A Self-Organizing Flock of Condors

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The need for sharing compute-cycles

- Scientific applications
  - Complex, large data sets
- Specialized hardware
  - Expensive
- Modern workstation
  - Powerful resource
  - Available in large numbers
  - Underutilized

➔Harness idle-cycles of network of workstations

Condor: High throughput computing

- Cost-effective idle-cycle sharing
- Job management facilities
  - Scheduling, checkpointing, migration
- Resource management
  - Policy specification/enforcement
- Solves real problems world-wide
  - 1200+ machines Condor pools, 100+ researchers @Purdue

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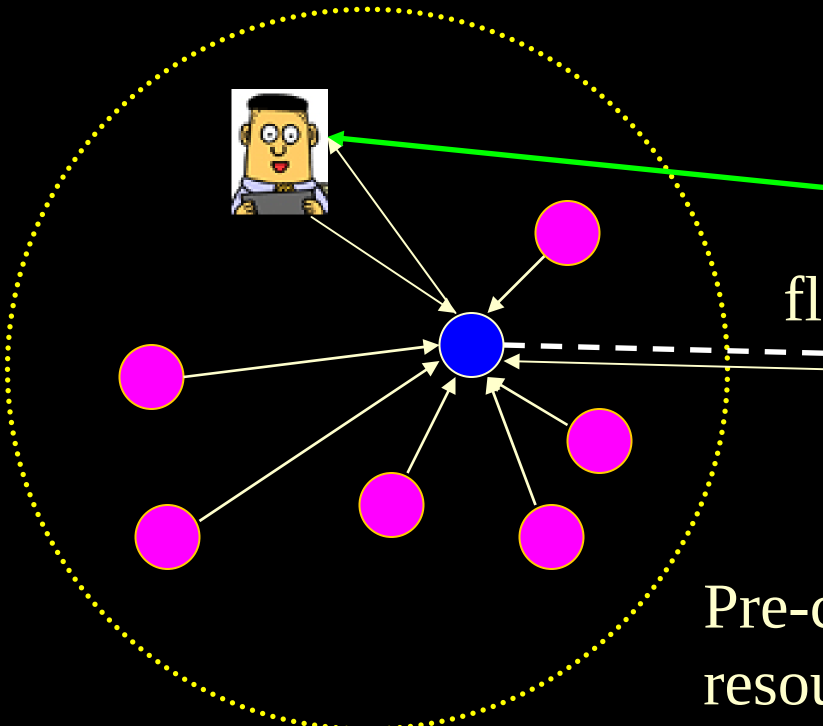
Sharing across pools: Flocking



Central manager

Flocking

- Static flocking requires
  - Pre-configuration
  - Apriori knowledge of all remote pools
    - Does not support dynamic resources

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Our contribution: Peer-to-peer based dynamic flocking

- Automated remote Condor pool discovery
- Dynamic resource management
  - Support dynamic membership
  - Support changing local policies

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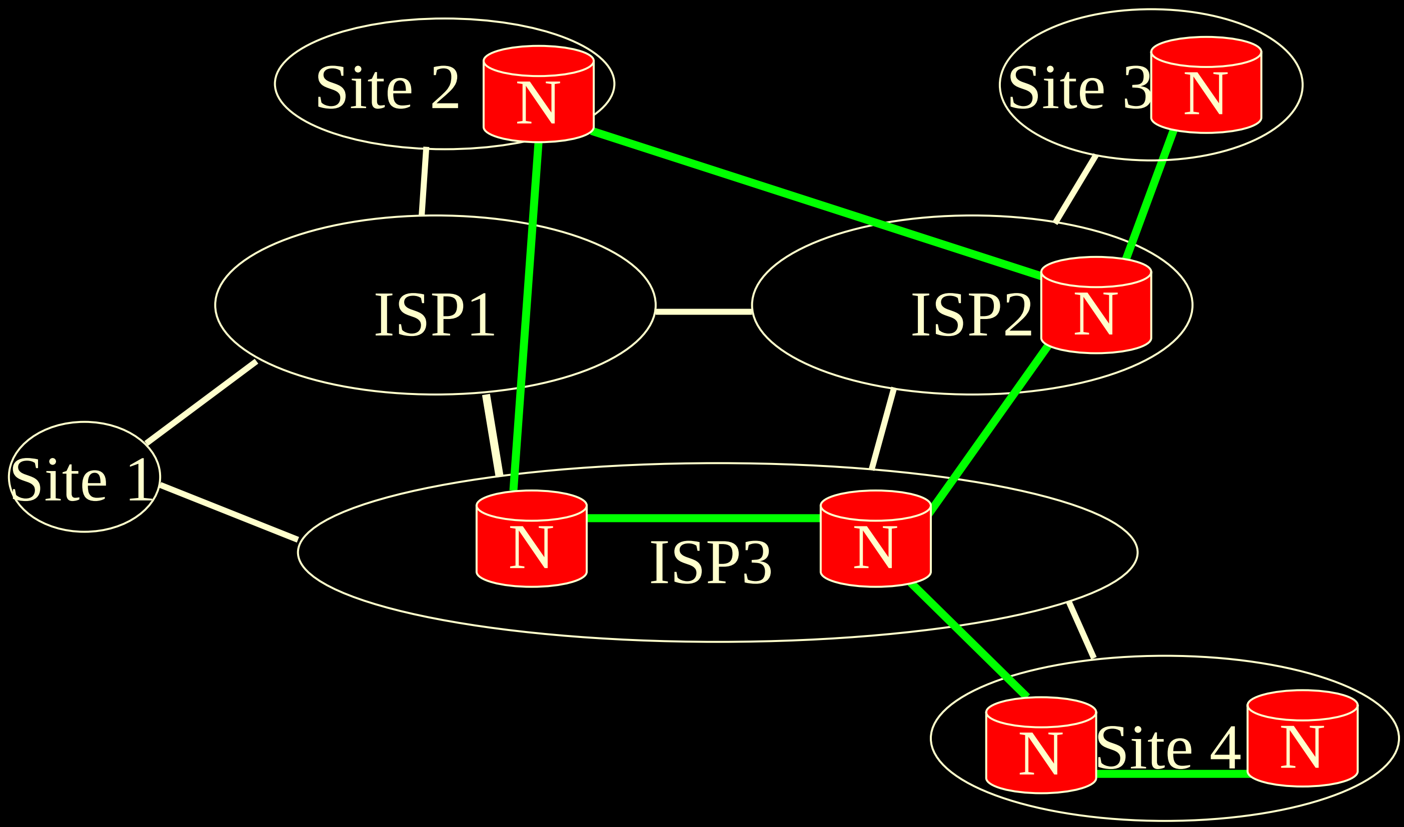
Agenda

- Background: peer-to-peer networks
- Proposed scheme
- Implementation
- Evaluation
- Conclusions

Overlay Networks



P2P networks are self-organizing overlay networks without central control

Advantages of structured p2p networks

- Scalable
- Self-organization
- Fault-tolerant
- Locality-aware
- Simple to deploy

- Many implementations available
  – E.g. Pastry, Tapestry, Chord, CAN…

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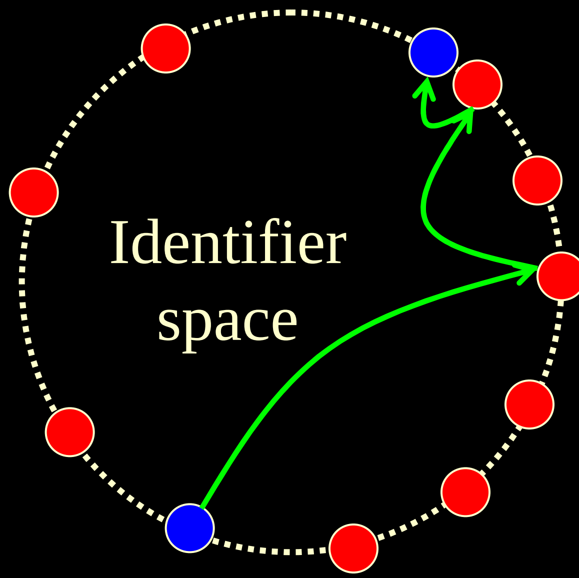
Pastry: locality-aware p2p substrate

- 128-bit circular identifier space
  - Unique random `nodeIds`
  - Message keys



- Routing: A message is routed reliably to a node with `nodeId` numerically closest to the key

- Routing in overlay < 2 * routing in IP

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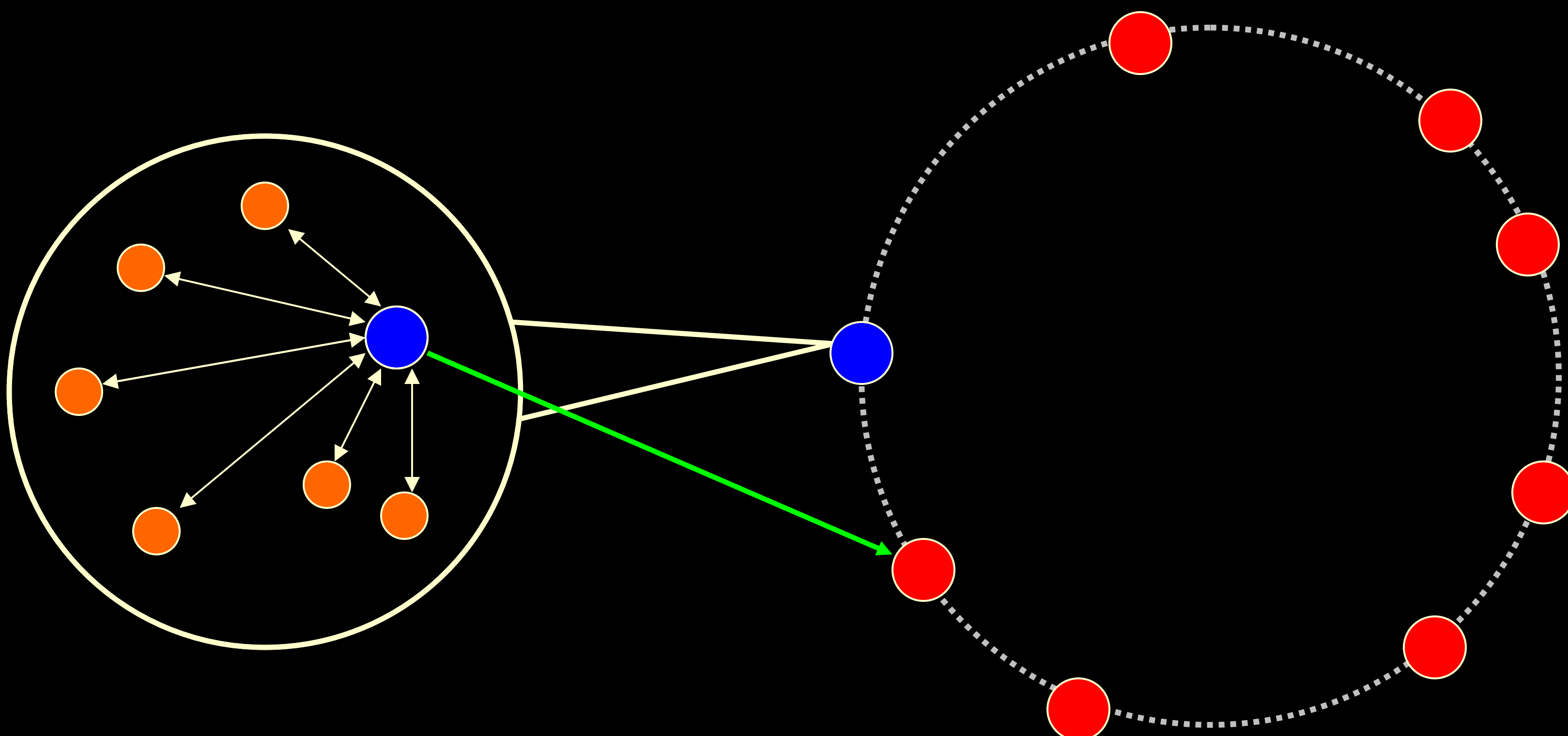
Step 1:
P2p organization of Condor pools

- Participating central managers join an overlay
  - Just need to know a single remote pool
- P2p provides self-organization
  - Pools can reach each other through the overlay
  - Pools can join/leave at anytime

P2p organized central managers



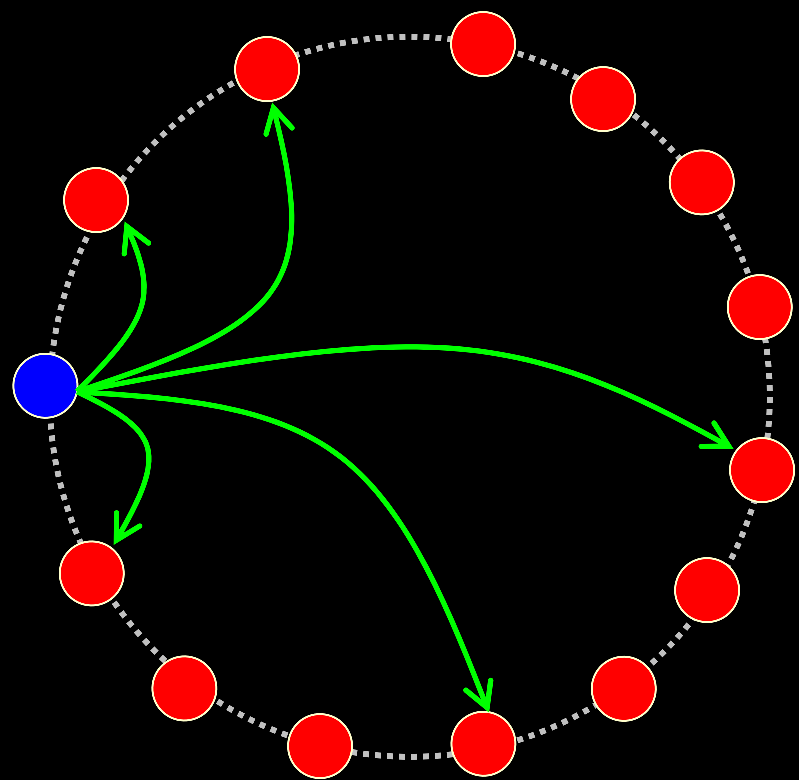
Central managers

Resources

Step 2: Disseminating resource information

- Announcements to nearby pools
  - Contain pool status information
  - Leverage locality-aware routing table
    - Routing table has *O(log N)* entries matching increasingly long prefix of local `nodeId`
  - Soft state
    - Periodically refreshed

Resource announcements



are physically close to

Step 3: Enable dynamic flocking

- Central managers flock with nearby pools
  - Use knowledge gained from resource announcements
  - Implement local policies
  - Support dynamic reconfiguration

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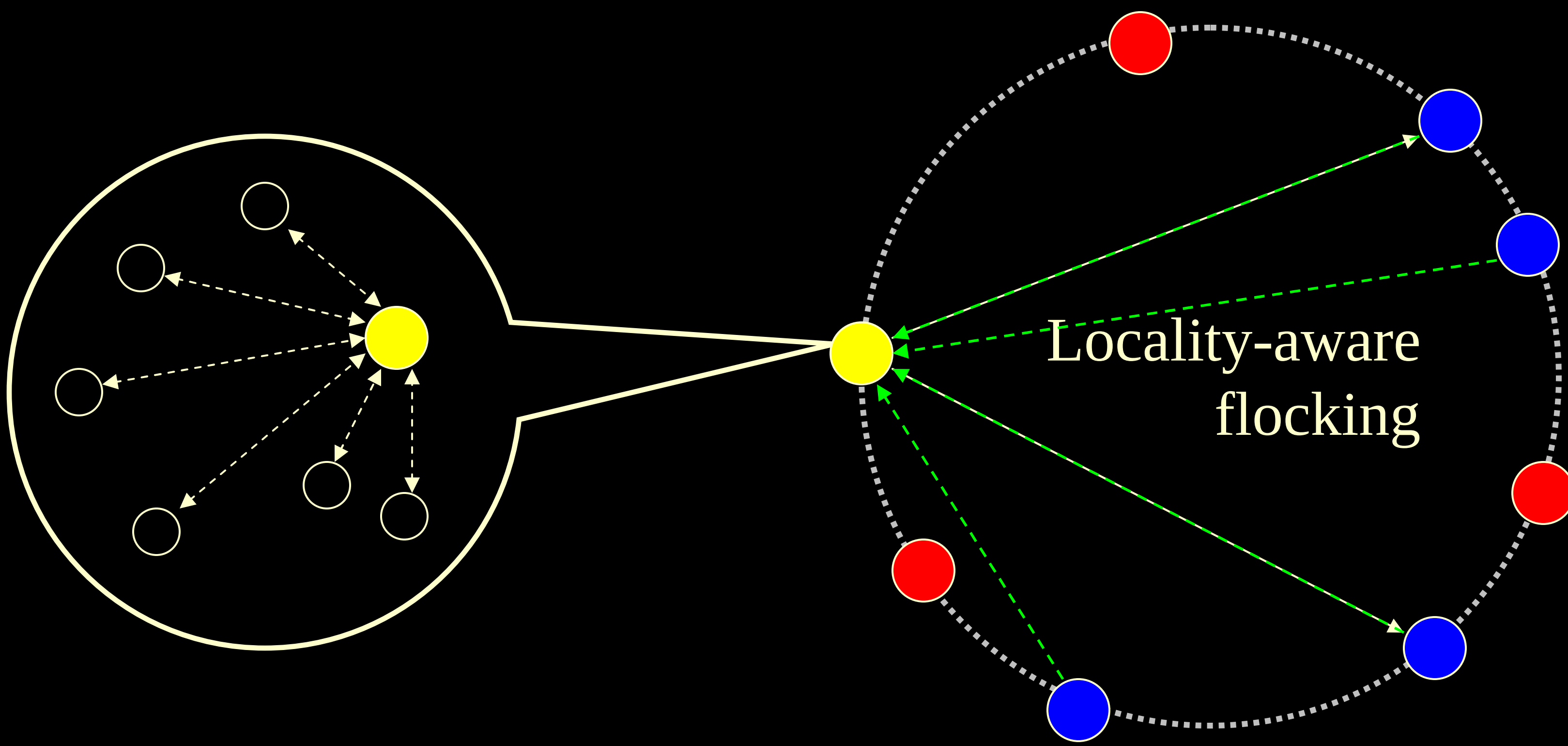
Interactions between central managers



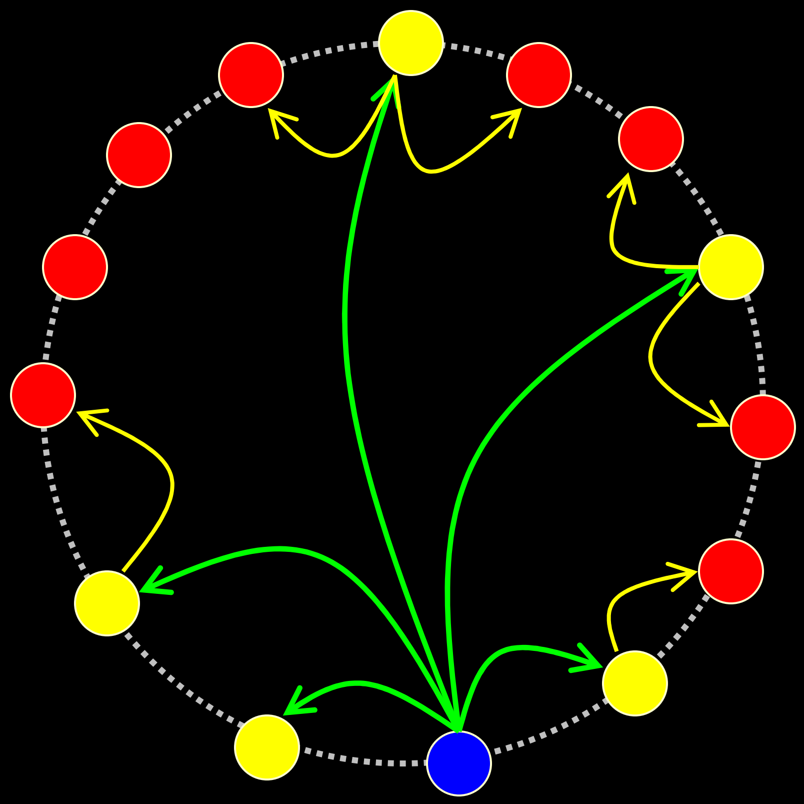
Central managers   Resources

Matchmaking

- Orthogonal to flocking
- Condor matchmaking within a pool

- P2p approach affects the flocking decisions only

Are we discovering enough pools?



- Only subset of nearby pools reached using the Pastry routing table
- Multi-hop TTL based announcement forwarding

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Software

- Implemented as a daemon: *poolD*
  - Leverages FreePastry 1.3 from Rice
  - Runs on central managers
  - Manages self-organized Condor pools
- Condor version 6.4.7
- Interfaced to Condor configuration control

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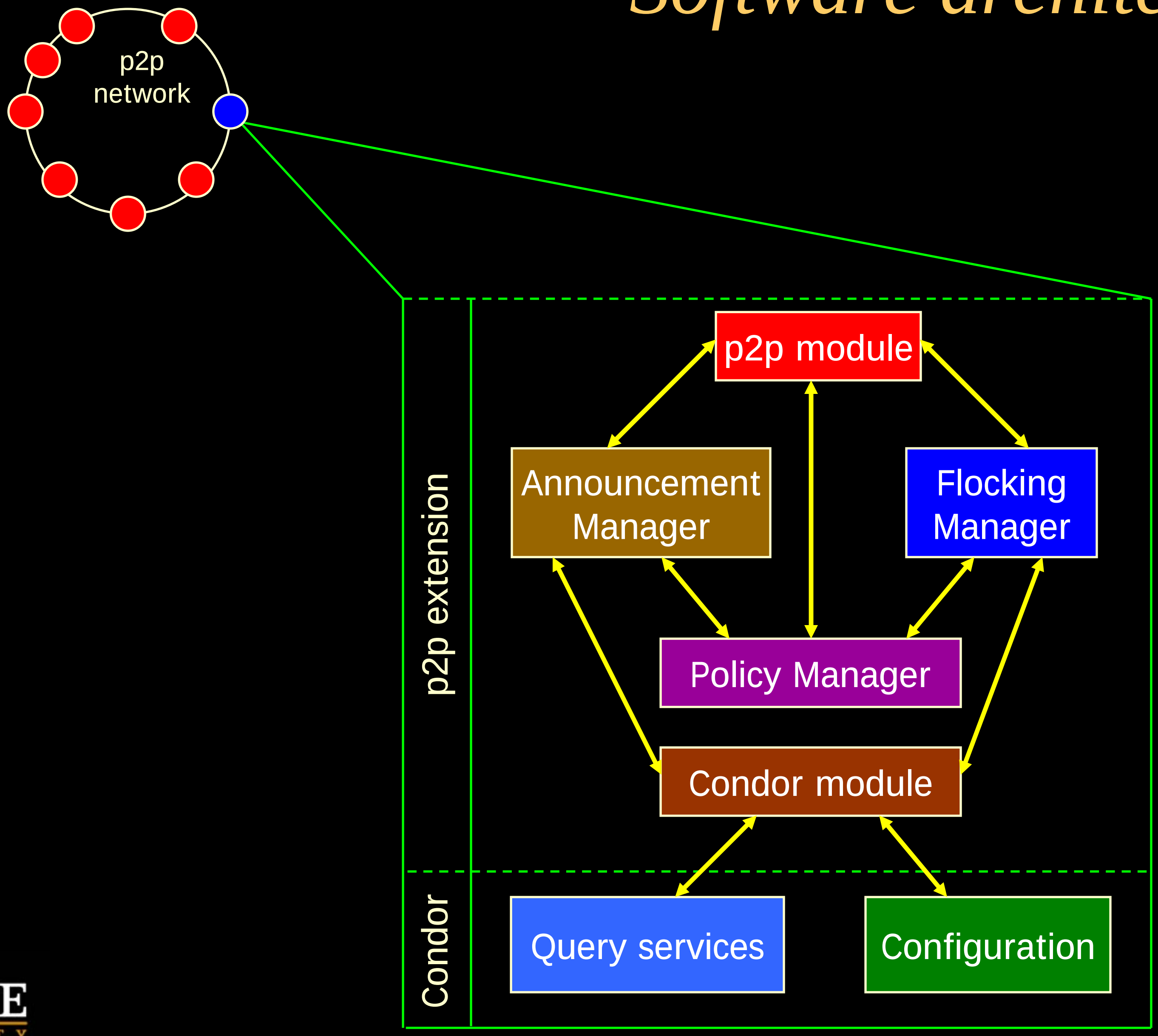
Software architecture



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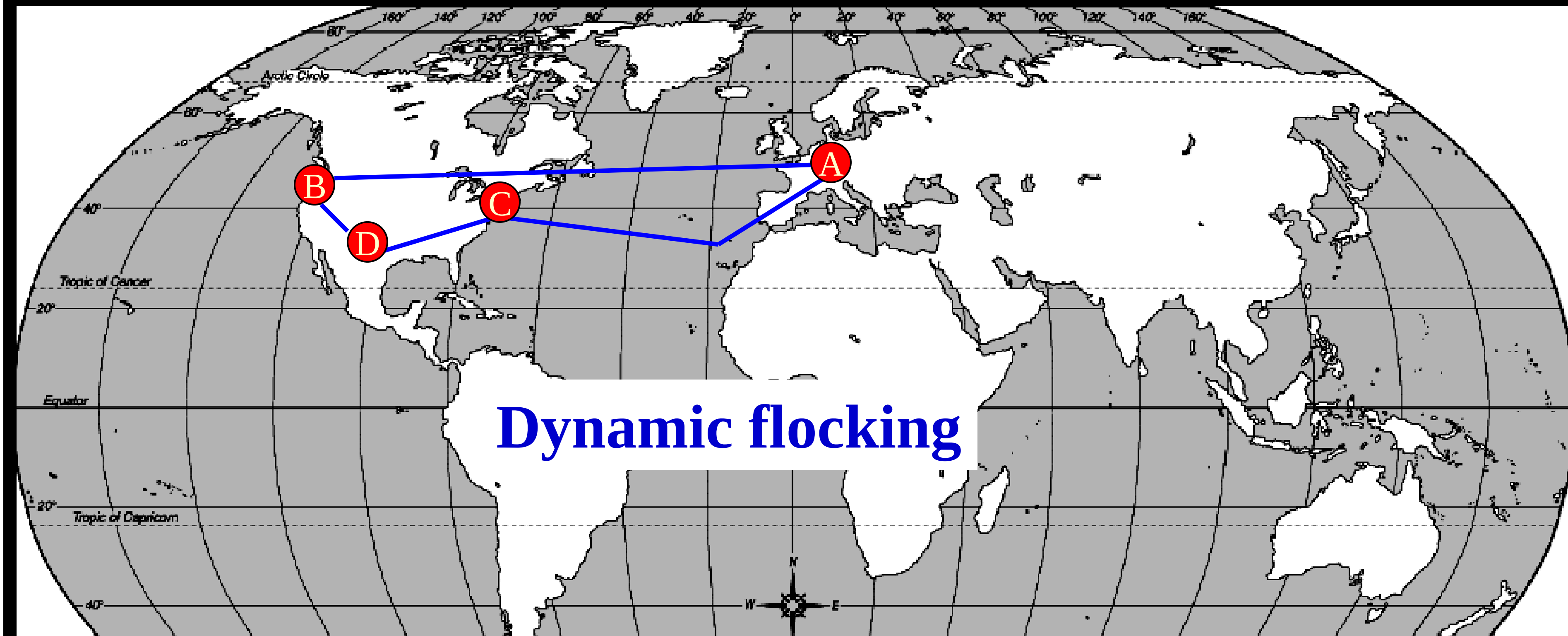
Evaluation

- Measured results
  - Effect of flocking on job throughput
    - Time spent in queue
  - Four pools, three compute machines each
  - Synthetic job trace

Job trace

- Sequence
  - 100 (issue time: T, job length: L) pairs
  - Interval ($T_n – T_{n-1}$), L uniform distribution [1,17]
  - Designed to keep a single machine busy
  - Random overload/idle periods
- Trace
  - One or more job sequences merged together

PlanetLab experimental setup



- (A) Interxion, Germany
- (B) U.C. Berkeley
- (C) Columbia
- (D) Rice

Time spent in queue

Pool	No.of sequences in traceh	Without flocking			
		mean	min	max	
A	2	1.76	0.03	14.32	
B	2	3.30	0.08	19.85	
C	3	46.58	0.03	97.17	
D	5	284.91	0.25	557.55	
overall	**12**	**131.20**	**0.03**	**557.55**	

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Simulations

- 1000 Condor pools
- GT-ITM transit-stub model
  - 50 transit domains
  - 1000 stub domains
- Size of pool: uniform distribution [25,225]
- Number of sequences in trace:
  uniform distribution [25,225]

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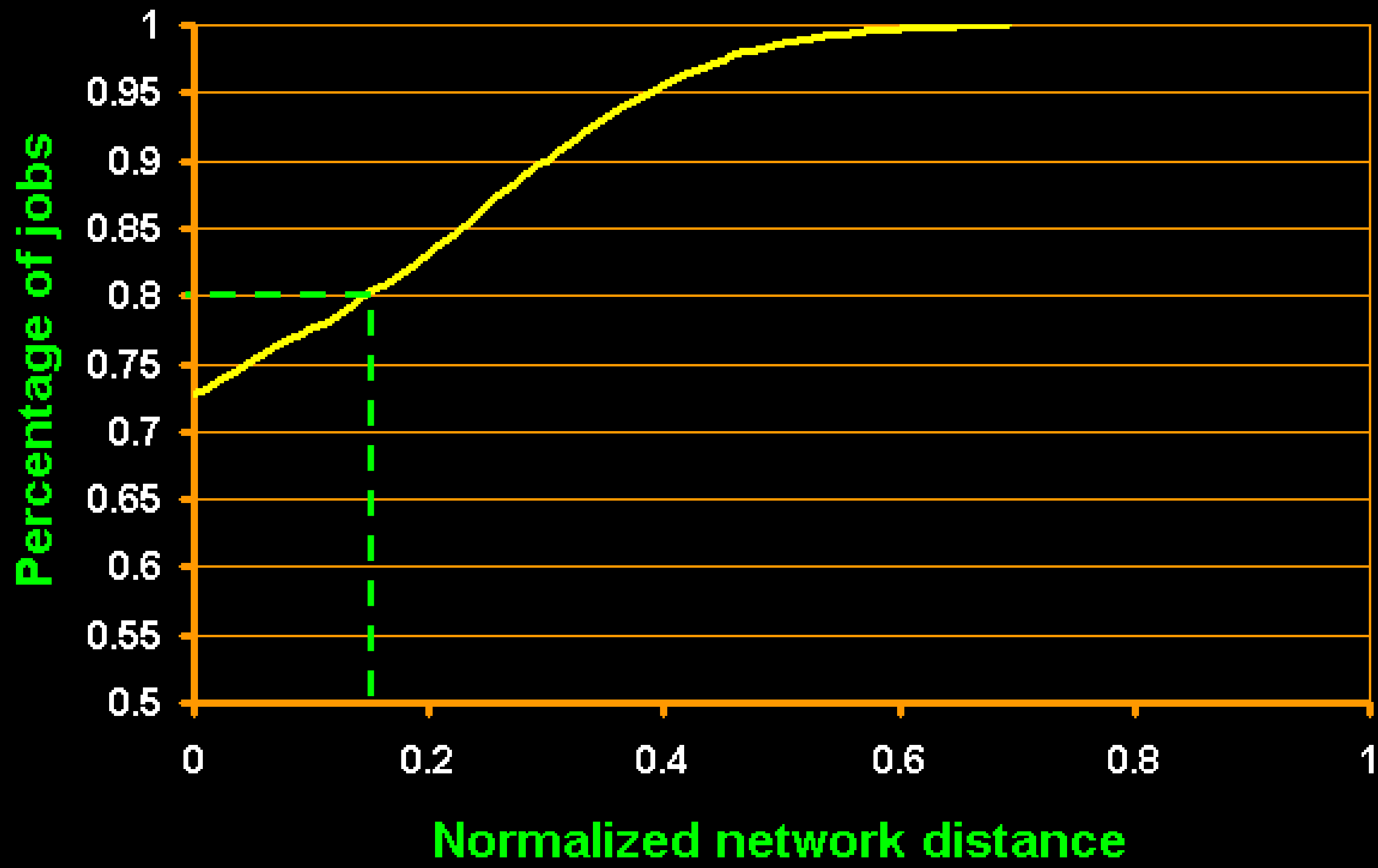
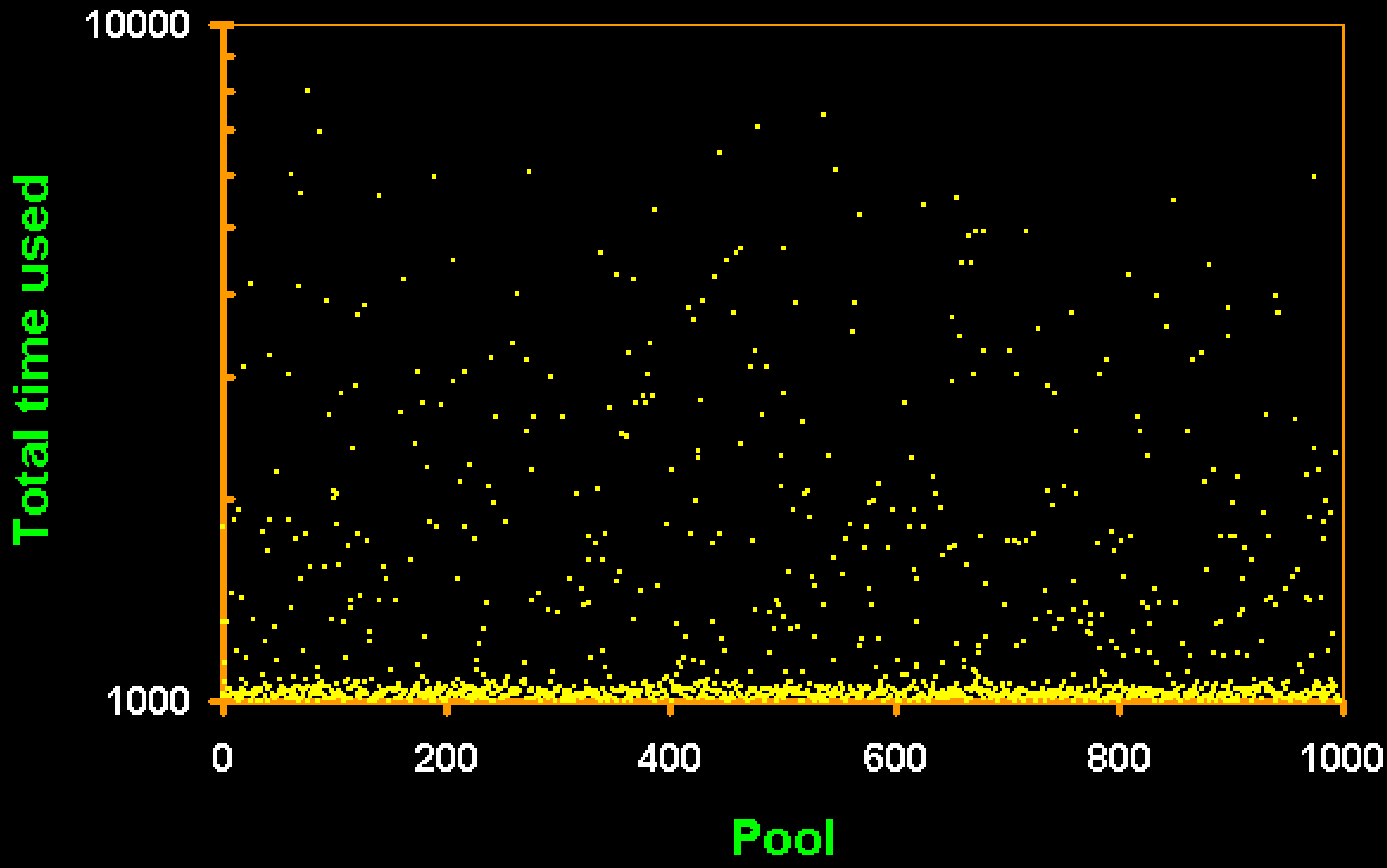
Cumulative distribution of locality



Total job completion time: without flocking



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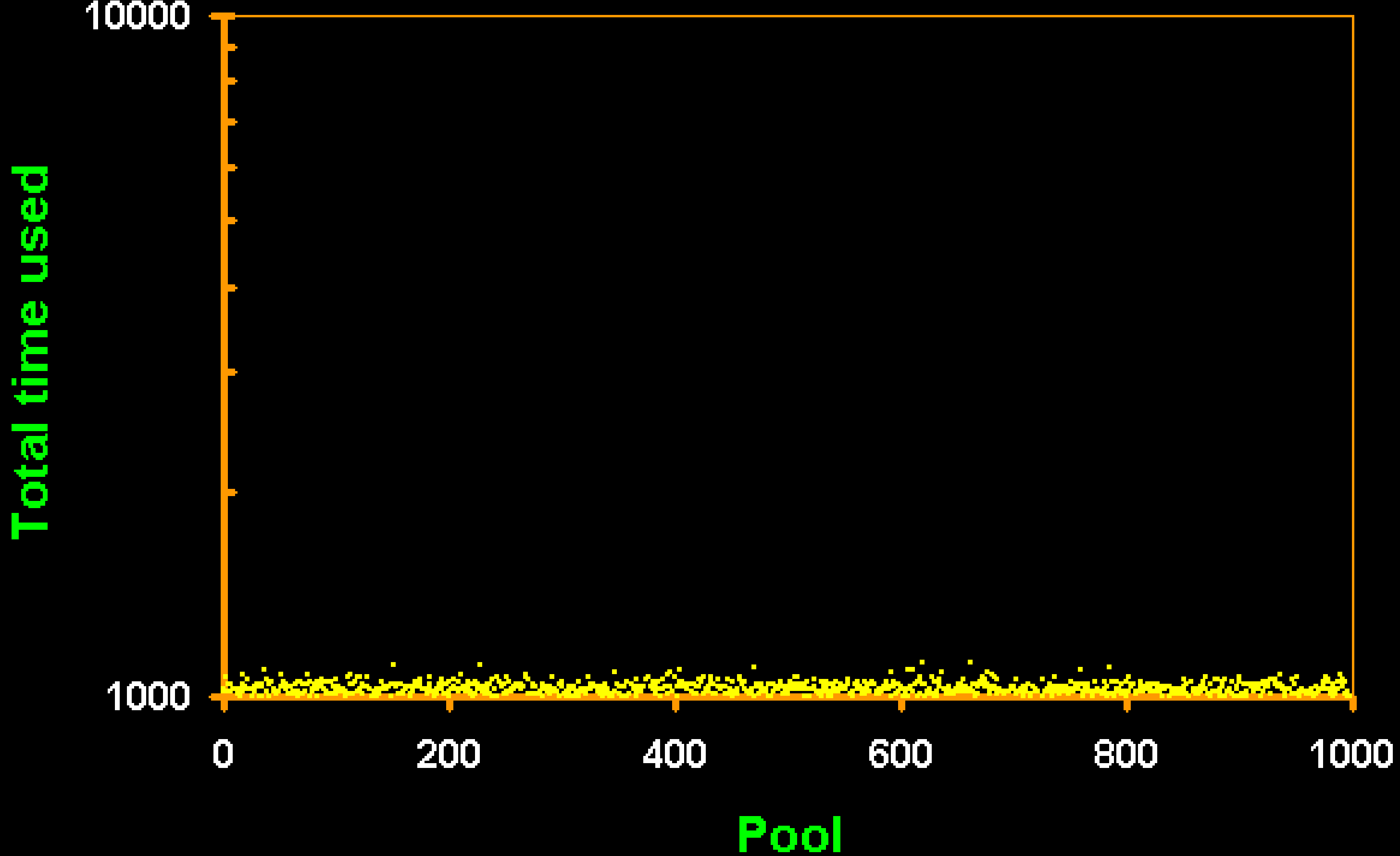
Total job completion time: with flocking



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Conclusions

- Design and implementation of a self-organizing flock of Condors
  - Scalability
  - Fault-tolerance
  - Locality-awareness which yields flocking with nearby resources
  - Local sharing policy enforced

- P2p mechanisms provide an effective substrate for discovery and management of dynamic resources over the wide-area network

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Questions?

What about security?

- Authenticated pools / users
  - Enforced by policy manager
  - Accountability
- Restricted access
  - Limited privileges e.g. UNIX user `nobody`
  - Condor libraries
- Controlled execution environment
  - Sandboxing
  - Process cleanups on job completion
- Intrusion detection