Best Practices for Stream Processing with GridGain and Apache Ignite and Kafka

Alexey Kukushkin

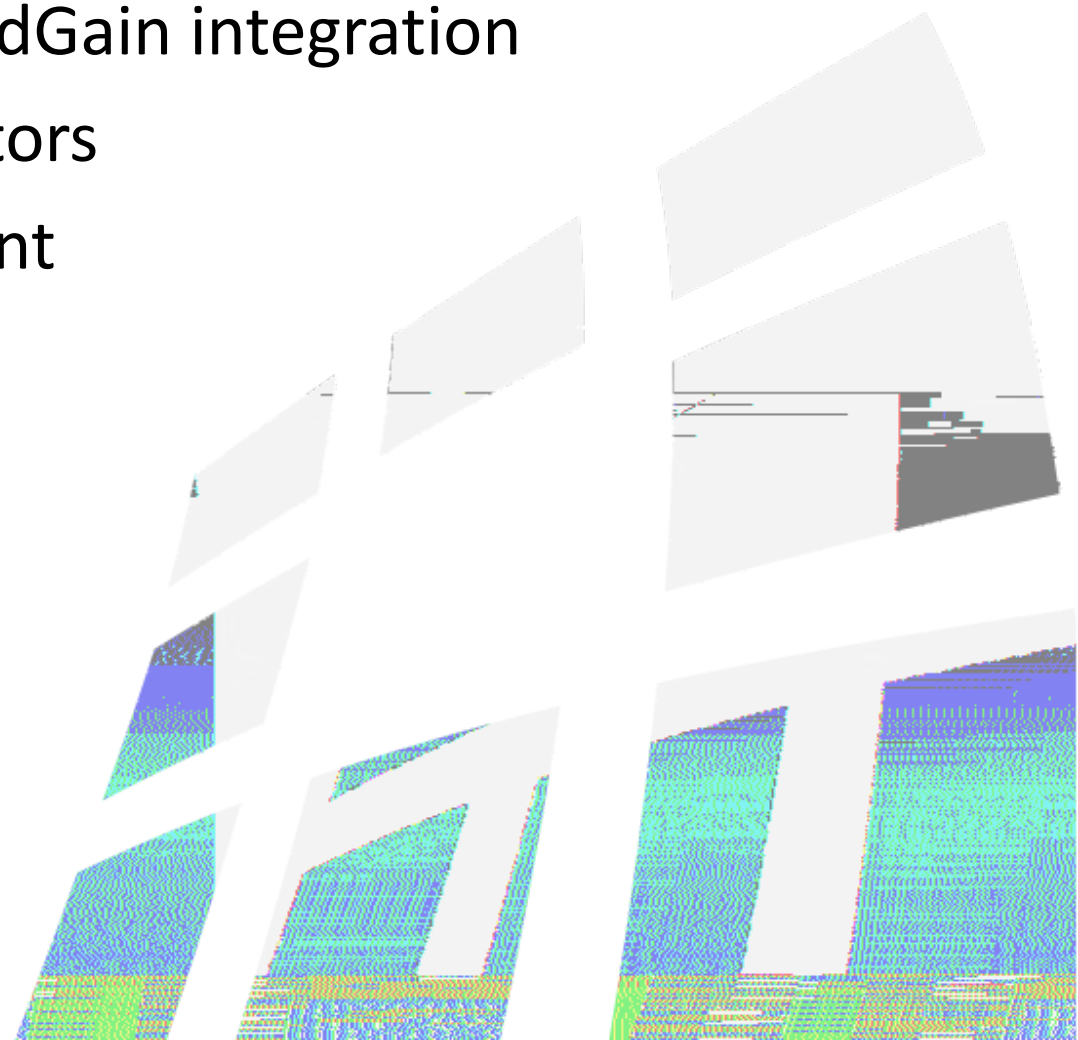
Professional Services

Rob Meyer

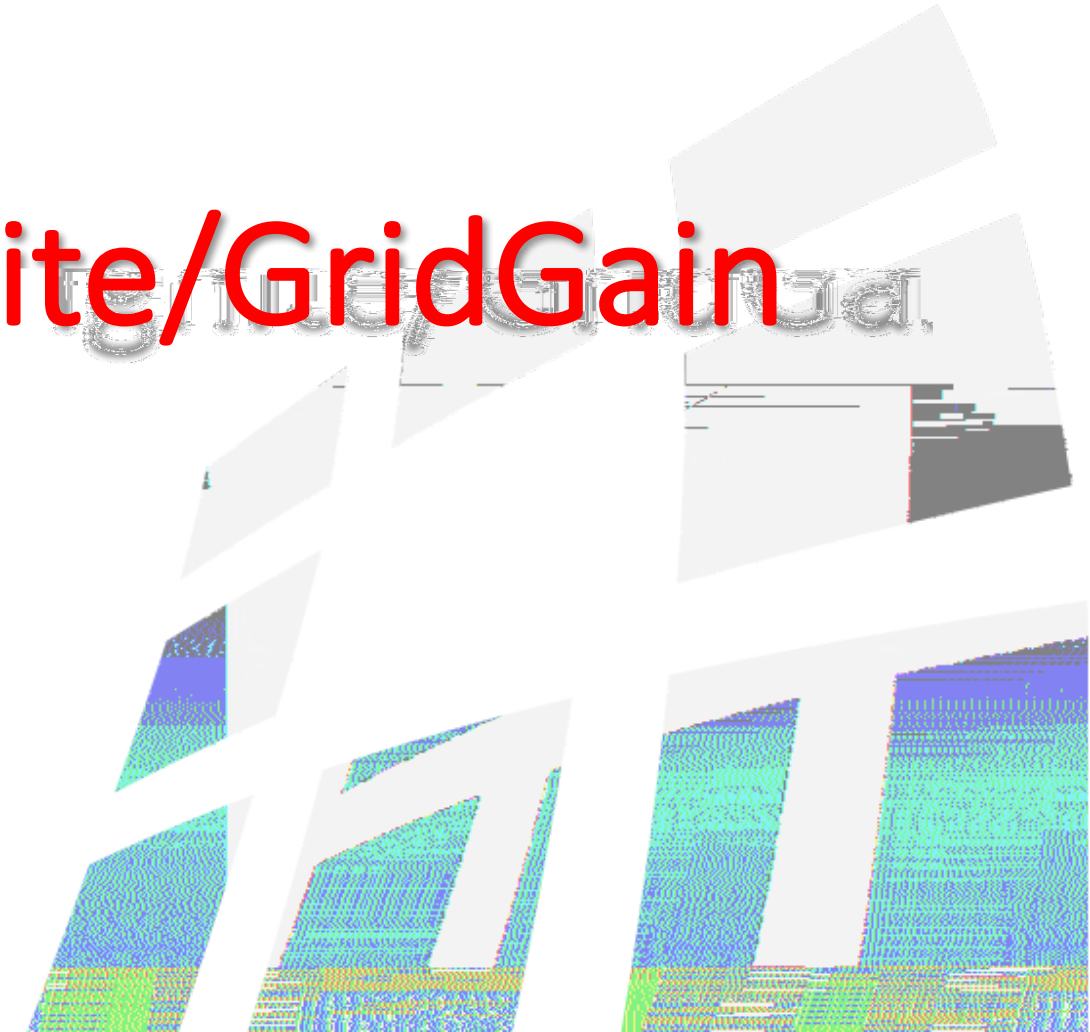
Outbound Product Management

Agenda

- Why we need Kafka/Confluent-Ignite/GridGain integration
- Ignite/GridGain Kafka/Confluent Connectors
- Deployment, monitoring and management
- Integration Examples
- Performance and scalability tuning
- Q & A



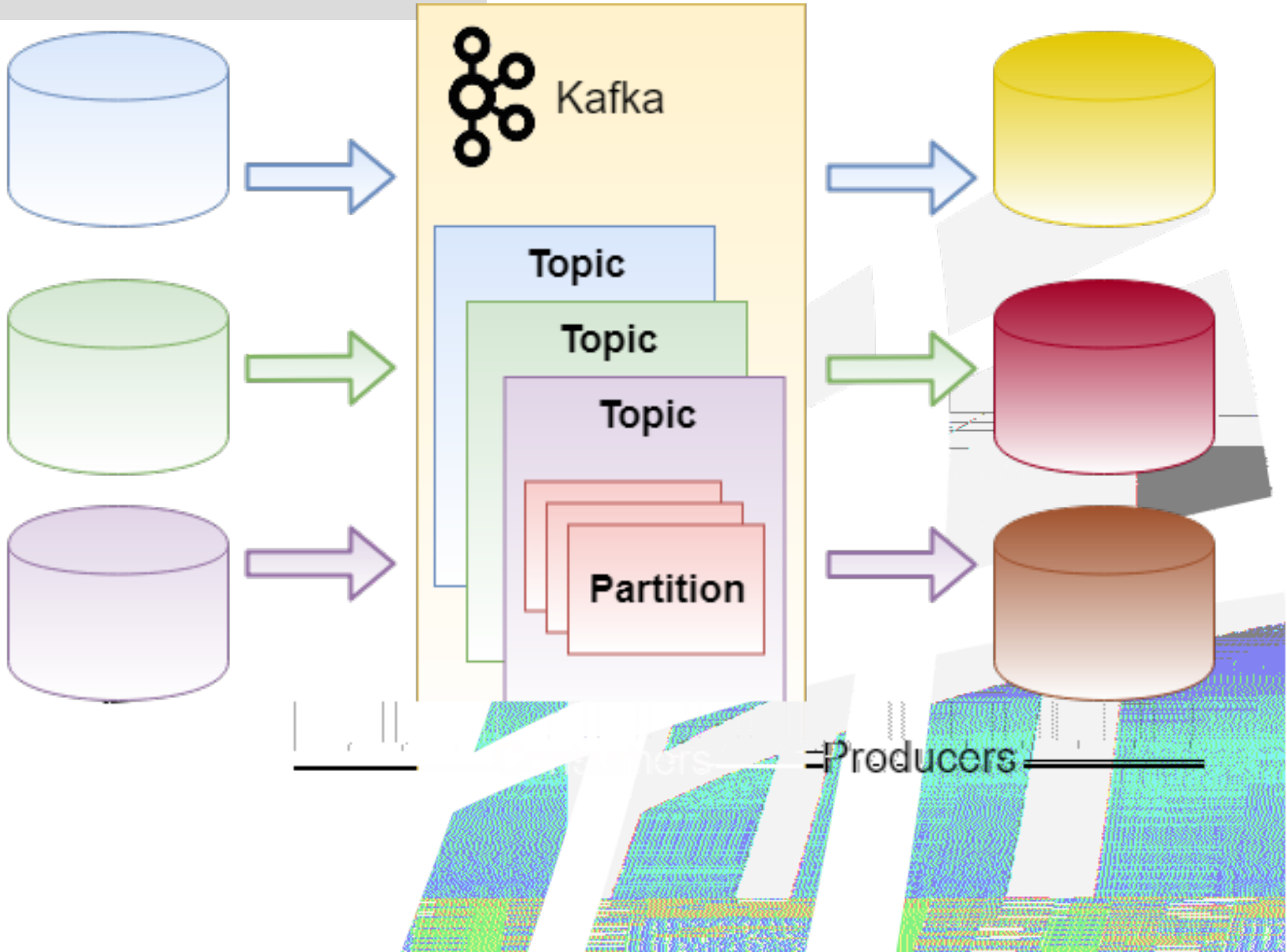
Why we need Kafka/Confluent-Ignite/GridGain integration



Apache Kafka and Confluent

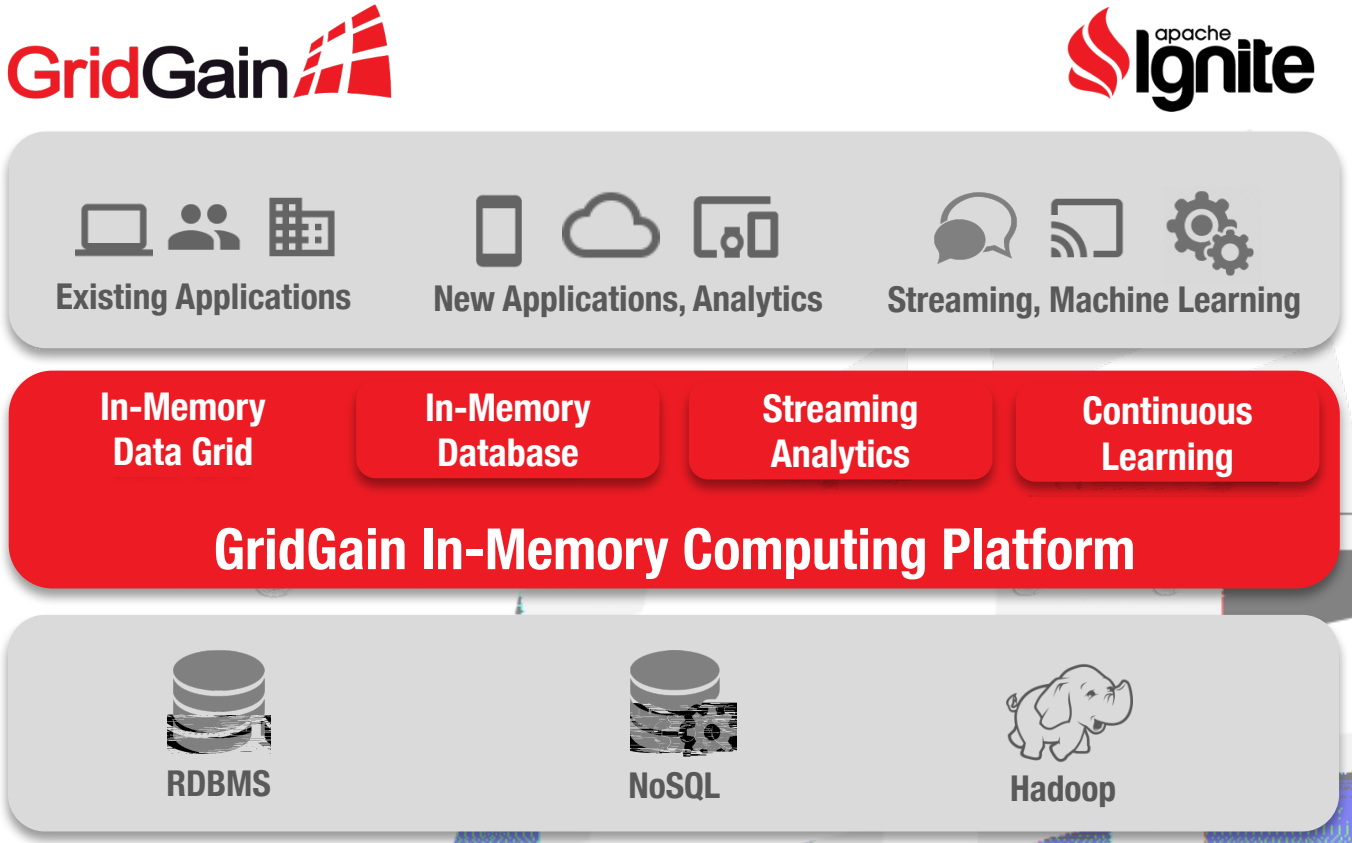
A distributed streaming platform:

- Publish/subscribe
- Scalable
- Fault-tolerant
- Real-time
- Persistent
- Written mostly in Scala

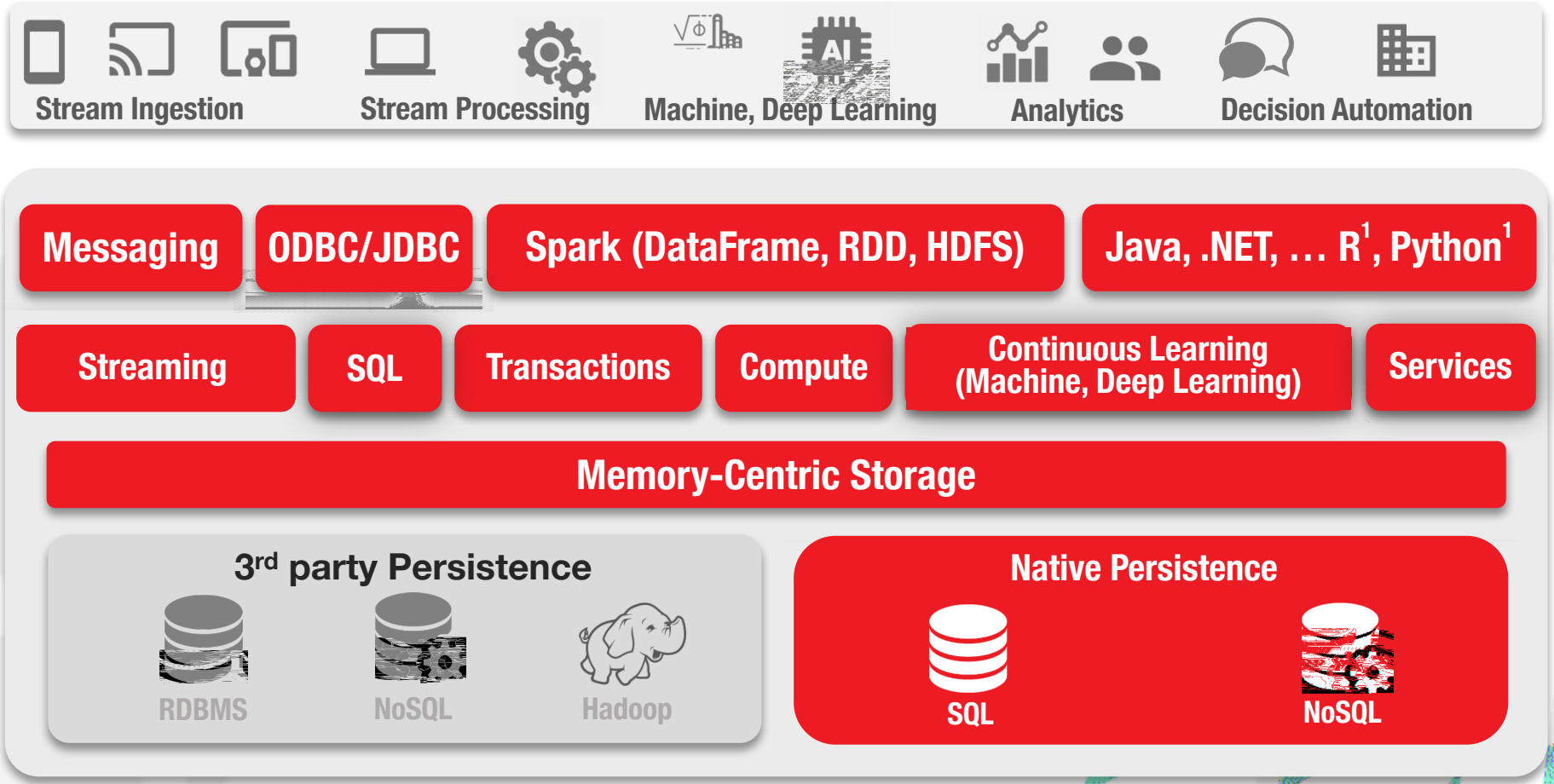


GridGain In-Memory Computing Platform

- Built on Apache Ignite
  - Comprehensive platform that supports all projects
  - No rip and replace
  - In-memory **speed**, petabyte **scale**
  - Enables HTAP, streaming analytics and continuous learning
- What GridGain adds
  - Production-ready releases
  - Enterprise-grade security, deployment and management
  - Global support and services
  - Proven for mission critical apps



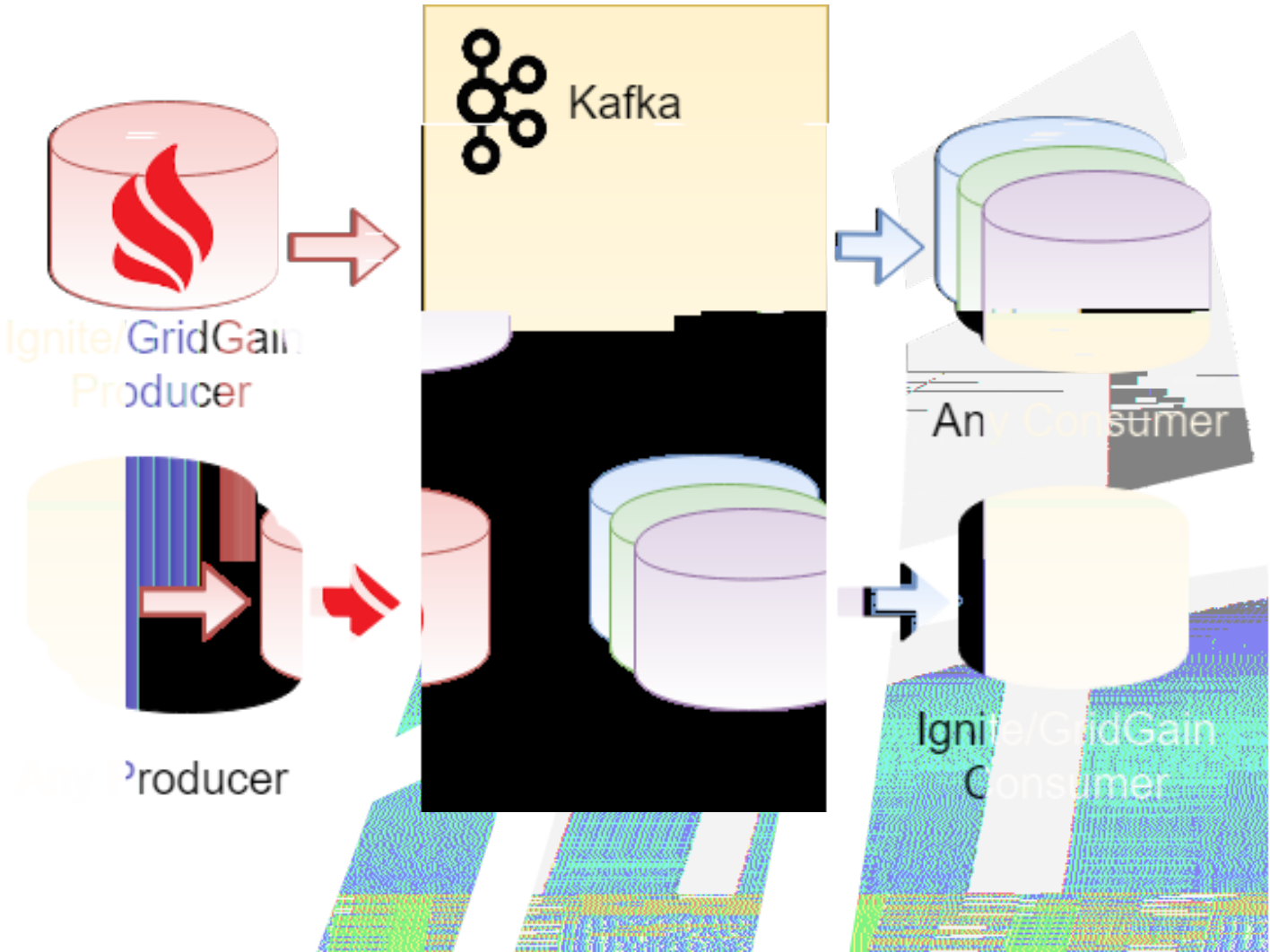
Streaming Analytics, Machine and Deep Learning



1. R and Python developers currently invoke Java classes. Direct R and Python support planned.

Ignite/GridGain & Kafka Integration

- Kafka is commonly used as a messaging backbone in a heterogeneous system
- Add Ignite/GridGain to a Kafka-based system



https://www.imcsummit.org/2018/eu/session/embracing-service-consumption-shift-banking

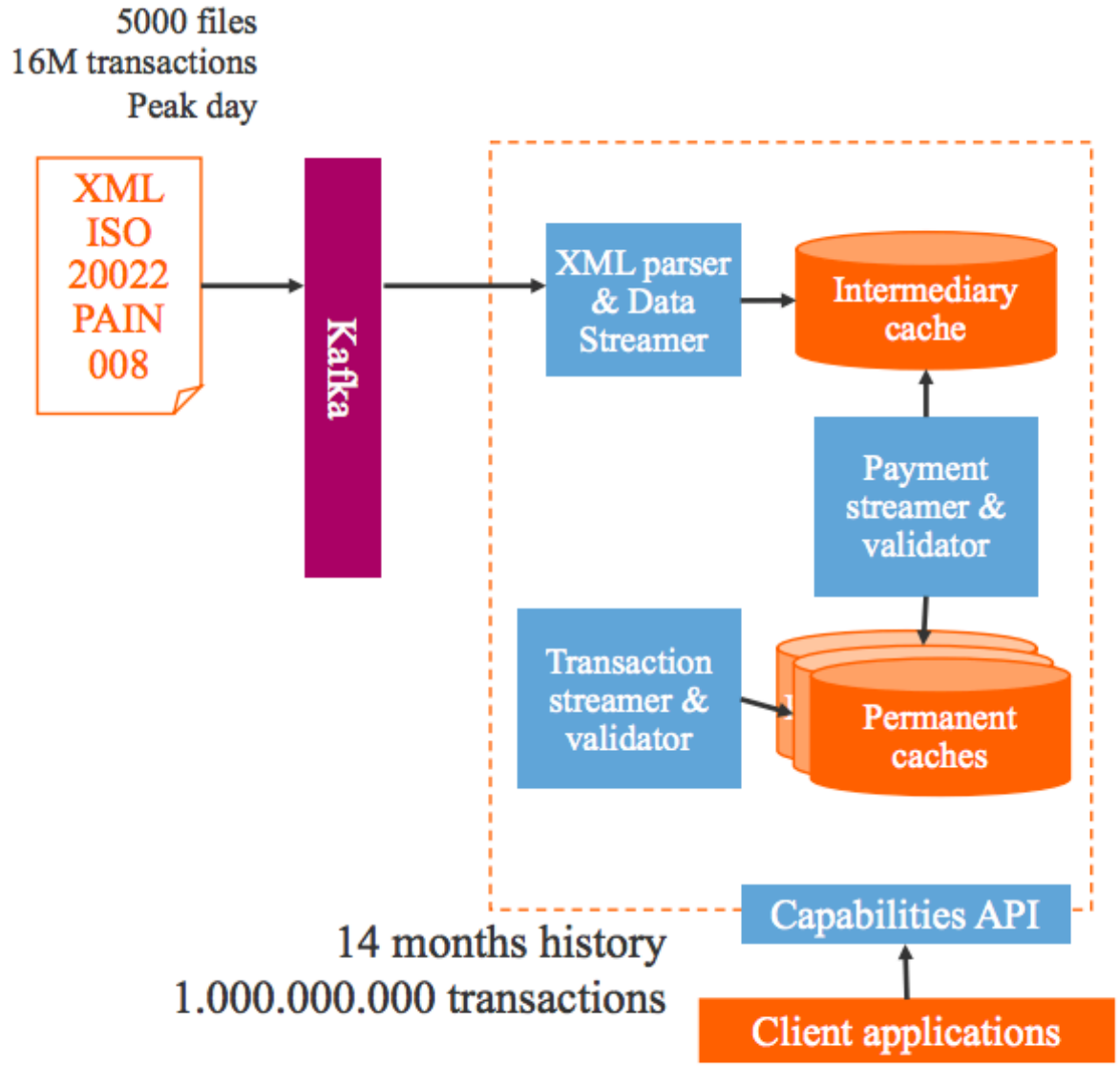
SEPA DD

Payment Initiation
Data Streamer & Data Grid

Business Validations
Distributed Compute Grid

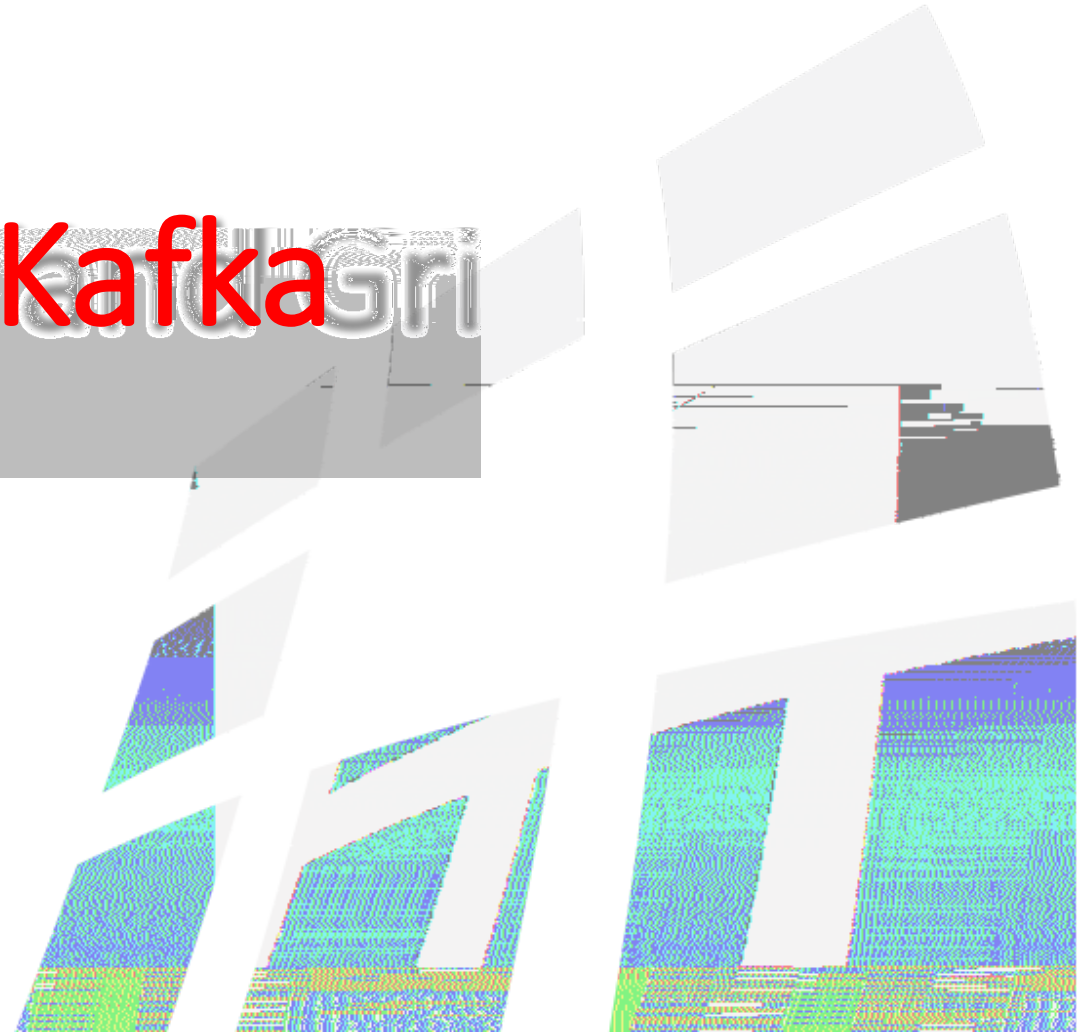
Computations and Aggregations
Distributed tasks using compute Grid

Custom Capability REST APIs
Client Nodes & Cache Query



ING

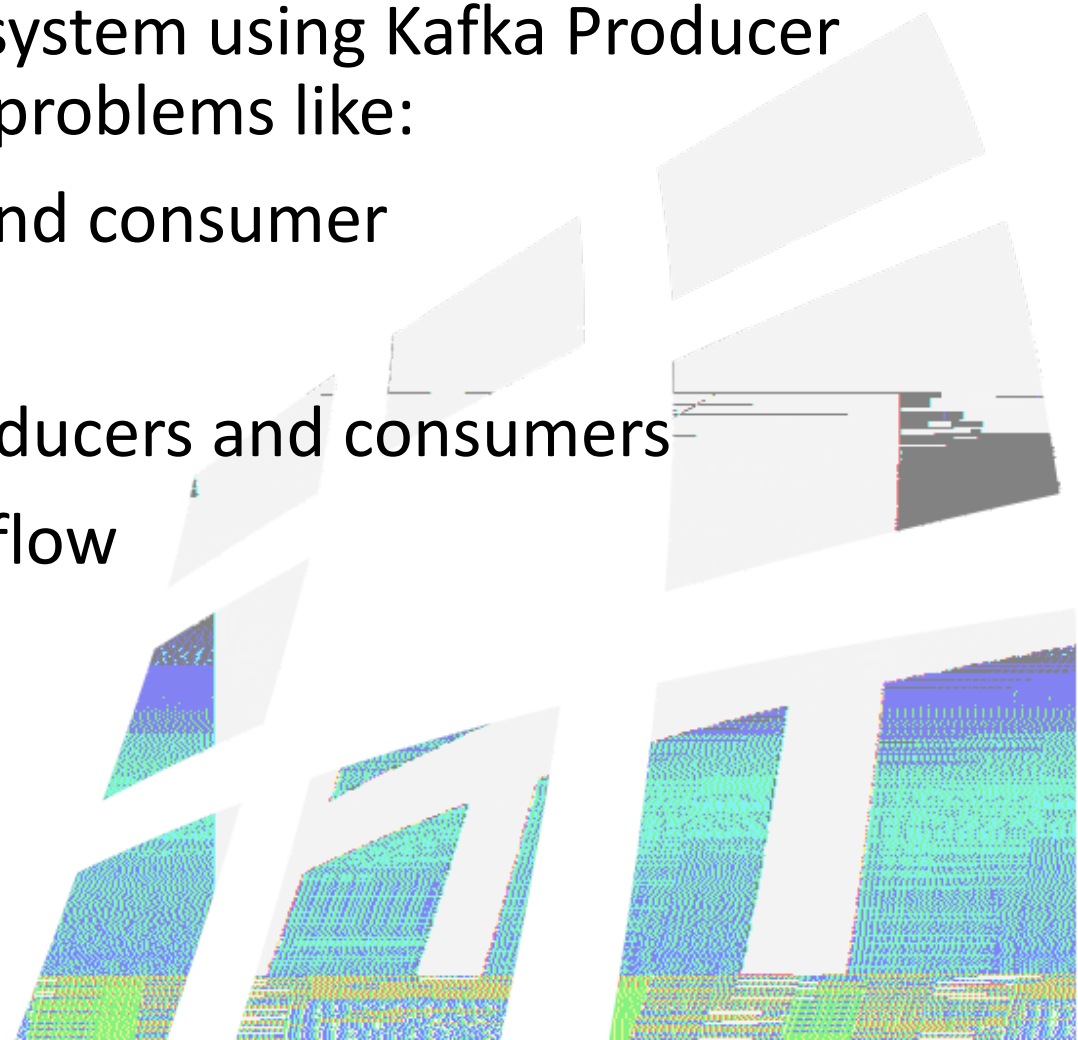
Ignite and GridGain Kafka Connectors



Developing Kafka Consumers & Producers

You can develop Kafka integration for any system using Kafka Producer and Consumer APIs but you need to solve problems like:

- How to use each API of every producer and consumer
- How Kafka will understand your data
- How data will be converted between producers and consumers
- How to scale the producer-to-consumer flow
- How to recover from a failure
- … and many more



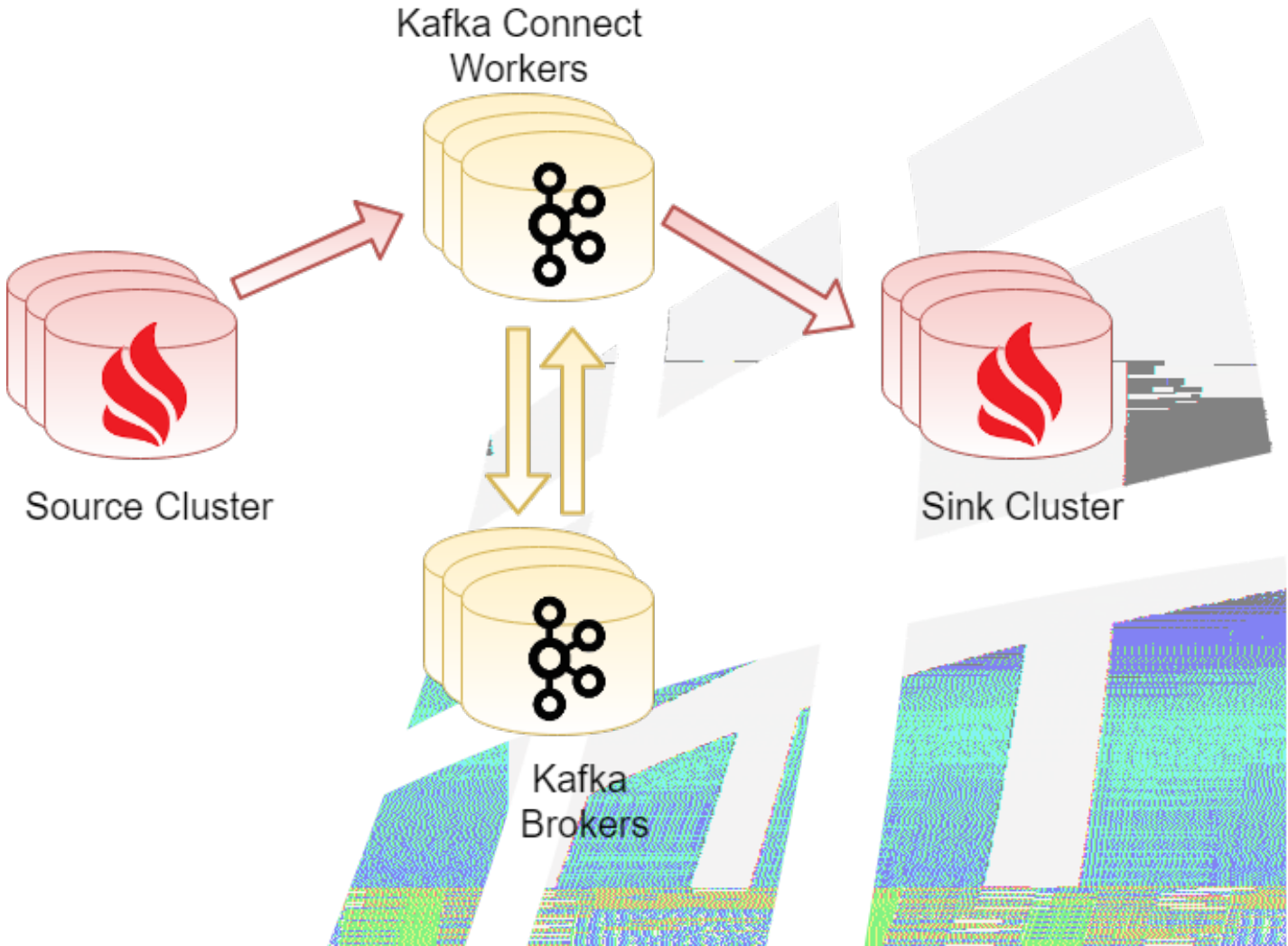
GridGain-Kafka Connector: Out-of-the-box Integration

- Addresses all the integration challenges using best practices
- Does not need any coding even in the most complex integrations
- Developed by GridGain/Ignite Community with help from Confluent to ensure both Ignite and Kafka best practices
- Based on Kafka Connect and Ignite APIs
  - Kafka Connect API encourages design for scalability, failover and data schema
  - GridGain Source Connector uses Ignite Continuous Queries
  - GridGain Sink Connector uses Ignite Data Streamer

Kafka Connect Server Types

In general, there are 4 separate clusters in Kafka Connect infrastructure:

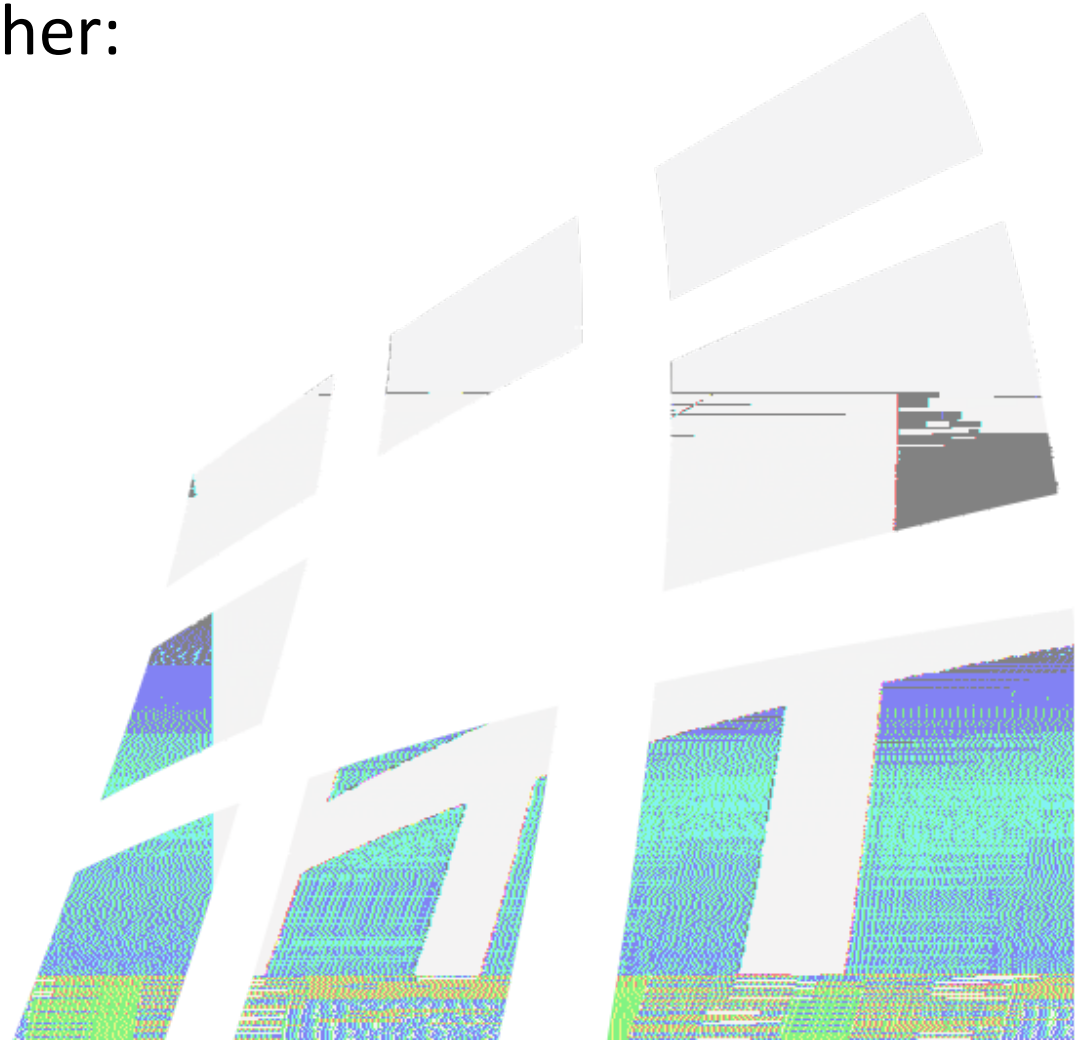
- Kafka cluster
  - cluster nodes called **Brokers**
- Kafka Connect cluster
  - cluster nodes called **Workers**
- Source and Sink GridGain/Ignite clusters
  - **Server Nodes**



GridGain Connector Features

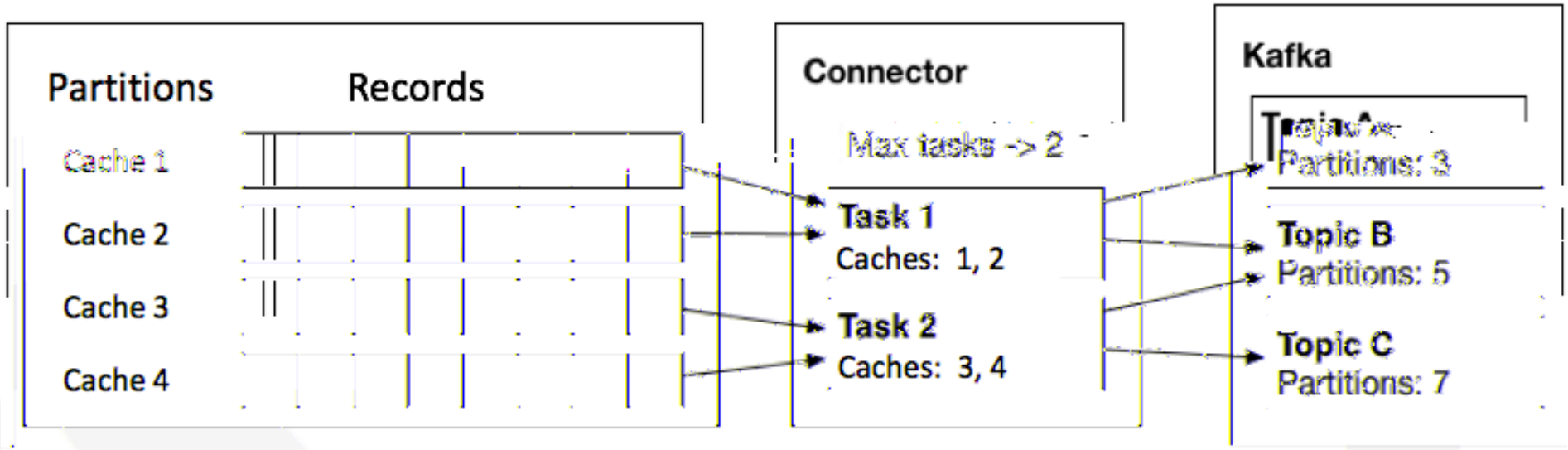
Two connectors independent from each other:

- GridGain Source Connector
  - streams data from GridGain into Kafka
  - uses Ignite continuous queries
- GridGain Sink Connector
  - streams data from Kafka into GridGain
  - uses Ignite data streamers



GridGain Source Connector: Scalability

Kafka Source Connector Model:



Scales by assigning multiple source **partitions** to Kafka Connect **tasks**.

For GridGain Source Connector:

- Partition = Cache
- Record = Cache Entry

GridGain Source Connector: Rebalancing and Failover

Rebalancing: re-assignment of Kafka Connectors and Tasks to Workers when

- A Worker joins or leaves the cluster
- A cache is added or removed

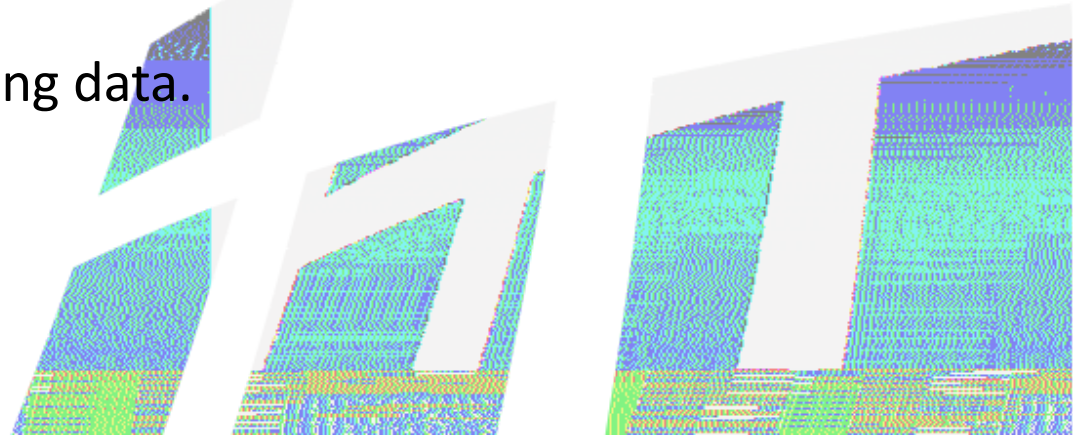
Failover: resuming operation after a failure

- how to resume after failure or rebalancing without losing cache updates occurred when Kafka Worker node was down?

Source Offset: position in the source stream. Kafka Connect:

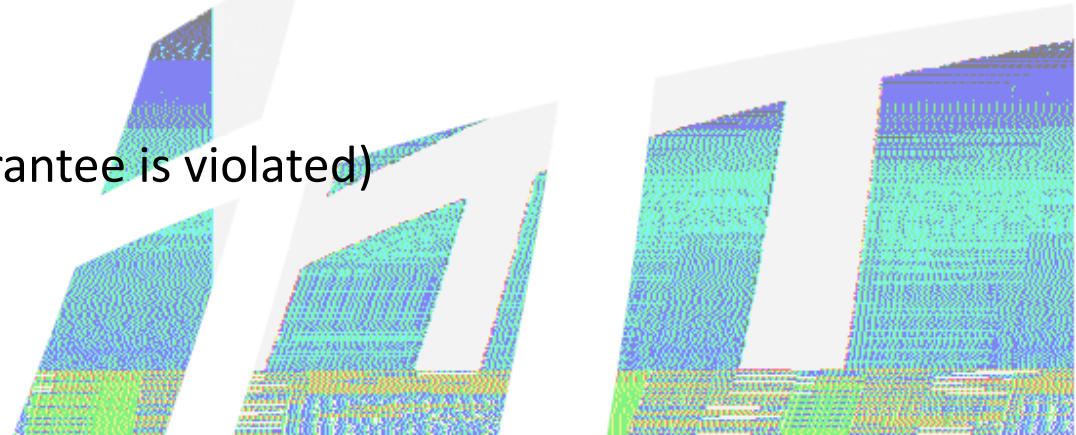
- provides persistent and distributed source offset storage
- automatically saves last committed offset
- allows resuming from the last offset without losing data.

Problem: caches have no offsets!



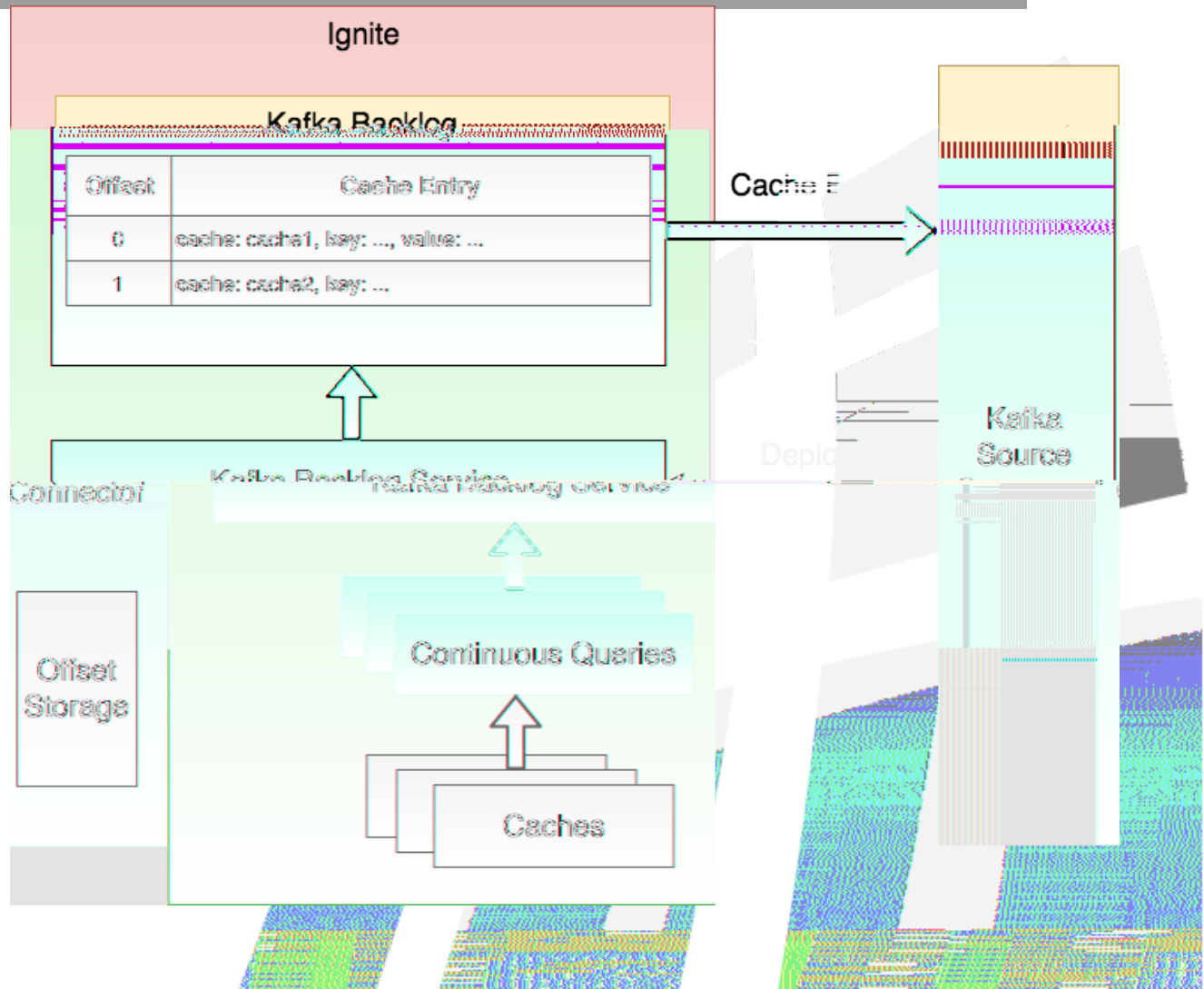
GridGain Source Connector: Failover Policies

- **None**: no source offset saved, start listening to current data after restart
  - Cons: updates occurred during downtime are lost (“at least once” data delivery guarantee violated)
  - Pros: fastest
- **Full Snapshot**: no source offset saved, always pull all data from the cache upon startup
  - Cons:
    - Slow, not applicable for big caches
    - Duplicate data (”exactly once” data delivery guarantee is violated)
  - Pros: no data is lost



GridGain Source Connector: Failover Policies

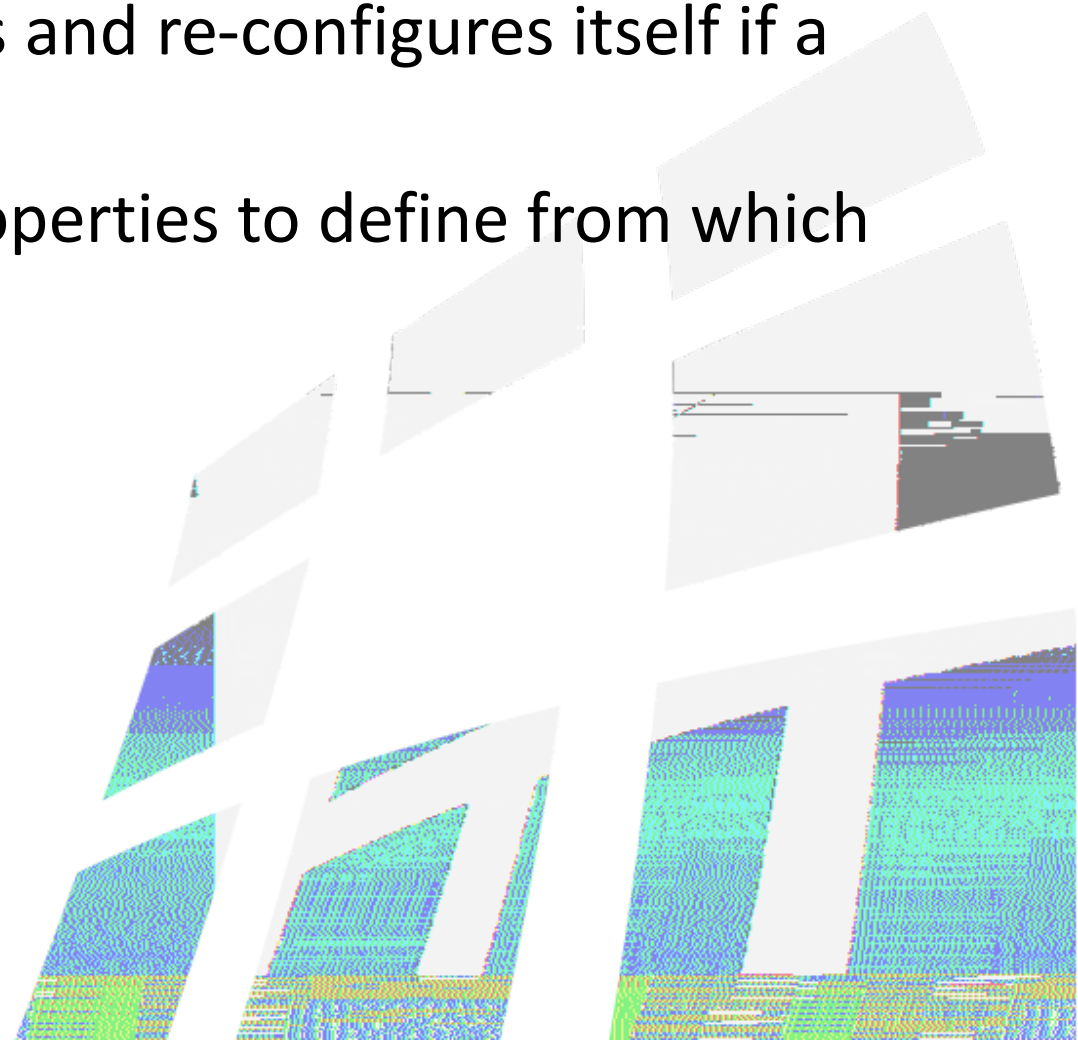
- **Backlog**: resume from the last committed source offset
  - Kafka Backlog cache in Ignite
    - Key: incremental offset
    - Value: cache name and serialized cache entries
  - Kafka Backlog service in Ignite
    - Runs continuous queries pulling data from source caches into Backlog
  - Source Connector gets data from Backlog from backlog starting from the last committed offset
  - Cons
    - Intrusive: GridGain cluster impact
    - Complex configuration: need to estimate amount of memory for Backlog



GridGain Source Connector: Dynamic Reconfiguration

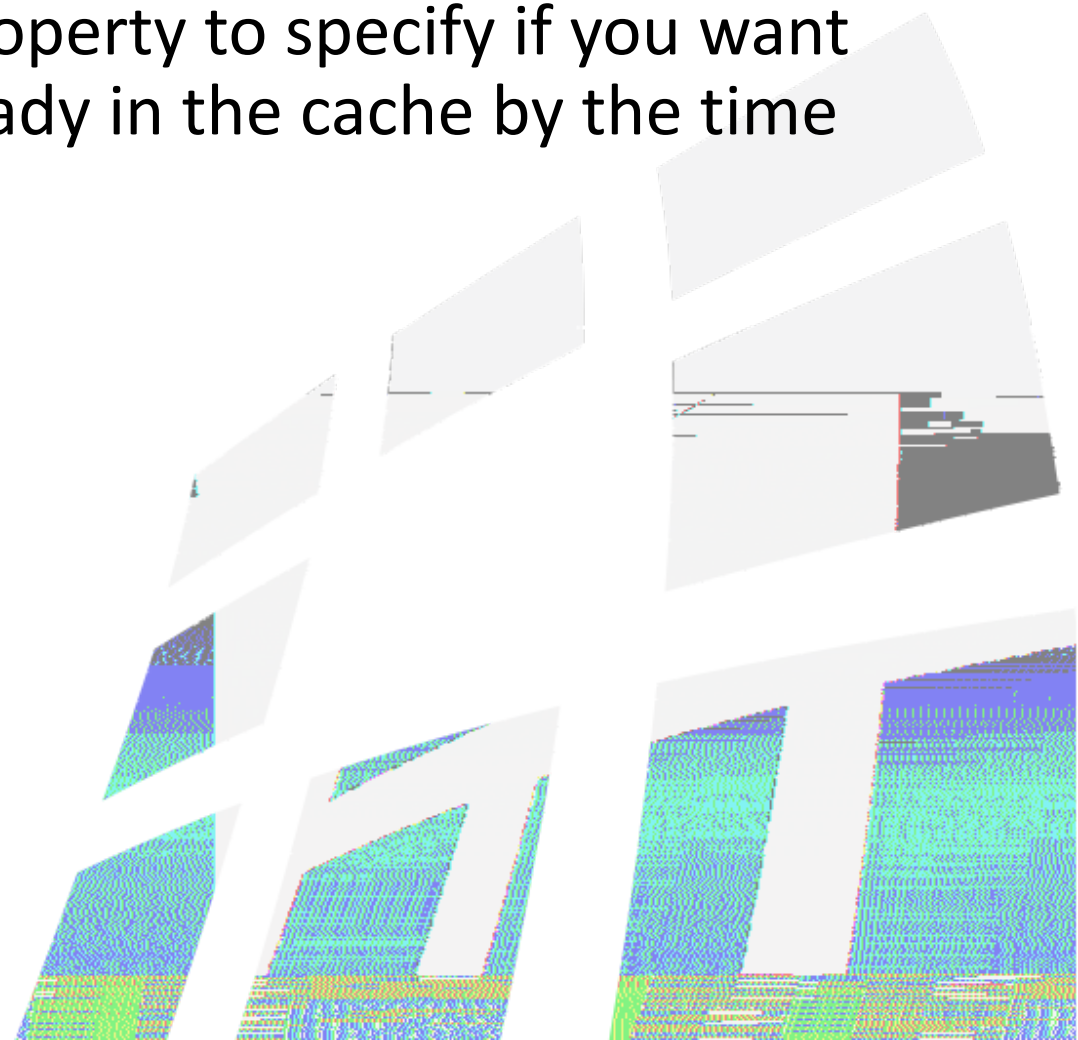
Connector monitors list of available caches and re-configures itself if a cache is added or removed.

Use and properties to define from which caches to pull data.



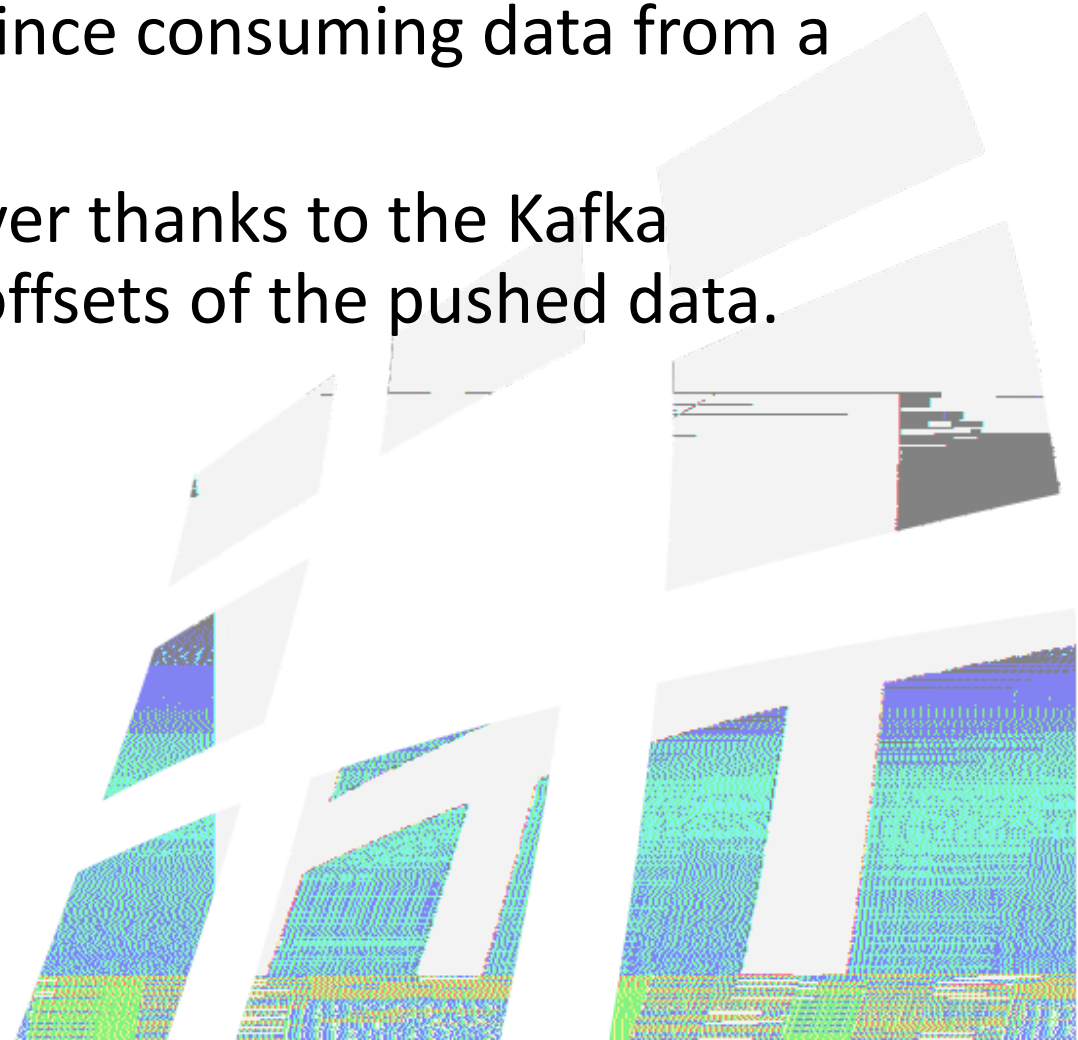
GridGain Source Connector: Initial Data Load

Use configuration property to specify if you want the Connector to load the data that is already in the cache by the time the Connector starts.



GridGain Sink Connector

- Sink Connectors are inherently scalable since consuming data from a Kafka topic is scalable
- Sink Connectors inherently support failover thanks to the Kafka Connector framework auto-committing offsets of the pushed data.



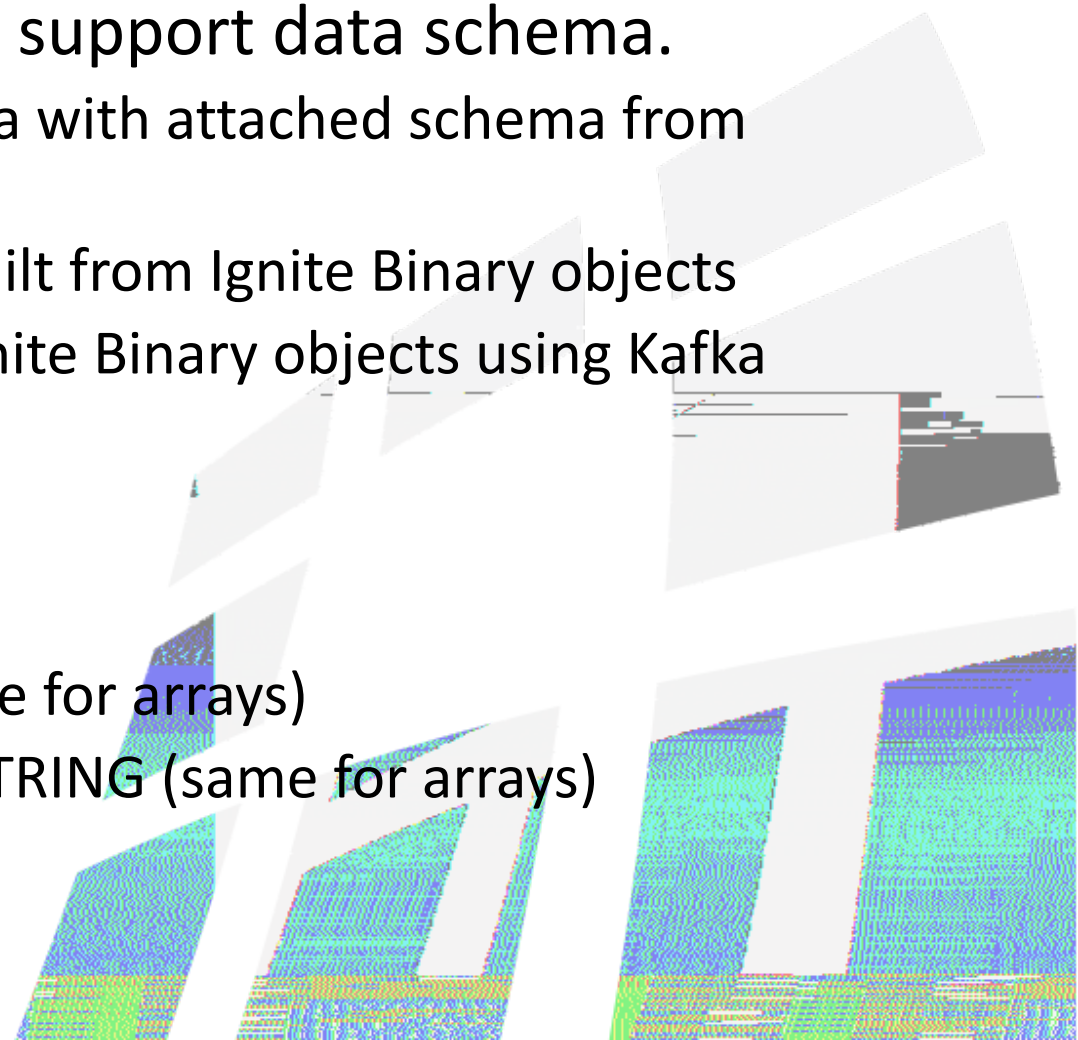
GridGain Connector Data Schema

Both Source and Sink GridGain Connectors support data schema.

- Allows GridGain Connectors understand data with attached schema from other Kafka producers and consumers
- Source Connector attaches Kafka schema built from Ignite Binary objects
- Sink Connector converts Kafka records to Ignite Binary objects using Kafka schema

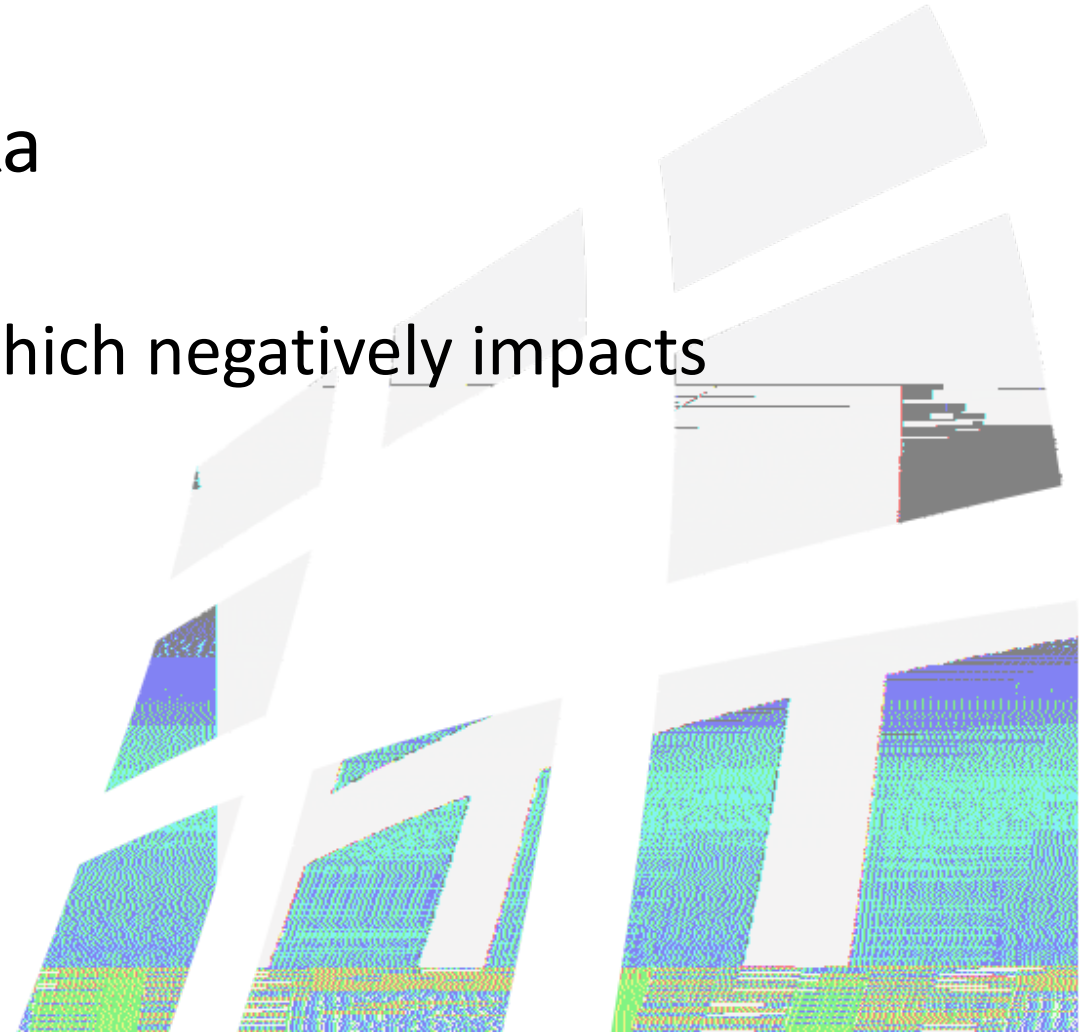
Limitations:

- Ignite Annotations are not supported
- Ignite CHAR converted to Kafka SHORT (same for arrays)
- Ignite UUID and CLASS converted to Kafka STRING (same for arrays)



Ignite Connector Features

- Ignite Source Connector
  - pushes data from Ignite into Kafka
  - uses Ignite Events
    - must enable **EVT_CACHE_OBJECT_PUT**, which negatively impacts cluster performance
- Ignite Sink Connector
  - pulls data from Kafka into Ignite
  - use Ignite data streamer



Apache Ignite vs. GridGain Connectors

Feature	Apache Ignite Connector	GridGain Connector
Scalability	**Limited** Source connector is not parallel Sink connector is parallel	Source connector creates a task per cache Sink connector is parallel
Failover	**NO** Source data is lost during connector restart or rebalancing	**YES** Source connector can be configured to resume from the last committed offset
Preserving source data schema	**NO**	**YES**
Handling multiple caches	**NO**	**YES** Connector can be configured to handle any number of caches
Dynamic Reconfiguration	**NO**	**YES** Source connector detects added or removed caches and re-configures itself

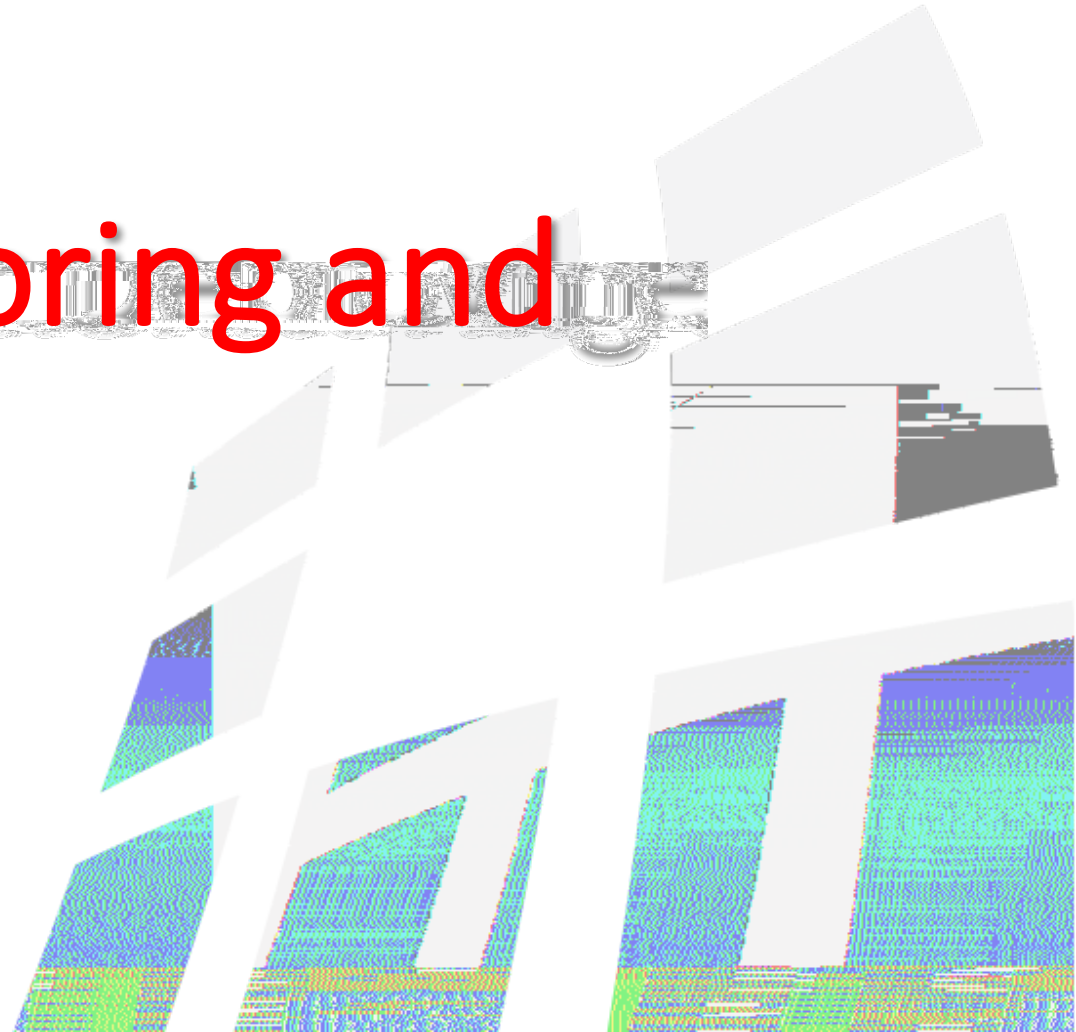
Apache Ignite vs. GridGain Connectors

Feature	Apache Ignite Connector	GridGain Connector
Initial Data Load	**NO**	**YES**
Handling data removals	**YES**	**YES**
Serialization and Deserialization of data	**YES**	**YES**
Filtering	**Limited** Only source connector supports a filter	**YES** Both source and sink connectors support filters
Transformations	Kafka SMTs	Kafka SMTs

Apache Ignite vs. GridGain Connectors

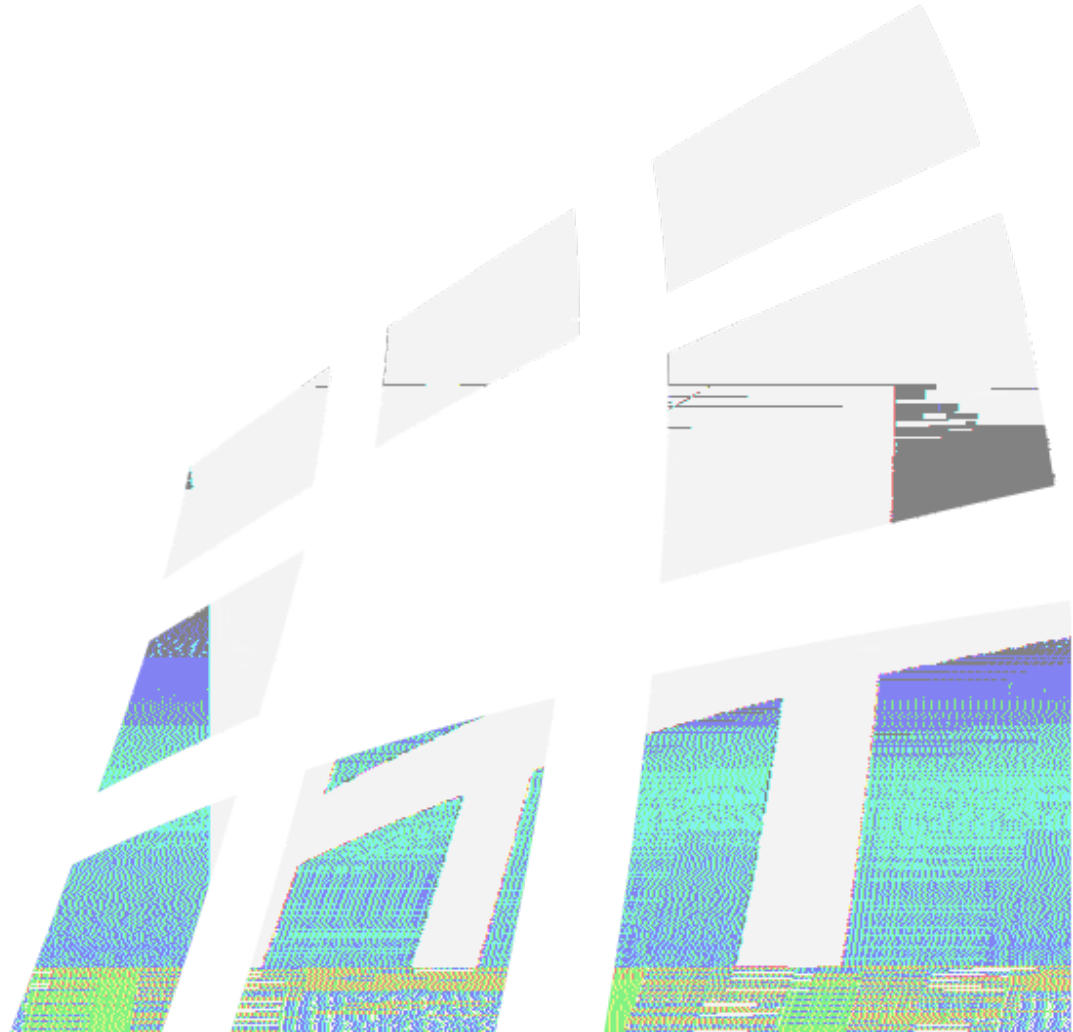
Feature	Apache Ignite Connector	GridGain Connector
DevOps	Some free-text error logging	Health Model defined
Support	Apache Ignite Community	Supported by GridGain, certified by Confluent
Packaging	Uber JAR	Connector Package
Deployment	Plugin PATH on all Kafka Connect workers	Plugin PATH on all Kafka Connect workers. CLASSPATH on all GridGain nodes.
Kafka API Version	0.10	2.0
Source API	Ignite events	Ignite continuous queries
Sink API	Ignite data streamer	Ignite data streamer

Deployment, monitoring and management



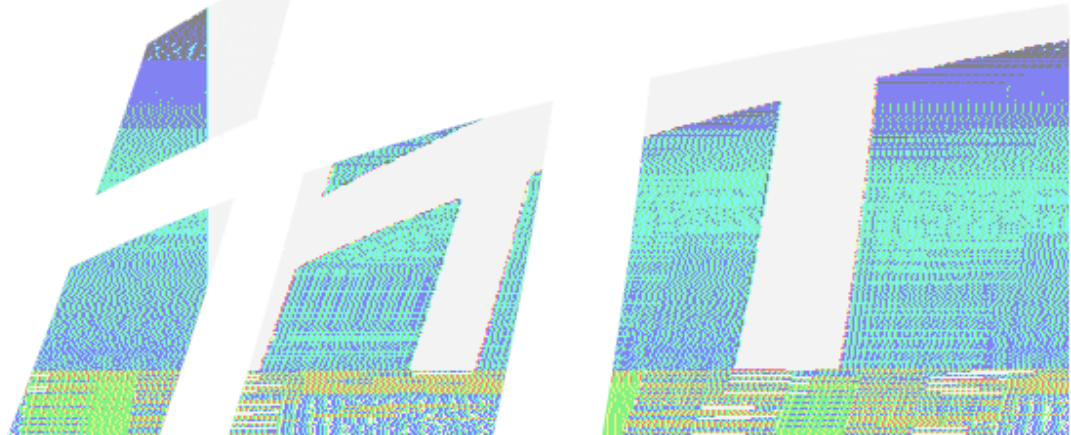
GridGain Connector Deployment

1. Prepare Connector Package
2. Register Connector with Kafka
3. Register Connector with GridGain



Prepare GridGain Connector Package

1. GridGain-Kafka Connector is part of GridGain Enterprise and Ultimate 8.5.3 (to be released in the end of October 2018)
2. The connector is in
   - (GRIDGAIN_HOME environment variable points to the root GridGain installation directory)
3. Pull missing connector dependencies into the package:



Register GridGain Connector with Kafka

For every Kafka Connect Worker:

1. Copy GridGain Connector package directory to where you want Kafka Connectors to be located

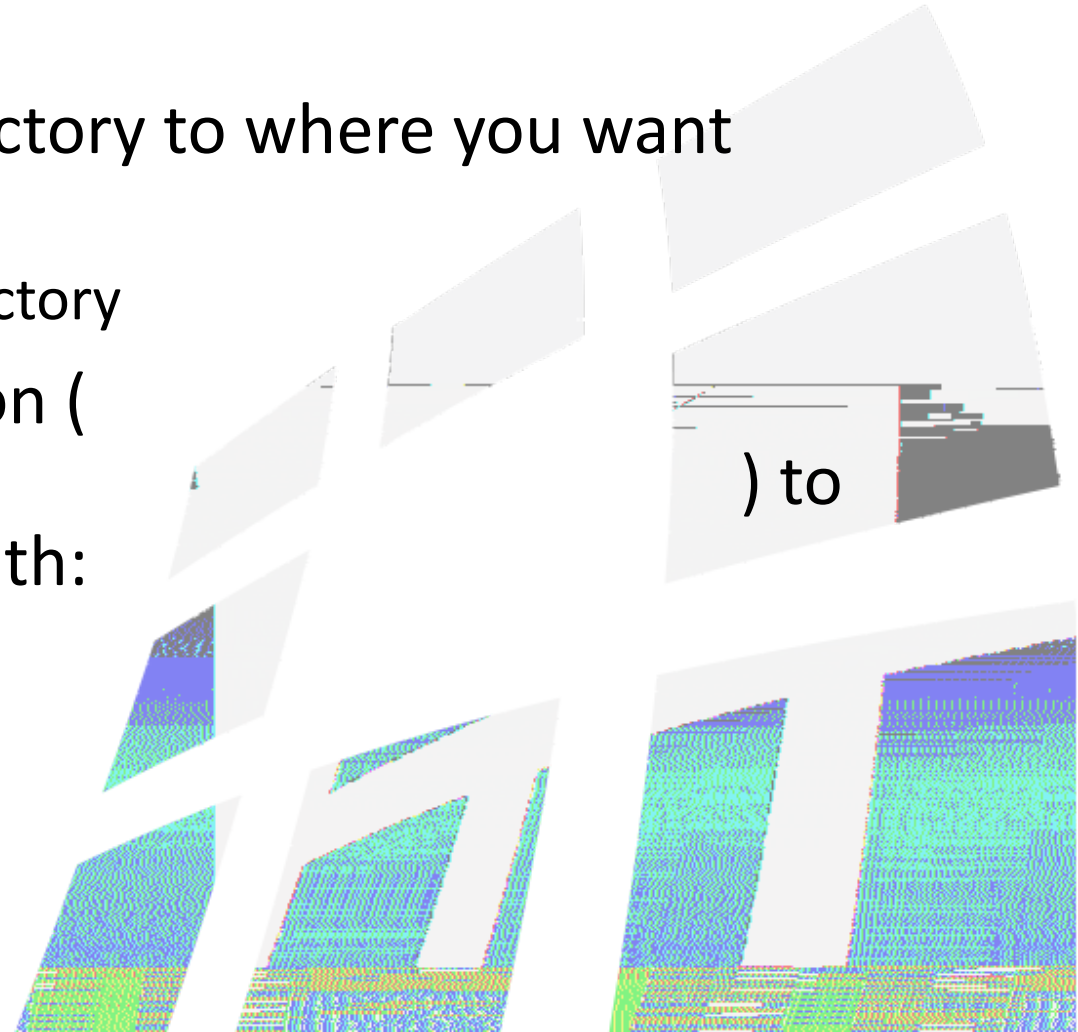
   for example, into directory

2. Edit Kafka Connect Worker configuration (

   or

   register the connector on the plugin path:

) to

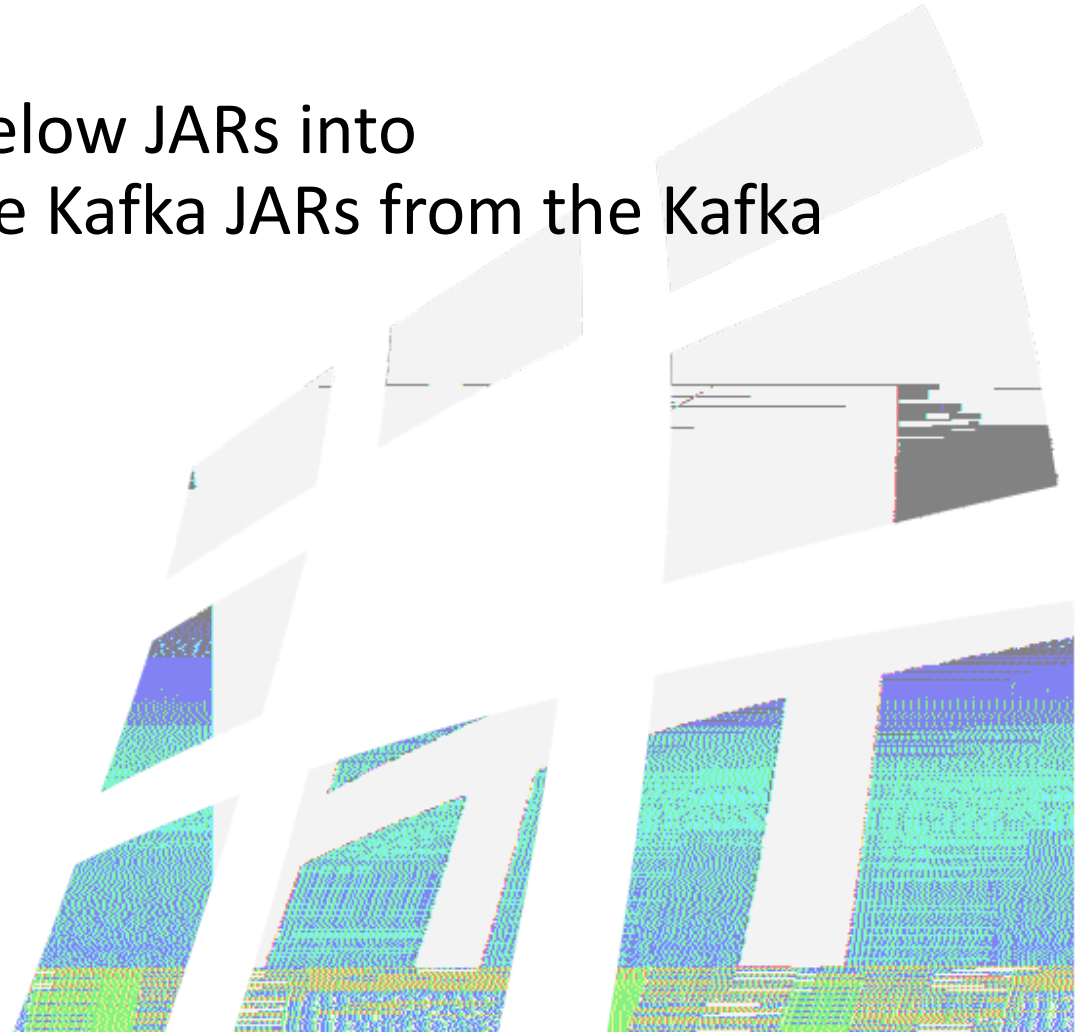


Register GridGain Connector with GridGain

This assumes GridGain version is 8.5.3

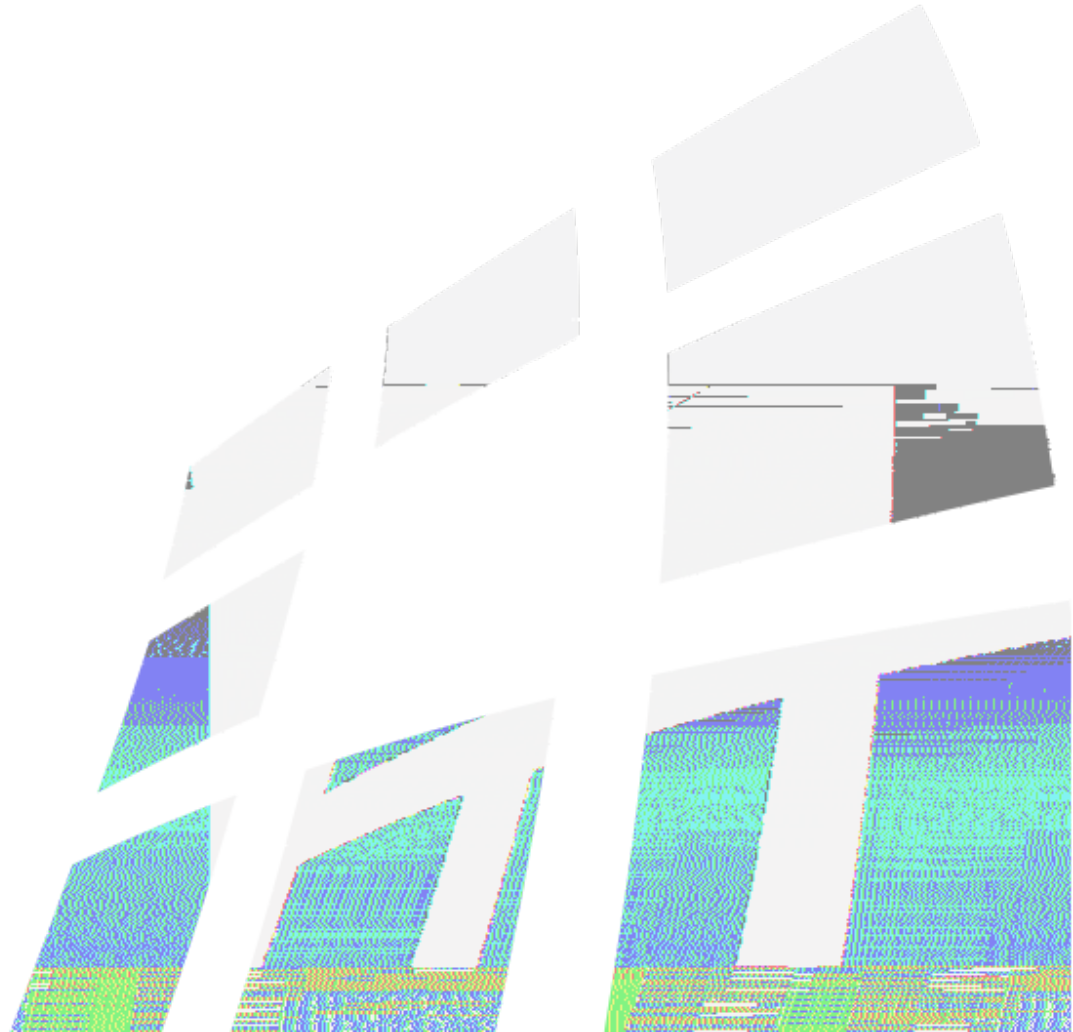
On every GridGain server node copy the below JARs into
directory. Get the Kafka JARs from the Kafka
Connect workers:

•
•
•



Ignite Connector Deployment

1. Prepare Connector Package
2. Register Connector with Kafka

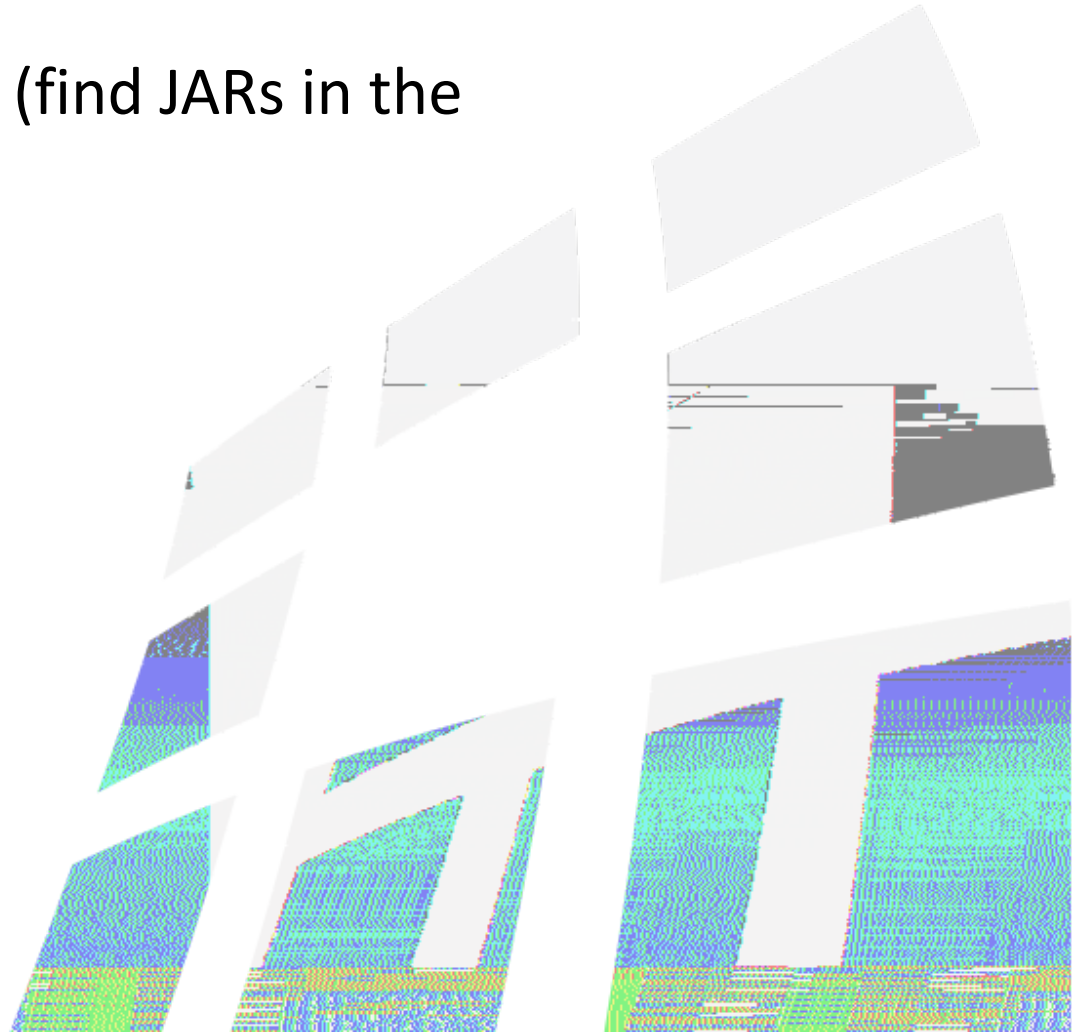


Prepare Ignite Connector Package

This assumes Ignite version is 2.6.

Create a direcotory containing the below JARs (find JARs in the sub-directories):

-
-
-
-
-
-
-
-
-
-



Register GridGain Connector with Kafka

For every Kafka Connect Worker:

1. Copy Ignite Connector package directory to where you want Kafka Connectors to be located

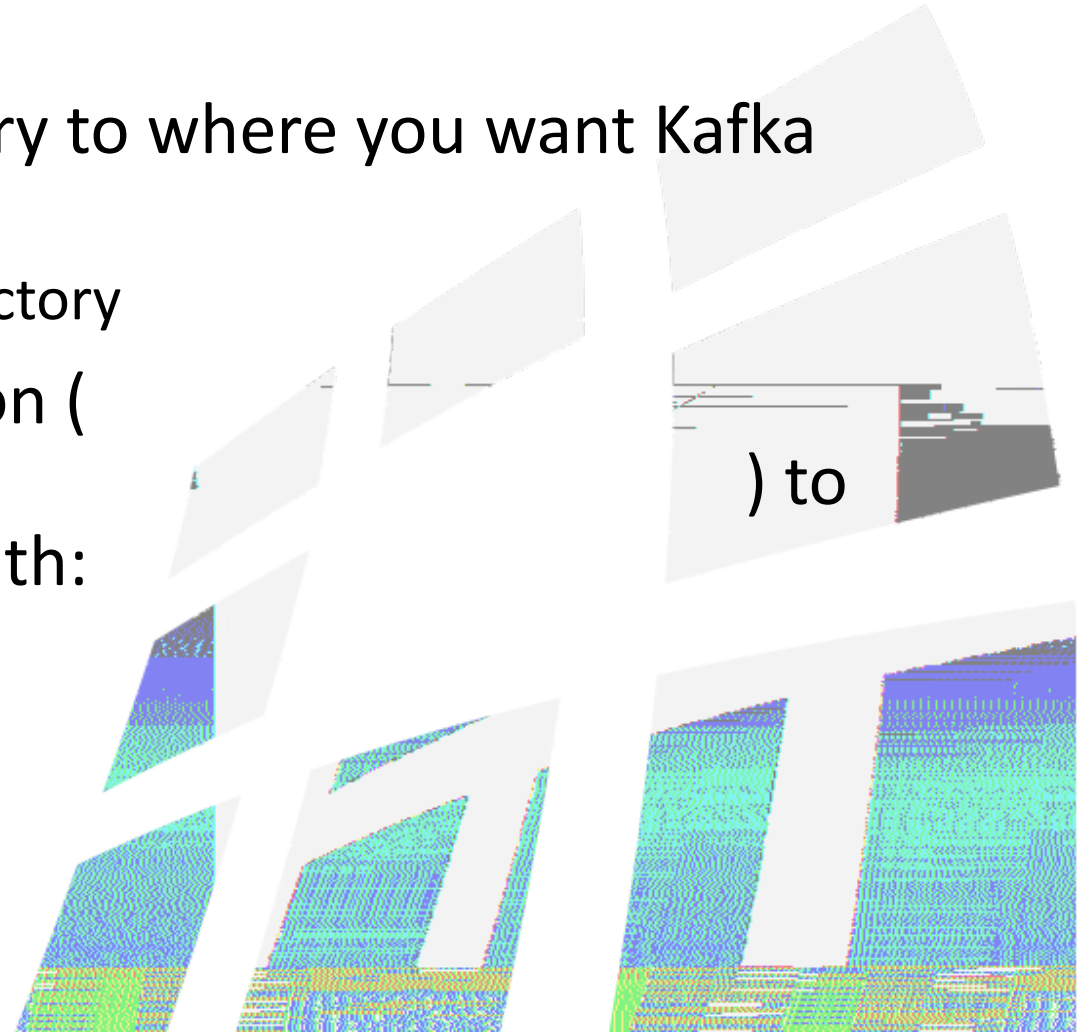
   for example, into directory

2. Edit Kafka Connect Worker configuration (

   or

   register the connector on the plugin path:

) to



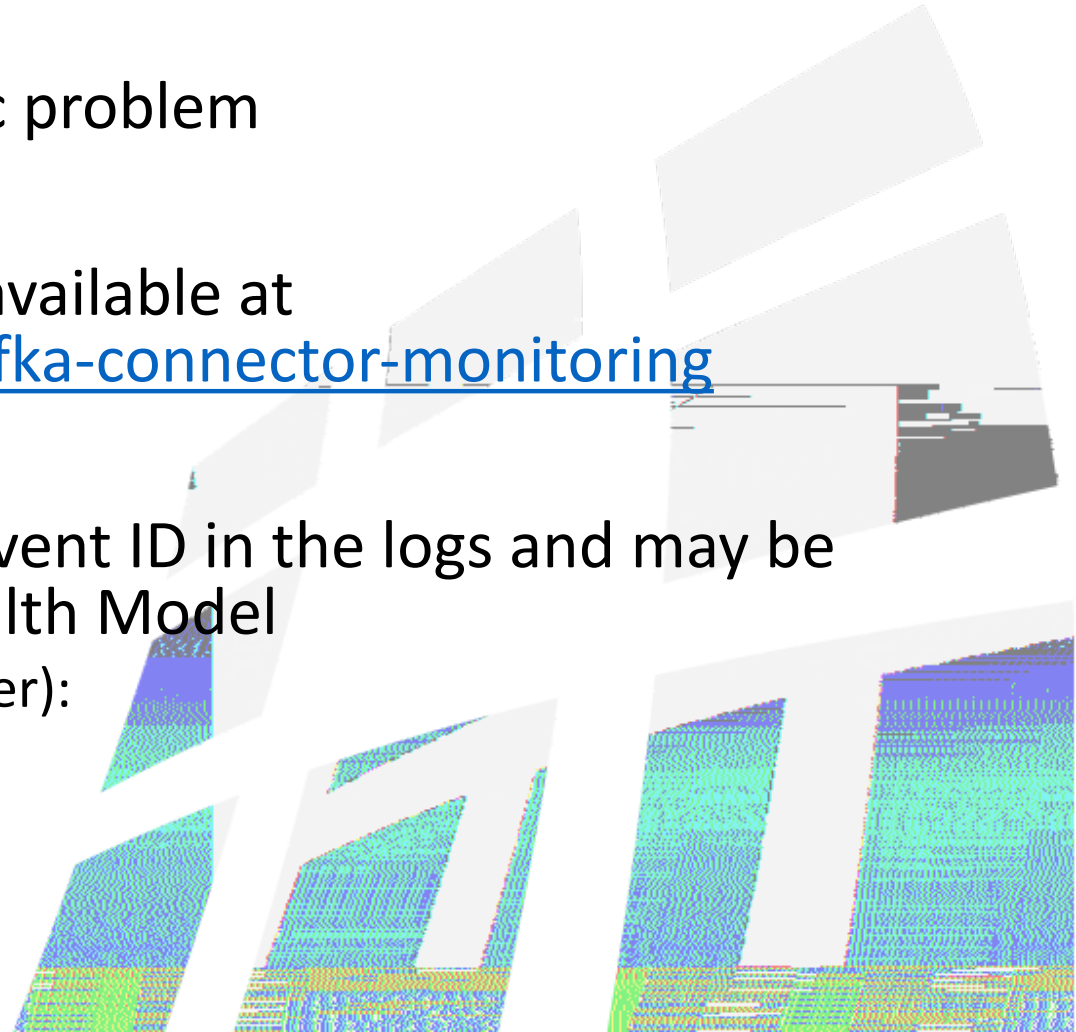
Monitoring: GridGain Connector

Well defined Health Model:

- Numeric Event ID uniquely identifies specific problem
- Event severity
- Problem description and recovery action is available at https://docs.gridgain.com/docs/certified-kafka-connector-monitoring

Configure your monitoring system to detect event ID in the logs and may be run automated recovery as defined in the Health Model

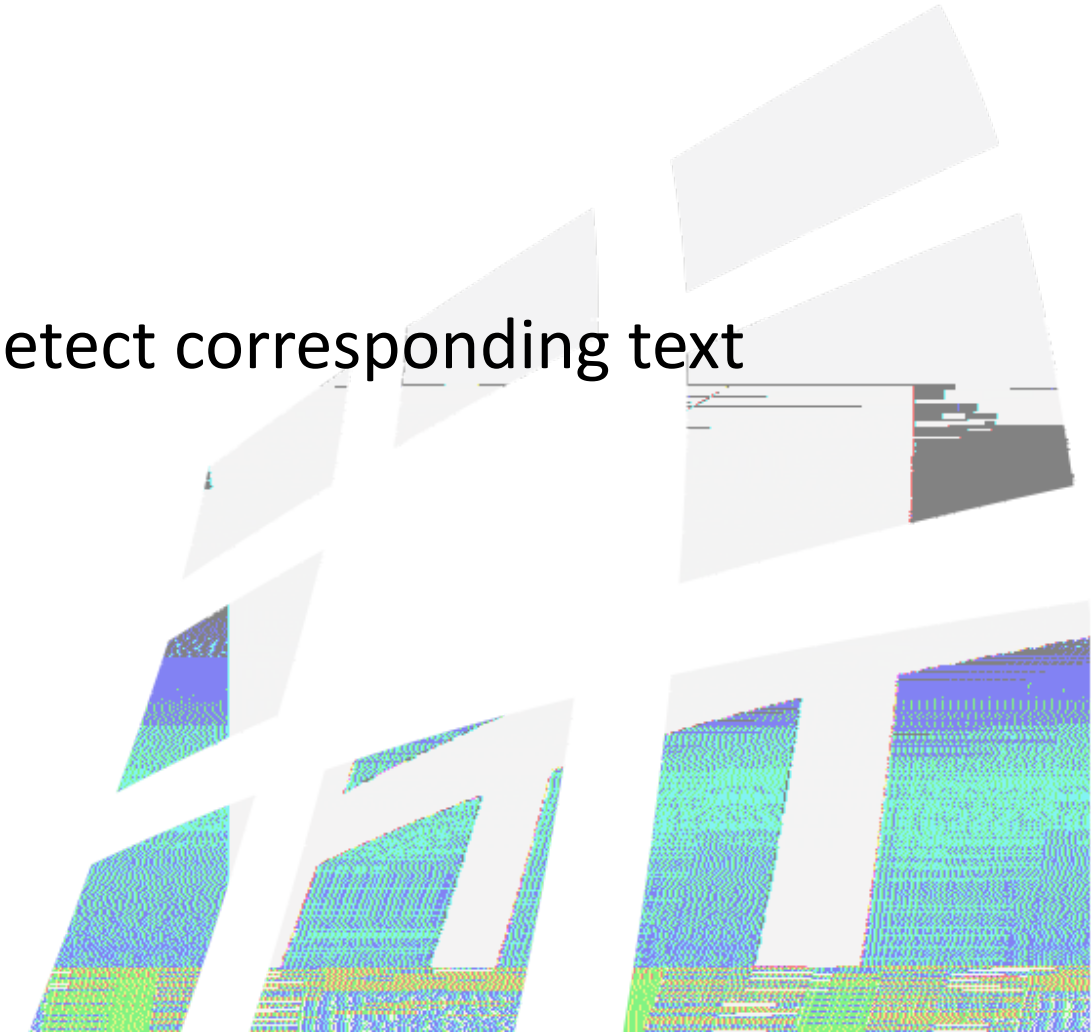
- Sample structured log entry (# used as a delimiter):



Monitoring: Ignite Connector

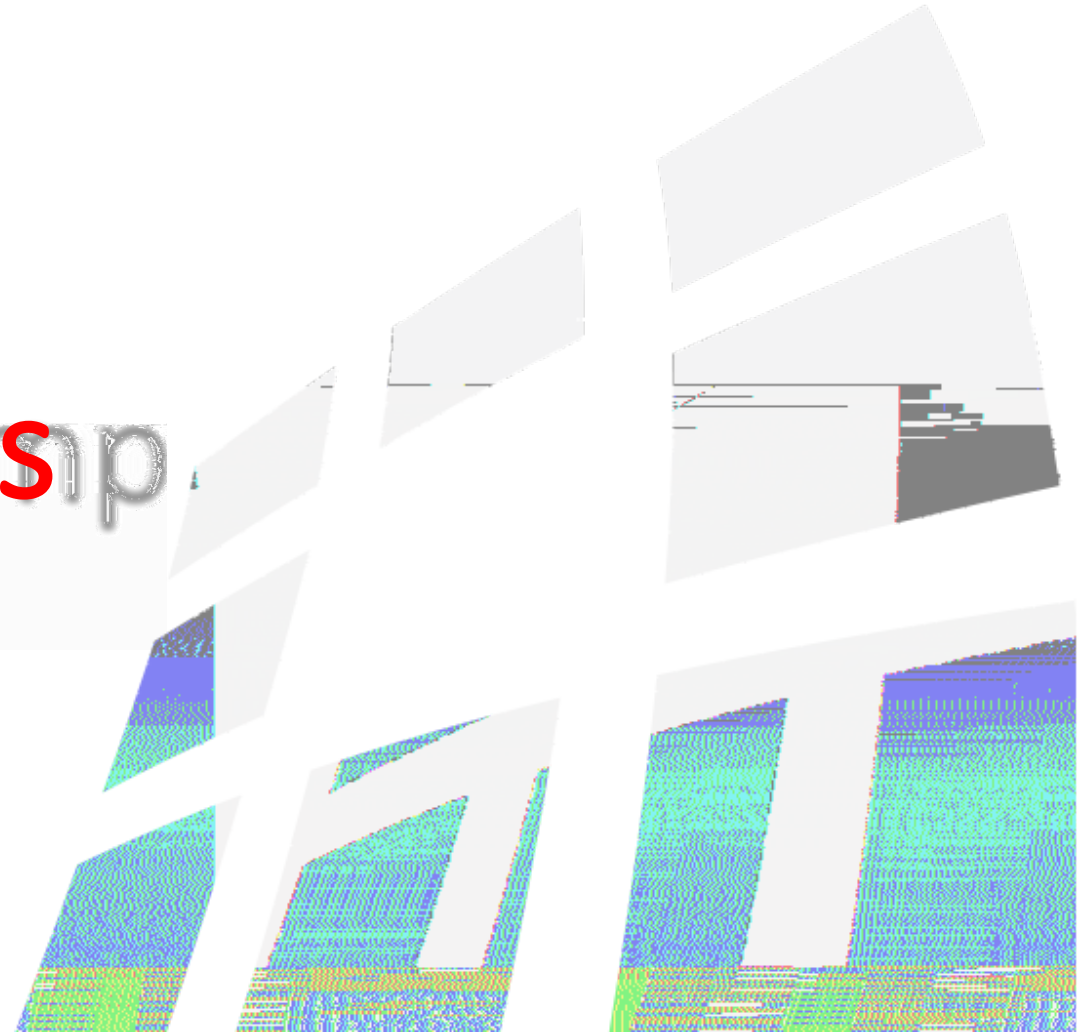
No Health Model is defined.

1. Run negative tests
2. Check Kafka and Ignite logs output
3. Configure your monitoring system to detect corresponding text patterns in the logs



Integration Examples

Propagating RDBMS updates into GridGain

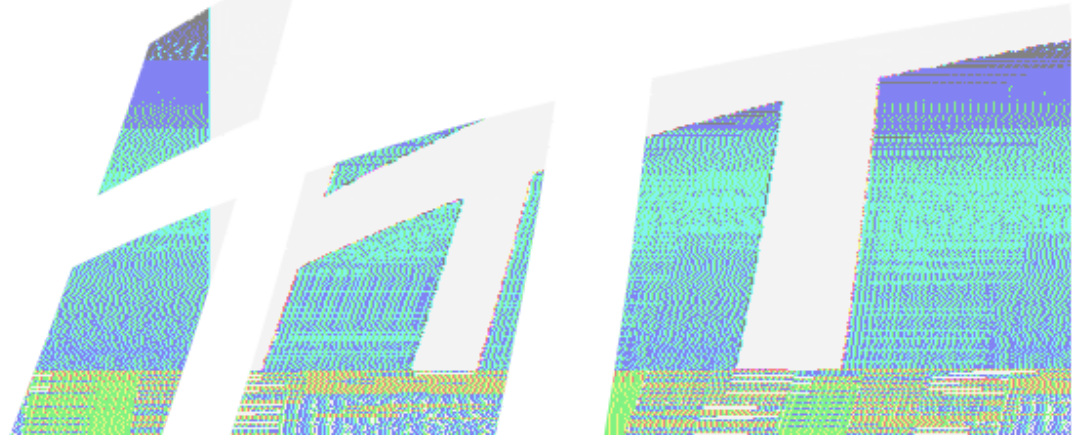


Propagating RDBMS updates into GridGain

Ignite/GridGain has a 3rd Party Persistence feature (Cache Store) that allows:

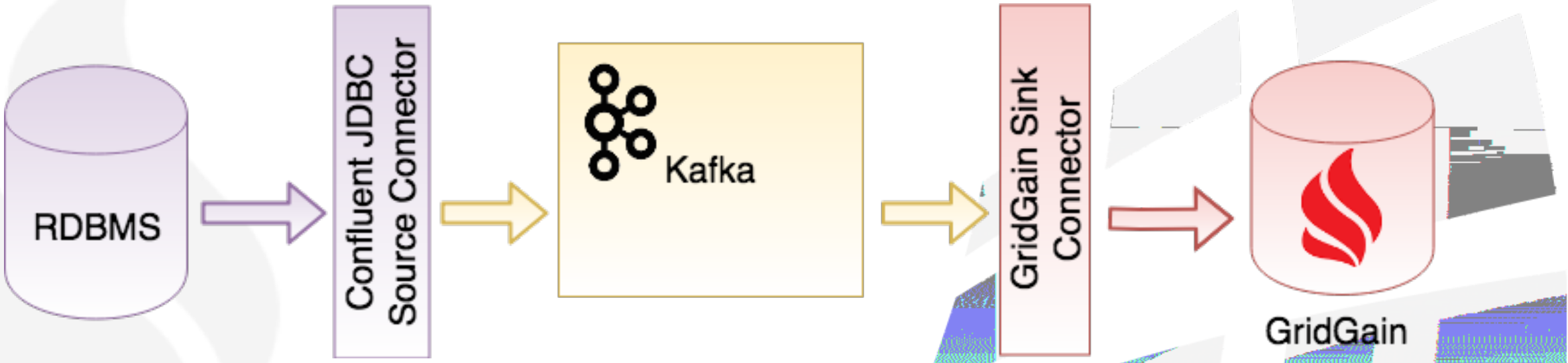
- Propagating cache changes to external storage like RDBMS
- Automatically copying data from external storage to Ignite upon accessing data missed in Ignite

What if you want to propagate external storage change to Ignite at the moment of the change? - 3rd Party Persistence cannot do that!



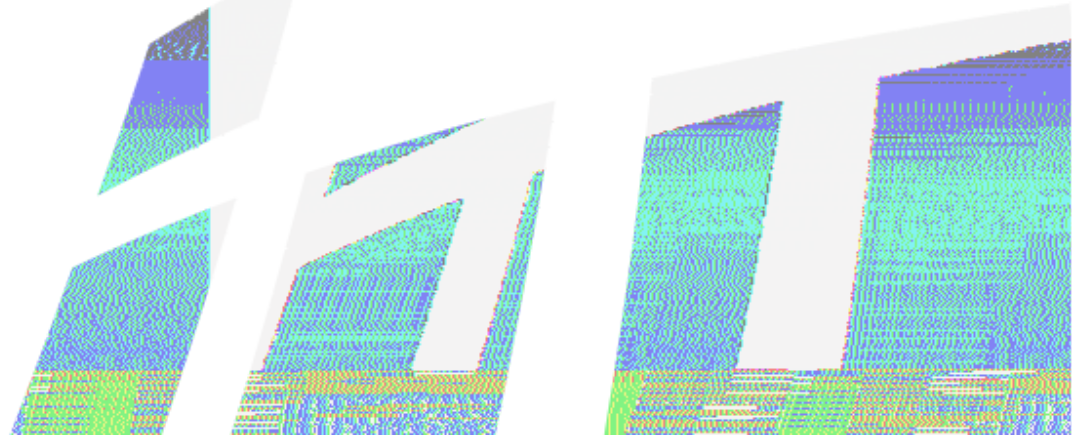
Propagating RDBMS updates into GridGain

Use Kafka to achieve that without writing single line of code!



Assumptions

- For simplicity we will run everything on the same host
  - In distributed mode GridGain nodes, Kafka Connect workers and Kafka brokers are running on different hosts
- GridGain 8.5.3 cluster with GRIDGAIN_HOME variable set on the nodes
- Kafka 2.0 cluster with KAFKA_HOME variable set on all brokers



1. Run DB Server

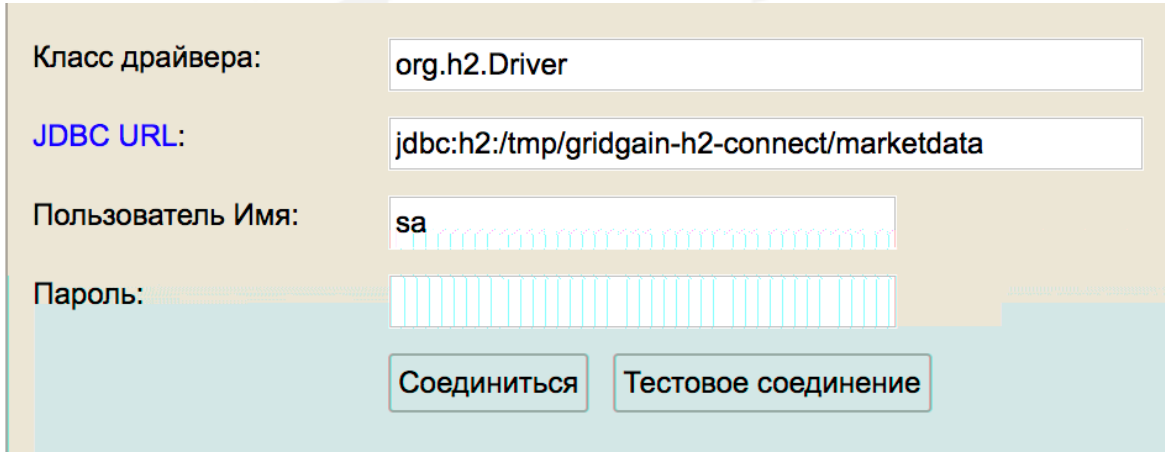
We will use H2 Database in this demo.

We will use as a work directory.

- Download H2 and set H2_HOME environment variable.
- Run H2 Server:

- In the opened H2 Web Console specify JDBC URL:

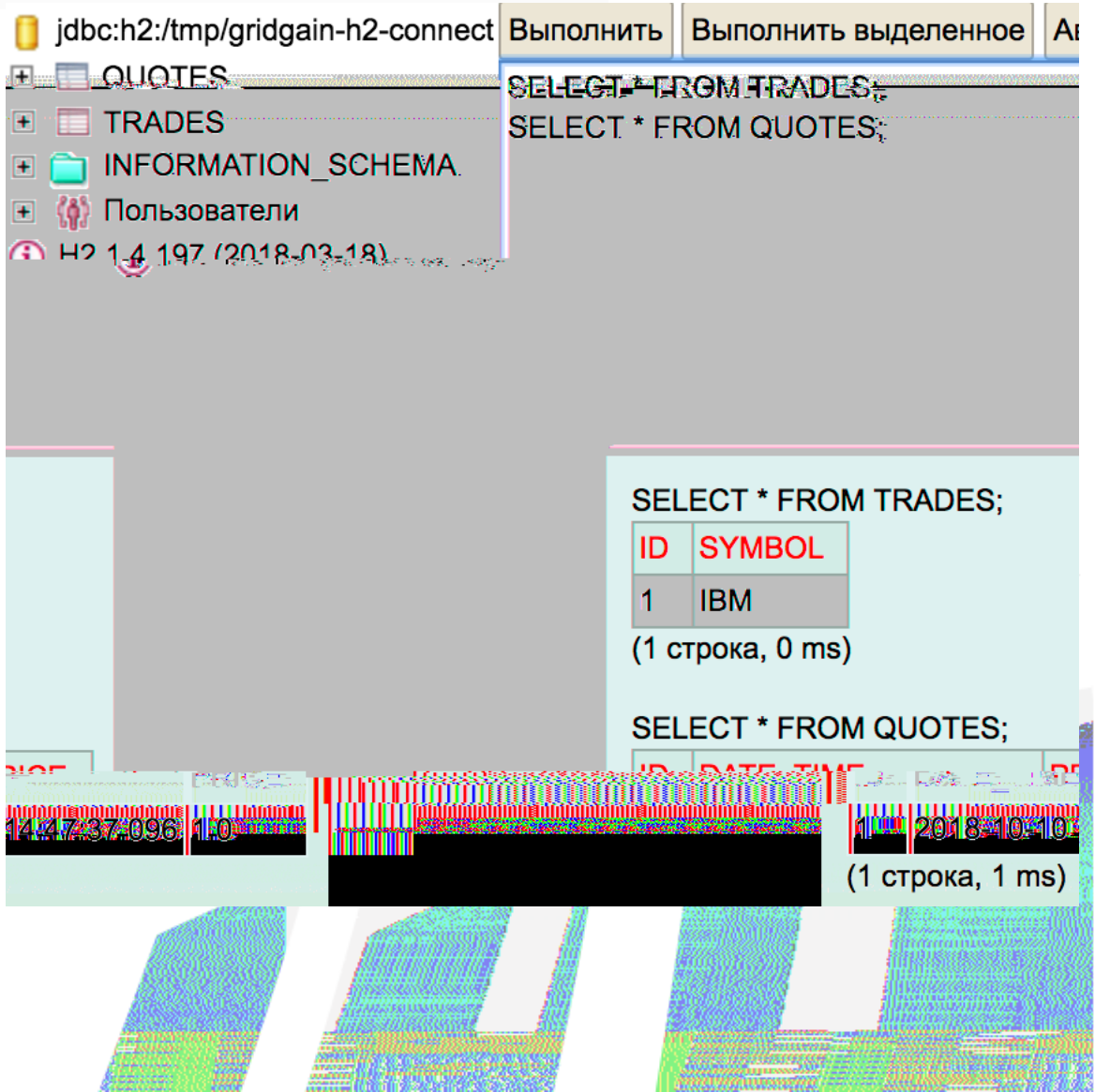
- Press Connect



2. Create DB Tables and Add Some Data

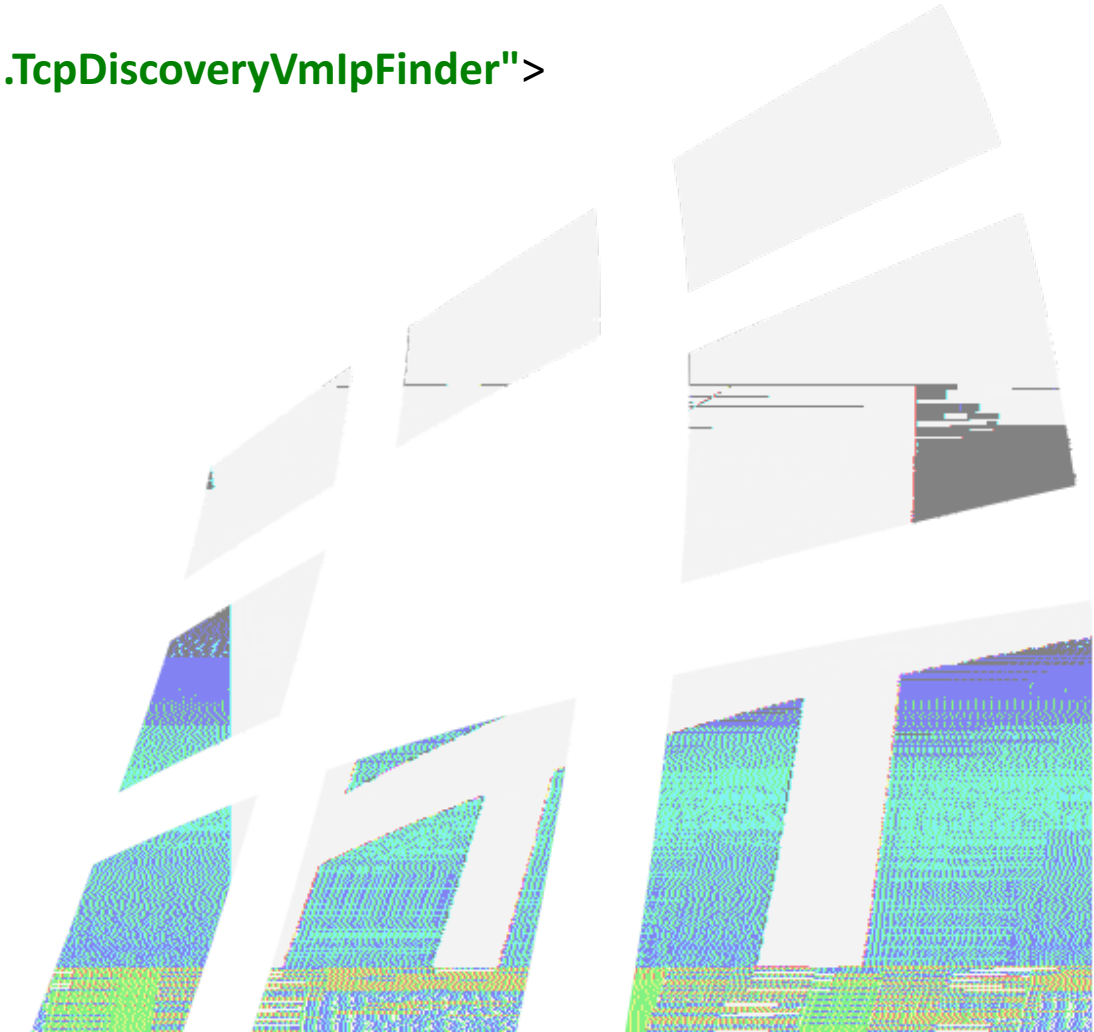
In H2 Web Console Execute:

- `QUOTES`
- `TRADES`
-
-



3. Start GridGain Cluster (Single-node)

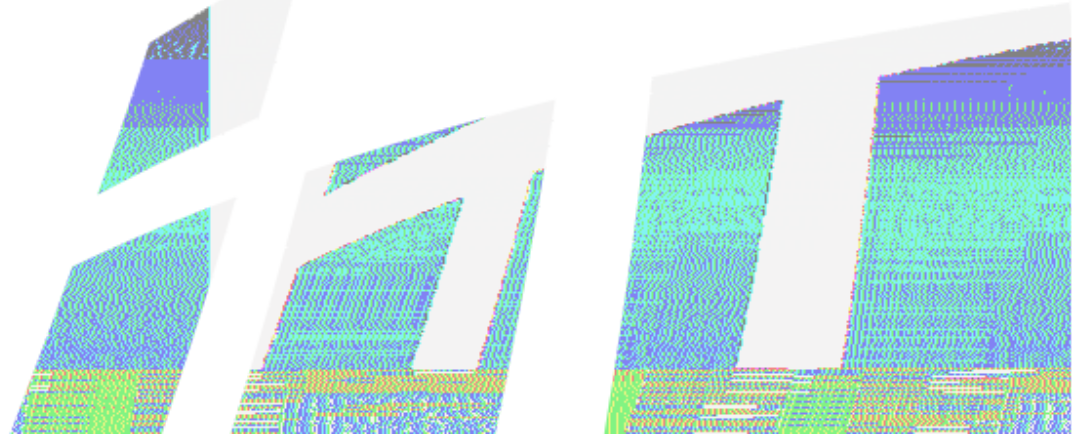
```
<bean id="ignite.cfg" class="org.apache.ignite.configuration.IgniteConfiguration">
    <property name="discoverySpi">
      <bean class="org.apache.ignite.spi.discovery.tcp.TcpDiscoverySpi">
        <property name="ipFinder">
          <bean class="org.apache.ignite.spi.discovery.tcp.ipfinder.vm.TcpDiscoveryVmIpFinder">
            <property name="addresses">
              <list>
                <value>127.0.0.1:47500</value>
              </list>
            </property>
          </bean>
        </property>
      </bean>
    </property>
  </bean>
```



4. Deploy Source and Sink Connectors

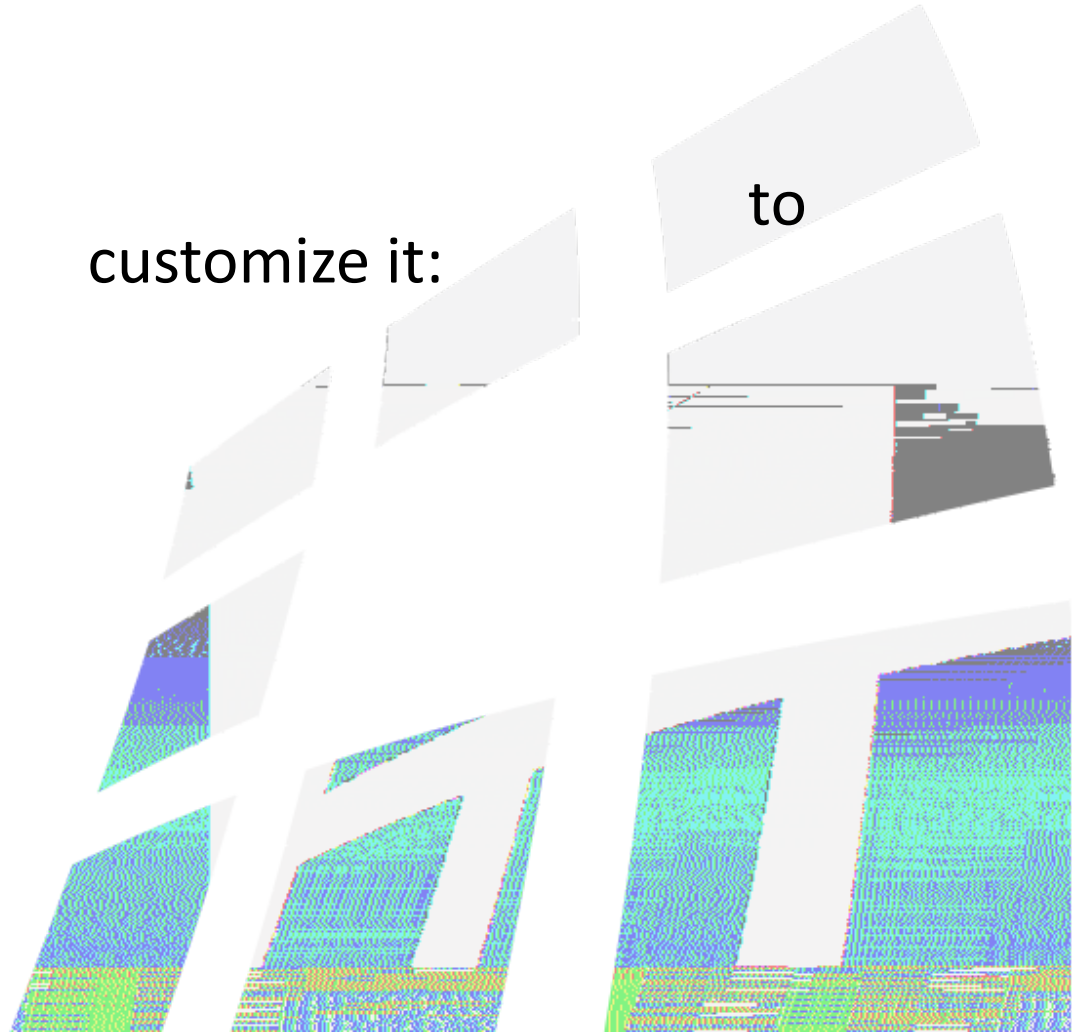
- Download Confluent JDBC Connector package from https://www.confluent.io/connector/kafka-connect-jdbc/
- Unzip Confluent JDBC Connector package into
- Copy GridGain Connector package from into
- Copy Kafka worker configuration file from into and set the plugin path property:

`plugin.path`



5. Start Kafka Cluster (Single-broker)

- Configure Zookeeper with :
- Start Zookeeper:
- Configure Kafka broker: copy default to customize it:
- Start Kafka broker:



6. Configure Source JDBC Connector

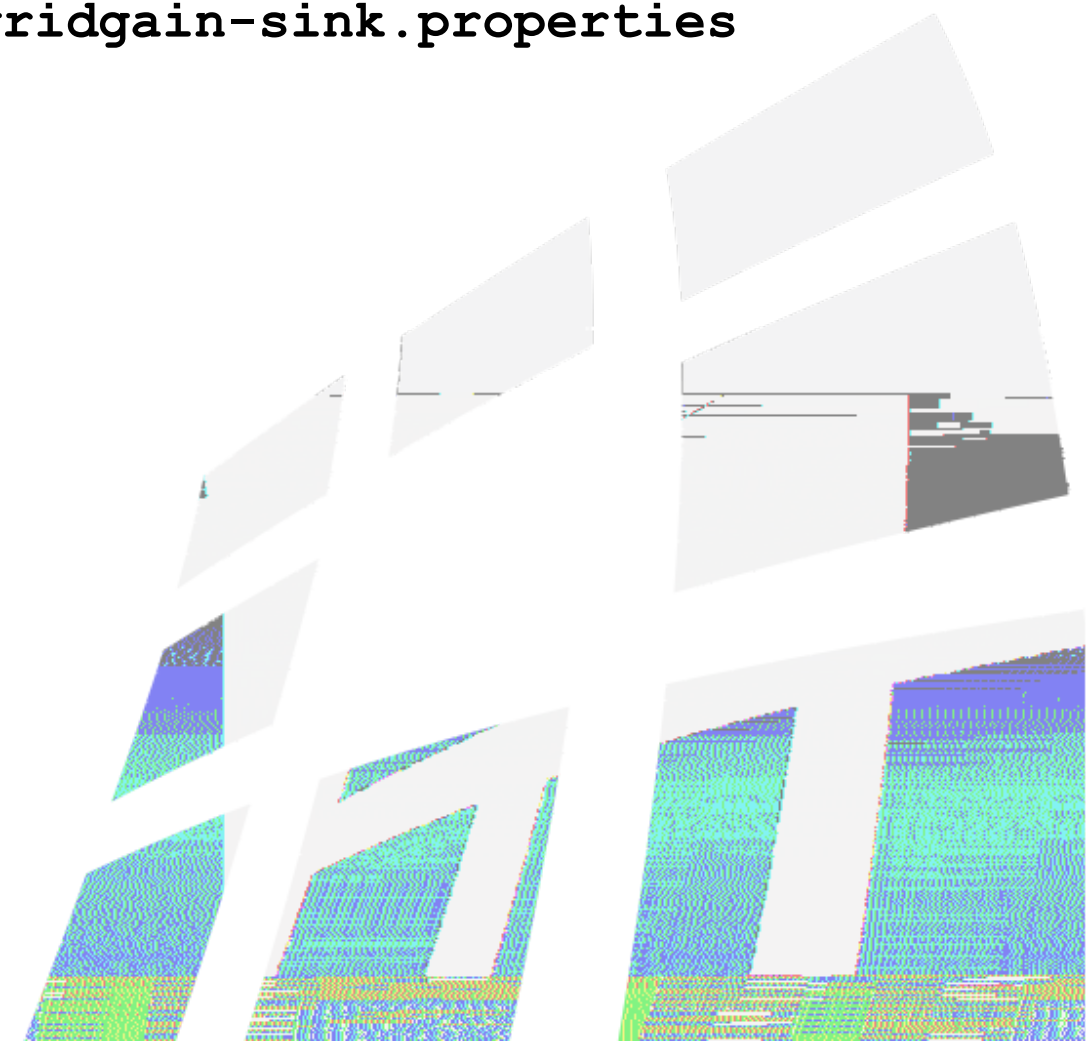
`kafka-connect-h2-source.properties`

```
name=h2-marketdata-source
connector.class=io.confluent.connect.jdbc.JdbcSourceConnector
tasks.max=10

connection.url=jdbc:h2:tcp://localhost:19092//tmp/gridgain-h2-connect/marketdata
table.whitelist=quotes,trades

mode=timestamp+incrementing
timestamp.column.name=date_time
incrementing.column.name=id

topic.prefix=h2-
```

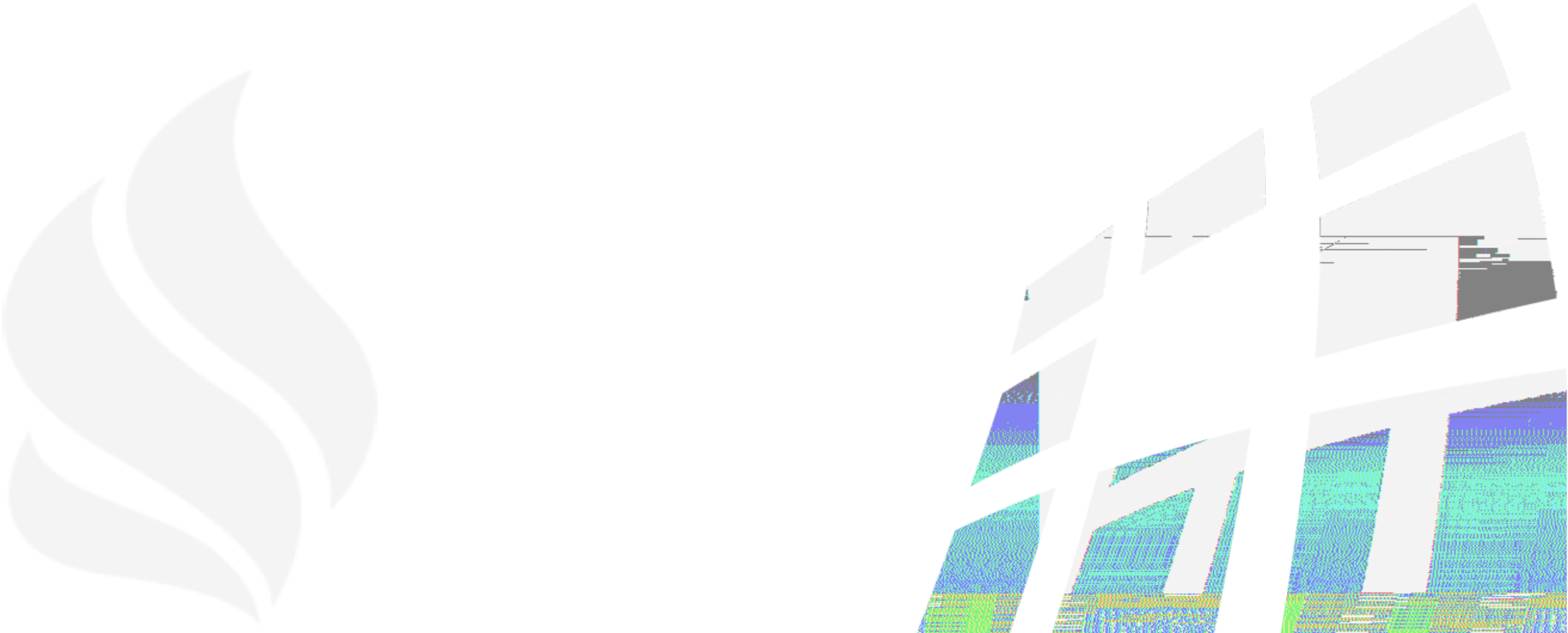
7. Configure Sink GridGain Connector

kafka-connect-gridgain-sink.properties

```
name=gridgain-marketdata-sink
topics=h2-QUOTES,h2-TRADES
tasks.max=10
connector.class=org.gridgain.kafka.sink.IgniteSinkConnector

igniteCfg=/tmp/gridgain-h2-connect/ignite-client-sink.xml
topicPrefix=h2-
```



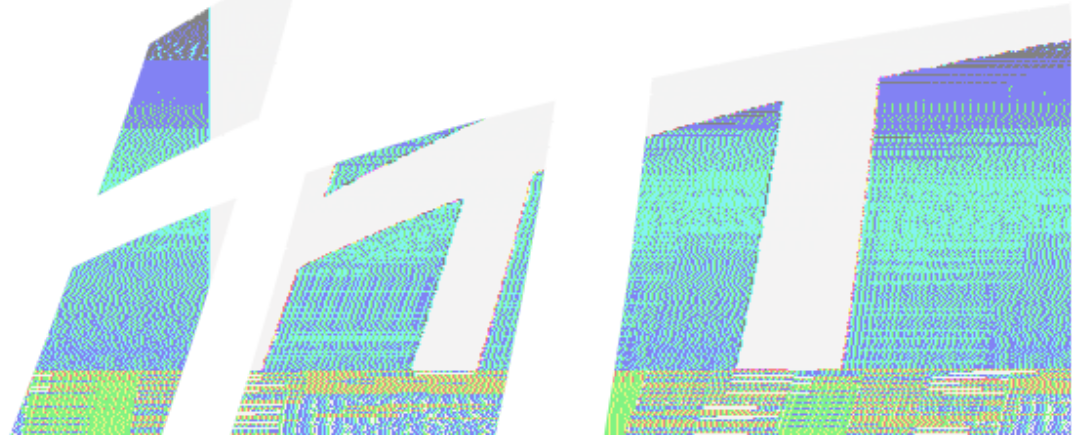
8. Start Kafka-Connect Cluster (Single-worker)



9. See Caches Created in GridGain

Open GridGain Web Console Monitoring Dashboard at https://console.gridgain.com/monitoring/dashboard and see GridGain Sink Connector created QUOTES and TRADES caches:

Backup	Name	ID	M	On-heap entries				Off-heap entries	
				Total	Primary	Backup	Near	Total	Primary
0	QUOTES	-1895070345	P	0	0	0	0	1	1
0	TRADES	-1812385905	P	0	0	0	0	1	1



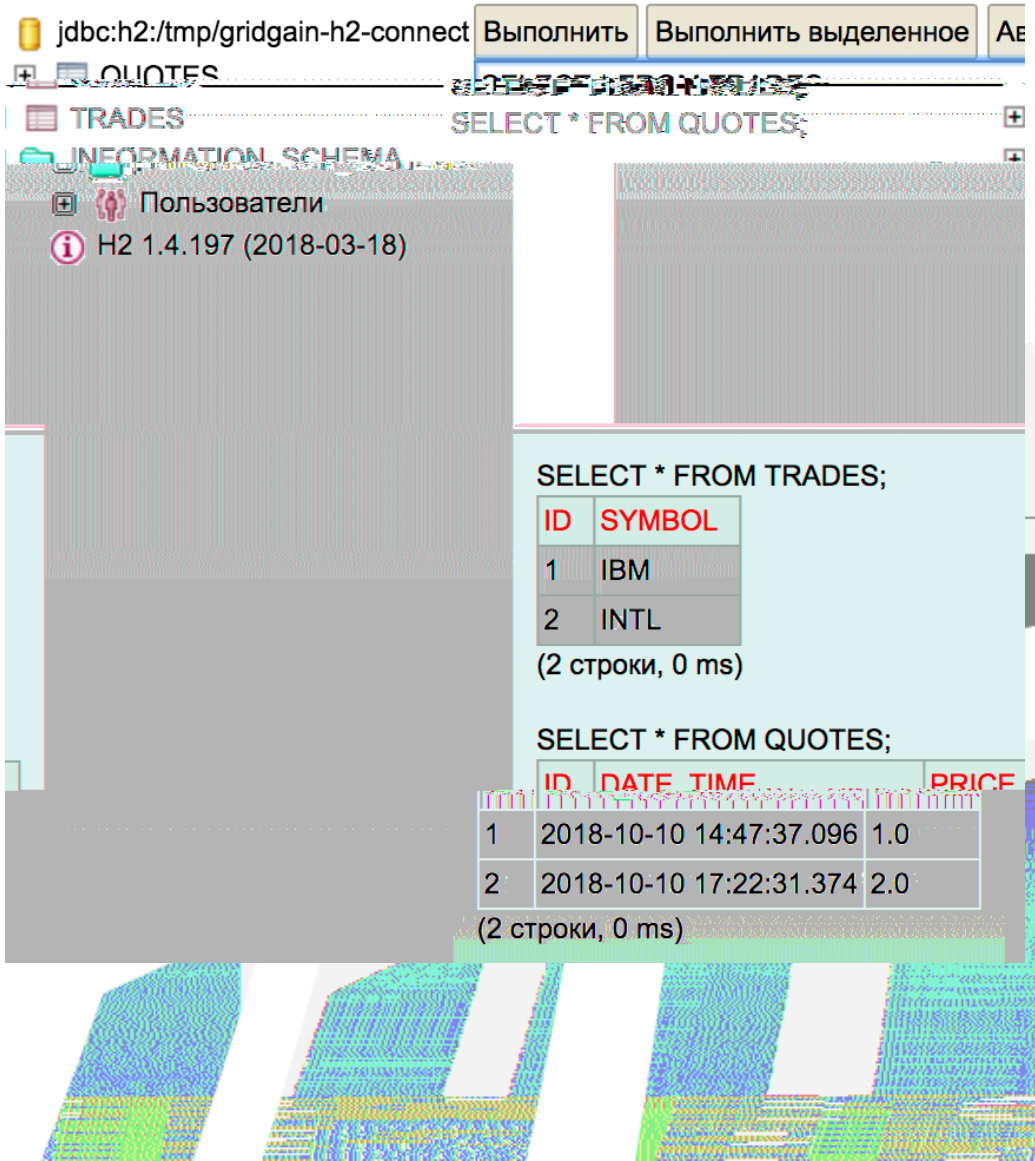
10. See Initial H2 Data in GridGain

Open GridGain Web Console Queries page and run Scan queries for QUOTES and TRADES:

11. Update H2 Tables

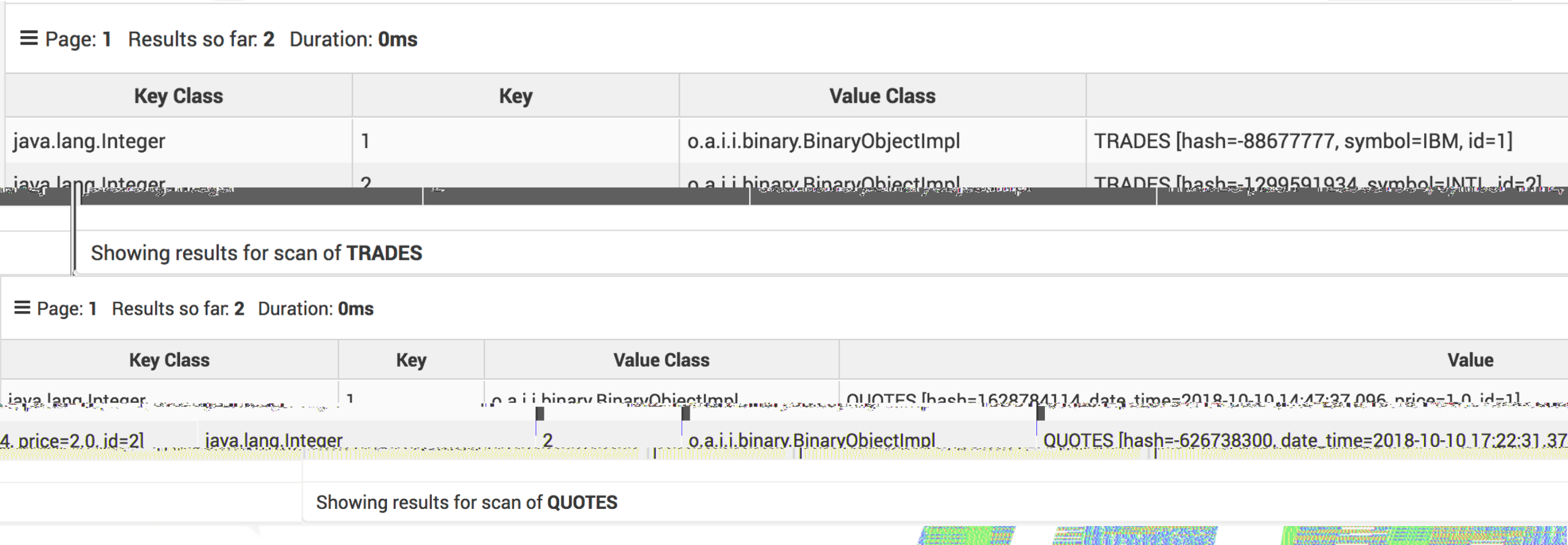
In H2 Web Console Execute:

-
-

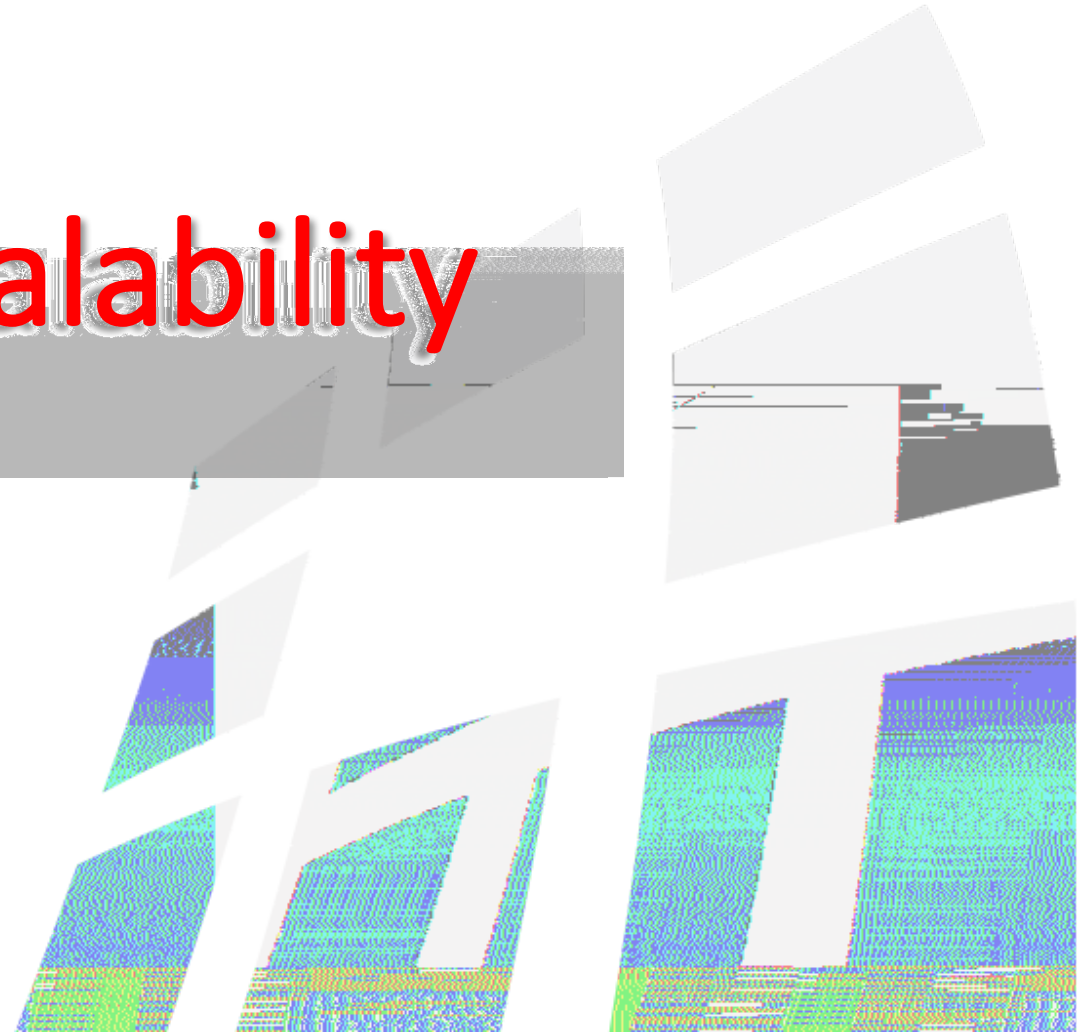


12. See Realtime H2 Data in GridGain

Open GridGain Web Console Queries page and run Scan queries for QUOTES and TRADES:



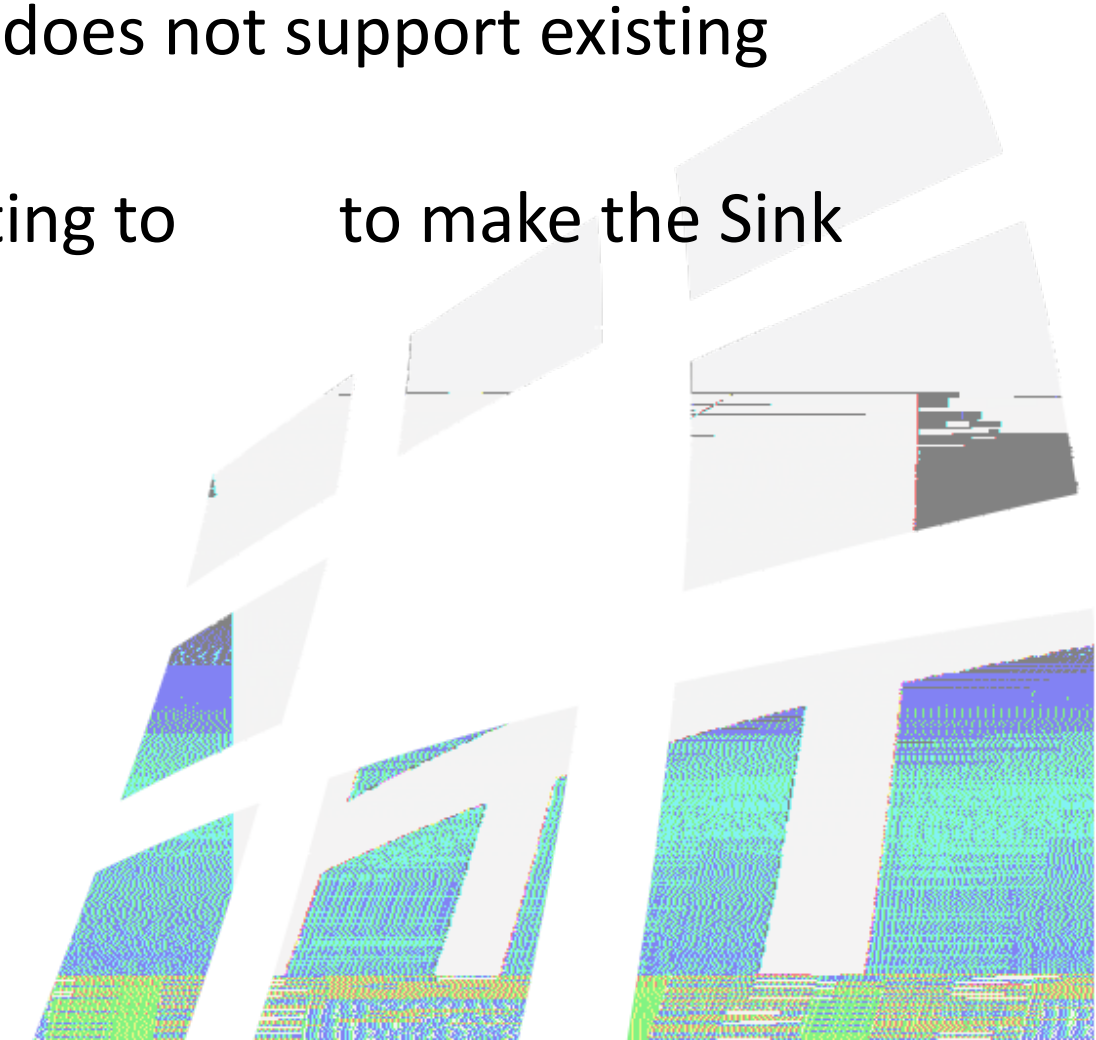
Performance and scalability tuning



Disable Processing of Updates

For performance reasons, Sink Connector does not support existing cache entry update by default.

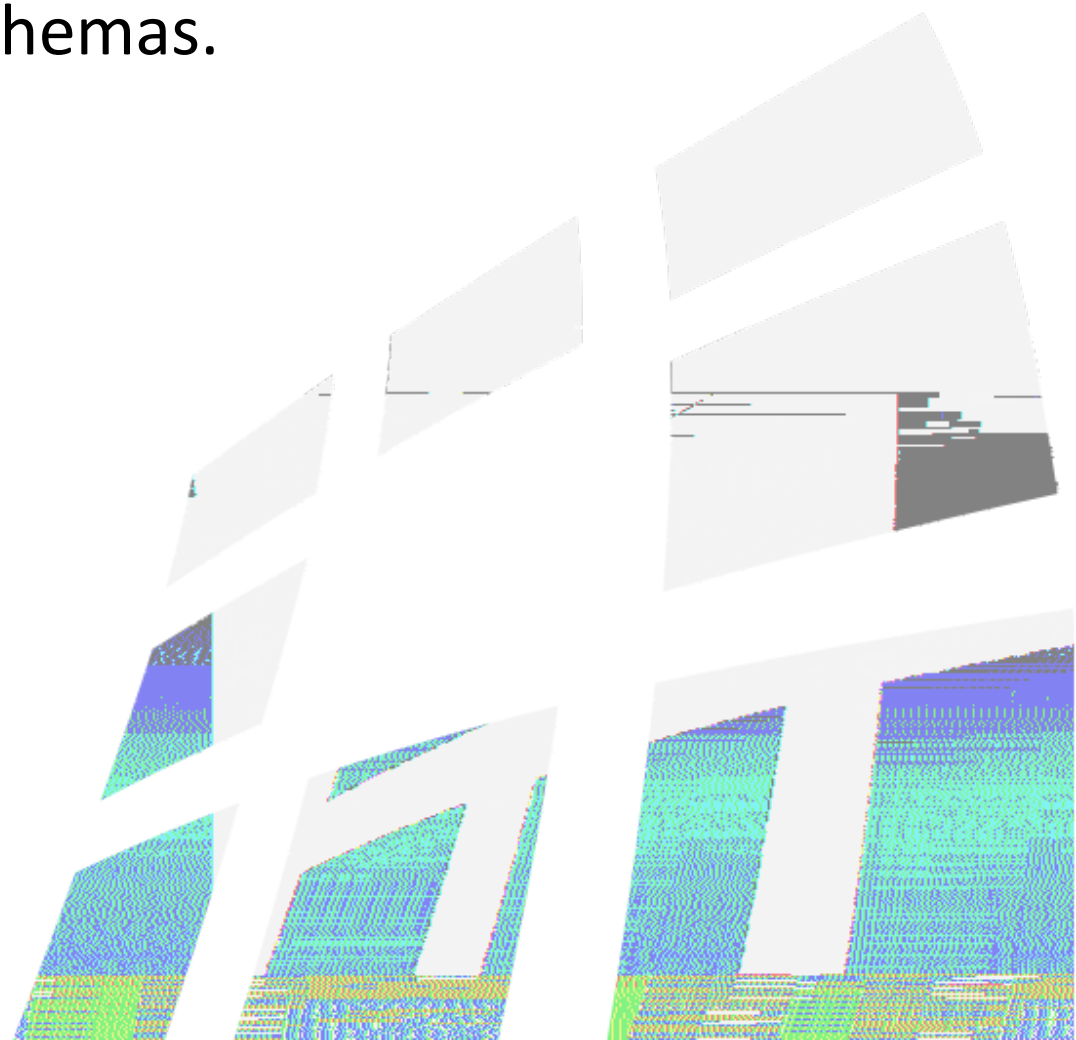
Set configuration setting to to make the Sink Connector update existing entries.



Disable Dynamic Schema

Source connector caches key and values schemas.

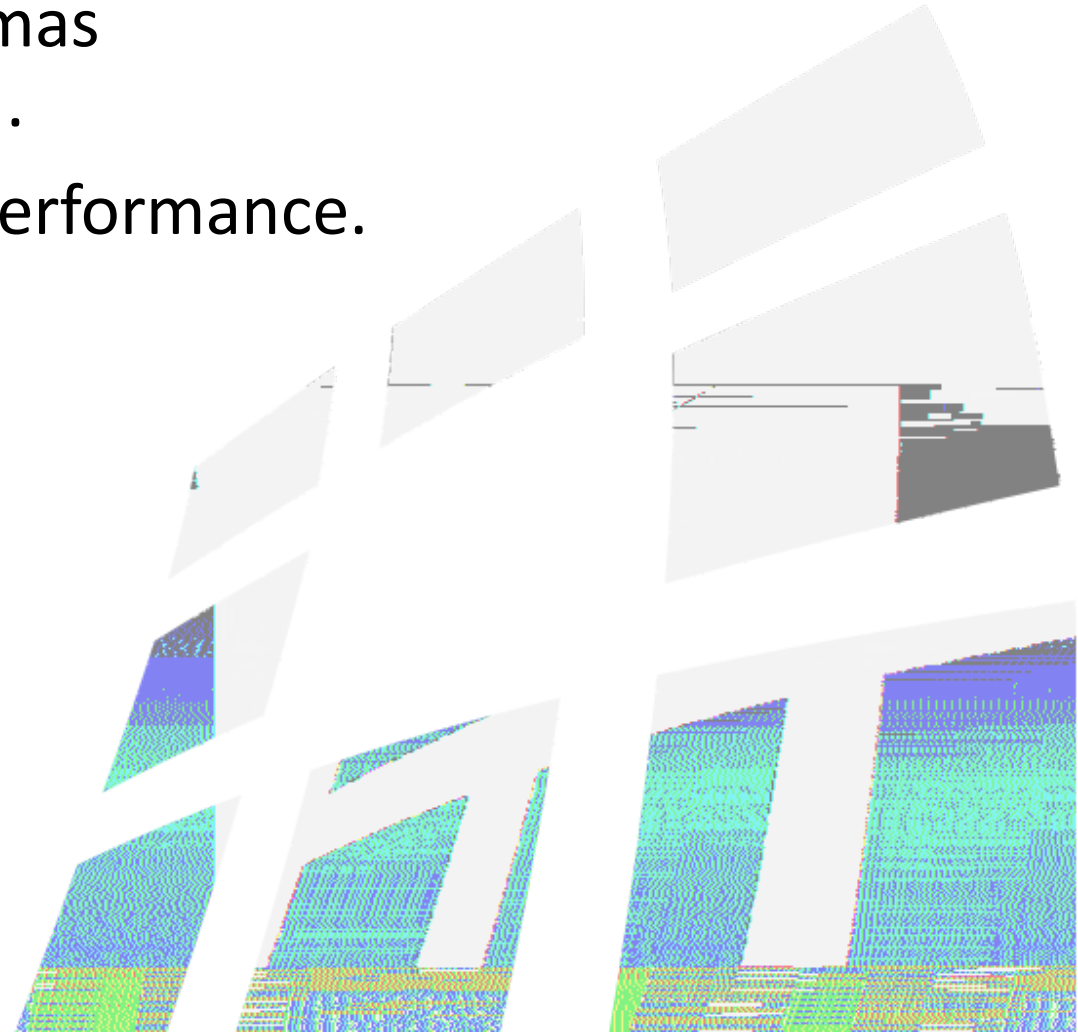
-



Consider Disabling Schema

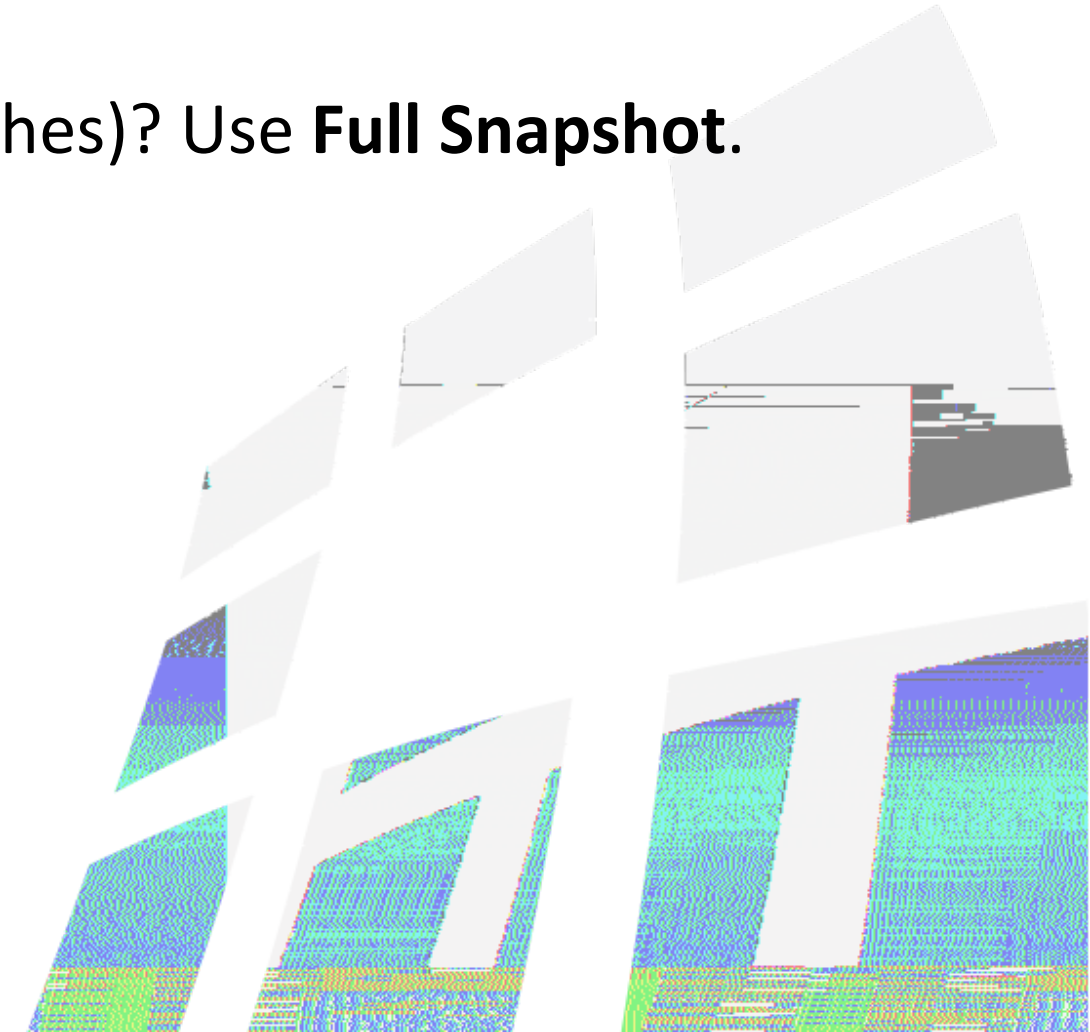
Source Connector does not generate schemas
if configuration setting is .

Disabling schemas significantly improves performance.



Carefully Choose Failover Policy

- Can allow losing data? Use **None**.
- Caches are small (e.g. reference data caches)? Use **Full Snapshot**.
- Otherwise use **Backlog**.



Plan Kafka Connect Backlog Capacity

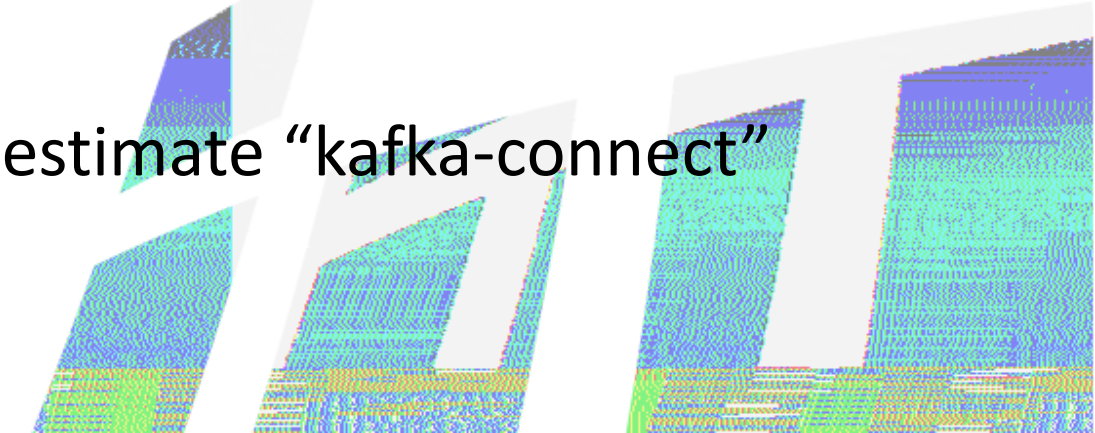
Only **Backlog** failover policy supports both “at least once” and “exactly once” delivery guarantee.

GridGain Source Connector creates Backlog in the “kafka-connect” memory region, which requires capacity planning to avoid losing data by eviction (unless persistence is enabled).

Consider the worst case scenario:

- Maximum Kafka Connector worker downtime allowed in your system
- Peak traffic

Multiple peak traffic by max downtime to estimate “kafka-connect” data region size.



Q & A

Thank you!