

SWC DB (Super Wide Column Database)

<https://github.com/kashirin-alex/swc-db>

The database is structured in columns, not by Tables or Namespaces, as familiar SQL is 'select columns from "table_name";', with "Super Wide Column DB" It is 'select [where_clause [Columns-Intervals]]; '.

The "Super Wide Column" comes to its meaning by the column's key is a list-set of keys eg. A column cell's key is keys=(k1,k2,k3,k4,kN), comparing to a "Wide Column" key that is row, column-family, column-family-qualifier in the "Super Wide Column DB" it is equal to keys=(k1(row),k2(cf),k3(cq)) or(similar) column=cf with keys=(k1(row),k3(cq)) . Majority of the developments are planned to be on bases of Hypertable (<https://github.com/kashirin-alex/hypertable>).

The storage-form in the "Super Wide Column DB" is based on column-id and range-id, which on path consist CellStores and CommitLogs files at any point one server is responsible for a range-id on column-id.

The CellStores are Files storing Cells in serialized form that are after latest compaction whereas CommitLogs are the open-file-descriptor to which current data is added.

The Serialization of data in a CellStore/CommitLog file: (delimited with "|" for visual-representation of NONE)

|Blocks(Header | Compressor(Cells)) | Fixed-Index | Variable-Index | CellStore-Trailer|

The Cell-Serialization: |Key-length(int32)|Key-serialized| Value-length(int32)|Value-Data|

Key serialization: |Key-flag(int8)|Key-control(int8)|Keys-count(int8)|joined(Keys[N]\0)|Timestamp(int64)|Revision(int64)|

The Cells Ranges, a range is a Keys-start to Keys-end, SWC DB use a self-explanatory master-ranges that define ranges to meta-ranges of data-ranges(cells-range) whereas on range-locator it includes the Keys comparison on the comparators of request, resulting in as most narrowed scan of cells-ranges.

System's reserved columns id[1-9],

1: IDENTIFIER a counter type column

2: RANGES

3: RID(RANGE-ID) to RS(N)

4: Column ID, Column Name and serialized Column-Scheme

The limitations that can be over-seen are:

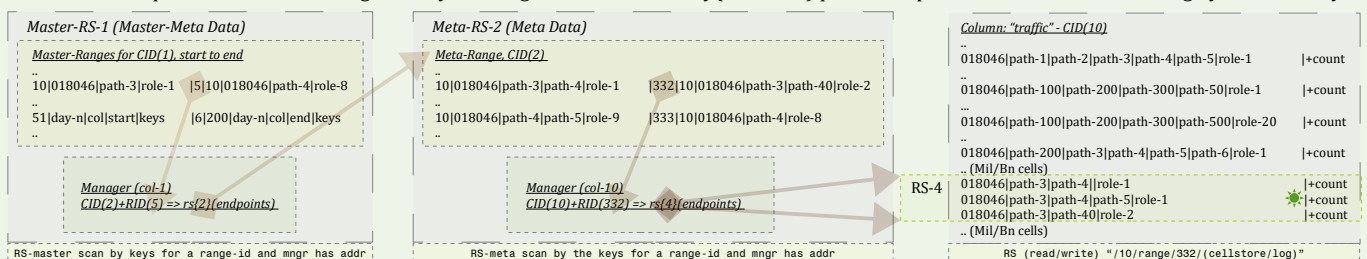
- ✗ Maximum number of columns, it is store-size of $\text{int64}(2^{64}) - 10$ (reserved cols) which can be improved by CID to be a string-type.
- ✗ Maximum size of Value or Key(after serialization), it is 4GB, while for such data size other limitations probably apply

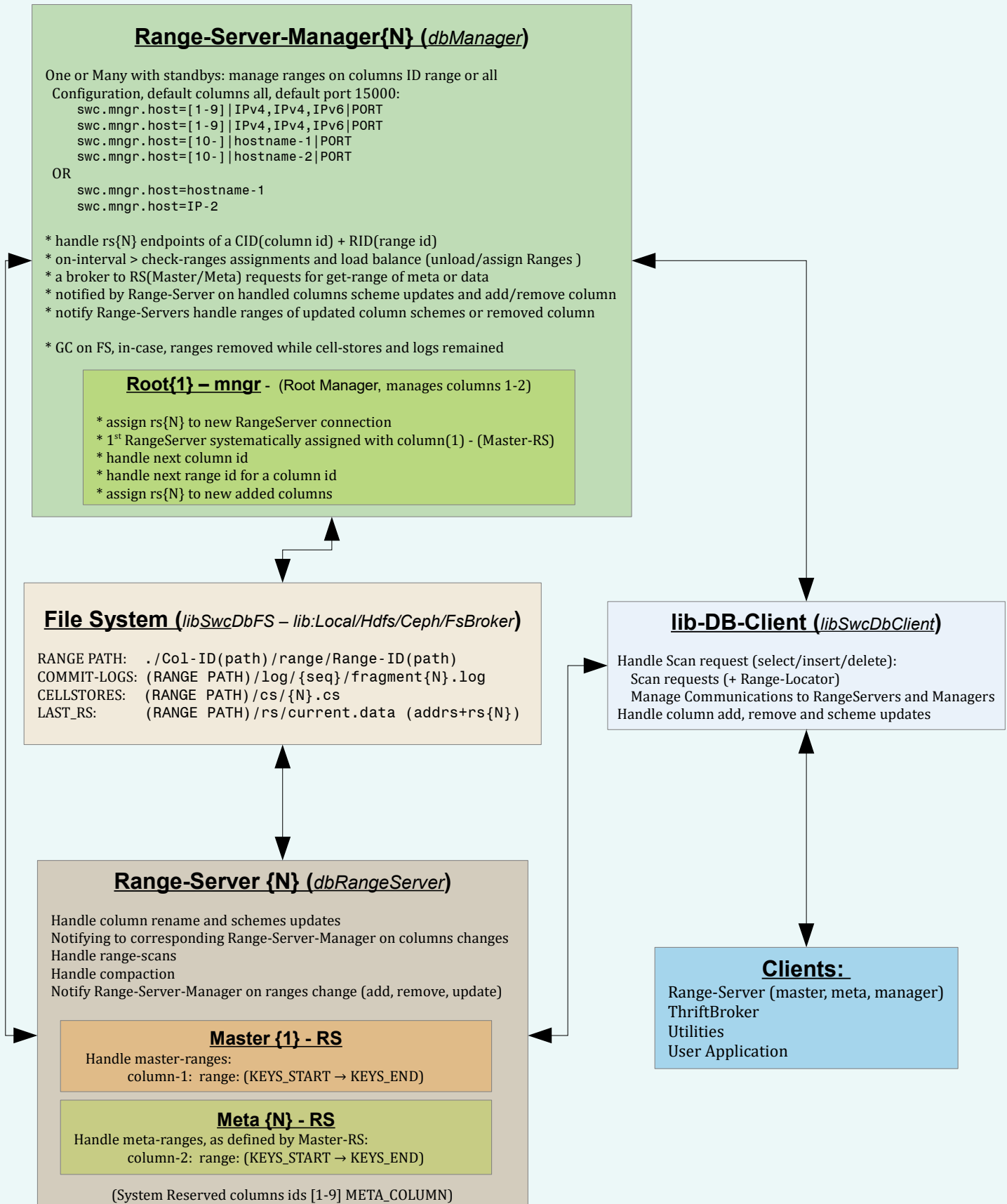
The capabilities to expect:

- ✓ Supposing one server can handle 2bil cells with one cell is being keys(1024B) and value(1024B) a 4TB in volume over 1300 ranges, to apply such base to RS-master means there are 500k RS-meta with 667mil RS-data with cell value being just a 4KB, that makes a SWC DB cluster in total handling 5.7ZB(zettabyte) of data volume and more on a compression ratio.
- ✓ A client can read at 100%(while Client's and RS's are equivalent) bandwidth, considering a perfect scan case of each client is requesting on different ranges, number of clients at a given time can be by the number of RS-data using 100% bandwidth each.
- ✓ Maximum number of concurrent connections to a given server instance, it is the total available ports on the server by the number of configured IPv4 and IPv6 with support of multiple interfaces,

Some examples:

- Search indexing at <https://thither.direct/opensearch/> with Wide Column it is being row="sequences-of-words:domain:path" cf="lang" whereas with Super Wide Column it can be changed to keys=["sequences-of-words", "domain", "path", "lang"], makes the scan-select much optimized, especially if to query words-data of a domain & path, it would go on to ranges that start with domain & path skipping the seek through ranges of several other many domains that as well include the same word-sequences. While to have the same query on a Wide Column would require tripling the volume of data by using more indexes of word-sequences on a domain (and path) such as. row="domain:sequences:path" & row="domain:path:sequences". At current period the "open-search" on Thither.Direct does not offer querying data(words) on a site:domain or info:url-path as it is unreasonable over the data-volume overheads.
- A theoretical requirement for a building security tracking. Track of how many(an atomic-counter) personnel passed in an area of a building by role on a day:

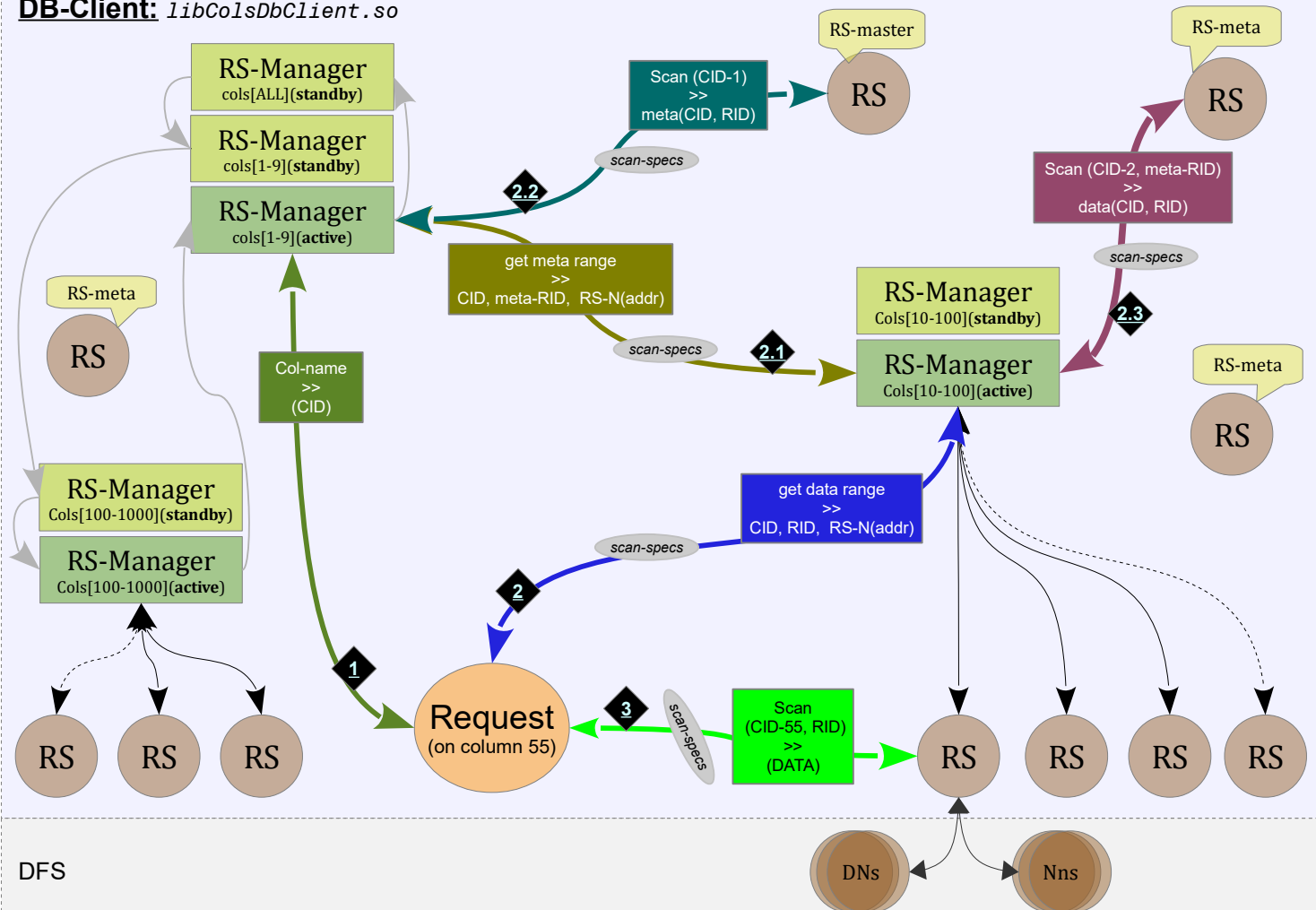




- ✓ A failed request to a RS-Manager is a connection fail-over to next in list from 'swc.mngr.host' configuration.
- ✓ A failed request to a RS(Master, Meta, Data)-N is fail-over to the new RS(addr) assign to RS-N by RS-Manager.
- ✓ RS-Manager, on interval or disconnection of a managed RS(either role), request to load ranges to another RS.
- ✓ RS-Master, as been a single instance, have connections only with It's RS-Manager. (in case, of only master-ranges)
- ✓ Distribute File System, depends on the system and it's feature of routing to a datanode .
- ✓ RS(any) in case a connection or file-descriptor failure try to reconnect to the DFS.
- ✓ Communication over-heads of a resolved-data to column-name, RID-location or RS-address are kept while connection and data discard by TTL or a notification from RS-Managers on changes.

In worst case of outdated data being used with a request the RS return an error of a NOT_LOADED_RANGE.

DB-Client: *libColsDbClient.so*



SWC DB: LIB-DB-Client, Scan request (+ Range-Locator)

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Basic Process Flow of Scan request (+ Range-Locator)

Ranges Scan is done on per column base in-parallel(a client's max-range-locators config) with column's Scan Specifications

Scan-Specifications = cid, ScanSpecCellKeys(keys_start, keys_finish)

result = new_results = 0,

last_cell_keys = rid(meta) = 0,

keys_start(meta,data) = ScanSpec.keys_start

1 get column-ID by name => (cid)
Req. RS-MANAGER[cid-1](SCHEME-MNGR) - req, ([="ReqColName"]) => (cid)

DO get_ranges_data:

2 get range-data by (cid, keys_start(meta,data), keys_finish, rid(meta))
=> (cid,rid(data),rs{N}(addr), next_rid(meta,data)?, rid(meta))
Req. RS-MANAGER[cid]:
If not rid(meta):
2.1 get range-meta by (cid, keys_start(meta), keys_finish)
=> (cid, rid(meta), rs-meta{N}(addr), next_rid(meta)?):
Req. RS-MANAGER[cid-1]:
2.2 get range-master-meta => (rid(meta), next_rid(meta)?)
Req. RS-MASTER:
Scan-do (2-cell)(cid-1, [>="cid", keys_start(meta)], [<"cid", keys_finish]) = rid(meta)
2.3 get range-data by (cid, rid(meta), keys_start(data), keys_finish) => (cid, rid, rs{N}(addr), next_rid(data)?):
Req. RS-META - rs-meta{N}(addr):
Scan-do (2-cell)(cid-2, [>="cid", keys_start(data)], [<"cid", keys_finish]) = rid(data)

If no range-data:

goto finish

EXCEPT COMM:

goto get_ranges_data

DO scan_range_data:

scan range-data by (cid, rid(data), ScanSpecs) => (new_results):

Req. RS-DATA - rs{N}(addr):

Scan-do (cell-limit) (ScanSpecs) = results(data)

if new_results

(call_back) (available results), result+=new_results

last_cell_keys=more_results[-1]

EXCEPT COMM, NOT_LOADED_RANGE:

goto get_ranges_data

if result < limit(cell_limit):

Move Scan Offset by keys_start changed to last_cell_keys, setting -ge comparator to -gt

if next_rid(data):

start_keys(data) = last_cell_keys

goto get_ranges_data

if next_rid(meta):

rid(meta) = 0

start_keys(meta) = last_cell_keys

goto get_ranges_data

DO finish:

return result (call_back)

SWC DB: Query (SQL) scan

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```
select [where_clause [Columns-Intervals or Cells-Intervals]] [Flags(global-scope)];
```

Columns-Intervals: if not set, it is all columns from keys start to finish.

```
col(column-name-a1) = ( [Cells-Intervals] [and] [Cells-Intervals] [and] .. [Cells-Intervals] )
[and] ..
col(column-name-b1, .., column-name-b2) = ( [Cells-Intervals] [and] [Cells-Intervals] [and] .. [Cells-Intervals] )
```

Cells-Intervals: if not set, it is keys start to finish.

```
cells = ( [Cells-Interval] Flags(interval-scope) )
[and]
cells = ( [Cells-Interval] Flags(interval-scope) )
[and]..
cells = ( [Cells-Interval] Flags(interval-scope) )
```

Cells-Interval:

```
[ Condition-Keys ] [and] [ Condition-Value ] [and] [ Condition-Timestamp ]
```

Condition-Keys: keys comparator apply to every key that do not have a dedicated comparator, exact-match is keys=('k1', 'k2',,, 'kN')

```
keys [comparator] ( [comparator] "str-1", [comparator] "str-2", [comparator] "str-3", [comparator] "str-N" )
or (in-range)
([comparator] "str-1", [comparator] "str-N") [ <= or < ] keys [ <= or < ] ([comparator] "str-1", [comparator] "str-N")
```

Condition-Value:

```
value [comparator] "string"
or (for columns of counter type), not applicable comparators (prefix and regexp)
value [comparator] "int64_t(string)"
```

Condition-Timestamp: not applicable comparators (prefix and regexp)

```
timestamp [comparator] "YYYY/MM/DD HH:MM:ss.mmmuuunnn"
or (in-range)
"YYYY/MM/DD HH:MM:ss.mmmuuunnn" [ <= or < ] timestamp [ <= or < ] "YYYY/MM/DD HH:MM:ss.mmmuuunnn"
```

Comparator:

```
[ ^= ] : prefix (starts-with)
[ > ] : -gt (greater-than)
[ >= ] : -ge (greater-equal)
[ = ] : -eq (equal)
[ <= ] : -le (lower-equal)
[ < ] : -lt (lower-than)
[ != ] : -ne (not-equal)
[ re ] : regexp (regular-expression)

* -gt, -ge, -le, -lt are a bit-wise comparison
```

Flags: at global-scope apply to Cells-Interval flags to which does not have flags definitions

```
[ keys_only ] = TRUE on set # default FALSE
[ return_deletes ] = TRUE on set # default FALSE
[ limit ] = NUMBER(uint32_t) # default ALL
[ limit_by ] = "KEYS" or "." # default KEYS
[ offset ] = NUMBER(uint32_t) # default 0
[ offset_by ] = "KEYS" or "." # default KEYS
[ max_versions ] = NUMBER(uint32_t) # default ALL
```

An Example:

```
select
where
  col(ColNameA1) = (
    cells = ( (>='1-') <= keys = (<='1-1-', "1") and value = "Value-Data-1" and timestamp > "2010/05/29" limit=10 limit_by="KEYS" )
  )
and
  col(ColNameB1, ColNameB2) = (
    cells = ( (>='2-') <= keys = (<='2-2-', "1") and value = "Value-Data-2" and timestamp > "2010/05/29" )
    and
    cells = ( keys = (<='21-', "1") and timestamp > "2010/05/29" )
  )
max_versions=1;
```

SWC DB: Scan Specs & Results

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Scan Specs, lib-DB-Client:

ScanSpec (ListColumns columns; Flags flags;) 	ColumnIntervals (int64_t oid ListCellsInterval cells_intervals) The object-type is applied to the range-locator (Client)	CellsInterval (Keys keys_start, keys_finish; Value value; Timestamp ts_start, ts_finish; Flags flags;) 	Keys (ListKeys keys;)
Flags (uint32_t limit, offset, max_versions; LimitType limit_by, offset_by; bool return_deletes, keys_only;) 	Key (const char* key; size_t key_len; Comparator comp;) 	Value (const char* value; size_t value_len; Comparator comp;) 	Timestamp (int64_t ts; Comparator comp;)

Scan Response, lib-DB-Client:

Result (List<Col> cols // ResponseFlag status = OK/PARTIAL/ERROR // Strings error_rs = ["N",]) 	Col (String name String id List<Cell> cells) 	Cell (Strings keys int64_t timestamp char-array value uint32_t value_len)
---	---	---

SWC DB: Column Schema & Actions on Columns

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Although, there are schemas in the SWC-DB these can be considered as schema-less, exception to TTL, Counter and Max-Versions at the Cells level.

Location of Schema and Column-Name to ID:

Reserved Column-ID 4 with cell:

Keys = ("FLAG" "Col-Name", "CID")

Value = (value-serialized)version(int8)

|counter(int8)|ttl(int32)|compression(int8)|bloomfilter(int8)|max_versions(int32)|time_order(int8)|replication(int8)|blocksize(int32)

Configuration Options:

The following configurations available in the Column-Schema:

- CELL-LEVEL:
 - TTL: (int32_t) seconds
 - COUNTER: (bool), default False
 - MAX_VERSIONS: (int32_t), default 1 - not applicable with COUNTER
 - TIME_ORDER: ASC/DESC, default ASC – applied to order of MAX_VERSIONS
- BLOCK-LEVEL:
 - COMPRESSION: none/snappy/zlib/zstd/bmz/lzo/quicklz
 - BLOCKSIZE: (int32_t)
- CELLSSTORE-LEVEL:
 - REPLICATION: (int8_t) – replication factor applied to the DFS supporting file-replication , default 3
 - BLOOMFILTER: (int8_t) – none/all-keys

Adding a Column

SQL:

```
add column (  
    NAME="string",  
    COUNTER=bool,  
    MAX_VERSIONS=number,  
    TTL=number,  
    COMPRESSION="string",  
    BLOCKSIZE=number,  
    REPLICATION=number,  
    BLOOMFILTER="string"  
);
```

lib-DB-Client:

```
ColumnSpec (  
    String          name  
    int64_t         cid  
    Bool            counter  
    int32_t         max_versions  
    int32           ttl  
    Compressor::ENUM compression  
    int8_t          replication  
    BloomFilter     bloomfilter(TYPE::ENUM, factor, functions)  
)
```