What the heck is ClickHouse tiered storage?

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Brief Intros

Robert Hodges - CEO

30+ years on DBMS plus virtualization and security.

ClickHouse is DBMS #20

Altinity

www.altinity.com

Leading software and services provider for ClickHouse

Major committer and community sponsor in US and Western Europe

Data Storage in ClickHouse

(And how to improve it)

Overview of ClickHouse

Understands SQL

Runs on bare metal to cloud

Shared nothing architecture

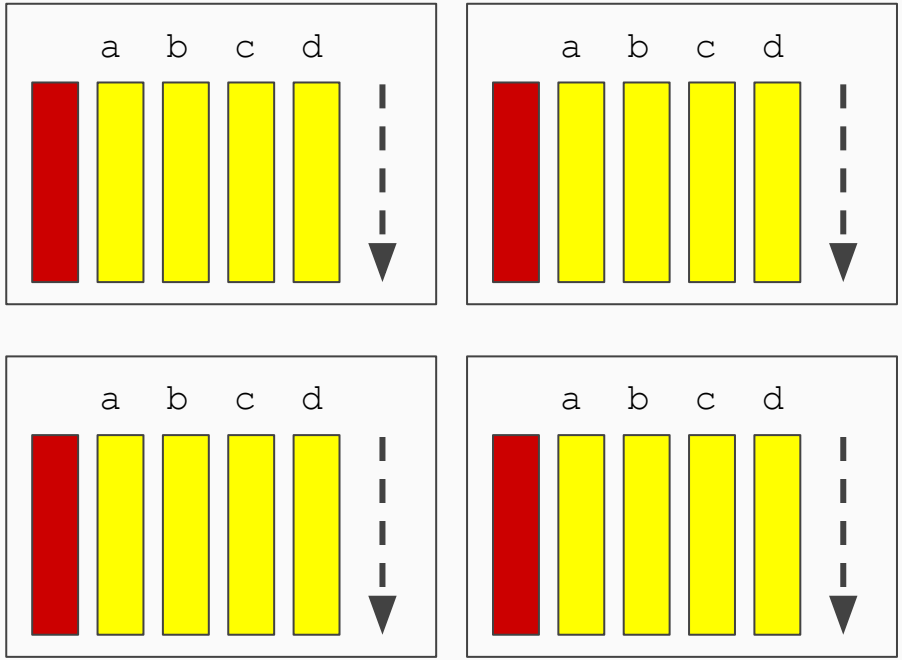
Stores data in columns

Parallel and vectorized execution

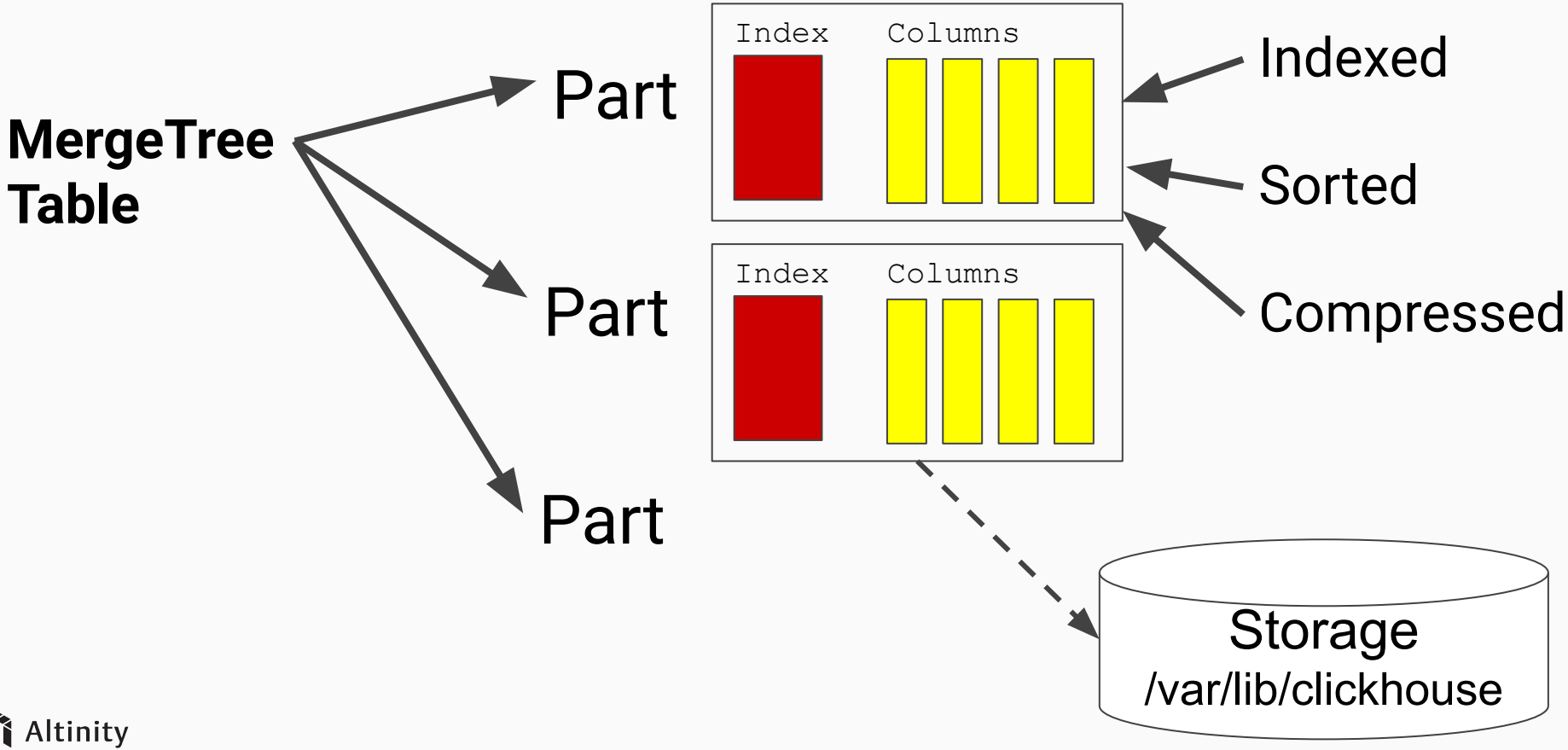
Scales to many petabytes

Is Open source (Apache 2.0)

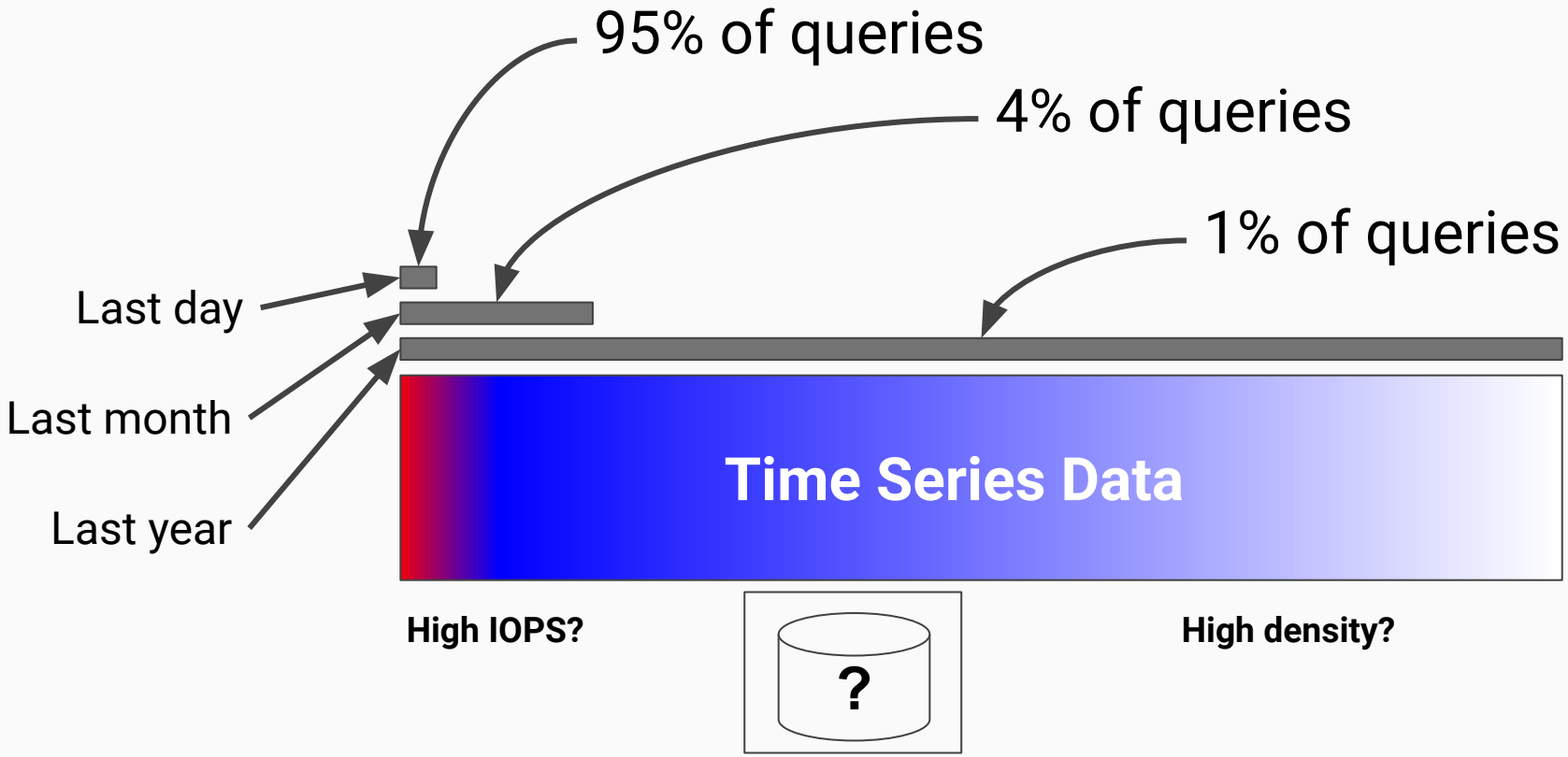
And it's <u>really</u> fast!



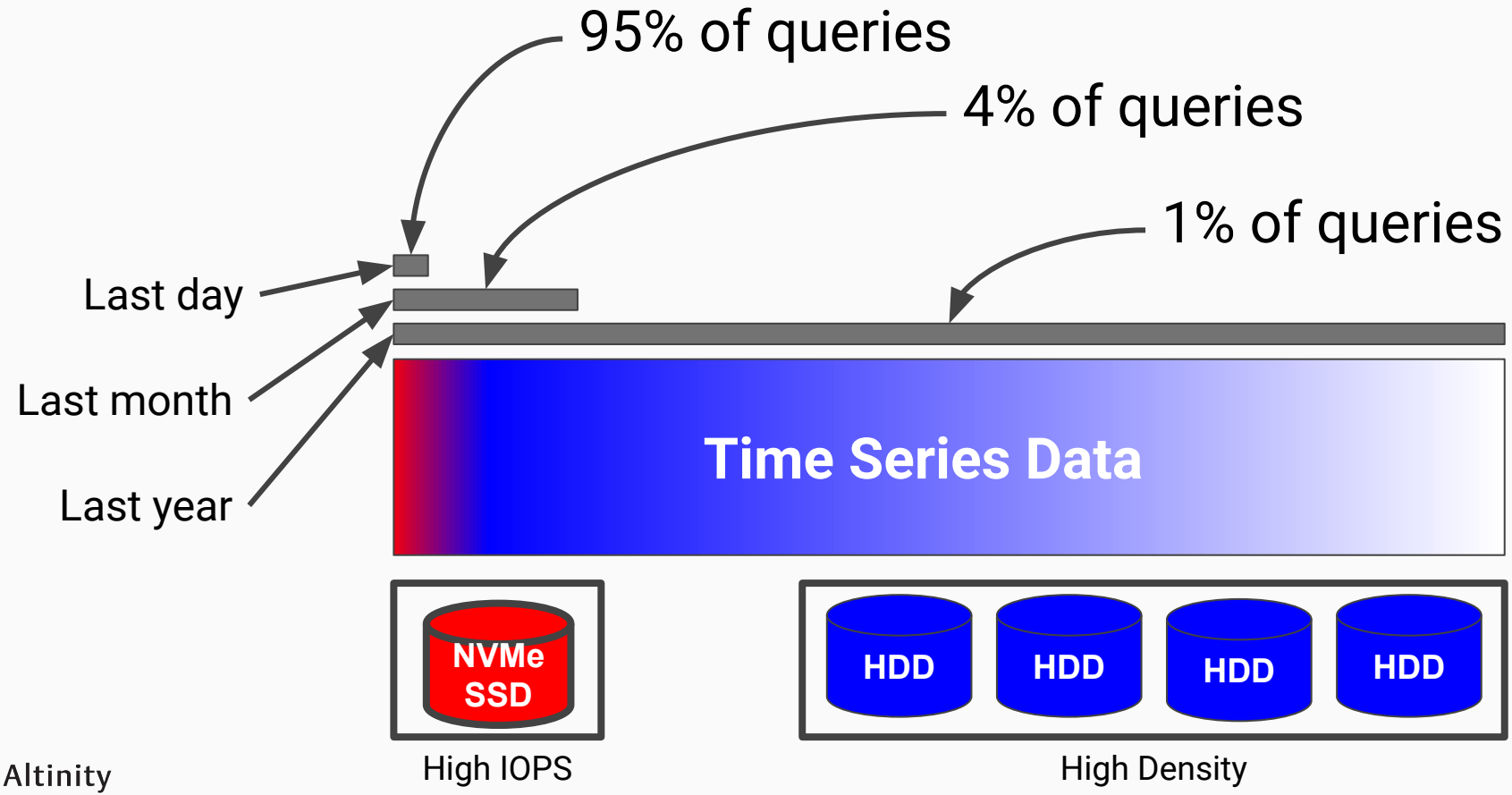
ClickHouse stores data in just one directory



Downsides of a single mount for data

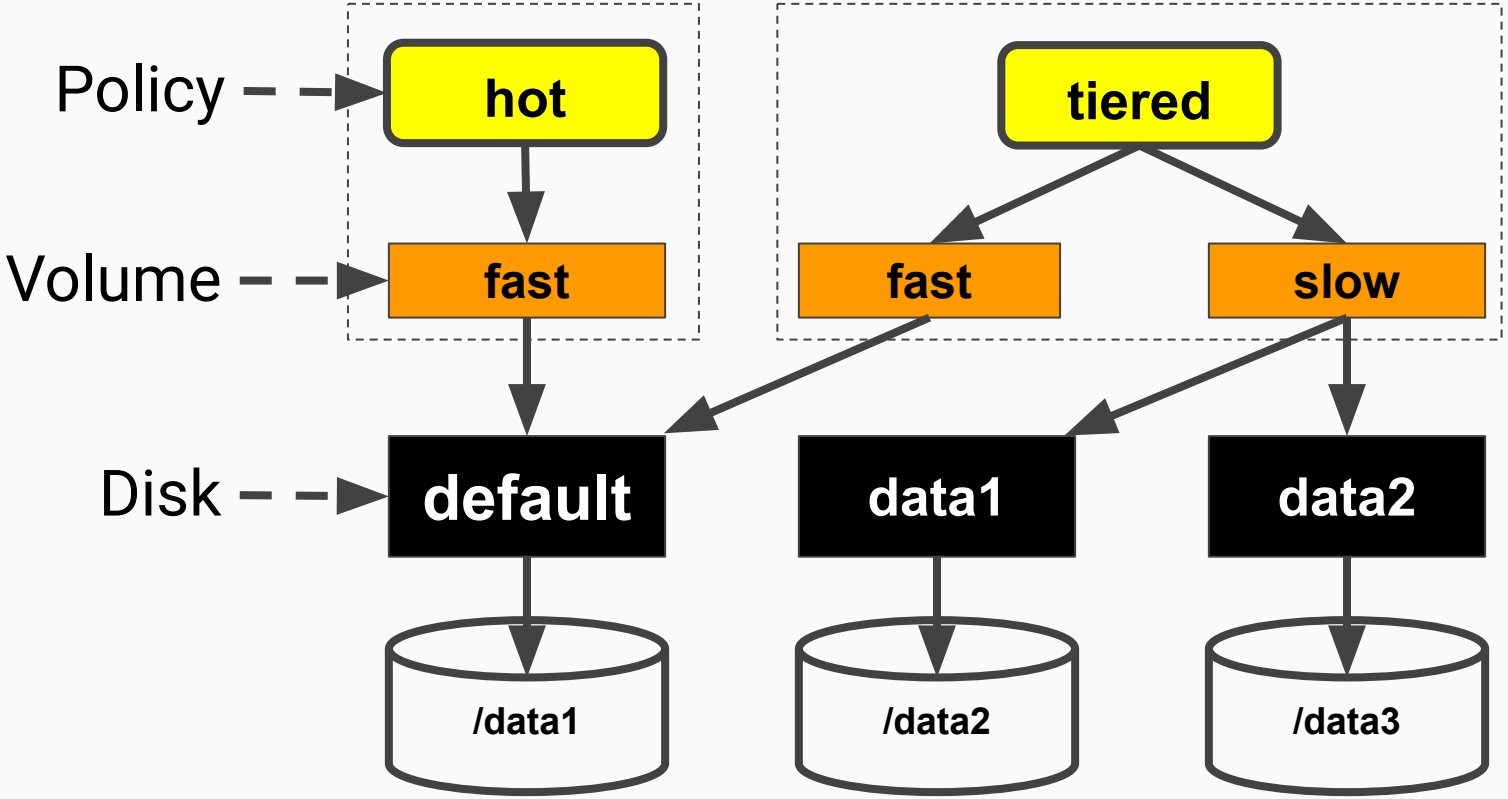


Tiered storage matches storage to access



Introducing Storage Configurations

Storage configurations organize devices



Disks tag lists your devices

```
<yandex>
<storage_configuration>
  <disks>
    <default>
      <keep_free_space_bytes>1024</keep_free_space_bytes>
    </default>
    <data2>
      <path>/data2/clickhouse/</path>
    </data2>
    <data3>
      <path>/data3/clickhouse/</path>
    </data3>
  </disks>
</storage_configuration>
```

Default disk gets path from config.xml

Storage reserve

Other disks provide a path

Policies tag has storage rules for tables

```
<yandex>
<storage_configuration>
  …
  <policies>
    <hot>
      <volumes>
        <fast>
          <disk>default</disk>
        </fast>
      </volumes>
    </hot>
  </policies>
</storage_configuration>
```

Table DDL refers to policy name

Volumes group disks

Disk tags assign volume data to specific disks

There is a new system table to see disks

```
SELECT name, path,
    formatReadableSize(free_space) AS free,
    formatReadableSize(total_space) AS total,
    formatReadableSize(keep_free_space) AS reserved
FROM system.disks
```

name	path	free	total	reserved
data2	/data2/clickhouse/	933.21 GiB	983.30 GiB	0.00 B
data3	/data3/clickhouse/	933.21 GiB	983.30 GiB	0.00 B
default	/data1/clickhouse/	41.19 GiB	274.01 GiB	1.00 KiB

...And another to see storage policies

```
SELECT
    policy_name,
    volume_name,
    volume_priority,
    disks
FROM system.storage_policies
```

policy_name	volume_name	volume_priority	disks
cold	slow	1	['data2','data3']
default	default	1	['default']
hot	fast	1	['default']
tiered_auto	fast	1	['default']
tiered_auto	slow	2	['data2','data3']
tiered_ttl	fast	1	['default']
tiered_ttl	slow	2	['data2','data3']

Building up to tiered storage

Simple example of using a storage policy

```
-- Example of a storage policy.
CREATE TABLE fast_readings (
    sensor_id Int32 Codec(DoubleDelta, LZ4),
    time DateTime Codec(DoubleDelta, LZ4),
    date ALIAS toDate(time),
    temperature Decimal(5,2) Codec(T64, LZ4)
) Engine = MergeTree
PARTITION BY toYYYYMM(time)
ORDER BY (sensor_id, time)
SETTINGS storage_policy = 'hot'
```

Policy for table storage

Simple example of using ‘hot’ storage policy

```
-- Load data ...
INSERT ...

-- Look at parts.
SELECT table, disk_name, count() AS parts,
    formatReadableSize(sum(bytes_on_disk)) AS total_size,
    formatReadableSize(avg(bytes_on_disk)) AS avg_size
FROM system.parts
WHERE (database = currentDatabase()) AND active
GROUP BY table, disk_name ORDER BY table ASC, disk_name ASC
```

table	disk_name	parts	total_size	avg_size
fast_readings	default	4	318.47 MiB	79.62 MiB

Add data on one disk

Storage policy to spread data across disks

```
<yandex>
<storage_configuration>
  ...
  <policies>
     <cold>
       <volumes>
         <slow>
           <disk>data2</disk>
           <disk>data3</disk>
         </slow>
       </volumes>
     </cold>
  <policies>
  ...
```

Inserts go to either disk

Use a policy to store data on slow HDD

```
CREATE TABLE fast_readings (
...
) Engine = MergeTree
PARTITION BY toYYYYMM(time)
ORDER BY (sensor_id, time)
SETTINGS storage_policy = 'cold'
```

Policy for table storage

Parts are distributed over multiple disks

```
-- Look at parts after loading
SELECT table, disk_name, count() AS parts,
    formatReadableSize(sum(bytes_on_disk)) AS total_size,
    formatReadableSize(avg(bytes_on_disk)) AS avg_size
FROM system.parts
WHERE (database = currentDatabase()) AND active
GROUP BY table, disk_name ORDER BY table ASC, disk_name ASC
```

table	disk_name	parts	total_size	avg_size
fast_readings	default	4	318.47 MiB	79.62 MiB
slow_readings	**data2**	**2**	**169.63 MiB**	**84.81 MiB**
slow_readings	**data3**	**2**	**148.84 MiB**	**74.42 MiB**

Tiered policies move data between volumes

```
<yandex>
<storage_configuration>
  <policies>
    <tiered_auto>
      <volumes>
        <fast>
          <disk>default</disk>
          <priority>1</priority>
<max_data_part_size_bytes>200000000</max_data_part_size_bytes>
        </fast>
        <slow>
          <disk>data2</disk>
          <disk>data3</disk>
          <priority>2</priority>
<max_data_part_size_bytes>0</max_data_part_size_bytes>
        </slow>
         </volumes>
    </tiered_auto>
  <policies>
```

Writes initially go to this volume (prio = 1)

Move to priority 2 volume if disk exceeds reserve or part > 200M bytes

Apply tiered storage policy on table

```
CREATE TABLE fast_readings (
...
) Engine = MergeTree
PARTITION BY toYYYYMM(time)
ORDER BY (sensor_id, time)
SETTINGS storage_policy = 'tiered_auto'
```

Parts are distributed over multiple disks

```
-- Look at part locations after loading
```

table	disk_name	parts	total_size	avg_size
auto_tiered_readings	**default**	**4**	**318.47 MiB**	**79.62 MiB**
fast_readings	default	4	318.47 MiB	79.62 MiB
slow_readings	data2	2	169.63 MiB	84.81 MiB
slow_readings	data3	2	148.84 MiB	74.42 MiB

```
-- Force table merge.
OPTIMIZE TABLE auto_tiered_readings FINAL

-- Look again after optimization.
```

table	disk_name	parts	total_size	avg_size
auto_tiered_readings	**data2**	**1**	**318.47 MiB**	**318.47 MiB**
fast_readings	default	4	318.47 MiB	79.62 MiB
slow_readings	data2	2	169.63 MiB	84.81 MiB
slow_readings	data3	2	148.84 MiB	74.42 MiB

Use simpler policies for TTL movement

```
<yandex>
<storage_configuration>
  <policies>
    <tiered_ttl>
      <volumes>
        <fast>
          <disk>default</disk>
        </fast>
        <slow>
          <disk>data2</disk>
          <disk>data3</disk>
        </slow>
      </volumes>
    </tiered_ttl>
  <policies>
```

Writes go to default if there's no priority specified

TTL clauses take care of movement automatically

Add TTL move and delete rules to table

```
CREATE TABLE fast_readings (
...
) Engine = MergeTree
PARTITION BY toYYYYMM(time)
ORDER BY (sensor_id, time)
TTL time + INTERVAL 1 DAY TO VOLUME 'slow',
  time + INTERVAL 1 YEAR DELETE
SETTINGS storage_policy = 'tiered_auto'
```

Available in version 20.1.x

Load data and check distribution

```
-- Load data...

-- Check parts after merge
```

table	disk_name	parts	total_size	avg_size
ttl_tiered_readings	data2	4	414.24 MiB	103.56 MiB
ttl_tiered_readings	data3	4	207.52 MiB	51.88 MiB
ttl_tiered_readings	default	1	7.81 MiB	7.81 MiB

Hot volume contains only data from today

TTL rules are applied on load

So...What can cause a part to move?

- Free space on disk < keep_free_space_bytes value
- Free space on disk < move_factor ratio
- Part size > max_data_part_size_bytes
- Move TTL has expired
- You move it yourself with ALTER TABLE MOVE PARTITION

Triggers for evaluating rules:
INSERT, background merge, ALTER TABLE MOVE PARTITION

Yes! You can move partitions yourself

```
-- Who is using data2 disk?
SELECT table, partition, disk_name
FROM system.parts WHERE disk_name = 'data2'
```

table	partition	disk_name
slow_readings	201901	data2
slow_readings	201901	data2

```
-- Move partitions to data3
ALTER TABLE slow_readings
   MOVE PARTITION 201901 TO DISK 'data3'
```

Roadmap

Roadmap for storage

- Eradicate remaining special cases in tiered storage
  - Pick up storage_configuration changes without restart
- Add S3-compatible object storage as a storage tier
- Backup
- And more!

Thank you!

We're hiring!

Presenter:
rhodges@altinity.com

ClickHouse:
https://github.com/yandex/ClickHouse

Altinity Blog:
https://www.altinity.com/blog

SQL script to load tables

```
INSERT INTO ttl_tiered_readings (sensor_id, time, temperature)
WITH
  toDateTime(toDate('2020-01-01')) as start_time,
  10000 as num_sensors,
  365 as num_days,
  24*60 as num_minutes,
  num_days * num_minutes as total_minutes
SELECT
  intDiv(number, num_minutes) % num_sensors as sensor_id,
  start_time + (intDiv(number, num_minutes*num_sensors) as day)*24*60*60 + (number % num_minutes
as minute)*60 time,
  60 + 20*sin(cityHash64(sensor_id)) /* median deviation */
  + 15*sin(2*pi()/num_days*day) /* seasonal deviation */
  + 10*sin(2*pi()/num_minutes*minute)*(1 + rand(1)%100/2000) /* daily deviation */
  + if(sensor_id = 473869 and
      time between '2019-08-27 13:00:00' and '2019-08-27 13:05:00', -50 + rand(2)%100, 0)
      /* sensor outage, generates huge error on 2019-08-27 */
  as temperature
FROM numbers_mt(500000000)
SETTINGS max_block_size=1048576;
```

(Change table name)

(Change table size)