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Berlin, September 3-5, 2018

# Efficient Window Aggregation with Stream Slicing


**Jonas Traub**
Research Associate (TU Berlin)



**Philipp M. Grulich**
Research Assistant (DFKI)

German Research Center for Artificial Intelligence

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# Stream Slicing Example

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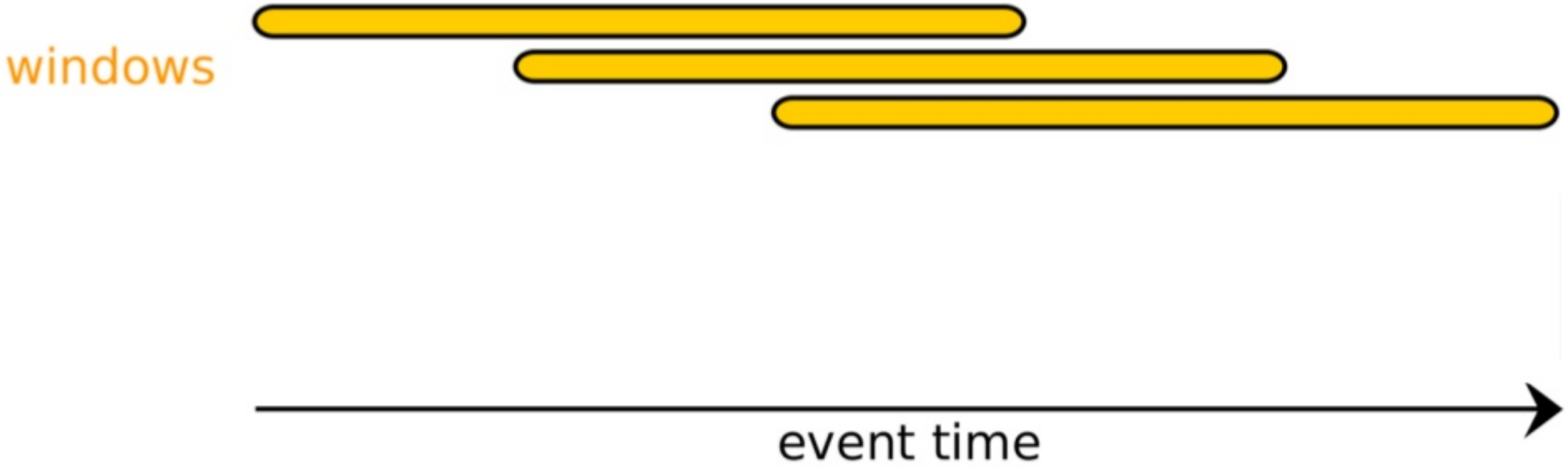

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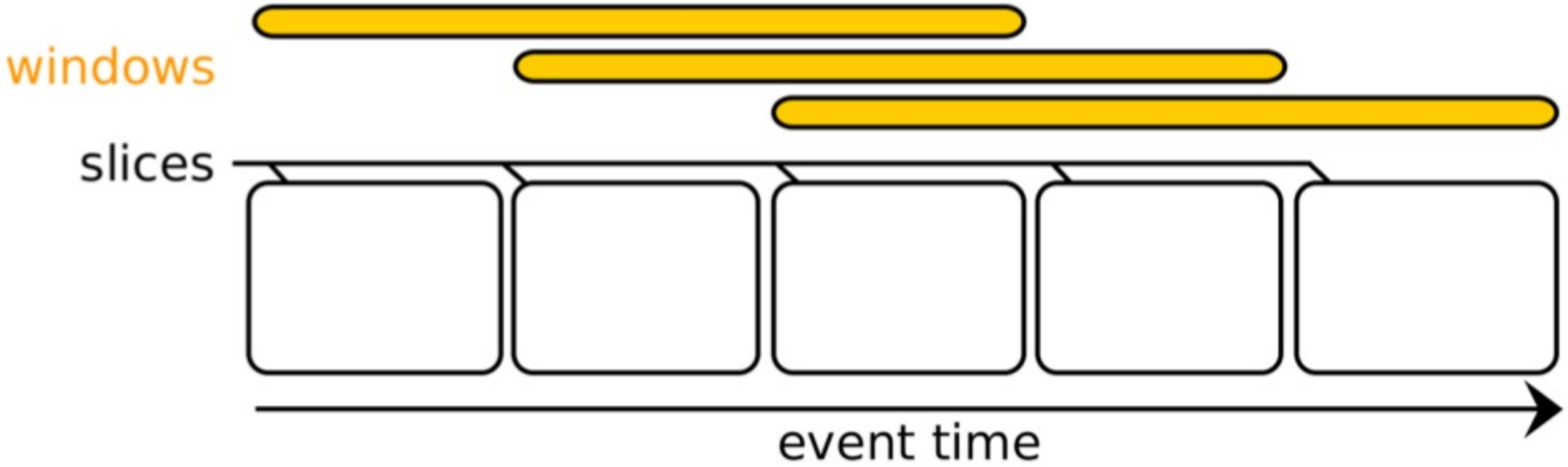

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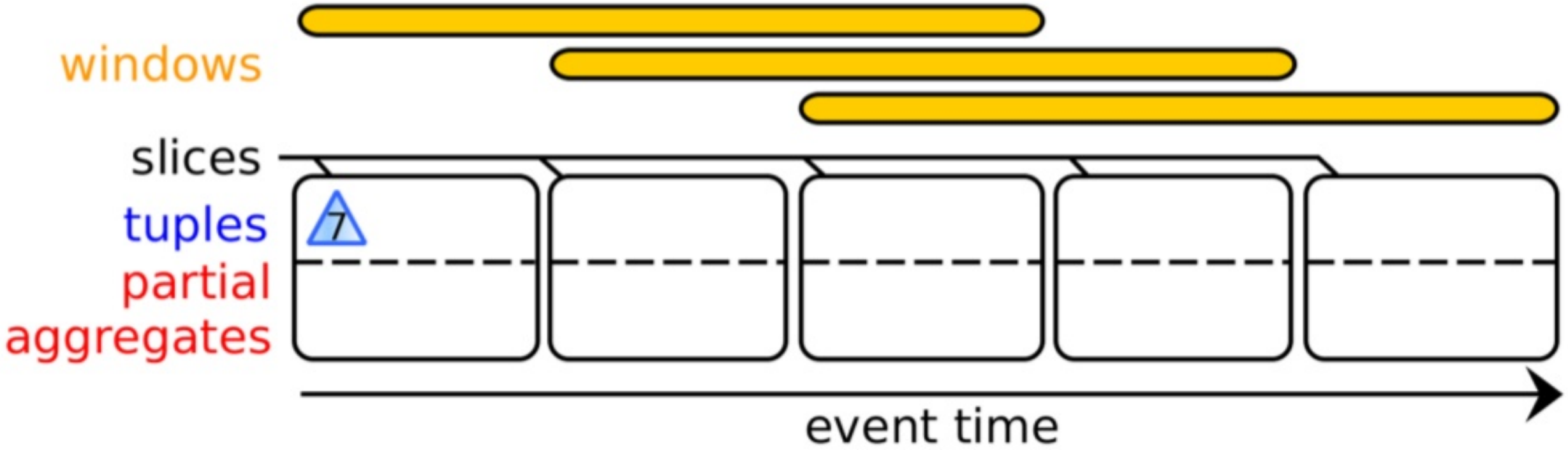

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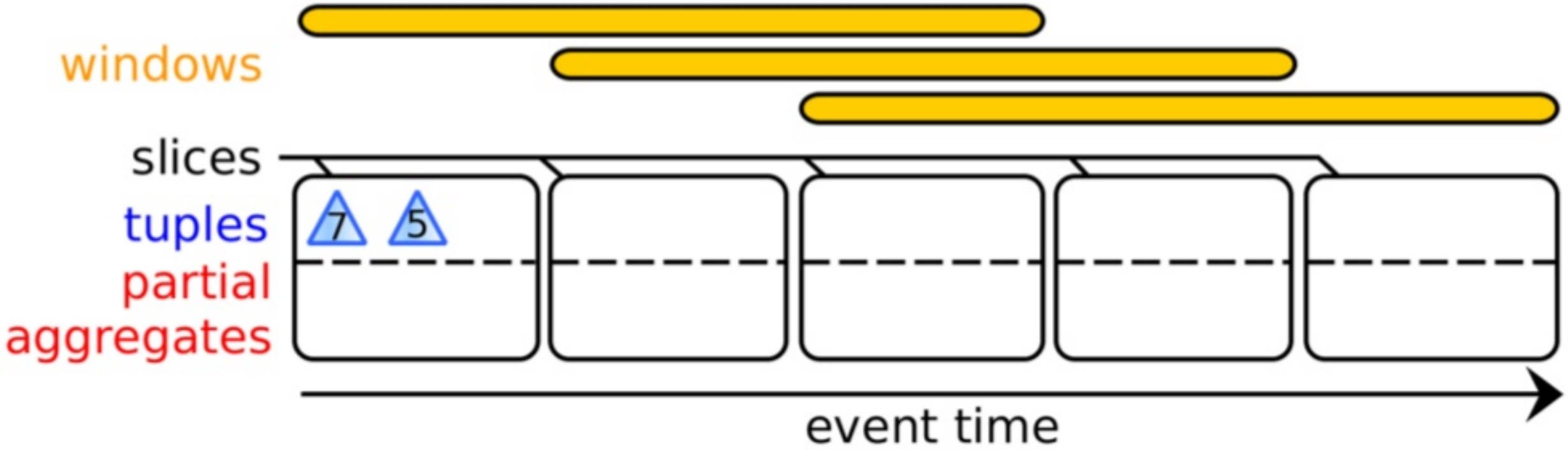

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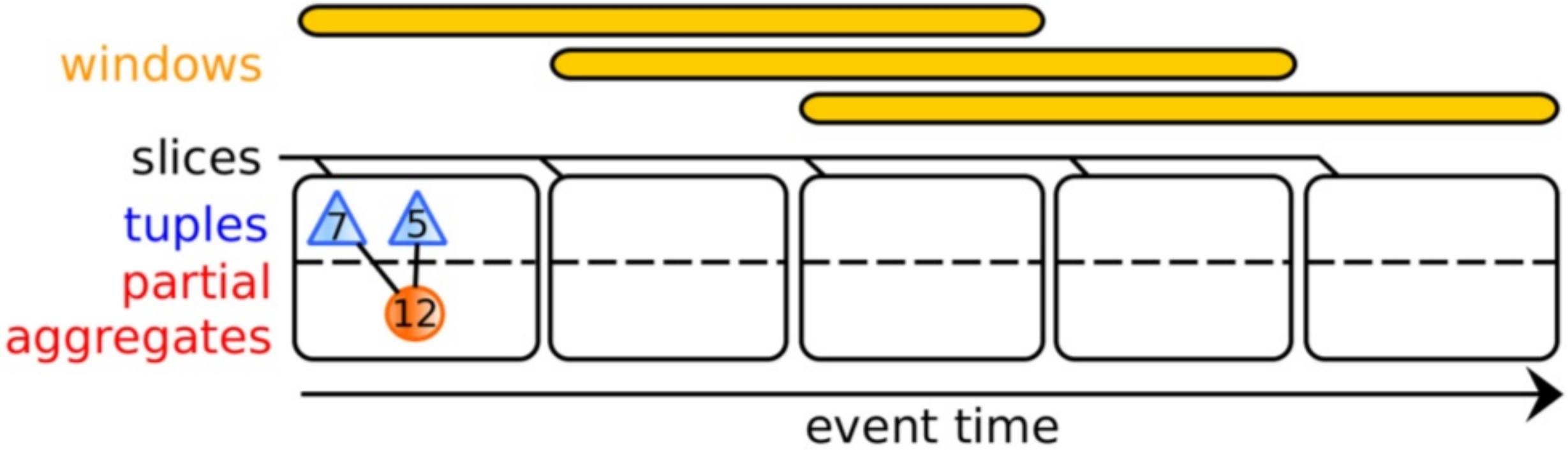

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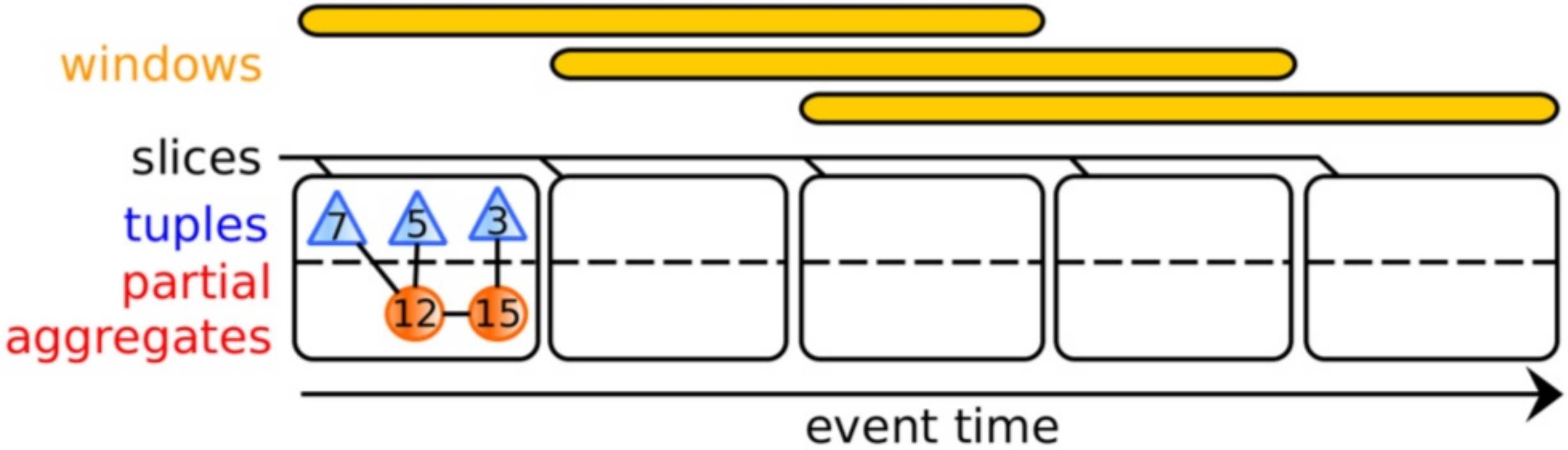

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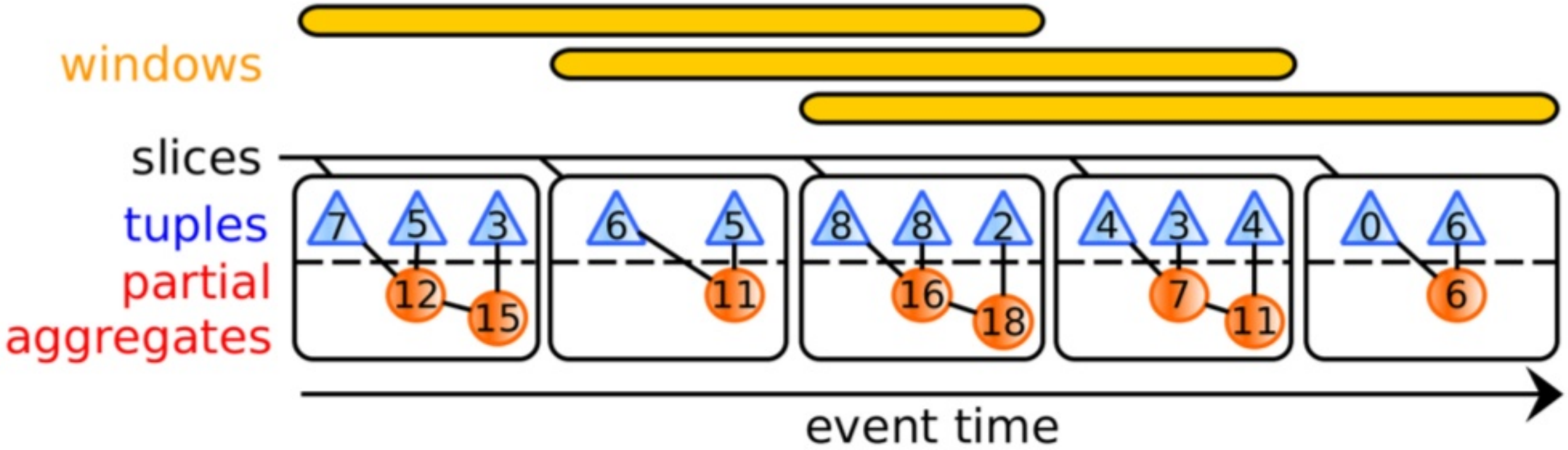

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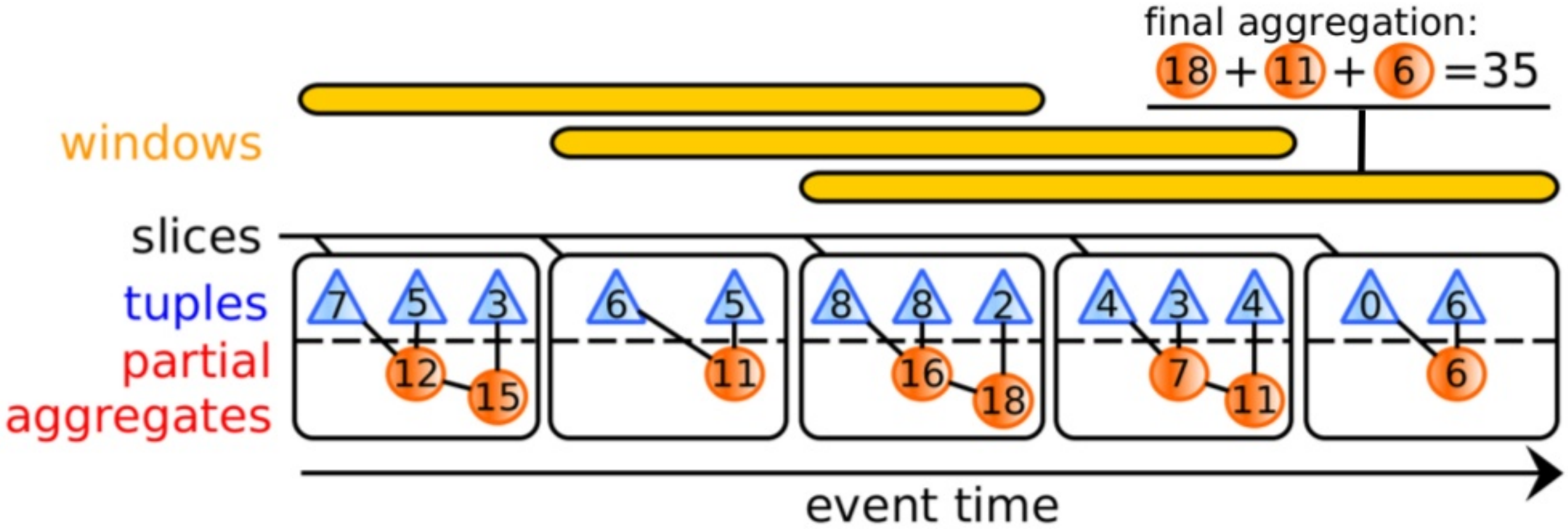

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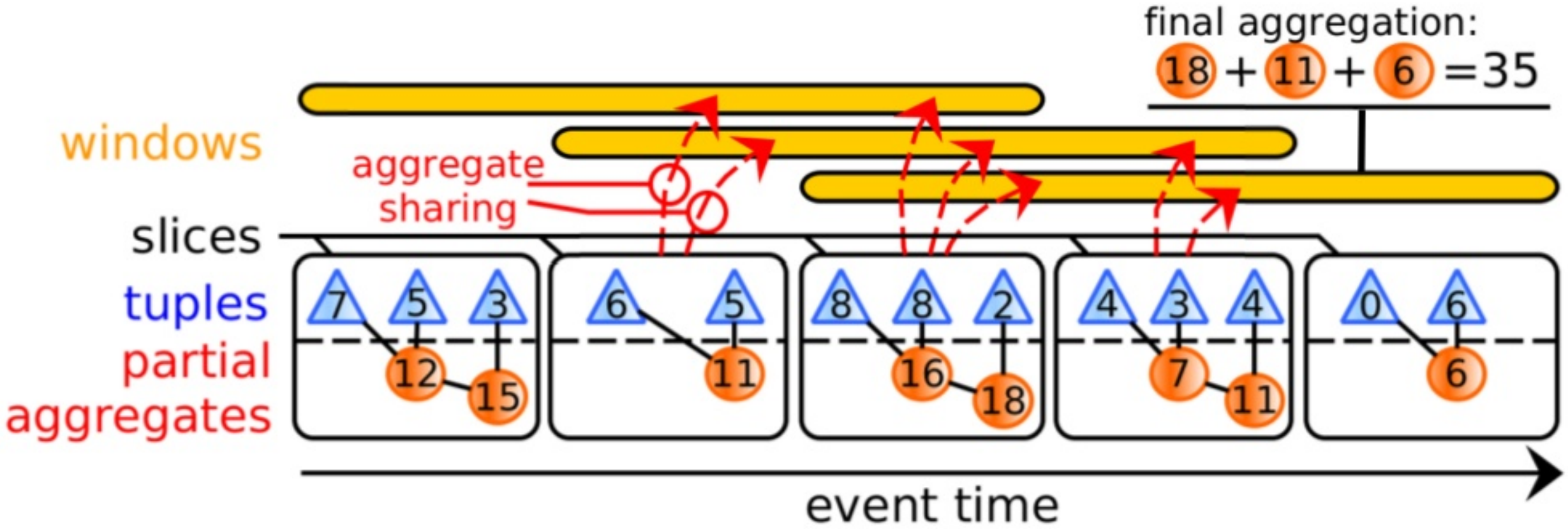

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# Stream Slicing Research

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CIKM 2016

## Cutty: Aggregate Sharing for User-Defined Windows

Paris Carbone† Jonas Traub‡ Asterios Katsifodimos‡
Seif Haridi† Volker Markl‡

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CIKM 2016

**Cutty: Aggregate Sharing for User-Defined Windows**

Paris Carbone[†] Jonas Traub[‡] Asterios Katsifodimos[‡]
Seif Haridi[†] Volker Markl[‡]

ICDE 2018

**Scotty: Efficient Window Aggregation for out-of-order Stream Processing**

Jonas Traub[1], Philipp M. Grulich[2], Alejandro Rodríguez Cuéllar[1], Sebastian Breß[1,2]
Asterios Katsifodimos[3], Tilmann Rabl[1,2], Volker Markl[1,2]

# Flink Windowing Bottlenecks

Example Query:

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.window(SlidingEventTimeWindows.of(Time.minutes(1), Time.seconds(10)))
.sum()
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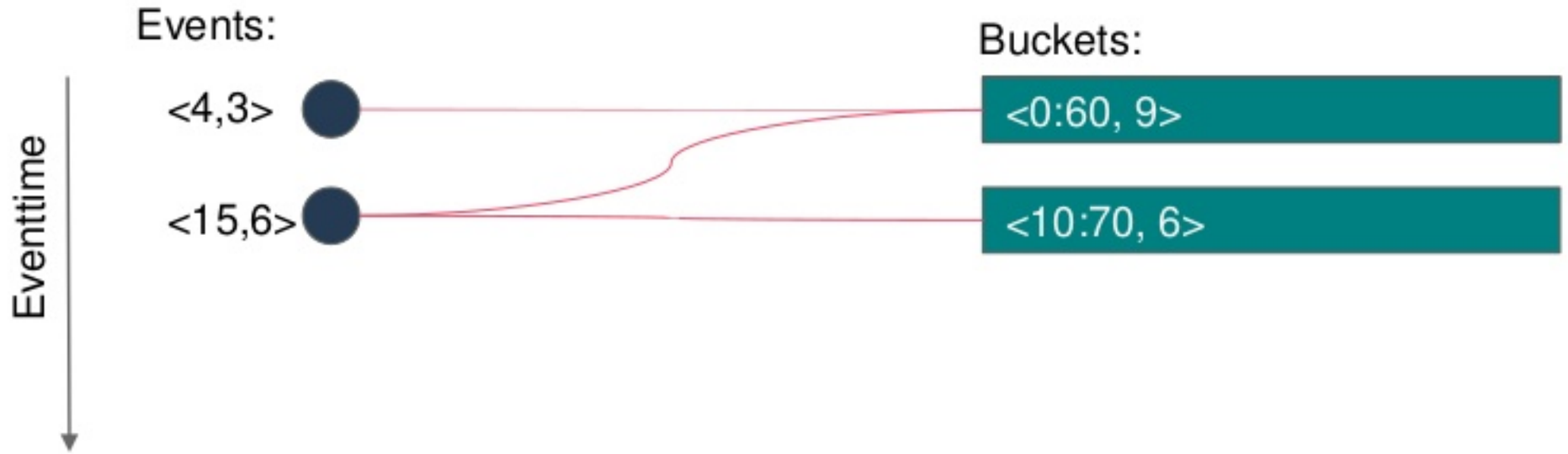

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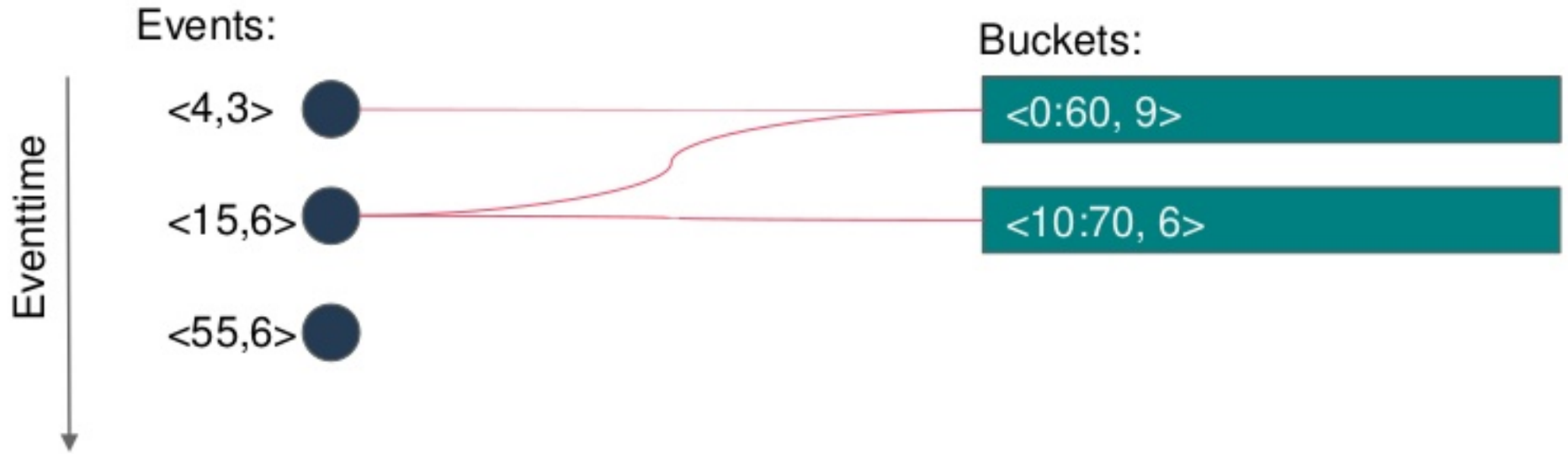

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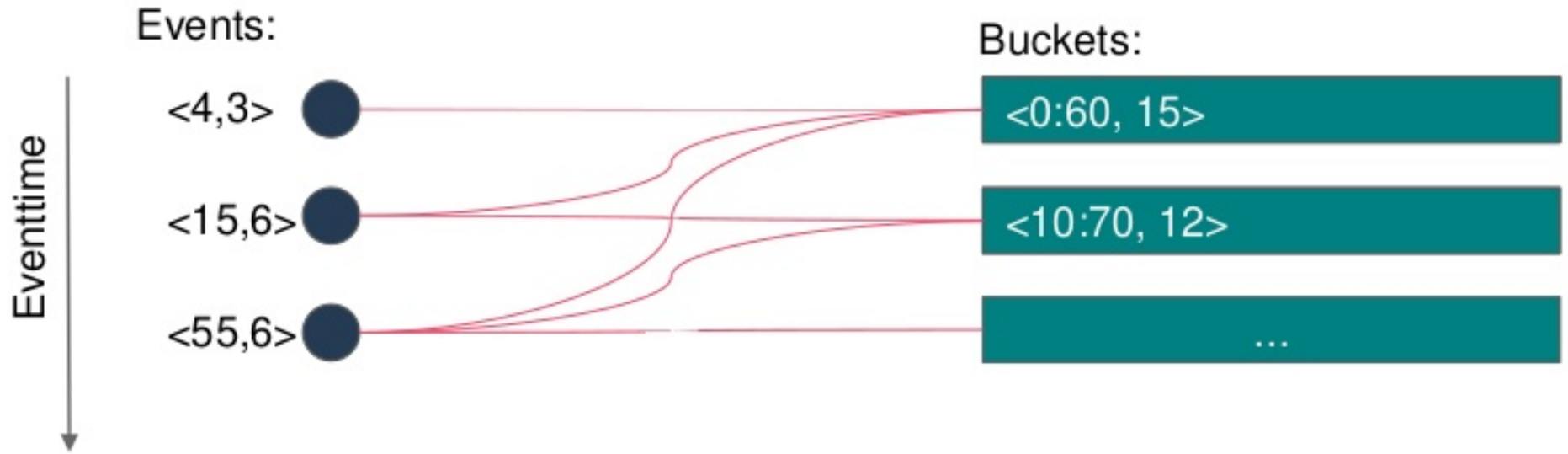

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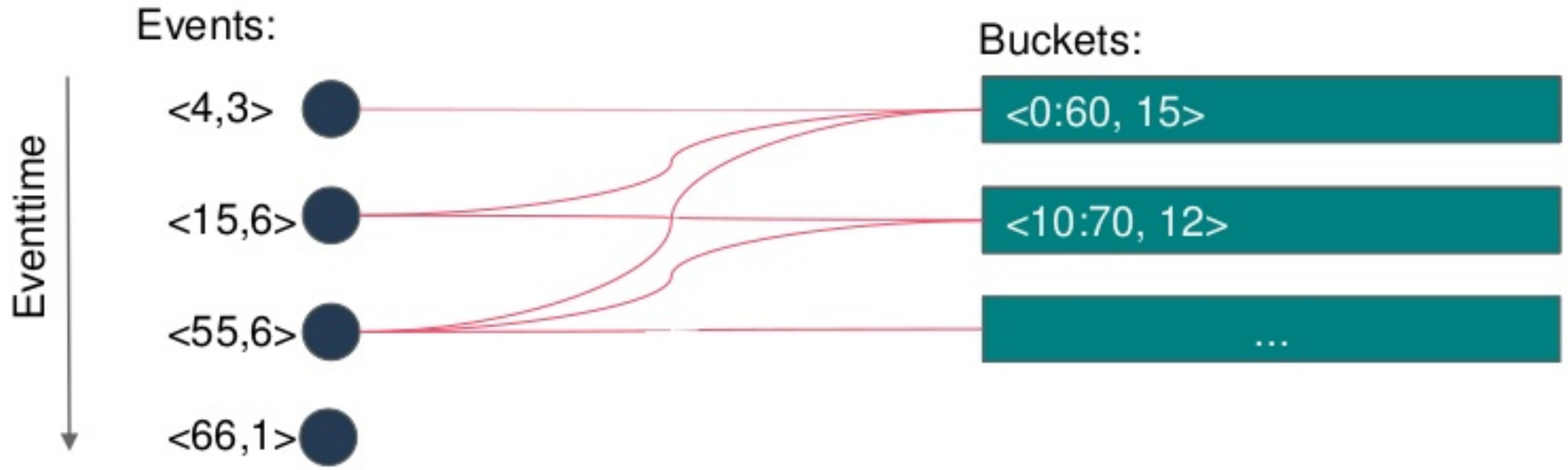

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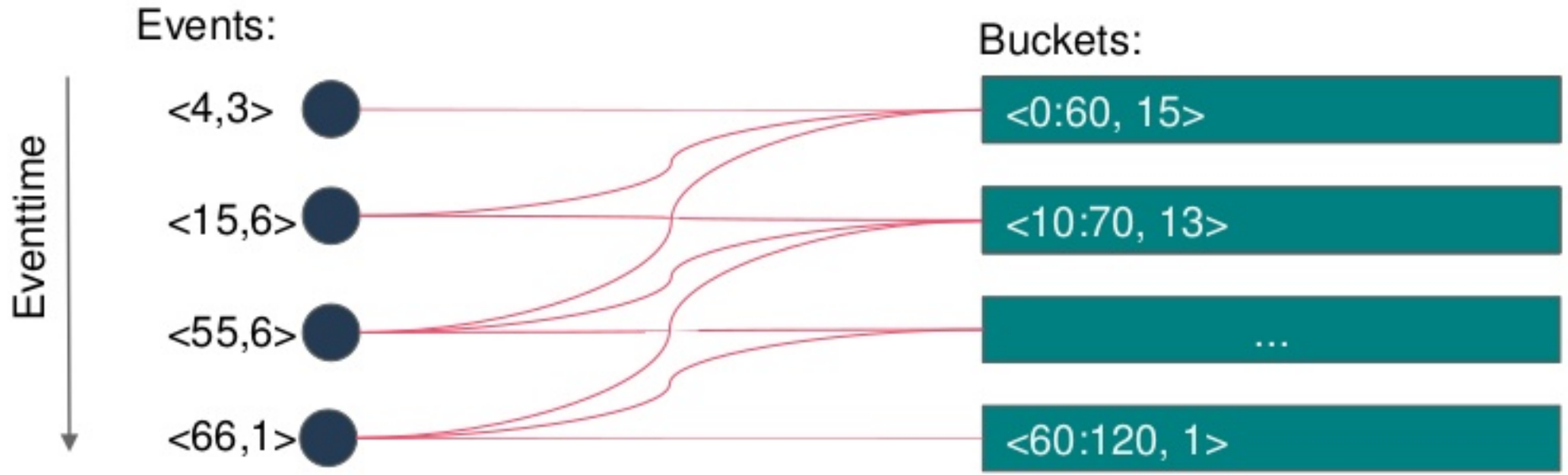

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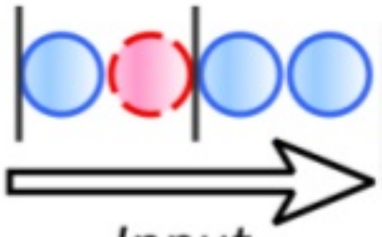
Overlapping windows cause:

- Every event is assigned to many windows.
- Repeated aggregations --> aggregation function is called on every window
- High memory consumption --> especially for windows without incremental aggregation
- Check for merging windows

# Architecture Overview




in-order tuple  out-of-order tuple  Watermark  Slice Separator

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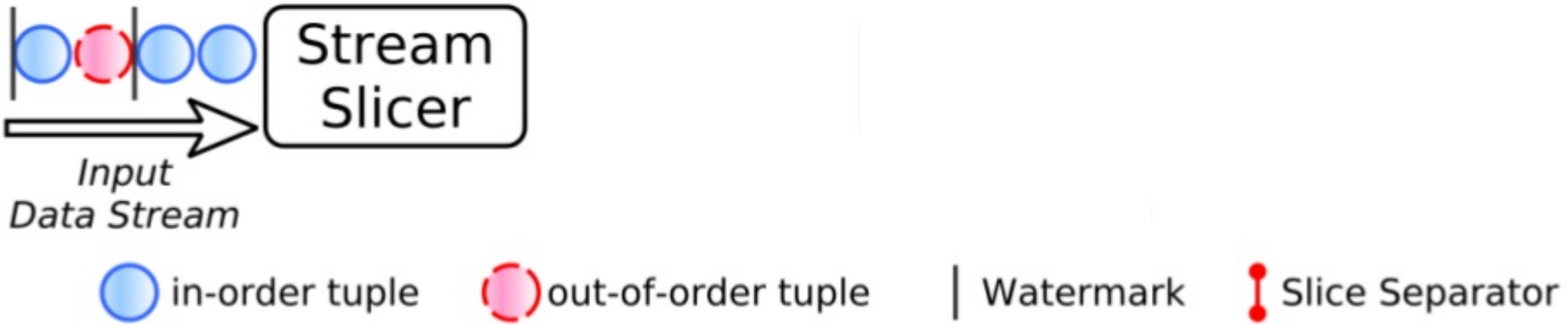

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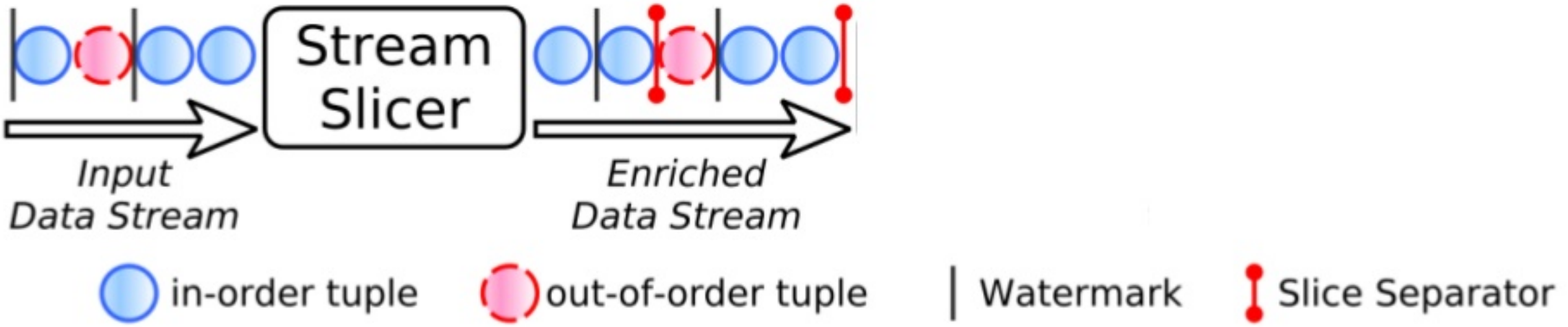

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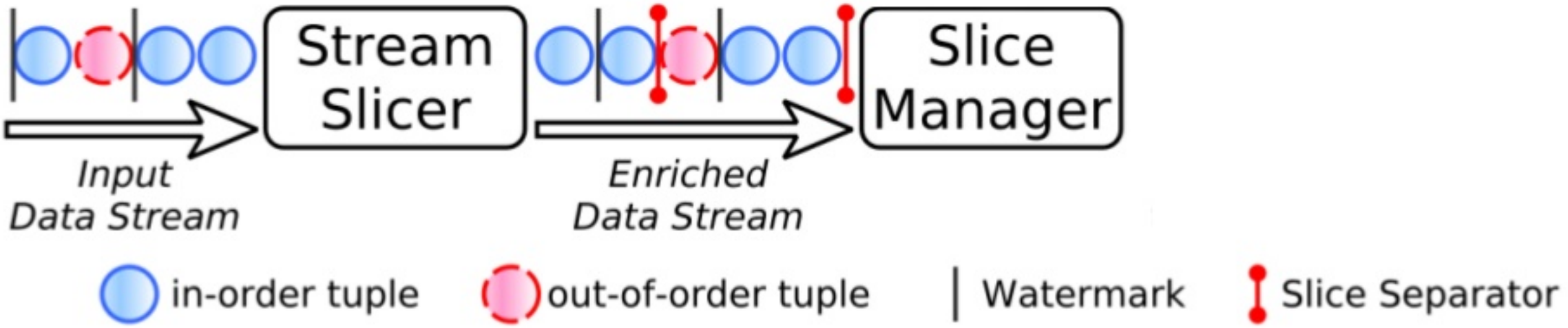

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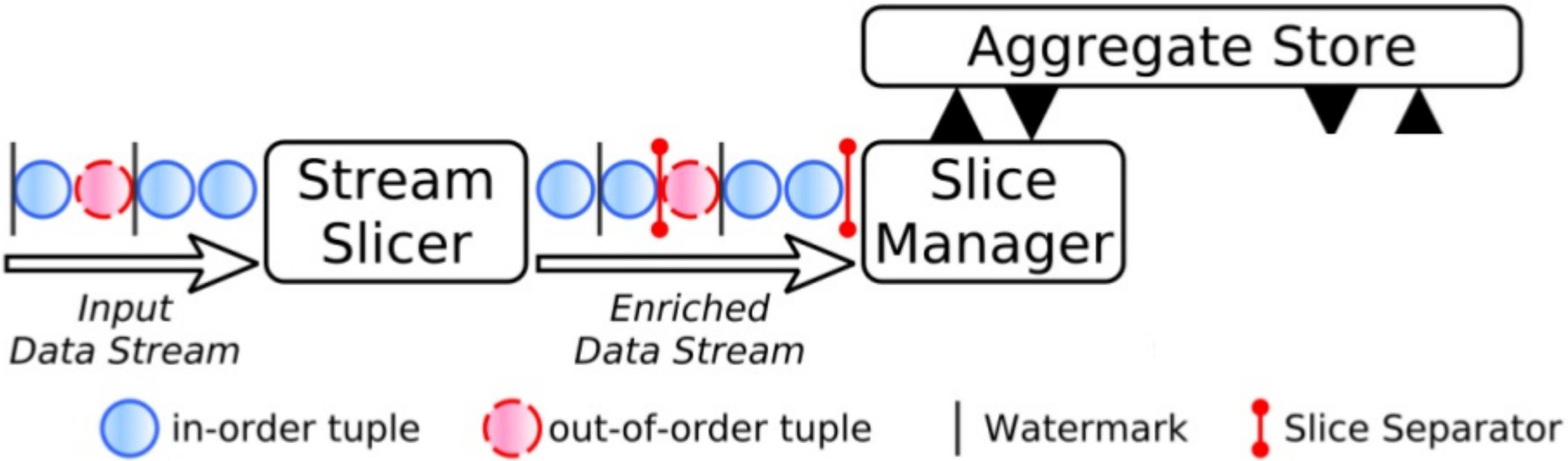

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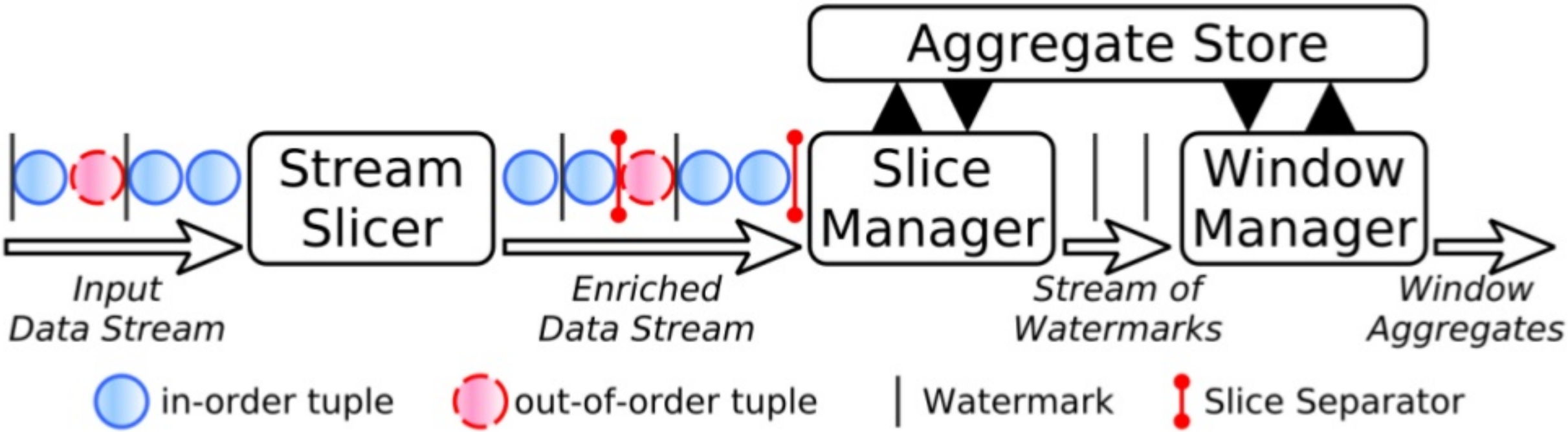
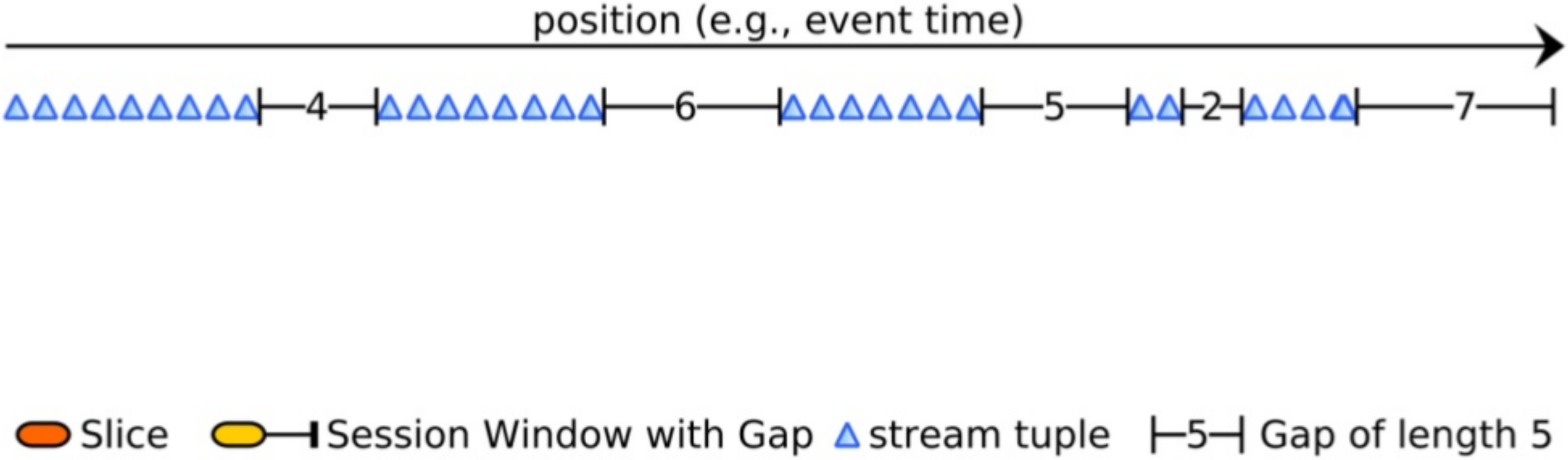


# Session Window Aggregate Sharing



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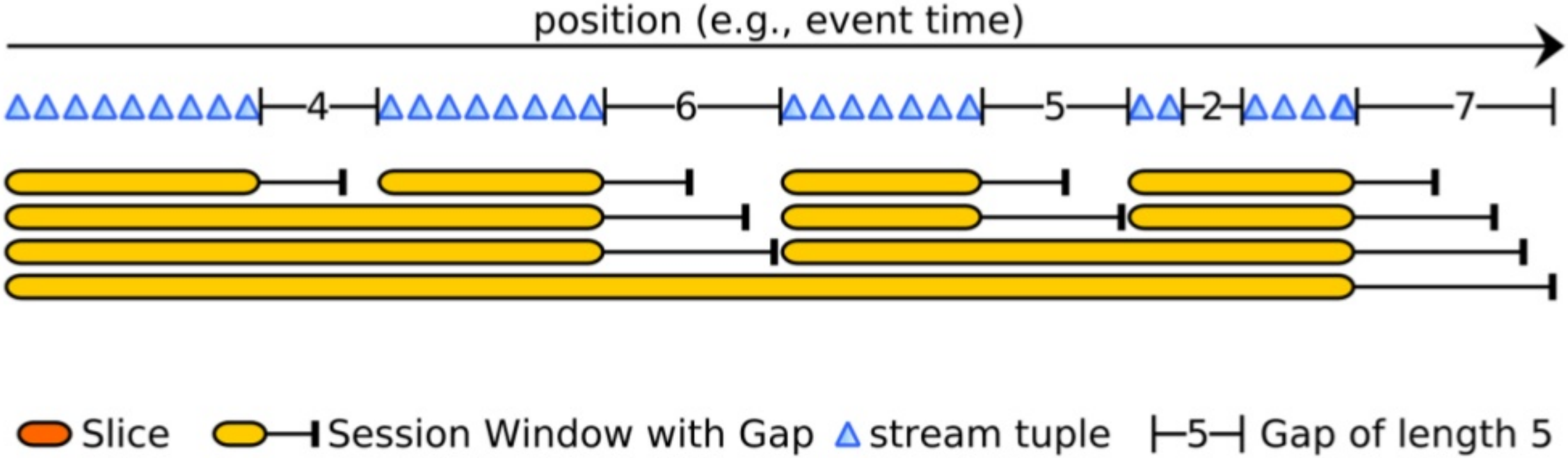

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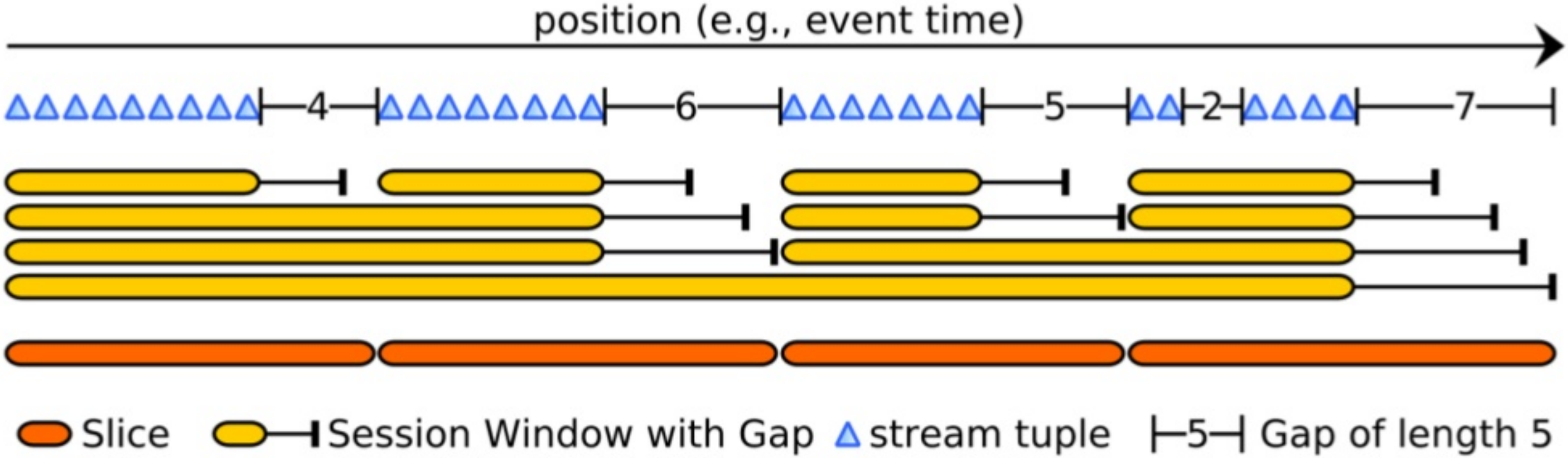


# Out-of-Order Processing and Sessions


1) Insert:

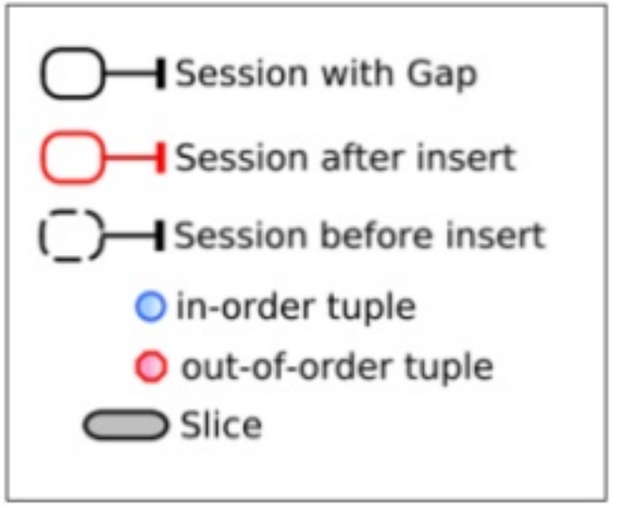
1.1) Simple Insert:

1.2) Right Insert:

1.3) Left Insert:

2) Fuse Sessions:

3) New Session:



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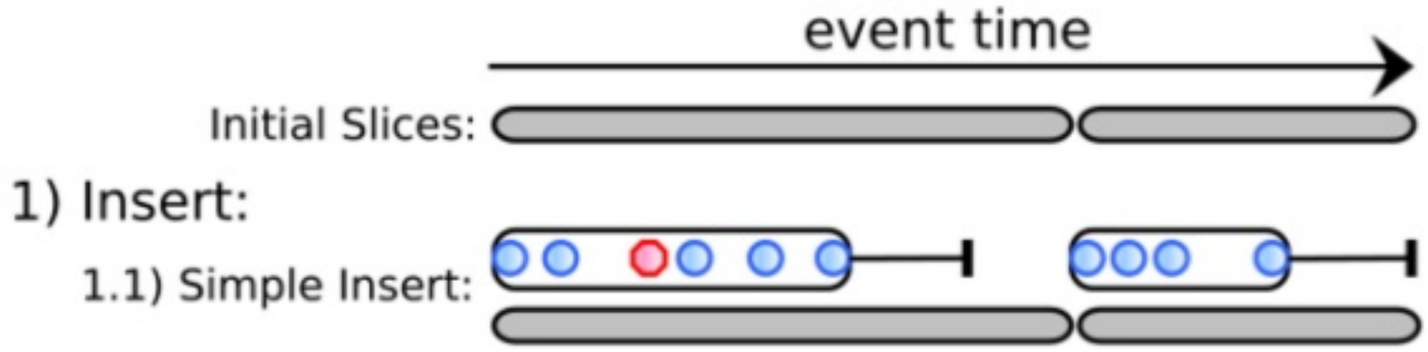


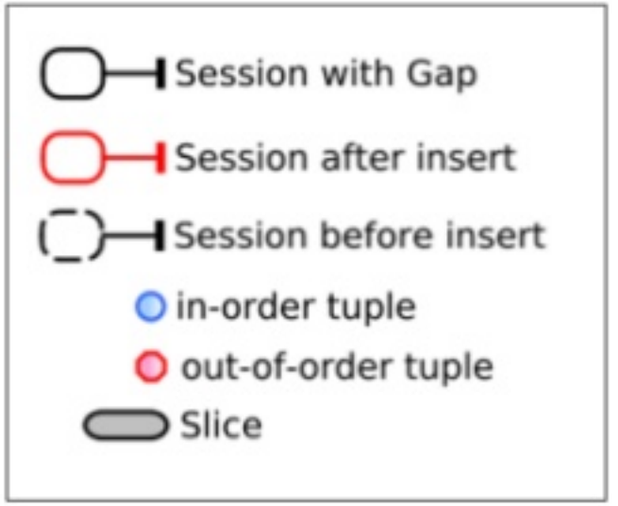

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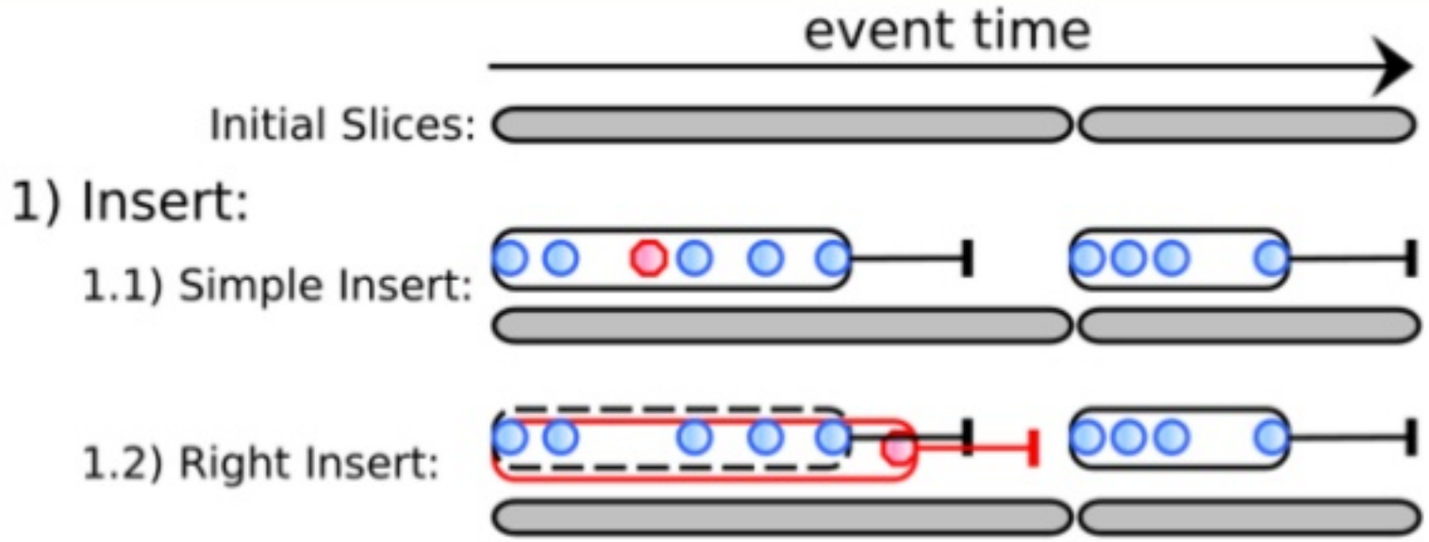


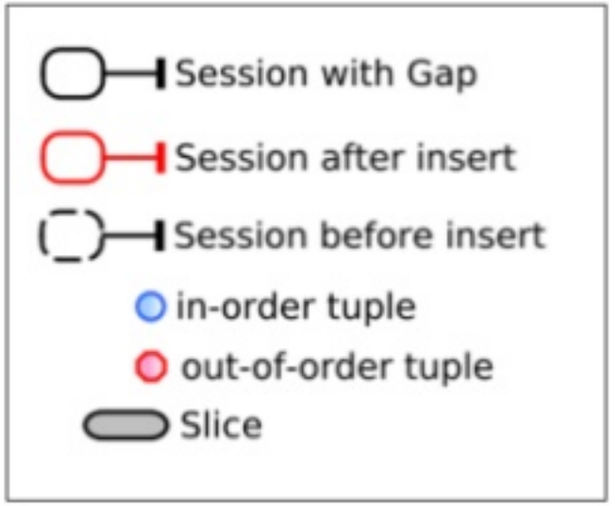

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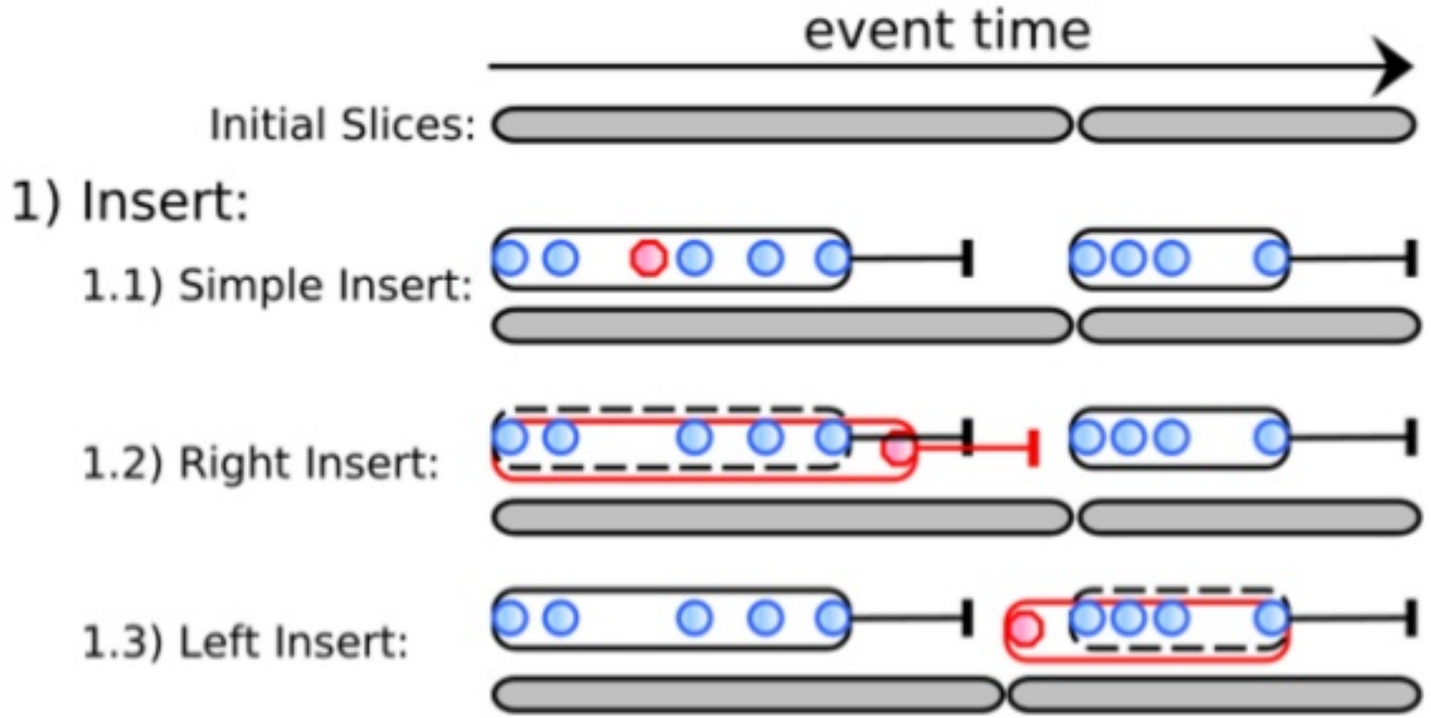


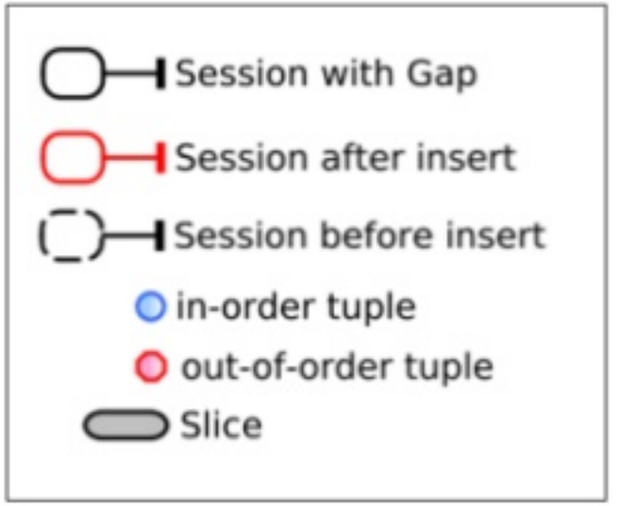

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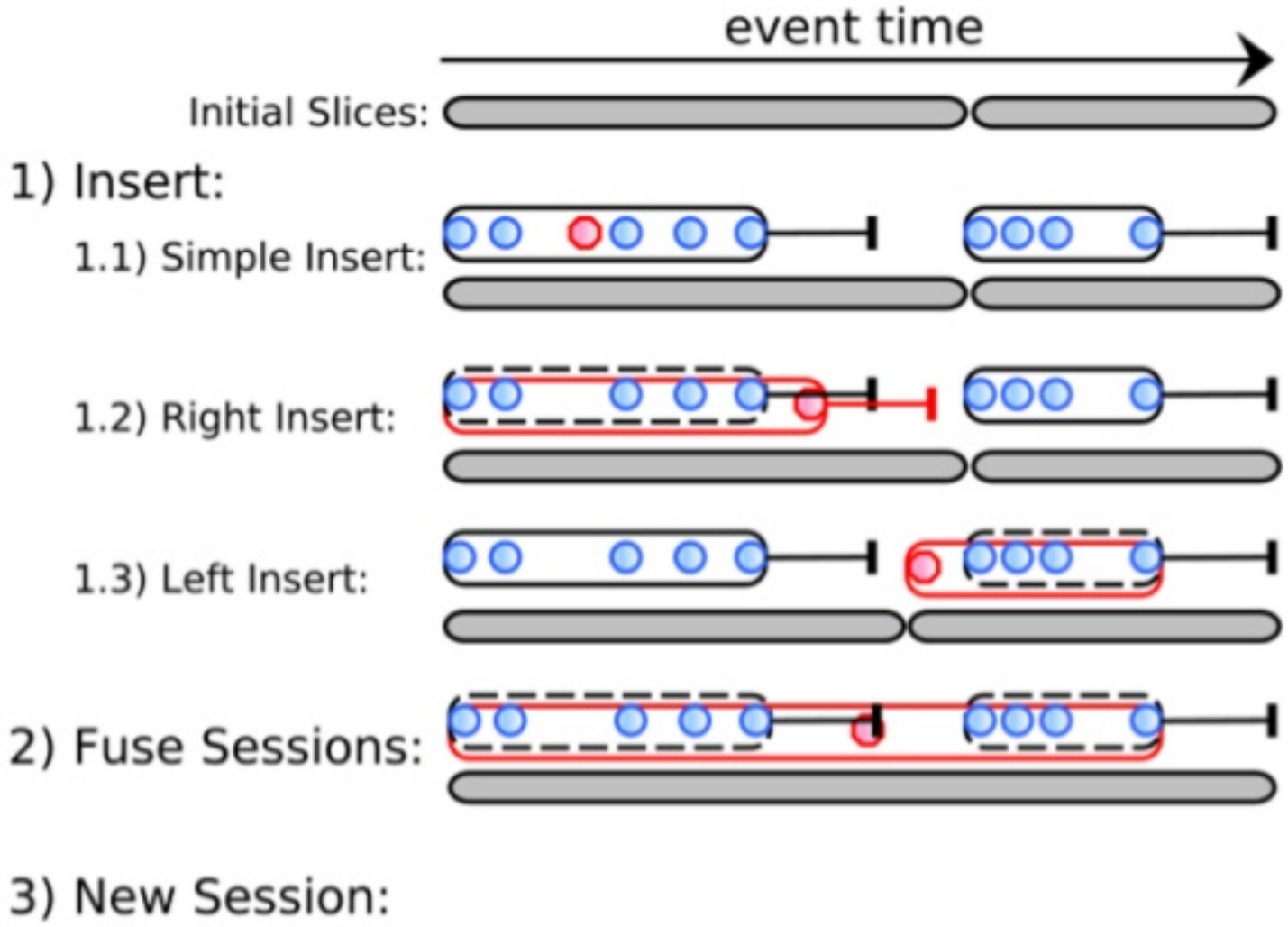


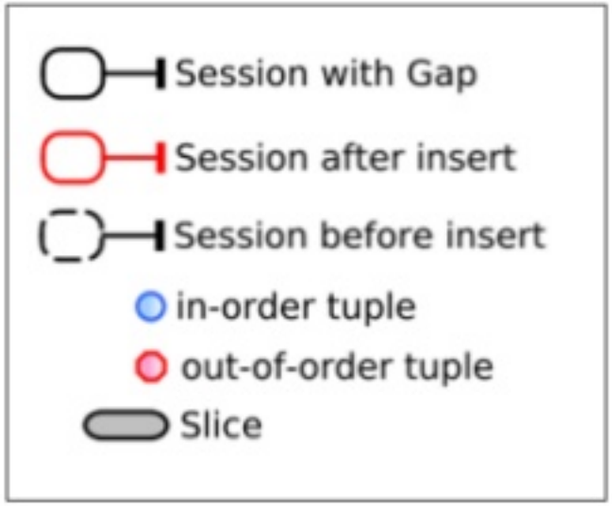

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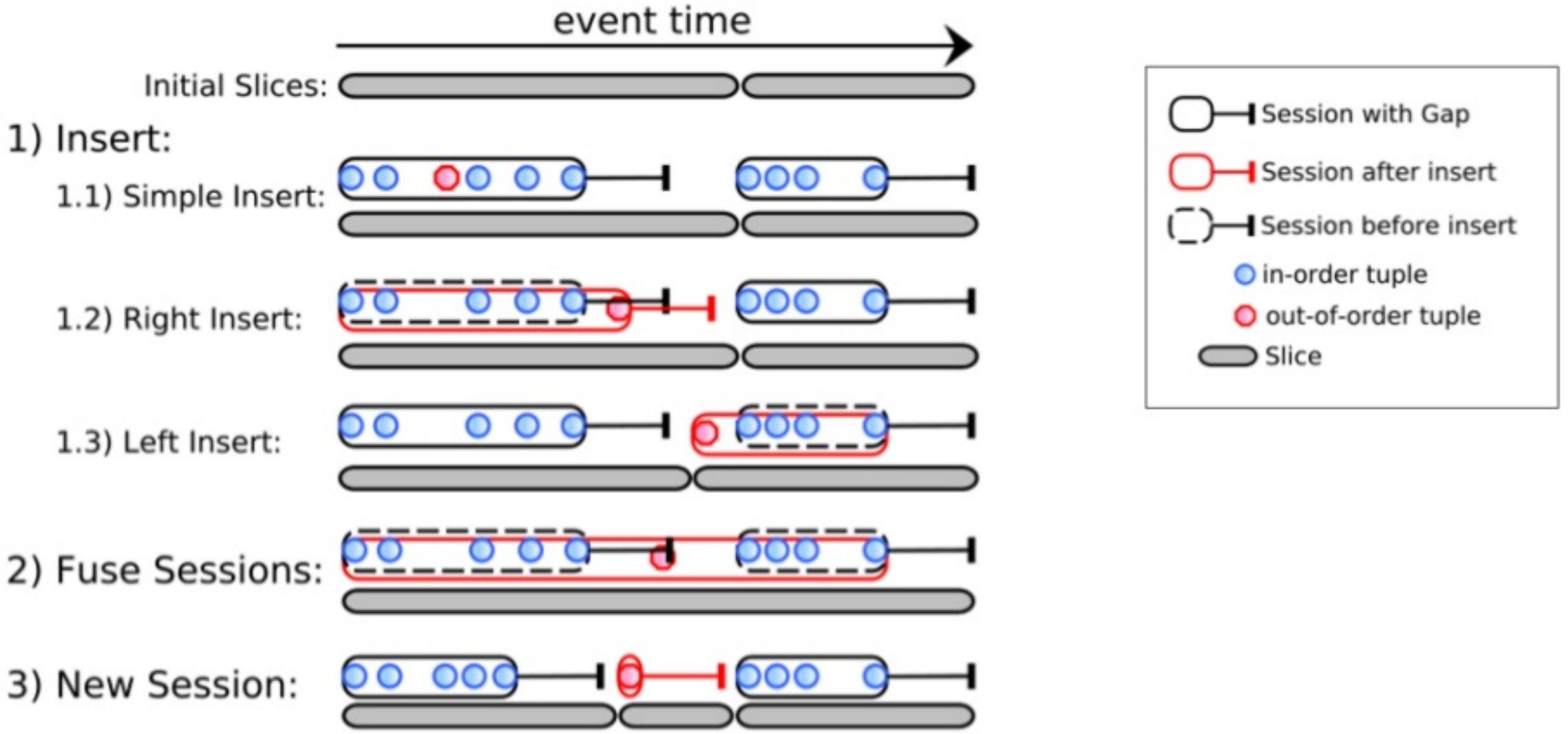
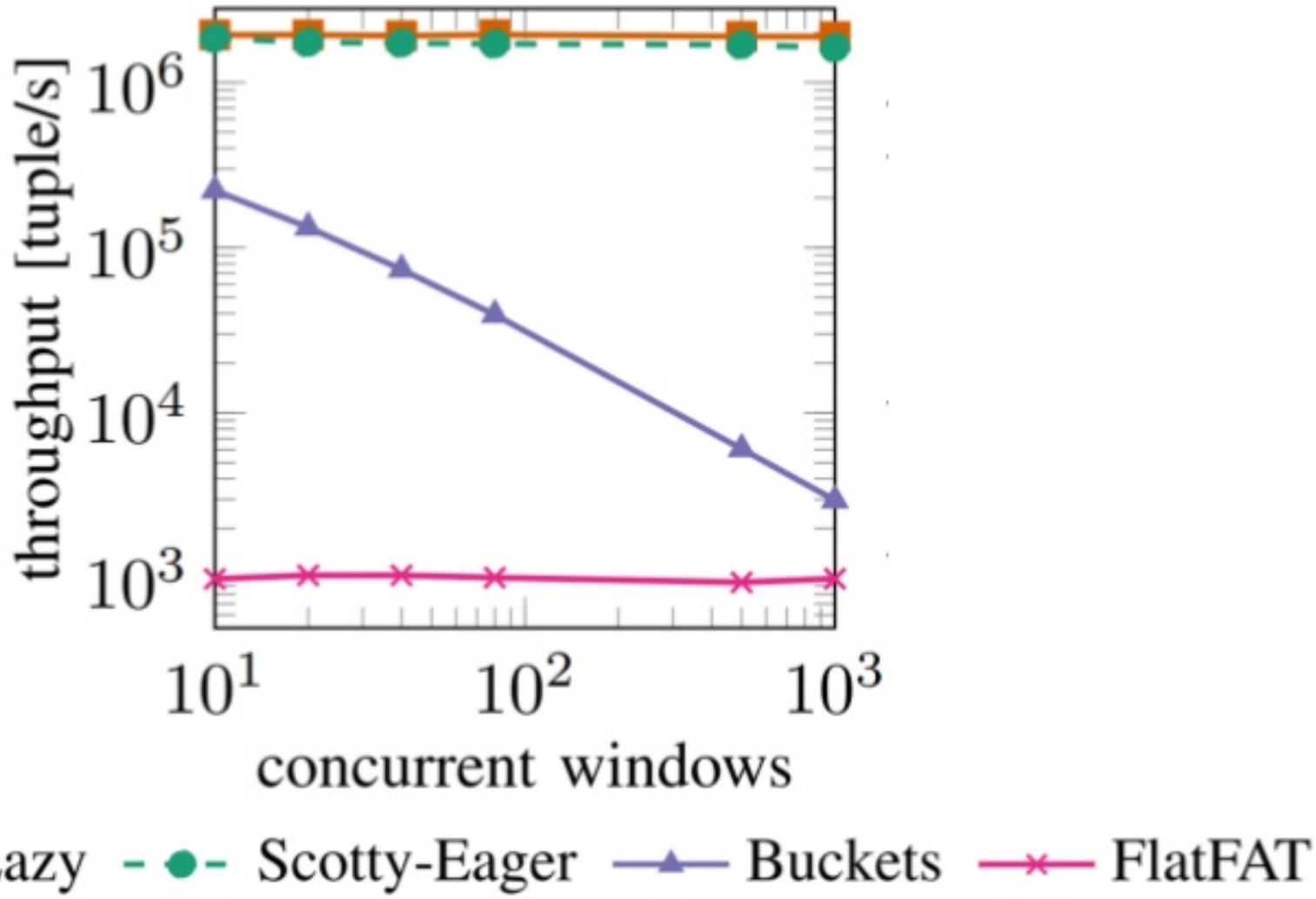


# Multi-Window Processing

## Multi-Window Processing (Example: Fitness Tracker)

```
[...].window(
      // Daily report:
      TumblingEventTimeWindows.of(Time.days(1)),
      // Monitoring dashboard (last hour):
      SlidingEventTimeWindows.of(Time.hours(1), Time.seconds(1)),
      // Activity periods:
      EventTimeSessionWindows.of(Time.minutes(1)))
.sum()
```

# Stream Slicing Performance



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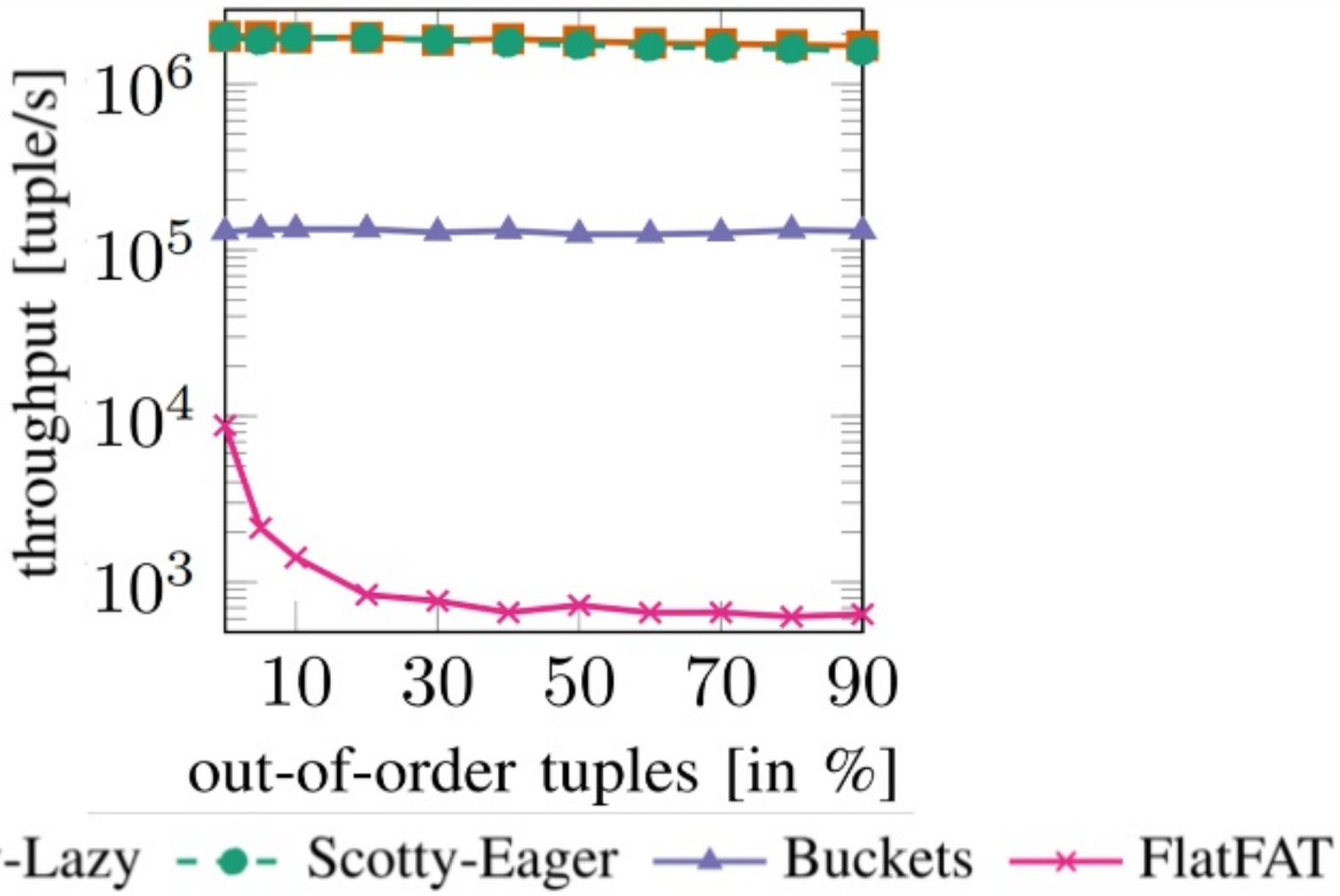

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# Runtime-Dynamic Windows

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Event Stream:

Window Definition Stream:

<WindowDefinition>

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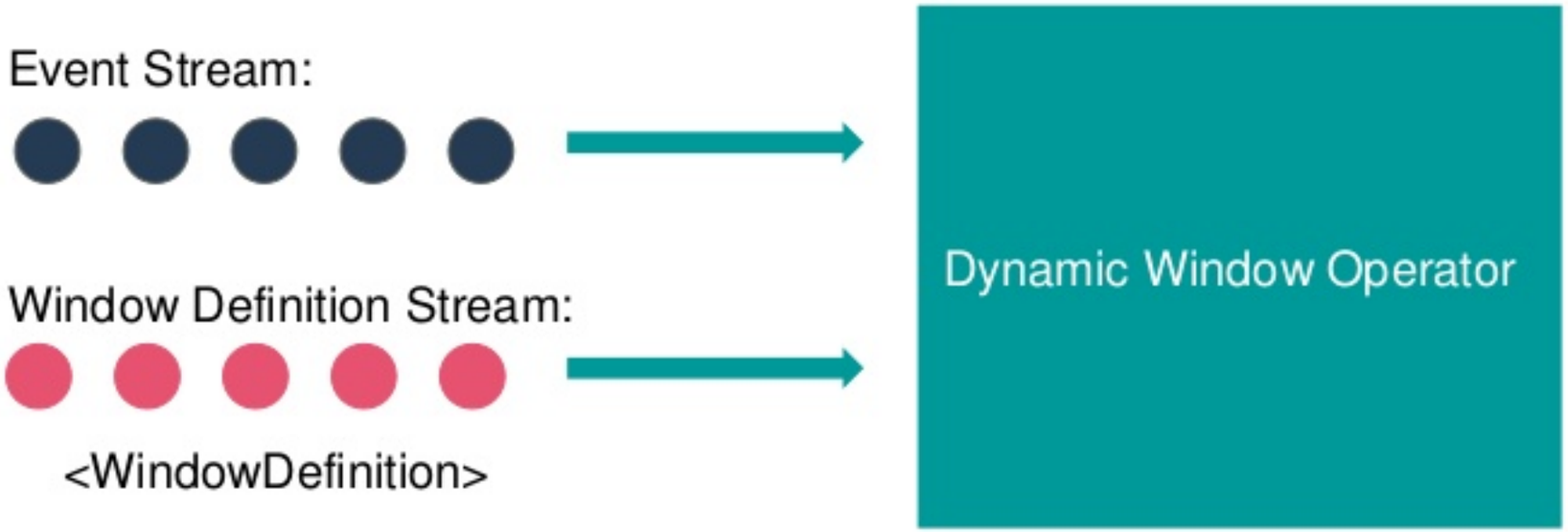

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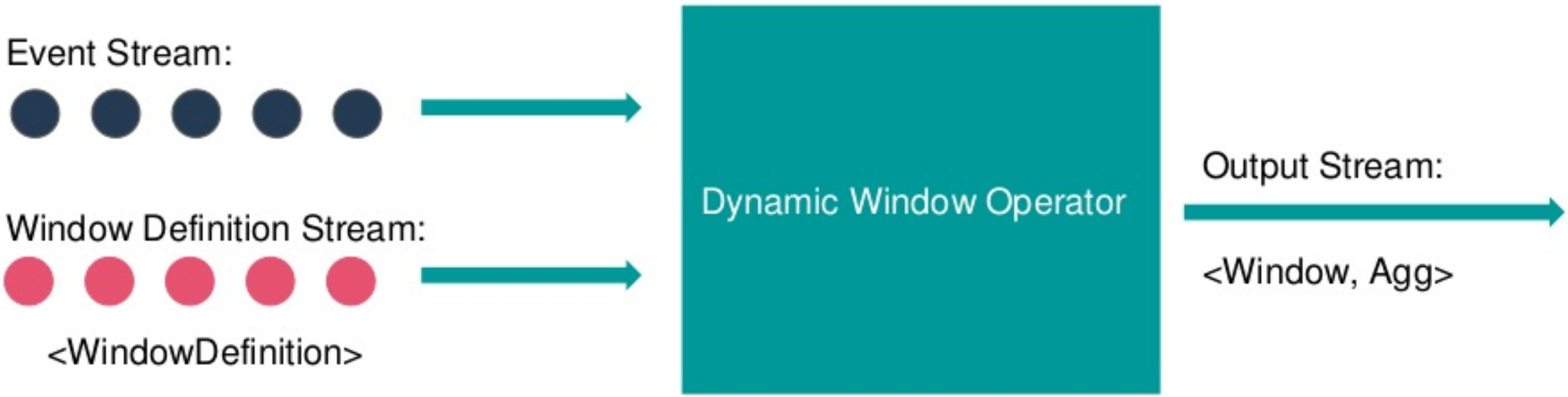

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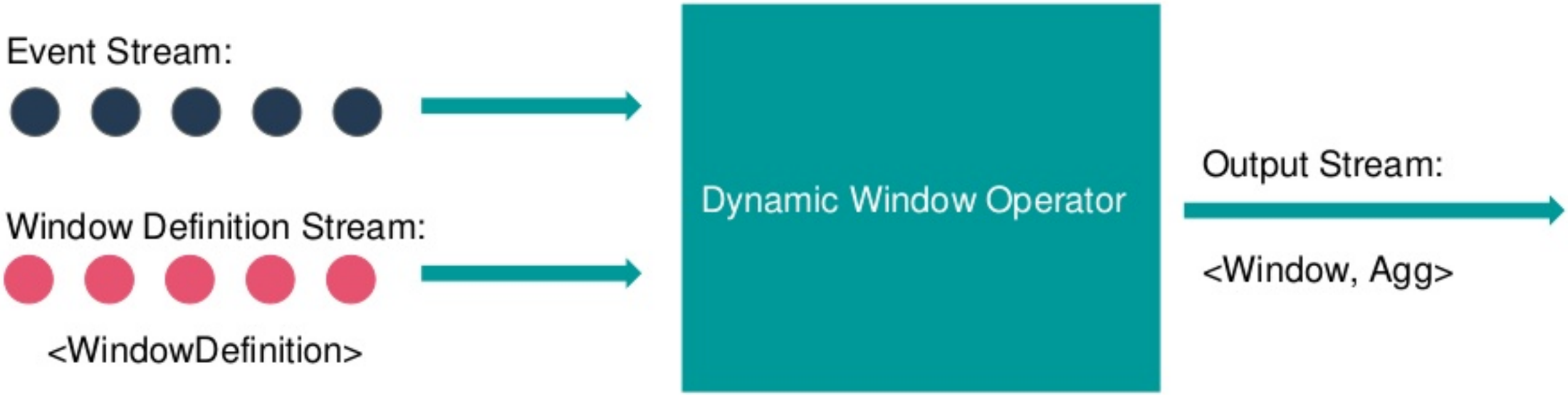


```
.dynamicWindow(windowDefinitionStream)
.sum()
```

# From Research to Production

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- Implement complete fault-tolerance and state-management

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- Implement complete fault-tolerance and state-management
- State migration

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- Implement complete fault-tolerance and state-management
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  - Hard limitation: Aggregated buckets in state snapshots cannot be migrated

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**Research**

**Production**

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  - Hard limitation: Aggregated buckets in state snapshots cannot be migrated
- Sophisticated testing

**How to expose multi-windows and dynamic-windows to users?**

# Wrap-Up

**Scotty Features:**

- stream slicing
- pre-aggregation
- aggregate sharing
- out-of-order processing
- session window support
- multi-window support
- runtime-dynamic window support

**Let's bring it to production!**

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