New Free Space Map and Visibility Map

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Part 1: Free Space Map

- Free Space Map stores information about free space in a relation
- Used by INSERTs and UPDATEs

Pre-8.4 Free Space Map

- Used a shared memory block
  - Size was fixed at startup
- max_fsm_pages, max_fsm_relations
- Saved to global/pg_fsm.cache at shutdown
  - Lost on crash or PITR
- Protected by a single lock (FreeSpaceLock)

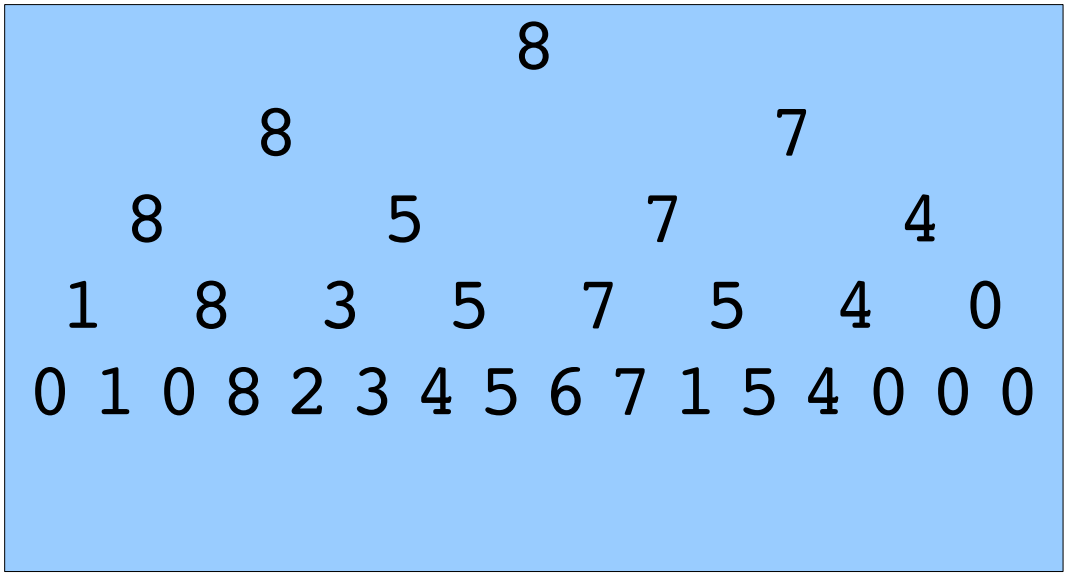
New Free Space Map

- Completely rewritten
- Stored on-disk in normal 8k pages
  - Cached in shared_buffers
  - Goodbye max_fsm_pages and max_fsm_relations

```
$ ll data/base/11562/56553*
-rw------- 1 hlinnaka hlinnaka 3219456 2009-02-08 00:45 56553
-rw------- 1 hlinnaka hlinnaka   24576 2009-02-08 00:45 56553_fsm
-rw------- 1 hlinnaka hlinnaka    8192 2009-02-08 00:45 56553_vm
```

FSM page structure

- Binary tree



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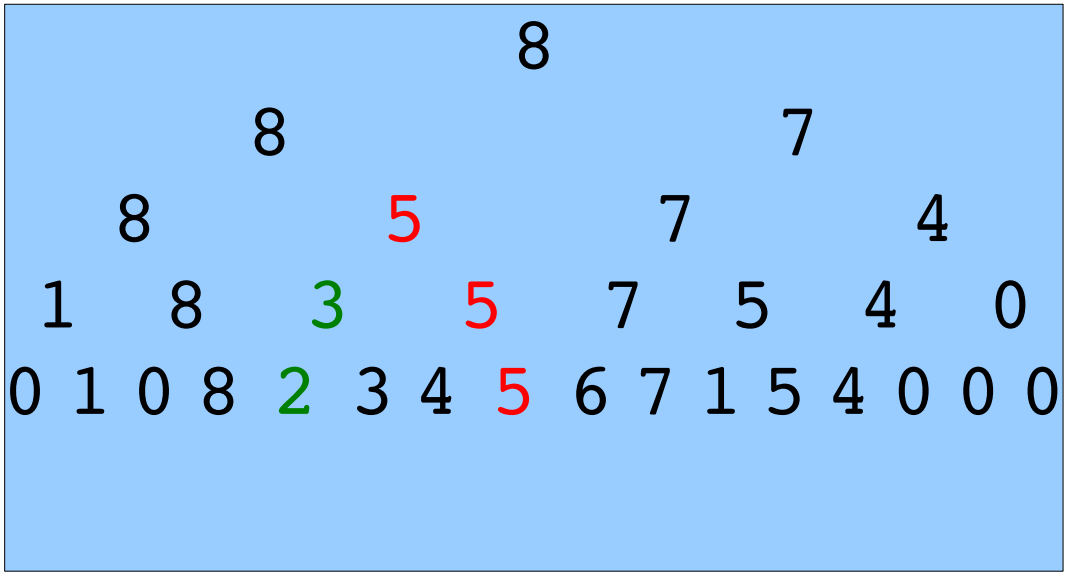
FSM page structure

- Search for a page with 5 units of free space
  - Start from the bottom, at the green node
  - Climb up until we hit a node >= 5
  - Climb down, following the path with >= 5



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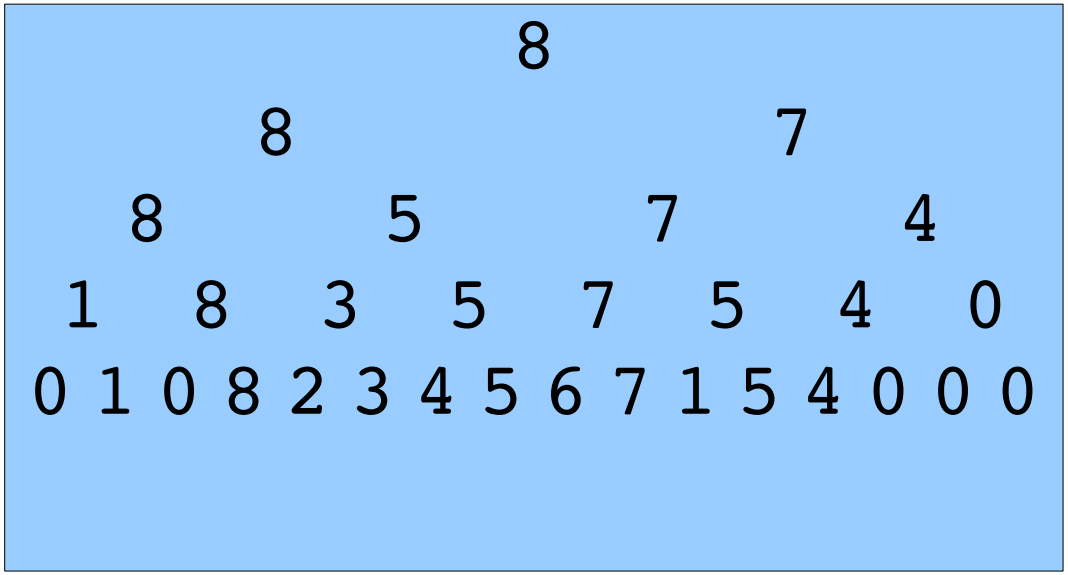
FSM page structure

- Auto-repairing
  - Upper levels can be reconstructed from bottom
  - No pointers



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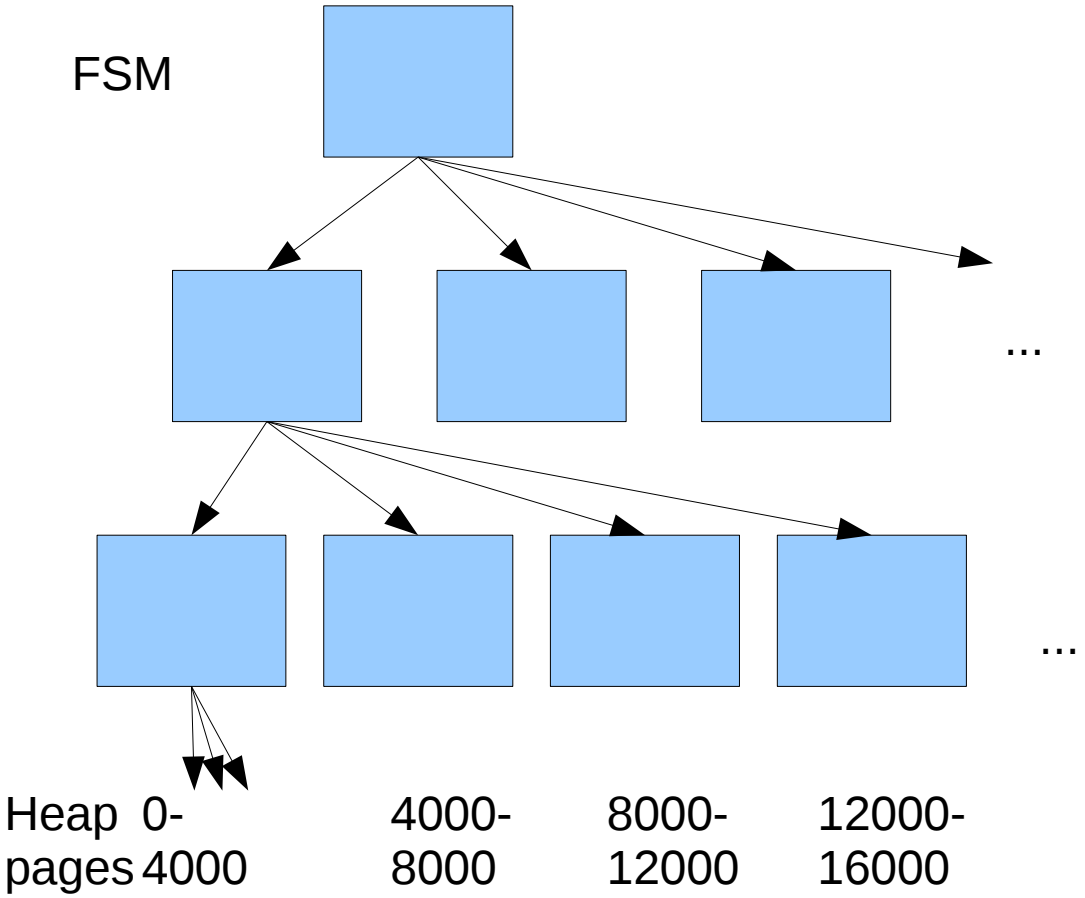
FSM high-level structure

- Tree of three levels



FSM operations

- Search
  - Can prefer pages close to given page
- Update
  - Allows retail updates

Part 2: Visibility Map

- A bitmap of heap pages
- 1 means “all tuples on page are visible to all transactions”
- Bits are set in VACUUM
- Cleared at INSERT/UPDATE/DELETE

Partial VACUUM

- VACUUM can now skip pages that are already marked in visibility map
- Still needs to scan all indexes

Partial VACUUM Example

```
postgres=# CREATE TABLE foo (id int4);
CREATE TABLE
postgres=# INSERT INTO foo SELECT
  generate_series(1,100000);
INSERT 0 100000
postgres=# DELETE FROM foo WHERE id <
  50000;
DELETE 49999
```

Partial VACUUM Example (cont)

```
postgres=# VACUUM VERBOSE foo;
INFO:  vacuuming "public.foo"
INFO:  "foo": removed 49999 row versions in 197 pages
INFO:  "foo": found 49999 removable, 50001 nonremovable
   row versions in 393 out of 393 pages
DETAIL:  0 dead row versions cannot be removed yet.
There were 0 unused item pointers.
0 pages are entirely empty.
CPU 0.00s/0.05u sec elapsed 0.05 sec.
VACUUM
```

Partial VACUUM Example (cont)

```
postgres=# VACUUM VERBOSE foo;
INFO:  vacuuming "public.foo"
INFO:  "foo": found 0 removable, 8141 nonremovable row
   versions in 228 out of 393 pages
DETAIL:  0 dead row versions cannot be removed yet.
There were 49999 unused item pointers.
0 pages are entirely empty.
CPU 0.00s/0.00u sec elapsed 0.00 sec.
VACUUM
```

Partial VACUUM Example (cont)

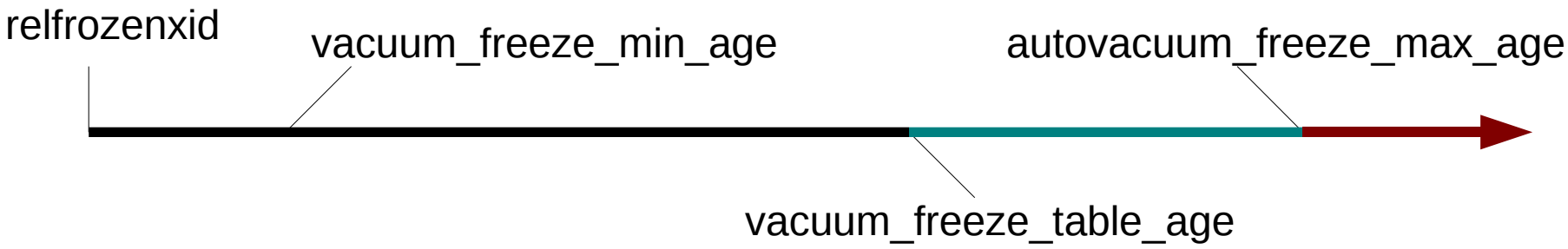
```
postgres=# VACUUM VERBOSE foo;
INFO:  vacuuming "public.foo"
INFO:  "foo": found 0 removable, 0 nonremovable row
   versions in 31 out of 393 pages
DETAIL:  0 dead row versions cannot be removed yet.
There were 7905 unused item pointers.
0 pages are entirely empty.
CPU 0.00s/0.00u sec elapsed 0.00 sec.
VACUUM
```

Partial VACUUM and Freezing

- A partial VACUUM can't advance relfrozenxid
- Whole-table scanning VACUUMs are still needed to avoid transaction ID wraparound
- New configuration variable: vacuum_freeze_table_age

Configuring Freezing

- autovacuum_freeze_max_age = 200 M (200 M)
- vacuum_freeze_min_age = 50 M (100 M)
- vacuum_freeze_table_age = 150 M



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Questions?

- Future Works
  - Partial freezing
  - Index-only scans

- Let me know how it works