DATASTAX®

Realistic Pulsar Load testing made easy with NoSQLBench

Yabin Meng | ApacheCon NA 2022 | Oct 5, 2022

Agenda

1. Introduction
2. Apache Pulsar and Load Testing
3. NoSQLBench(NB) Introduction and NB Pulsar driver(s)
4. Demo
5. Q&A

Introduction

Who am I?

- DataStax Streaming Solutions Architecture Practice Lead
- 6 years at DataStax - C* and Pulsar
- 20+ years IT experience with the focus on database, messaging/streaming and related technologies
- Dedicated to NoSQL and Streaming technology consulting in recent years

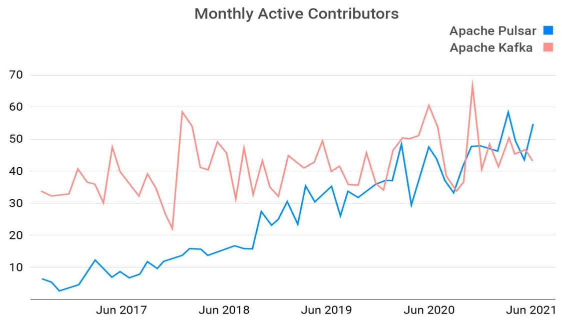
Who is DataStax?

- DataStax was founded by Jonathan Ellis and Matt Pfeil in 2010 - The C* company
- Opens Source @ DataStax
  - DataStax has always been a major contributor to the Apache Cassandra project since early days of C*
  - DataStax has become one of the top contributors to Apache Pulsar project and Bookkeeper project
  - Other key OSS contributions: Stargate, K8ssandra, Starlight APIs for Pulsar etc.
- Multi-cloud SaaS offering
  - Astra DB
  - Astra Streaming
- Enterprise support or Opens source
  - Luna
  - Luna Streaming

Apache Pulsar and Load Testing

Apache Pulsar

- Distributed messaging and streaming platform
  - Donated to ASF in 2016 by Yahoo!
  - Top-level Project in 2018 and very fast growing
  - Yahoo, Splunk, Overstock, Tencent, etc.
- Key Differentiators
  - Separation between Compute and Storage
  - Native Geo-replication
  - Robust multi-tenancy
  - Flexible message processing model



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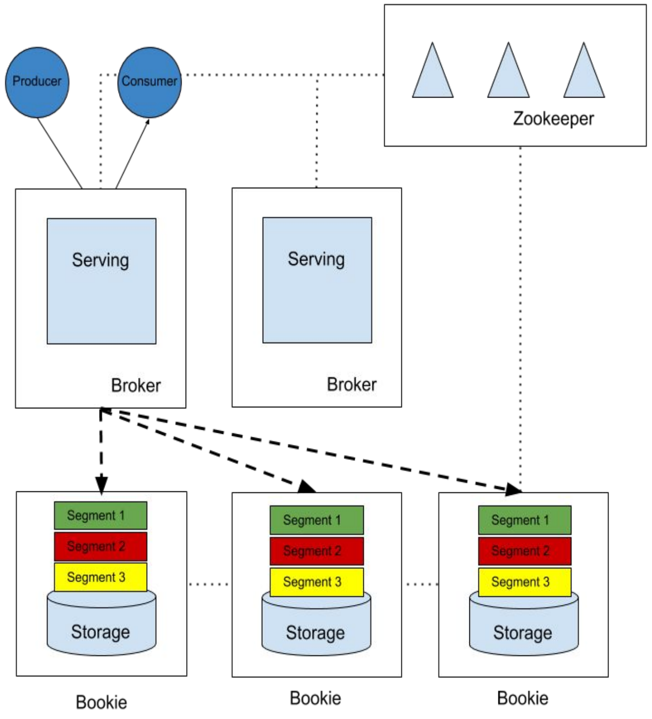


Pulsar Load Testing Tools

- pulsar-perf
  - Native piece of Pulsar; a standalone Pulsar client application
  - Built-in workload type: produce, consume, read, websocket-producer, managed-ledgers, transaction, …
  - Metrics: throughput and latency percentile
    - command line output and histogram file (HdrHistogram Plotter)
- Open Messaging Benchmark (OMB) framework
  - A Linux Foundation Collaborative project
  - A generic load test engine specifically designed for different messaging systems, including JMS, RabbitMQ, Kafka, Pulsar, and more
  - Takes a driver-worker model
    - Driver is for creating topic, producer, and consumer
    - Worker is for actual workload execution
  - Metrics: pub rate, cons rate, backlog, pub latency, delay latency
    - command line output and json file(s) (create_chart.py)
  - Out of the box only supports running on AWS and AliCloud (with terraform automation)

Pulsar Load Testing Tools, continued

Workload Modeling

pulsar-perf	● Simplified workload generation ● No workload modeling
OMB	

Workload Execution

pulsar-perf	● No scheduling capability
OMB	● Limited capability

A **common challenge** shared by many general-purpose load testing tools for different system!

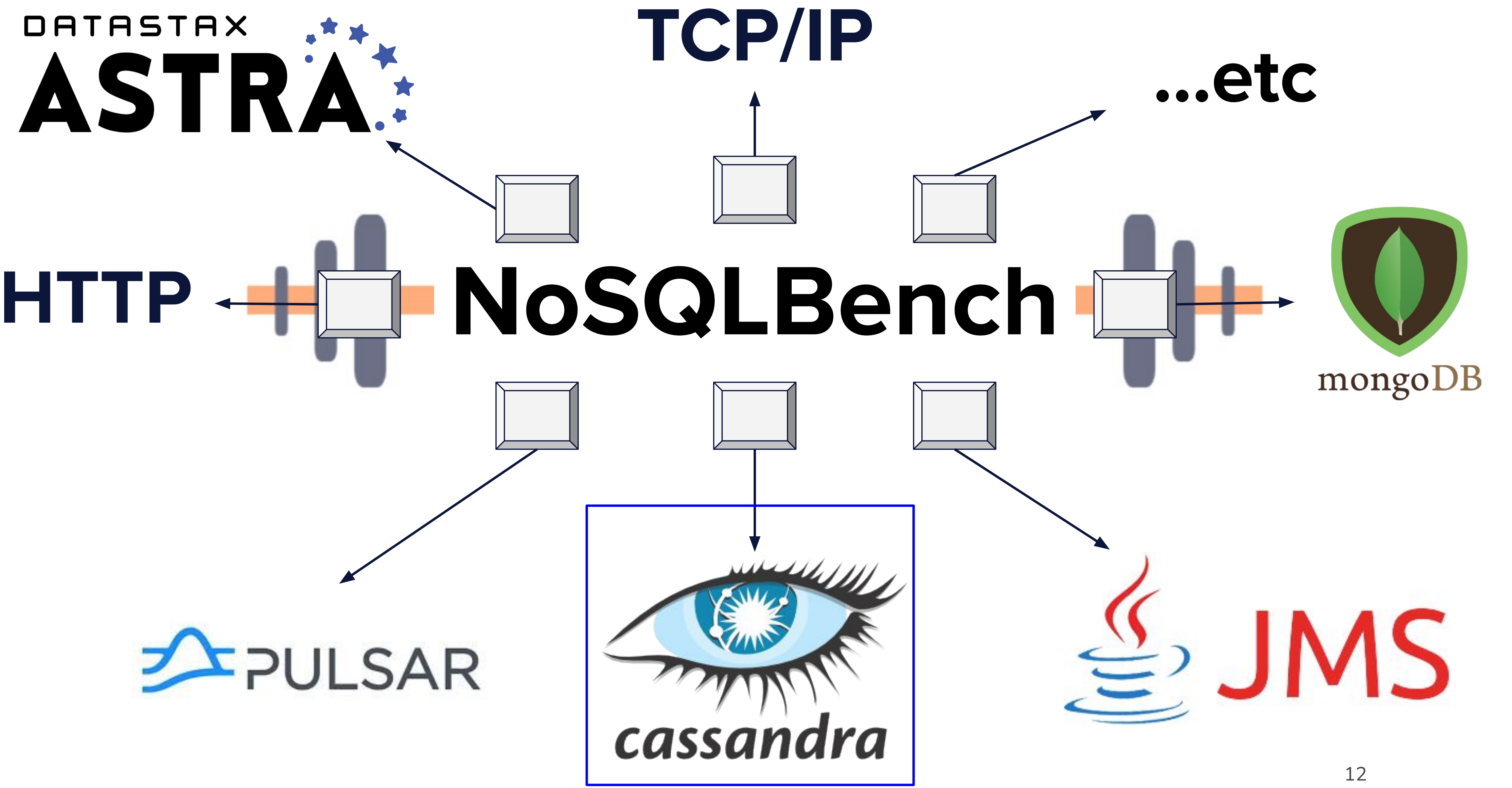
NoSQLBench

Overview

What is Nosqlbench?

NoSQLBench

"...is a workload simulation and performance testing tool for the ~~NoSQL~~ ecosystem"



NoSQLBench

DATASTAX ASTRA

TCP/IP

...etc

HTTP

mongoDB

PULSAR

cassandra

JMS

Why NoSQLBench?

Focus on business domain (data modeling)
Deterministic and repeatable testing
(Realistic Load Testing)

CAN'T YOU DO ANYTHING RIGHT?
GLASBERGEN
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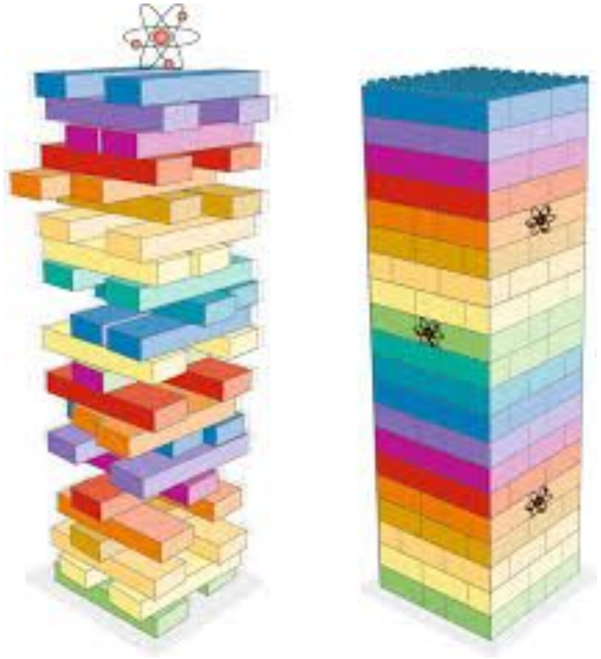
- Recipe-oriented procedural data generation
- Deterministic workload behavior
- Modular protocol (driver) support
- Configuration language for statements and data
- Scripting built-in (automation)
- Cycle-specific operations and diagnostics
- Docker-metrics dashboard
- Consistent view of high-fidelity metrics, multiple output formats and reporting options
- Support for coordinated omission

Note: credits to Jonathan Shook, the author of NosqlBench

NoSQLBench Core Concepts

- Scenario Definition (Yam File)
  - Bindings (data generation)
  - Statements (core execution)
    - Parameters
  - Blocks (of statements)
  - Tags

- Scenario Execution
  - Driver/Protocol (workload type: C*, Pulsar, etc.)
  - Cycles
  - Threads
  - Strides
  - … …



NoSQLBench C* Example - IoT Workload

```
nb run driver=cql workload=cql-iot-basic.yaml tags=phase:rampup threads=10 cycles=10M hosts=”<C*_hostname/ip>”
```

Simulate C* insert workload (10M records)

```
description: |
  This workload emulates a time-series data model and ramps up data after schema creation.
bindings:
  machine_id: Mod(10000); ToHashedUUID() -> java.util.UUID
  sensor_name: HashedLineToString('data/variable_words.txt')
  time: Mul(100); Div(10000L); ToDate()
  cell_timestamp: Mul(100L); Div(10000L); Mul(1000L)
  sensor_value: Normal(0.0,5.0); Add(100.0) -> double
  station_id: Div(10000);Mod(100); ToHashedUUID() -> java.util.UUID
  data: HashedFileExtractToString('data/lorem_ipsum_full.txt',800,1200)
blocks:
  - tags:
      phase: rampup
      statements:
        - insert-rampup: |
            insert into <<keyspace:baselines>>.<<table:iot>>
            (machine_id, sensor_name, time, sensor_value, station_id, data)
            values ({machine_id}, {sensor_name}, {time}, {sensor_value}, {station_id}, {data})
            using timestamp {cell_timestamp}
          idempotent: true
          prepared: true
          cl: LOCAL_QUORUM
```

data binding

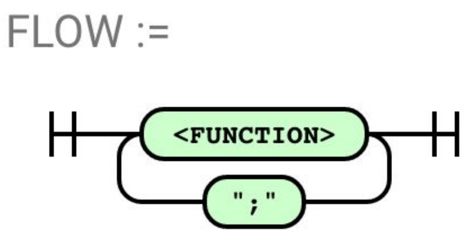
execution tag:phase

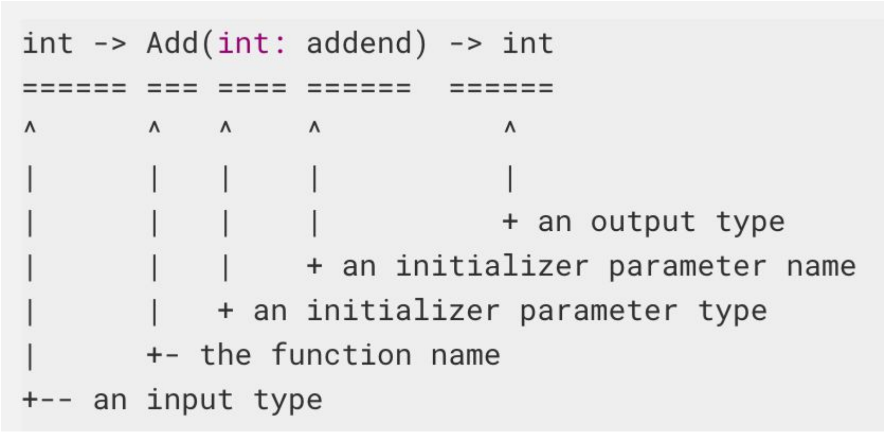
statement template

execution parameter

NoSQLBench Data Binding

- Procedural, deterministic data generation through bindings
  - http://docs.virtdata.io/
- Binding: <binding_name>:<binding_receipe>
  - e.g. **`machine_id`**`: Mod(10000); ToHashedUUID() -> java.util.UUID`
- Binding recipe: a **Function Flow**
- **Function**
  - Add(5)
  - int -> Add(5)
  - Add(5) -> int
  - int -> Add(5) -> 5
- A large set of available functions

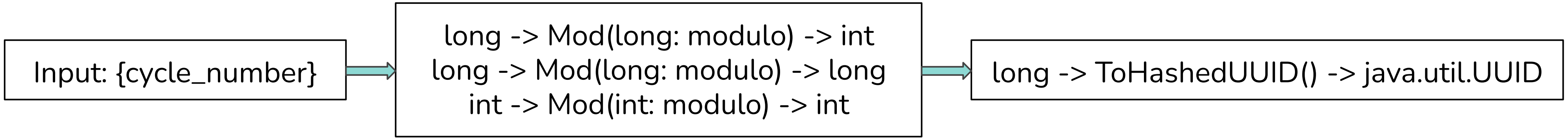




```
int -> Add(int: addend) -> int
====== === ==== ======  ======
^      ^   ^    ^          ^
|      |   |    |          |
|      |   |    |          + an output type
|      |   |    + an initializer parameter name
|      |   + an initializer parameter type
|      +- the function name
+-- an input type
```

NoSQLBench Data Binding Example

- **`machine_id`**`: Mod(5); ToHashedUUID() -> java.util.UUID`



Input: {cycle_number}

long -> Mod(long: modulo) -> int
long -> Mod(long: modulo) -> long
int -> Mod(int: modulo) -> int

long -> ToHashedUUID() -> java.util.UUID

- nb run driver=stdout workload=**mod-only.yaml** cycles=10
  - `machine_id: Mod(<<sources:5>>)`
- nb run driver=stdout workload=**mod-hash.yaml** cycles=10
  - `machine_id: Mod(<<sources:5>>); ToHashedUUID()`

```
machine_id=0
machine_id=1
machine_id=2
machine_id=3
machine_id=4
machine_id=0
machine_id=1
machine_id=2
machine_id=3
machine_id=4
```

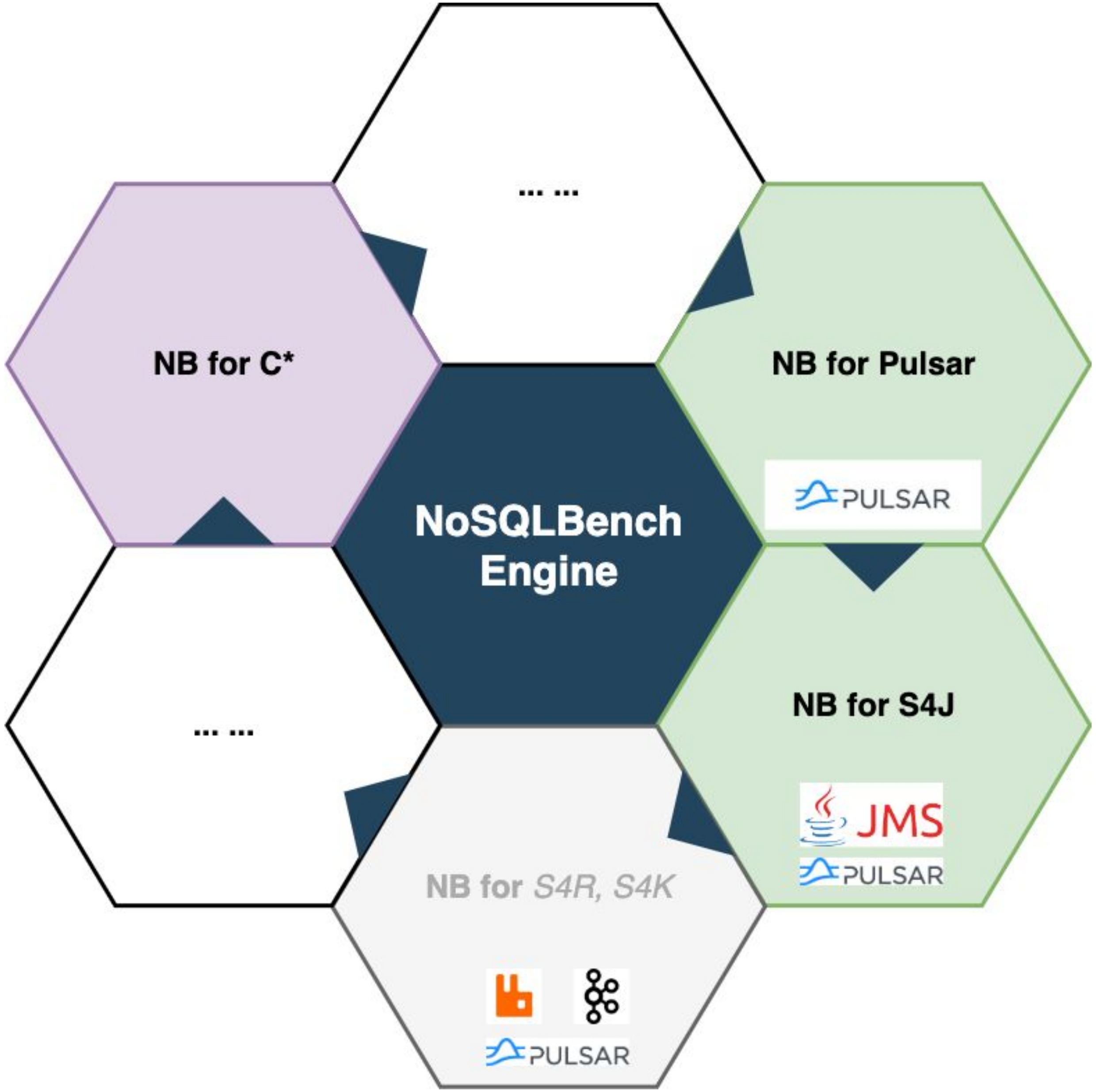
```
machine_id=28df63b7-cc57-43cb-9752-fae69d1653da
machine_id=5752fae6-9d16-43da-b20f-557a1dd5c571
machine_id=720f557a-1dd5-4571-afb2-0dd47d657943
machine_id=6fb20dd4-7d65-4943-9967-459343efafdd
machine_id=19674593-43ef-4fdd-bdf4-98b19568b584
machine_id=28df63b7-cc57-43cb-9752-fae69d1653da
machine_id=5752fae6-9d16-43da-b20f-557a1dd5c571
machine_id=720f557a-1dd5-4571-afb2-0dd47d657943
machine_id=6fb20dd4-7d65-4943-9967-459343efafdd
machine_id=19674593-43ef-4fdd-bdf4-98b19568b584
```

NoSQLBench Standard Metrics

- Metrics report options
  - --report-csv-to <dirname>
  - --report-graphite-to <addr>[:<port>]
    - --metrics-prefix <metrics-prefix>
  - --report-interval <interval-seconds> (default 10 seconds)
- HDR histogram
  - --log-histograms histodata.log
  - --log-histostats stats.csv
- Docker metrics
  - --docker-metrics
    - Dockerized Grafana and Prometheus

Field/Column Name	Meaning
t	The time that the metric sample was written
count	The running op count at that time
min, max	minimum and maximum latency (for that histogram, different for time-decaying vs discrete buckets)
mean	The mean value (since start)
stddev	one standard deviation for the current histogram
p50,p75,p95,p98,p99,p999	percentiles from the current histogram (latencies, unless otherwise specified)
mean_rate	mean rate since the start of the timer
m1_rate,m5_rate,m15_rate	one, five, fifteen minute moving average rates
rate_unit	generally "ops/second"
duration_unit	"nanoseconds"

NoSQLBench Pulsar Driver



- NB for native Pulsar client driver
- NB for Starlight for JMS API (S4J)
- NB for Starlight for RabbitMQ and Kafka (S4R and S4K)

Why NB Pulsar Driver?

Realistic Message Modeling

Complete Workload Execution Behavior Tuning

Authentic Multi-tenancy Testing

Deterministic and Repeatable Workload Execution

NB Pulsar Scn. Yaml and Workload Type

```
bindings:
 ... ...

params:
 topic_uri: "<pulsar_topic_name> (dynamic or static)"
 async_api: "[true|false]"
  … …

blocks:
 - name: <statement_block>
   tags:
     phase: <phase_identifier>
   statements:
     - name: <statement_name_1>
       optype: <statement_identifier>
       ... <statement_specific_parameters> ...
     - name: <statement_name_2>
       ... ...

 - name: <command_block_2>
   ...
```

- create/delete tenants
- create/delete namespaces
- create/delete topics
- producer
- consumer (single topic)
- reader
- consumer (multi-topic)

NB Pulsar - Realistic Messaging Modeling

```
blocks:
 - name: block1
   tags:
     phase: <phase_identifier>
   statements:
     - name: s1
       optype: msg-send
       topic_uri: "{topic_name}"
       msg_key: "{mykey}"
       msg_property: |
         {
           "site_id":  "{site_id_uuid}",
           "site_desc": "{site_desc_text}"
         }
       msg_value: |
         {
           "SensorID": "{sensor_id_uuid}",
           "SensorType": "{sensor_type}",
           "ReadingTime": "{reading_time}",
           "ReadingValue": {reading_value}
         }
       ratio: 1
```

- ☑ Complete message structure
  - Message Key, Properties, and Payload
- ☑ Message format reflecting actual business need
  - Avro and KeyValue schema support
- ☑ Multi-topics with varied message formats
  - Different tenants and/or namespaces
- ☑ Flexible mixture of message producing and consuming
- ☑ Precise workload ratio control

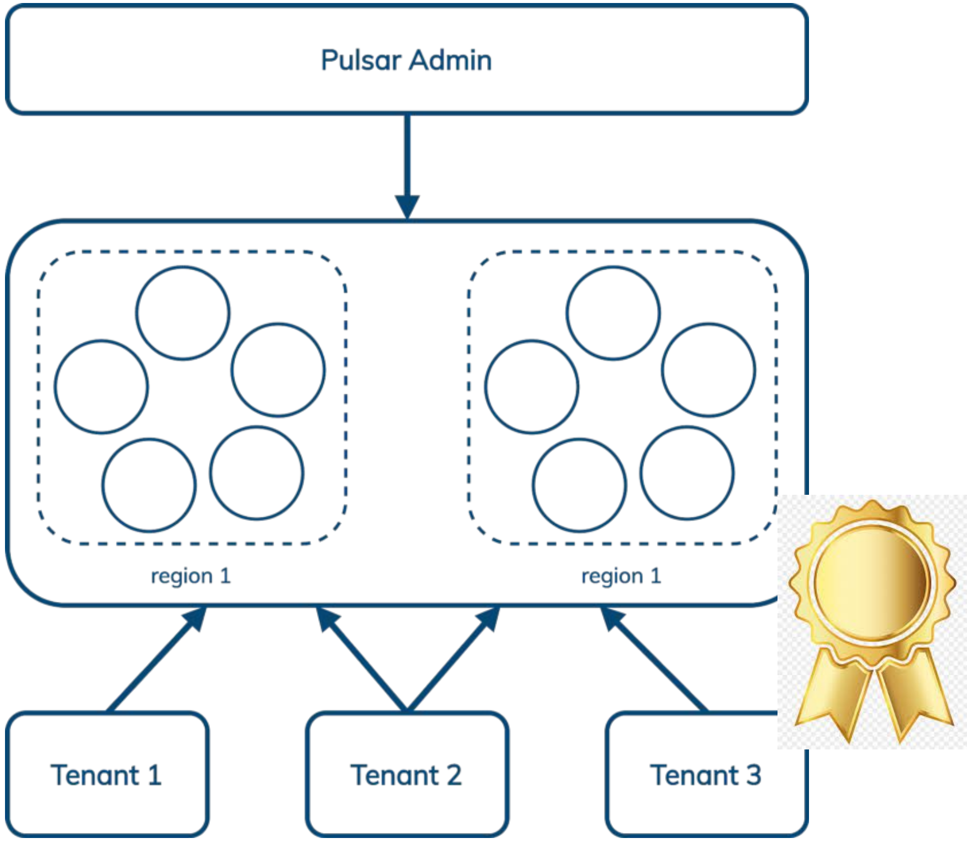
NB Pulsar - Workload Exec. Tuning (Tiered Config)

```
nb run driver=pulsar threads=10 cycles=10M web_url=http://localhost:8080 service_url=pulsar://localhost:6650
workload=</path/to/Scn.yaml> config=</path/to/config.properties>
```

```
### Schema related configurations
schema.type=
schema.definition=
...

### Pulsar client related configurations
client.connectionTimeoutMs=5000
client.authPluginClassName=
client.authParams=
...

### Producer related configurations - producer.xxx
producer.producerName=
producer.blockIfQueueFull=true
...

### Consumer related configurations - consumer.xxx
consumer.consumerName=
consumer.receiverQueueSize=
...
```

```
params:
  async_api: [true|false]
  use_transaction: [true|false]
  admin_delop: [true|false]
  seq_tracking: [true|false]
  … …

blocks:
 - name: consumer-block
   tags:
       phase: consumer
   statements:
       - name: s1
         optype: msg-consume
         subscription_name:
         subscription_type:
         consumer_name:
```

NB Pulsar - Authentic Multi-tenancy Testing

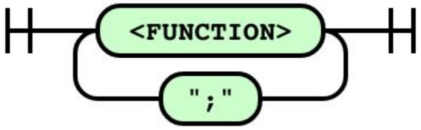


persistent://<tenant_name>/<namespace_name>/<topic_name>

- ❑ Multi-topic, multi-tenancy based testing is the **reality** !
  - ○ It is critical to understand of how multiple tenants impact each other in a single cluster and how effective resource segregation works.
- ❑ Existing Pulsar performance testing tools are pretty much single-topic oriented.

NB Pulsar - Deterministic and Repeatable Workload Execution

FLOW :=



NoSQLBench

NB Pulsar Examples - tenants, namespaces

```
# 10 tenants
bindings:
 tenant: Mod(10); ToString(); Prefix("tnt")

params:
 admin_delop: "false"

blocks:
 - name: create-tenant-block
   tags:
     phase: admin-tenant
     admin_task: true
   statements:
     - name: s1
       optype: admin-tenant
       admin_roles:
       allowed_clusters:
       tenant: "{tenant}"
```

```
bindings:
 # 20 namespaces: 10 tenants, 2 namespaces/tenant
 tenant: Mod(20); Div(2L); ToString(); Prefix("tnt")
 namespace: Mod(2); ToString(); Prefix("ns")

params:
 admin_delop: "false"

blocks:
 - name: create-namespace-block
   tags:
     phase: admin-namespace
     admin_task: true
   statements:
     - name: s1
       optype: admin-namespace
       namespace: "{tenant}/{namespace}"
```

NB Pulsar Examples - topics

```
bindings:
 # 100 topics: 10 tenants, 2 namespaces/tenant, 5 topics/namespace
 tenant: Mod(100); Div(10L); ToString(); Prefix("tnt")
 namespace: Mod(10); Div(5L); ToString(); Prefix("ns")
 core_topic_name: Mod(5); ToString(); Prefix("t")

params:
 admin_delop: "false"

blocks:
 - name: create-topic-block
   tags:
     phase: admin-topic
     admin_task: true
   statements:
     - name: s1
       optype: admin-topic
       topic_uri: "persistent://{tenant}/{namespace}/{core_topic_name}"
       enable_partition: "true"
       partition_num: "10"
```

NB Pulsar Examples - producers and consumers

Basic producer

```
statements:
  - name: producer-basic
    optype: msg-send
    topic_uri: "{topic_name_1}"
    msg_key:
    msg_property:
    msg_value: "{msg_value}"
    producer_name:
```

Avro producer

```
statements:
  - name: producer-avro
    optype: msg-send
    topic_uri: "{topic_name_2}"
    msg_key: "{msg_key}"
    msg_property: |
     {
        ……
     }
    msg_value: |
     {
        ……
     }
    producer_name:
```

KeyValue with Avro is also supported

```
schema.type=avro
schema.definition=/path/to/avr
o/definition/file
```

Single topic consumer

```
statements:
  - name: consumer-single
    optype: msg-consume
    topic_uri: "{topic_name_1}"
    subscription_name: "{sub_name}"
    subscription_type:
    consumer_name:
```

Multi topic consumer

```
statements:
 - name: s1
   optype: msg-mt-consume
   topic_names: "{topic_name_list}"
   topics_pattern: "{topic_name_pattern}"
   subscription_name: "{sub_name}"
   subscription_type:
   consumer_name:
```

NB Pulsar Examples - topics

```
nb run driver=pulsar threads=1 cycles=10M \
   web_url=http://localhost:8080 \
   service_url=pulsar://localhost:6650 \
   workload=</path/to/Scn.yaml> \
   config=</path/to/config.properties> \
   cyclerate_per_thread=true cyclerate=1K \
   --progress console:10s -v \
   --report-graphite-to <graphite_server_ip>:9109 \
   --report-csv-to metrics
```

NB Pulsar Examples - Producer Execution Output

```
… …
2022-10-02 03:45:28,141 [pulsar-client-io-5-1] INFO : [[id: 0x401df668, L:/172.31.4.34:62285 - R:/10.166.90.105:6650]] Connected
to server
2022-10-02 03:45:28,686 [pulsar-client-io-5-1] INFO : Starting Pulsar producer perf with config: {
 "topicName" : " persistent://public/default/tp_large",
 "producerName" : null,
……
2022-10-02 03:45:29,730 [pulsar-client-io-5-1] INFO : [persistent://public/default/tp_large] [MyCluster1-1-26]    Created producer
on cnx [id: 0x9af6440d, L:/172.31.4.34:62286 - R:ip-10-166-90-105.us-west-2.compute.internal/10.166.90.105:6650]
… …
2022-10-02 03:45:30,028 [pulsar-client-io-5-1] INFO : Starting Pulsar producer perf with config: {
 "topicName" : " persistent://public/default/tp_small",
… ….
2022-10-02 03:45:30,449 [pulsar-client-io-5-1] INFO : [persistent://public/default/tp_small] [MyCluster1-1-28]    Created producer
on cnx [id: 0x9af6440d, L:/172.31.4.34:62286 - R:ip-10-166-90-105.us-west-2.compute.internal/10.166.90.105:6650]
… …
2022-10-02 03:47:24,860 [ProgressIndicator/logonly:10s] INFO :
/Users/yabinmeng/MyFolder/Yabin.Work/PSA.Vanguard/Conference/ApacheCon/NA2022/yaml/producer.yaml:    18.43%/Running (details: min=0
cycle=921680 max=5000000)
2022-10-02 03:47:28,717 [pulsar-timer-8-1] INFO : [persistent://public/default/tp_large] [MyCluster1-1-22] Pending messages: 67
--- Publish throughput: 2442.23 msg/s --- 26.68 Mbit/s --- Latency: med: 104.000 ms - 95pct: 184.000 ms - 99pct: 272.000 ms -
99.9pct: 325.000 ms - max: 392.000 ms --- Ack received rate: 2444.81 ack/s --- Failed messages: 0
2022-10-02 03:47:34,860 [ProgressIndicator/logonly:10s] INFO :
/Users/yabinmeng/MyFolder/Yabin.Work/PSA.Vanguard/Conference/ApacheCon/NA2022/yaml/producer.yaml:    20.16%/Running (details: min=0
cycle=1007900 max=5000000)
… …
2022-10-02 03:55:50,468 [pulsar-client-io-5-1] INFO : [persistent://public/default/tp_large] [MyCluster1-1-26]    Closed Producer
2022-10-02 03:55:50,468 [pulsar-client-io-5-1] INFO : [persistent://public/default/tp_small] [MyCluster1-1-28]    Closed Producer
… …
2022-10-02 03:55:52,560 [scenarios:001] INFO : scenario state: Finished
10/1/22, 10:55:52 PM ============================================================

-- Gauges ----------------------------------------------------------------------
… …

-- Histograms ------------------------------------------------------------------
… …

-- Timers ----------------------------------------------------------------------
… ….

2022-10-02 03:55:52,768 [main] INFO : executions: 1 scenarios, 1 normal, 0 errored
```

Initializing connection and producers

Real time progress report and message processing feedback

Closing connection and producers

Execution metrics high level summary

2 producers, 1 large payload and 1 small payload with ratio of 3:7

NB Pulsar Examples - Driver Metrics

- **Producer**/Consumer/Reader Gauges, e.g. for producer
  - Sent message count rate
  - Sent message bytes rate
  - Send failed
- Error detection Counters
  - Message duplication
  - Message loss
  - Message out-of-sequence
- Histograms
  - End-to-end message latency

NoSQLBench Demo

NB Pulsar Demo - Overview

- A small Pulsar cluster (K8s deployment) running on GKE
  - 3 zookeepers
  - 3 brokers
  - 3 bookkeepers
  - Other supporting components
- Two NB Pulsar testing client processes running locally
  - 1 producer
  - 1 consumer
- Message Model
  - 256 bytes text payload
  - 1 message property
  - No message key

Resources

- Project and Document Home page
  - Source code: https://github.com/nosqlbench/nosqlbench
  - Document: http://docs.nosqlbench.io/#/docs/
- NB Pulsar driver (Main/NB5 branch)
  - https://github.com/nosqlbench/nosqlbench/tree/main/driver-pulsar
- NB S4J driver (NB4 branch)
  - https://github.com/nosqlbench/nosqlbench/tree/nb4-maintenance/driver-s4j [**Doc**]
- Download
  - https://github.com/nosqlbench/nosqlbench/releases
- Online workshop (DataStax Academy)
  - DataStax Academy Github
    https://github.com/DataStax-Academy/nosqlbench-workshop-online

DATASTAX®

Thank you