Flink 监控与性能优化

极客时间

扫码试看/订阅

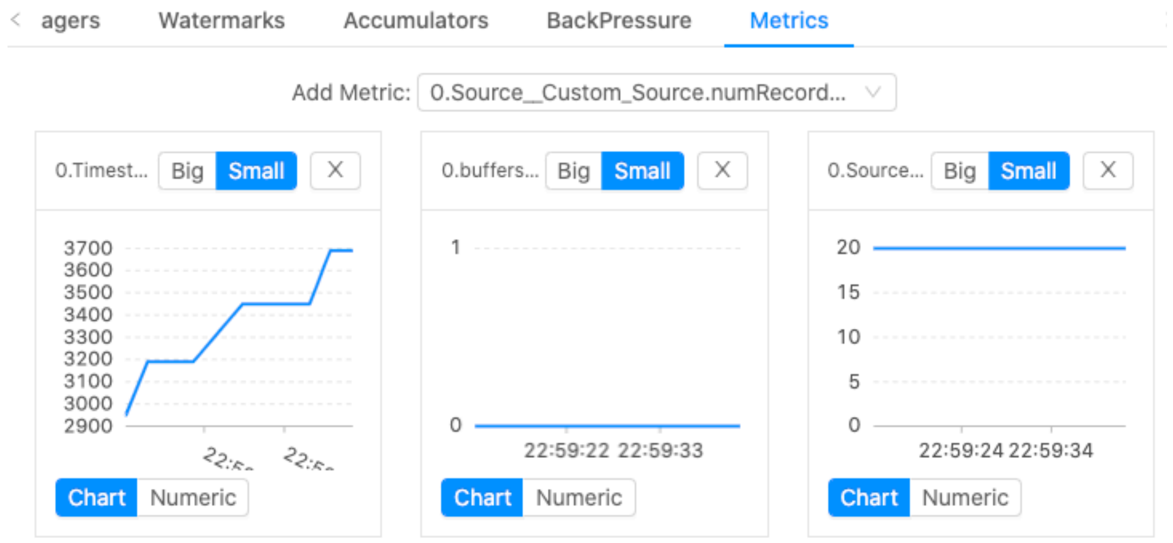
《Flink核心技术与实战》视频课程

目录

Metric 指标分类与采集

Metric 指标监控

- <identifier, measurement>
- Metric 类型：
  - Counter
    - 计数器
  - Gauge
    - 最简单的Metric，反映一个值
  - Meter
    - 单位时间内发生事件的次数
  - Histogram
    - 统计数据分布，Mean，Max，Min，StdDec 等
- Exposed via MetricReporters
- Also a REST API
- Visualized in the WebUI

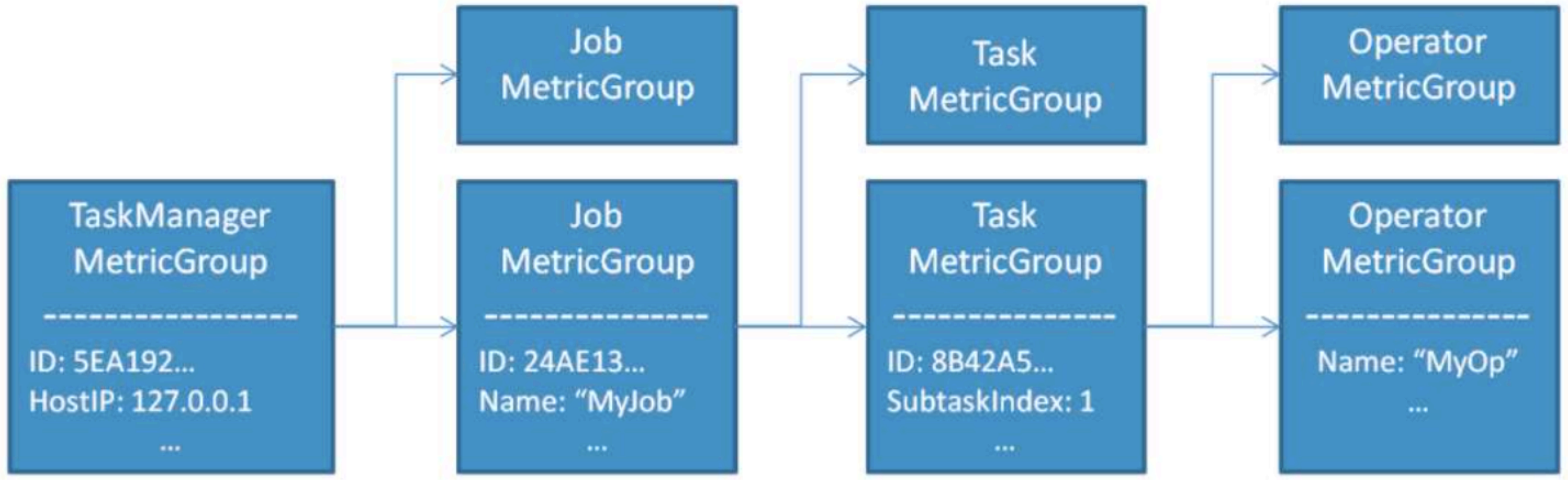


Metric 类型分类

- Counter
  - 计数器
- Gauge
  - 最简单的 Metric，反映一个值
- Meter
  - 单位时间内发生事件的次数
- Histogram
  - 统计数据分布，Mean，Max，Min，StdDec 等

MetricGroup

- Metric 在 Flink 内部有多层结构，以 Group 的方式组织
- Metric 唯一标识：Metric Group + Metric Name



eg: localhost.taskmanager.1234.MyJob.MyOperator.0.MyMetric

自定义 Counter

```
public class MyMapper extends RichMapFunction<String, String> {
  private transient Counter counter;

  @Override
  public void open(Configuration config) {
    this.counter = getRuntimeContext()
      .getMetricGroup()
      .counter("myCounter");
  }

  @Override
  public String map(String value) throws Exception {
    this.counter.inc();
    return value;
  }
}
```

自定义 Counter

```java
public class MyMapper extends RichMapFunction<String, String> {
  private transient Counter counter;

  @Override
  public void open(Configuration config) {
    this.counter = getRuntimeContext()
      .getMetricGroup()
      .counter("myCustomCounter", new CustomCounter());
  }

  @Override
  public String map(String value) throws Exception {
    this.counter.inc();
    return value;
  }
}
```

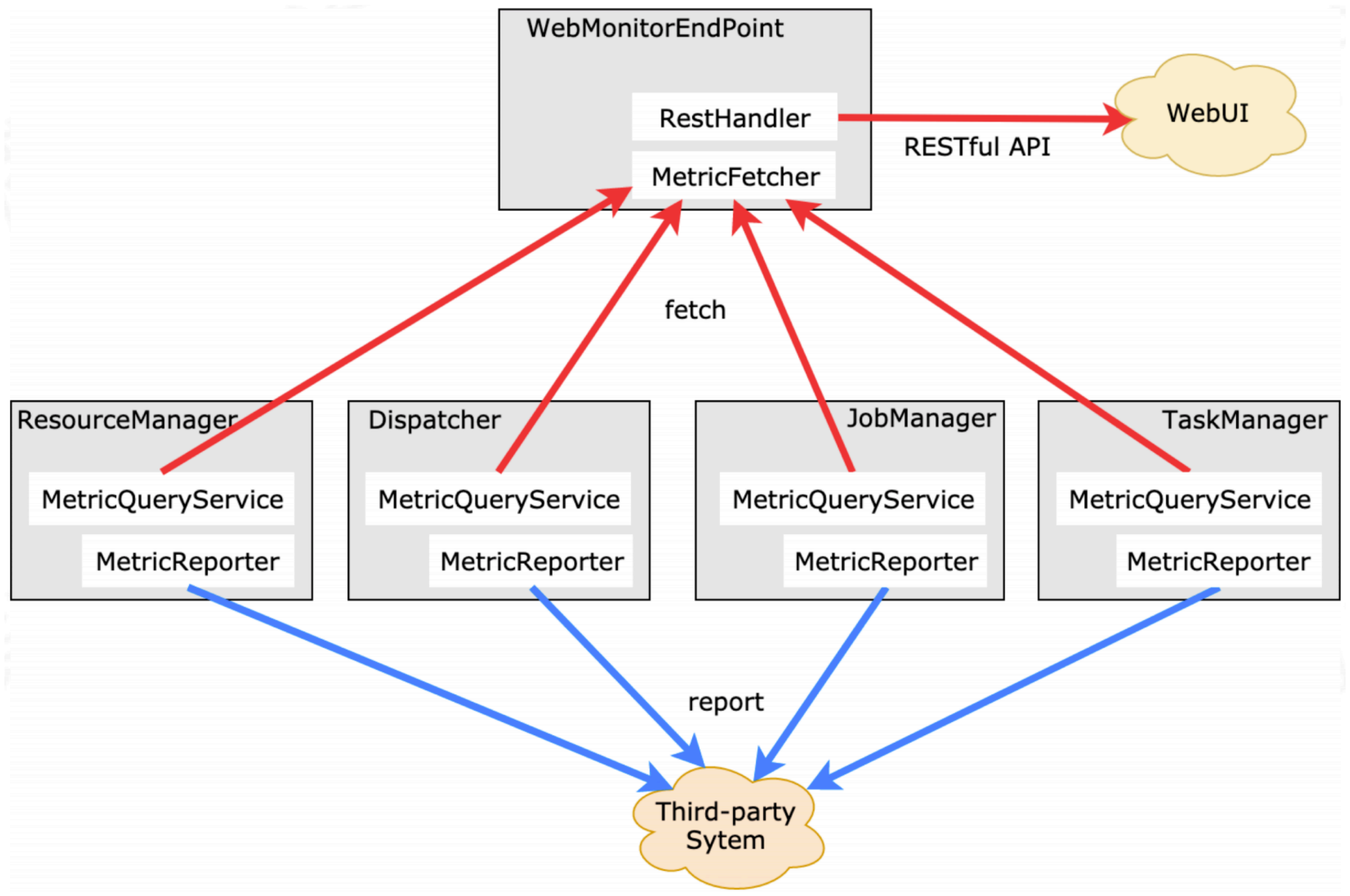
自定义 Gauge

```java
public class MyMapper extends RichMapFunction<String, String> {
  private transient int valueToExpose = 0;

  @Override
  public void open(Configuration config) {
    getRuntimeContext()
      .getMetricGroup()
      .gauge("MyGauge", new Gauge<Integer>() {
        @Override
        public Integer getValue() {
          return valueToExpose;
        }
      });
  }

  @Override
  public String map(String value) throws Exception {
    valueToExpose++;
    return value;
  }
}
```

获取 Metric



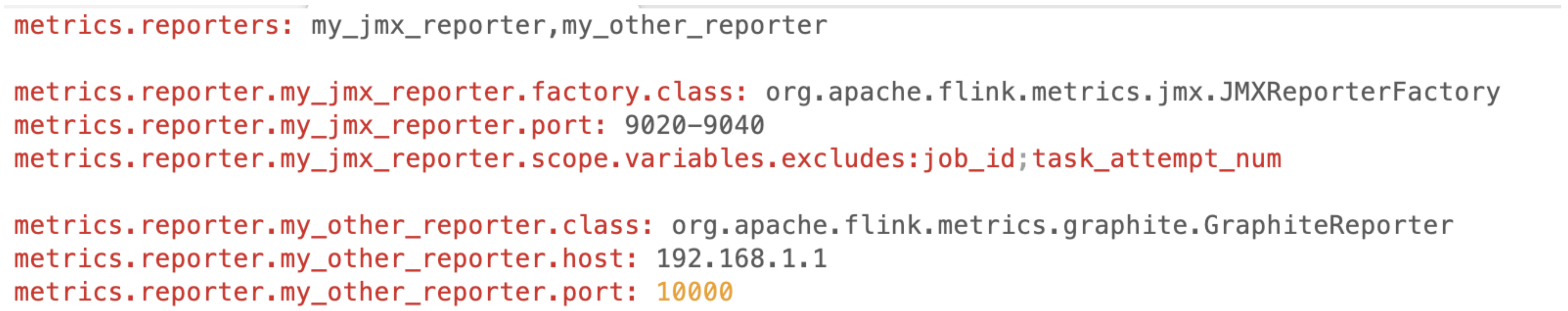
WebMonitorEndPoint
RestHandler
MetricFetcher
RESTful API
WebUI
fetch
ResourceManager
Dispatcher
JobManager
TaskManager
MetricQueryService
MetricReporter
report
Third-party Sytem

Metric Reporter

- Exposes metrics to the outside world
  - Ganglia
  - Graphite
  - JMX
  - StatsD
  - InfluxDB
  - Prometheus
  - or roll your own ...

JMXReporter 应用

通过在 conf/flink-conf.yaml 文件中配置



```
metrics.reporters: my_jmx_reporter,my_other_reporter

metrics.reporter.my_jmx_reporter.factory.class: org.apache.flink.metrics.jmx.JMXReporterFactory
metrics.reporter.my_jmx_reporter.port: 9020-9040
metrics.reporter.my_jmx_reporter.scope.variables.excludes:job_id;task_attempt_num

metrics.reporter.my_other_reporter.class: org.apache.flink.metrics.graphite.GraphiteReporter
metrics.reporter.my_other_reporter.host: 192.168.1.1
metrics.reporter.my_other_reporter.port: 10000
```

InfluxdbReporter 应用

```
metrics.reporter.influxdb.factory.class: org.apache.flink.metrics.influxdb.InfluxdbReporterFactory
metrics.reporter.influxdb.host: localhost
metrics.reporter.influxdb.port: 8086
metrics.reporter.influxdb.db: flink
metrics.reporter.influxdb.username: flink-metrics
metrics.reporter.influxdb.password: qwerty
metrics.reporter.influxdb.retentionPolicy: one_hour
metrics.reporter.influxdb.consistency: ANY
metrics.reporter.influxdb.connectTimeout: 60000
metrics.reporter.influxdb.writeTimeout: 60000
metrics.reporter.influxdb.interval: 60 SECONDS
```

Flink RestAPI 介绍与使用

Some available requests

/config

/overview

/jobmanager/metrics

/jobs

/jobs/<id>/metrics

/jobs/<id>/checkpoints

/jobs/<id>/vertices/<id>/metrics?get=0.numRecordsOutPerSecond ▯ /taskmanagers

/taskmanagers/<id>/metrics?get=<metric>

…

RestAPI 主要功能

- 系统监控指标
- 任务管理
- 集群管理
- 配置信息
- 资源上传（Jars）

Metric REST API integration

- 基于实体聚合指标:
  /jobmanager/metrics
  /taskmanagers/<taskmanagerid>/metrics
  /jobs/<jobid>/metrics
  /jobs/<jobid>/vertices/<vertexid>/subtasks/<subtaskindex>
- 基于类型聚合指标:
  /taskmanagers/metrics
  /jobs/metrics
  /jobs/<jobid>/vertices/<vertexid>/subtasks/metrics
- 基于指定子集聚合指标:
  /taskmanagers/metrics?taskmanagers=A,B,C
  /jobs/metrics?jobs=D,E,F
  /jobs/<jobid>/vertices/<vertexid>/subtasks/metrics?subtask=1,2,3

Checkpoint 监控与调优

Checkpoint 实现原理

Checkpoint 监控指标

Checkpoint Counts

Triggered: The total number of checkpoints that have been triggered since the job started.

In Progress: The current number of checkpoints that are in progress.

Completed: The total number of successfully completed checkpoints since the job started.

Failed: The total number of failed checkpoints since the job started.

Restored: The number of restore operations since the job started. This also tells you how many times the job has restarted since submission. Note that the initial submission with a savepoint also counts as a restore and the count is reset if the JobManager was lost during operation.

Latest Completed Checkpoint: The latest successfully completed checkpoints. Clicking on More details gives you detailed statistics down to the subtask level.

Latest Failed Checkpoint: The latest failed checkpoint. Clicking on More details gives you detailed statistics down to the subtask level.

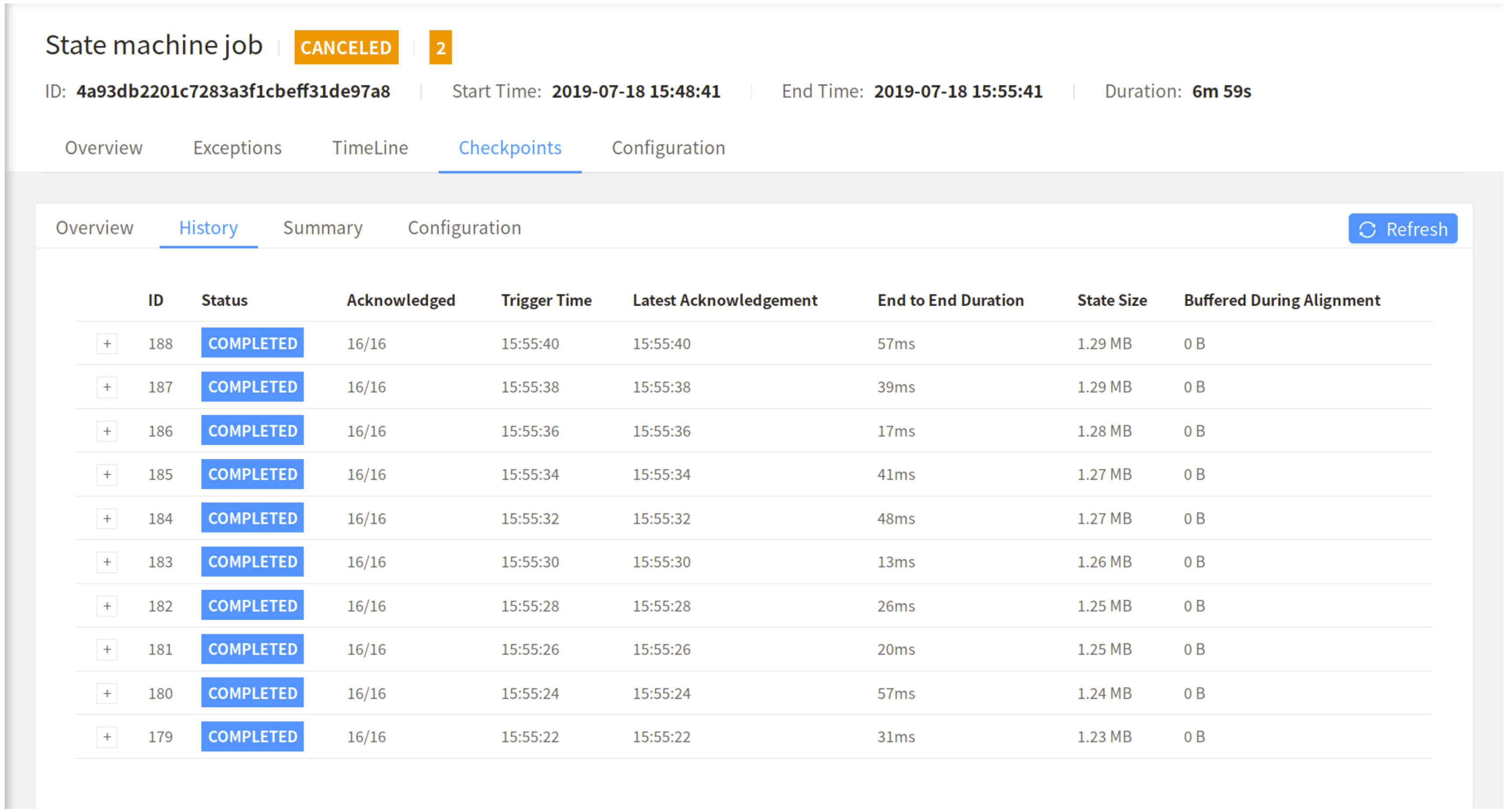
Latest Savepoint: The latest triggered savepoint with its external path. Clicking on More details gives you detailed statistics down to the subtask level.

Latest Restore: There are two types of restore operations.

Restore from Checkpoint: We restored from a regular periodic checkpoint.

Restore from Savepoint: We restored from a savepoint.

History Tab

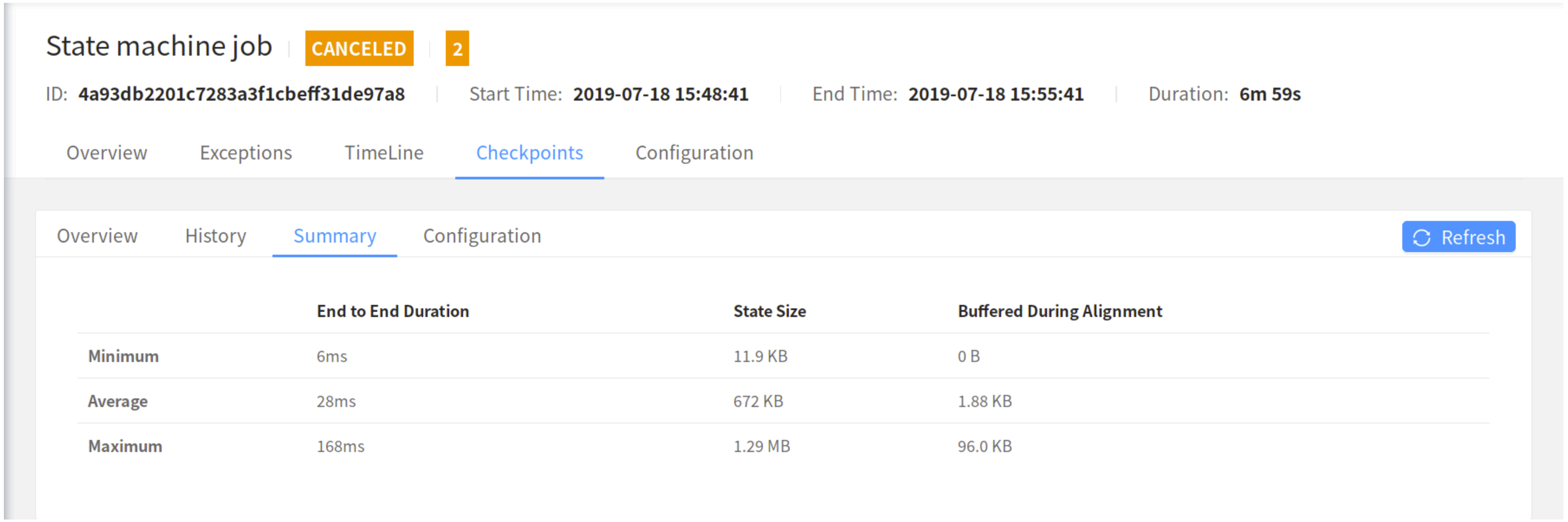


State machine job

ID: **4a93db2201c7283a3f1cbeff31de97a8** | Start Time: **2019-07-18 15:48:41** | End Time: **2019-07-18 15:55:41** | Duration: **6m 59s**

	ID	Status	Acknowledged	Trigger Time	Latest Acknowledgement	End to End Duration	State Size	Buffered During Alignment
+	188	COMPLETED	16/16	15:55:40	15:55:40	57ms	1.29 MB	0 B
+	187	COMPLETED	16/16	15:55:38	15:55:38	39ms	1.29 MB	0 B
+	186	COMPLETED	16/16	15:55:36	15:55:36	17ms	1.28 MB	0 B
+	185	COMPLETED	16/16	15:55:34	15:55:34	41ms	1.27 MB	0 B
+	184	COMPLETED	16/16	15:55:32	15:55:32	48ms	1.27 MB	0 B
+	183	COMPLETED	16/16	15:55:30	15:55:30	13ms	1.26 MB	0 B
+	182	COMPLETED	16/16	15:55:28	15:55:28	26ms	1.25 MB	0 B
+	181	COMPLETED	16/16	15:55:26	15:55:26	20ms	1.25 MB	0 B
+	180	COMPLETED	16/16	15:55:24	15:55:24	57ms	1.24 MB	0 B
+	179	COMPLETED	16/16	15:55:22	15:55:22	31ms	1.23 MB	0 B

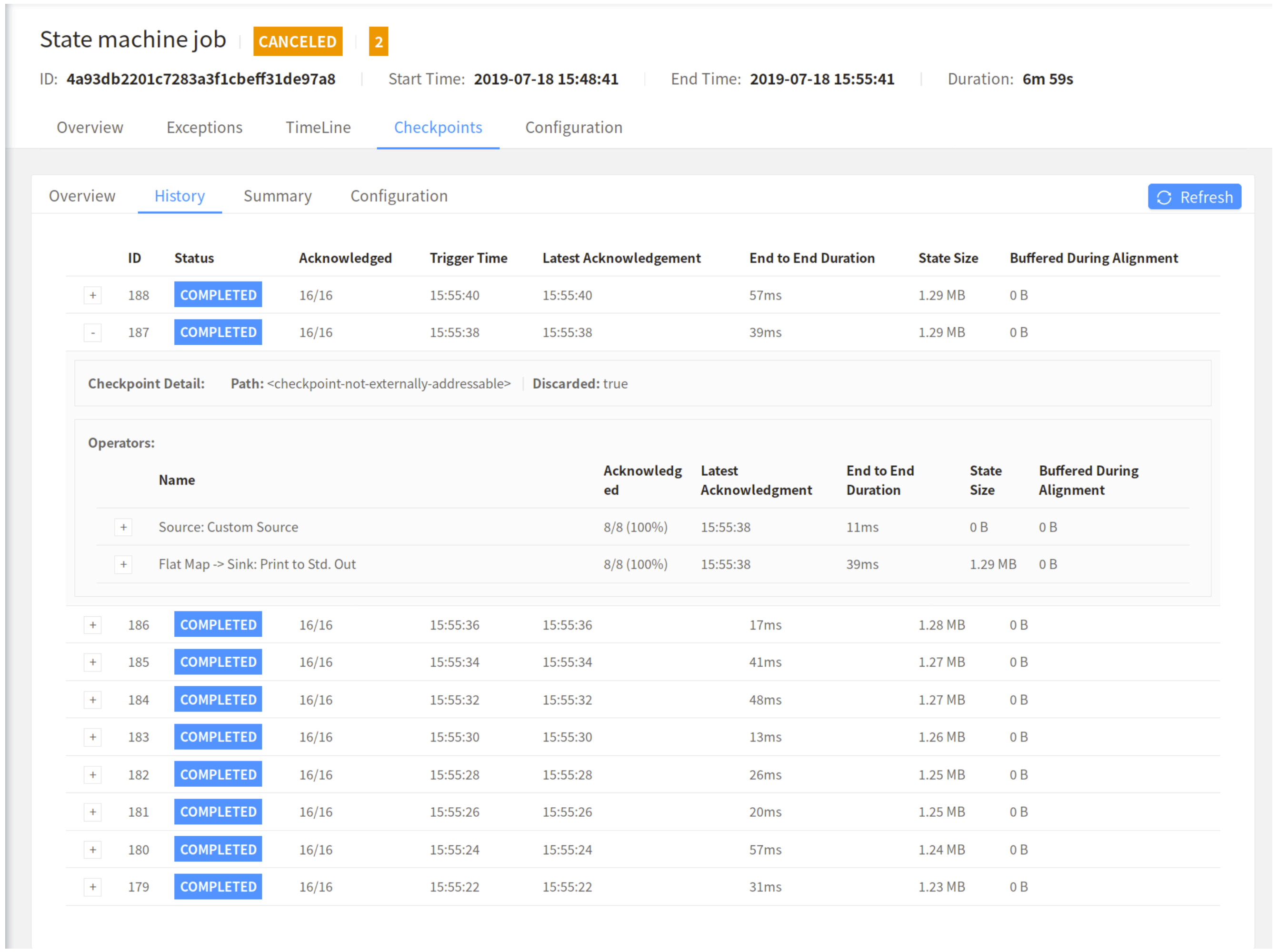
Summary Tab



ID: 4a93db2201c7283a3f1cbeff31de97a8 | Start Time: 2019-07-18 15:48:41 | End Time: 2019-07-18 15:55:41 | Duration: 6m 59s

	End to End Duration	State Size	Buffered During Alignment
Minimum	6ms	11.9 KB	0 B
Average	28ms	672 KB	1.88 KB
Maximum	168ms	1.29 MB	96.0 KB

Checkpoint Details



State machine job CANCELED 2

ID: 4a93db2201c7283a3f1cbeff31de97a8 | Start Time: 2019-07-18 15:48:41 | End Time: 2019-07-18 15:55:41 | Duration: 6m 59s

Overview | Exceptions | TimeLine | Checkpoints | Configuration

Overview | History | Summary | Configuration | Refresh

	ID	Status	Acknowledged	Trigger Time	Latest Acknowledgement	End to End Duration	State Size	Buffered During Alignment
+	188	COMPLETED	16/16	15:55:40	15:55:40	57ms	1.29 MB	0 B
-	187	COMPLETED	16/16	15:55:38	15:55:38	39ms	1.29 MB	0 B

Checkpoint Detail: **Path:** <checkpoint-not-externally-addressable> | **Discarded:** true

Operators:

	Name	Acknowledged	Latest Acknowledgment	End to End Duration	State Size	Buffered During Alignment
+	Source: Custom Source	8/8 (100%)	15:55:38	11ms	0 B	0 B
+	Flat Map -> Sink: Print to Std. Out	8/8 (100%)	15:55:38	39ms	1.29 MB	0 B

	ID	Status	Acknowledged	Trigger Time	Latest Acknowledgement	End to End Duration	State Size	Buffered During Alignment
+	186	COMPLETED	16/16	15:55:36	15:55:36	17ms	1.28 MB	0 B
+	185	COMPLETED	16/16	15:55:34	15:55:34	41ms	1.27 MB	0 B
+	184	COMPLETED	16/16	15:55:32	15:55:32	48ms	1.27 MB	0 B
+	183	COMPLETED	16/16	15:55:30	15:55:30	13ms	1.26 MB	0 B
+	182	COMPLETED	16/16	15:55:28	15:55:28	26ms	1.25 MB	0 B
+	181	COMPLETED	16/16	15:55:26	15:55:26	20ms	1.25 MB	0 B
+	180	COMPLETED	16/16	15:55:24	15:55:24	57ms	1.24 MB	0 B
+	179	COMPLETED	16/16	15:55:22	15:55:22	31ms	1.23 MB	0 B

Configuration Tab

Checkpointing Mode: Either Exactly Once or At least Once.

Interval: The configured checkpointing interval. Trigger checkpoints in this interval.

Timeout: Timeout after which a checkpoint is cancelled by the JobManager and a new checkpoint is triggered.

Minimum Pause Between Checkpoints: Minimum required pause between checkpoints. After a checkpoint has completed successfully, we wait at least for this amount of time before triggering the next one, potentially delaying the regular interval.

Maximum Concurrent Checkpoints: The maximum number of checkpoints that can be in progress concurrently.

Persist Checkpoints Externally: Enabled or Disabled. If enabled, furthermore lists the cleanup config for externalized checkpoints (delete or retain on cancellation).

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Checkpoint 配置参数

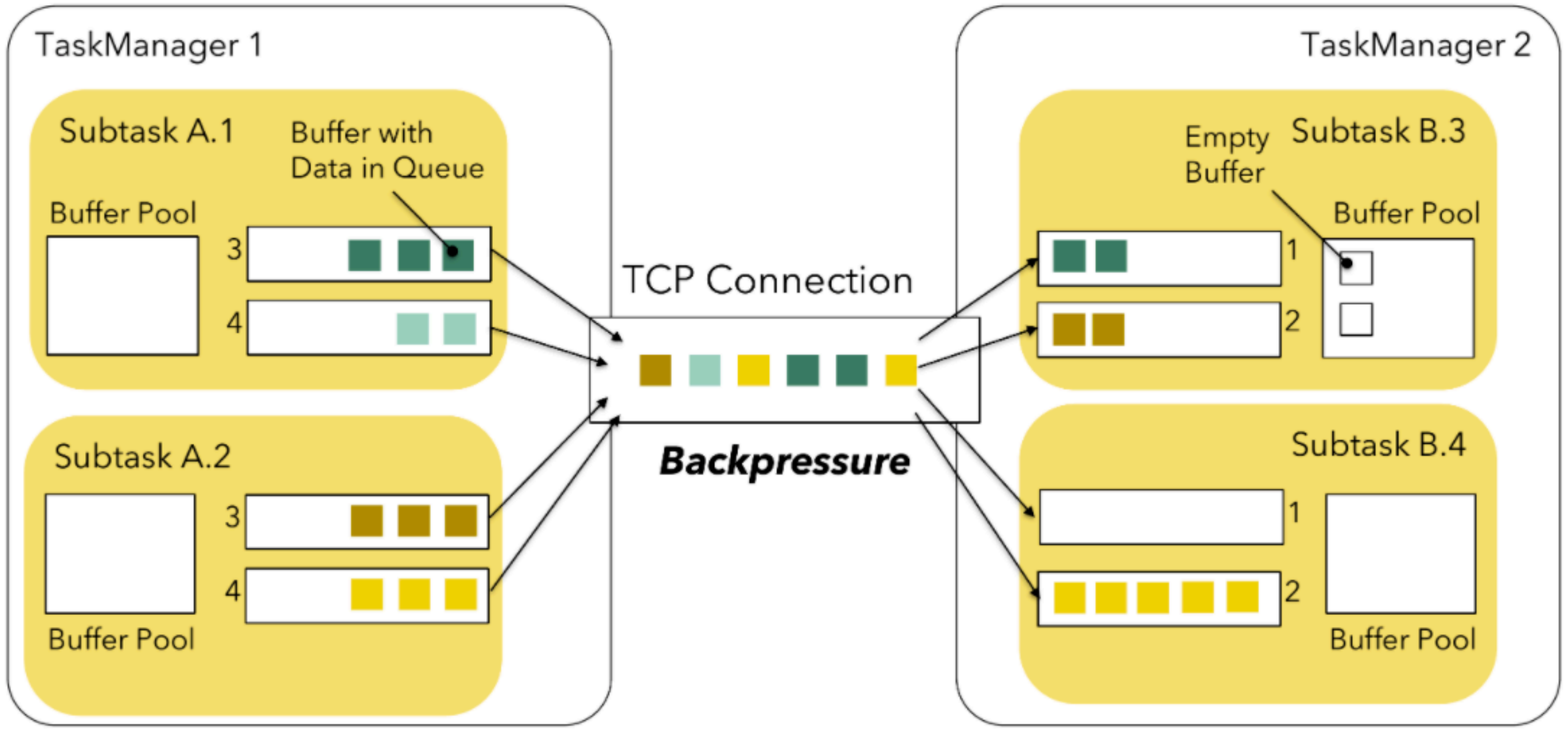
Key	Default	Type	Description
state.backend	(none)	String	StateBackend 类型
state.checkpoints.dir	(none)	String	Checkpoint数据持久化路径
state.savepoints.dir	(none)	String	Savepoint数据持久化路径
state.backend.incremental	FALSE	Boolean	是否增量Checkpoint
state.backend.local-recovery	FALSE	Boolean	是否支持本地恢复State，仅对keyed state backends有效，MemoryStateBackend不生效
state.checkpoints.num-retained	1	Integer	最大completed checkpoint保留个数
taskmanager.state.local.root-dirs	(none)	String	本地恢复需要指定的根路径

计时器（内存 vs. RocksDB）

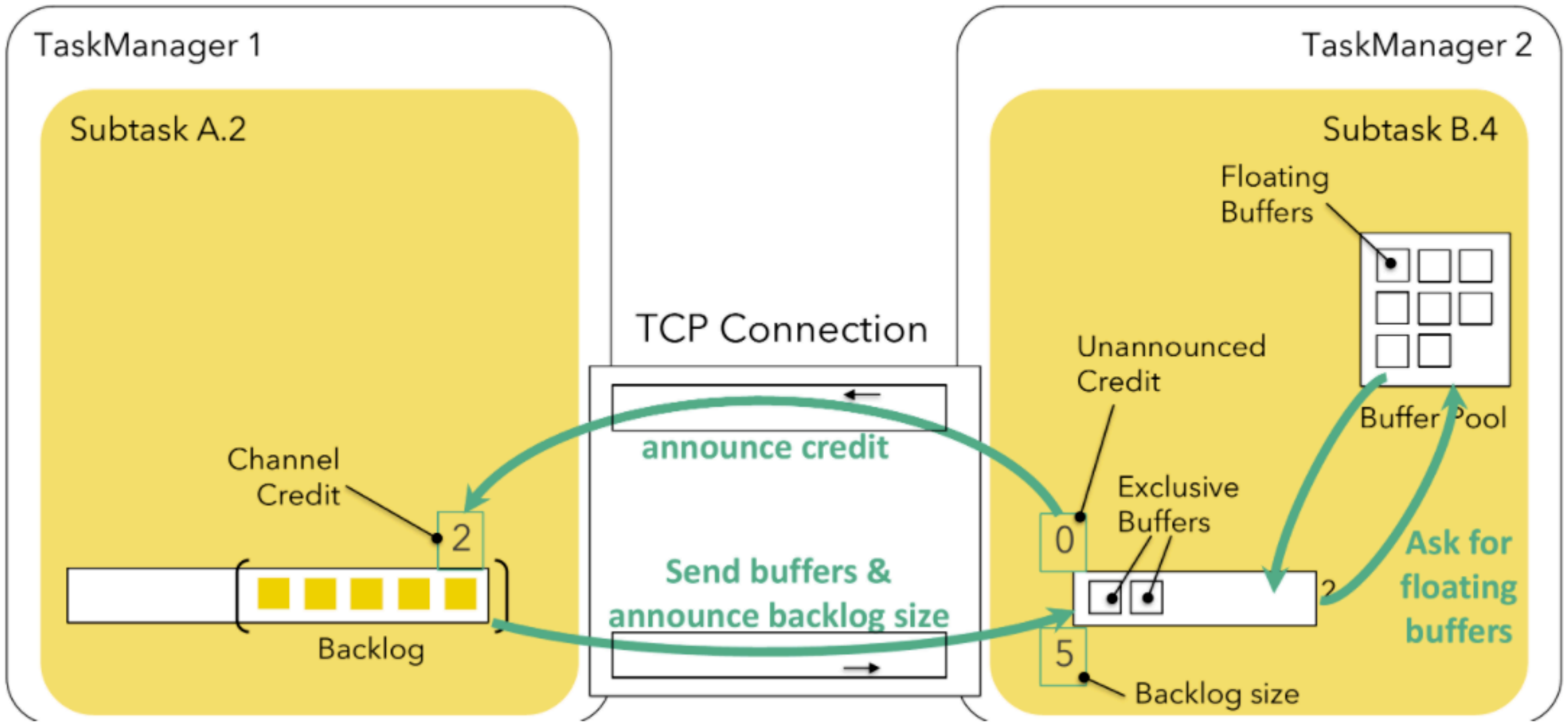
- 计时器（Timer）用于安排稍后的操作（基于事件时间或处理时间），例如触发窗口或回调 ProcessFunction。
- 当选择 RocksDBStateBackend 时，默认情况下计时器也存储在 RocksDB 中。这是一种健壮且可扩展的方式，允许应用程序使用很多个计时器。另一方面，在 RocksDB 中维护计时器会有一定的成本，因此 Flink 也提供了将计时器存储在 JVM 堆上而使用 RocksDB 存储其他状态的选项。
- 当计时器数量较少时，基于堆的计时器可以有更好的性能。
- 您可以通过将 state.backend.rocksdb.timer-service.factory 配置项设置为 heap（而不是默认的 rocksdb）来将计时器存储在堆上。

反压监控与原理

TCP 自带反压的局限性

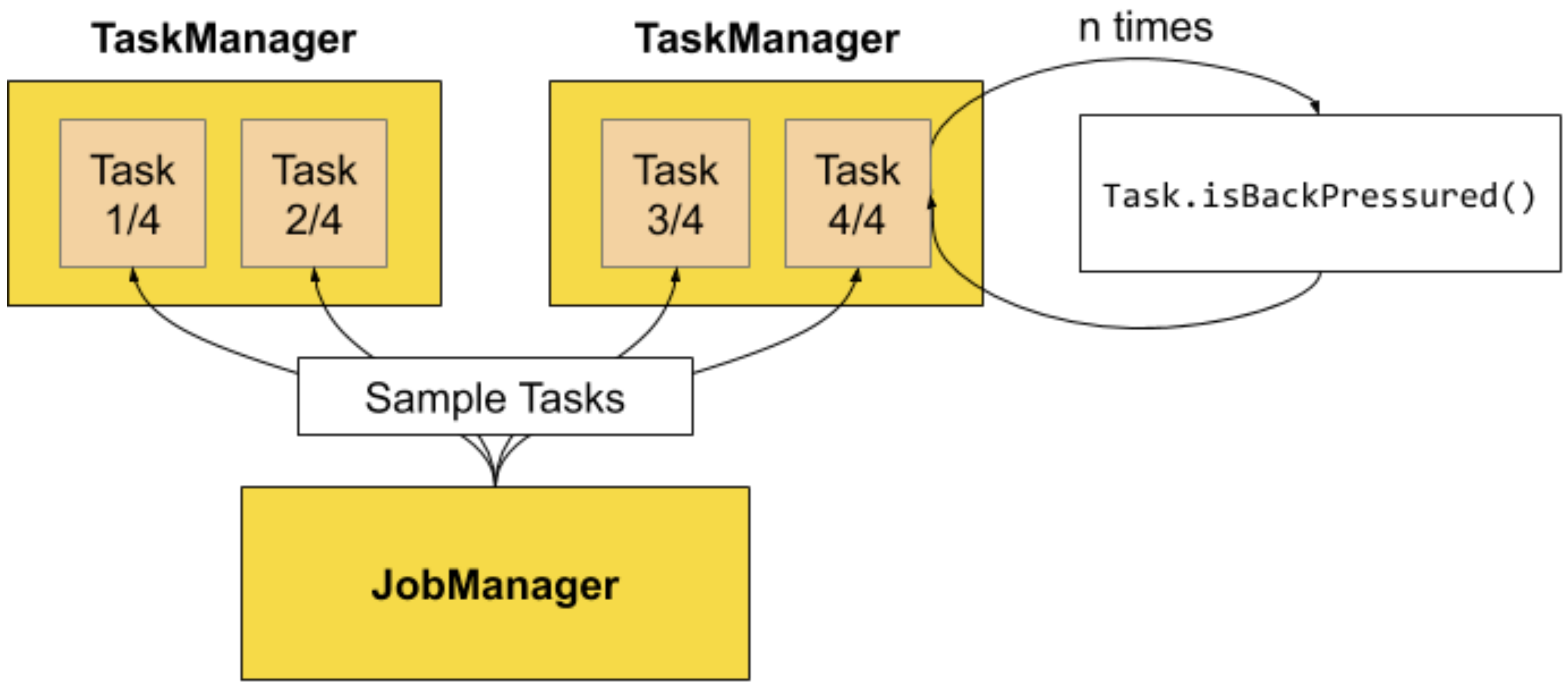


基于 Credit 反压机制

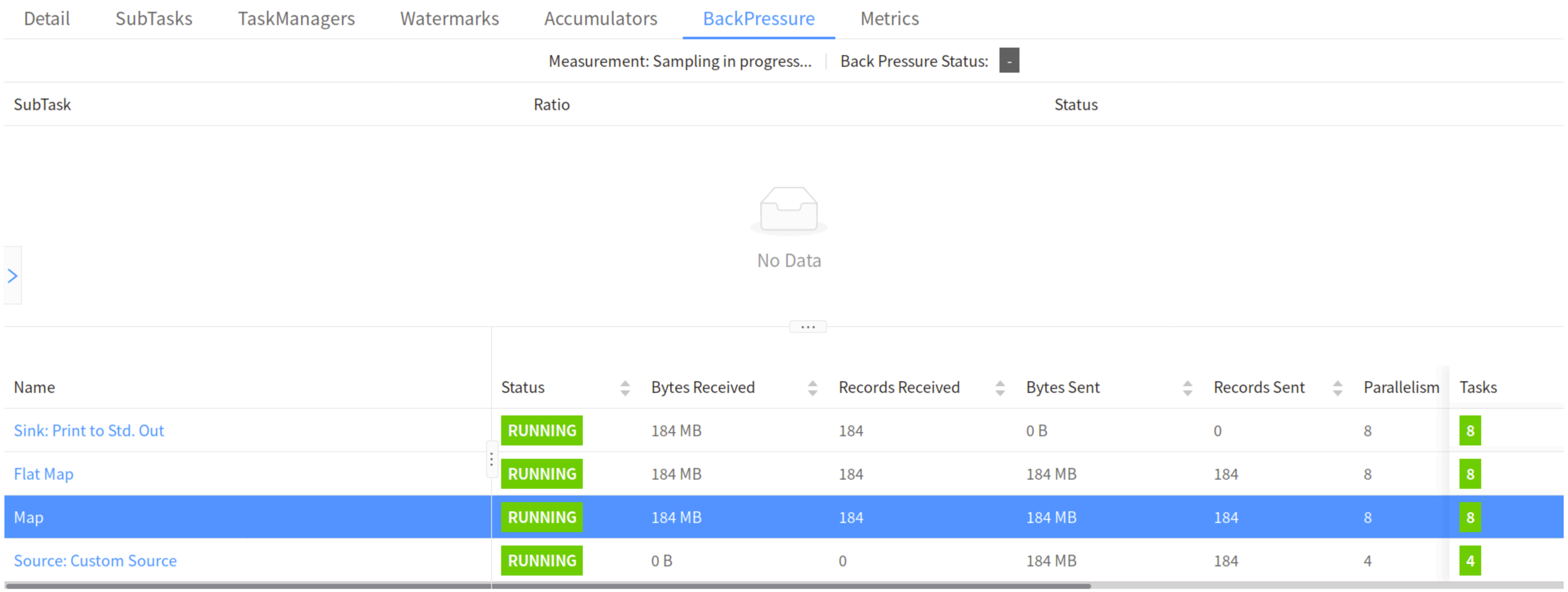


反压采样

OK: 0 <= 比例 <= 0.10
LOW: 0.10 < 比例 <= 0.5
HIGH: 0.5 < 比例 <= 1



反压采样进行中



Detail SubTasks TaskManagers Watermarks Accumulators BackPressure Metrics

Measurement: Sampling in progress... | Back Pressure Status: -

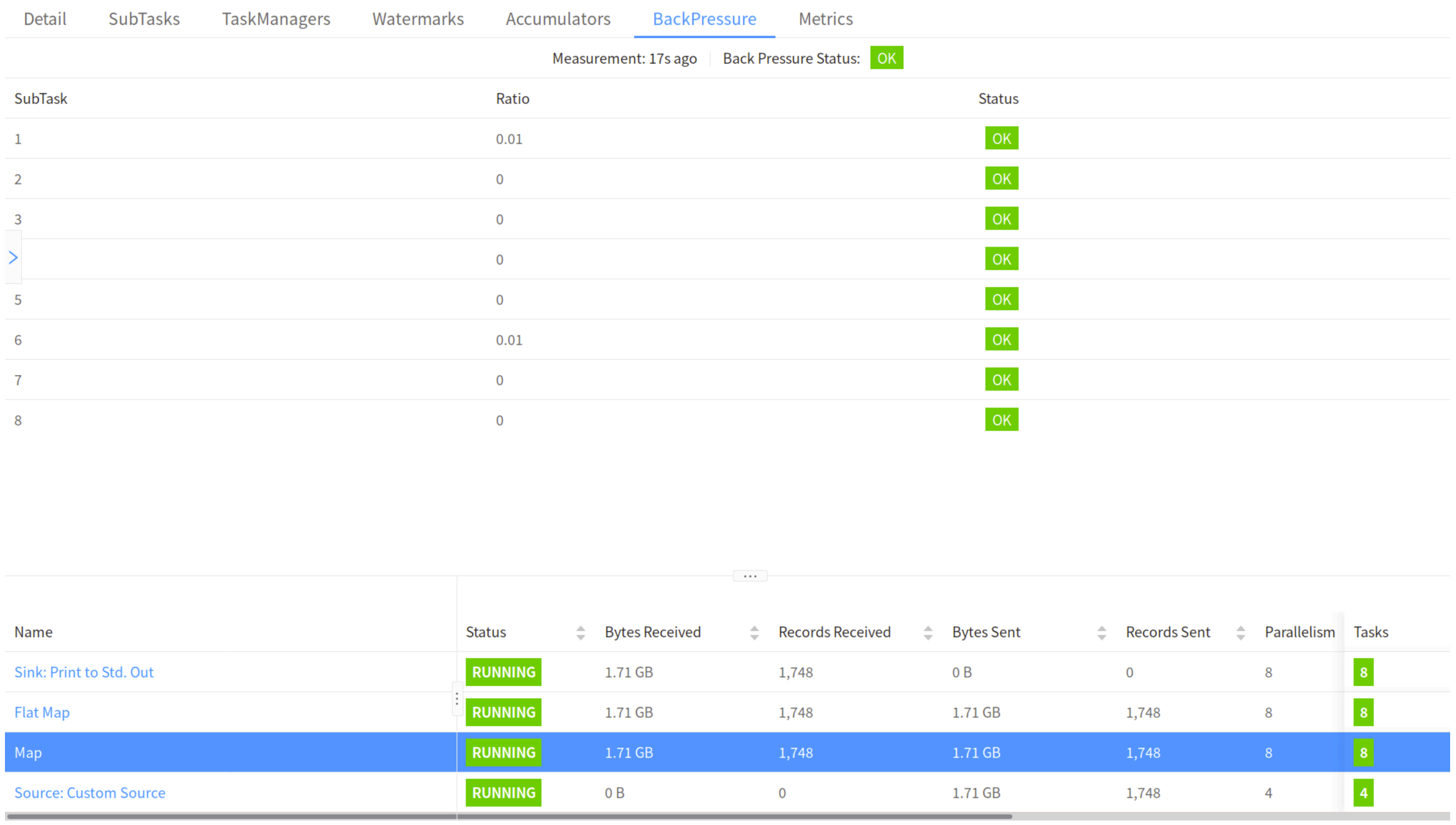
SubTask	Ratio	Status

No Data

Name	Status	Bytes Received	Records Received	Bytes Sent	Records Sent	Parallelism	Tasks
Sink: Print to Std. Out	RUNNING	184 MB	184	0 B	0	8	8
Flat Map	RUNNING	184 MB	184	184 MB	184	8	8
Map	RUNNING	184 MB	184	184 MB	184	8	8
Source: Custom Source	RUNNING	0 B	0	184 MB	184	4	4

极客时间

没有出现反压情况



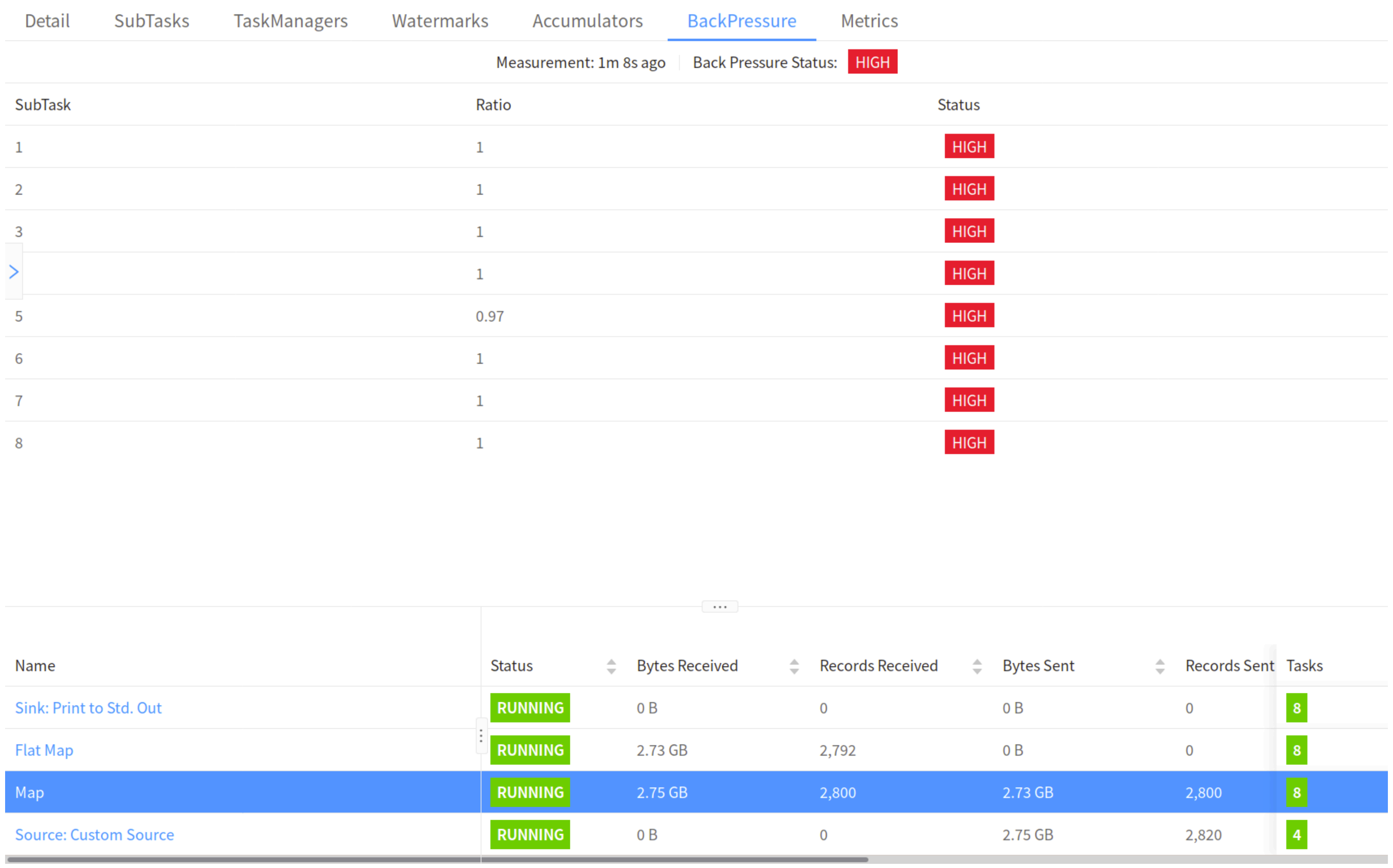
Detail | SubTasks | TaskManagers | Watermarks | Accumulators | BackPressure | Metrics

Measurement: 17s ago | Back Pressure Status: OK

SubTask	Ratio	Status
1	0.01	OK
2	0	OK
3	0	OK
>	0	OK
5	0	OK
6	0.01	OK
7	0	OK
8	0	OK

Name	Status	Bytes Received	Records Received	Bytes Sent	Records Sent	Parallelism	Tasks
Sink: Print to Std. Out	RUNNING	1.71 GB	1,748	0 B	0	8	8
Flat Map	RUNNING	1.71 GB	1,748	1.71 GB	1,748	8	8
Map	RUNNING	1.71 GB	1,748	1.71 GB	1,748	8	8
Source: Custom Source	RUNNING	0 B	0	1.71 GB	1,748	4	4

出现反压情况



Detail | SubTasks | TaskManagers | Watermarks | Accumulators | BackPressure | Metrics

Measurement: 1m 8s ago | Back Pressure Status: HIGH

SubTask	Ratio	Status
1	1	HIGH
2	1	HIGH
3	1	HIGH
	1	HIGH
5	0.97	HIGH
6	1	HIGH
7	1	HIGH
8	1	HIGH

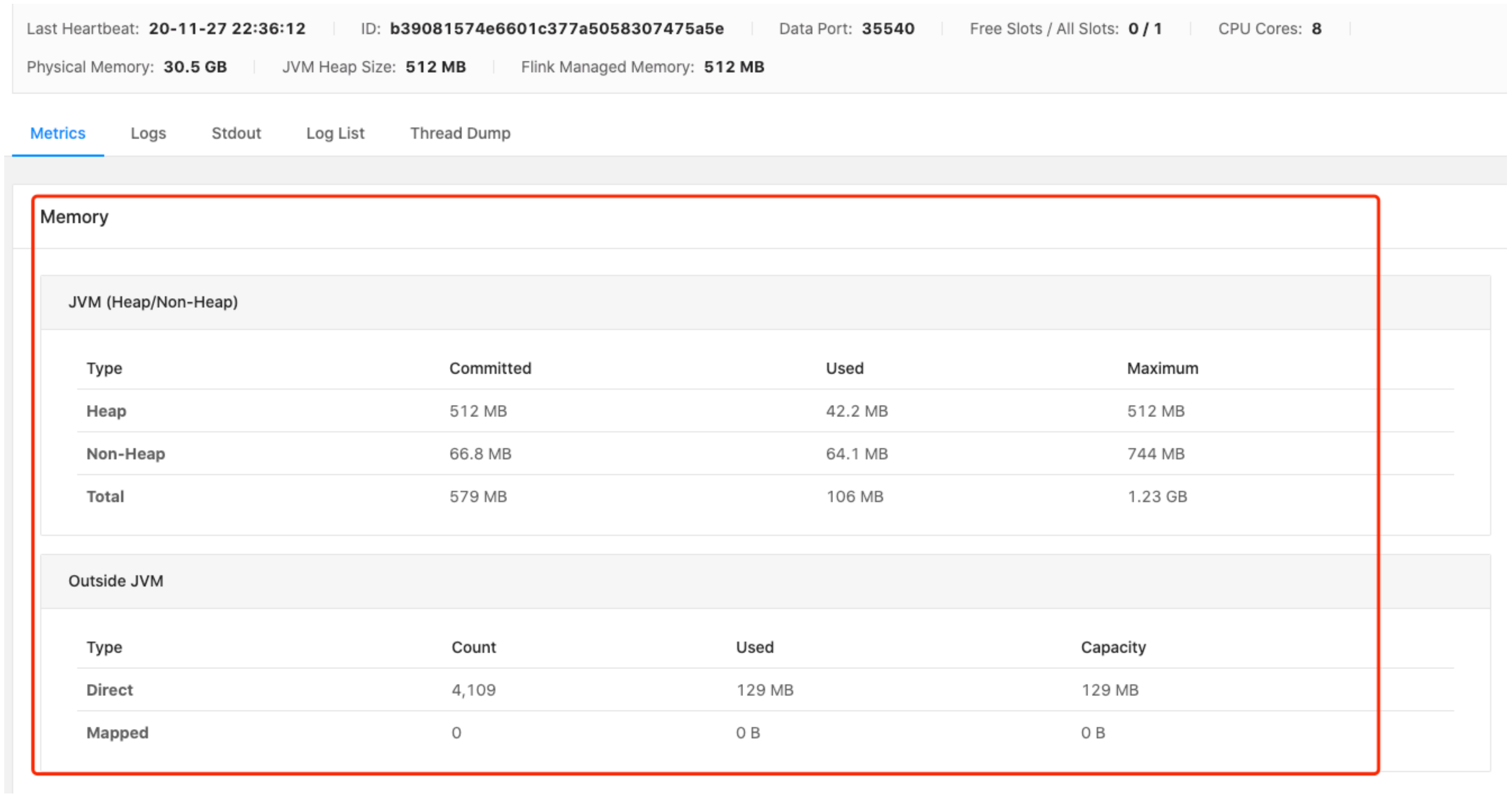
Name	Status	Bytes Received	Records Received	Bytes Sent	Records Sent	Tasks
Sink: Print to Std. Out	RUNNING	0 B	0	0 B	0	8
Flat Map	RUNNING	2.73 GB	2,792	0 B	0	8
Map	RUNNING	2.75 GB	2,800	2.73 GB	2,800	8
Source: Custom Source	RUNNING	0 B	0	2.75 GB	2,820	4

反压参数配置

- web.backpressure.refresh-interval:
  - 有效的反压结果被废弃并重新进行采样的时间 (默认: 60000, 1 min)。
- web.backpressure.num-samples:
  - 用于确定反压采样的样本数 (默认: 100)。
- web.backpressure.delay-between-samples:
  - 用于确定反压采样的间隔时间 (默认: 50, 50 ms)。

Flink 内存配置与调优

TaskManager 内存指标监控



Last Heartbeat: **20-11-27 22:36:12** | ID: **b39081574e6601c377a5058307475a5e** | Data Port: **35540** | Free Slots / All Slots: **0 / 1** | CPU Cores: **8**

Physical Memory: **30.5 GB** | JVM Heap Size: **512 MB** | Flink Managed Memory: **512 MB**

Memory

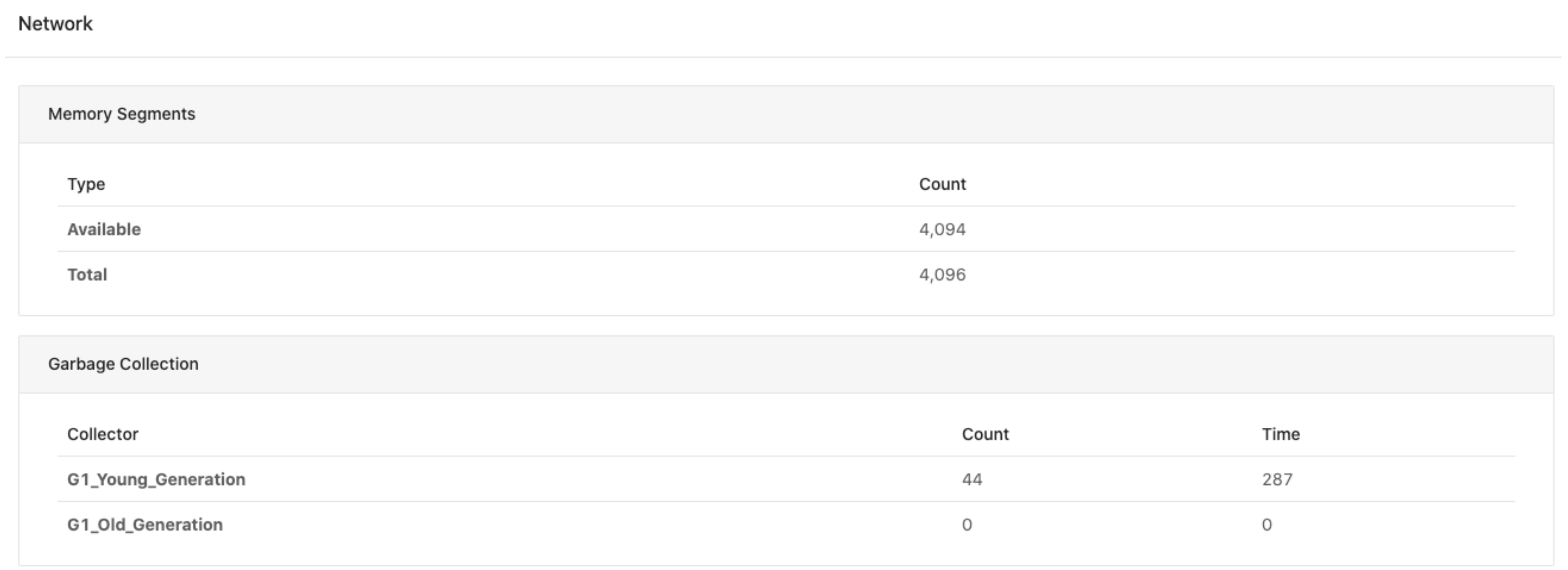
JVM (Heap/Non-Heap)

Type	Committed	Used	Maximum
Heap	512 MB	42.2 MB	512 MB
Non-Heap	66.8 MB	64.1 MB	744 MB
Total	579 MB	106 MB	1.23 GB

Outside JVM

Type	Count	Used	Capacity
Direct	4,109	129 MB	129 MB
Mapped	0	0 B	0 B

TaskManager 内存指标监控


Network

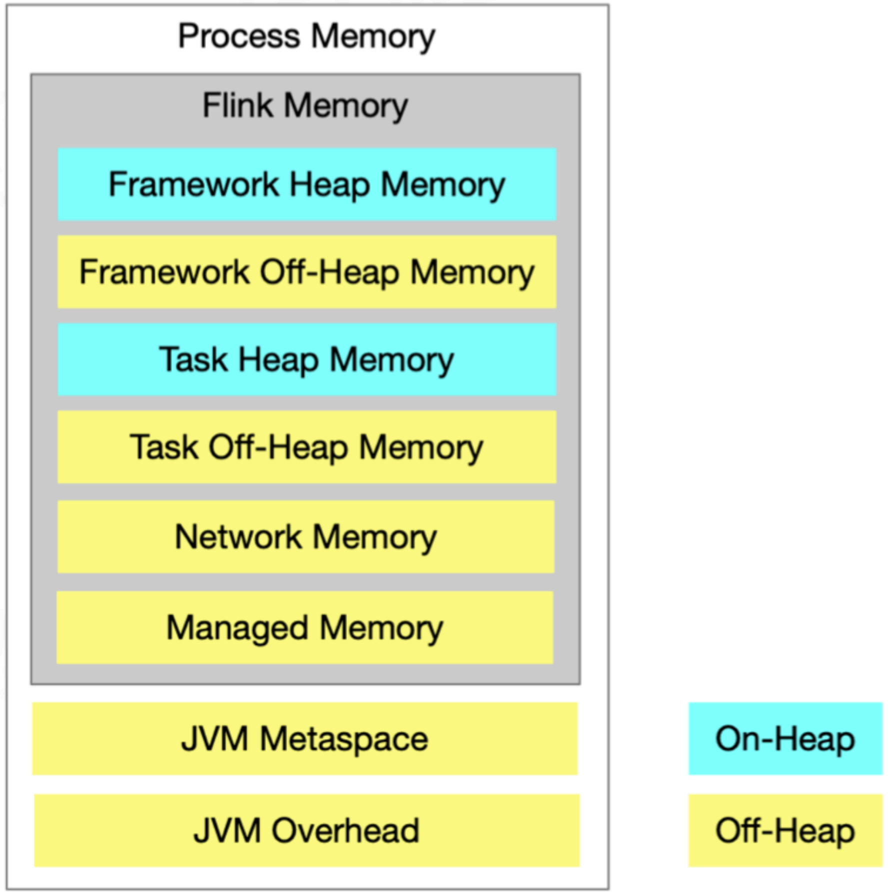
Memory Segments

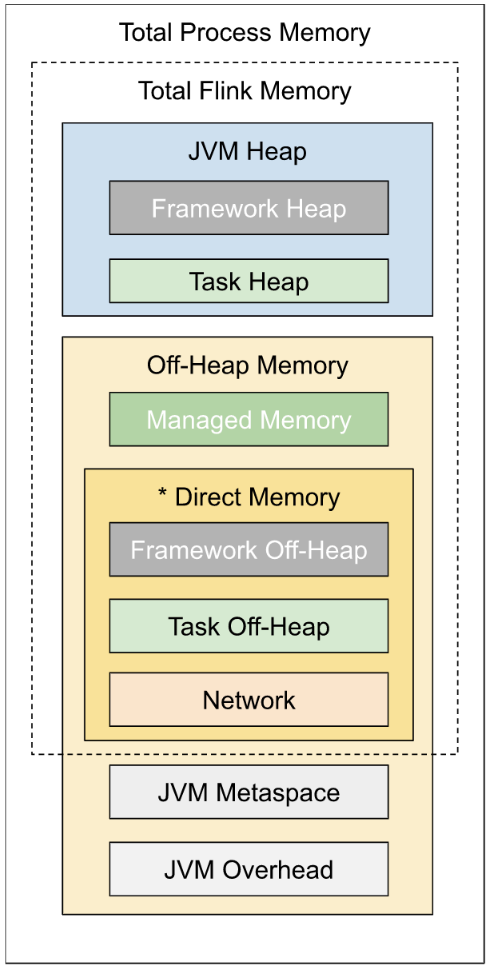
Type	Count
Available	4,094
Total	4,096

Garbage Collection

Collector	Count	Time
G1_Young_Generation	44	287
G1_Old_Generation	0	0

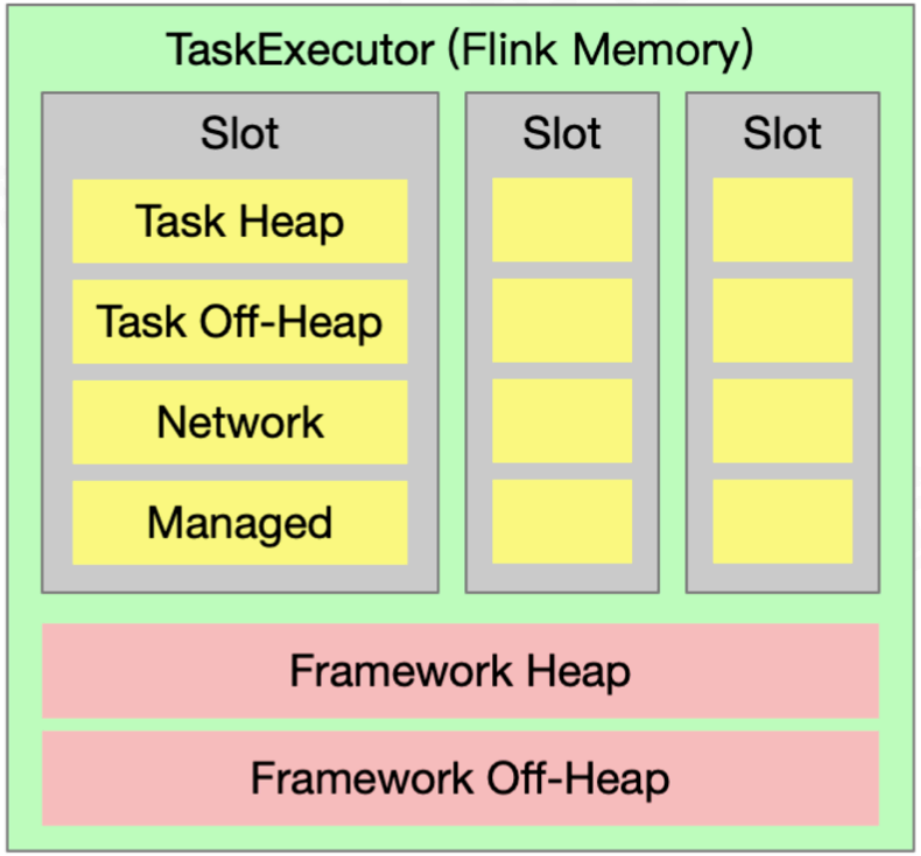
TaskManager 内存模型





Framework vs Task Memory

- 区别：是否计入 Slot 资源
- 总用量受限：
  - -Xmx = Framework Heap + Task Heap
  - -XX:MaxDirectMemorySize= Framewok Off-Heap + Task Off-Heap
- 无隔离
  - 后续社区会实现动态资源隔离（flip-56）



Heap VS Off-Heap Memory

- Heap
  - 堆内存，Java 对象数据
  - HeapStateBackend
- Off-Heap
  - Direct
    - DirectByteBuffer
      - ByteBuffer.allocateDirect()
    - MappedBytebuffer
      - FileChannel.map()
  - Native
    - JNI，C/C++，Python
  - 不区分 Direct 和 Native

Network Memory

- Direct Memory
- 主要用于网络数据传输
- 特点：
  - TaskManager 的各个 Slot 之间 没有隔离
  - 根据作业的拓扑确定 Network Memory
  - 主要决定于 Buffer数量

Managed Memory

- Native Memory 类型
- 主要用于
  - RocksDBStateBackend
  - Batch Operator
- 特点：
  - 同一 TaskExecutor 的各个 Slot 之间严格隔离
  - 多点少点都能跑，与性能挂钩

- RocksDB 内存限制
  - state.backend.rocksdb.memory.managed(default:true)
  - 设定RocksDB使用内存为Managed Memory 大小
  - 目的：防止容器内存超限
  - Standalone 可关闭限制

JVM Metaspace & Overhead

- JVM Metaspace
  - 存放 JVM 加载类的元数据
  - 加载的类越多需要的内存空间越大

- JVM Overhead
  - Native Memory
  - 用于其他 JVM 内存开销
    - Code Cache
    - Thread Stack

Flink 内存模型

组成部分	配置参数	描述
框架堆内存（Framework Heap Memory）	taskmanager.memory.framework.heap.size	用于 Flink 框架的 JVM 堆内存（进阶配置）。
任务堆内存（Task Heap Memory）	taskmanager.memory.task.heap.size	用于 Flink 应用的算子及用户代码的 JVM 堆内存。
托管内存（Managed memory）	taskmanager.memory.managed.size taskmanager.memory.managed.fraction	由 Flink 管理的用于排序、哈希表、缓存中间结果及 RocksDB State Backend 的本地内存。
框架堆外内存（Framework Off-heap Memory）	taskmanager.memory.framework.off-heap.size	用于 Flink 框架的堆外内存（直接内存或本地内存）（进阶配置）。
任务堆外内存（Task Off-heap Memory）	taskmanager.memory.task.off-heap.size	用于 Flink 应用的算计及用户代码的堆外内存（直接内存或本地内存）。
网络内存（Network Memory）	taskmanager.memory.network.min taskmanager.memory.network.max taskmanager.memory.network.fraction	用于任务之间数据传输的直接内存（例如网络传输缓冲）。该内存部分为基于 Flink总内存的受限的等比内存部分。
JVM Metaspace	taskmanager.memory.jvm-metaspace.size	Flink JVM 进程的 Metaspace。
JVM 开销	taskmanager.memory.jvm-overhead.min taskmanager.memory.jvm-overhead.max taskmanager.memory.jvm-overhead.fraction	用于其他 JVM 开销的本地内存，例如栈空间、垃圾回收空间等。该内存部分为基于进程总内存的受限的等比内存部分。