A Content Propagation Metric for Efficient Content Distribution

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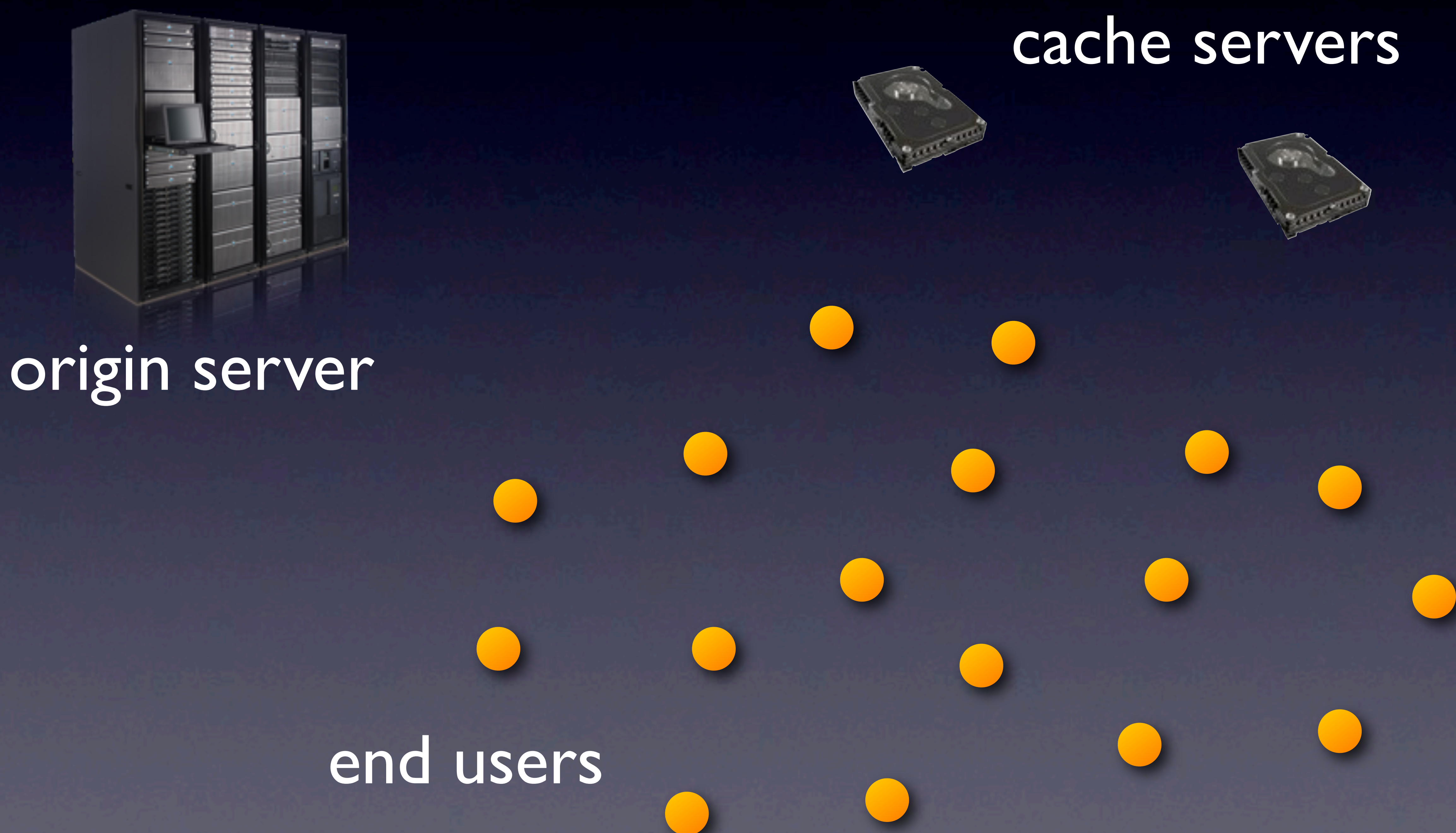
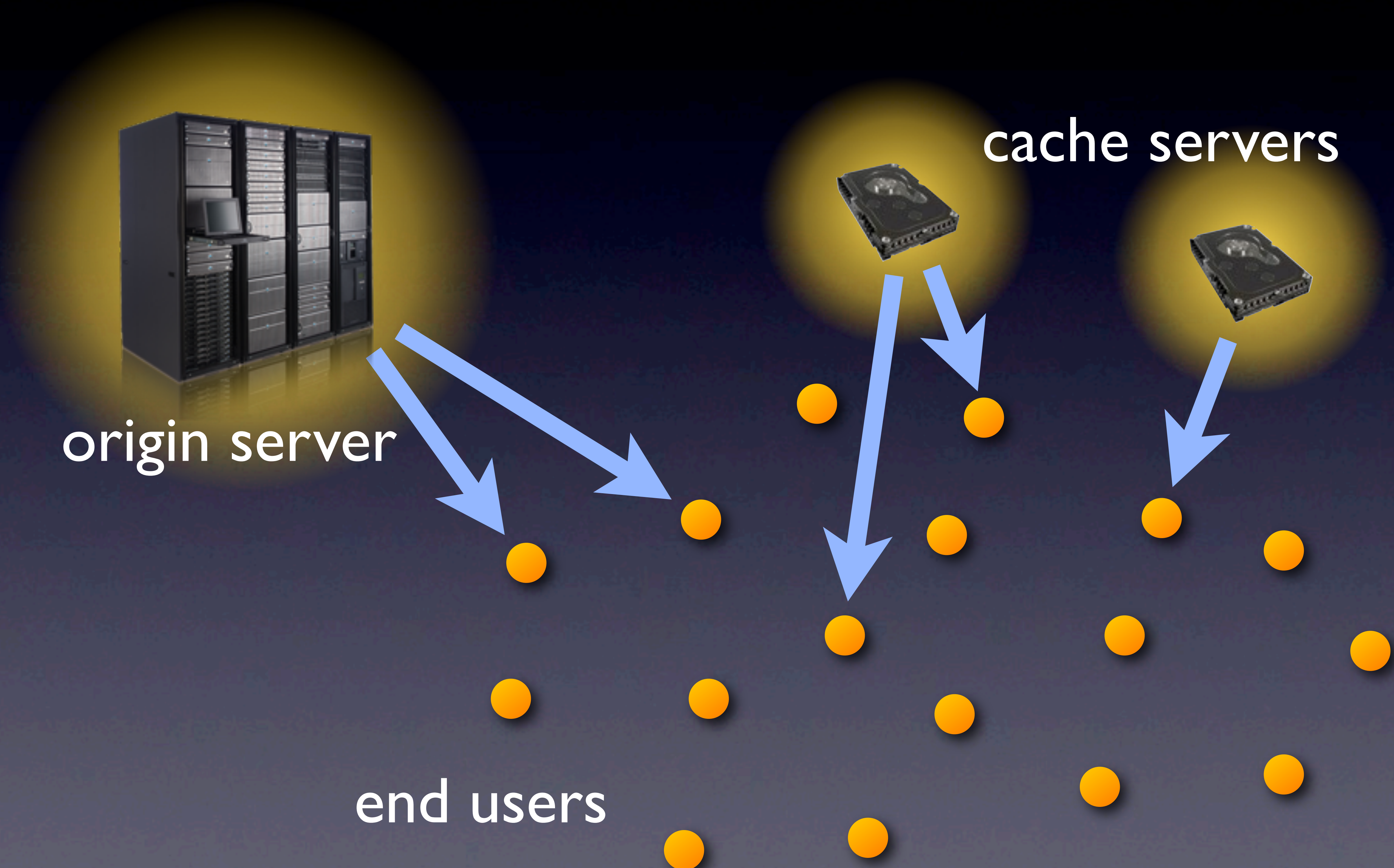
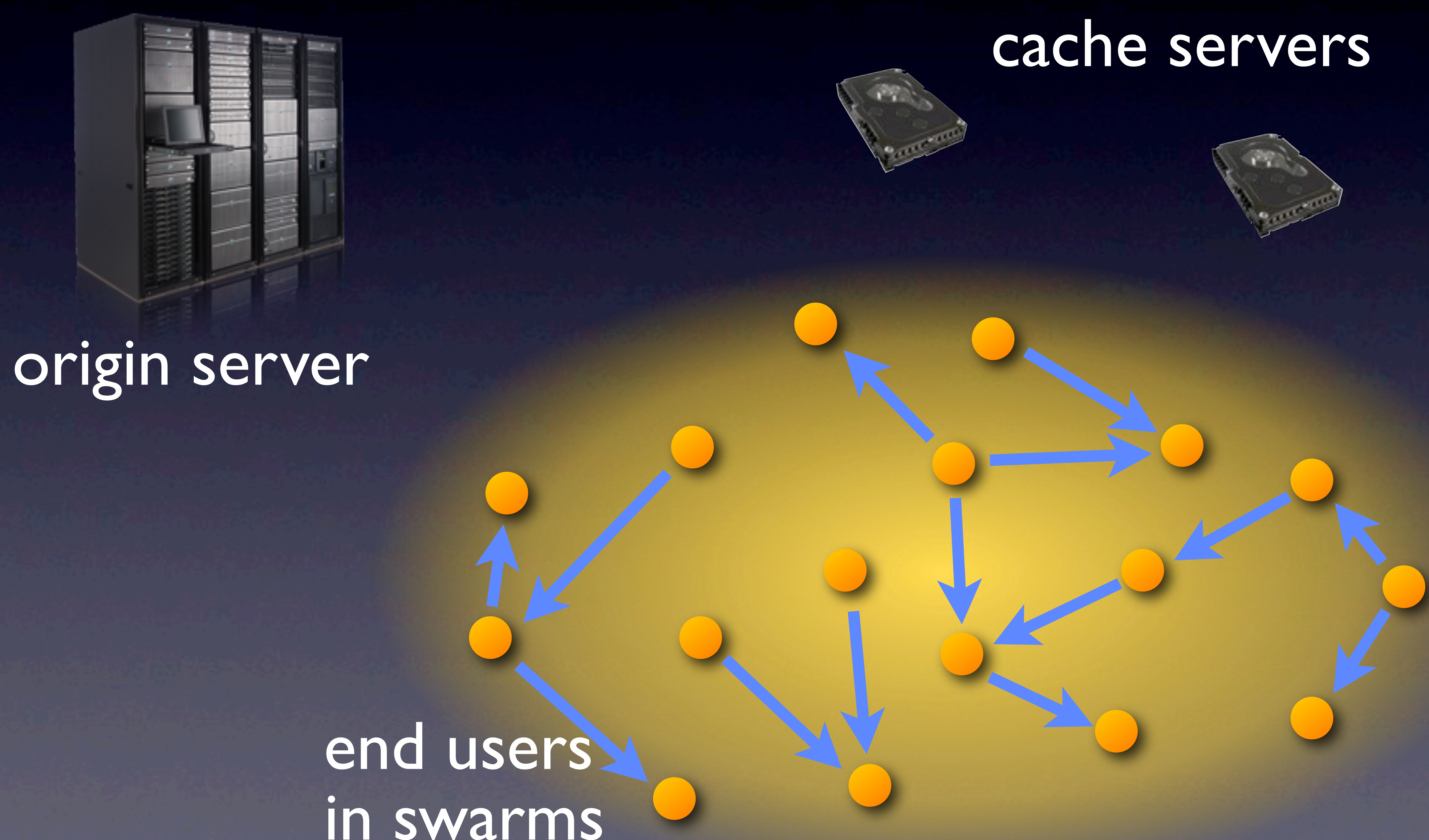
Content Distribution



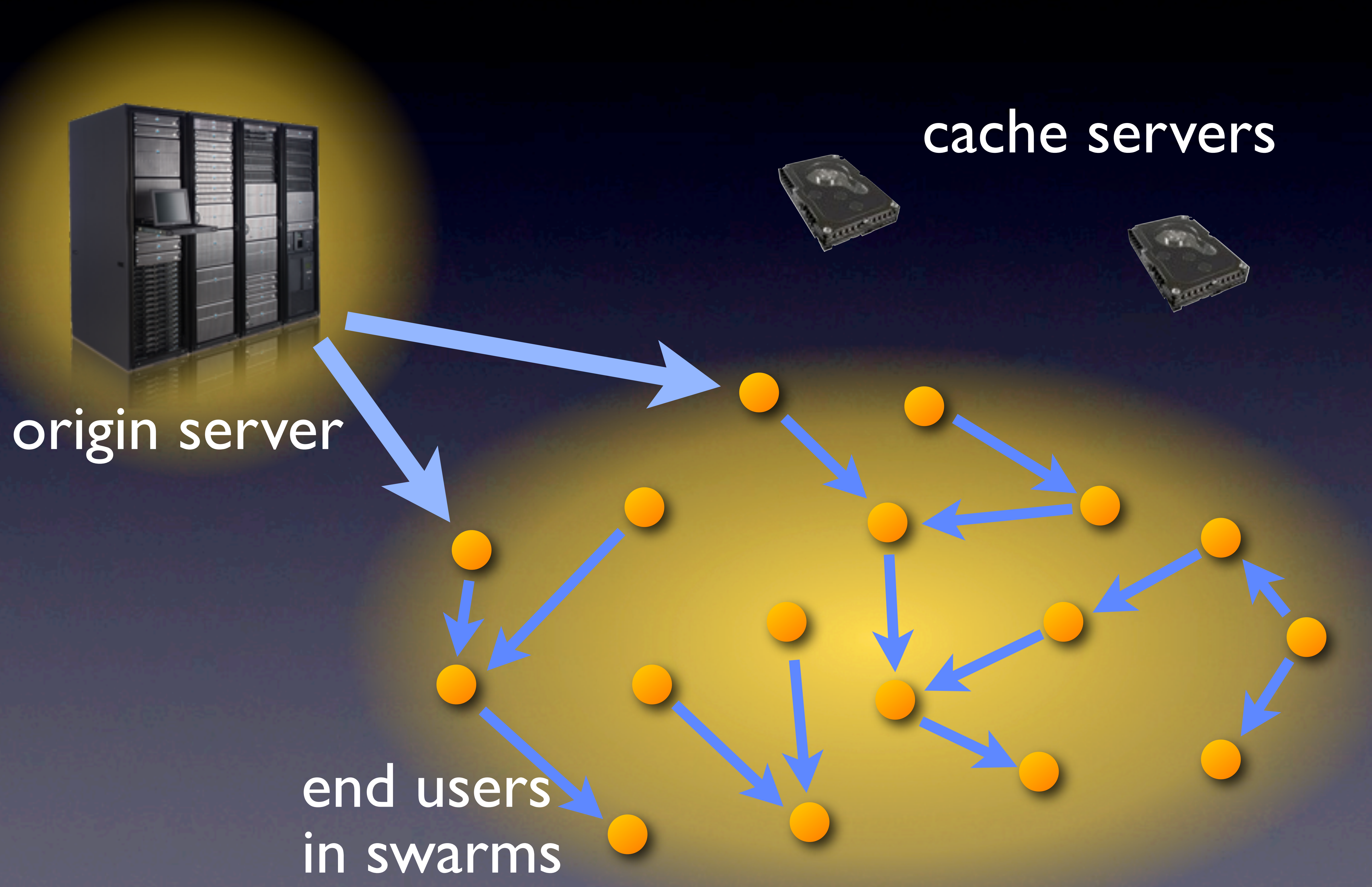
BW in Client-Server



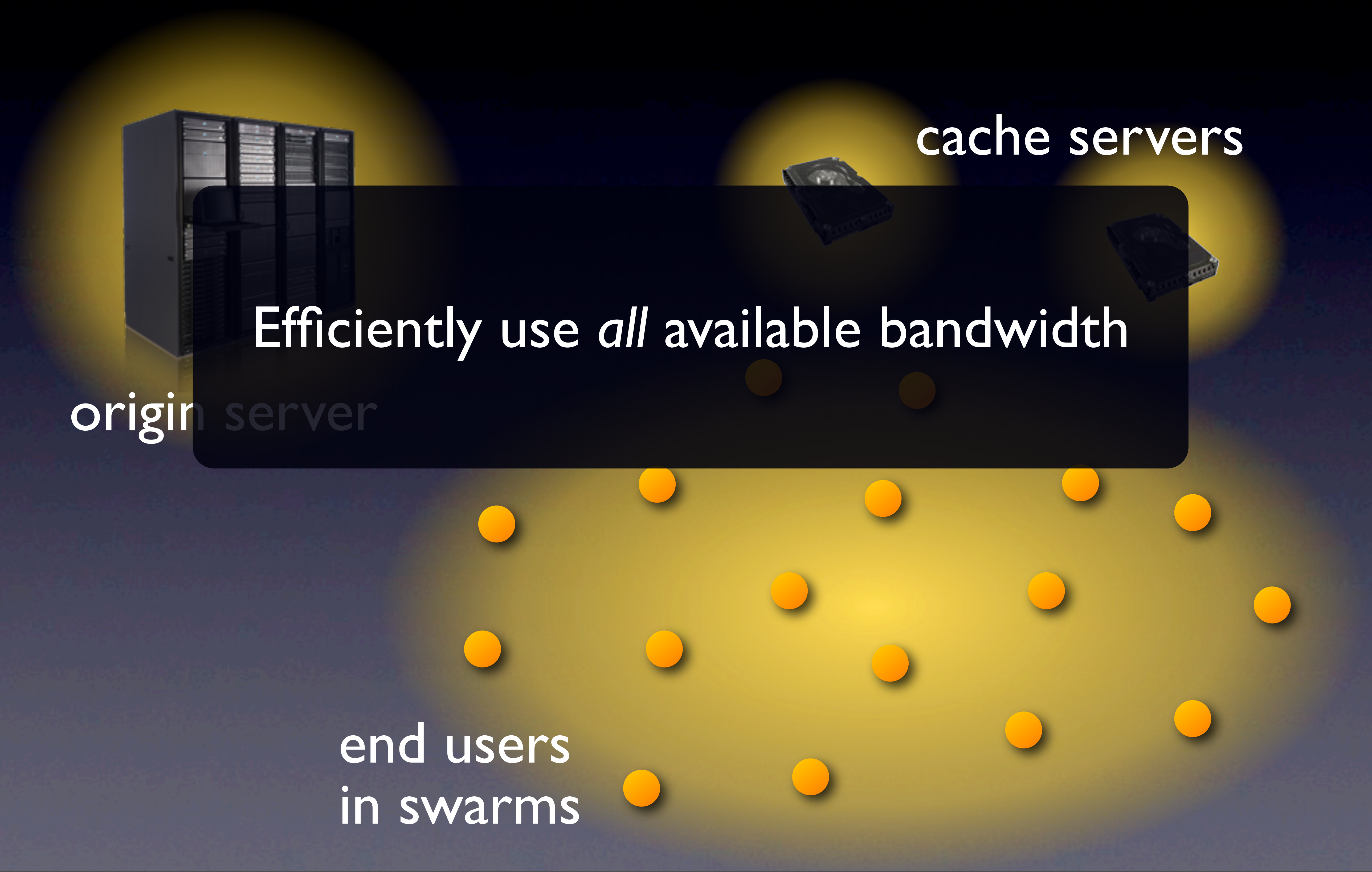
BW in Peer-to-Peer



BW in Antfarm



Goal



Efficiently use *all* available bandwidth

Problem Definition

- The general multi-swarm content distribution problem
  - given: hosts, swarms, and swarm memberships
  - find: allocation of each host's upload bandwidth among its swarms that maximizes system-wide bandwidth

Approach

New metric that steers hosts toward
a globally efficient allocation of resources

Enables each host to measure its impact on each swarm
and adjust its bandwidth allocations accordingly

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New metric that steers hosts toward
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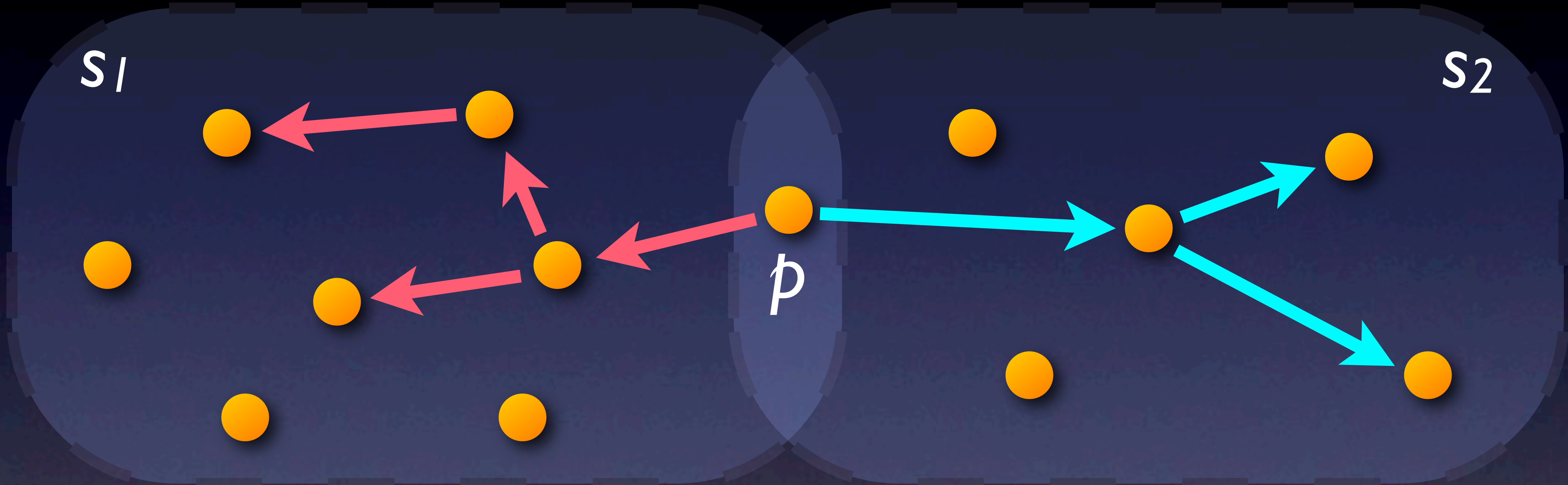
Content Propagation Metric

Outline

- The CPM
- V-Formation
- Evaluation

Benefit of a Block



p's choice: upload the next block to s_1 or s_2?

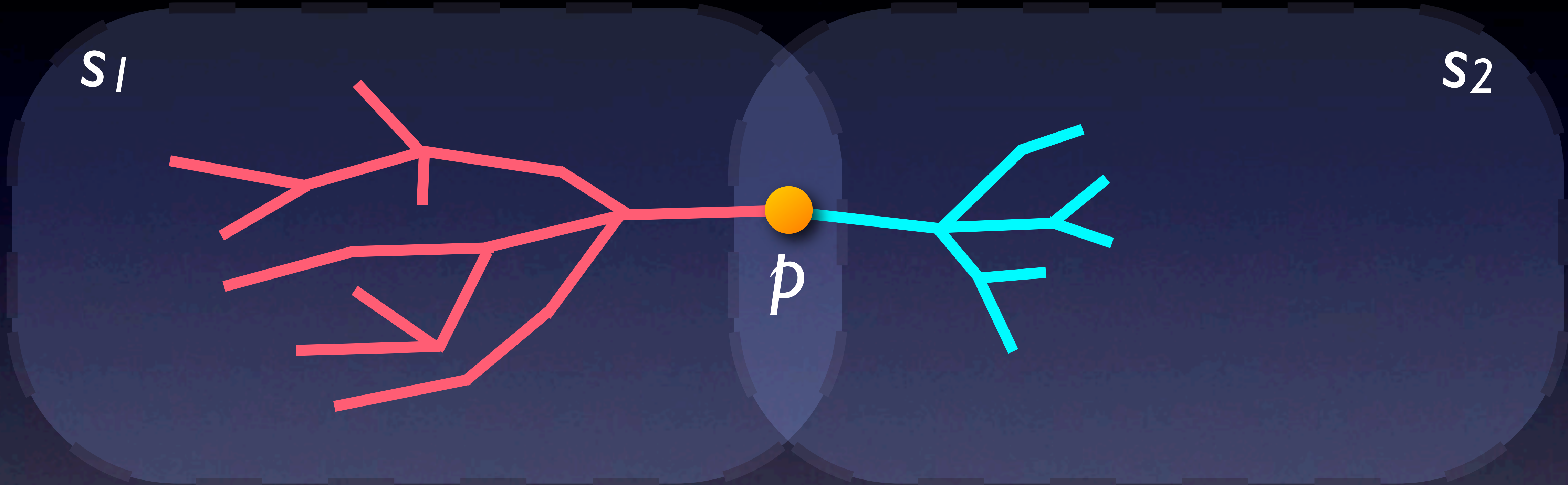
Which swarm will benefit more?

Determining Benefit

- What block *p* uploads
- Distribution of blocks in the swarms
- Sizes of the swarms
- Network conditions among peers
- The direct recipient of *p*'s block

Use history to predict the future

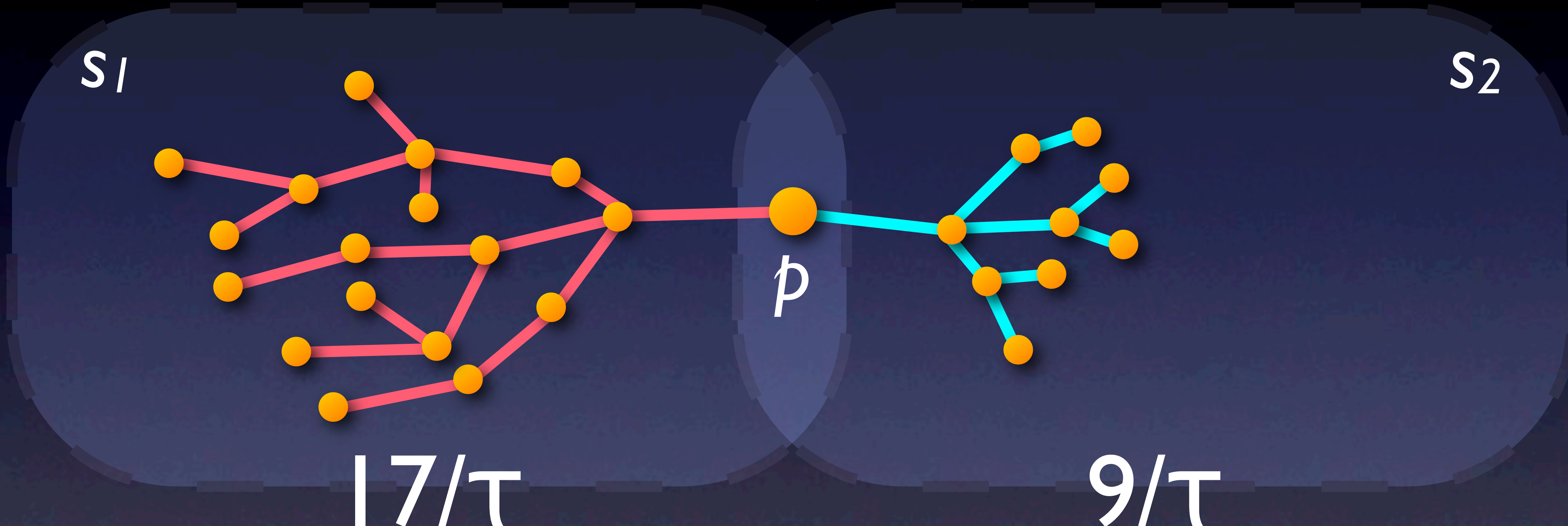
Intuition



Measure how "fast" p's blocks propagate in each swarm

Use the result as an estimate of the benefit that the swarms derive from p's blocks

Content Propagation Metric



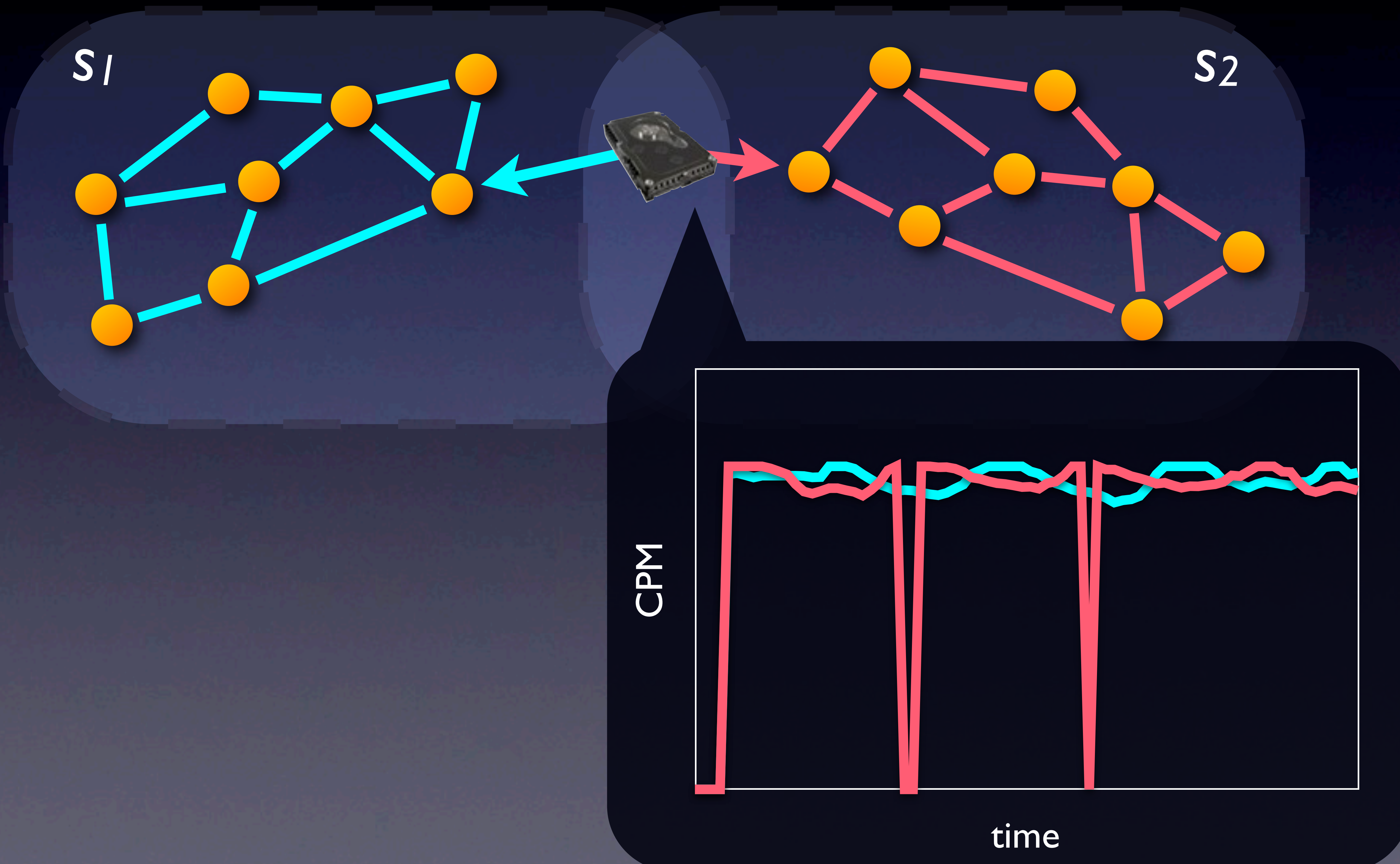
Block propagation bandwidth: rate that an uploaded block propagates in a fixed time interval τ

CPM: rolling average of a peer's recent block propagation bandwidths for a swarm

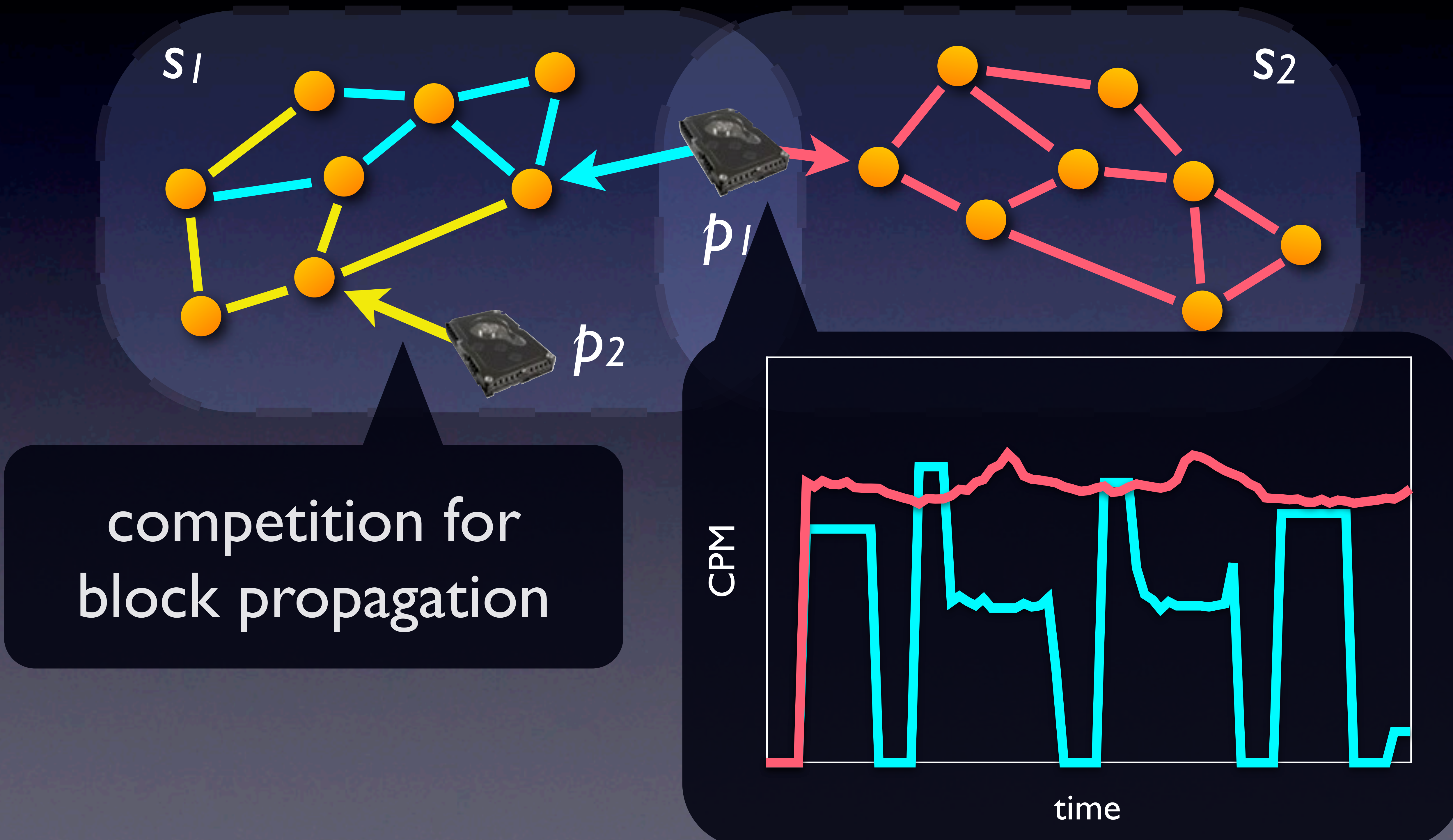
Using the CPM

- Each host measures random uploaded blocks to maintain a CPM value for each swarm
- Hosts upload to swarms with the largest CPM values when faced with competing requests
- Hosts proactively probe new swarms and swarms with stale CPM values

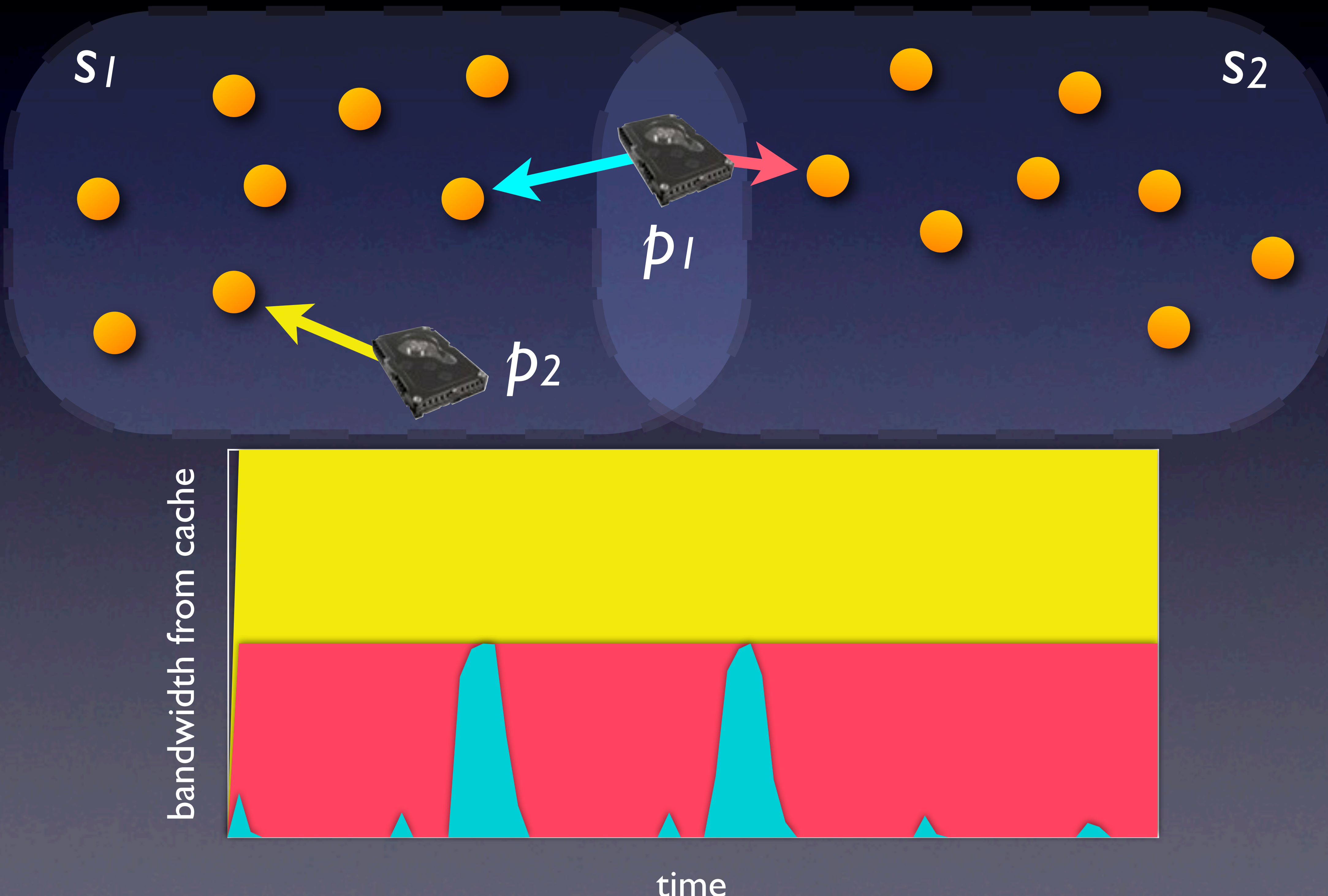
CPM Case Study



CPM Case Study



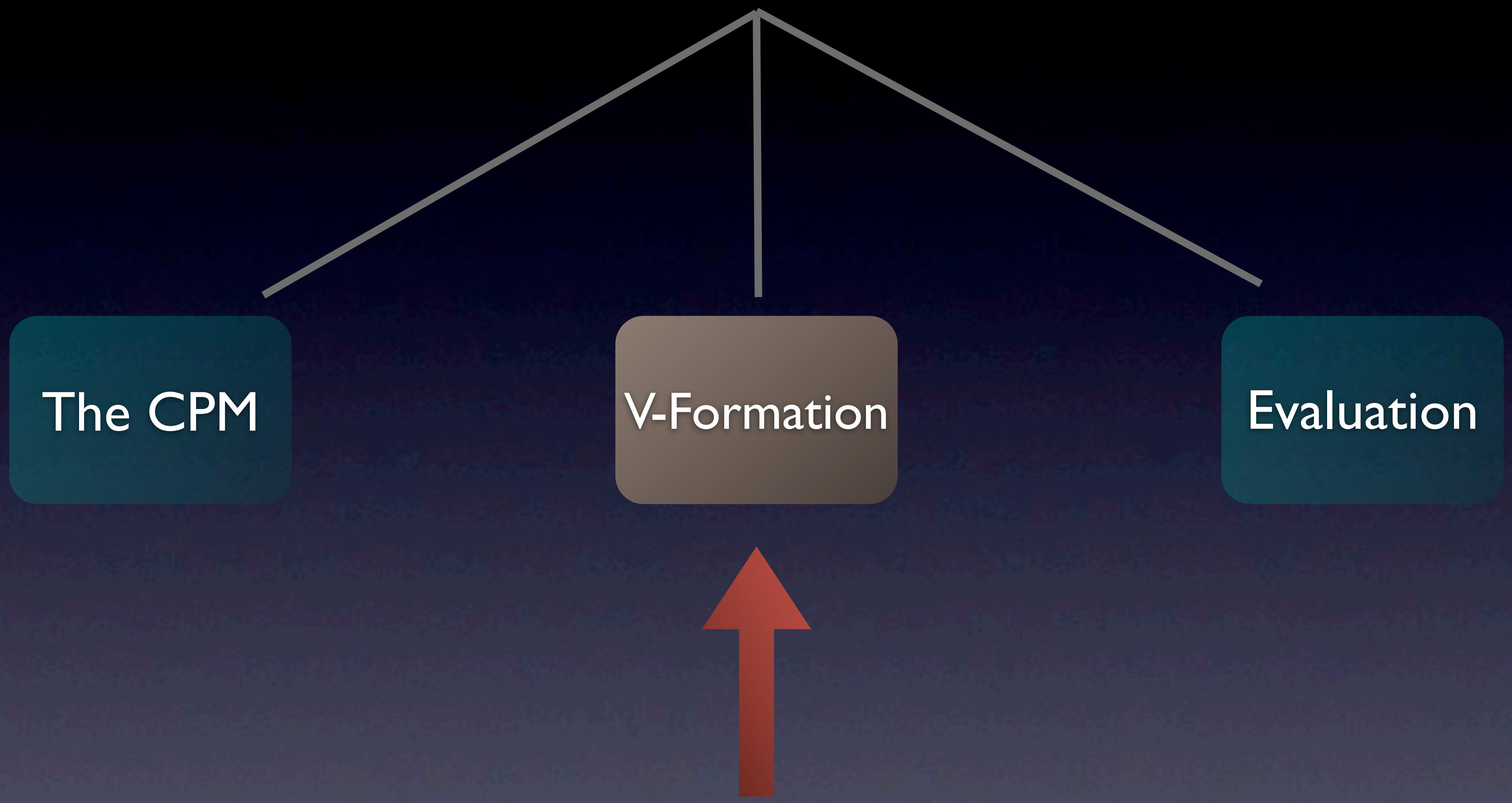
CPM Case Study



CPM Overview

- Identifies neediest swarms
- Easy to measure
- Can allocate bandwidth from a single server
- Accounts for interference from competing hosts

Outline



V-Formation

- Based on our hybrid architecture
- A logically centralized coordinator provides efficient bookkeeping
- A token protocol enables the coordinator to track blocks and monitor peers

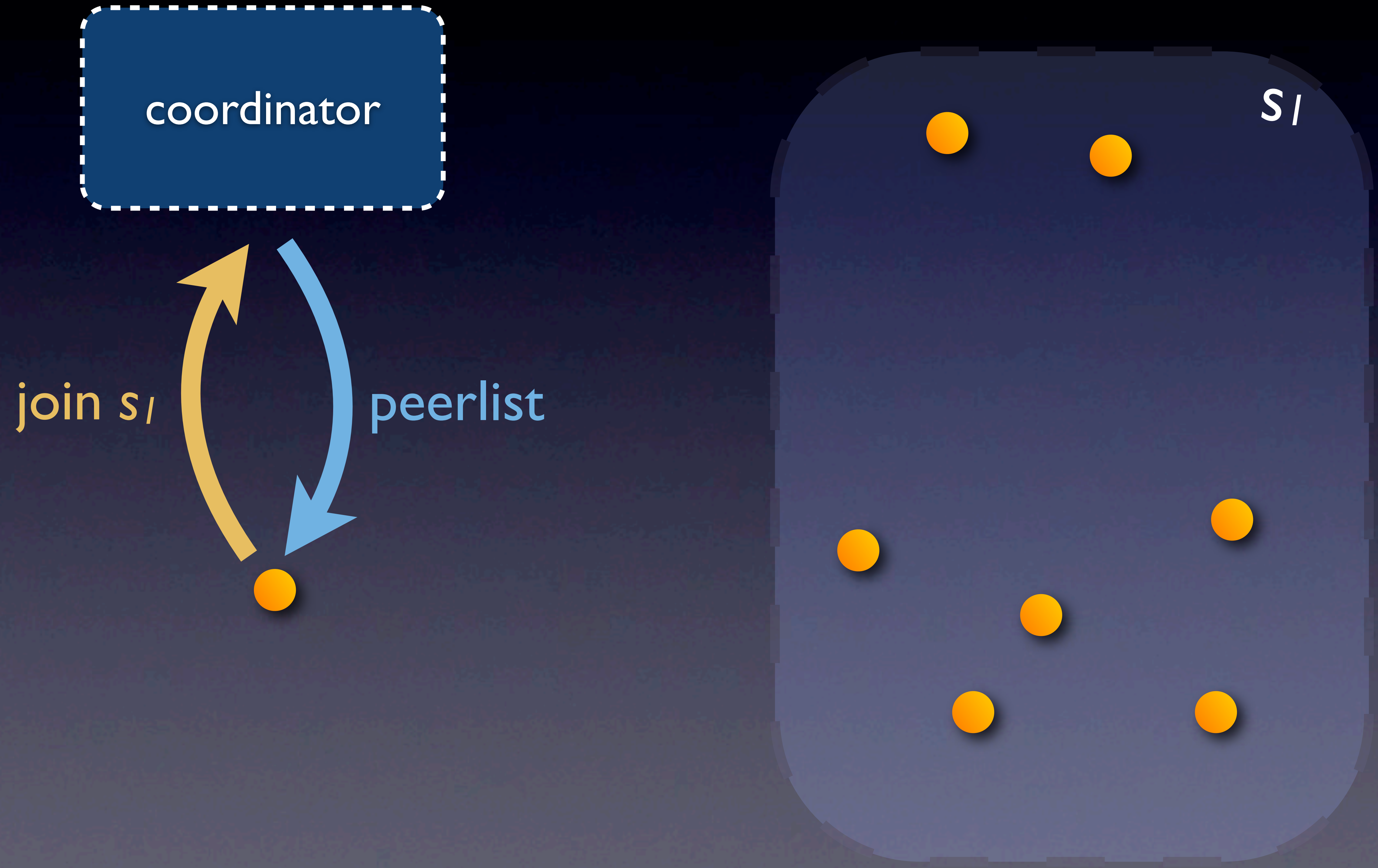
Coordinator

- Measures swarm dynamics
  - tracks block transfers based on spent tokens
- Computes peers' CPM values
  - periodically sends updates to peers
- Provides accountability
  - detects and blocks misbehaving peers

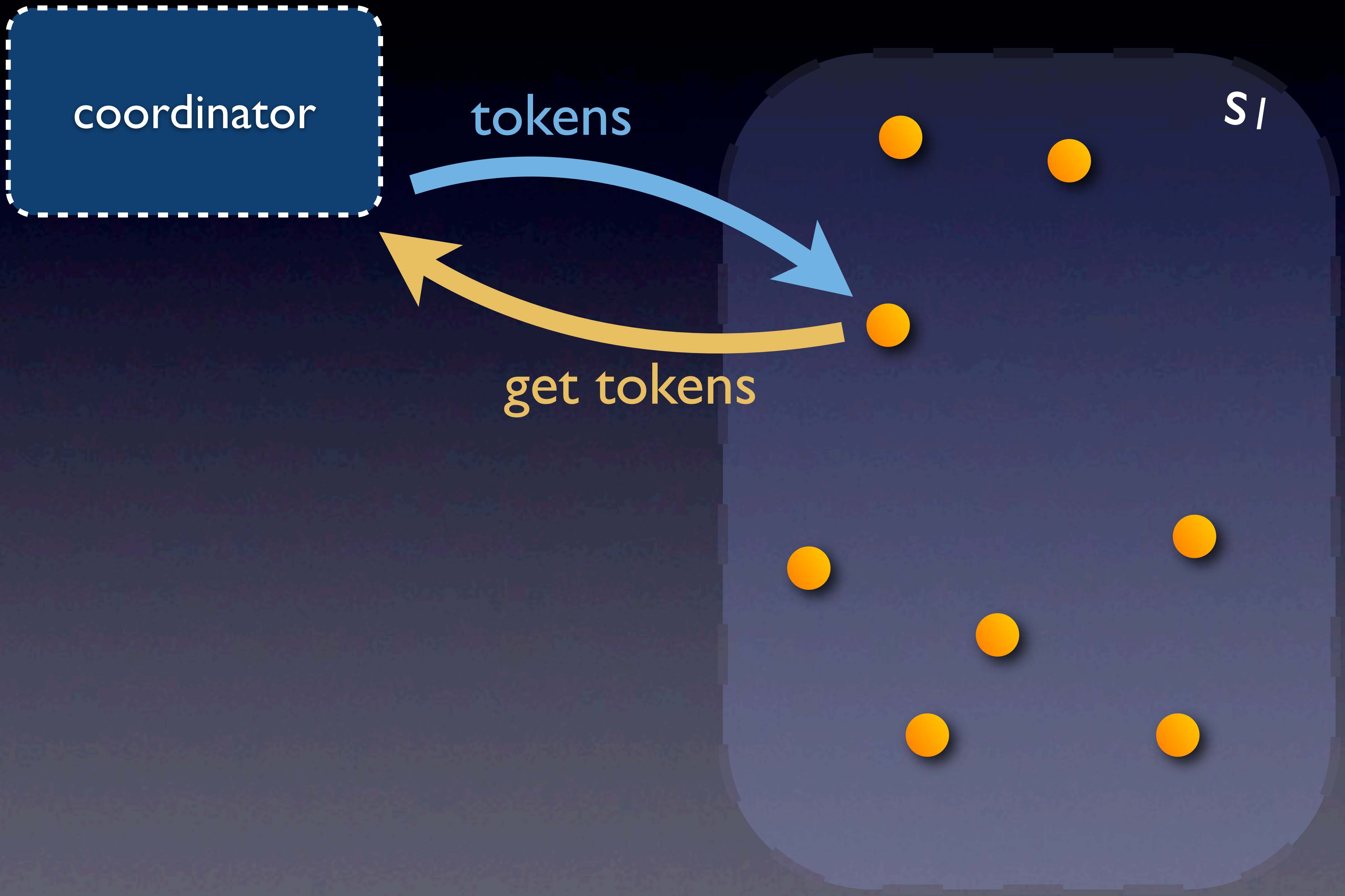
Wire Protocol Goals

- Track block transfers among peers
- Disseminate CPM values and peer lists
- Enforce peer behavior

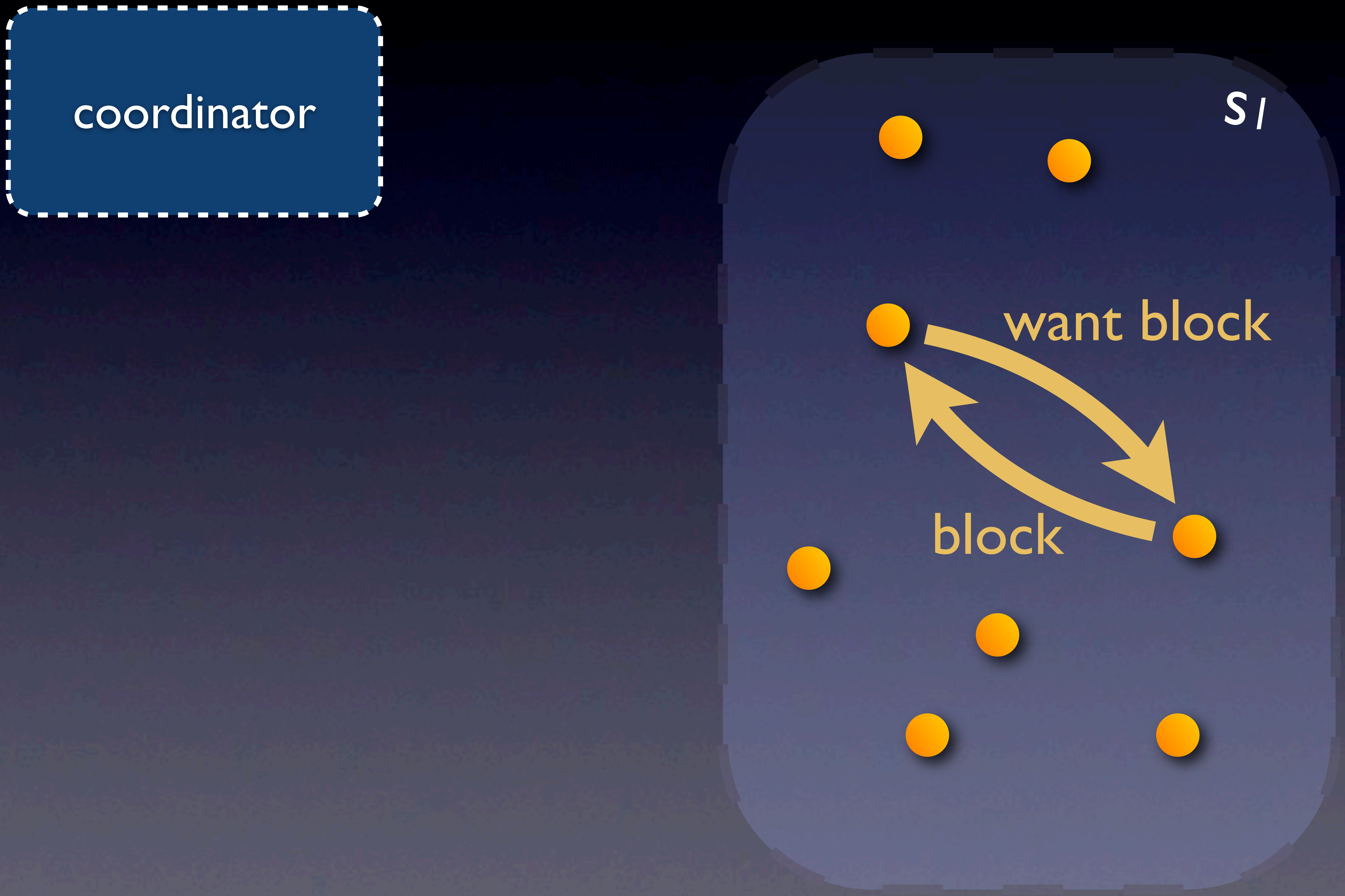
Wire Protocol



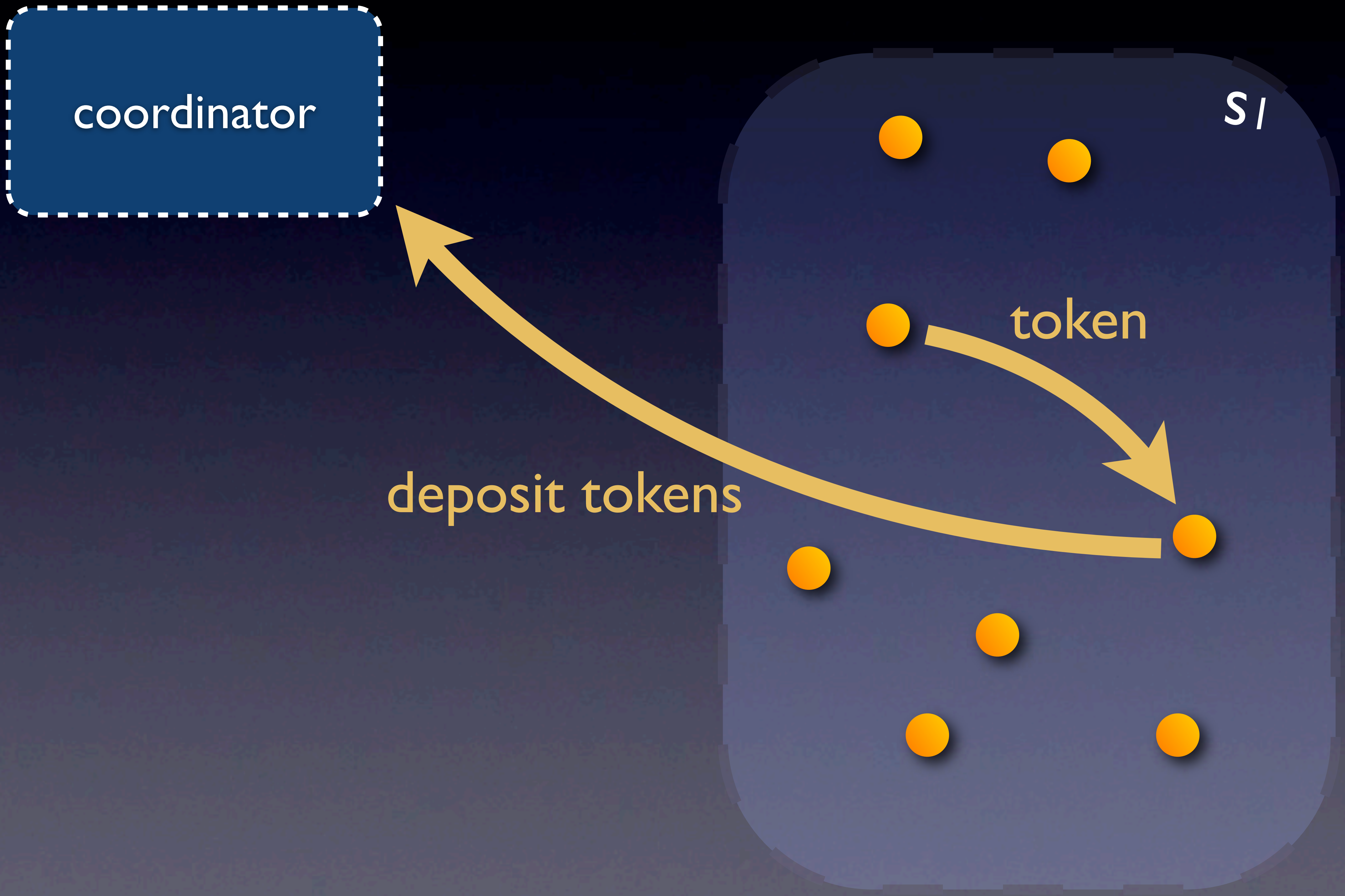
Wire Protocol



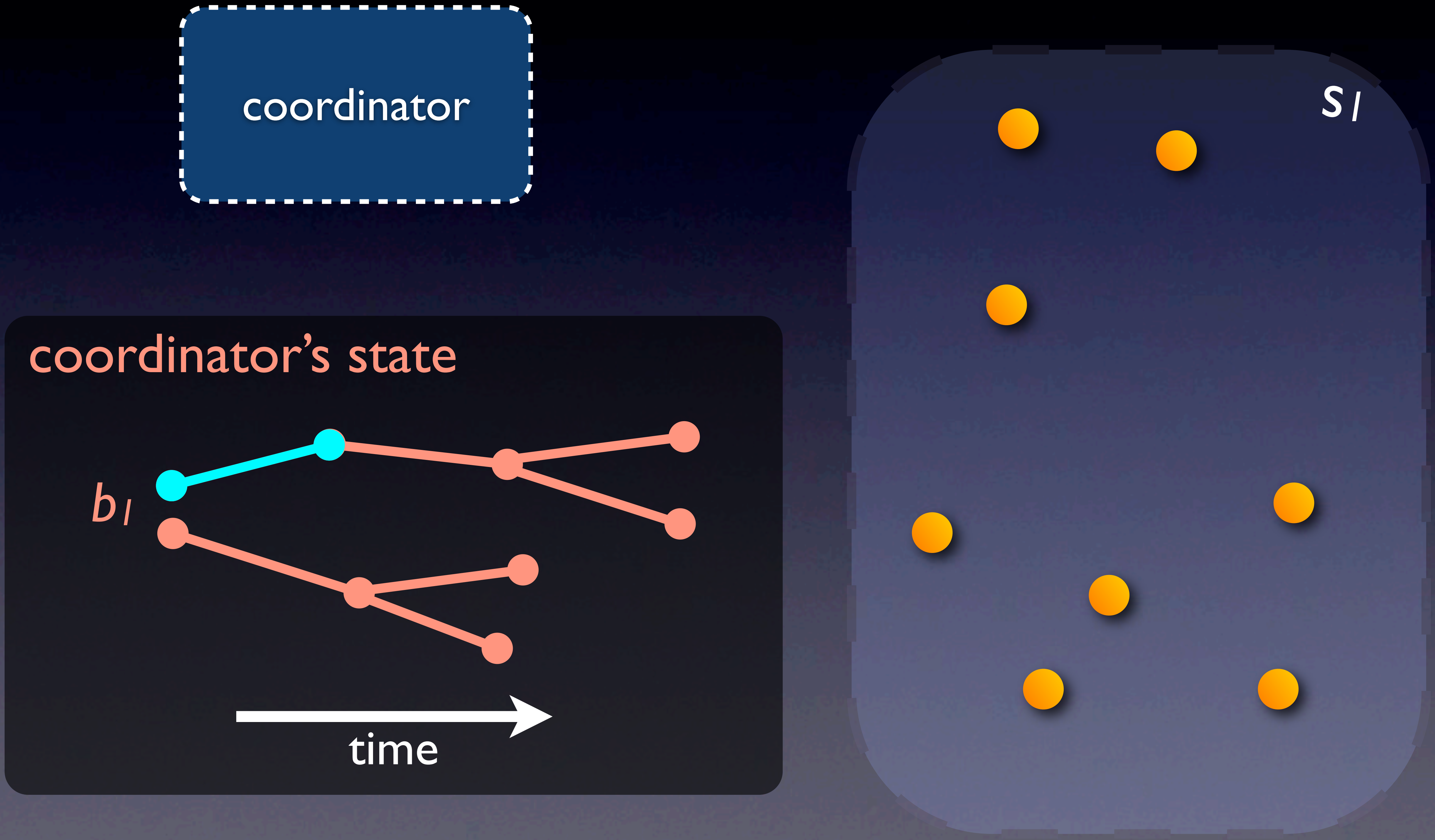
Wire Protocol



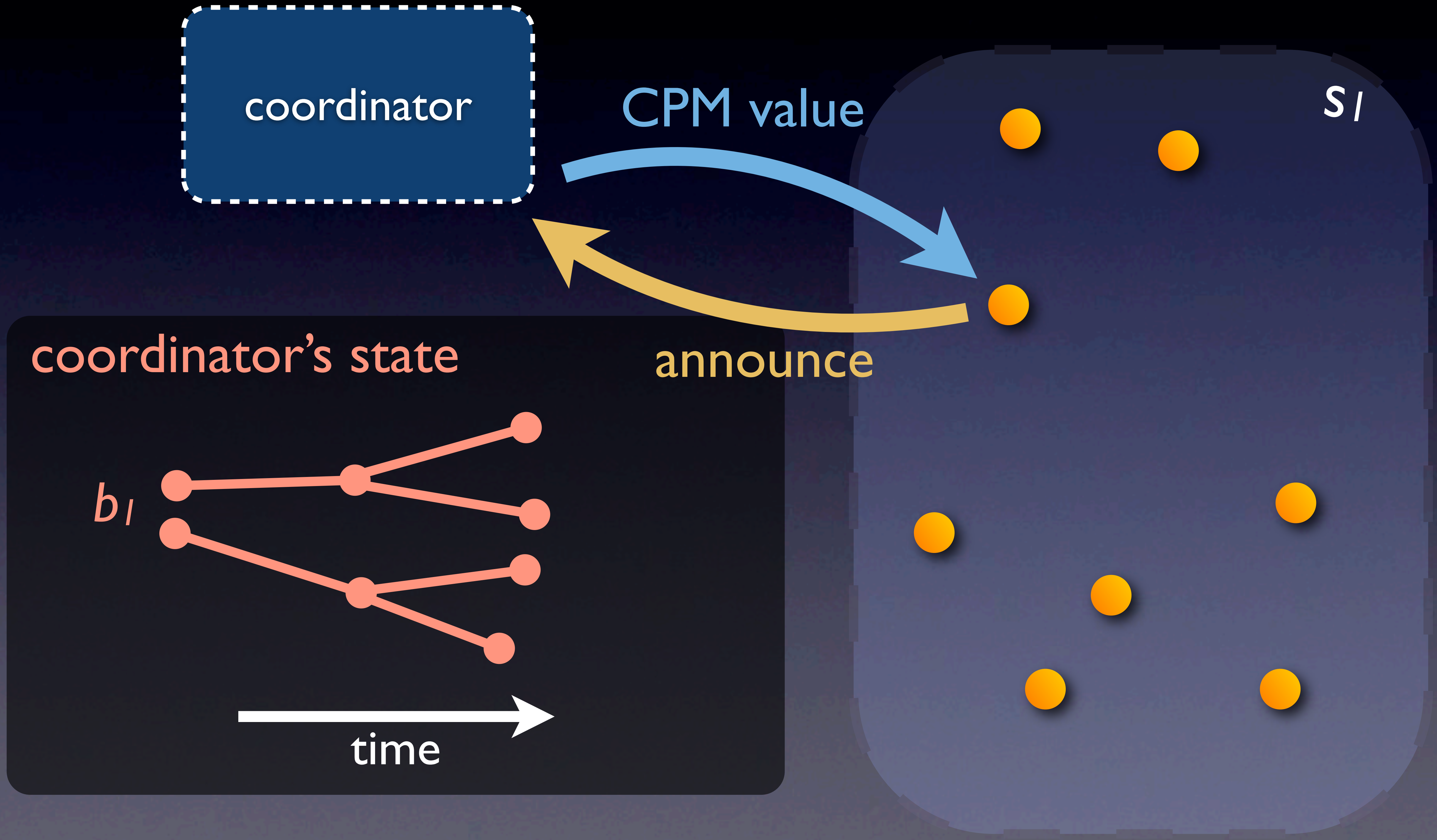
Wire Protocol



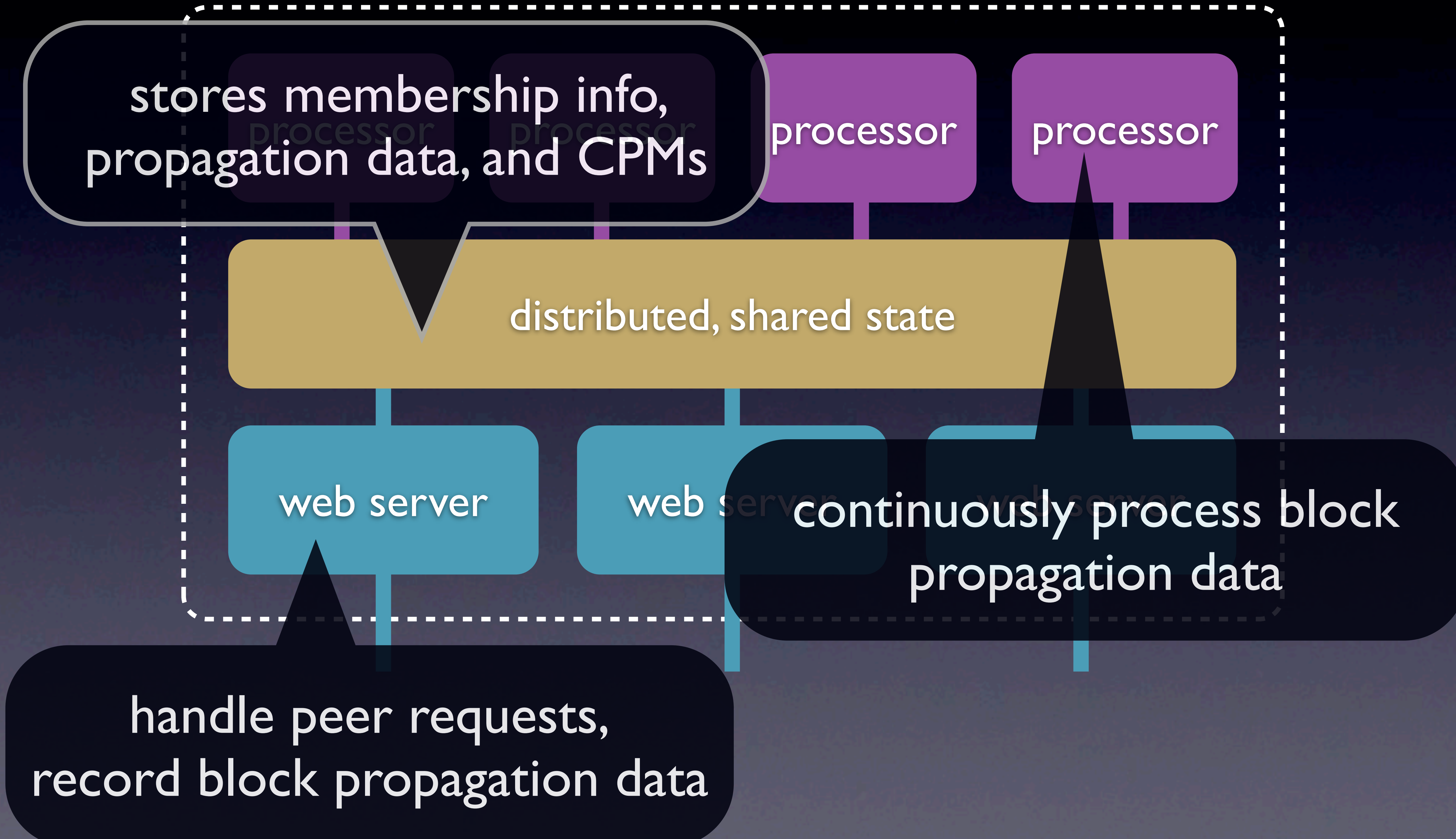
Wire Protocol



Wire Protocol



Coordinator Design



Coordinator State

- Soft state stored in memcached
    - Swarm: peers, number of blocks
    - Peers: addr, swarms, block propagation bandwidths, CPMs
    - Blocks: swarm, propagation graph with timestamped, peer-identified nodes
- Updated via atomic CAS operations

Outline

- The CPM
- V-Formation
- Evaluation

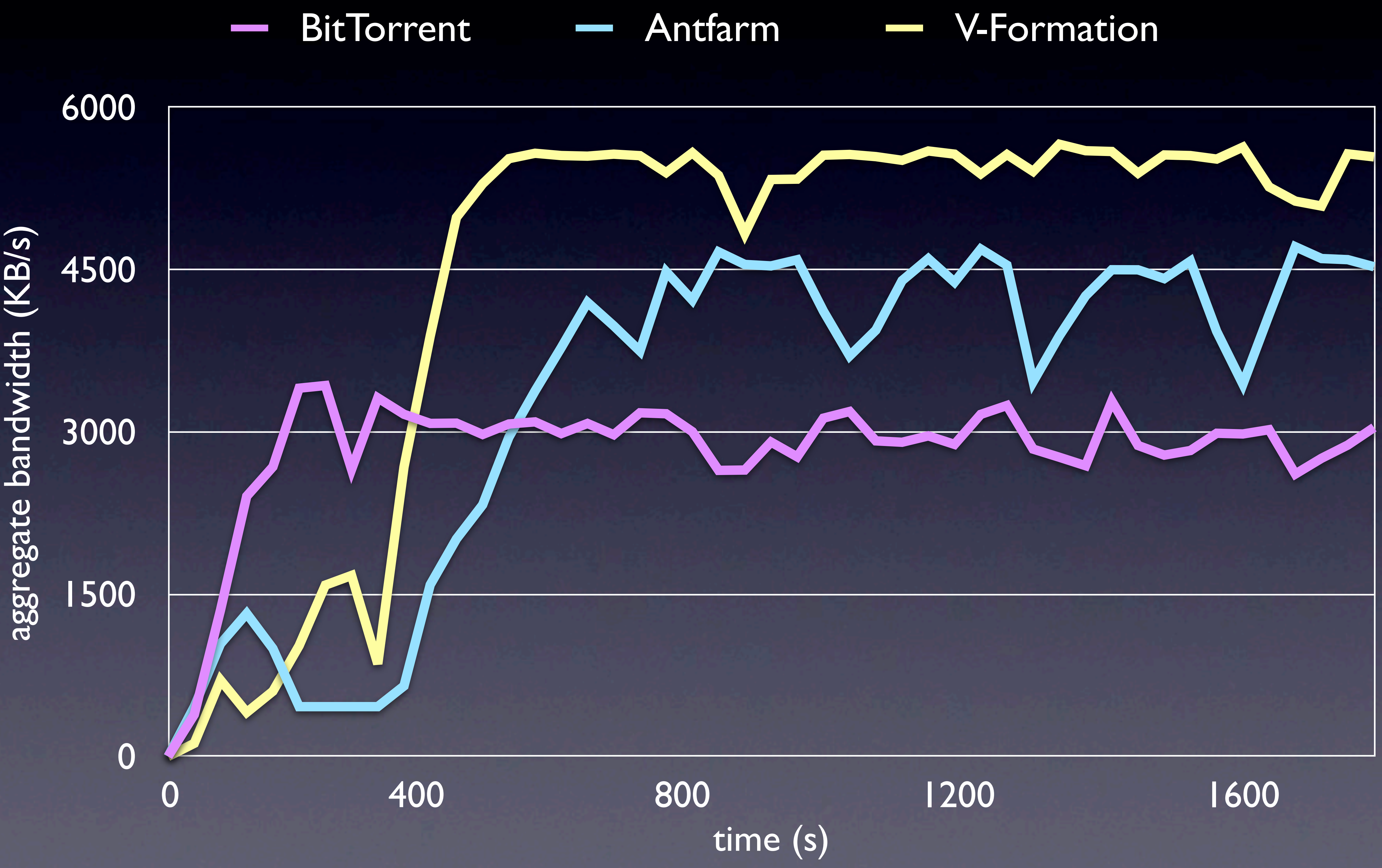
Evaluation

- Built and deployed V-Formation as a video-sharing service called FlixQ
- Uses the CPM to achieve high performance
- Coordinator scales to large deployments

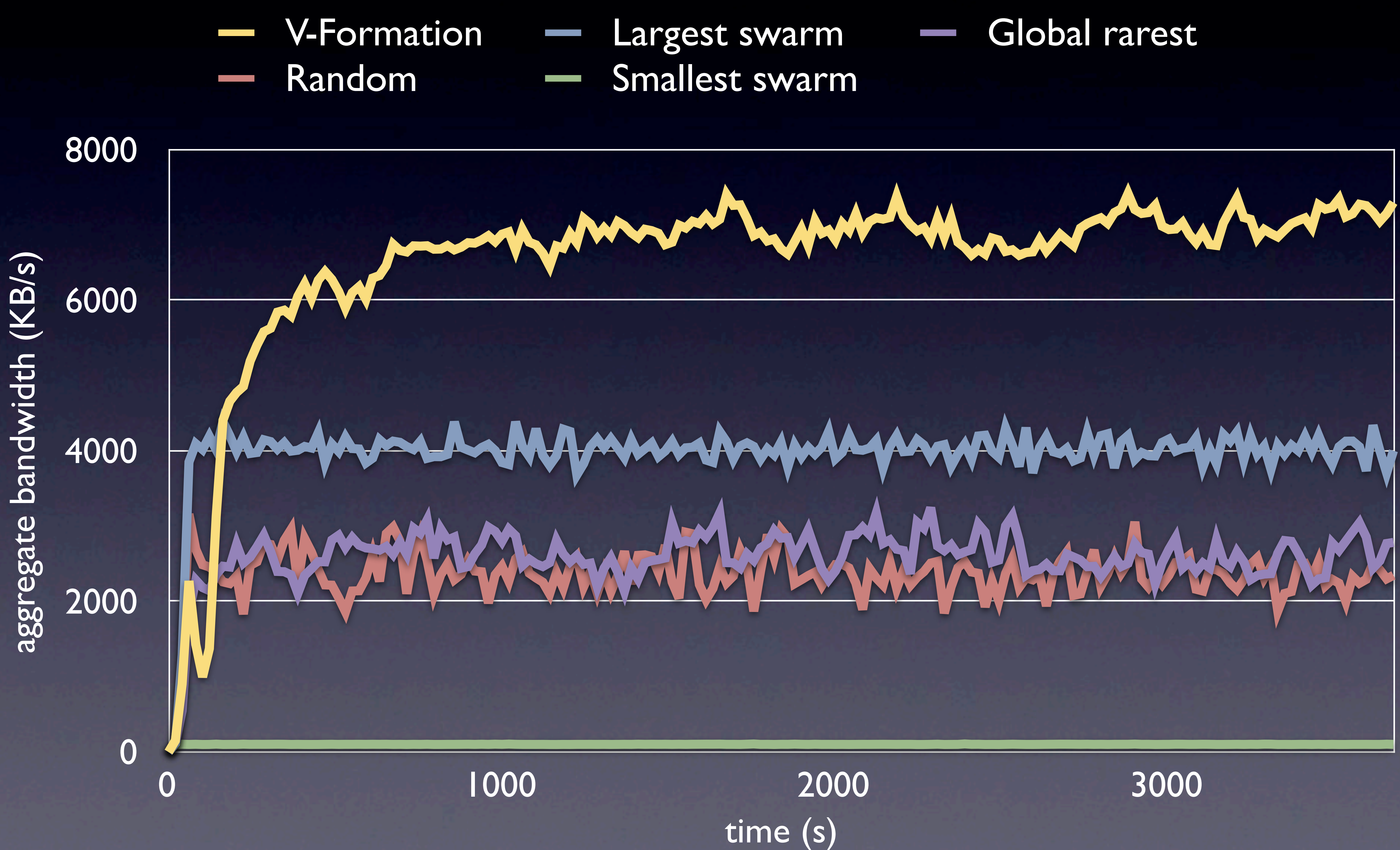
Experimental Setup

- Coordinator on Amazon EC2
- 380 peers on PlanetLab with realistic bandwidth capacities
- 200 swarms based on IMDb movie popularities and sizes
- 20% of peers belong to multiple swarms
- 2 caches with different subsets of content

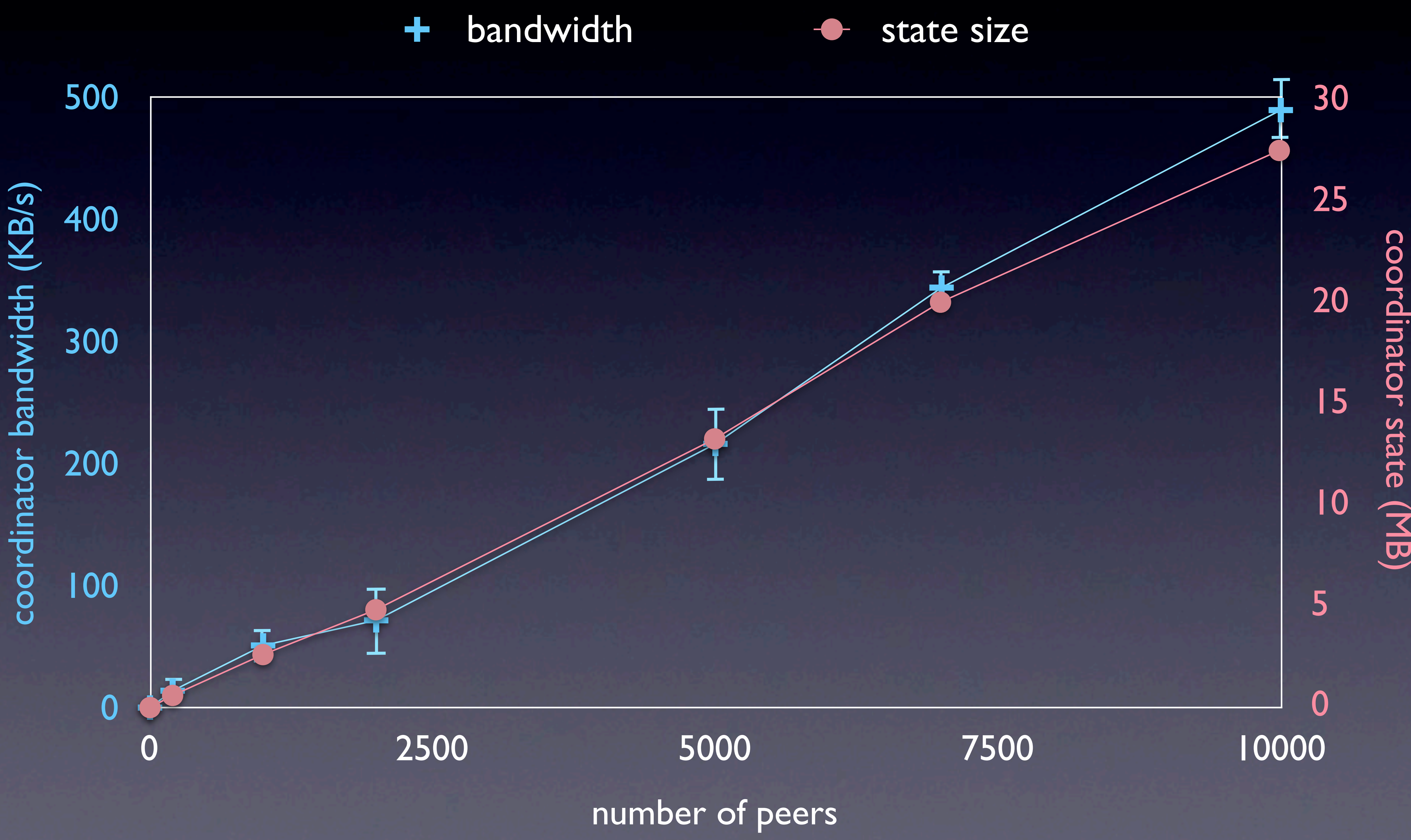
End-to-End Performance



Performance of Heuristics



Scalability



Related Work

- Content Distribution Networks
    - Antfarm, Akamai, CoBlitz, CoDeeN, ECHOS, Coral, Slurpie, YouTube, Hulu, GridCast, Tribler, Joost, Huang et al. 2008, Freedman et al. 2008, ...
- P2P Swarming
    - BitTorrent, BitTyrant, PropShare, BitTornado, BASS, Annapureddy et al. 2007, Guo et al. 2005, Pouwelse et al. 2005, Zhang et al. 2011, OneSwarm, ...
- Incentives and microcurrencies
    - Dandelion, BAR Gossip, Samsara, Karma, SHARP, PPay, Kash et al. 2007, Levin et al. 2009, iOwe, ...

Conclusions

- New hybrid approach for efficient bandwidth allocation
- Decentralized metric enables hosts to measure their global benefit
- Centralized implementation drives hosts toward globally efficient use of resources

http://flixq.com