Antfarm: Efficient Content Distribution with Managed Swarms

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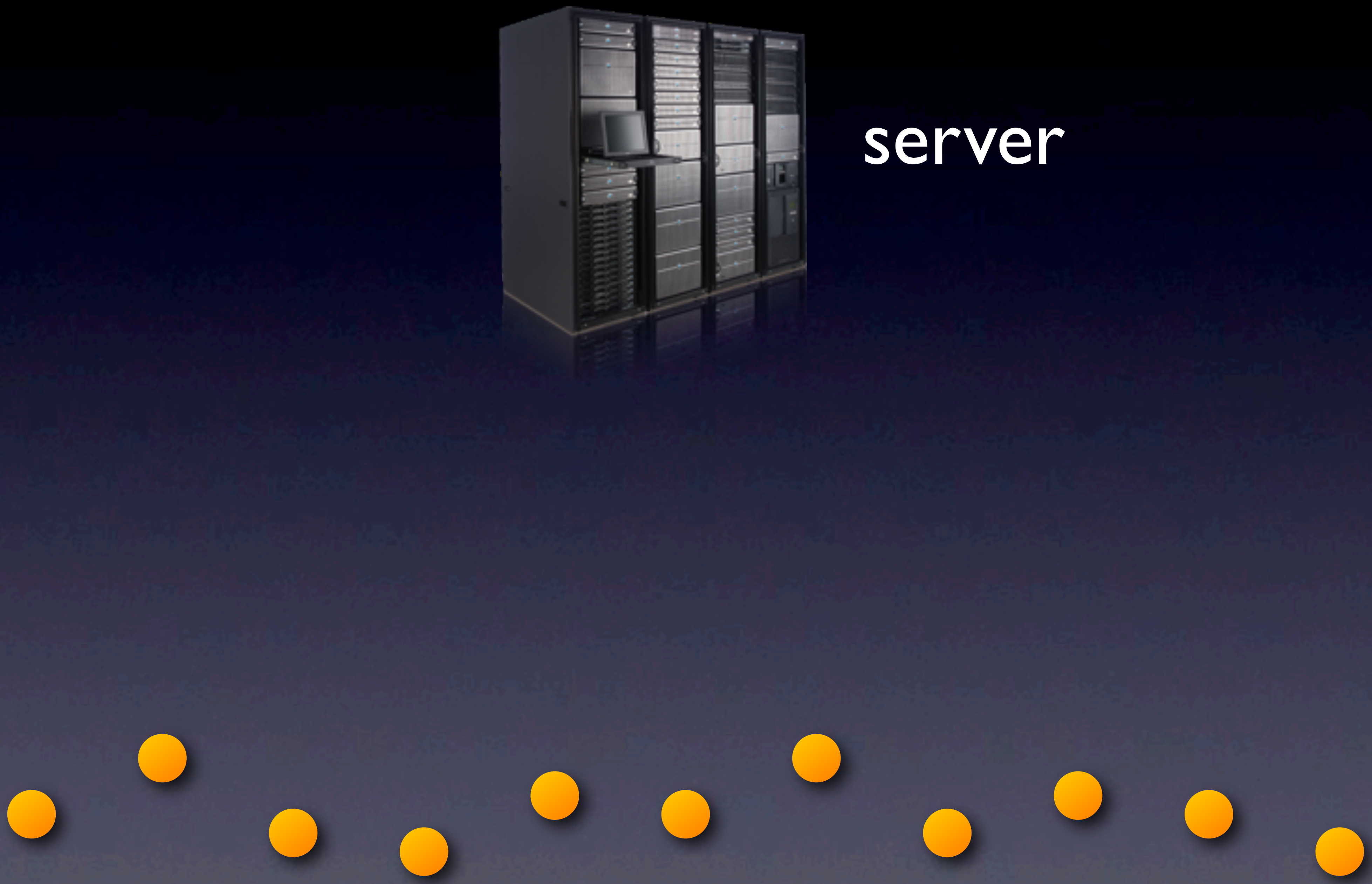
Problem Domain

What is the most efficient way to disseminate a large set of files to a large set of clients?

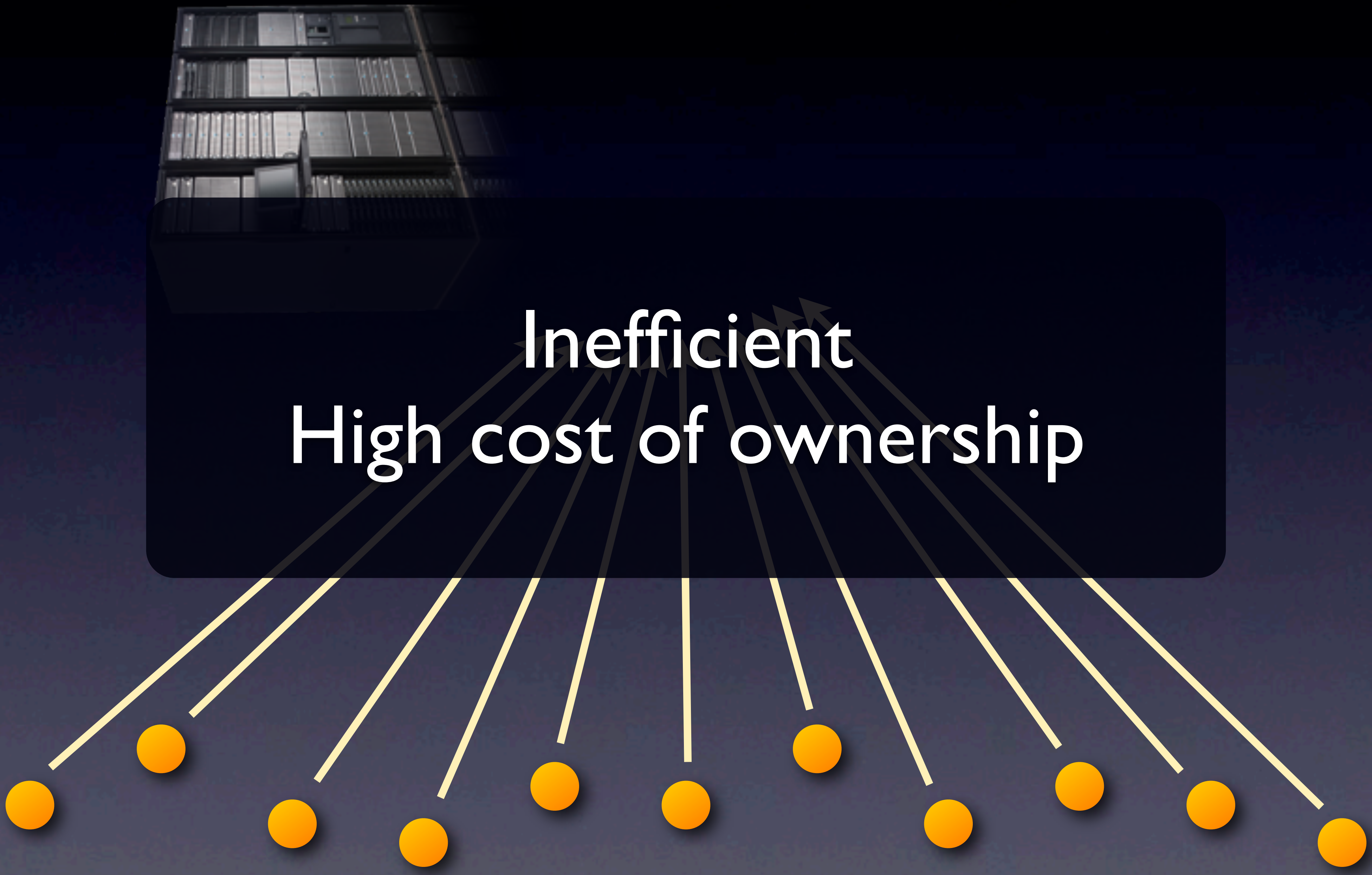
Client-Server



server

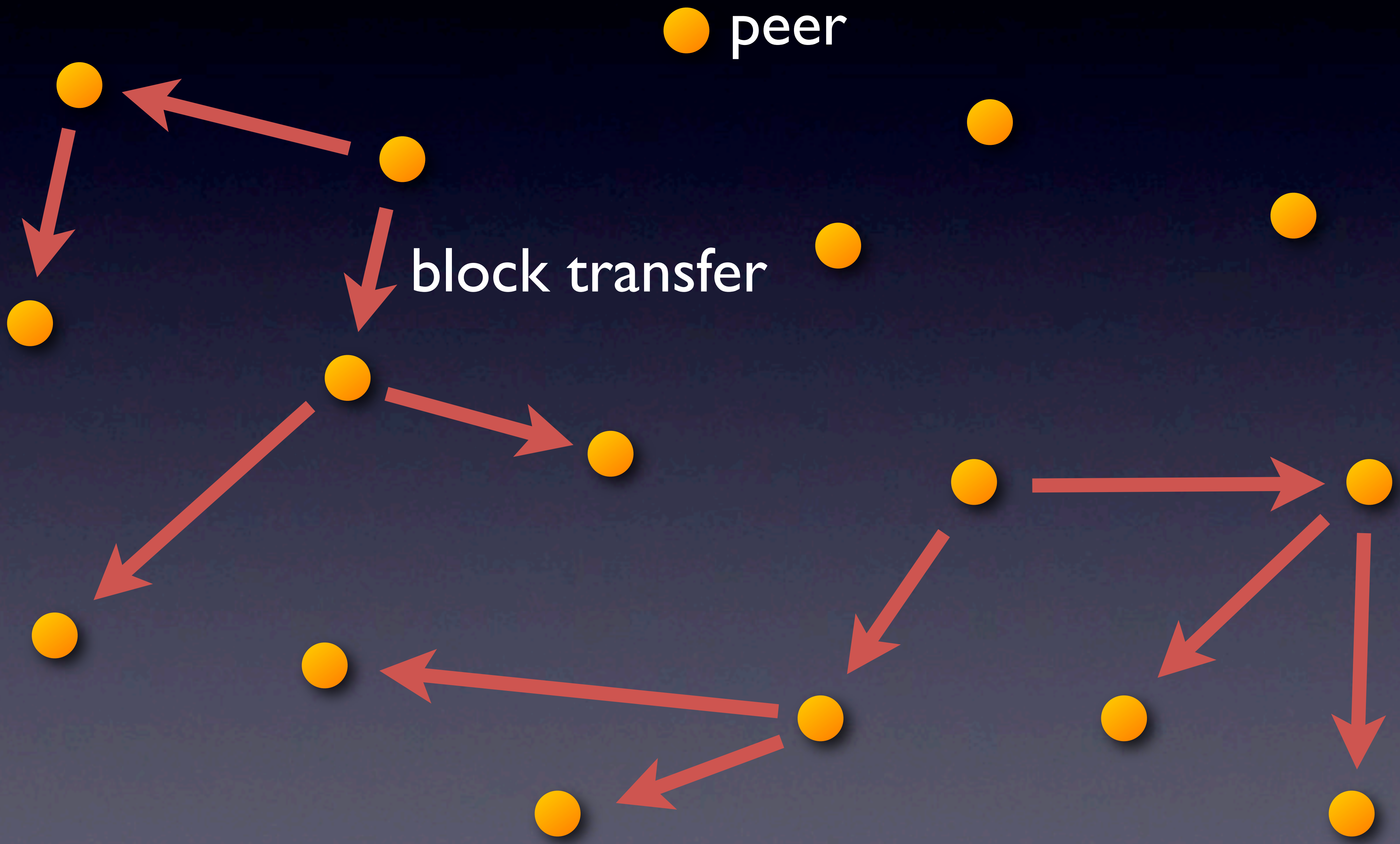
clients

Client-Server

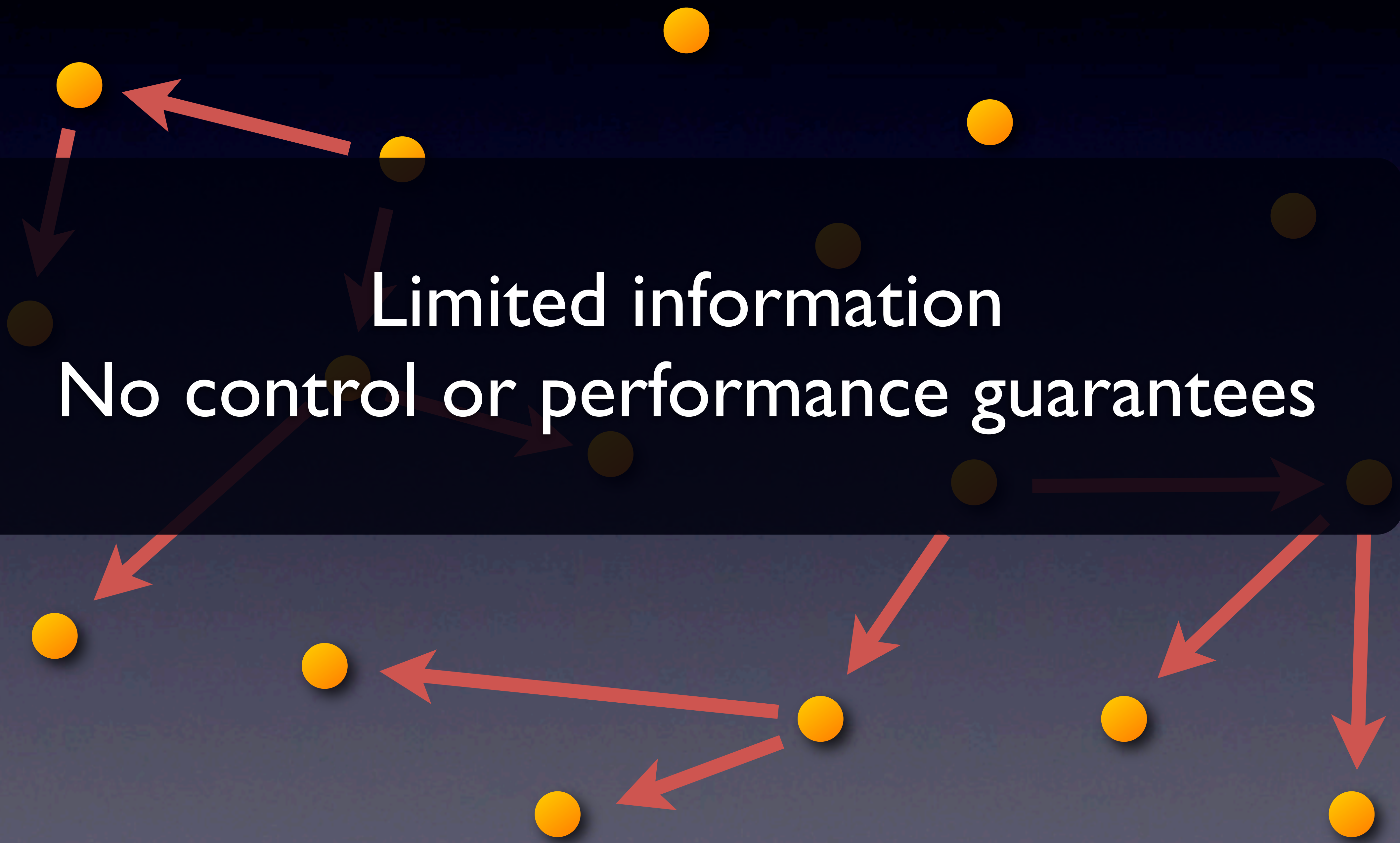


Inefficient
High cost of ownership

Peer-to-Peer



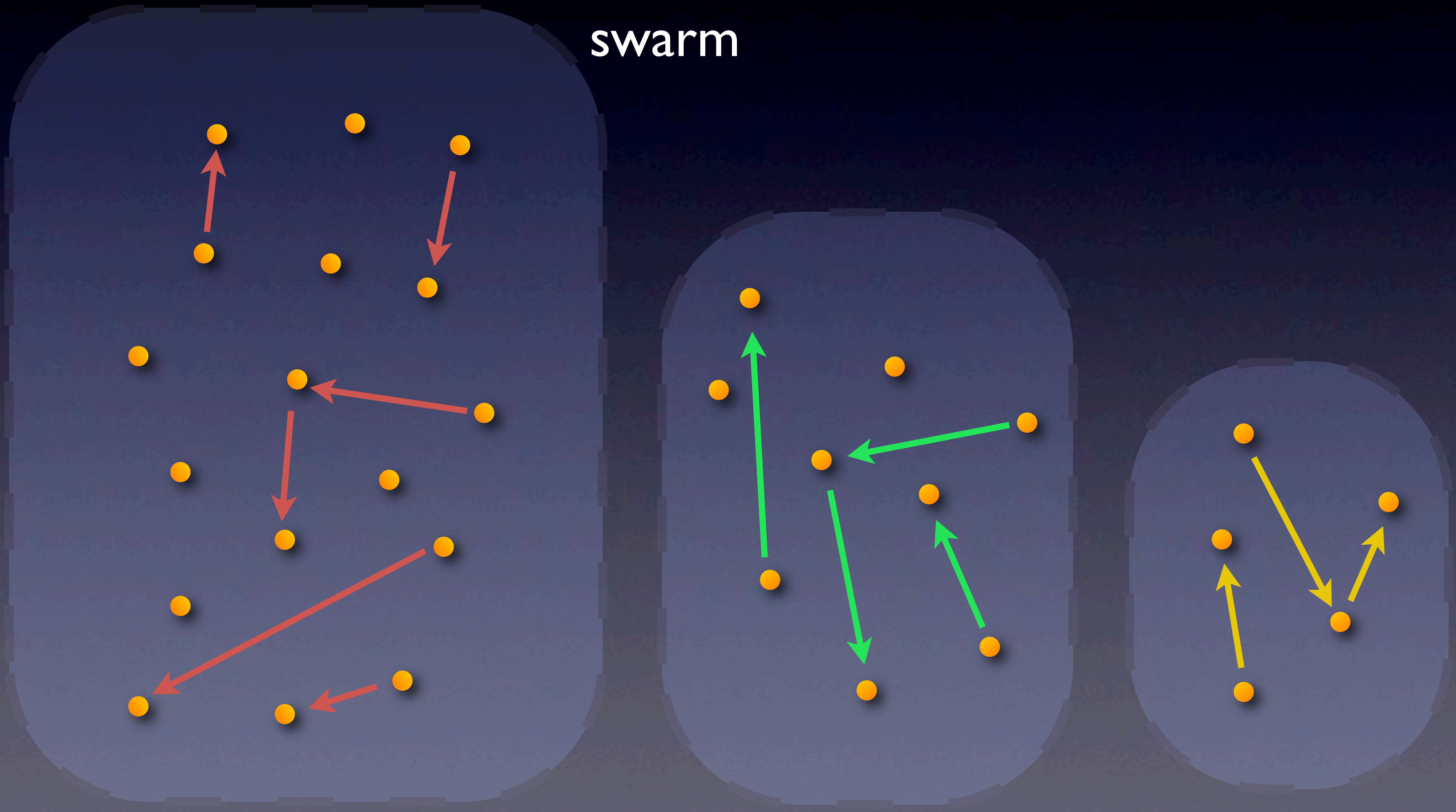
Peer-to-Peer



Limited information

No control or performance guarantees

Peer-to-Peer



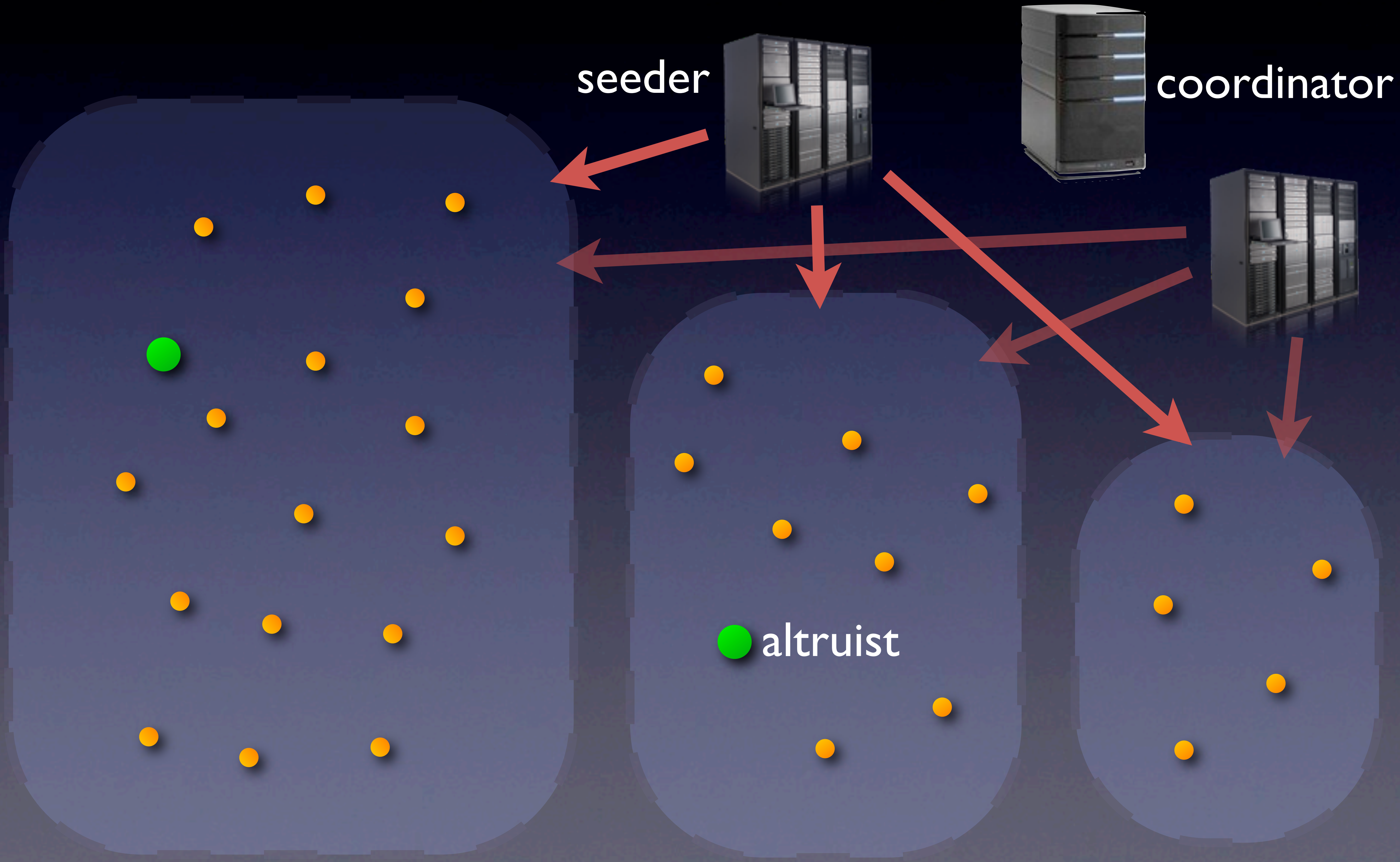
Antfarm Goals

- High performance
- Low cost of deployment
- Performance guarantees
  - Administrator control over swarm performance
- Accounting
  - Enables different resource contribution policies

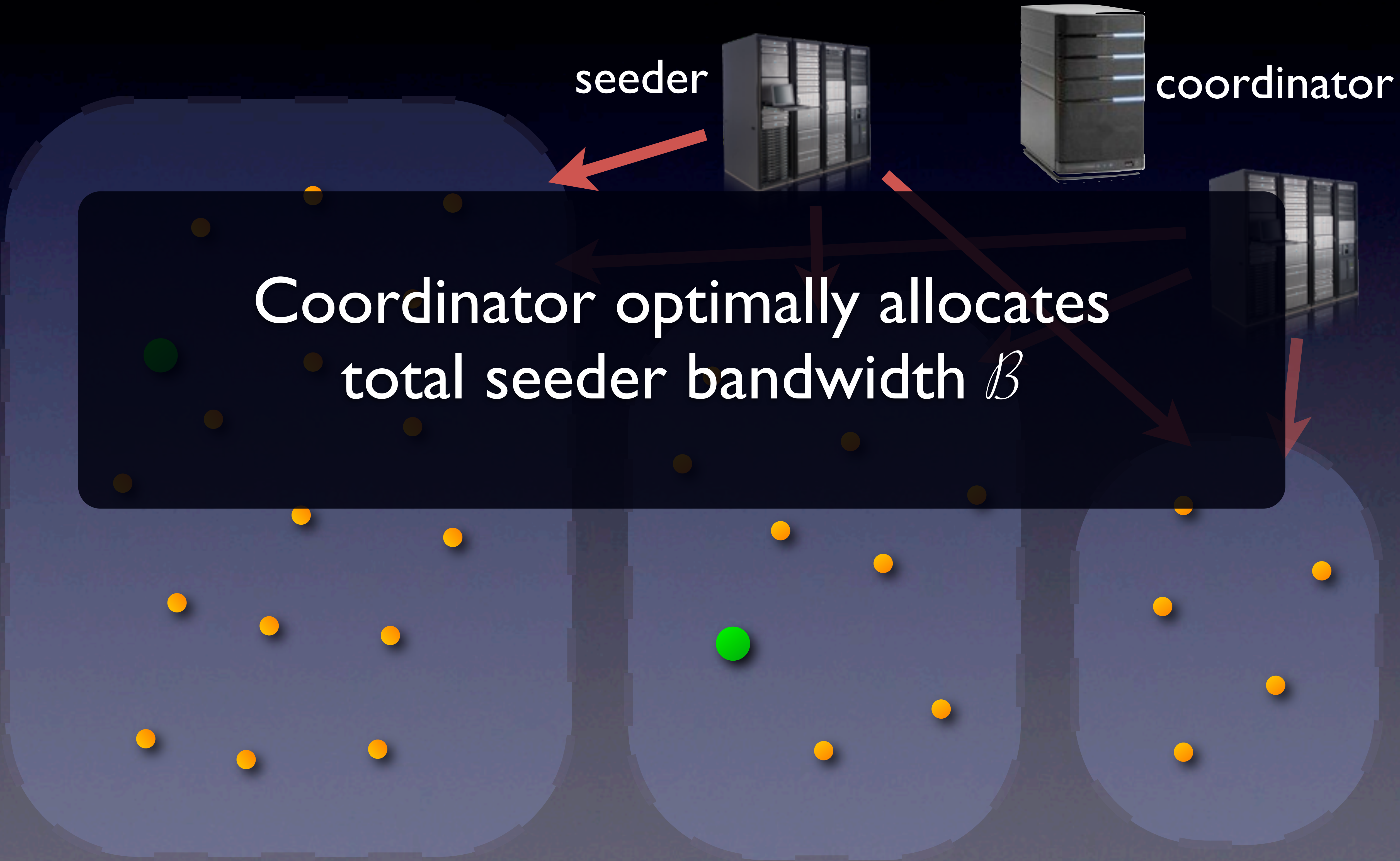
Antfarm Approach

- Key insight: view content distribution as an optimization problem
- Hybrid architecture
  - P2P swarming with a logically centralized coordinator
- Clean slate protocol

Antfarm System Model

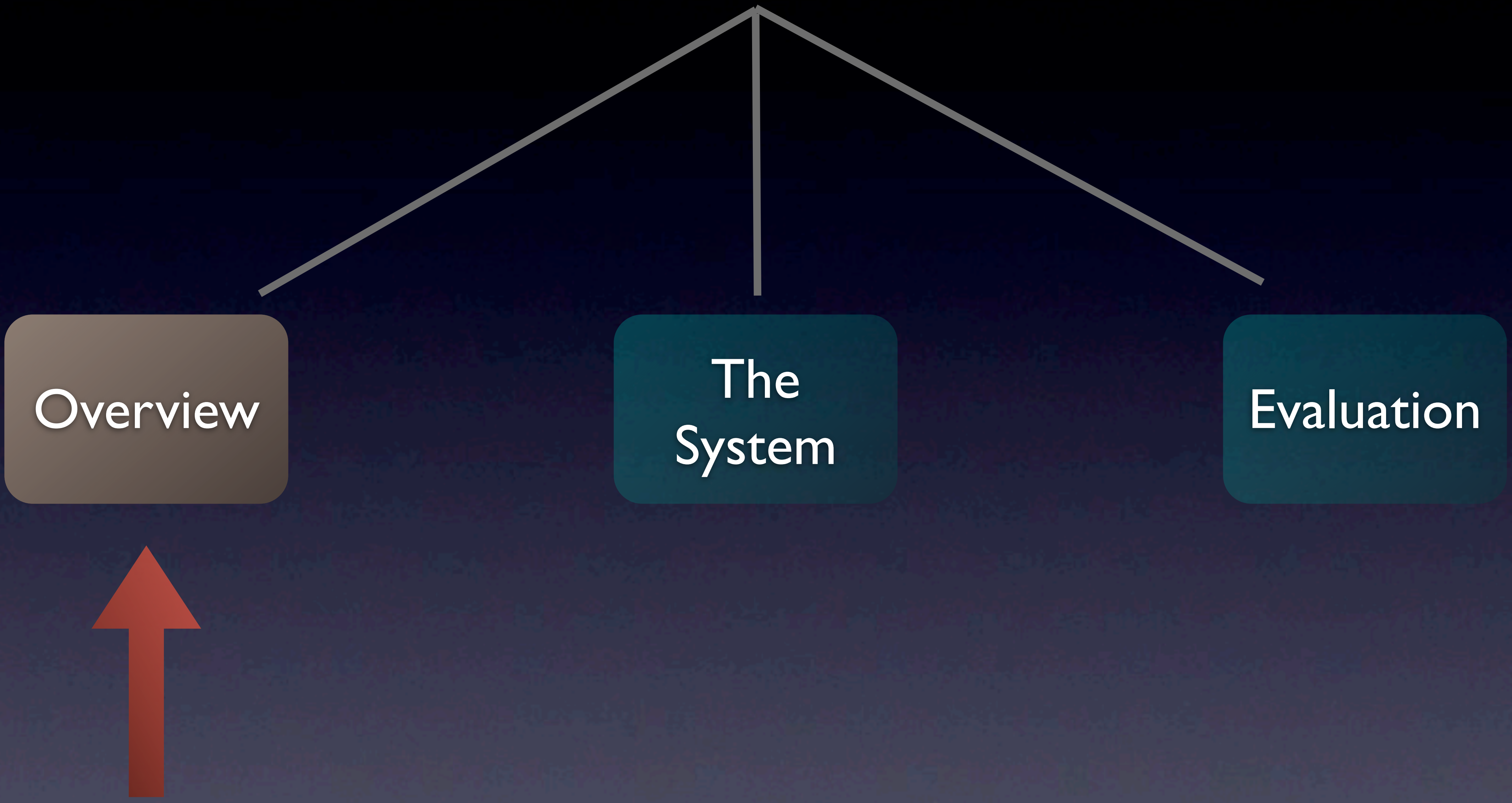


Antfarm System Model



Coordinator optimally allocates total seeder bandwidth $\mathcal{B}$

Antfarm

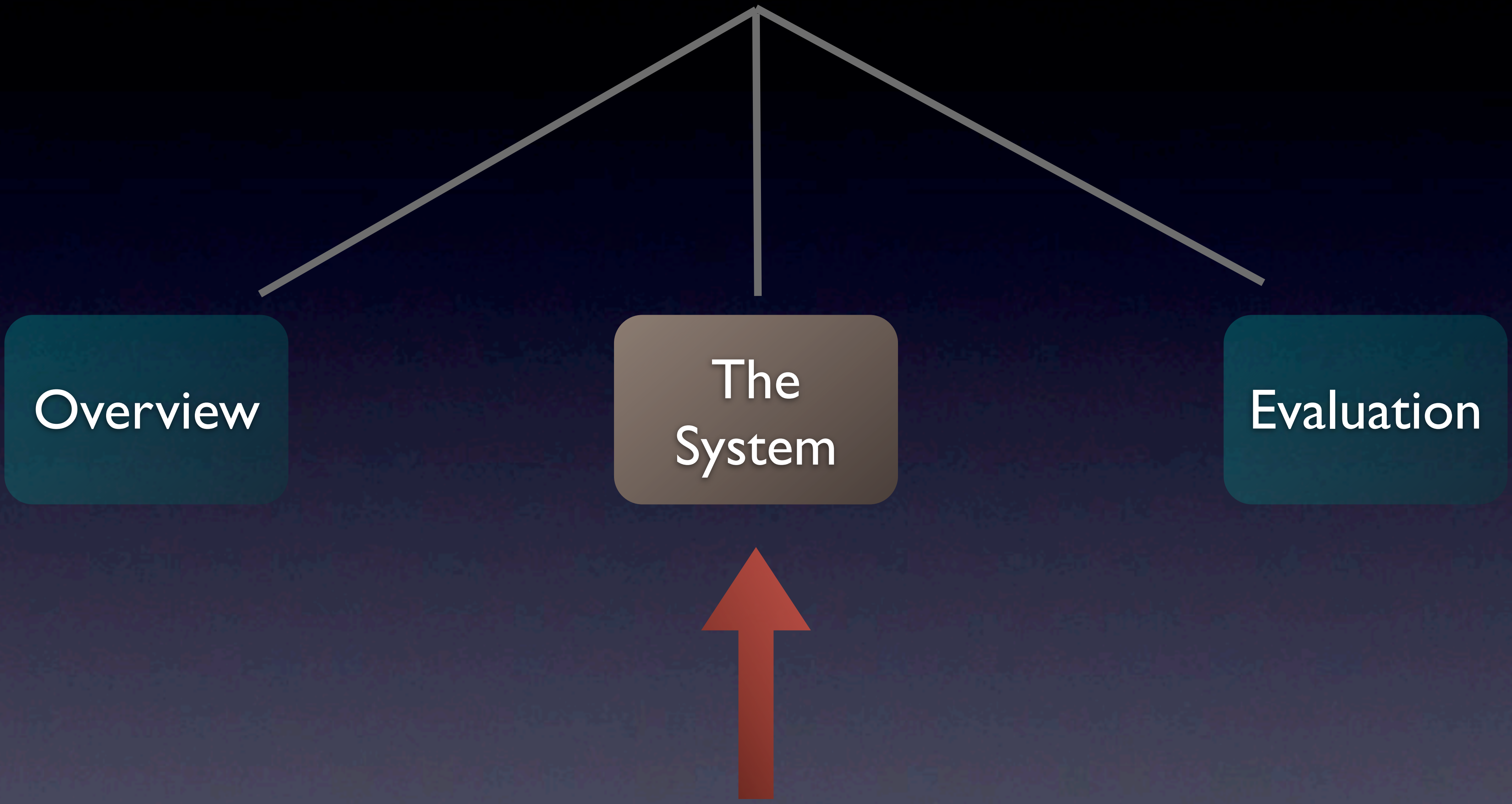


Overview

The System

Evaluation

Antfarm



Overview

The System

Evaluation

Strawman Coordinator

- One could schedule every data transfer in the system
    - All packets for all time
    - Unscalable, impractical!
- Antfarm coordinator makes critical decisions based on observed dynamics

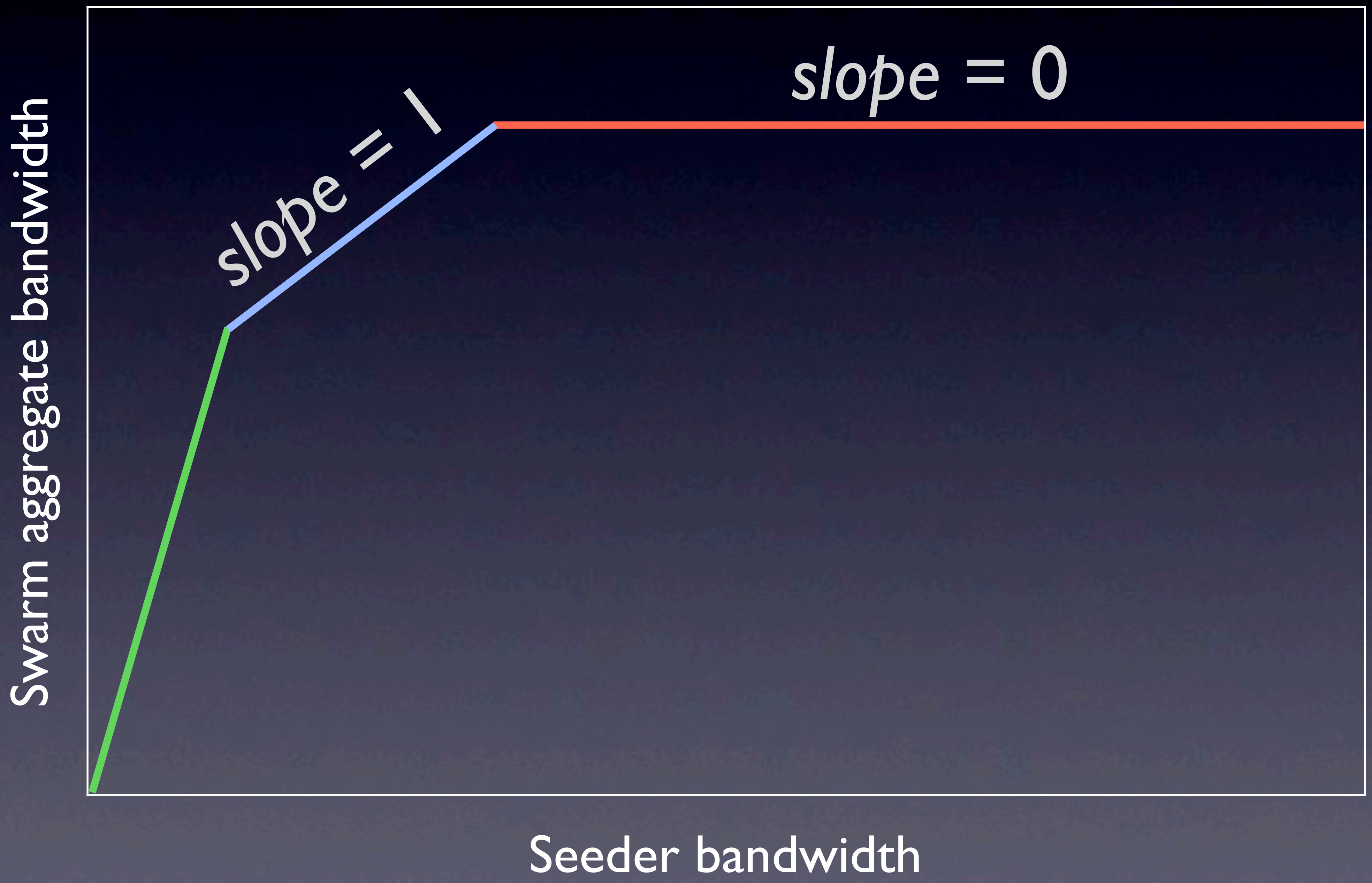
Antfarm Coordinator

- Models swarm dynamics
  - Measures and extracts key parameters
- Formulates optimization problem
  - Calculates optimal bandwidth allocation
- Enacts allocation decisions
  - Maximizes aggregate bandwidth
  - Minimizes average download time

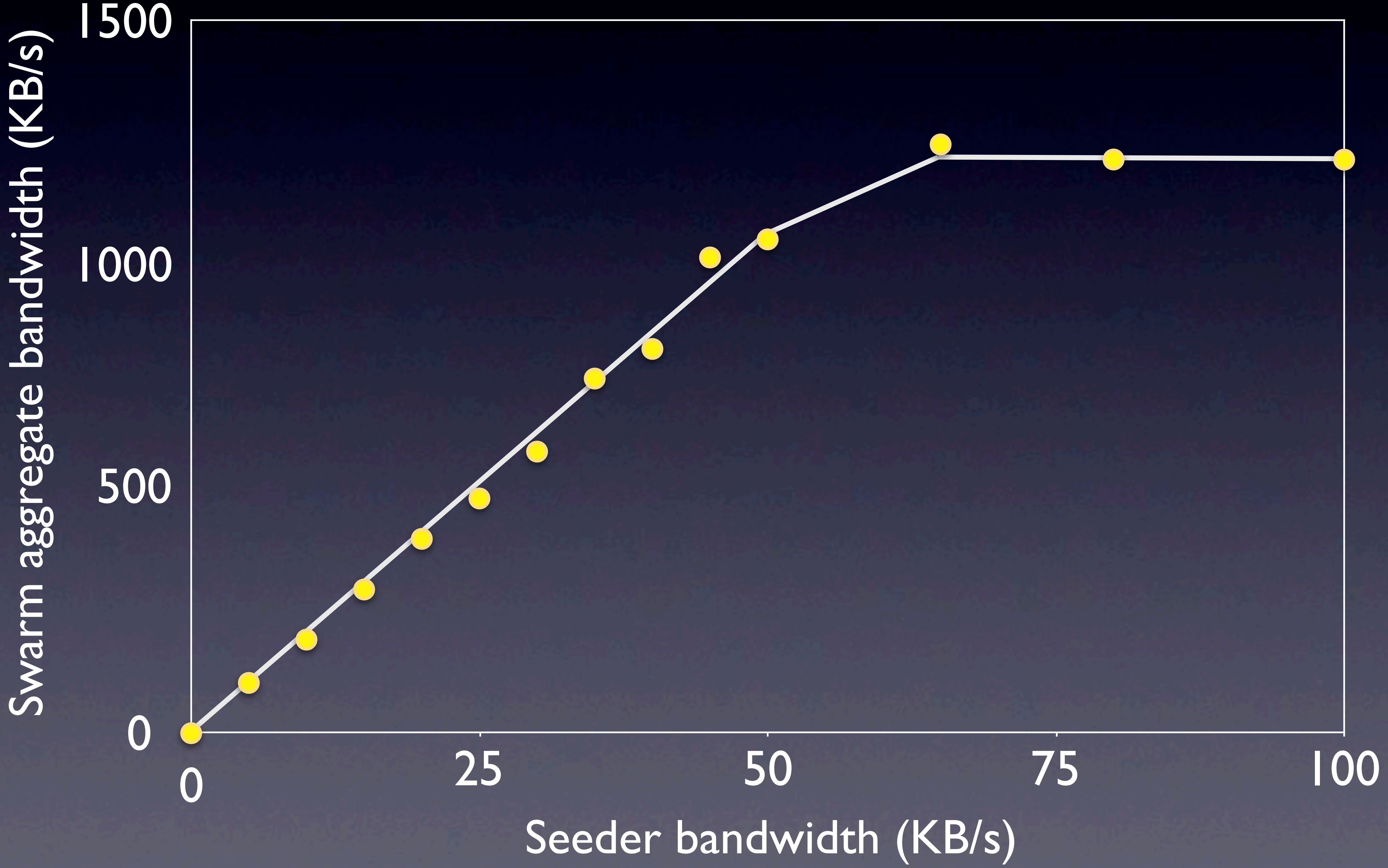
Antfarm Formalization

Maximize system-wide aggregate bandwidth subject to a bandwidth constraint

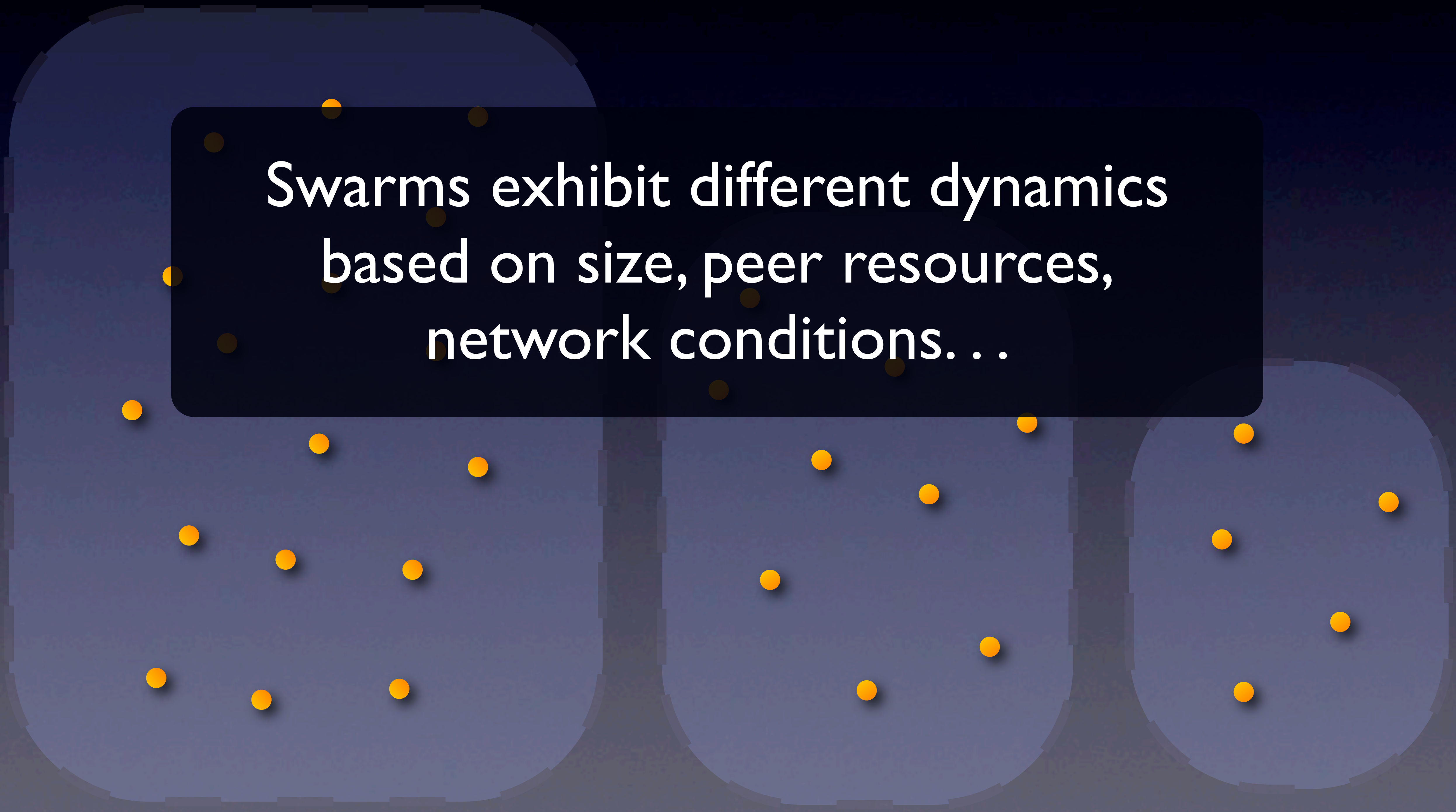
Response Curves



Response Curves

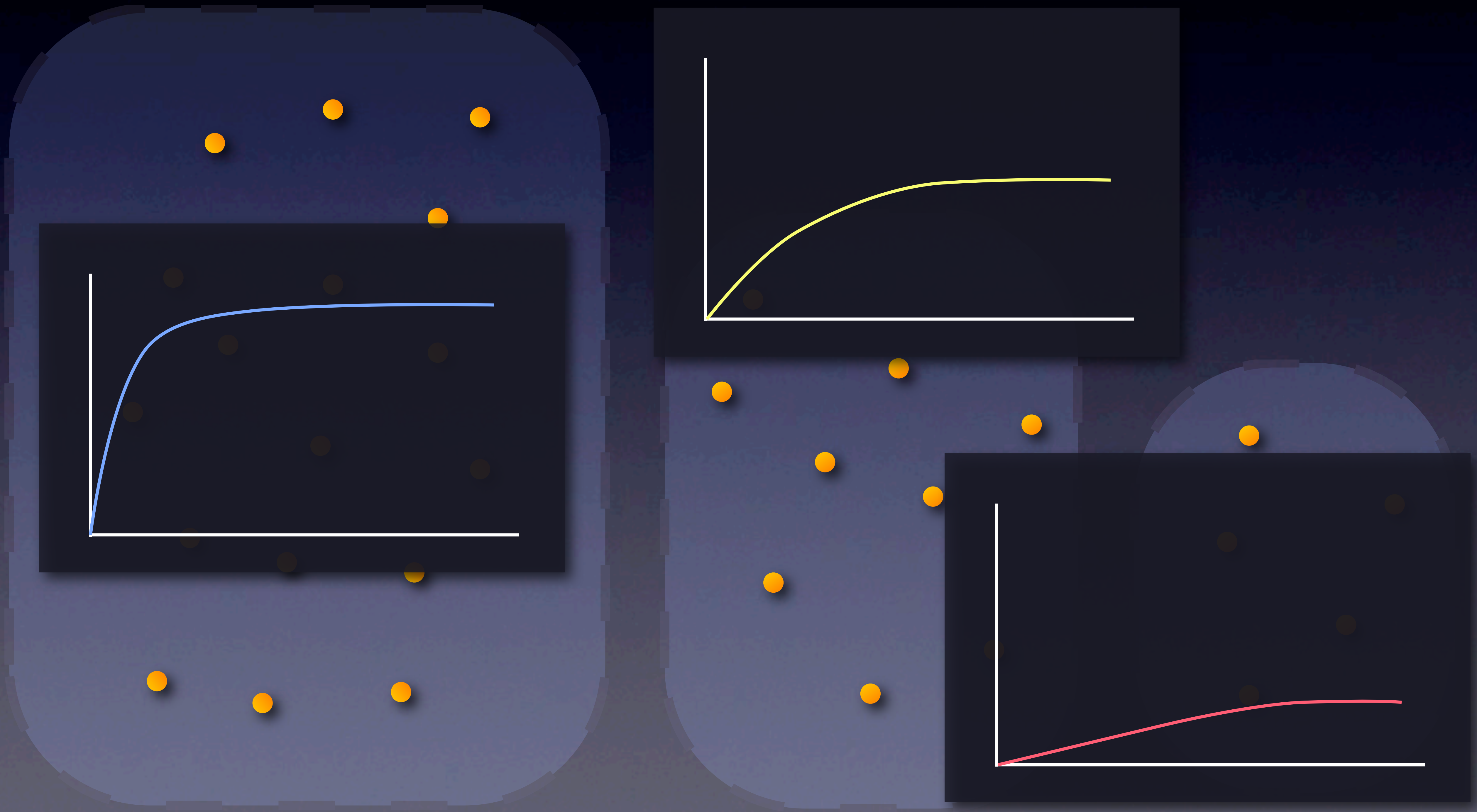


Swarm Dynamics

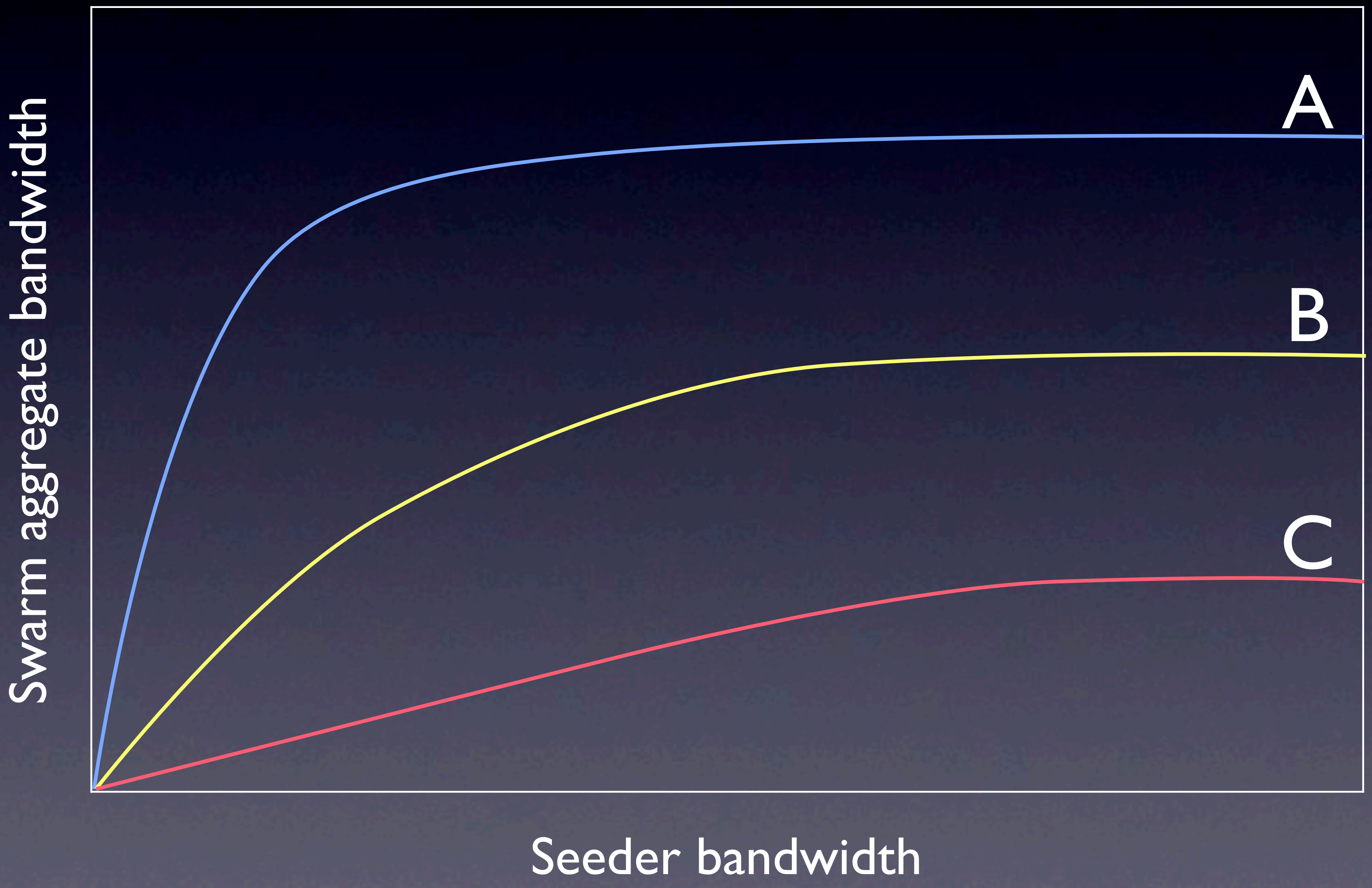


Swarms exhibit different dynamics based on size, peer resources, network conditions. . .

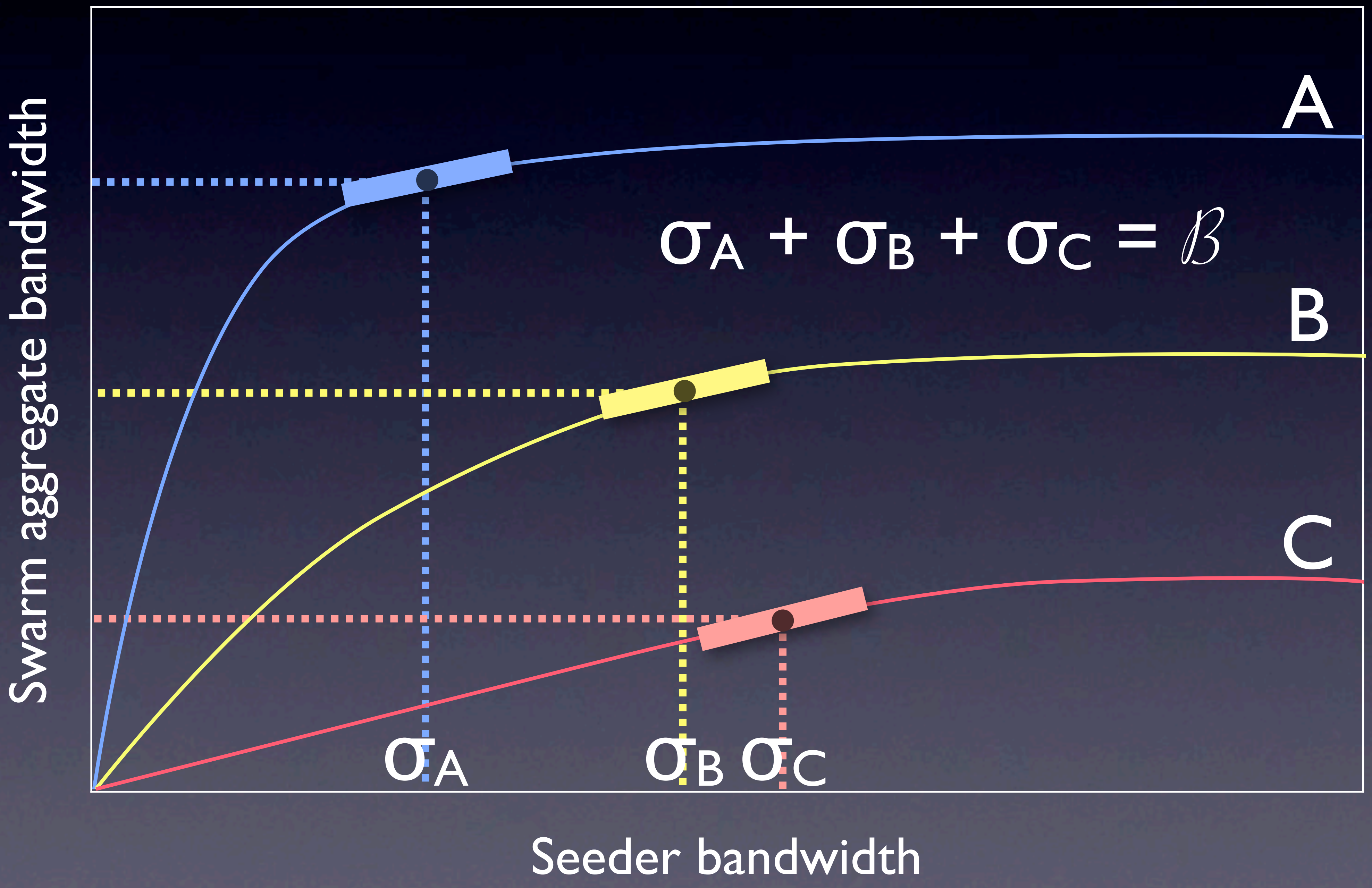
Swarm Dynamics



Antfarm Optimization



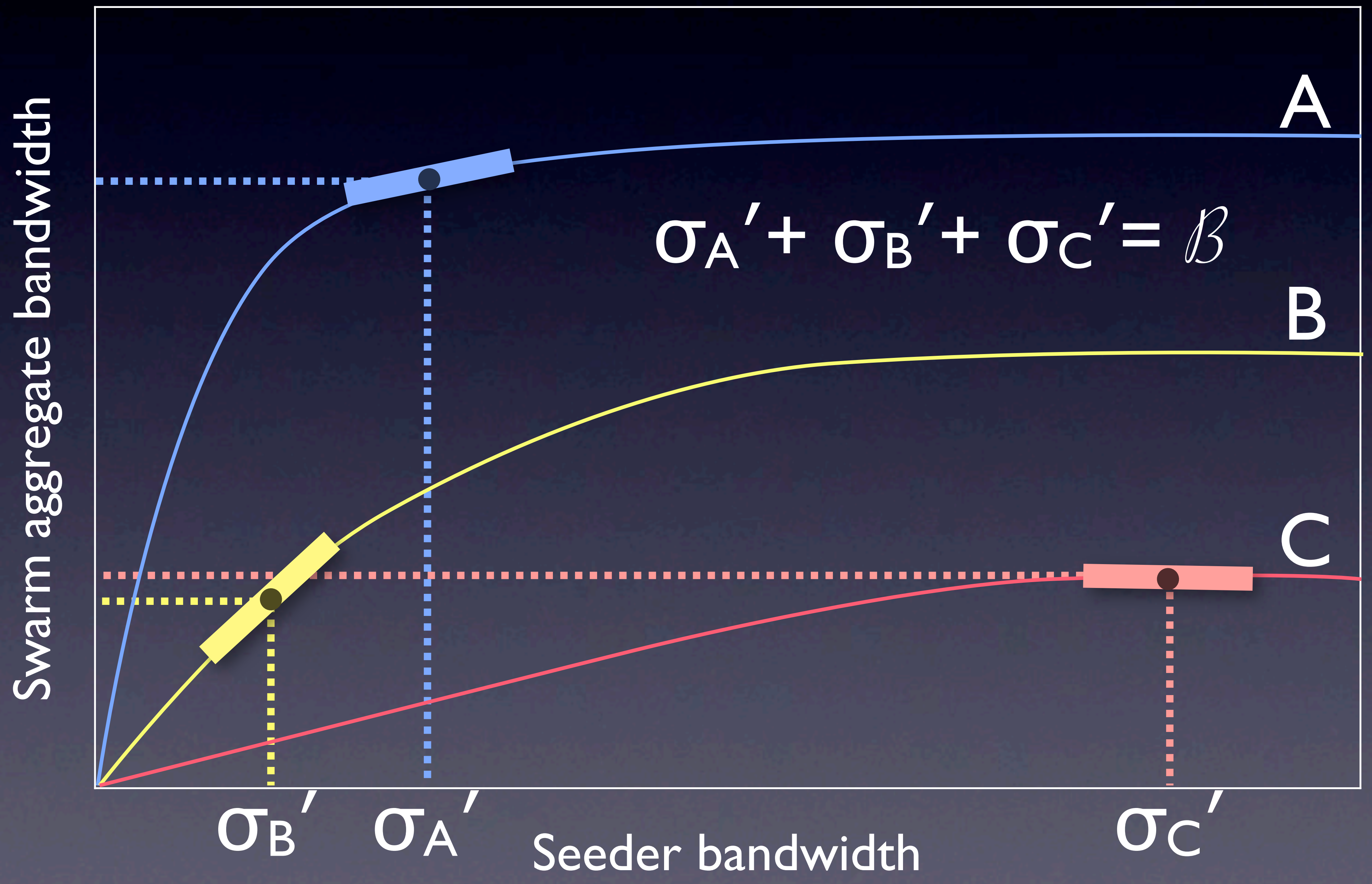
Antfarm Optimization



Performance Control

- Can provide swarm performance guarantees
  - Guarantee minimum level of service
  - Prioritize swarms

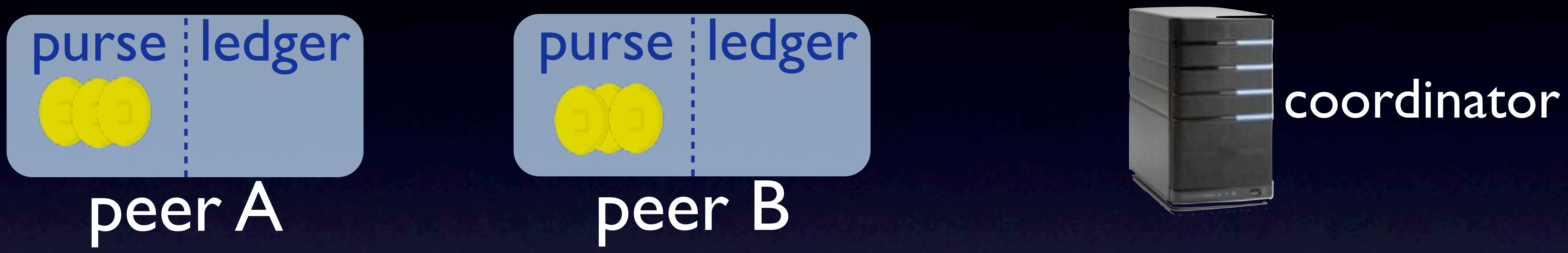
Antfarm Allocation



Adapting to Change

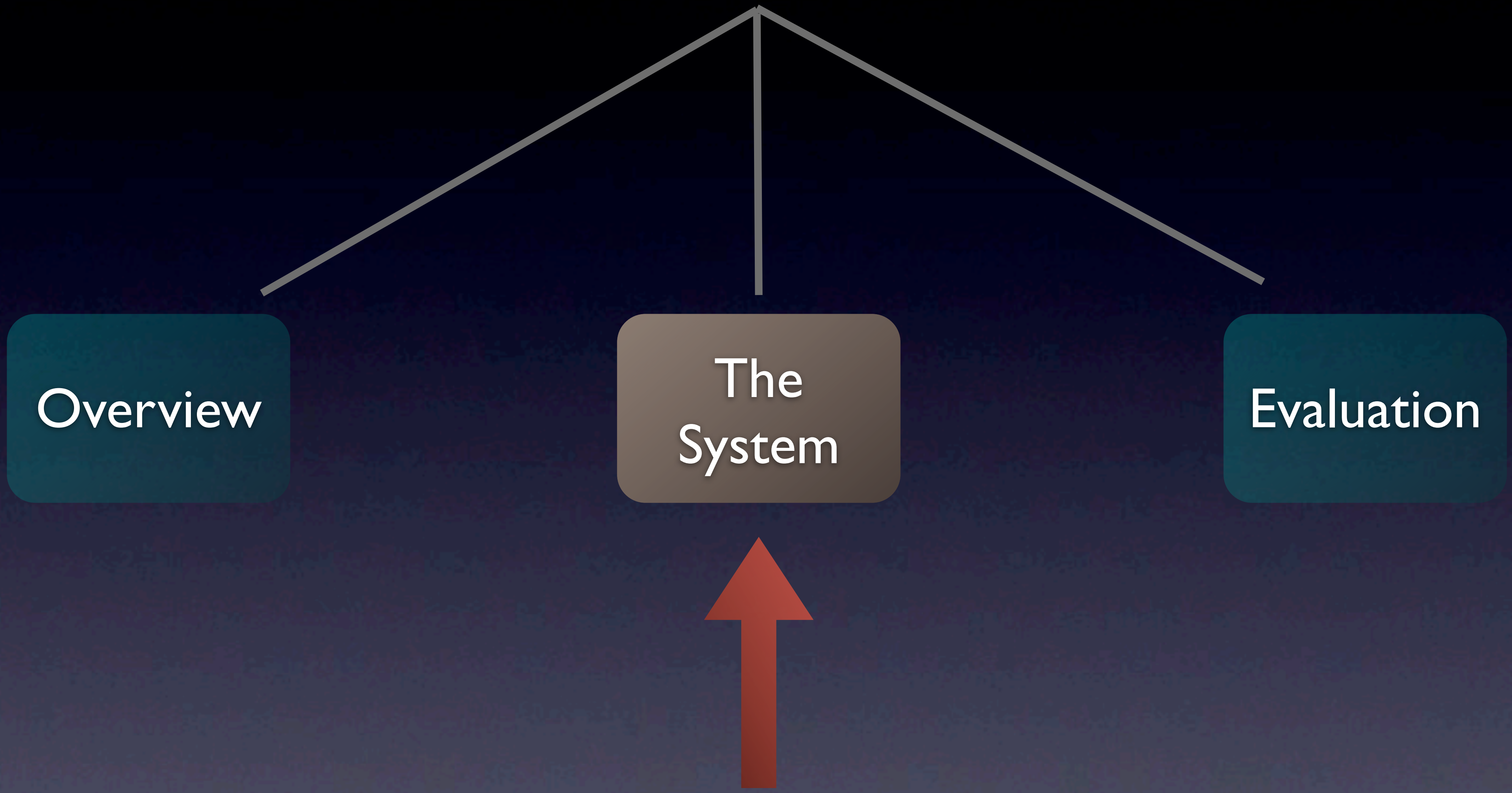
- Swarm dynamics change
  - Churn
  - Network conditions
- Antfarm updates response curves
  - Coordinator explores around point of operation

Wire Protocol



- Coordinator mints small, unforgeable tokens
- Peers trade each other tokens for blocks
- Peers return spent tokens to the coordinator as proof of contribution

Antfarm



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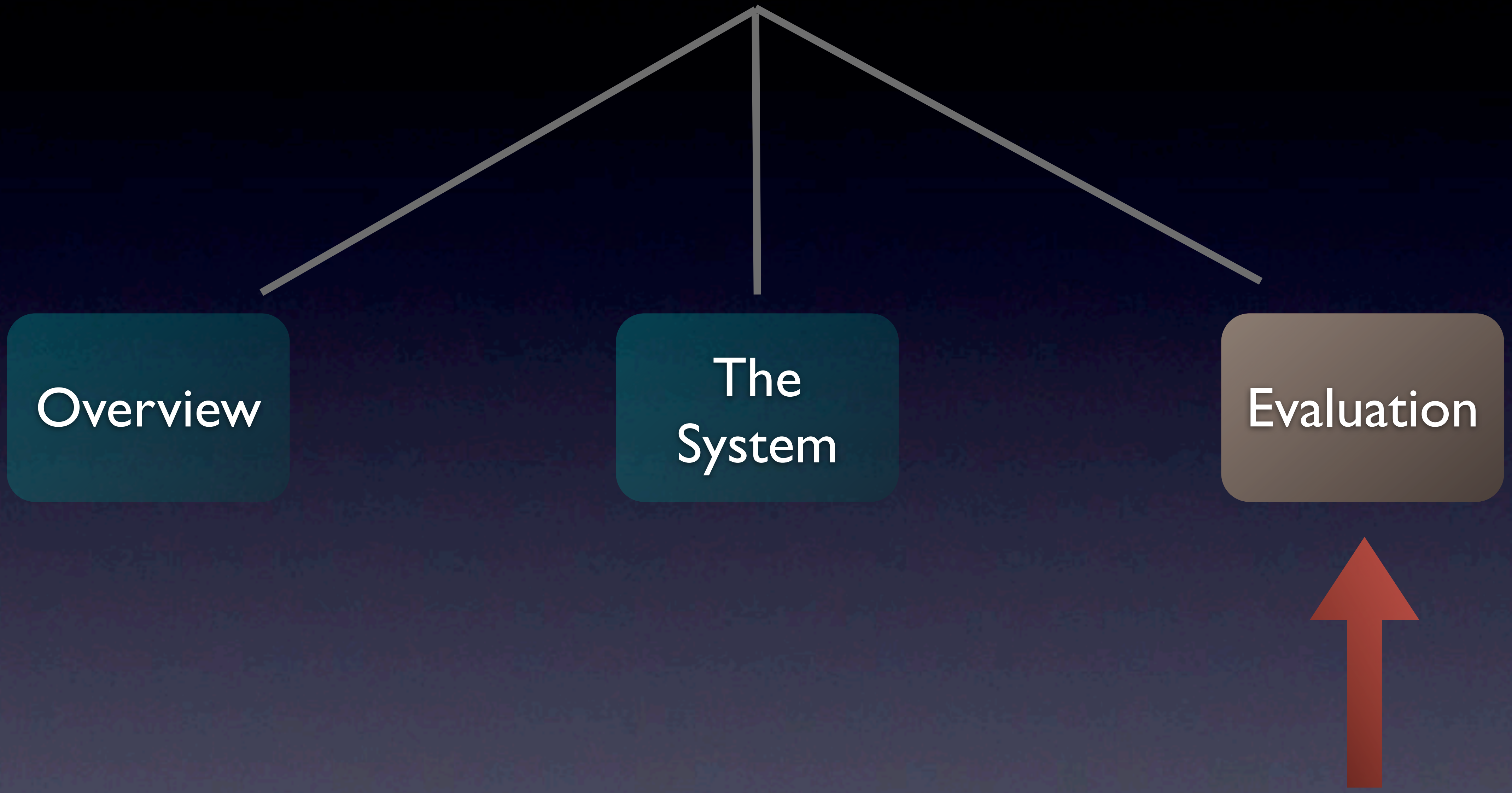
Antfarm



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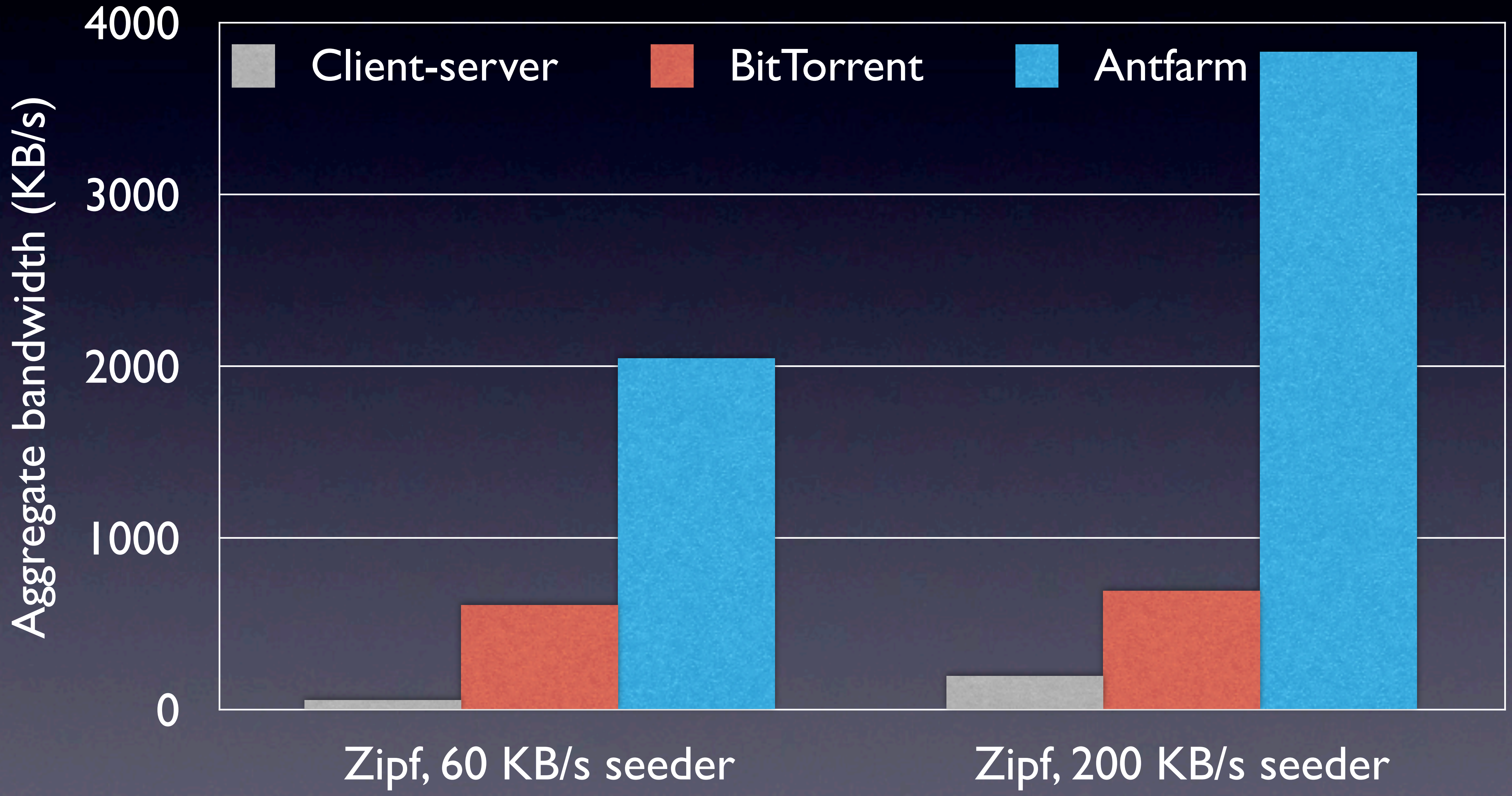
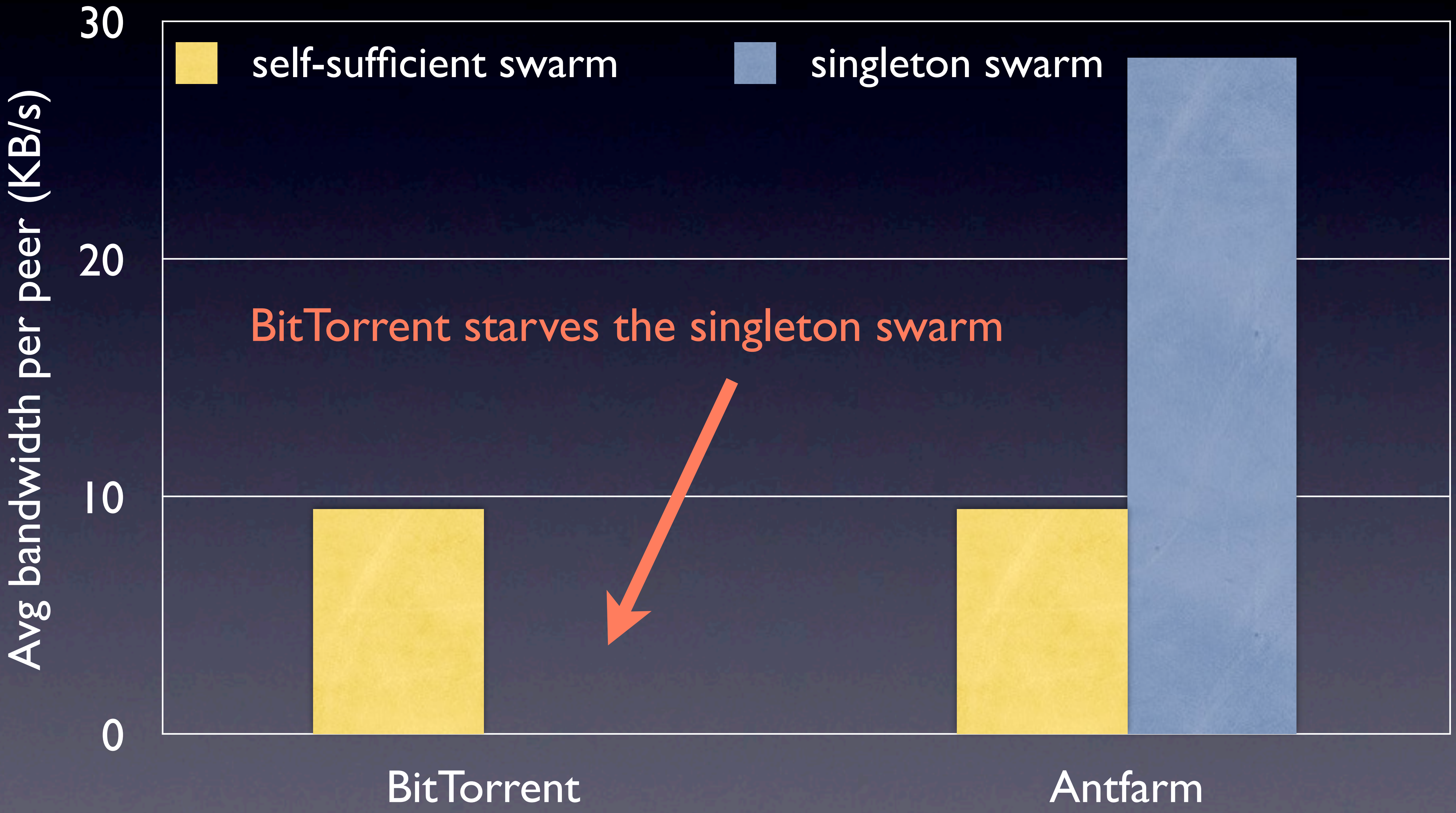
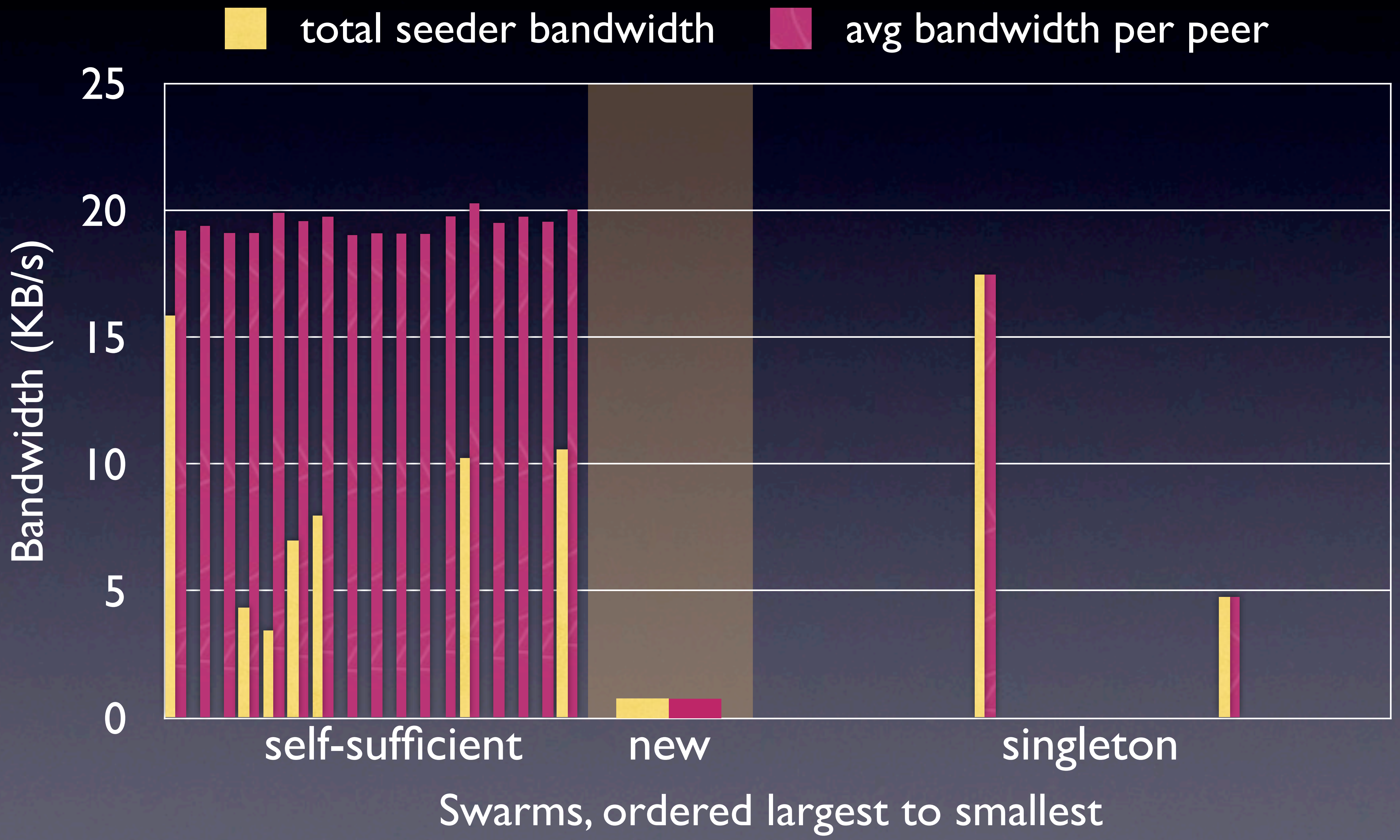
Antfarm Performance



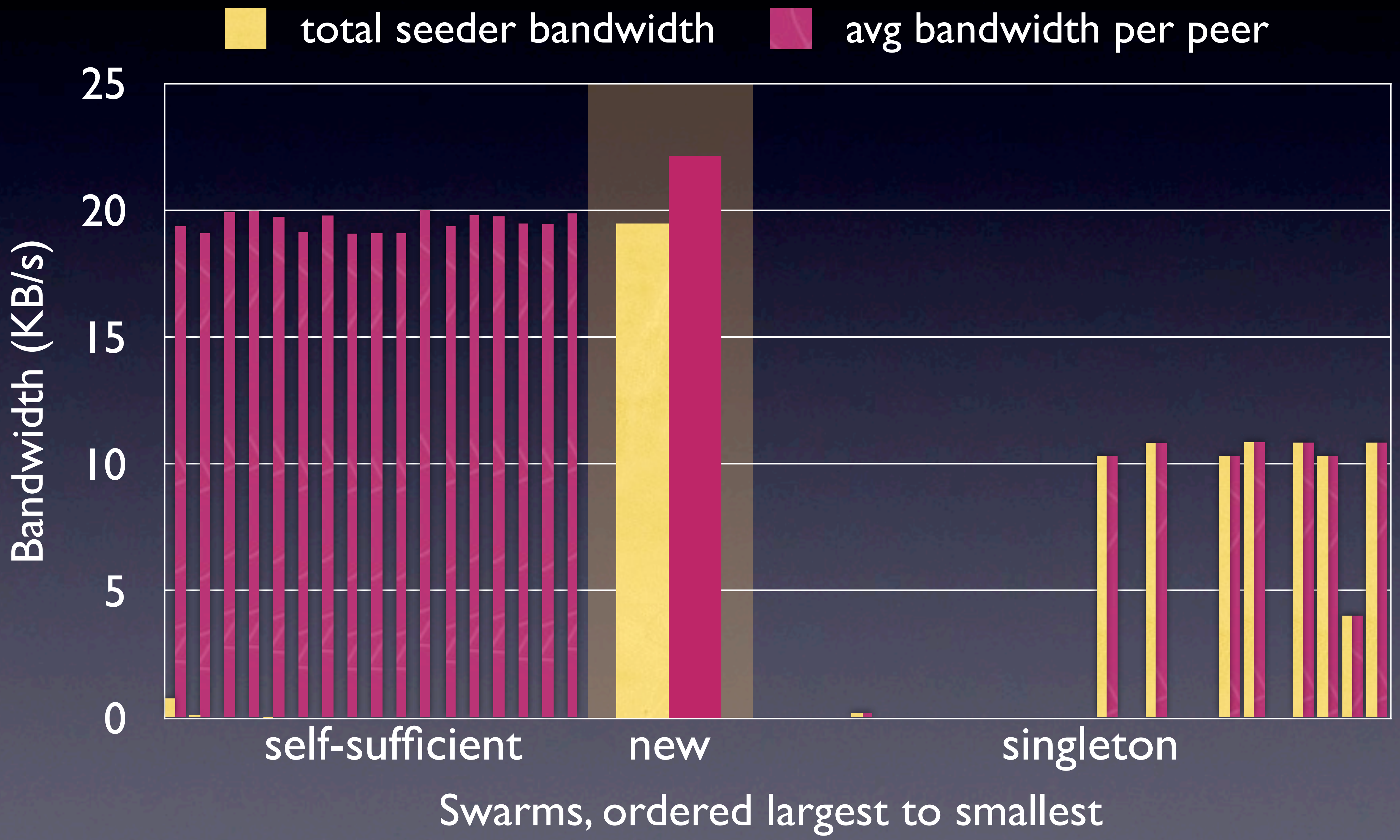
Swarm Starvation



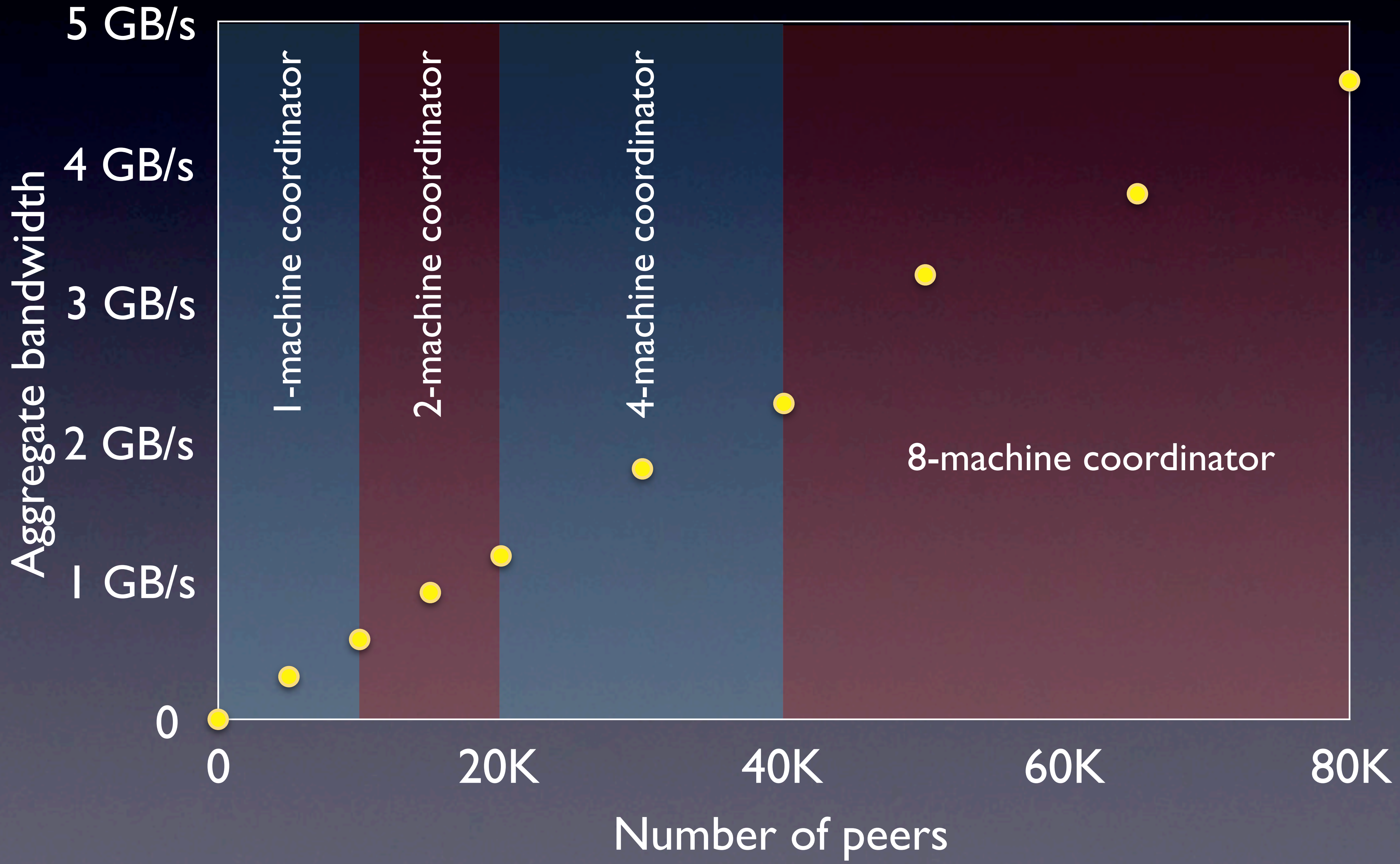
BitTorrent: Starves New Swarm



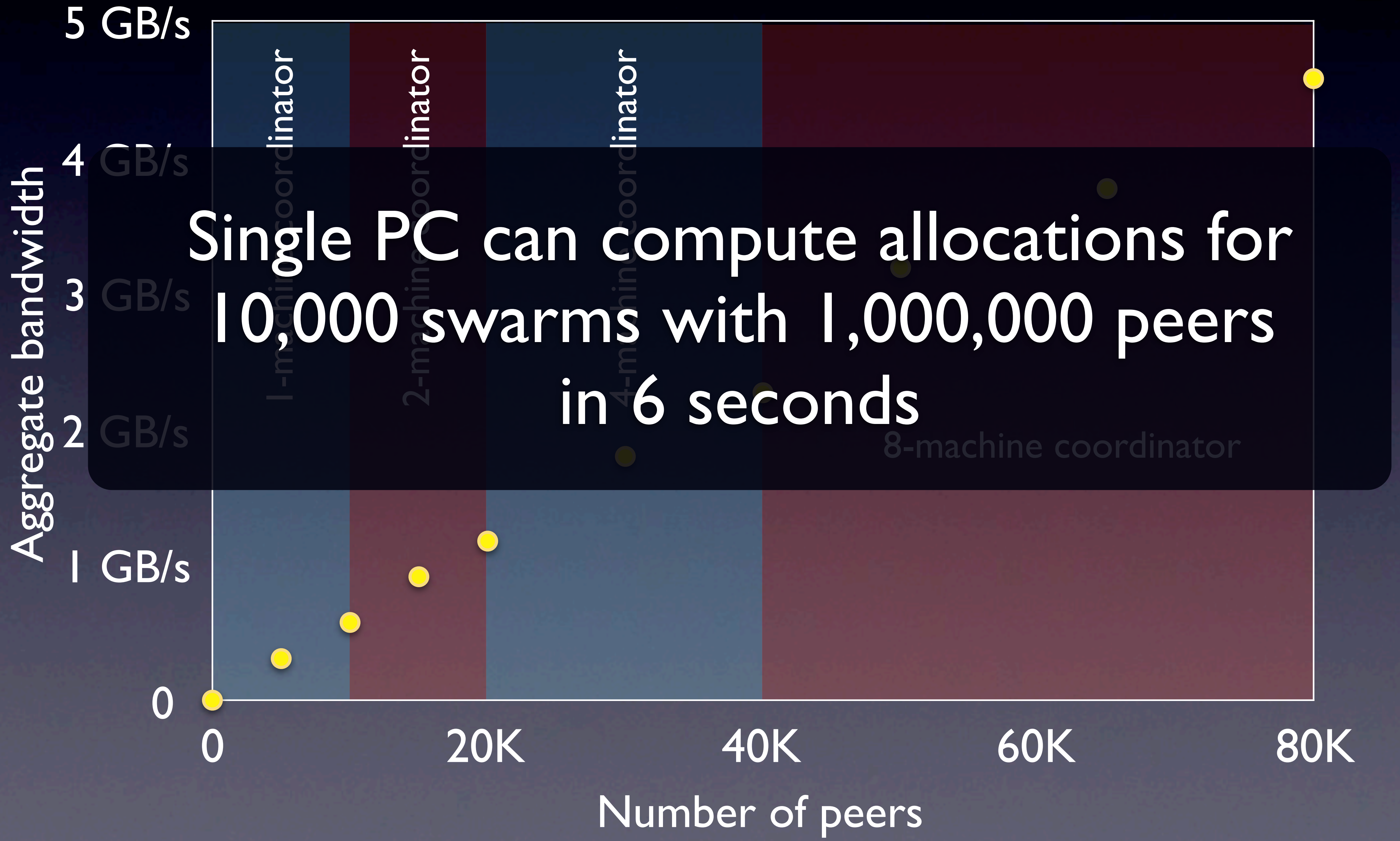
Antfarm: Seeds New Swarm



Scalability



Scalability



Single PC can compute allocations for 10,000 swarms with 1,000,000 peers in 6 seconds

Antfarm Implications

- No fine-tuning
- Subsumes hacks devised for BitTorrent
  - Share ratio
  - Manual pruning

Related Work

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

Conclusions

- Model swarm dynamics and allocate bandwidth optimally
- Novel hybrid architecture
- PlanetLab deployment shows that Antfarm outperforms client-server and P2P

Questions?