CS 744: BIG DATA SYSTEMS

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ADMINISTRIVIA

- Assignment 1
- Projects
- Piazza

MOTIVATION

Storing large amounts of semi-structured data

- Traditionally done using database systems

Varied processing needs

- low latency to bulk processing
- data size
- schema

BIGTABLE: HIGHLIGHTS

1. Scalability: Petabytes of data, thousands of machines

2. Wide applicability: Handles > 60 applications

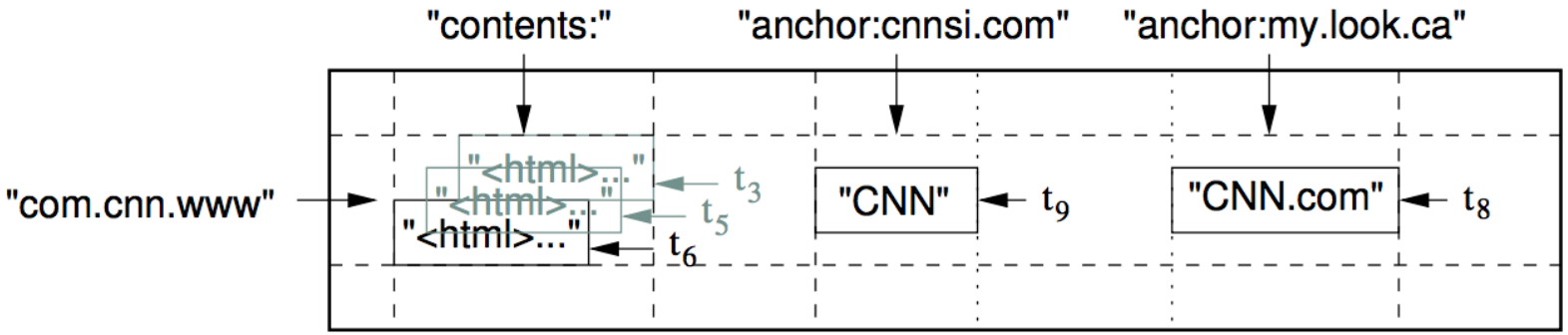
3. Fault tolerant: High availability

4. High Performance

OUTLINE

- Data Model and API
- Architecture
- Master, Tabletserver functionality
- Optimizations

DATA MODEL



Rows

Column Families

Versions
“Timestamps”

WRITE API

Single row at a time!

Set a number of columns or delete some

Apply is atomic

Support for read-modify-write transactions

```
// Open the table
Table *T = OpenOrDie("/bigtable/web/webtable");

// Write a new anchor and delete an old anchor
RowMutation r1(T, "com.cnn.www");
r1.Set("anchor:www.c-span.org", "CNN");
r1.Delete("anchor:www.abc.com");
Operation op;
Apply(&op, &r1);
```

SCAN API

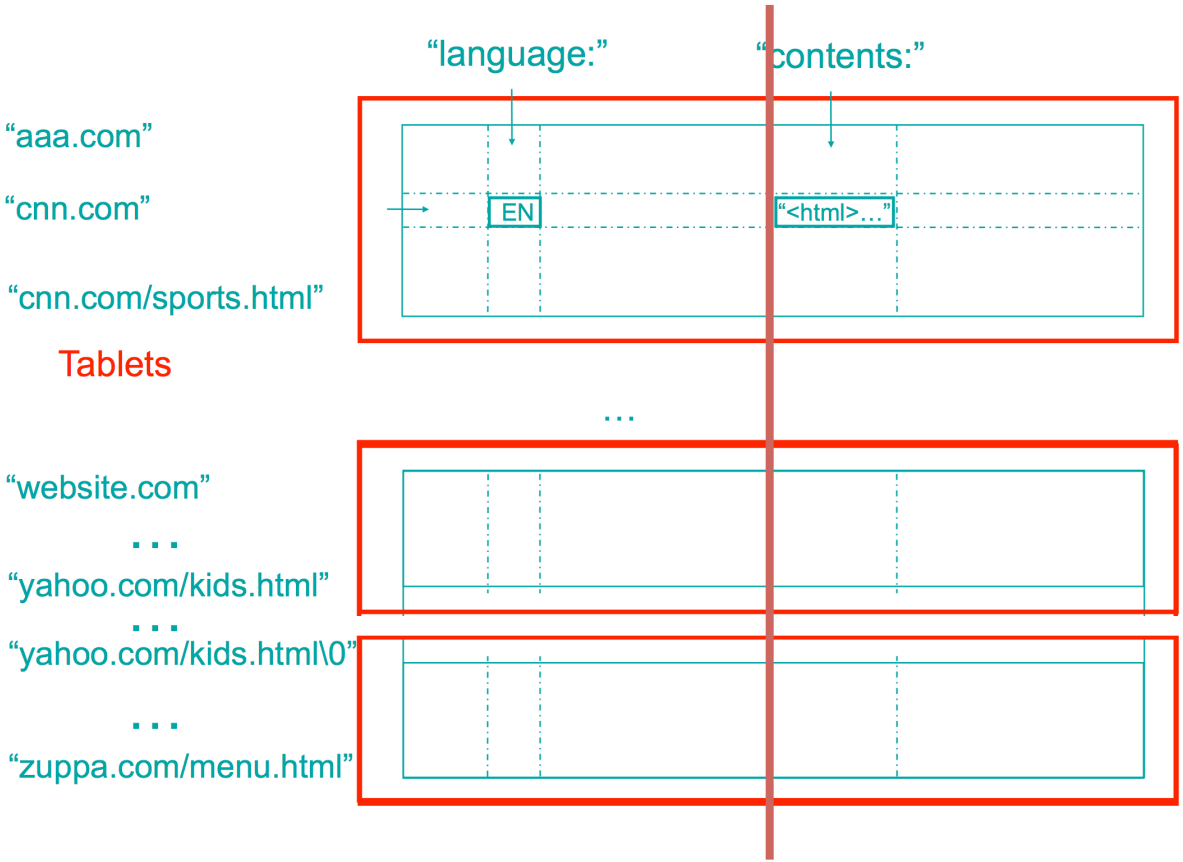
Fetch any number of columns, column families

Filter rows by regex

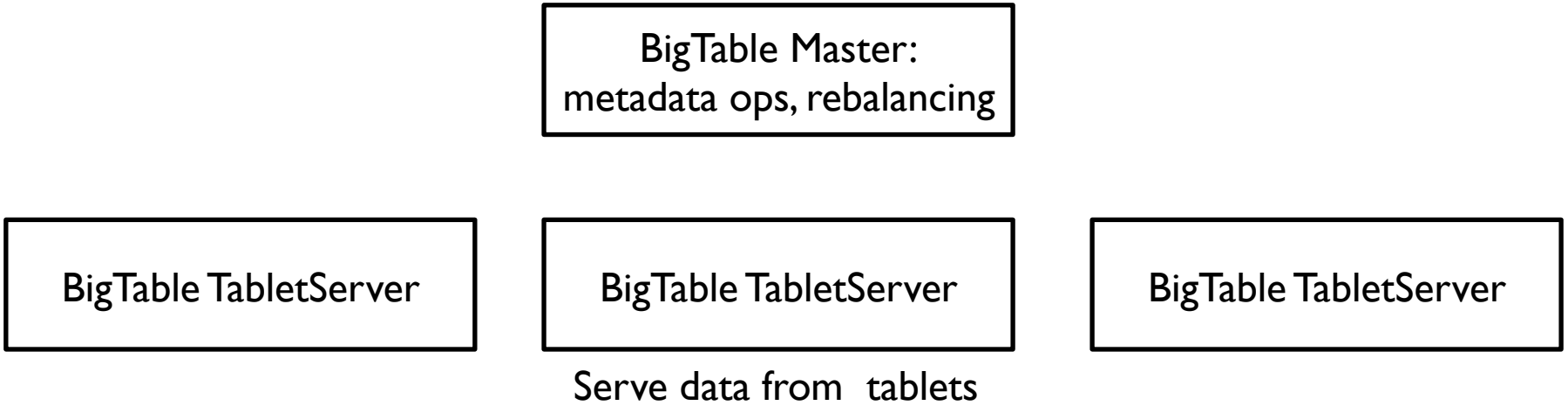
Iterator pattern, rows arriving in sorted order

```
Scanner scanner(T);
ScanStream *stream;
stream = scanner.FetchColumnFamily("anchor");
stream->SetReturnAllVersions();
scanner.Lookup("com.cnn.www");
for (; !stream->Done(); stream->Next()) {
  printf("%s %s %lld %s\n",
         scanner.RowName(),
         stream->ColumnName(),
         stream->MicroTimestamp(),
         stream->Value());
}
```

TABLETS


“language:”
“contents:”
“aaa.com”
“cnn.com”
“cnn.com/sports.html”
EN
“<html>…”
Tablets
…
“website.com”
. . .
“yahoo.com/kids.html”
. . .
“yahoo.com/kids.html\0”
. . .
“zuppa.com/menu.html”

SYSTEM ARCHITECHTURE



CHUBBY: A LOCK SERVICE

Leader election: Classic problem in distributed systems

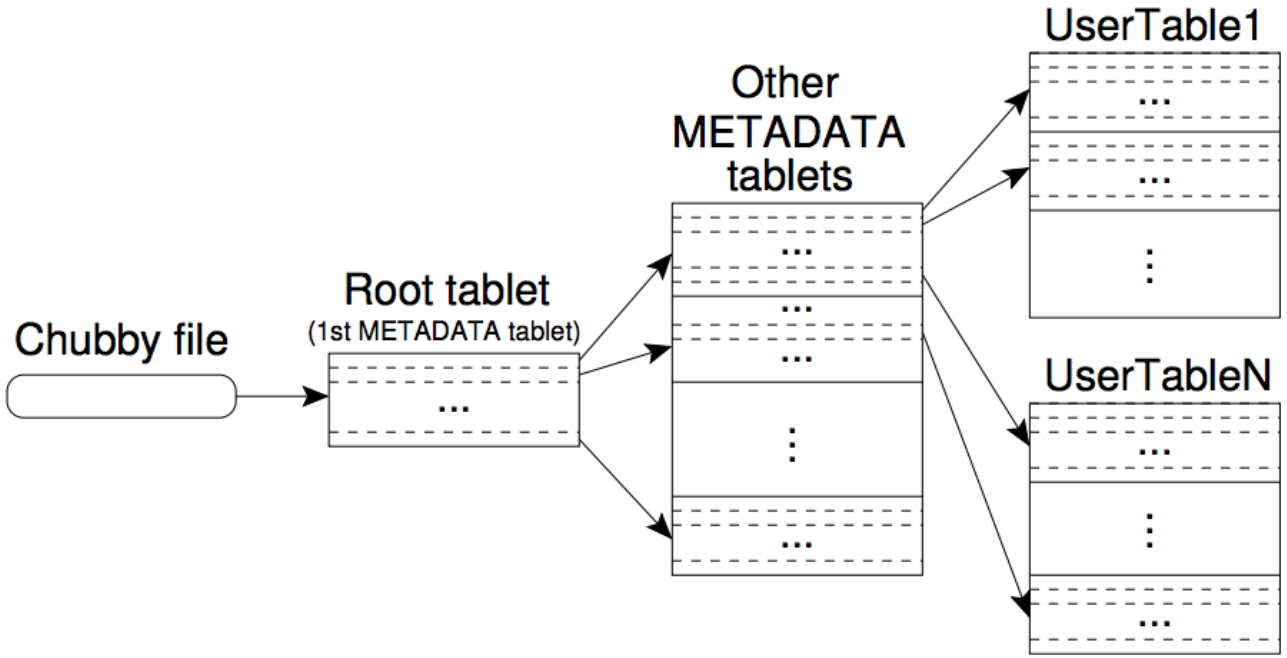
Approach: Build a separate service to handle leader election

Properties:

- Uses Paxos algorithm
- Low write throughput
- Store small amounts of data

TABLET LOCATION

- Hierarchical metadata
- Root of metadata in Chubby
- Client library caches tablet locations



MASTER FUNCTIONALITIES

Tablet assignment

- Master tracks tablet → tablet server mapping
- `METADATA` has the complete list of tablets
- Each tabletserver has list of tablets that are being served

- Uses heartbeat + Chubby to detect tablet server failures
- On master failure, scan `METADATA` and list tablet servers

WORKER FUNCTIONALITY

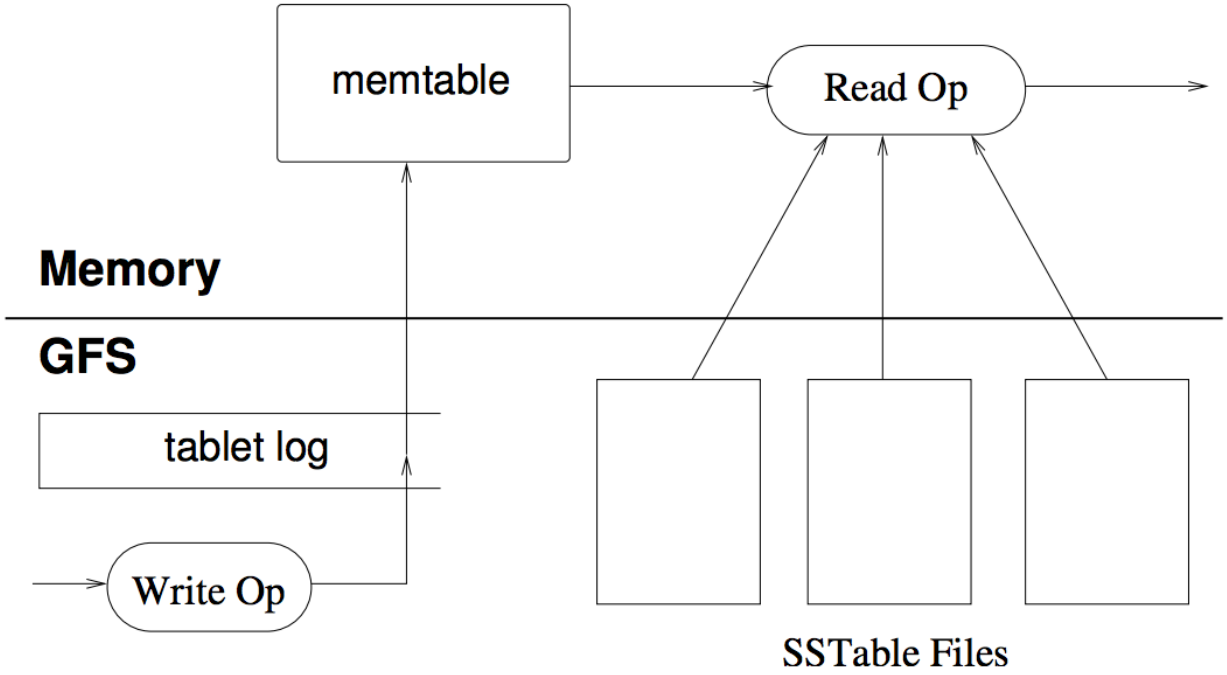
Tablets stored in GFS

Writes

- Commit log
- Insert memtable

Read

- Merge SSTable and memtable



WORKER FUNCTIONALITY

Challenge: Memtable keeps growing over time

Minor Compaction

- Freeze memtable, write it as SSTable to disk
- But now need to merge more SSTables

Major Compaction

- Read memtable + all SSTables for this tablet
- Write out new SSTable. Handles garbage collection

NOTABLE OPTIMIZATIONS

Caching

- Scan Cache: key-value pairs returned by the SSTable
- Block Cache: SSTables blocks that were read from GFS.

Bloom filter

- Probabilistic data structure: Definitely not or maybe in it
- Use this to eliminate SSTables that need to be read

OTHER OPTIMIZATIONS

- Single commit log per tabletserver
- Sort commit log entries during recovery

- Tablet Splitting
  - Tablet server records changes in METADATA table
  - Child tablets share SSTables with parent

BigTable Replication (New Since OSDI'06)

LADIS (2009)

- Configured on a per-table basis
- Typically used to replicate data to multiple bigtable clusters in different data centers
- *Eventual consistency model*: writes to table in one cluster eventually appear in all configured replicas
- Nearly all user-facing production uses of BigTable use replication

BIGTABLE: DISCUSSION

Generality vs. Specificity

Simplicity, Layering

Scalability

User overheads

QUESTIONS / DISCUSSION ?