Creating a Robust Desktop Grid using Peer-to-Peer Services

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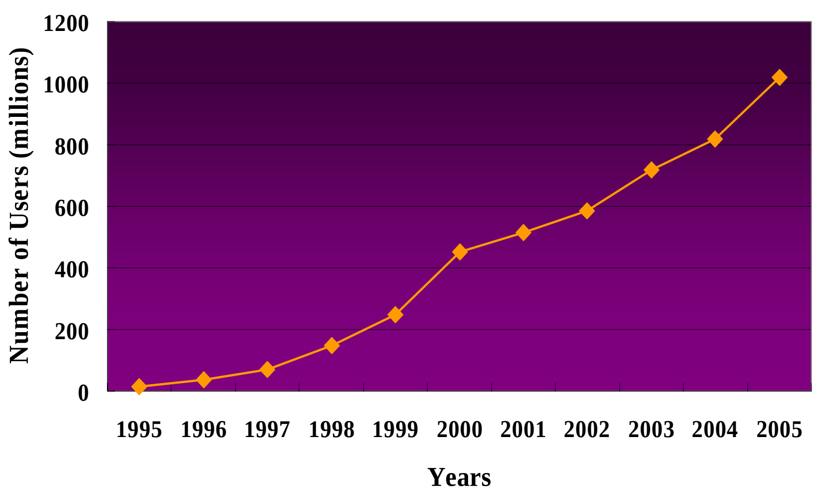
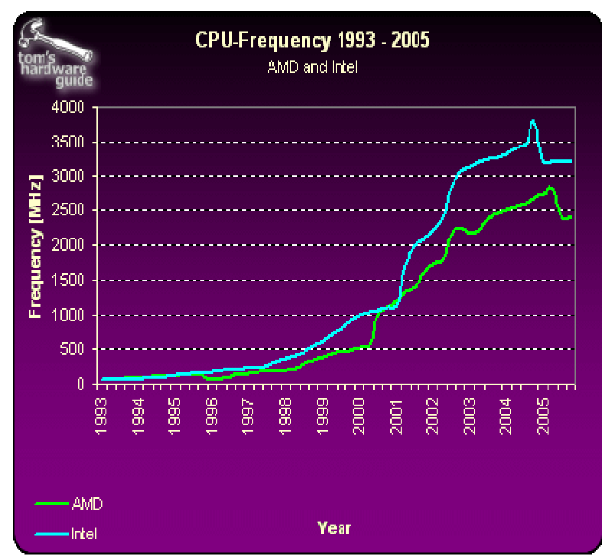
Desktop Grid Computing

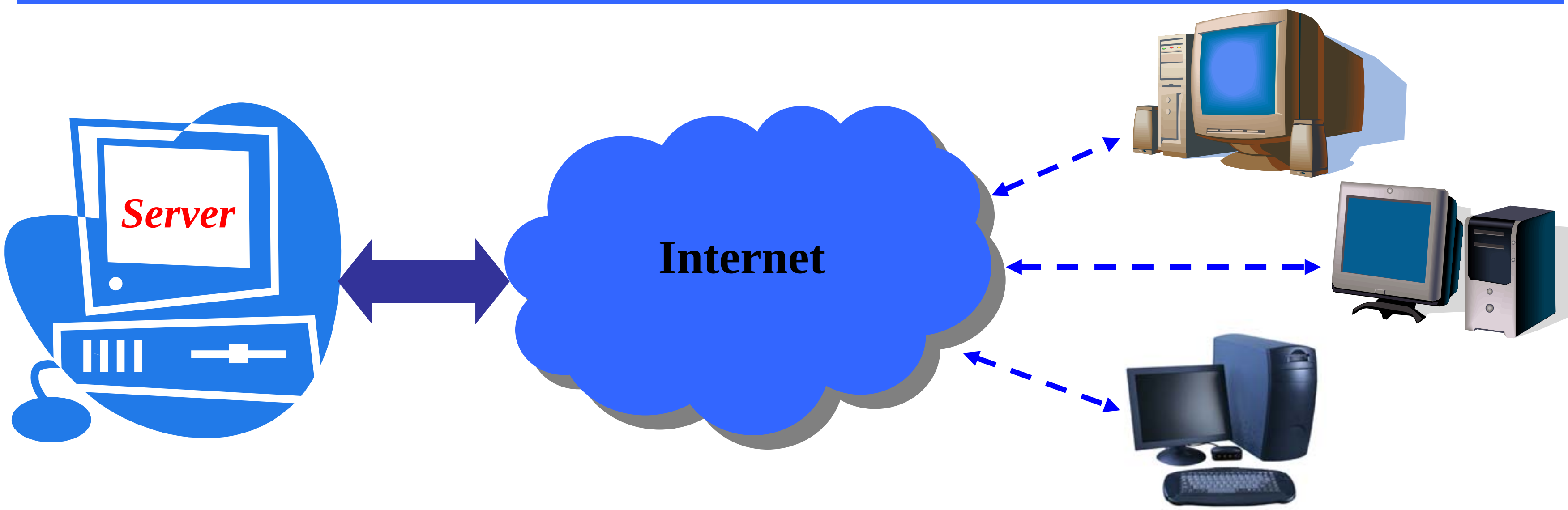
to Compute !

Growth of Internet (*Internet Worlds Stats*)

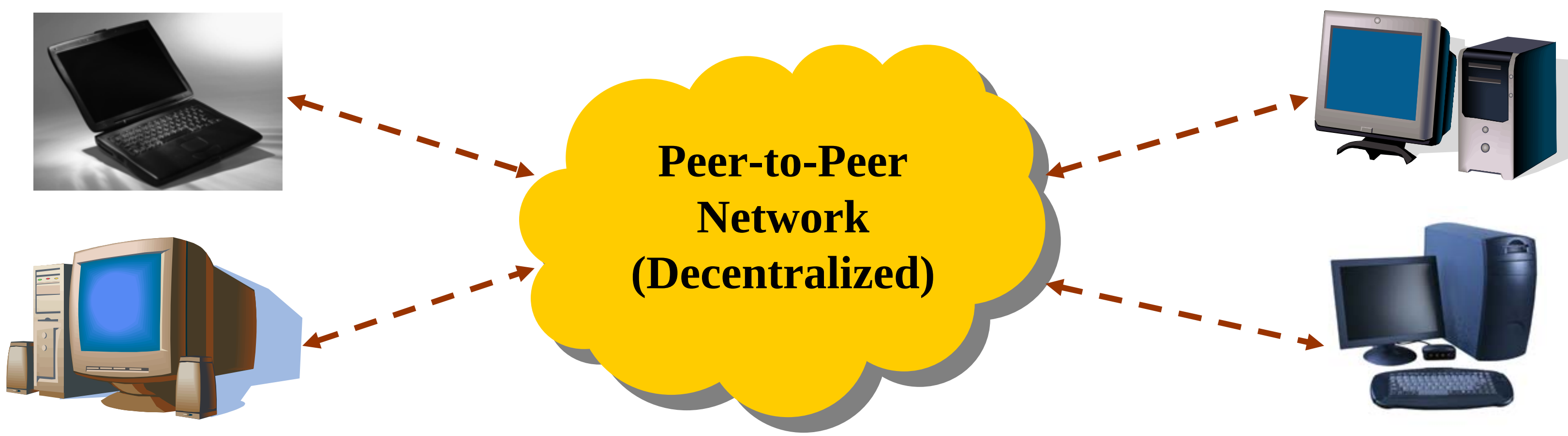




Confluence of P2P and Grid



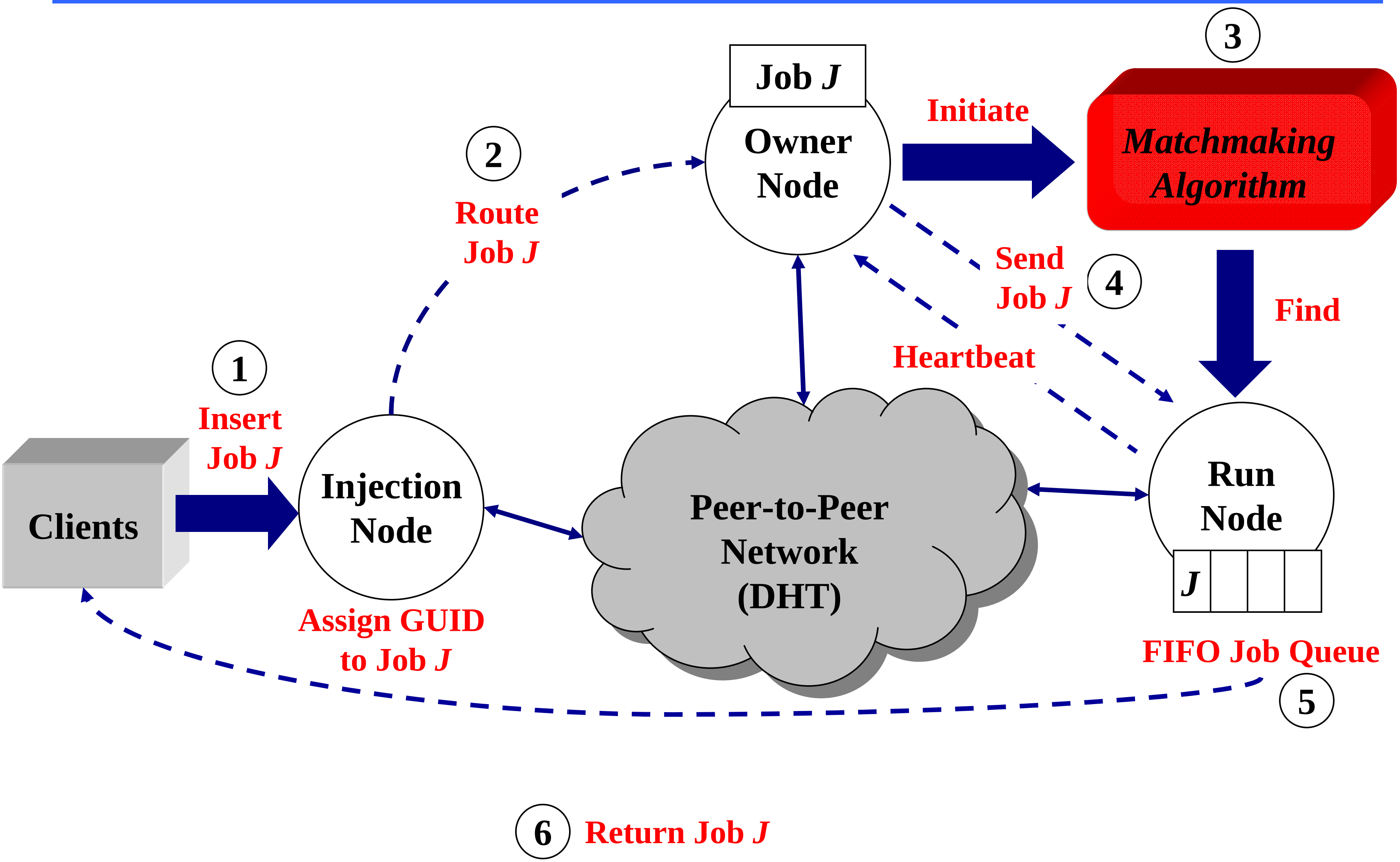
Robustness, Reliability and Scalability?



Hard Problems / Issues

- Submitting jobs
- Finding a resource that meets the minimum resource requirements of a job
- Load balancing
- Resilience to failure

System Architecture



Workload Assumptions

- *Must* accommodate heterogeneous clusters of nodes running heterogeneous batches of jobs
- *Clustering* in nodes (resource capabilities) and jobs (requirements)
  - A small number of equivalent classes of nodes
  - Parameter sweeps, e.g., N-body or weather simulations

Nodes \ Jobs	**Clustered**	**Mixed**
Clustered		Condor
Mixed	BOINC/ SETI@Home	

Goals of Matchmaking Algorithms

- *Low overhead*
  - Routing must not add significant overhead
- *Completeness*
  - A valid assignment of a job to a node must be found if such an assignment exists
    - TTL-based mechanisms are not applicable
- *Precision*
  - Resources should not be wasted
- *Load balance*
  - Distribute load across multiple candidates

Basic Assumptions

- Underlying *Distributed Hash Table* (DHT)
  - Object location and routing in P2P network
  - Reformulate the problem of matchmaking to one of routing
- *Job* in the system
  - Data and associated profile
  - All jobs are *independent*
- Optimization criterion
  - Minimize time to complete all jobs (combination of throughput and response time)

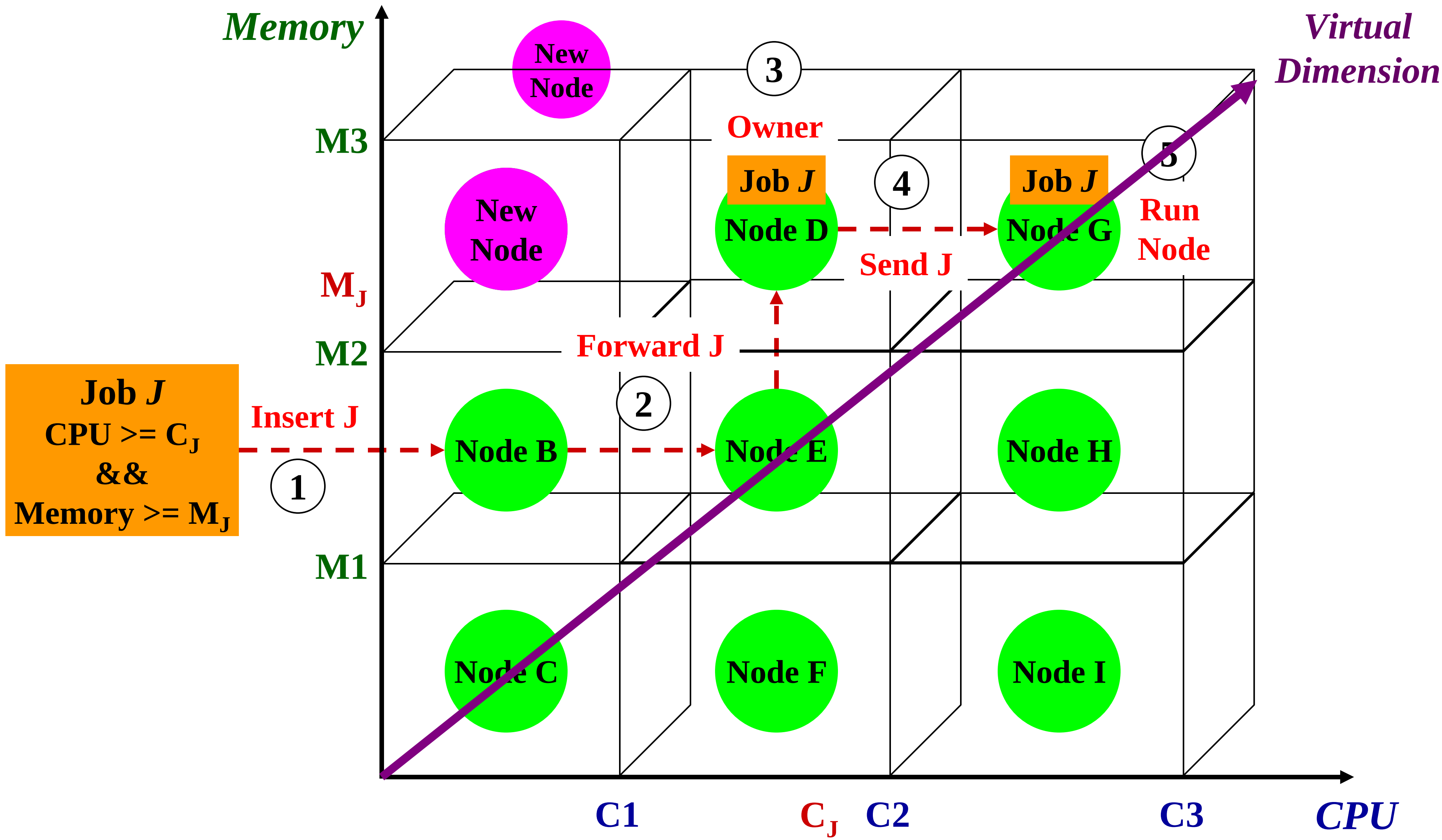
Modified Content-Addressable Network

- Basic CAN
  - Logical *d*-dimensional space
    - zone, neighbors, greedy forwarding
- Formulate the matchmaking problem as a routing problem in CAN space
  - Treat each *resource type* as a distinct CAN dimension
  - Map nodes and jobs into the CAN space
    - Resource capabilities and Requirements, respectively
  - Search for *the closest node whose coordinates in all dimensions meet or exceed the job's requirements*

Modified Content-Addressable Network

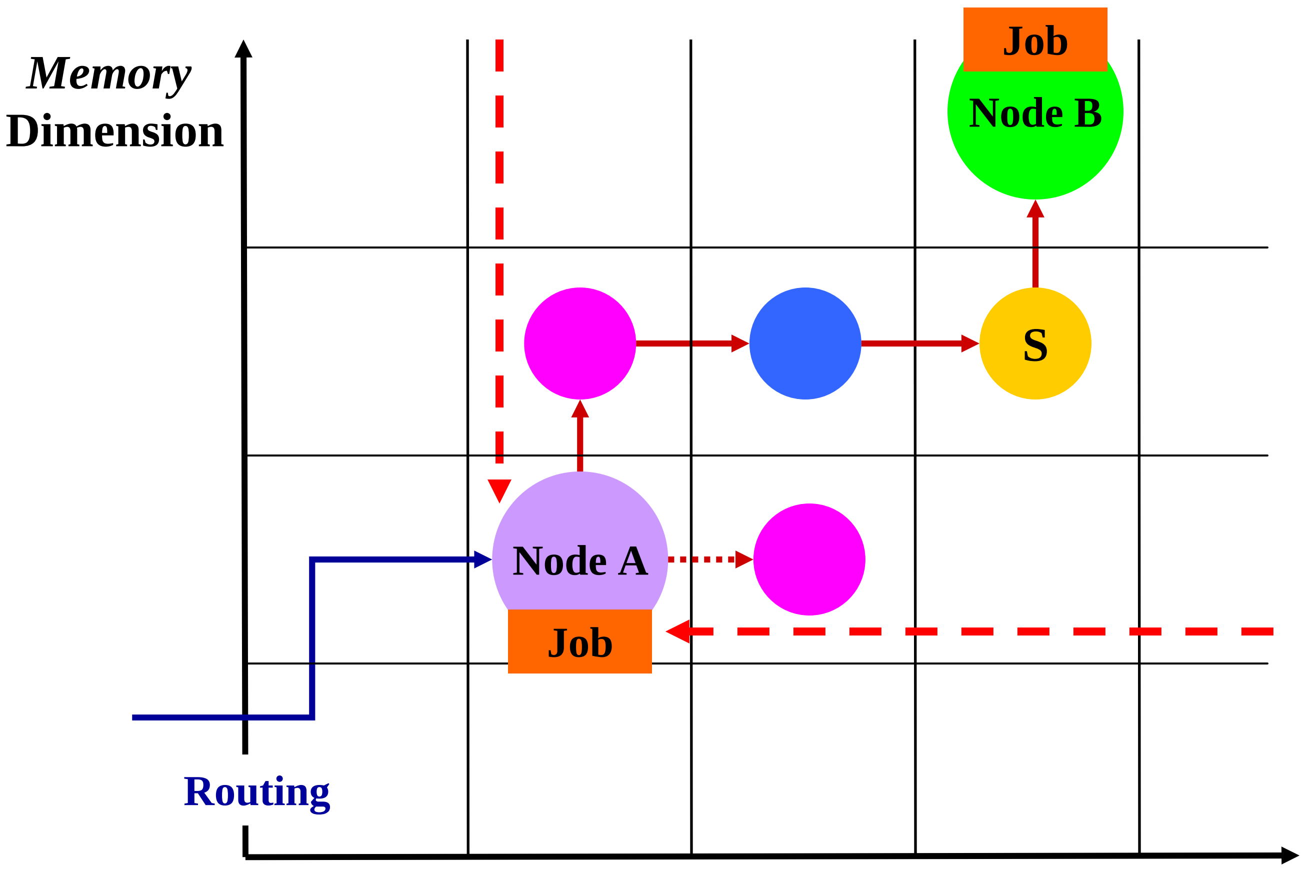
- *Virtual* Dimension
  - Clustering of nodes and jobs
    - Resource capabilities and Requirements
    - Distribution of ownership of a zone and Load imbalance
  - Supplement the *real* dimensions
    - Corresponding to node capabilities
  - Coordinates for nodes and jobs for the virtual dimension generated *uniformly at random*

Modified Content-Addressable Network



Improving CAN-based Algorithm

- Employing Dynamic Aggregated Resource Information (HPDC'07)



- ❖ Aggregate Resource Information
- ❖ Choose the least loaded direction
- ❖ Push a job into under-loaded region
- ❖ Stop pushing
- ❖ Choose the best run node

Rendezvous Node Tree

- *Implicit* tree built on top of P2P network
  - 1-1 mapping from DHT (*Chord*) nodes to RN-Tree nodes
- Why use a tree?
  - Need to *aggregate* current resource information to perform matchmaking
  - Aggregated Resource Information
    - *Maximal* amount of each resource available at some node in the subtree rooted at a node

Results from Simulations (Grid 2006)

- CAN and RN-Tree algorithms balance load almost as well as centralized algorithm
  - with low overhead (few messages)
- Overall, the CAN algorithm produces significantly lower wait times than RN-Tree for most workloads
  - with comparable overhead
  - and with dynamic aggregate load info, CAN is better for **all** workloads

Current Status

- Resource discovery algorithms thoroughly simulated and verified
- CAN-based implementation ongoing
  - Basic CAN services working – node join, leave, job assignment
  - Basic CAN matchmaking working
    - Enhanced with dynamic aggregate load info under way
  - Basic authentication mechanism for hosts and jobs in place, based on certificates and public-key authentication
  - Job management and GUI client interface under development

Future Work

- Deploying the prototype system for real workloads and real machines
- Better characterization of real workloads
  - via consultation with Astronomy collaborators, and automated mining of Condor system logs

The Project Team

- Faculty members
  - Alan Sussman, Pete Keleher, Bobby Bhattacharjee, Derek Richardson (Astronomy), Dennis Wellnitz (Astronomy)
- Prototype implementation
  - Michael Marsh, Beomseok Nam
- Matchmaking algorithms and simulations
  - Jik-Soo Kim
- Project funding from NASA and NSF
  - to develop algorithms, and build and deploy the system