Full Compactions in YugabyteDB & How to Schedule Them

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YugabyteDB Friday Tech Talks

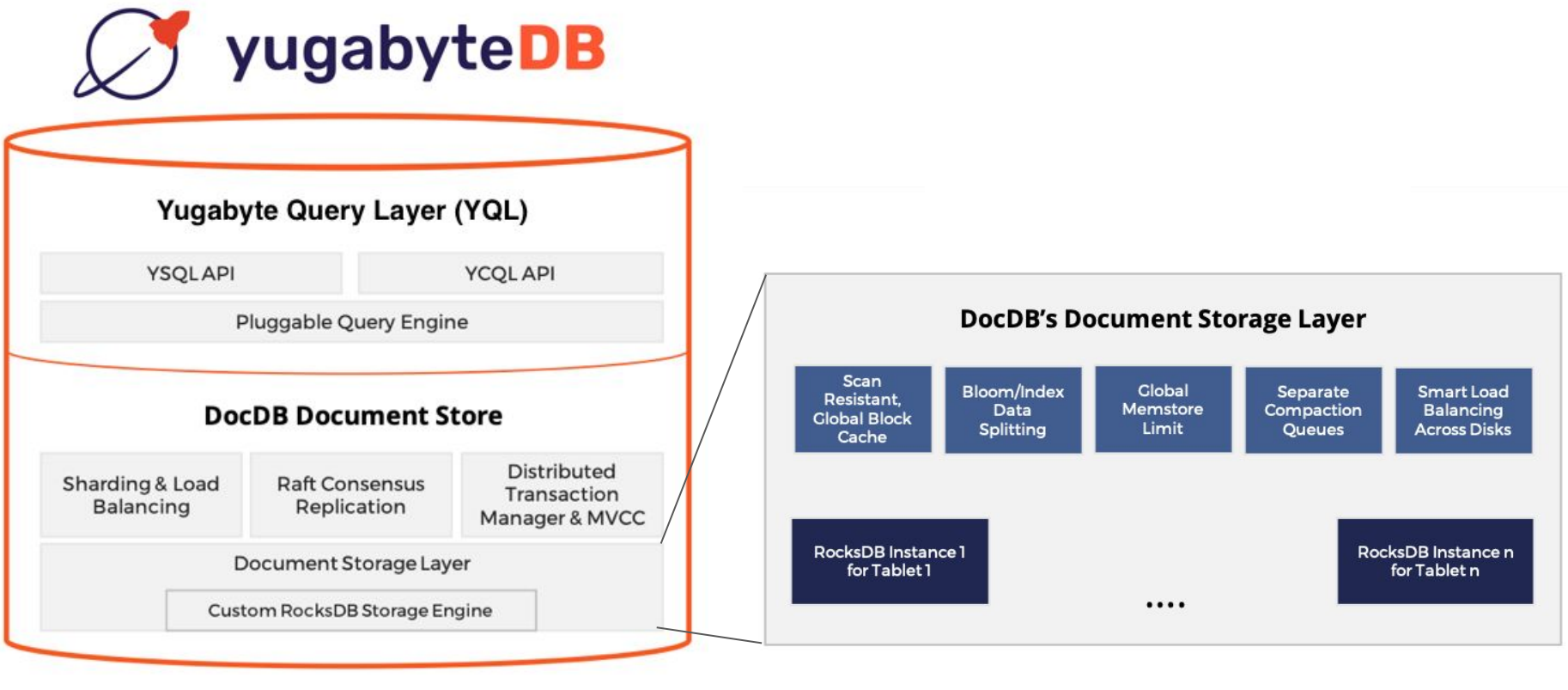
YFTT

Talks by Engineers for Engineers

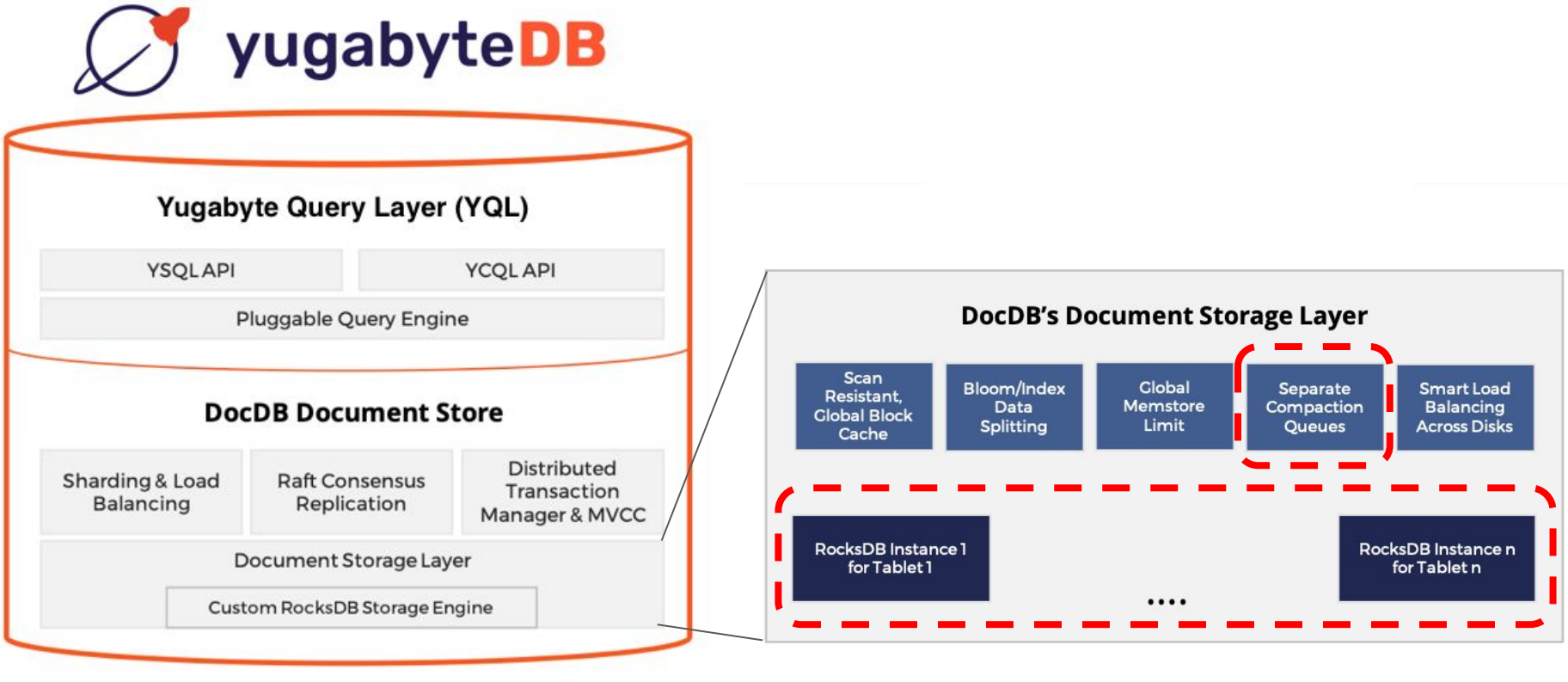
yugabyteDB

Layered architecture of YugabyteDB

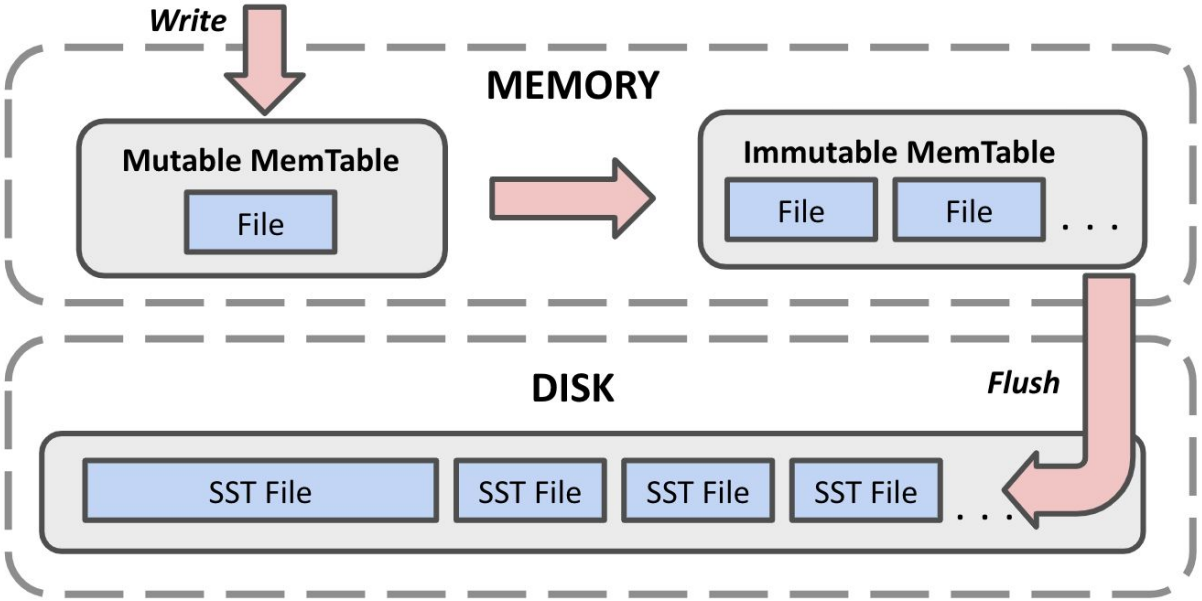
Storage layer of YugabyteDB



Storage layer of YugabyteDB



Writing to DocDB



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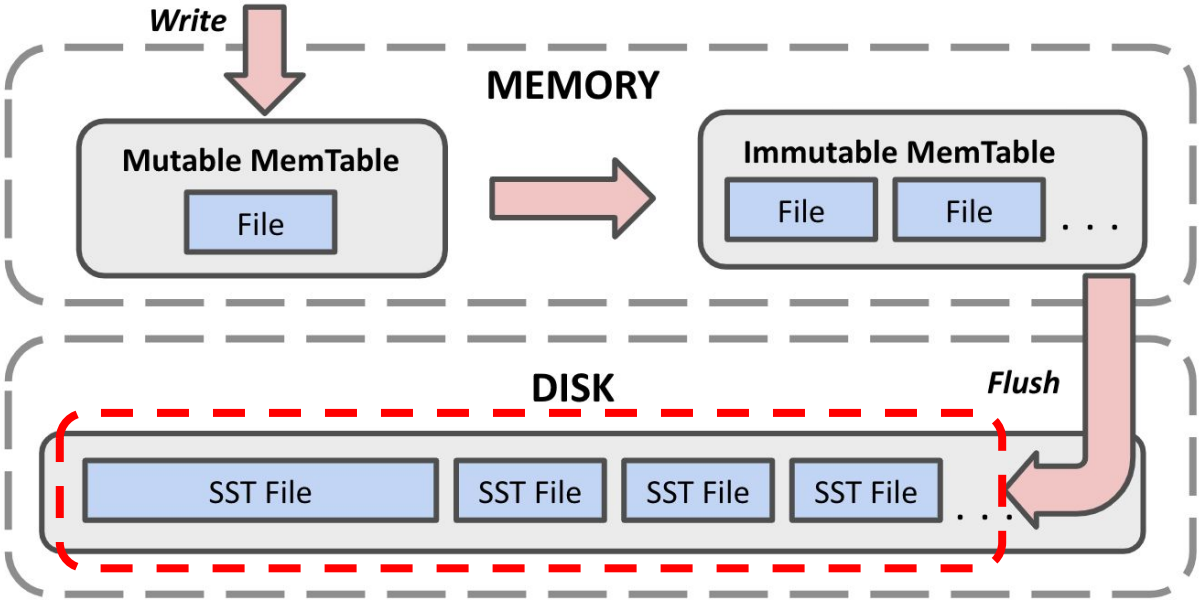
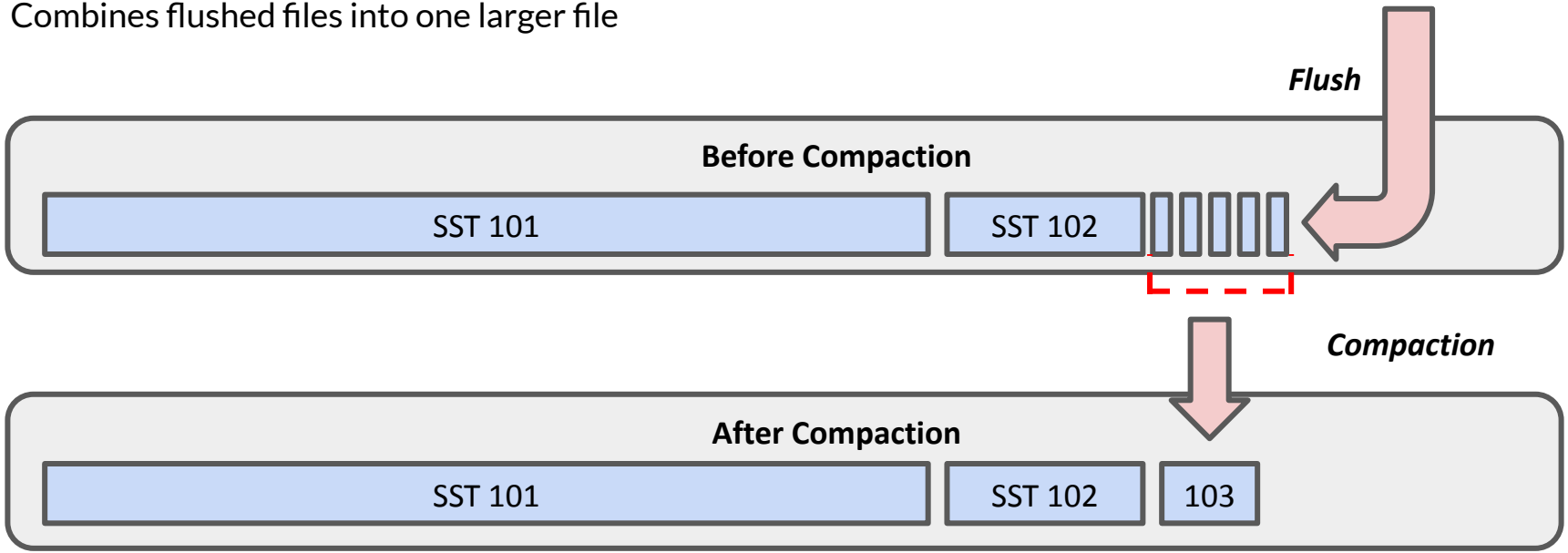


Background Compactions

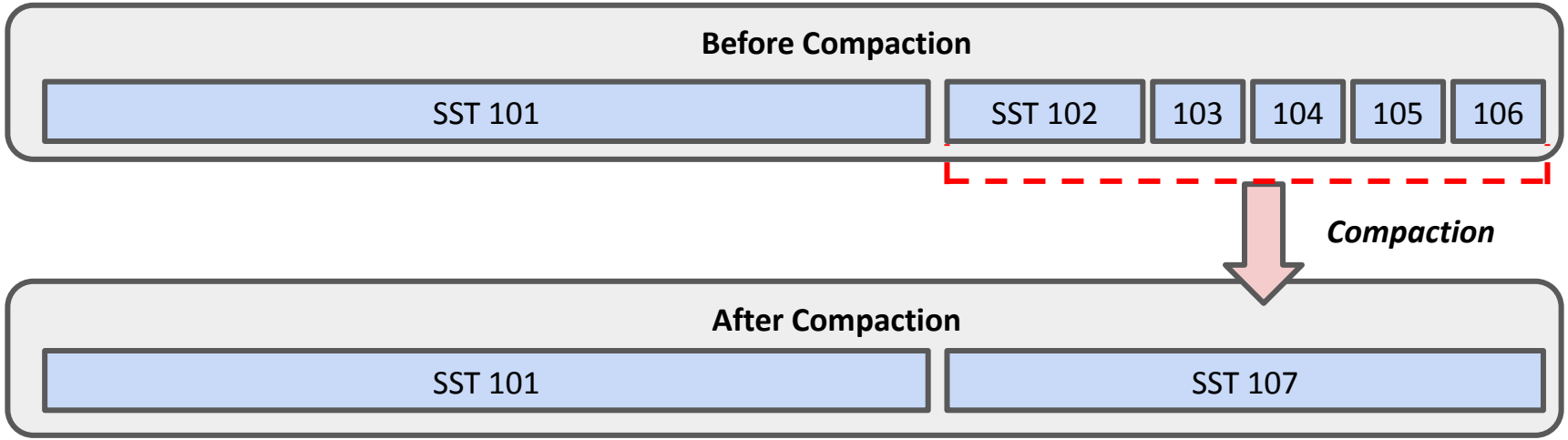
Universal compactions in DocDB

Combines flushed files into one larger file



Universal compactions in DocDB

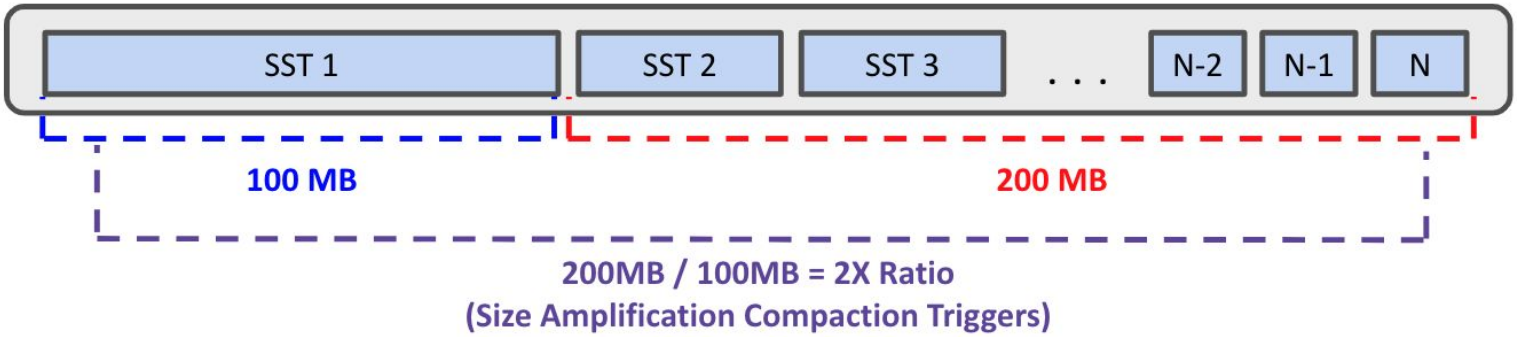
Combines smaller files into one larger file, garbage collecting any deleted/expired data



Algorithm 1: Size amplification

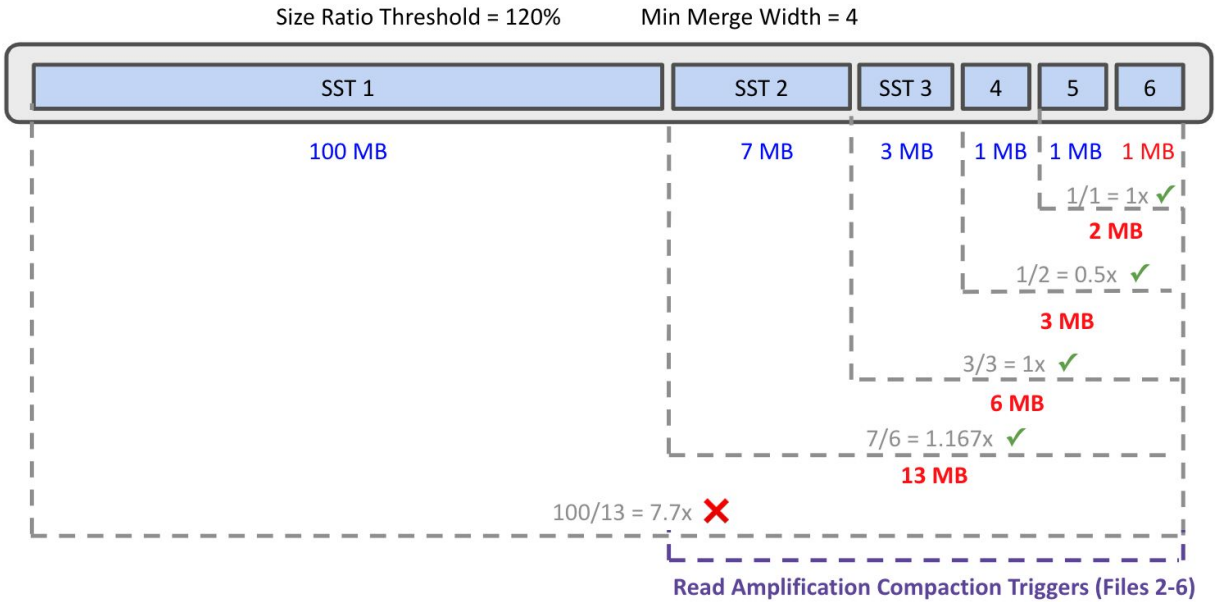
- Looks for *N* consecutive files such that the size of the first is less than **half** the combined size of the other *N-1*
  - i.e. size amplification threshold = **2x**

size amplification ratio = (size(R_N) + size(R_{N-1}) + ... size(R_2)) / size(R_1)

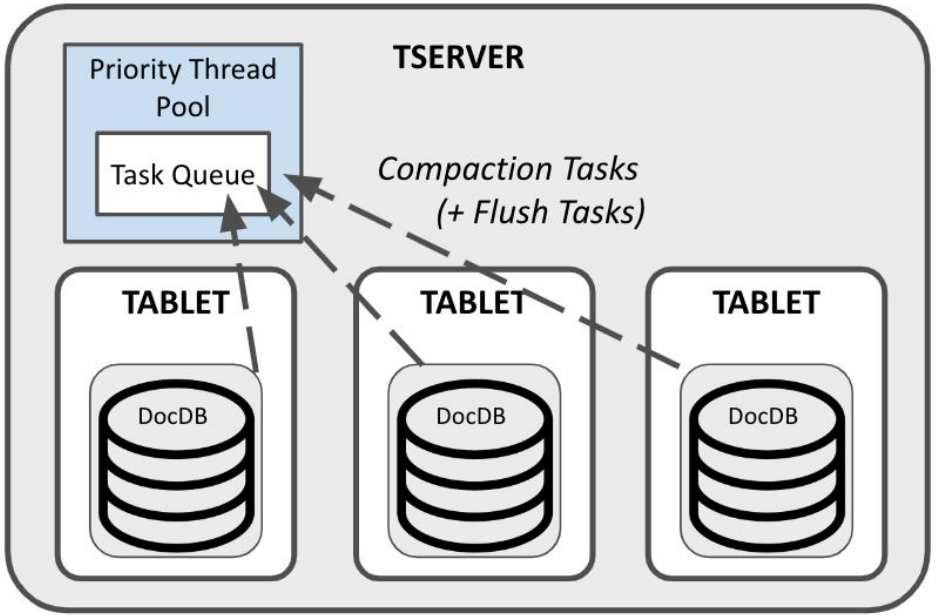


Algorithm 2: Read amplification

- Looks for at least ***[min merge width]*** files (as many as possible) such that the combined size of the latter *N-1* files are less than ***[size ratio threshold]*** from the first file's size
  - Default min merge width = **4** (***rocksdb_universal_min_merge_width*** = 4)
  - Default size ratio threshold = **120%** (***rocksdb_universal_compaction_size_ratio*** = 20)



Compaction prioritization



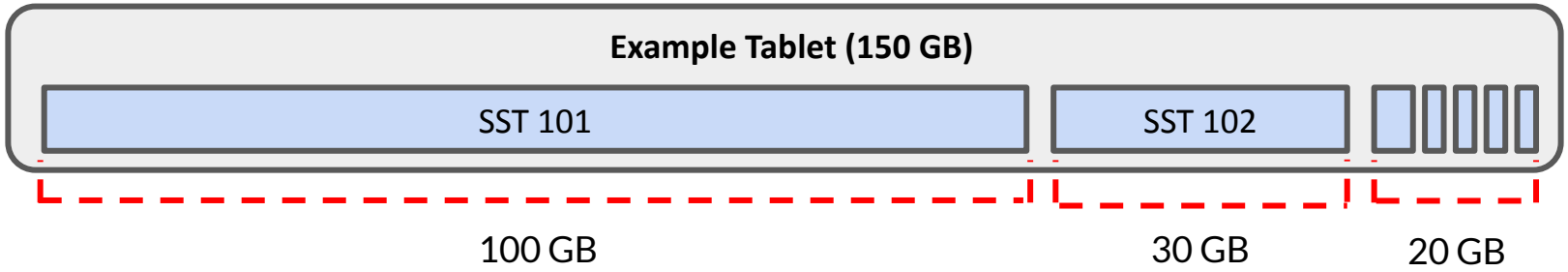
- Shared set of resources (CPU/IO) for all compactions in a TServer
- Managed by a priority thread pool
  - Max threads scale with # of CPUs
- Priorities (in general):
  - Flushes > compactions (if same pool is used)
  - Small compactions > large ones
  - Background compactions > full compactions

Background compaction TServer flags

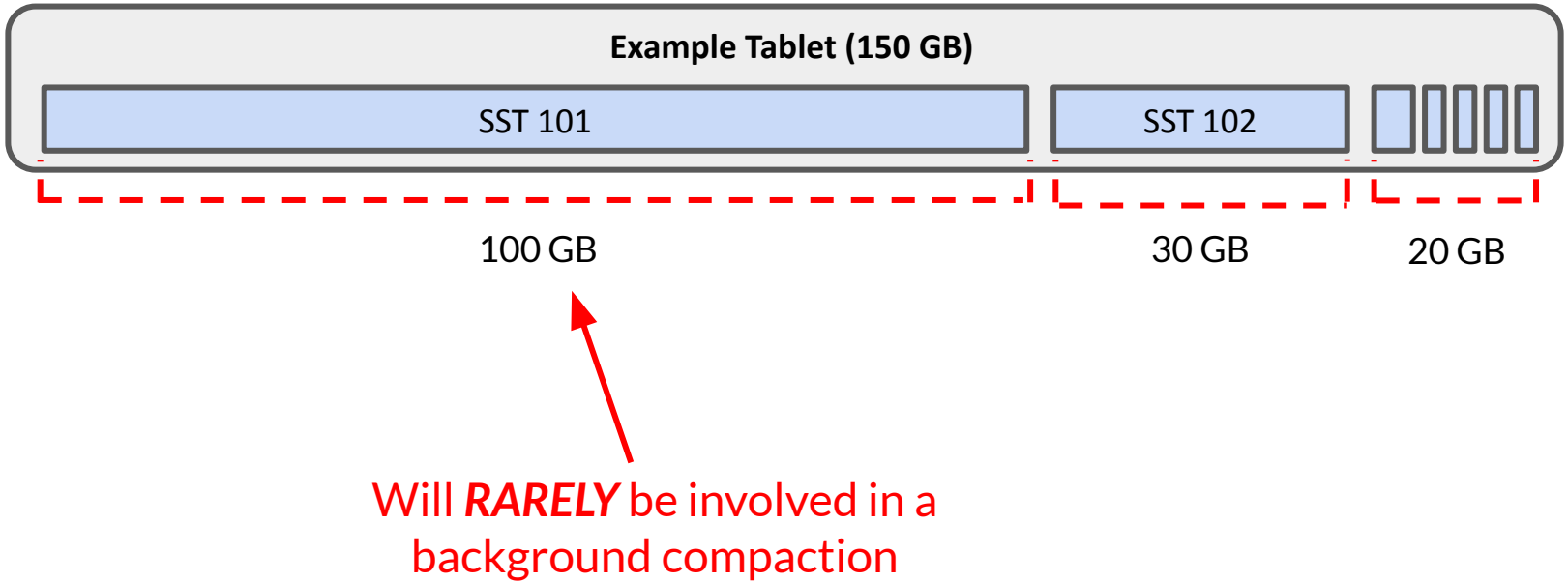
- ***rocksdb_max_background_compactions***
  - Maximum number of simultaneous running compactions allowed per TServer
  - Default: -1 / auto (scales per CPU)
- ***rocksdb_compact_flush_rate_limit_bytes_per_sec***
  - The write rate limit for flushes and compactions (per TServer by default)
  - Default: 1 GB
- ***rocksdb_compaction_size_threshold_bytes***
  - Threshold beyond which a compaction is considered “large”
  - Default: 1 GB
- ***sst_files_soft_limit / sst_files_hard_limit***
  - The soft and hard limits of the number of SSTs allowed per tablet
    (i.e. if reached, the tablet is behind on compactions!)
  - Writes will be throttled when the soft limit is reached, and stopped at the hard limit
  - Default: 24 / 48

Motivation

Example large tablet after many compactions



Example large tablet after many compactions



Times when background compactions may not be enough

Update- or Delete- Heavy Workloads

- Older data versions or deleted data remain in files for extended periods of time
- Read and space amplification

TTL (Time-To-Live) Workloads

- Older data expires over time, and remains in large files for extended periods of time

Deletion Compliance

- Deleted data must be removed from the system by a certain date

Example table

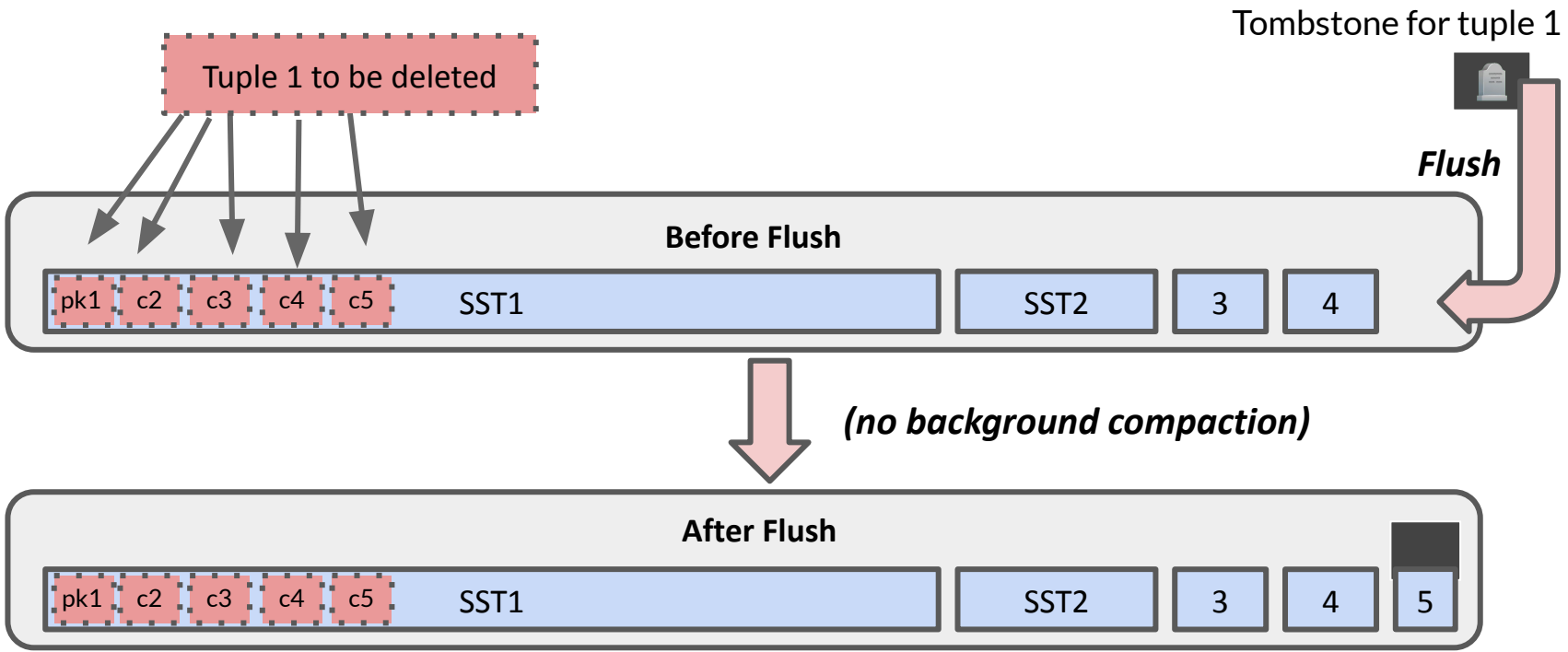
```
CREATE TABLE example (
    pk1  bigint NOT NULL,
    c2   varchar(255),
    c3   varchar(255),
    c4   varchar(255),
    c5   varchar(255),
    PRIMARY KEY (id1));
```

pk1 (PK)	c2 (varchar)	c3 (varchar)	c4 (varchar)	c5 (varchar)

```
INSERT INTO example (pk1, c2, c3, c4, c5)
  SELECT s_id, md5(random()::text), md5(random()::text),
         md5(random()::text), md5(random()::text)
   FROM generate_series(1,1000000) AS s_id;
```

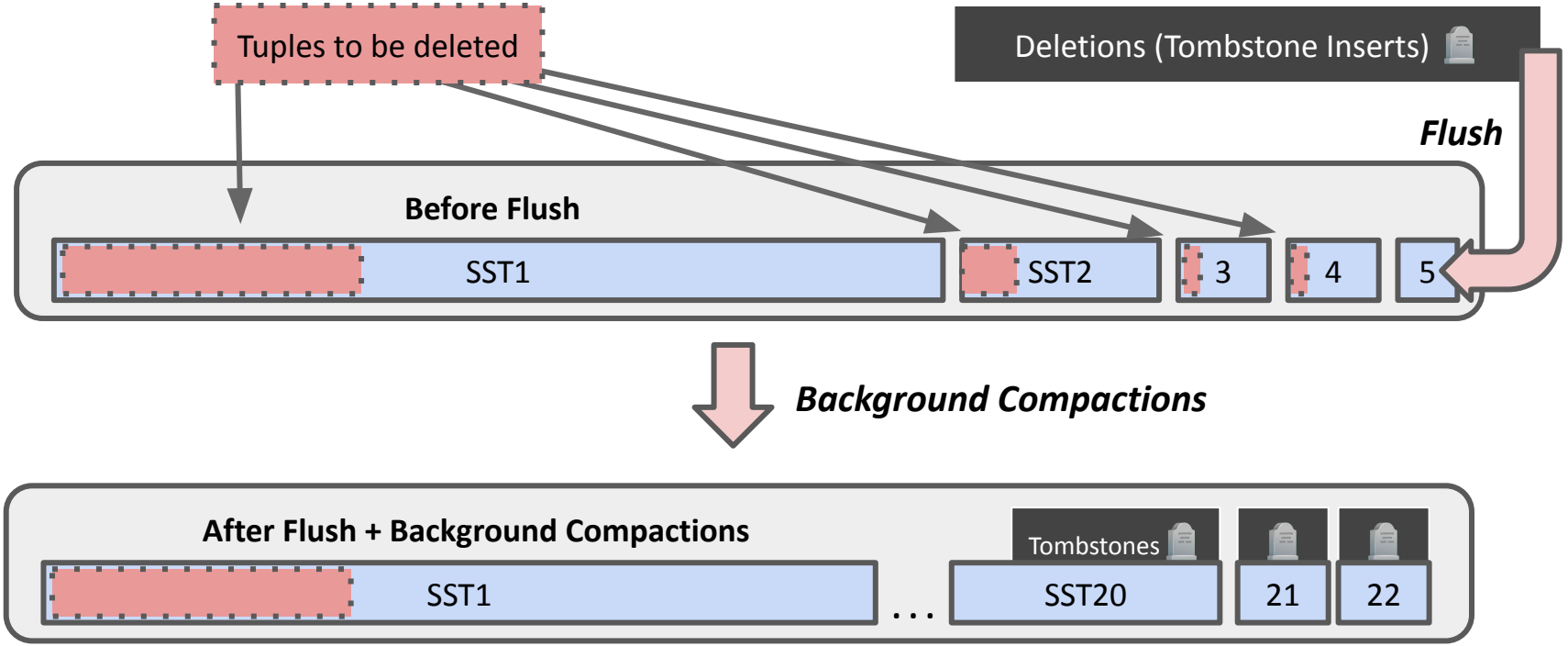
Tuple deletion

```
DELETE FROM example WHERE pk1 = 1;
```



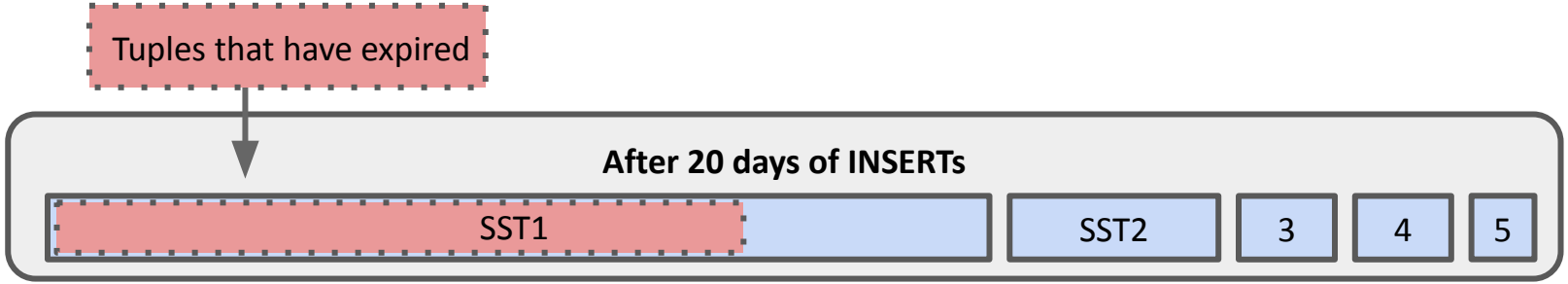
Tuple deletion

```
DELETE FROM example WHERE pk1 >= 500000 AND pk1 < 700000;
```



Default TTL (Time-to-Live)

```
ALTER TABLE example WITH default_time_to_live = 10*24*60*60; // 10 days
```



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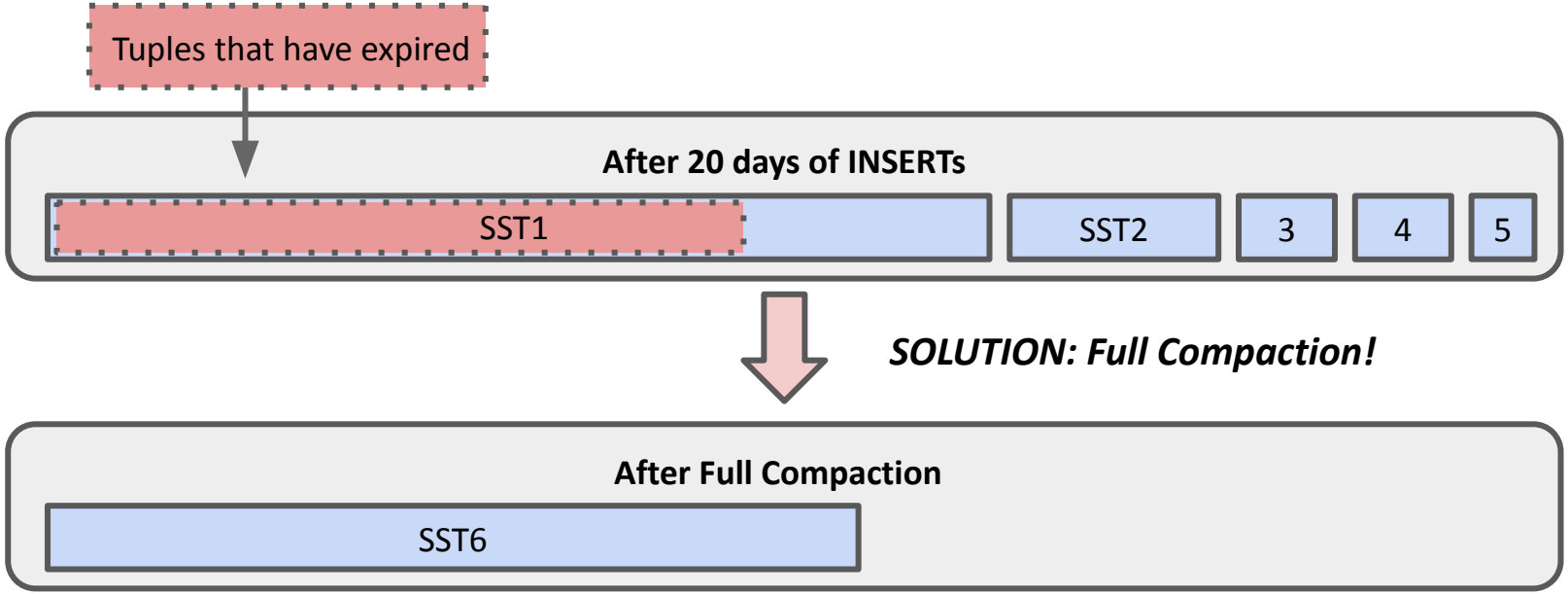


Scheduled Full Compactions

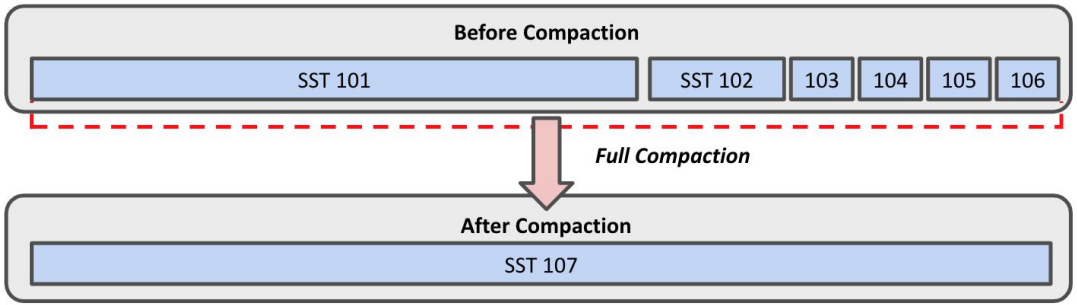
Full compactions

Compaction that includes all SSTs for a tablet

- All files will be compacted into one single file
- Iterates through all data items of all files, ignores deleted/expired data

Resources required (same as background compactions)

- CPU cycles on threads dedicated to compactions (same thresholds apply)
- Disk IO for copying to a new file
- Disk space for temporary copy of all live data in tablet (capped if tablet splitting enabled)
- **NO LOCKS REQUIRED**



How to use scheduled full compactions (TServer flags)

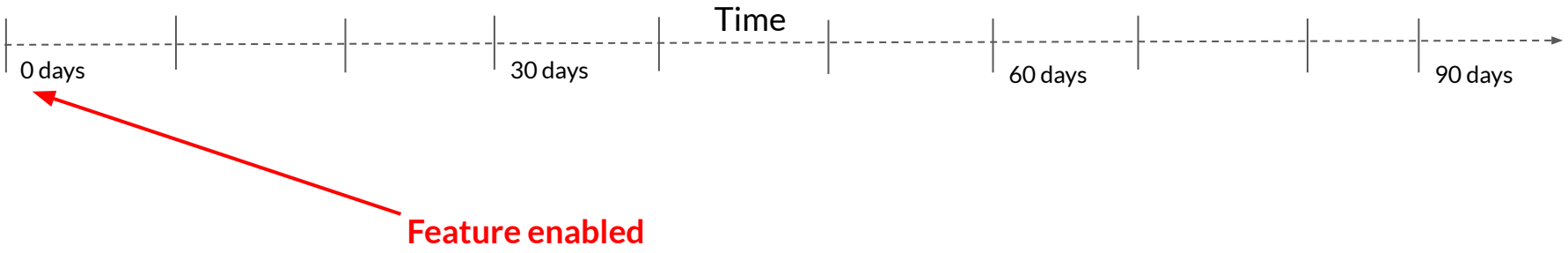
Compaction Frequency (*scheduled_full_compaction_frequency_hours*)

- Upper bound for how frequently full compaction should be run
- Default value: 0 (i.e. feature turned off)
- Recommended values:
  - Every 30 days (720 hours), or every 2 weeks (336 hours)
  - Not less than every 7 days (168 hours)

Jitter Factor (*scheduled_full_compaction_jitter_factor_percentage*)

- Determines the “jitter” introduced into the scheduling
- Reduces likelihood of many tablets scheduled simultaneously
- Default value: 33 (recommended)
  - i.e. 33% of the frequency of schedule is allotted for jitter.
  - Example: if compactions are scheduled every 30 days with 33% jitter, each tablet will be scheduled for compaction pseudorandomly every 20 to 30 days

Scheduling with Jitter Factor



1 Tablet 1 Full Compaction

2 Tablet 2 Full Compaction

3 Tablet 3 Full Compaction

Full Compaction Frequency: **30 days**

Jitter Factor Percentage: **33%**

Jitter Factor: **10 days**

Scheduling with Jitter Factor

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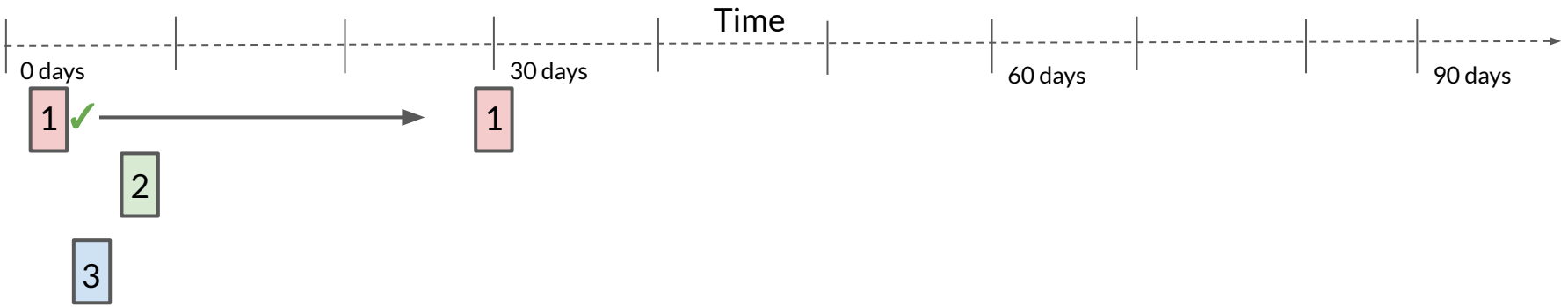

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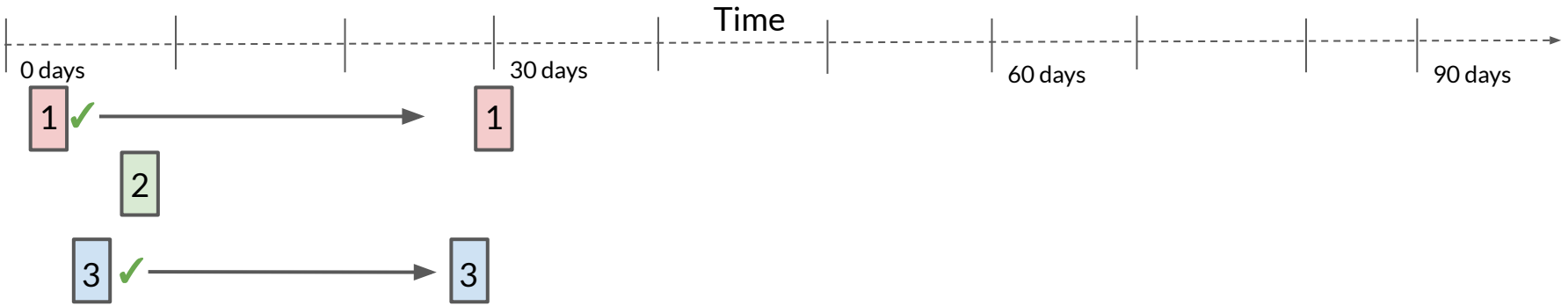

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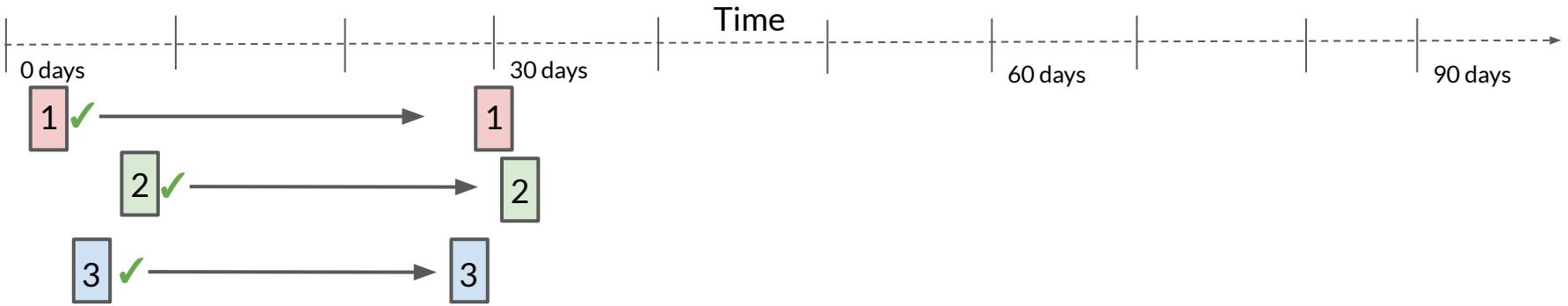

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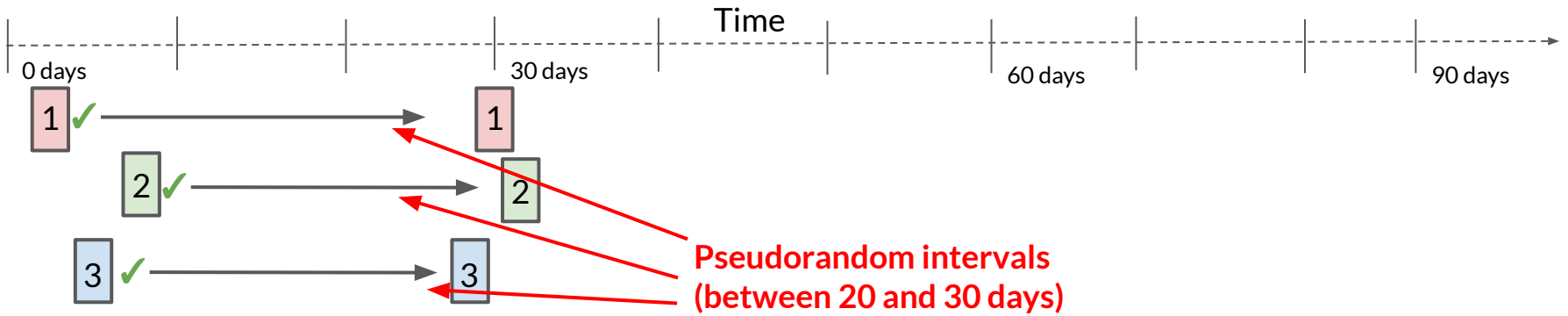

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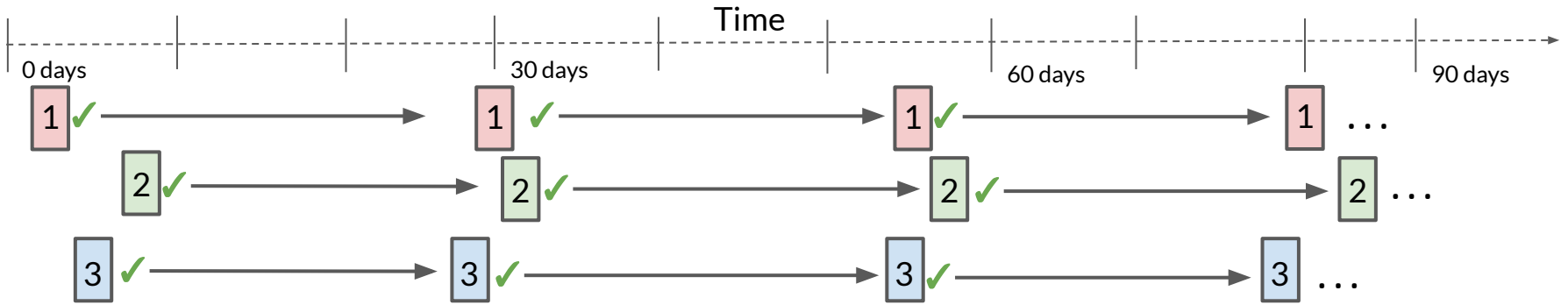

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Demo

Future feature improvements

Auto-trigger full compactions when needed

- Automatically improve the performance of some range queries via a full compaction when needed

Specify off-peak “preferred” compaction times

- Schedule more full compactions at workload off-peak hours/days

Client-side full compaction status reporting/monitoring

- Improved visibility into full compaction status

Thank You

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