BigTable

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BigTable

In the early 2000s, Google had *way* more data than anybody else did

Traditional databases couldn't scale

Want something better than a filesystem (GFS)

BigTable optimized for:

- Lots of data, large infrastructure
- Relatively simple queries

Relies on Chubby, GFS (next time)

Chubby

Chubby

Distributed coordination service

Goal: allow client applications to synchronize and manage dynamic configuration state

Intuition: only some parts of an app need consensus!

- Lab 2: Highly available view service
- Master election in a distributed FS (e.g. GFS)
- Metadata for sharded services

Implementation: (Multi-)Paxos SMR

Why Chubby?

Many applications need coordination (locking, metadata, etc).

> Every sufficiently complicated distributed system contains an ad-hoc, informally-specified, bug-ridden, slow implementation of Paxos

Paxos is a known good solution

(Multi-)Paxos is hard to implement and use

How to do consensus as a service

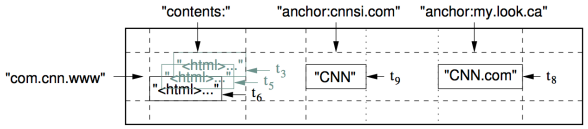
Chubby provides:

- Small files
- Locking
- "Sequencers"

Filesystem-like API

- Open, Close, Poison
- GetContents, SetContents, Delete
- Acquire, TryAcquire, Release
- GetSequencer, SetSequencer, CheckSequencer

Back to BigTable



Uninterpreted strings in rows and columns

(r : string) -> (c : string) -> (t : int64) -> string

Mostly schema-less; column “families” for access

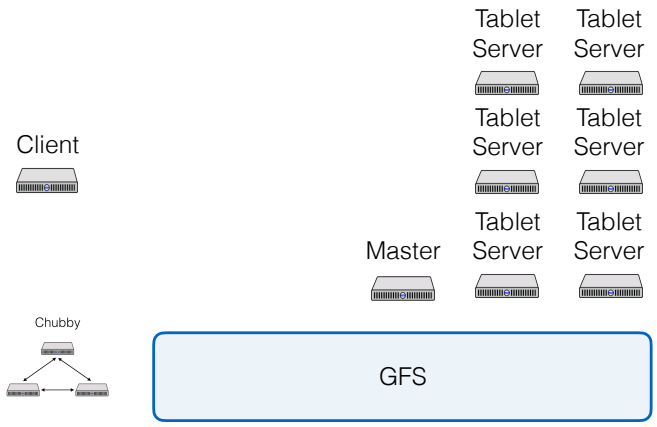
Data sorted by row name

- lexicographically close names likely to be nearby

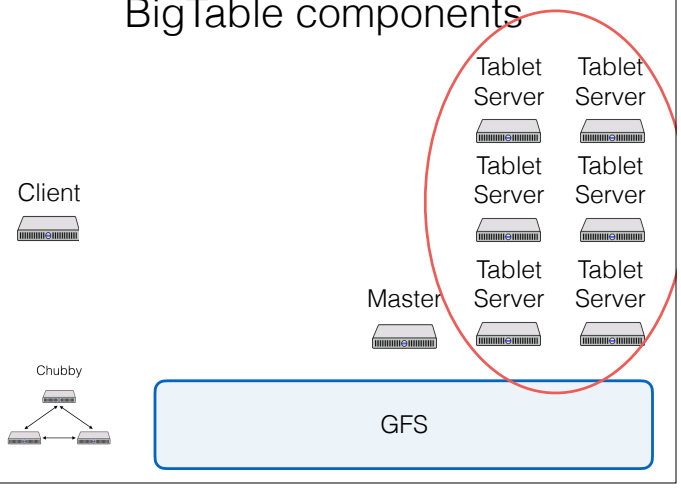
Each piece of data versioned via timestamps

- Either user- or server-generated
- Control garbage-collection

BigTable components



BigTable components



Tablets

a	*data*
b	*data*
c	*data*
d	*data*

Each table composed of one or more tablets

Starts at one, splits once it’s big enough

- Split at row boundaries

Tablets ~100MB-200MB

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Tablets

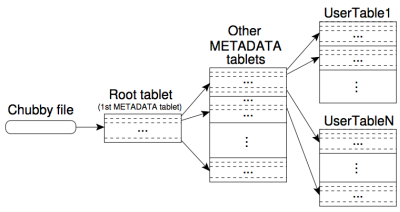
A tablet is indexed by its range of keys

- <START> - "c"
- "c" - <END>

Each tablet lives on at most one tablet server

Master coordinates assignments of tablets to servers

Tablets



Tablet locations stored in METADATA table

Root tablet stores locations of METADATA tablets

Root tablet location stored in Chubby

Tablet serving

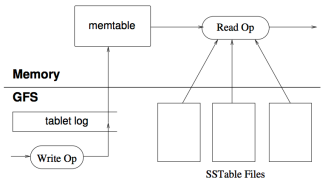
Tablet data persisted to GFS

- GFS writes replicated to 3 nodes
- One of these nodes should be the tablet server!

Three important data structures:

- memtable: in-memory map
- SSTable: immutable, on-disk map
- Commit log: operation log used for recovery

Tablet serving



Writes go to the commit log, then to the memtable

Reads see a merged view of memtable + SSTables

- Data could be in memtable or on disk
- Or, some columns in each

Compaction and compression

Memtables spilled to disk once they grow too big

- "minor compaction": converted to SSTable

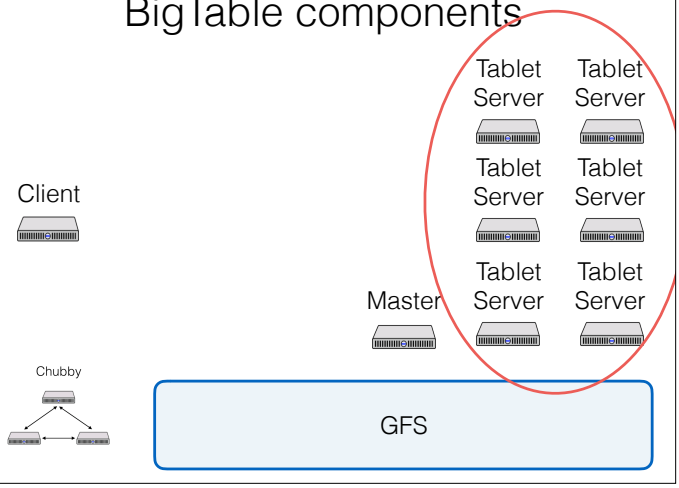
Periodically, all SSTables for a tablet compacted

- "major compaction": many SSTables -> one

Compression: each block of an SSTable compressed

- Can get enormous ratios with text data
- Locality helps—similar web pages in same block

BigTable components



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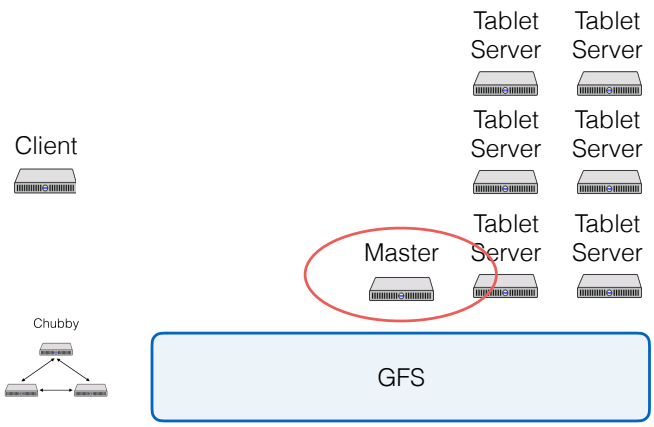


Master

Tracks tablet servers (using Chubby)

Assigns tablets to servers

Handles tablet server failures

Master startup

- Acquire master lock in Chubby

- Find live tablet servers (each tablet server writes its identity to a directory in Chubby)

- Communicate with live servers to find out who has which tablet

- Scan METADATA tablets to find unassigned tablets

Master operation

Detect tablet server failures

- Assign tablets to other servers

Merge tablets (if they fall below a size threshold)

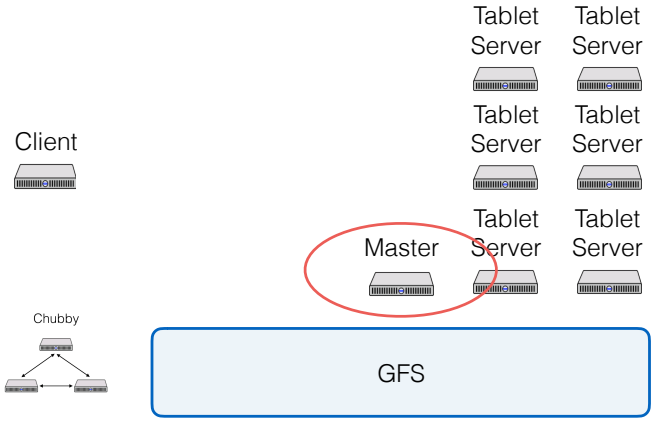
Handle split tablets

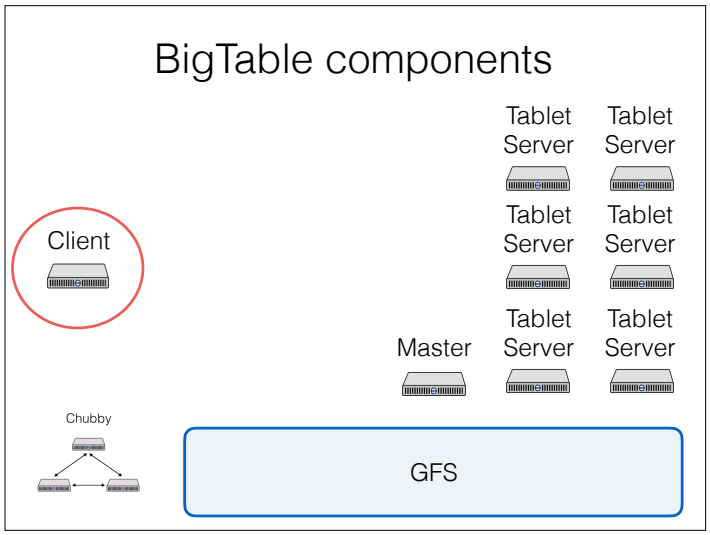
- Splits initiated by tablet servers

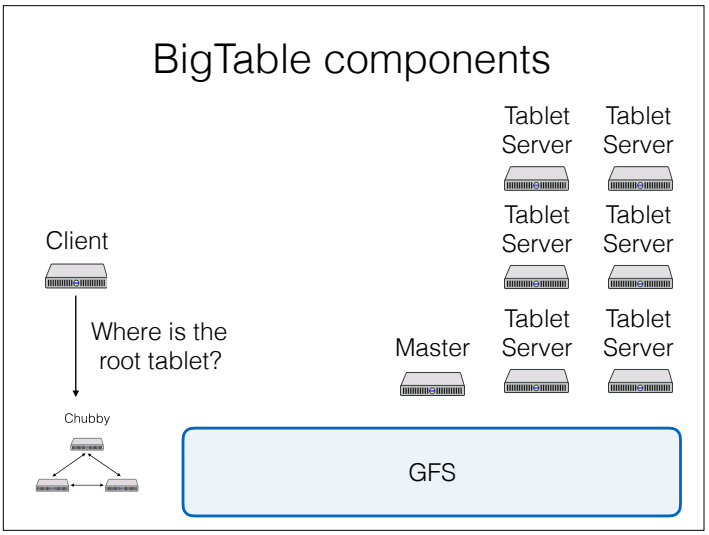
- Master responsible for assigning new tablet

Clients never read from master (why?)

BigTable components




BigTable components
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Client
Master
Chubby
GFS


BigTable components
Tablet Server
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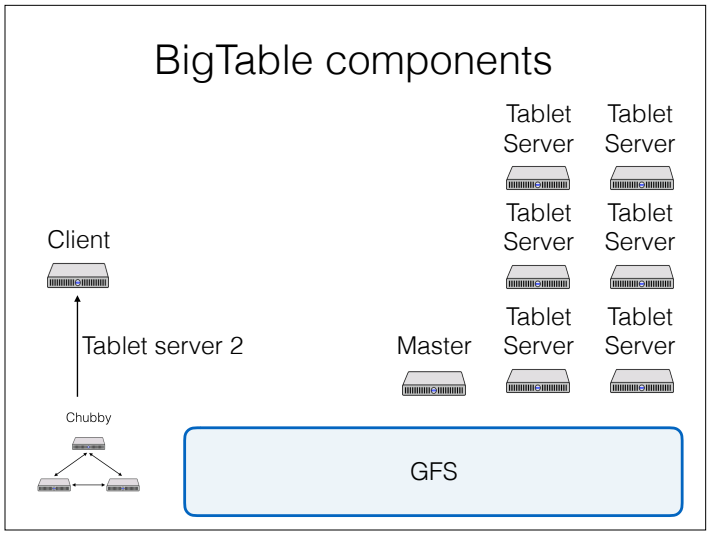
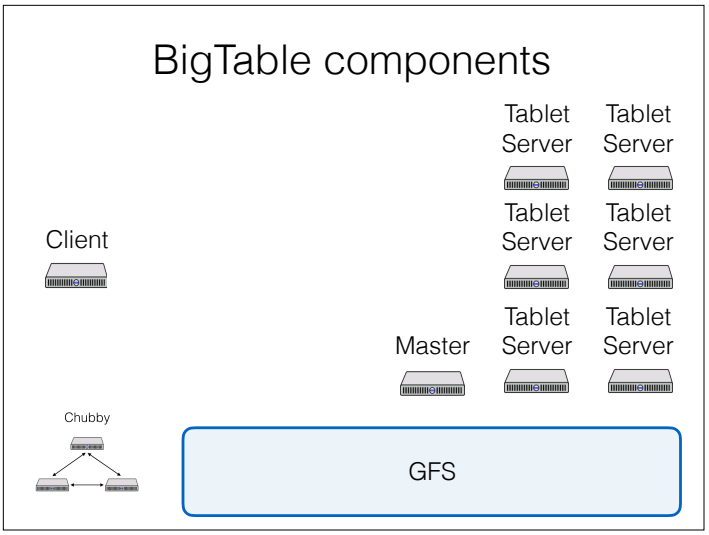
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Client
Where is the root tablet?
Master
Chubby
GFS


BigTable components
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Client
Tablet server 2
Master
Chubby
GFS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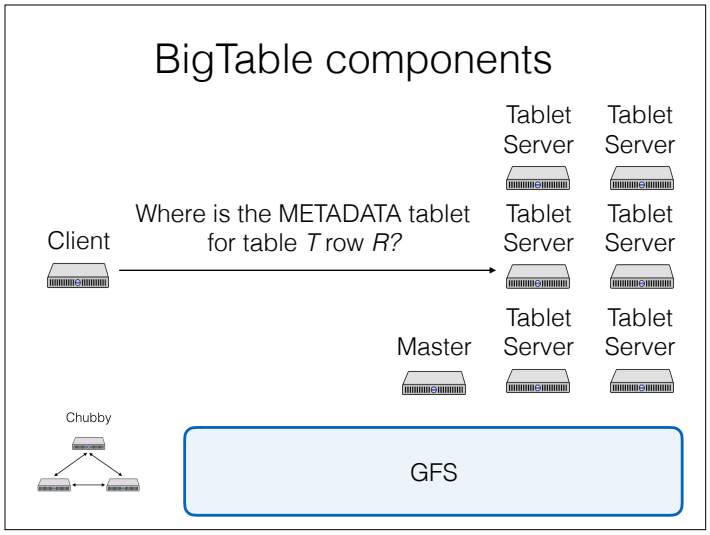
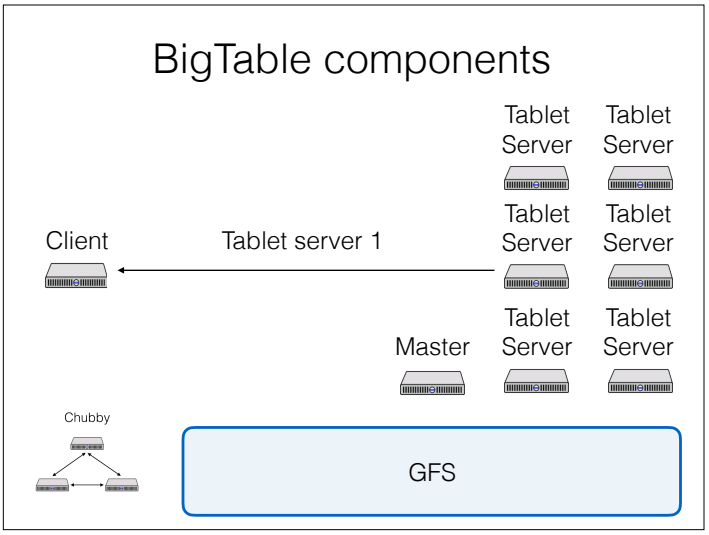
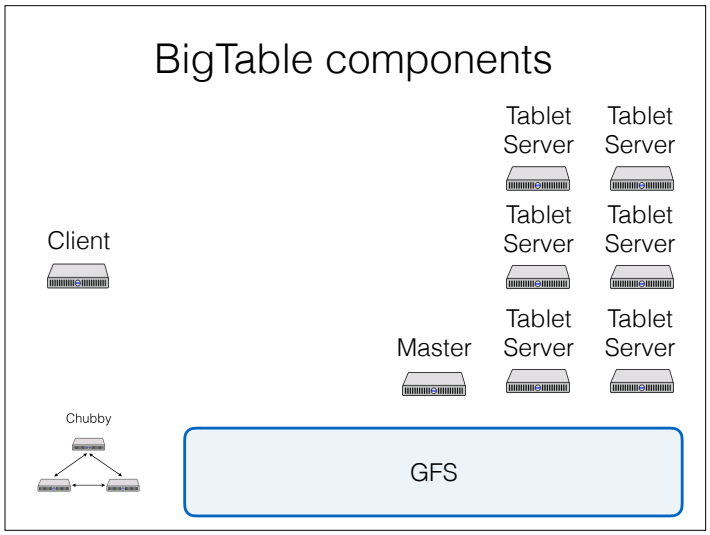

BigTable components
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Client
Where is the METADATA tablet for table T row R?
Master
Chubby
GFS


BigTable components
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Client
Tablet server 1
Master
Chubby
GFS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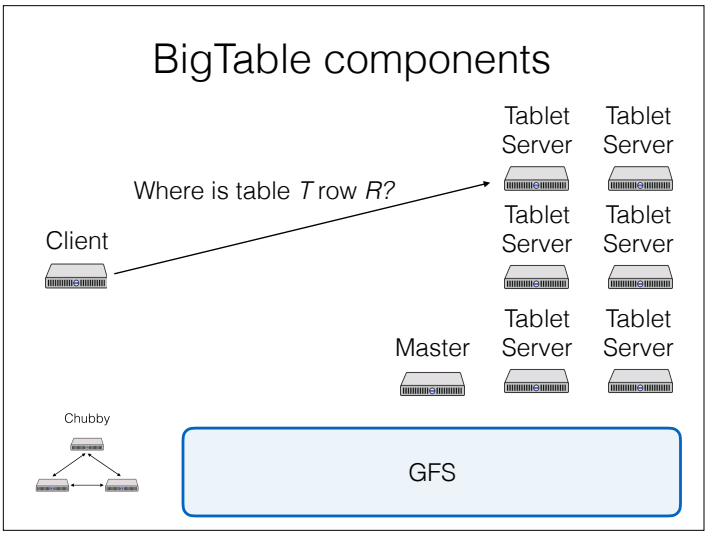
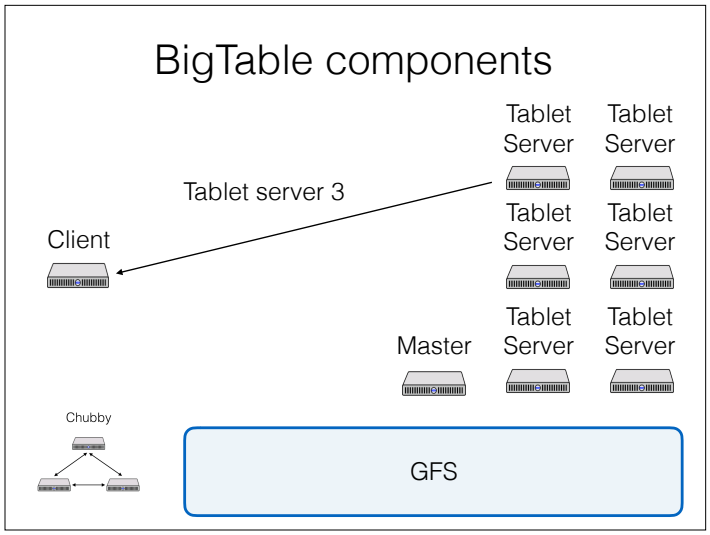
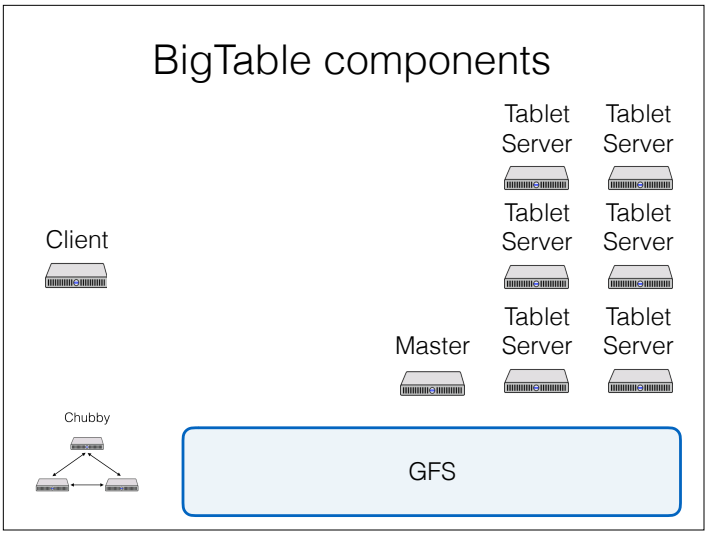
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Client
Master
Chubby
GFS


BigTable components
Where is table T row R?
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Client
Master
Chubby
GFS


BigTable components
Tablet server 3
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Client
Master
Chubby
GFS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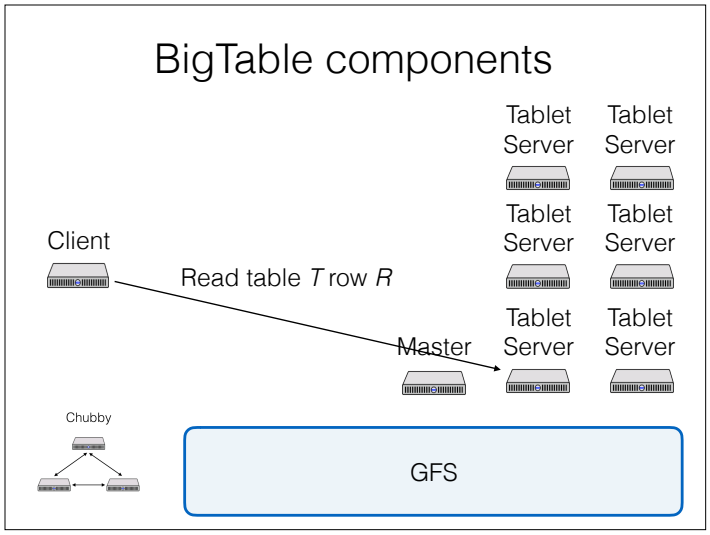
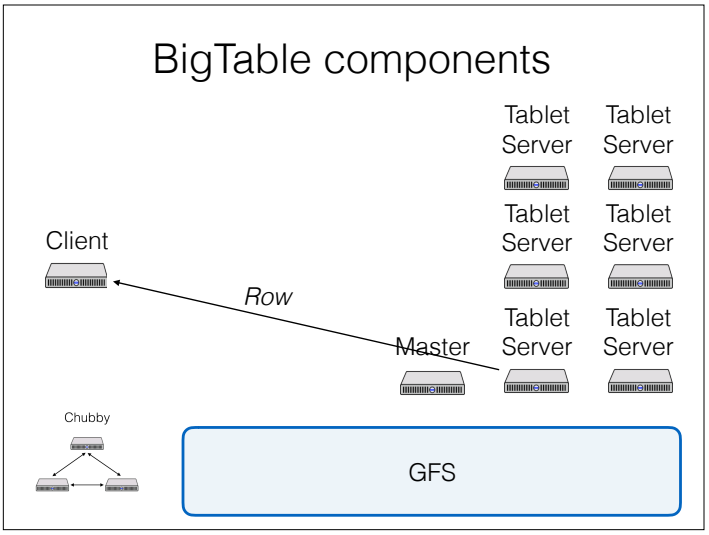

BigTable components
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Client
Read table T row R
Master
Chubby
GFS


BigTable components
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Tablet Server
Client
Row
Master
Chubby
GFS

Optimizations

Clients cache tablet locations

- Tablet servers only respond if Chubby session active, so this is safe

Locality groups

- Put column families that are infrequently accessed together in separate SSTables

Smart caching on tablet servers

Bloom filters on SSTables