Bigtable

A Distributed Storage System for Structured Data

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What is Bigtable?

BIG

TABLE

What is Bigtable?

Let's start saying what Bigtable is **NOT**

- **Not** a database
- **Not** a *sharded* database
- **Not** a distributed hashtable

What is Bigtable?

A distributed, persistent, sorted, associative array

(row:string, column: string, time:int64) → string

Why did they implement it?

Quoting Jeff Dean:

- Applications at Google place very different demands on the storage system
- Handle petabytes of data
- Scale to thousands of commodity servers
- Fun

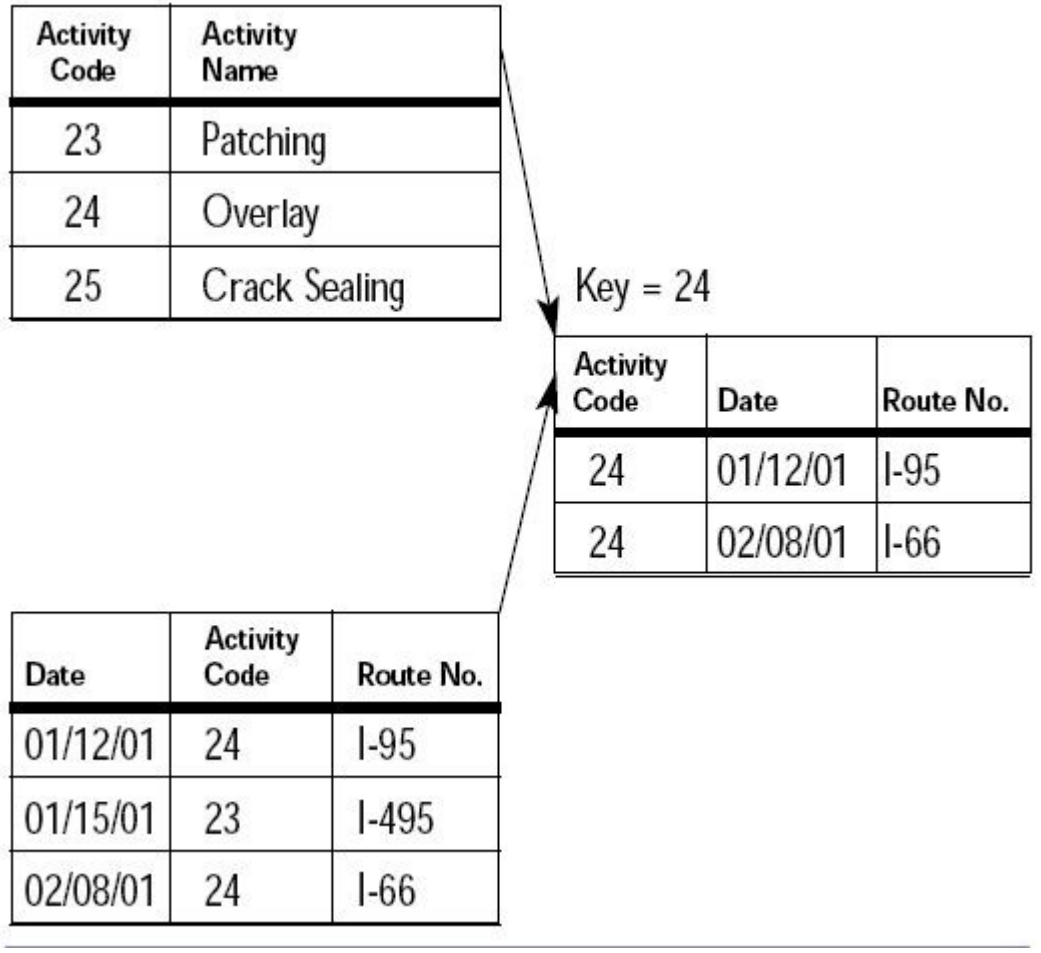
Outline

- Data model
- Architecture
- Use cases
- Performance evaluation
- Great excitement

Data model

Data Model

Remember the Relational Model?



Activity Code	Activity Name
23	Patching
24	Overlay
25	Crack Sealing

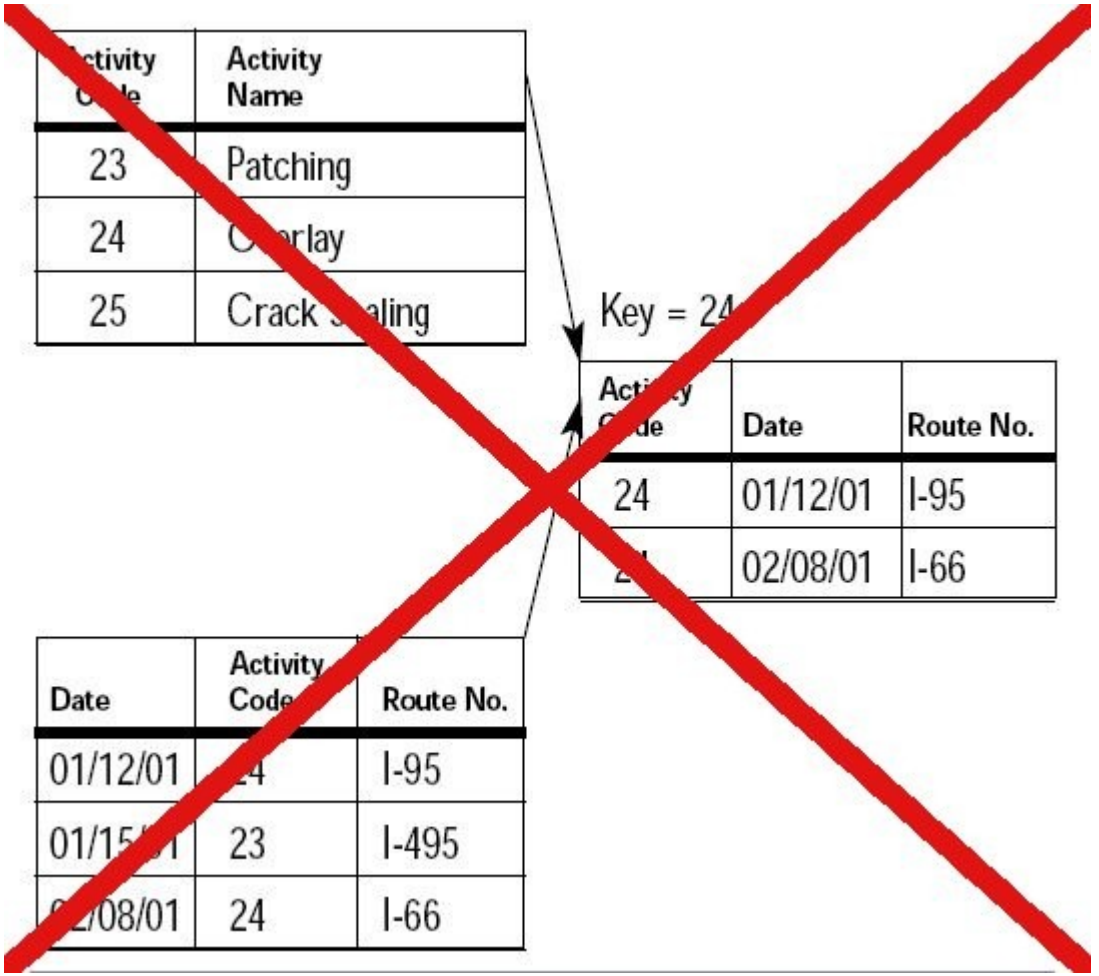
Key = 24

Activity Code	Date	Route No.
24	01/12/01	I-95
24	02/08/01	I-66

Date	Activity Code	Route No.
01/12/01	24	I-95
01/15/01	23	I-495
02/08/01	24	I-66

Data Model

Forget it!



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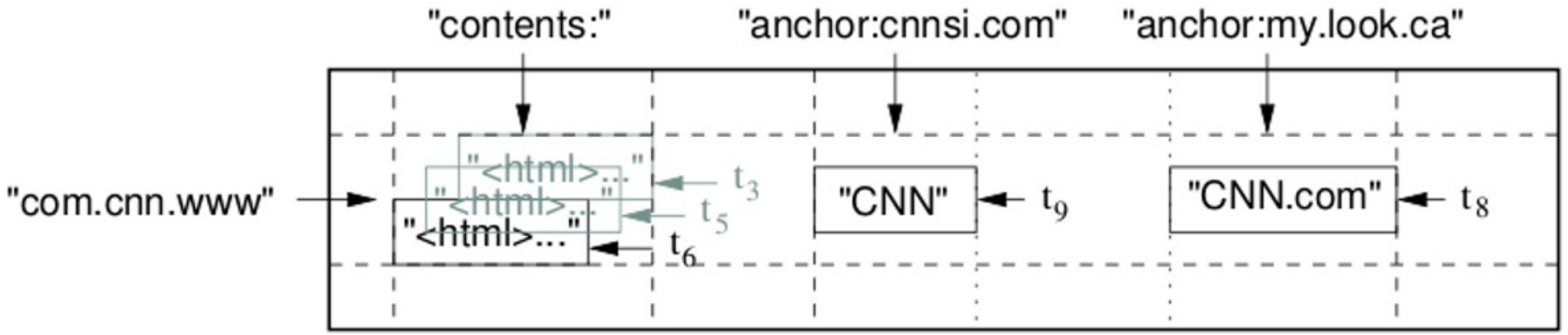
Data Model

Simpler than the Relational Model:
Dynamic control over data layout

Data Model



Indexed by: row key, column key, timestamp

Data Model

Data is maintained in lexicographic order by row key

- Allows (forces) developers to reason about the locality properties of their data
- Reads of short row ranges are efficient and require communication with a small number of machines

Data Model

Row range for a table dynamically partitioned

- Partitions are called **TABLETS**
- 1 GFS file per tablet
- Unit of distribution and load balancing

Data Model

- Reads/writes under a single row key are atomic
- Timestamps can be used to store multiple versions of the same item: garbage collection

Architecture

Architecture

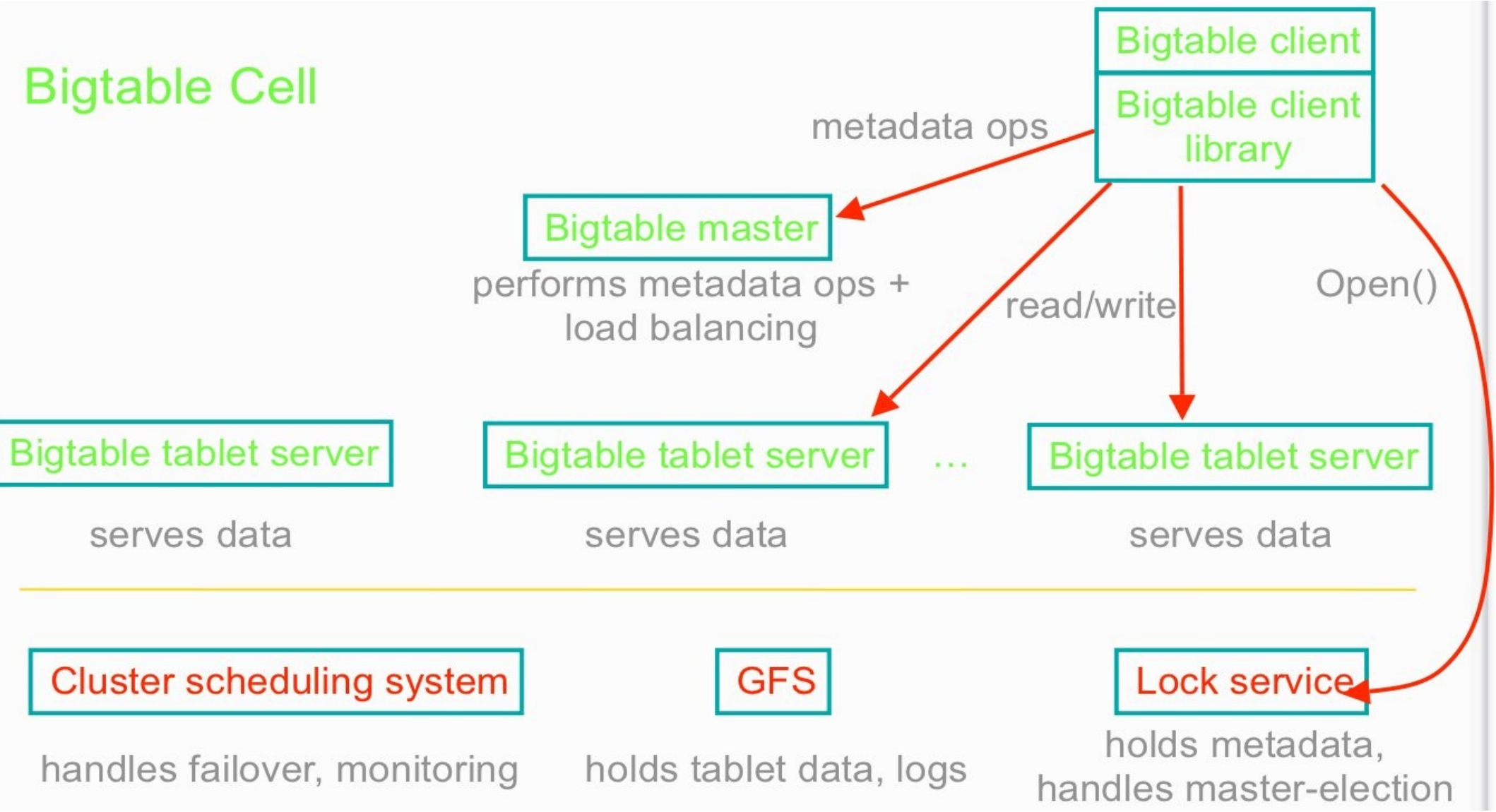
Building blocks:

- Google File System
- Cluster scheduling system
- Chubby: High available, persistent, distributed lock service

Architecture

1 master server,
N tablet servers

Architecture



Architecture

The tablet server

- Can be dynamically added or removed from a cluster according to changes in the workload
- Manages a set of N tablets (10 < N < 1000)
- Handles reads / writes to rows located in its tablets
- Splits tablets that have grown too large

Architecture

The master server

- Assigns tablets to tablets servers
- Detects when a tablet server joins / leaves
- Balances tablet ↔ server load

Architecture

The poor master is usually...
Quite bored.

Use Cases

Use Cases

- Web indexing
- Gmail
- Youtube
- Google Maps, Earth, Reader, Code
- …
- **Google App Engine**

Performance Evaluation

Performance Evaluation

Experimental Setup

- N tablet servers
- Huge GFS cell: 1786 machines, 2x 400 GB disks each

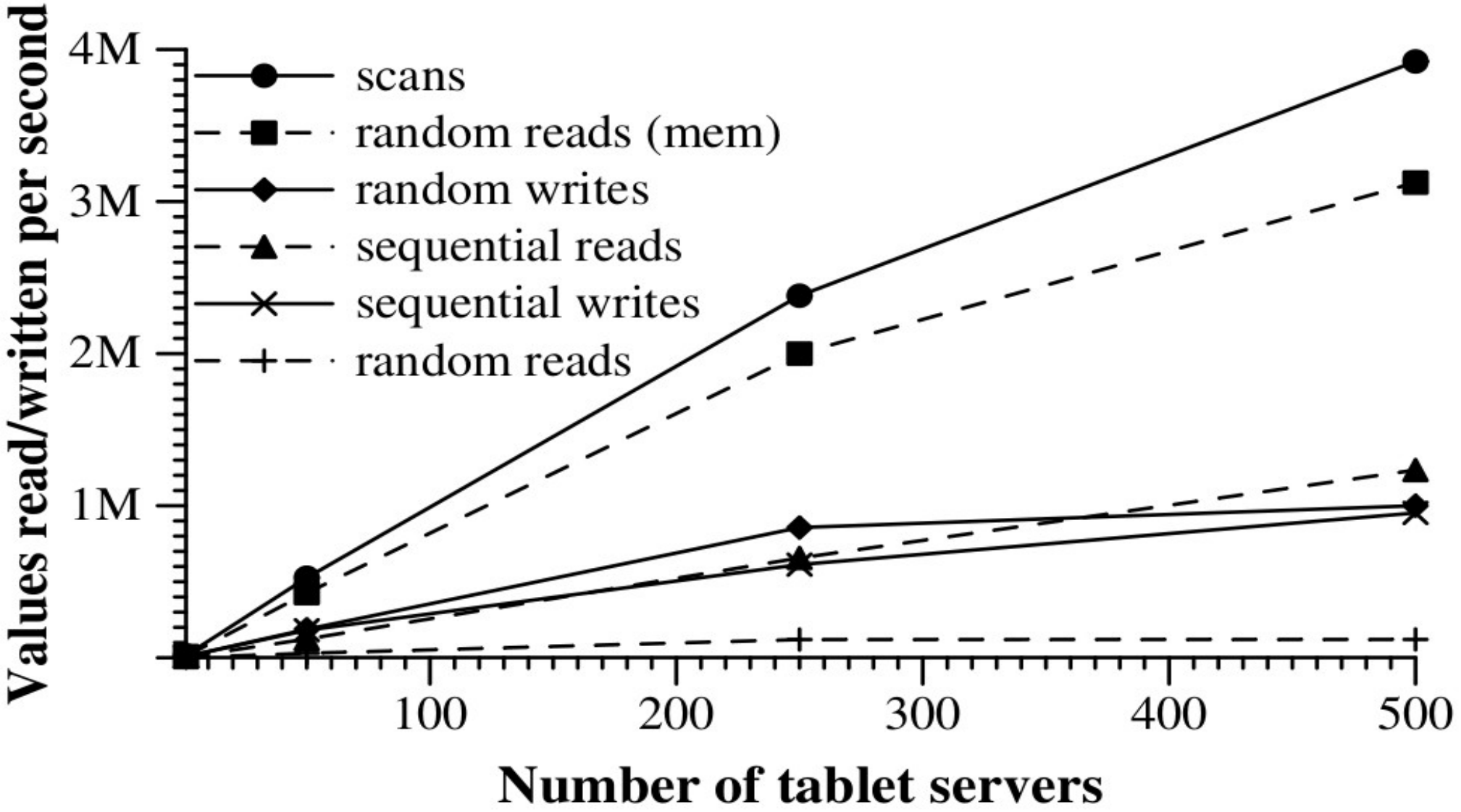
Performance Evaluation

Benchmarks

- Sequential write
- Sequential read
- Random write
- Random read
- Scan

Performance Evaluation

Bigger values are better



Performance Evaluation

- Scans are superfast: RPC overhead is amortized
- Random reads from memory also scale very well
- Random reads from GFS show the worst scaling

Why did they implement it?

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Conclusions

Bigtable scales to petabytes of data across thousands of commodity Linux servers

Developers can have an hard time adapting to different models

Google's structured storage needs are satisfied

```
class Person(db.Expando):
    name = db.StringProperty()
    surname = db.StringProperty()

def person_example():
    ema = Person(name="Emanuele", surname="Rocca")
    ema.wears_glasses = True

    john = Person(name="John", surname="Smith")
    john.comes_from = "Malta"

    ema.put()
    john.put()

    for person in Person.all():
        print person.name, person.surname

    print Person.all().filter("wears_glasses", True).count(), "with glasses"
    print Person.all().filter("comes_from", "Malta").count(), "from Malta"
    print Person.all().filter("comes_from", "Italy").count(), "from Italy"


"feeds/models.py" 121L, 3066C written
```

```
help      -> Python's own help system.
object?   -> Details about 'object'. ?object also works, ?? prints more.

In [1]: import feeds.models

In [2]: feeds.models.person_example()
Emanuele Rocca
John Smith
1 with glasses
1 from Malta
0 from Italy
```