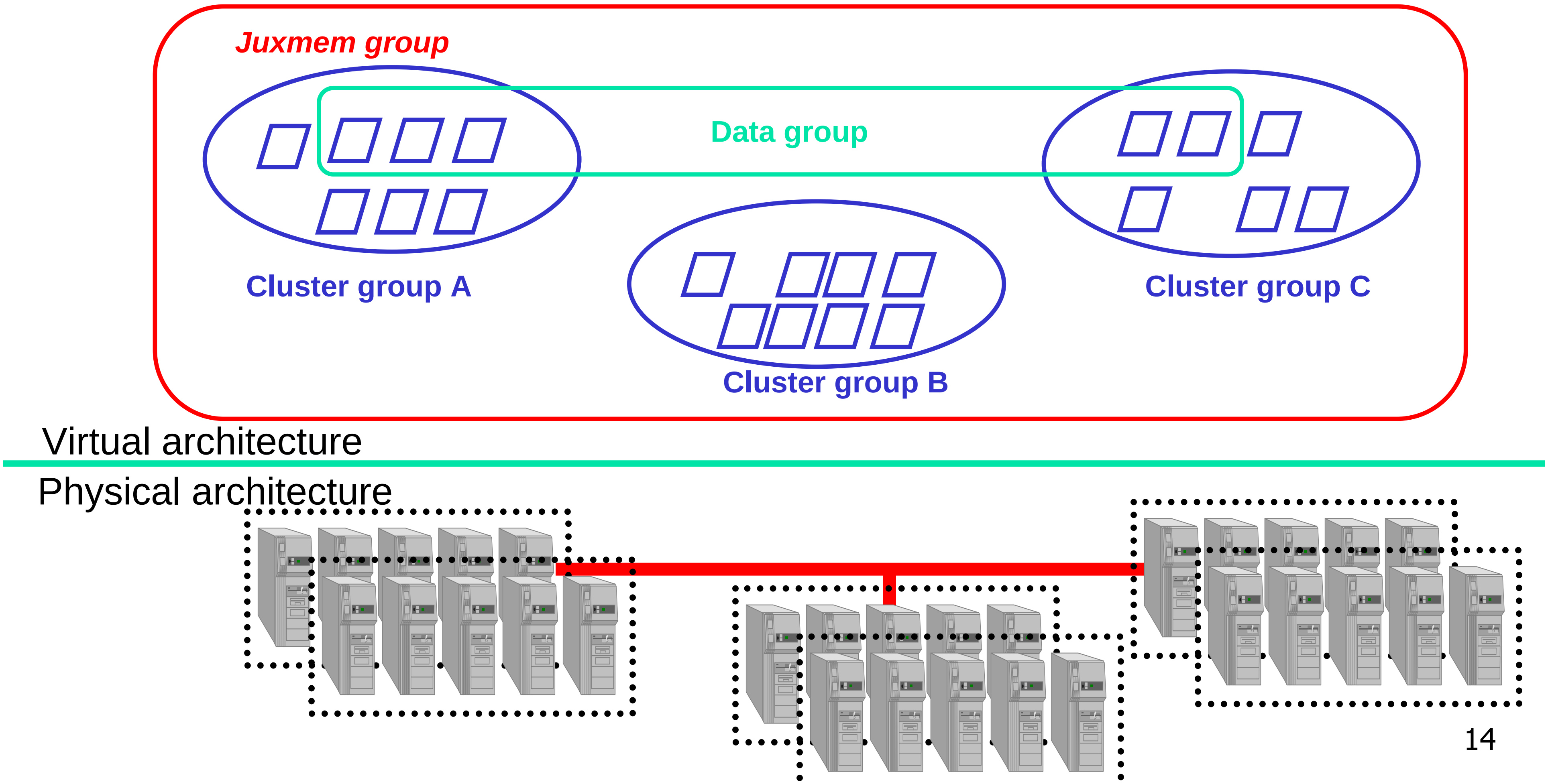
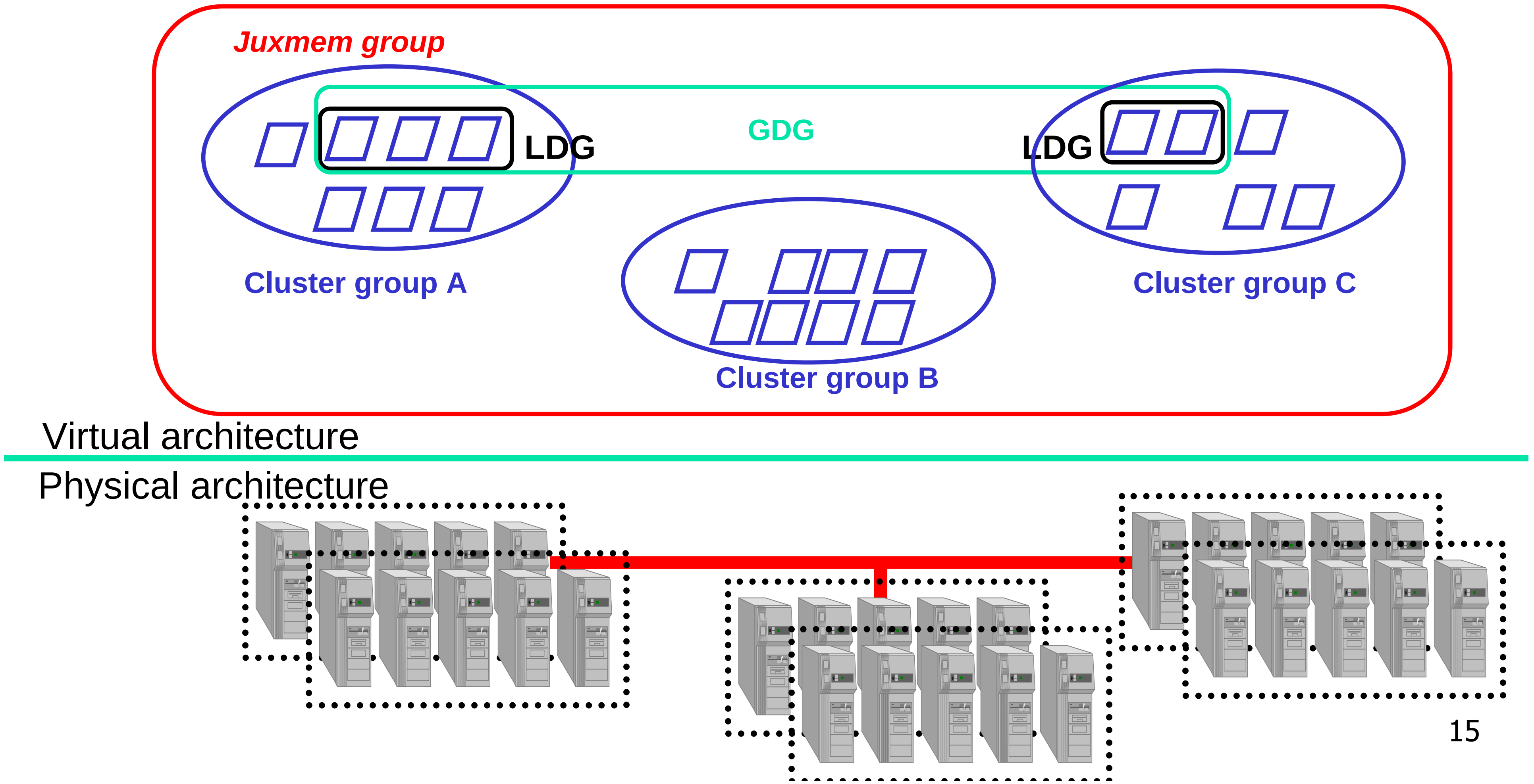
The JuxMem Framework

- DSM systems: consistency and transparent access
- P2P systems: scalability and high dynamicity
- Based on JXTA, P2P framework [Sun Microsystems]



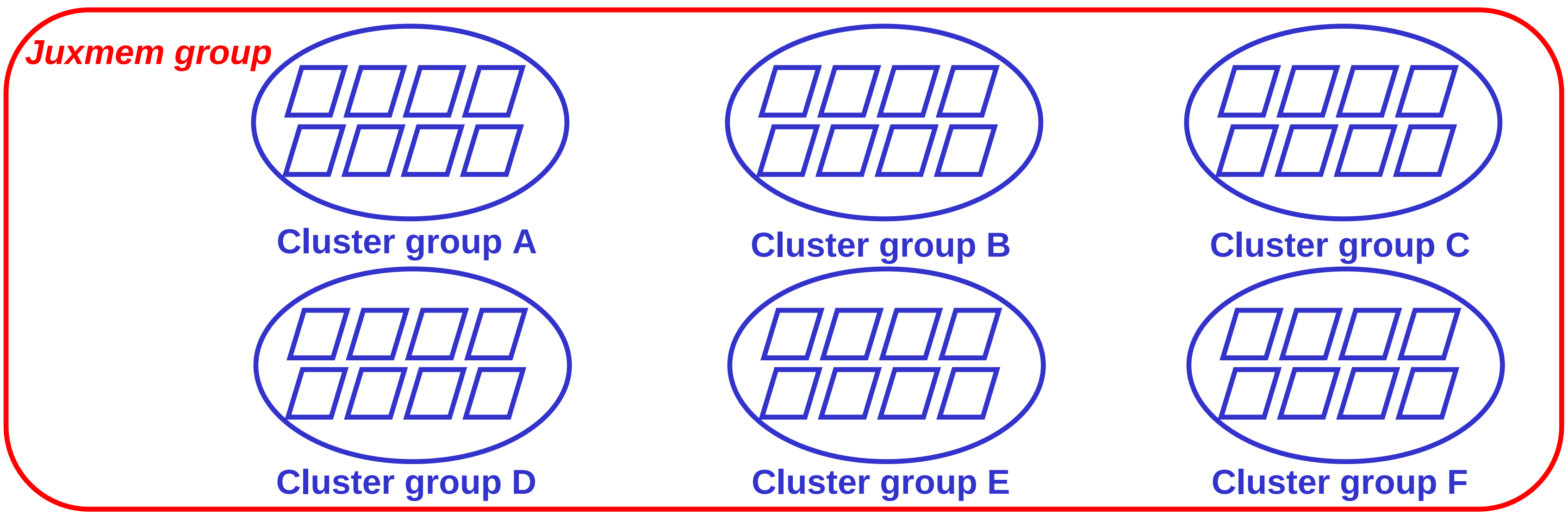
Implementation in JuxMem

- Data group ≈ GDG + LDG



Preliminary Evaluation

- Experiments
  - Allocation cost depending on replication degree
  - Cost of the basic data access operations
    - read/update
- Testbed: *paraci* cluster (IRISA)
  - Bi Pentium IV 2,4 Ghz, 1 Go de RAM, Ethernet 100
  - Emulation of 6 clusters of 8 nodes



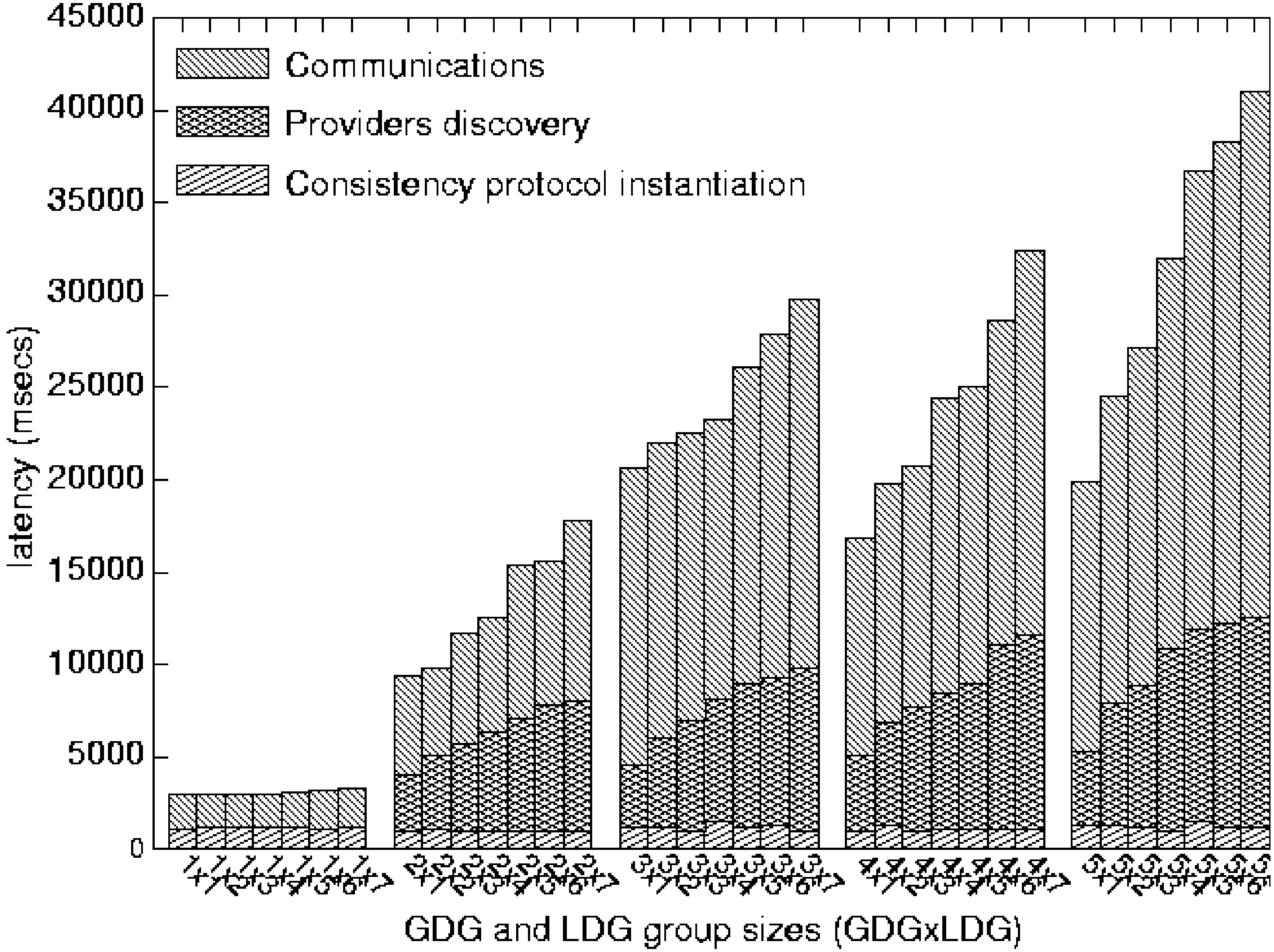
Allocation Process

1. Discover *n* providers according to the specified replication degree

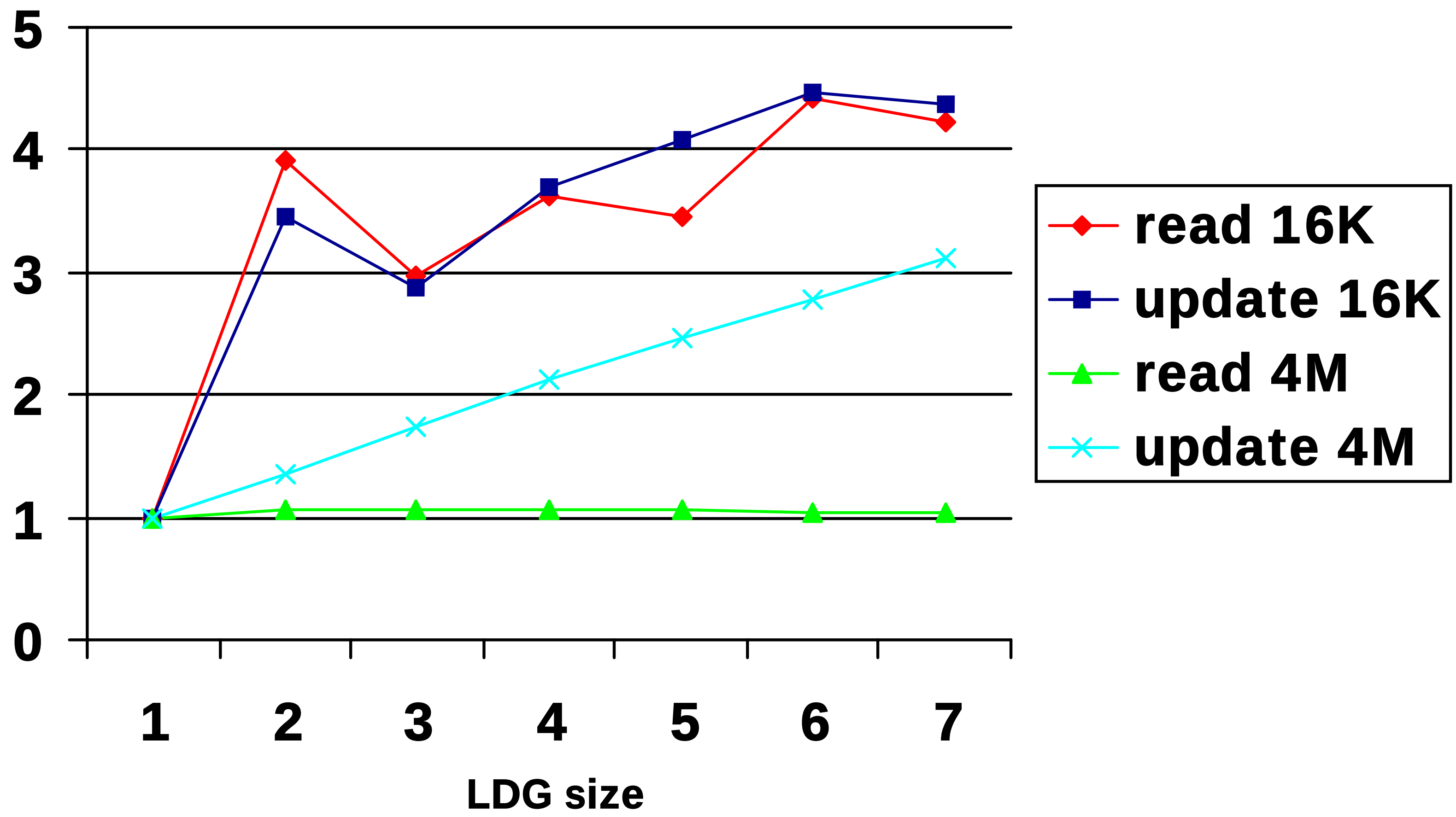
2. Send an allocation request to the *n* discovered providers

3. On each provider receiving an allocation request:
   - Instantiate the protocol layer and the fault-tolerant building blocs

Preliminary Evaluation: Allocation Cost



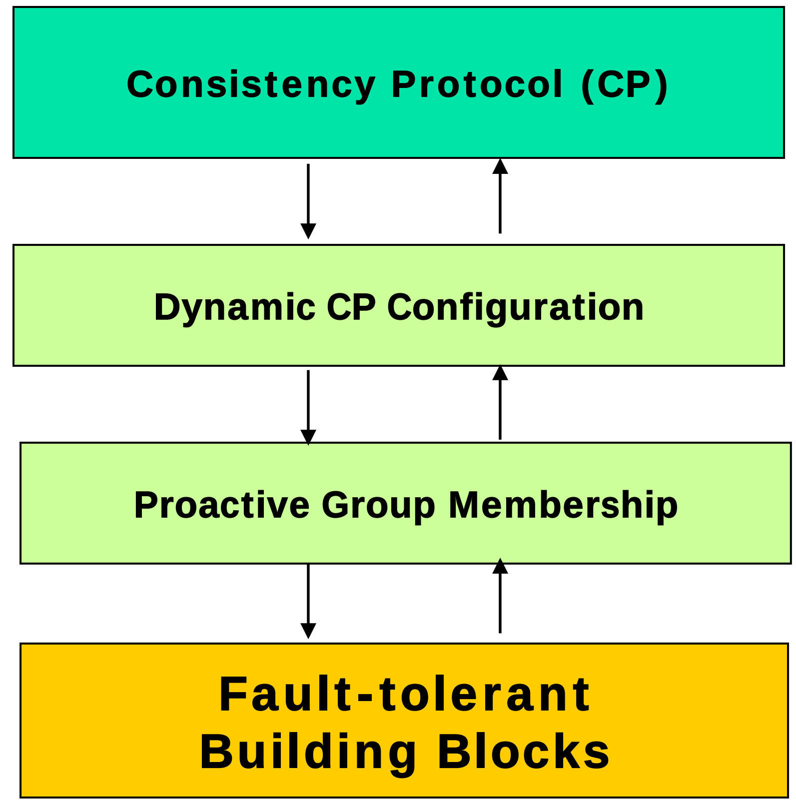
Cost of Basic Primitives: read/update



Conclusion

- Handling consistency of mutable, replicated data in a volatile environment

- Experimental platform for studying the interaction
  fault-tolerance <-> consistency protocols



Future Work (AGridM 2003)

- Consistency protocols in a dynamic environment
- Replication strategies for fault tolerance
- Co-scheduling computation and data distribution
- Integrate high-speed networks: Myrinet, SCI.

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Future Work (AGridM 2004)

- Goal: build a Grid Data Service
  - Experiment various implementations of fault-tolerant building blocks (atomic multicast, failure detectors, …)
  - Parametrizable replication techniques
  - Experiment various consistency protocols with various replication techniques
  - Experiment with realistic grid applications at large scales
- GDS (Grid Data Service) project of ACI MD:

http://www.irisa.fr/GDS