OverCite:

A Distributed, Cooperative CiteSeer

Jeremy Stribling, Jinyang Li, Isaac G. Councill,
M. Frans Kaashoek, Robert Morris

MIT Computer Science and Artificial Intelligence Laboratory
UC Berkeley/New York University
Pennsylvania State University

People Love CiteSeer

- Online repository of academic papers
- Crawls, indexes, links, and ranks papers
- Important resource for CS community

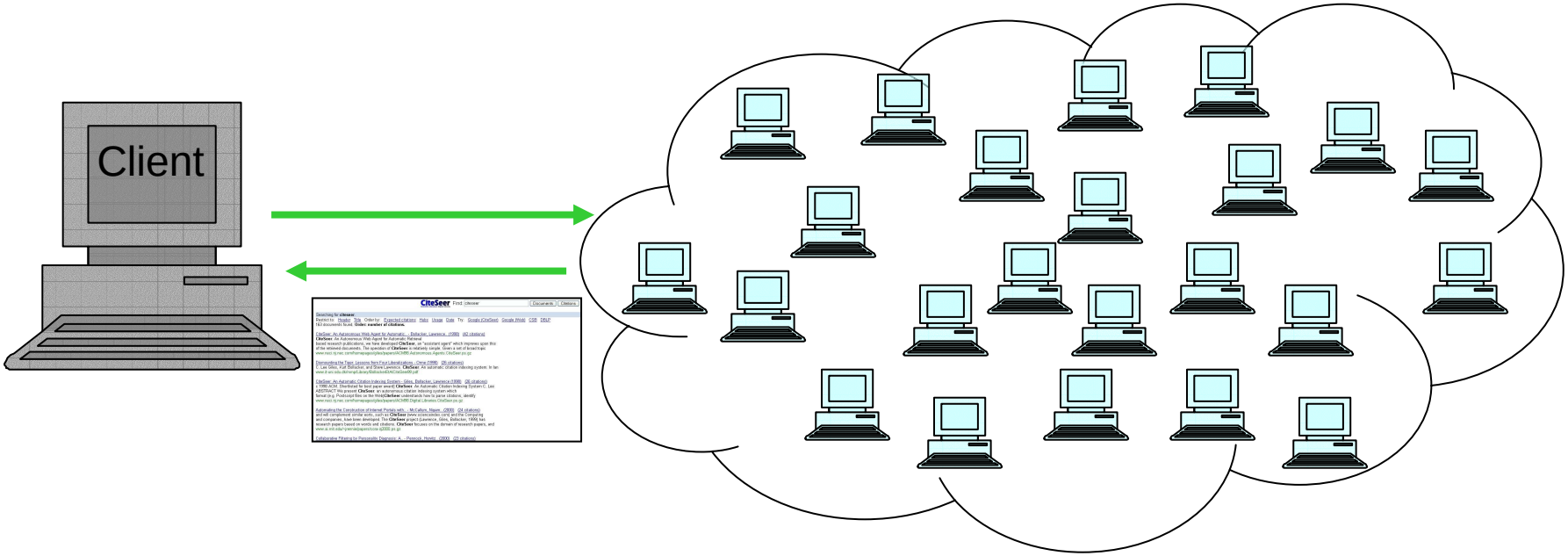
People Love CiteSeer Too Much

- Burden of running the system forced on one site
- Scalability to large document sets uncertain
- Adding new resources is difficult

What Can We Do?

- Solution #1: All your © are belong to ACM
- Solution #2: Donate money to PSU
- Solution #3: Run your own mirror
- Solution #4: Aggregate donated resources

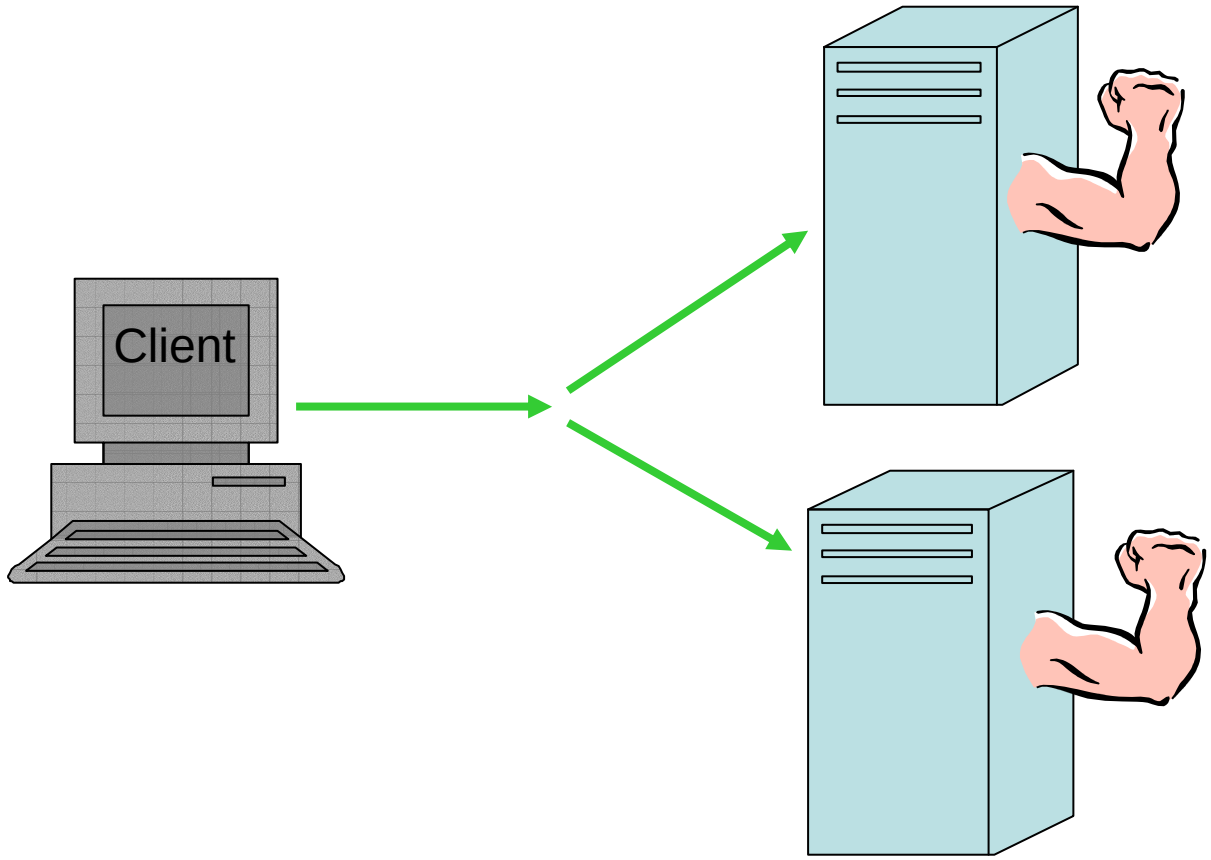
Solution: OverCite



Rest of the talk focuses on how to achieve this

CiteSeer Today: Hardware

- Two 2.8-GHz servers at PSU



CiteSeer Today: Search

Search keywords

CiteSeer Find: citeseer Documents Citations

Searching for **citeseer**.

Restrict to: Header Title Order by: Expected citations Hubs Usage Date Try: Google (CiteSeer) Google (Web) CSB DBLP

163 documents found. **Order: number of citations.**

Results meta-data

CiteSeer: An Autonomous Web Agent for Automatic.. - Bollacker, Lawrence.. (1998) (42 citations)
CiteSeer: An Autonomous Web Agent for Automatic Retrieval
based research publications, we have developed **CiteSeer**, an "assistant agent" which improves upon this
of the retrieved documents. The operation of **CiteSeer** is relatively simple. Given a set of broad topic
www.neci.nj.nec.com/homepages/giles/papers/ACM98.Autonomous.Agents.CiteSeer.ps.gz

Context

Dismounting the Tiger: Lessons from Four Liberalizations - Orme (1998) (26 citations)
C. Lee Giles, Kurt Bollacker, and Steve Lawrence. **CiteSeer**: An automatic citation indexing system. In Ian
www.it-uni.sdu.dk/mmp/Library/BollackerEtAlCiteSeer99.pdf

CiteSeer: An Automatic Citation Indexing System - Giles, Bollacker, Lawrence (1998) (26 citations)
c 1998 ACM. Shortlisted for best paper award] **CiteSeer**: An Automatic Citation Indexing System C. Lee
ABSTRACT We present **CiteSeer**: an autonomous citation indexing system which
format (e.g. Postscript files on the Web)**CiteSeer** understands how to parse citations, identify
www.neci.nj.nec.com/homepages/giles/papers/ACM98.Digital.Libraries.CiteSeer.ps.gz

Automating the Construction of Internet Portals with.. - McCallum, Nigam.. (2000) (24 citations)
and will complement similar eorts, such as **CiteSeer** (www.scienceindex.com) and the Computing
and companies, have been developed. The **CiteSeer** project (Lawrence, Giles, Bollacker, 1999) has
research papers based on words and citations. **CiteSeer** focuses on the domain of research papers, and
www.ai.mit.edu/~jrennie/papers/cora-irj2000.ps.gz

Collaborative Filtering by Personality Diagnosis: A.. - Pennock, Horvitz.. (2000) (23 citations)

CiteSeer Today: Documents

CiteSeer: An Automatic Citation Indexing System (1998) (Make Corrections) (34 citations)
C. Lee Giles, Kurt D. Bollacker, Steve Lawrence
Digital Libraries 98 - The Third ACM Conference on Digital Libraries

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Homepages: C.Giles HPSearch (Update Links)

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Abstract: We present CiteSeer: an autonomous citation indexing system which indexes academic literature in electronic format (e.g. Postscript files on the Web). CiteSeer understands how to parse citations, identify citations to the same paper in different formats, and identify the context of citations in the body of articles. CiteSeer provides most of the advantages of traditional (manuall constructed) citation indexes (e.g. the ISI citation indexes), including: literature retrieval by following... (Update)

Cited by: More
Search Engine-Crawler Symbiosis: Adapting to - Community Interests Gautam
eBizSearch: A Niche Search Engine for e-Business - Lee Giles Yves
Natural Communities in Large Linked Networks - John Hopcroft Omar (2003)

Cited by

Similar documents (at the sentence level):
9.6%: CiteSeer: An Autonomous Web Agent for Automatic.. - Bollacker, Lawrence.. (1998)

Active bibliography (related documents): More All
2.6: Dismounting the Tiger: Lessons from Four Liberalizations - Orme (1998)
0.6: Essays of an Information Scientist: Creativity, Delayed.. - Vo Curre Nt (1989)
0.6: CitEc: an Autonomous Citation Index for Economics - Krichel, Lawrence (1999)

Similar documents based on text: More All
1.6: A System For Automatic Personalized Tracking of.. - Bollacker, Lawrence.. (1999)
1.4: Distributed Error Correction - Lawrence, Bollacker, Giles (1999)
1.4: Autonomous Citation Matching - Lawrence, Giles, Bollacker (1999)

Related documents from co-citation: More All
8: The anatomy of a large-scale hypertextual Web search engine - Brin, Page
6: Citation Indexing: Its Theory and Application in Science (context) - Garfield - 1979
6: Identifying and merging related bibliographic records - Hylton - 1996

BibTeX entry: (Update)

C. Lee Giles, Kurt Bollacker, and Steve Lawrence. CiteSeer: An automatic citation indexing system. In Ian Witten, Rob Akscyn, and Frank M. Shipman III, editors, Digital Libraries 98 - The Third ACM Conference on Digital Libraries, pages 89--98, Pittsburgh, PA, June 23--26 1998. ACM Press. http://citeseer.csail.mit.edu/article/giles98citeseer.html More

```
@inproceedings{ giles98citeseer,
    author = "C. Lee Giles and Kurt Bollacker and Steve Lawrence",
    title = "{CiteSeer}: An Automatic Citation Indexing System",
```

CiteSeer: Local Resources

# documents	675,000 ←
Document storage	803 GB
Meta-data storage	45 GB
Index size	22 GB
Total storage	870 GB ←
Searches	250,000/day ←
Document traffic	21 GB/day
Total traffic	34.4 GB/day ←

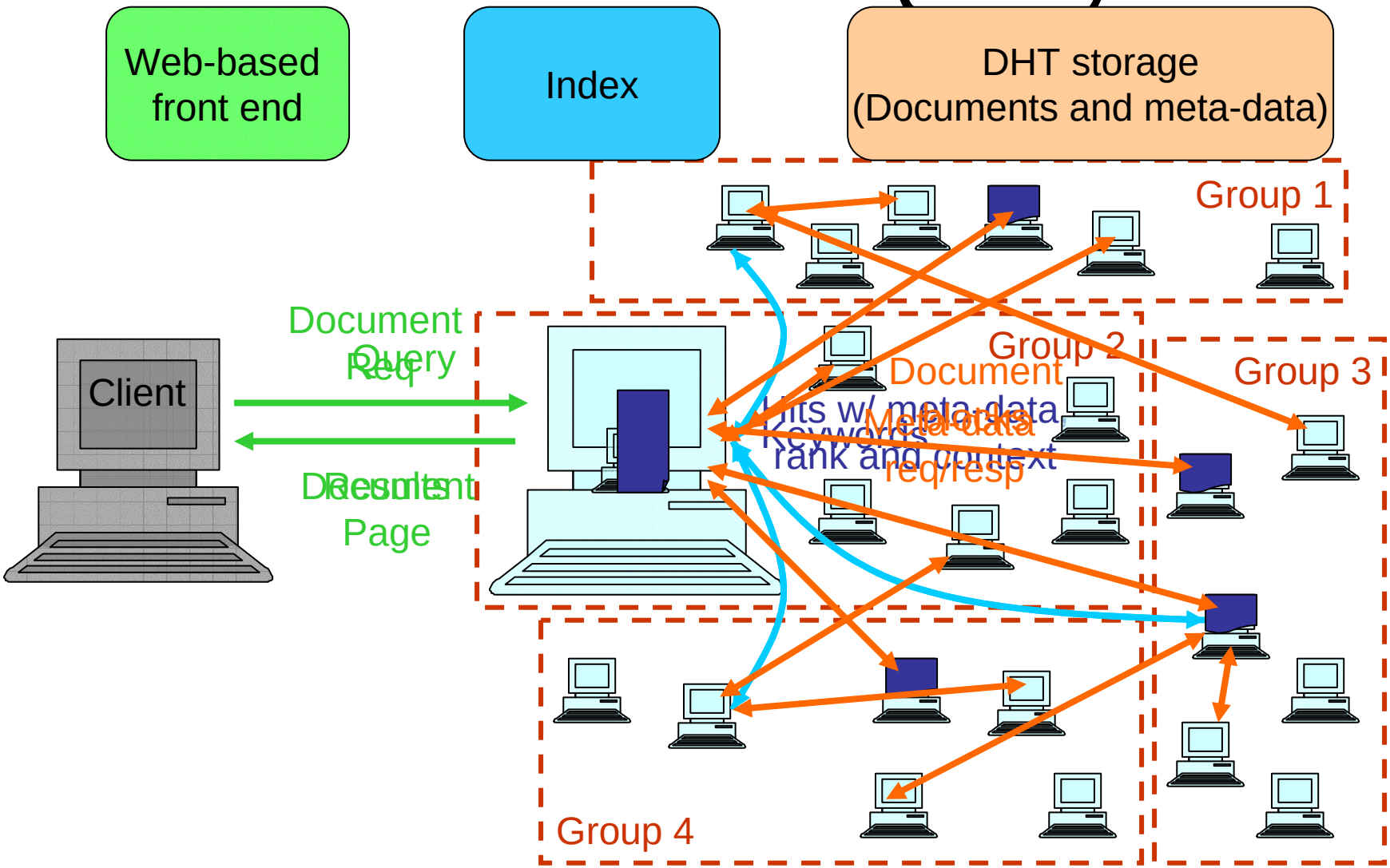
Goals and Challenge

- Goals
  - Parallel speedup
  - Lower burden per site
- Challenge: Distribute work over wide-area nodes
  - Storage
  - Search
  - Crawling

OverCite's Approach

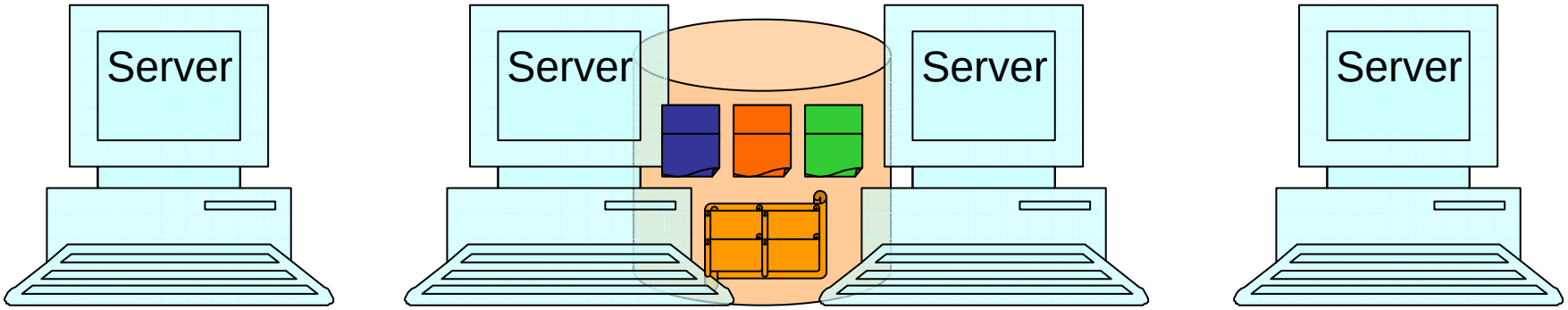
- Storage:
  - Use DHT for documents and meta-data
  - Achieve parallelism, balanced load, durability
- Search:
  - Divide docs into partitions, hosts into groups
  - Less search work per host
- Crawling
  - Coordinate activity via DHT

The Life of a Query



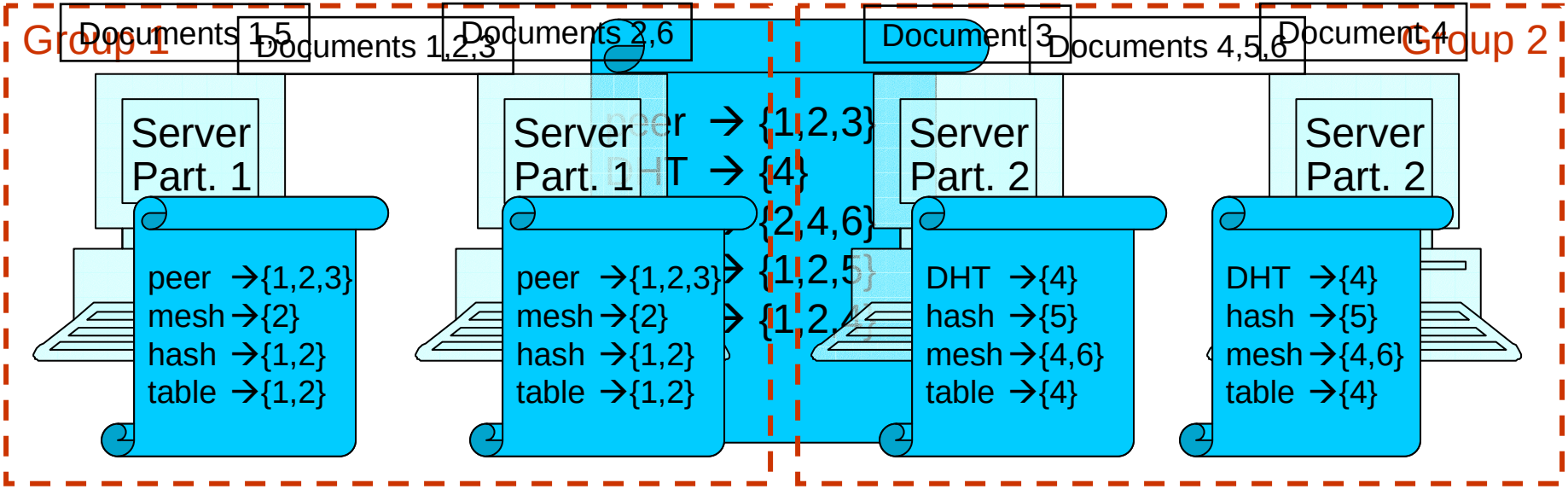
Store Docs and Meta-data in DHT

- DHT stores papers for durability
- DHT stores meta-data tables
  - e.g., document IDs → {title, author, year, etc.}
- DHT provides load-balance and parallelism



Parallelizing Queries

- Partition by document
- Divide the index into *k* partitions
- Each query sent to only *k* nodes



Considerations for *k*

- If *k* is small
  - + Send queries to fewer hosts → less latency
  - + Fewer DHT lookups
  - – Less opportunity for parallelism
- If *k* is big
  - + More parallelism
  - + Smaller index partitions → faster searches
  - – More hosts → some node likely to be slow
  - – More DHT lookups
- Current deployment: *k* = 2

Implementation

- Storage: Chord/DHash DHT
- Index: Searchy search engine
- Web server: OKWS
- Anycast service: OASIS

- Event-based execution, using libasync
- 11,000 lines of C++ code

Deployment

- 27 nodes across North America
  - 9 RON/IRIS nodes + private machines
  - 47 physical disks, 3 DHash nodes per disk
  - Large range of disk and memory

Map source: http://www.coralcdn.org/oasis/servers

Evaluation Questions

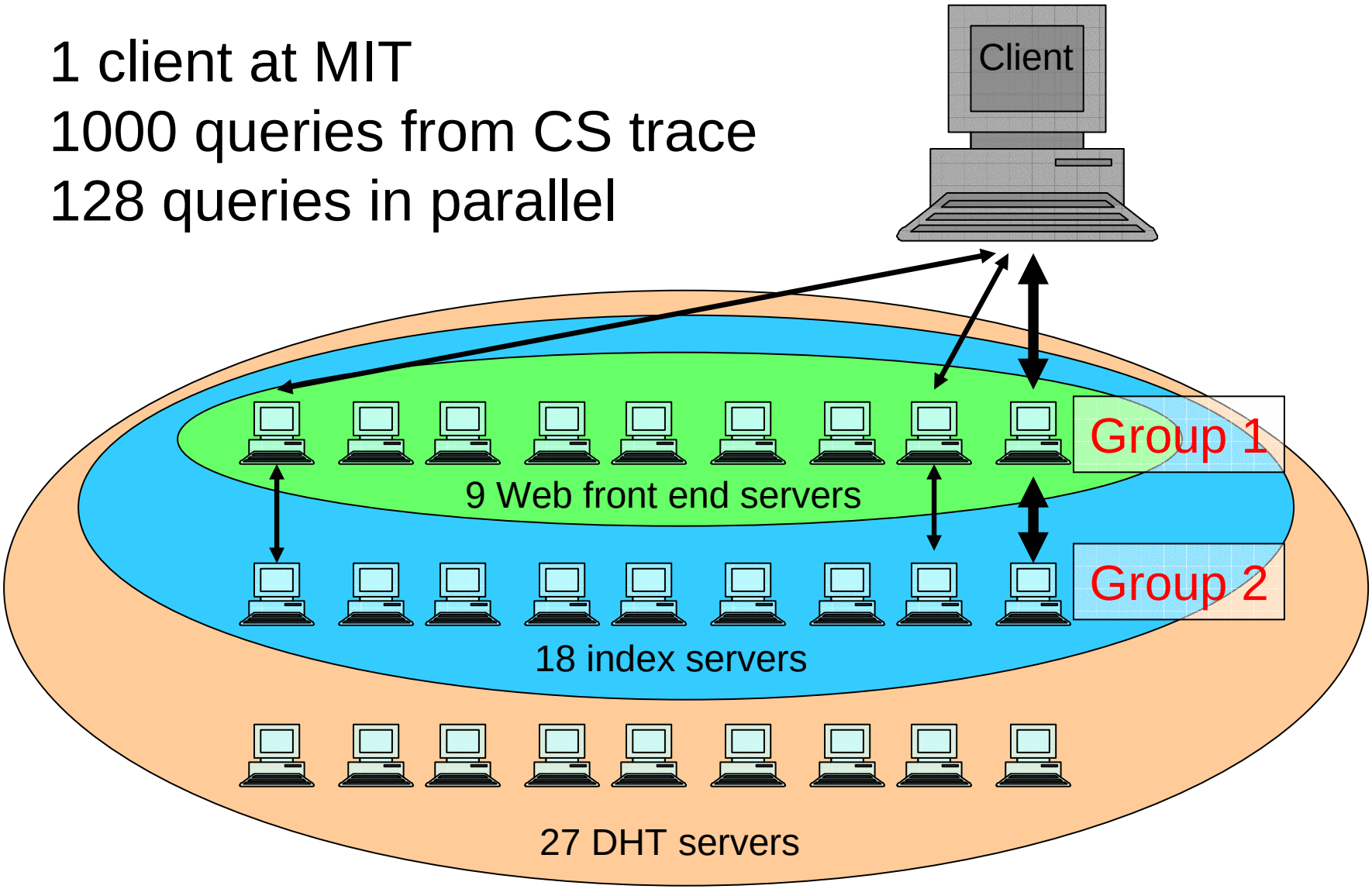
- Does OverCite achieve parallel speedup?
- What is the per-node storage burden?
- What is the system-wide storage overhead?

Configuration

- Index first 5,000 words/document
- 2 partitions (k = 2)
- 20 results per query
- 2 replicas/block in the DHT

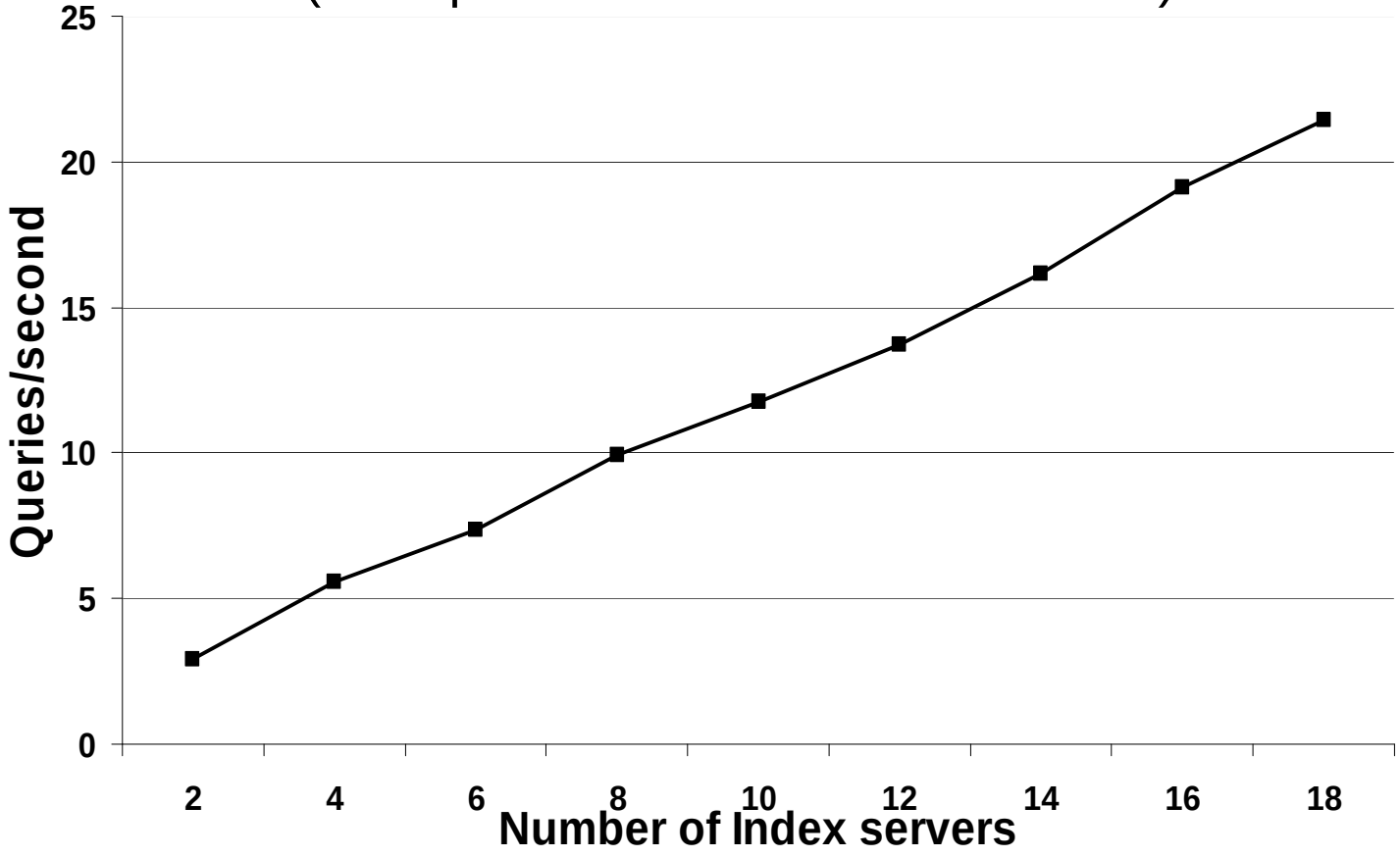
Evaluation Methods

1 client at MIT
1000 queries from CS trace
128 queries in parallel



More Servers → More Queries/sec

(All experiments use 27 DHT servers)



- 9x servers → 7x query throughput
- CiteSeer serves 4.8 queries/sec

Per-node Storage Burden

Property	**Individual Cost**
Document/ meta-data storage	18.1 GB
Index size	6.8 GB
Total storage	24.9 GB

System-wide Storage Overhead

Property	**System Cost**
Document/ meta-data storage	18.1 GB * 47 = **850.7 GB**
Index size	6.8 GB * 27 = **183.6 GB**
Total storage	**1034.3 GB**

4x as expensive as raw underlying data

Future Work

- Production-level public deployment
- Distributed crawler
- Public API for developing new features

Related Work

- Search on DHTs
  - Partition by keyword

    [Li et al. IPTPS ’03, Reynolds & Vadhat Middleware ’03, Suel et al. IWWD ’03]
  - Hybrid schemes

    [Tang & Dwarkadas NSDI ’04, Loo et al. IPTPS ’04, Shi et al. IPTPS ’04, Rooter WMSCI ‘05]
- Distributed crawlers

  [Loo et al. TR ’04, Cho & Garcia-Molina WWW ’02, Singh et al. SIGIR ‘03]
- Other paper repositories

  [arXiv.org (Physics), ACM and Google Scholar (CS), Inspec (general science)]

Summary

- A system for storing and coordinating a digital repository using a DHT
- Spreads load across many volunteer nodes
- Simple to take advantage of new resources
- Run CiteSeer as a community
- Implementation and deployment

http://overcite.org