Complex Event Processing with Flink The state of FlinkCEP

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dataArtisans

dA
PLATFORM

Original creators of Apache Flink®

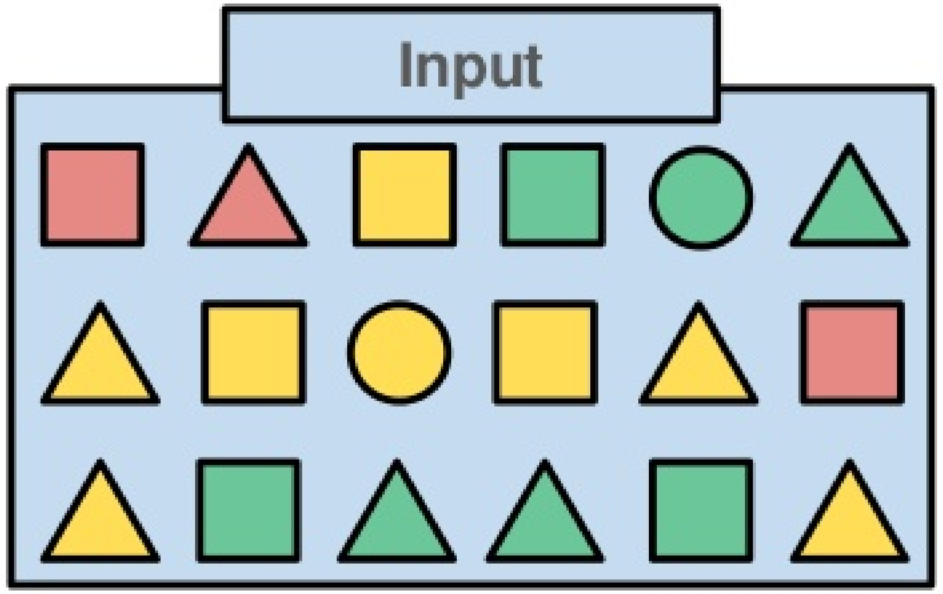
Providers of
dA Platform 2, including
open source Apache Flink +
dA Application Manager

What is CEP?

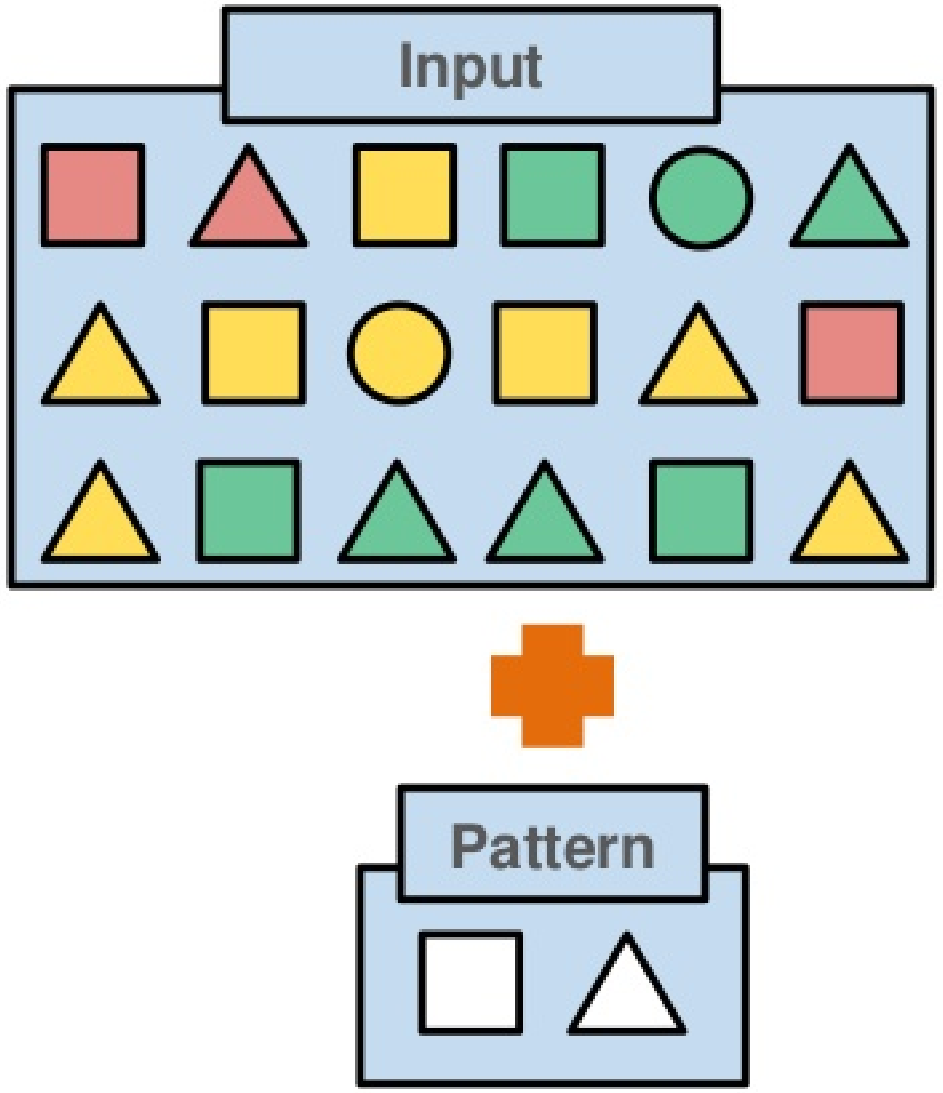
CEP: Complex Event Processing

- Detecting event patterns
- Over continuous streams of events
- Often arriving out-of-order

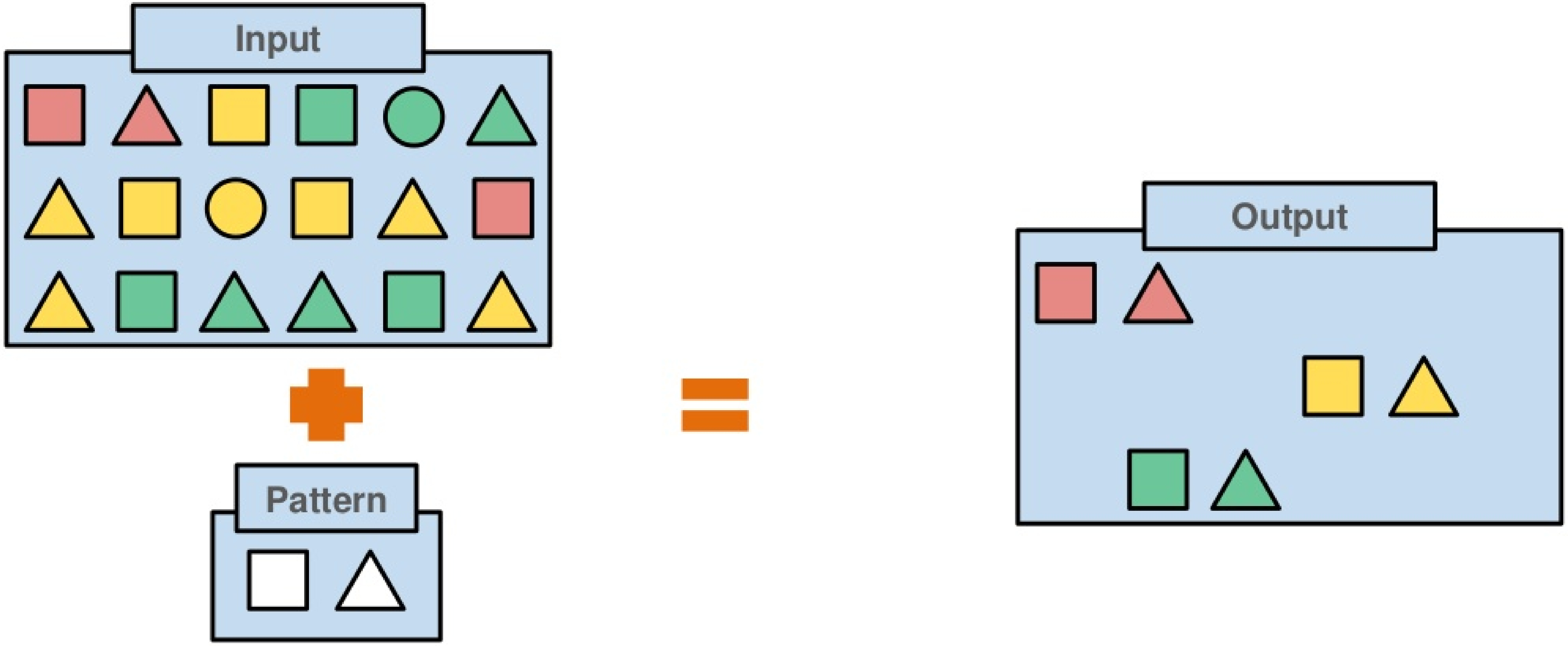
CEP: Complex Event Processing



CEP: Complex Event Processing



CEP: Complex Event Processing

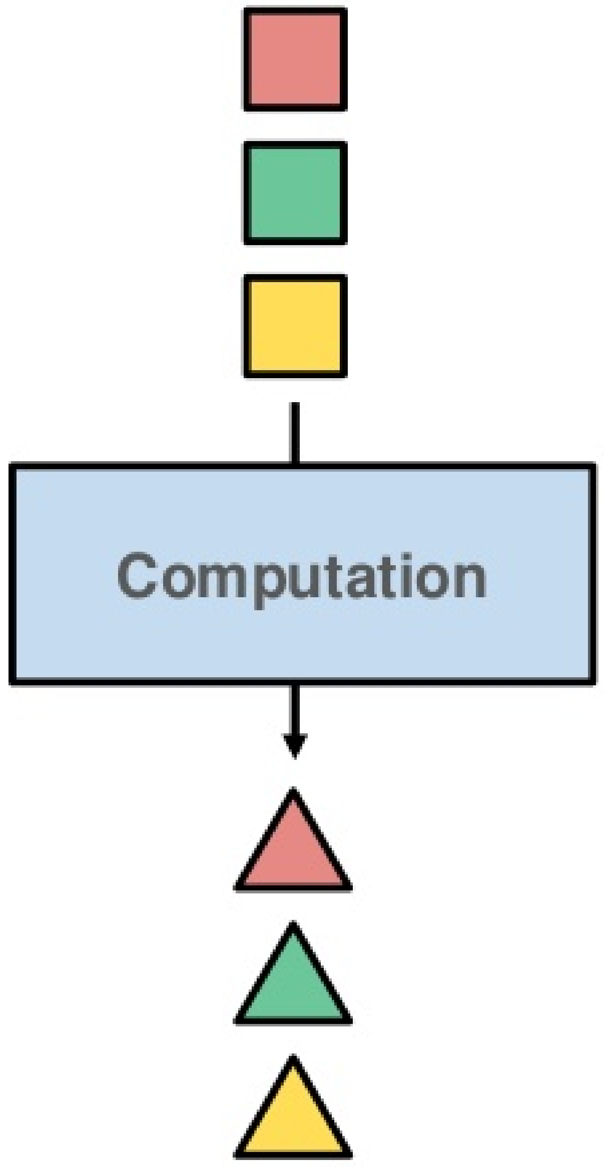


CEP: use-cases

- IoT
- Infrastructure Monitoring and Alarms
- Intrusion detection
- Inventory Management
- Click Stream Analysis
- Trend detection in financial sector
- *...yours?*

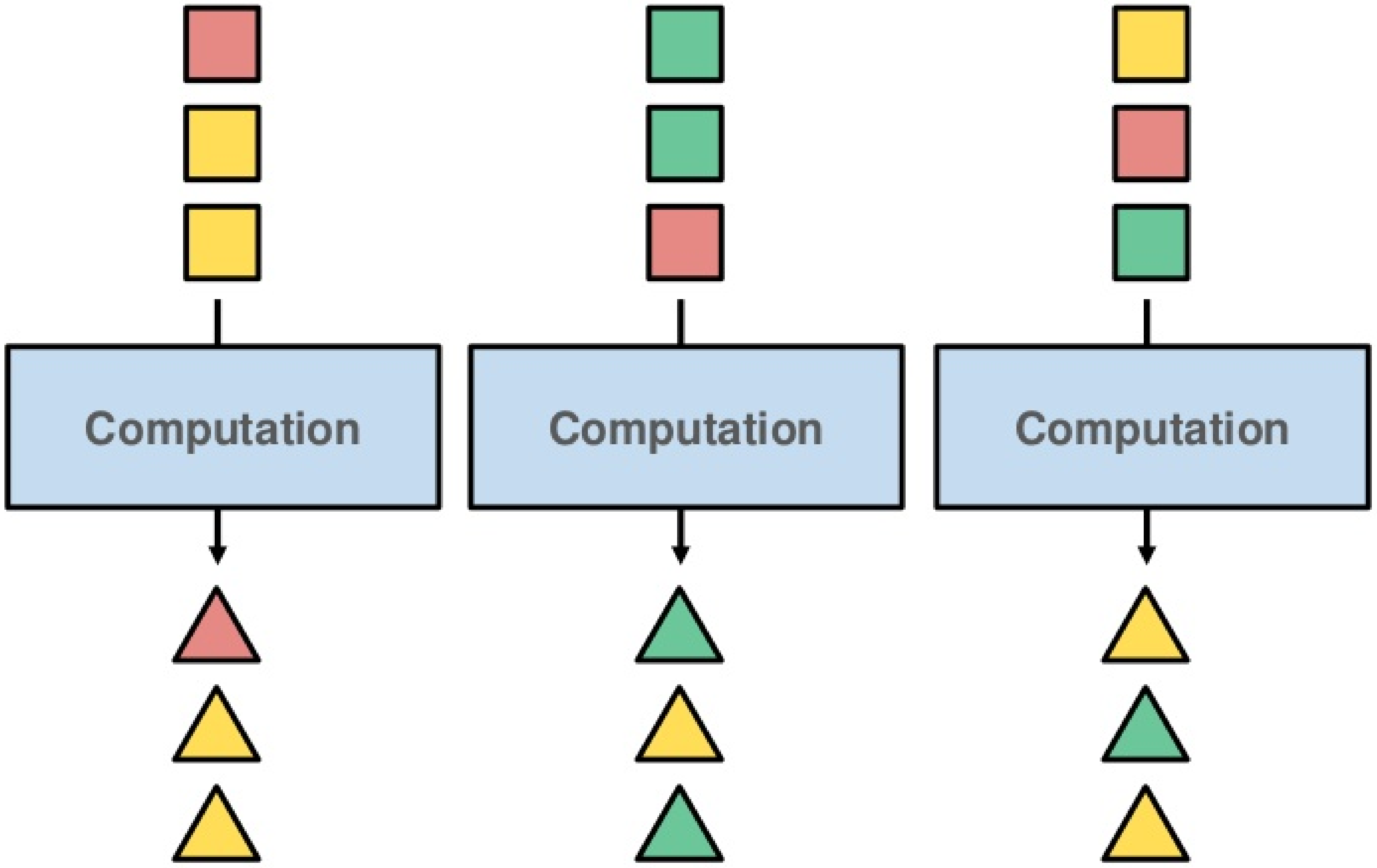
What is Stream Processing?

Stream Processing



Computations on
never-ending
“streams” of events

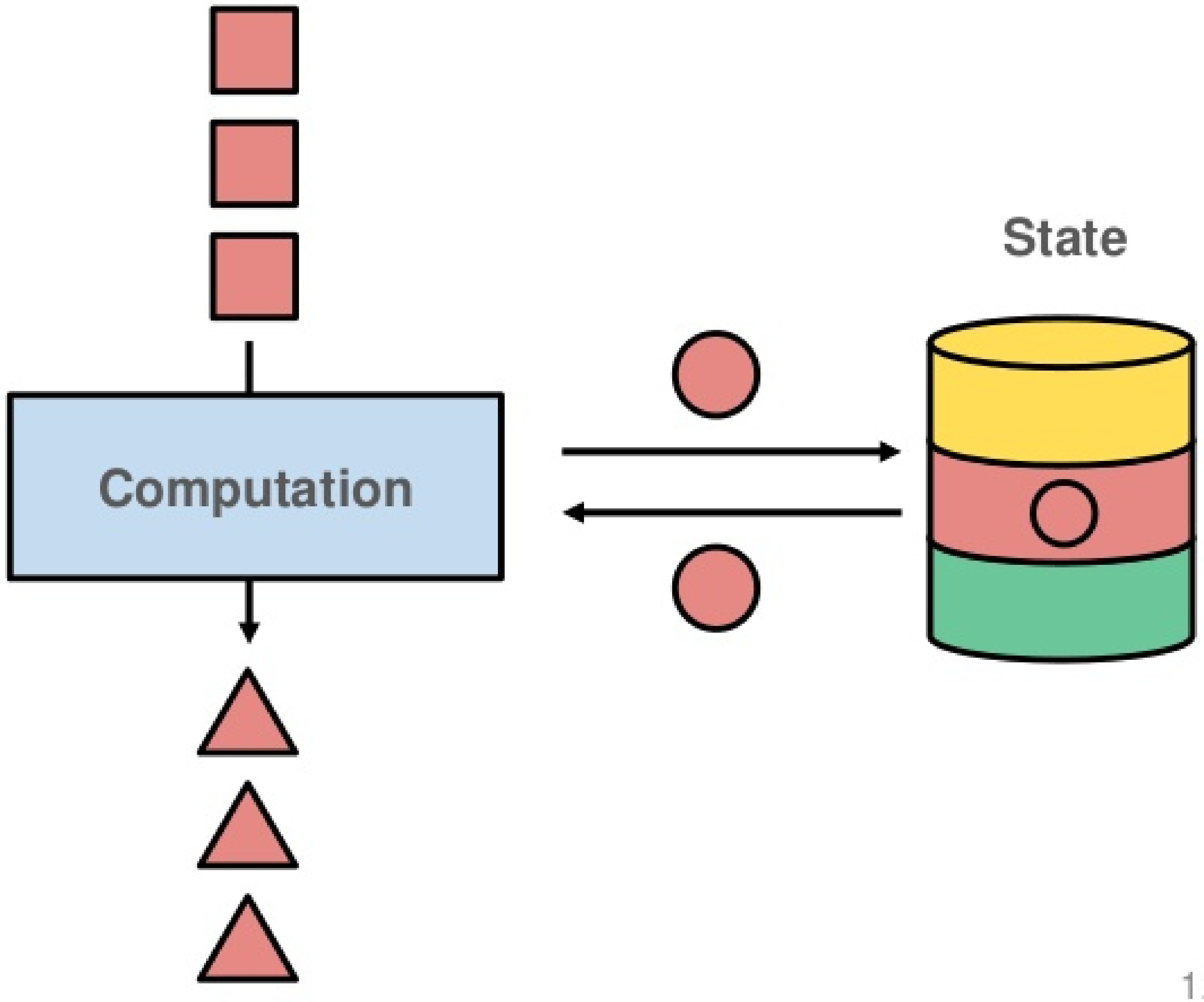
Distributed Stream Processing



Computation spread across many machines

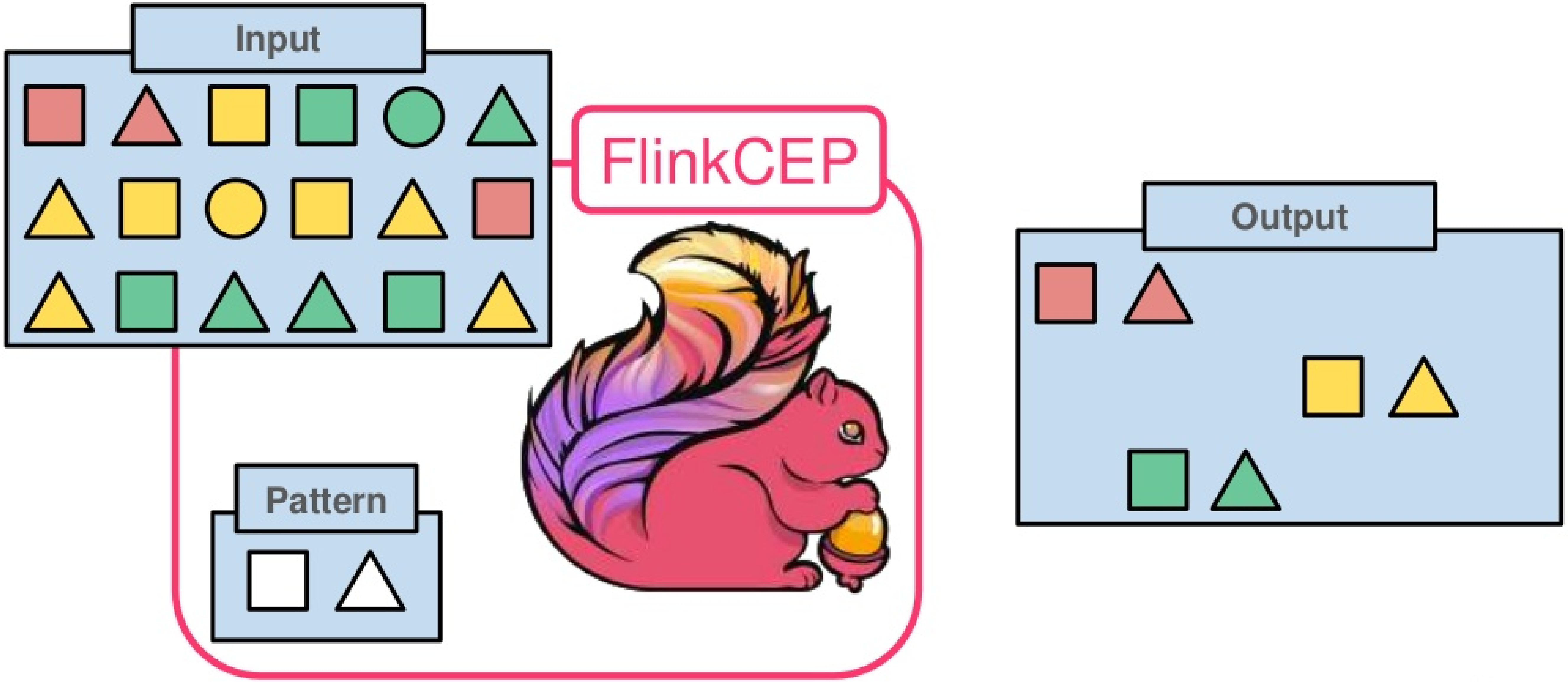
Stateful Stream Processing

Result depends on history of stream



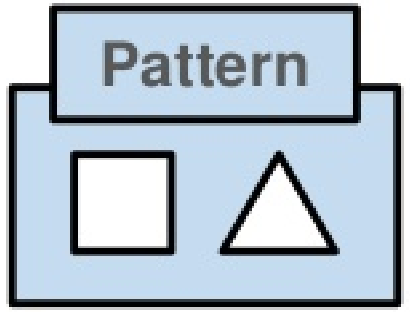
Stream Processors are a natural fit for **CEP**

FlinkCEP



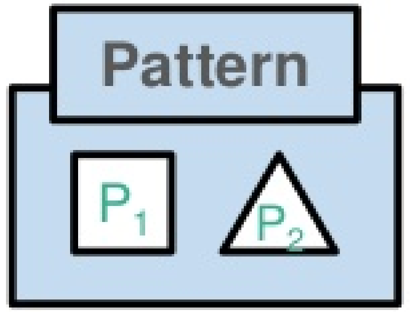
What does FlinkCEP offer?

Pattern Definition



Pattern Definition

- Composed of Individual Patterns
  - □ P_1(shape == rectangle)
  - △ P_2(shape == triangle)



Pattern Definition

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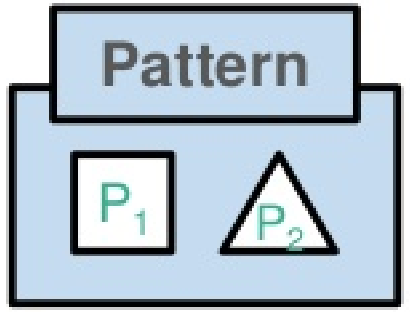
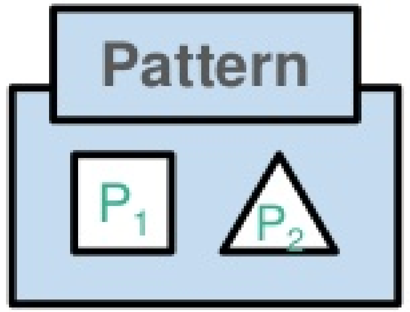


- Combined by Contiguity Conditions
  - ...later

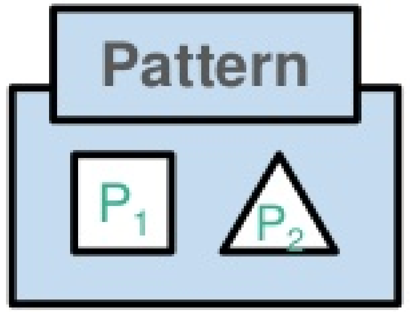
FlinkCEP Individual Patterns



- Unique Name
- Quantifiers : how many times ?
  - Looping oneOrMore(), times(from, to), greedy()
  - Optional optional()
- Condition : which elements to accept ?
  - Simple *e.g* shape == rectangle
  - Iterative *e.g* rectangle.surface < triangle.surface
  - Stop until(cond.)

FlinkCEP Complex Patterns

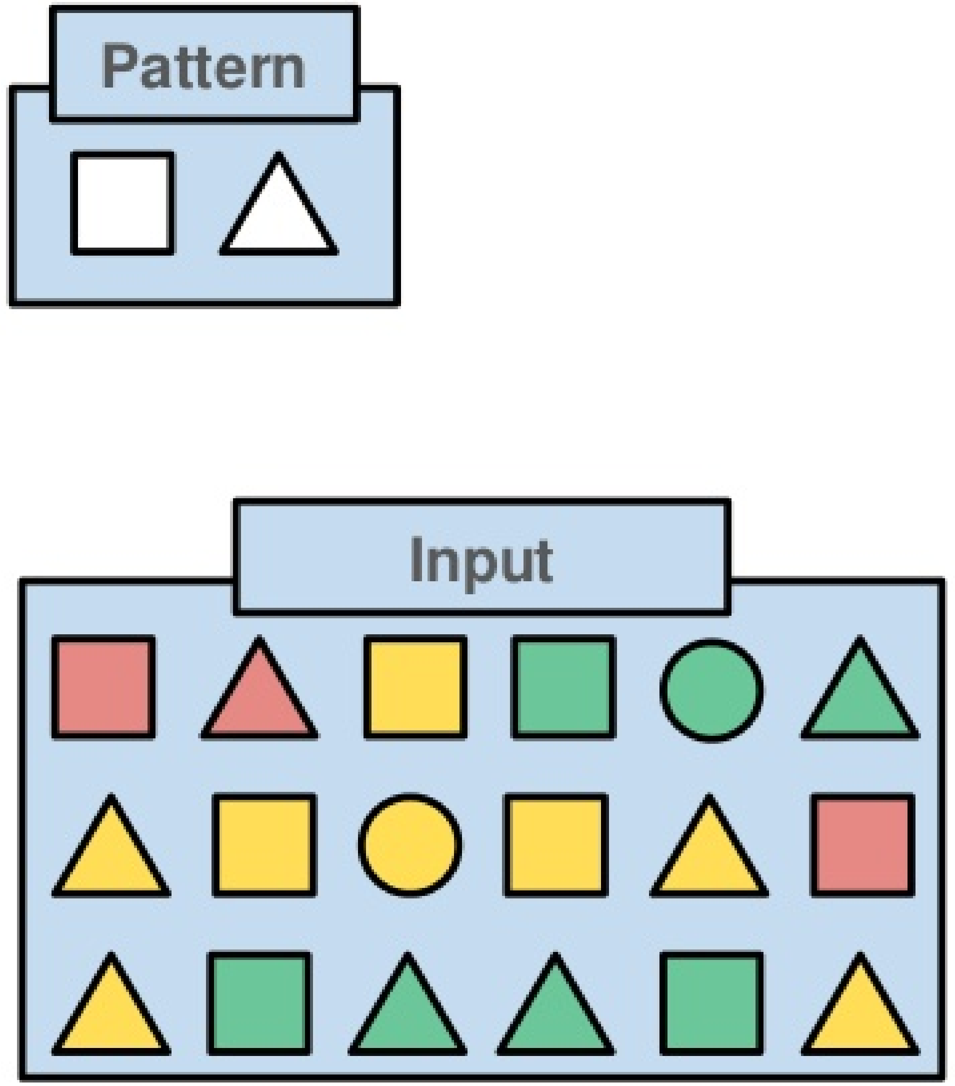
- Combine Individual Patterns



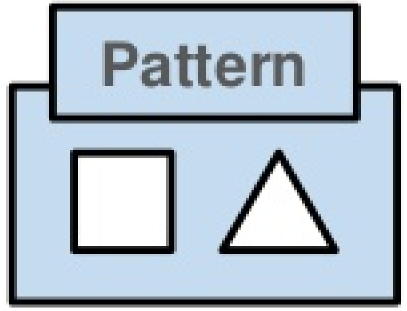
- Contiguity Conditions
  - *how to select relevant events* given an input mixing relevant and irrelevant events

- Time Constraints (event/processing time)
  - *within(time) e.g.* all events have to come within 24h

FlinkCEP Contiguity Conditions

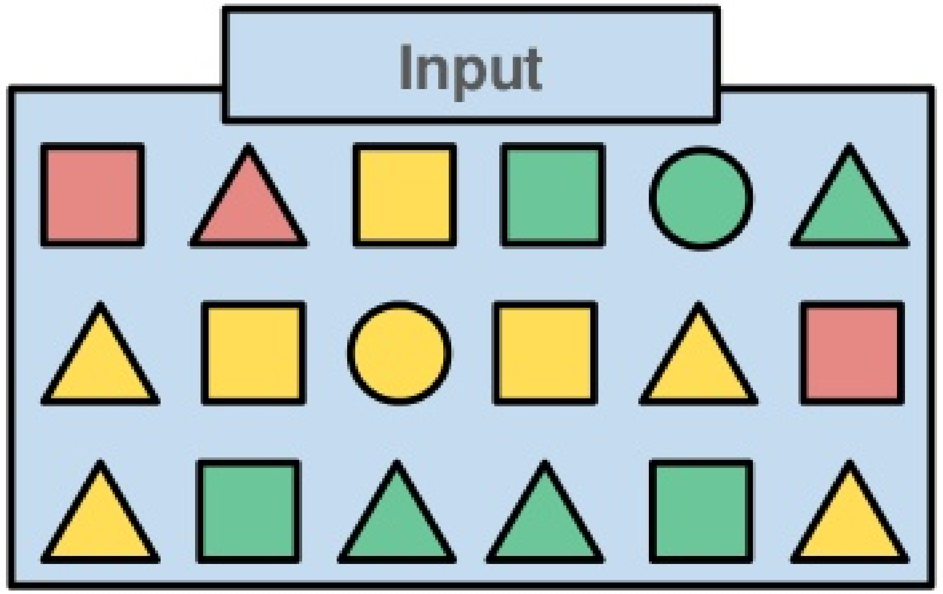


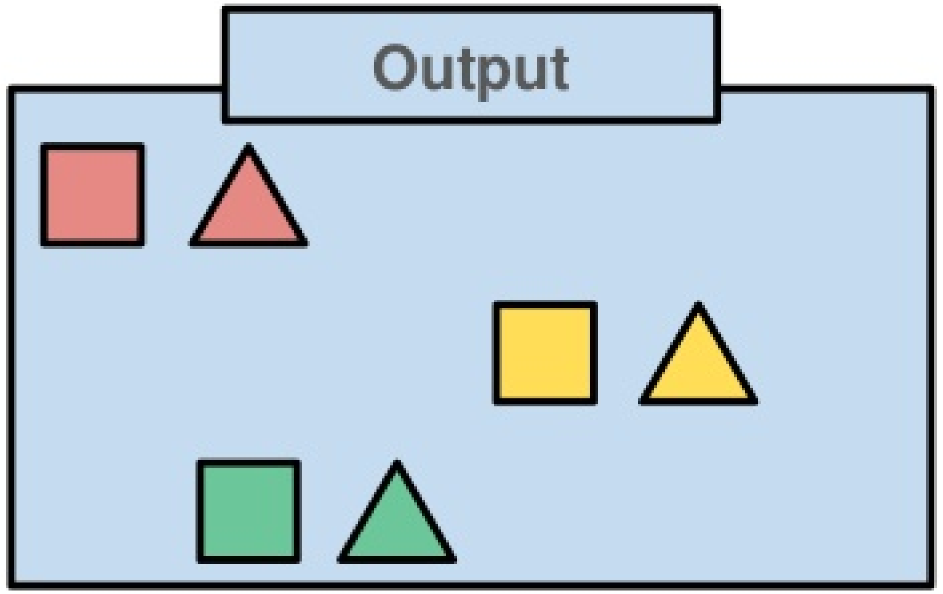
FlinkCEP Contiguity Conditions



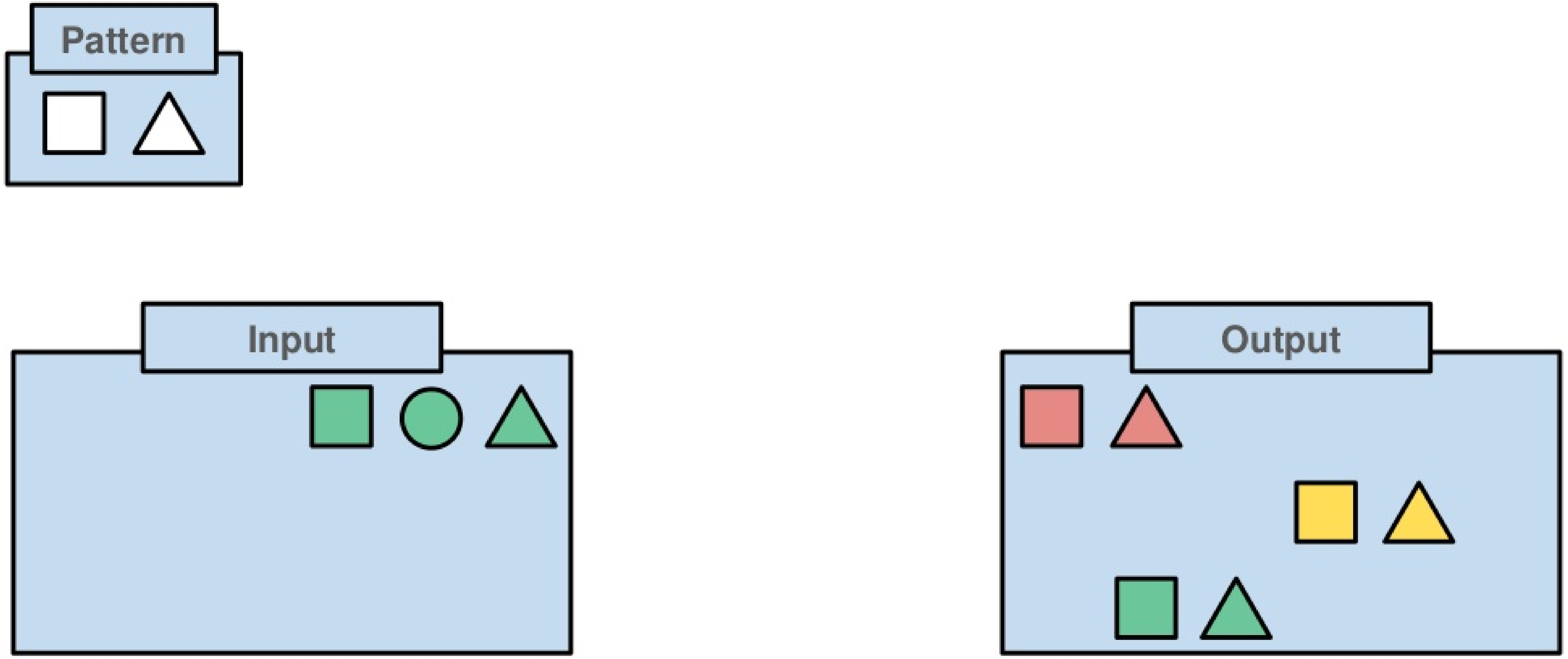
Strict Contiguity

- matching events strictly follow each other

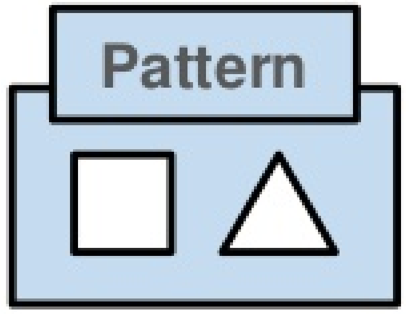




FlinkCEP Contiguity Conditions

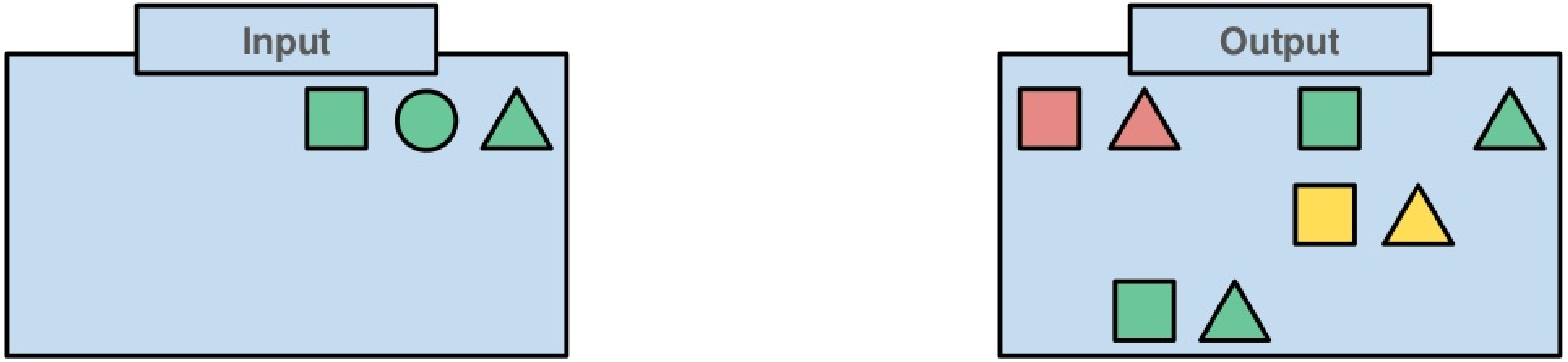


FlinkCEP Contiguity Conditions

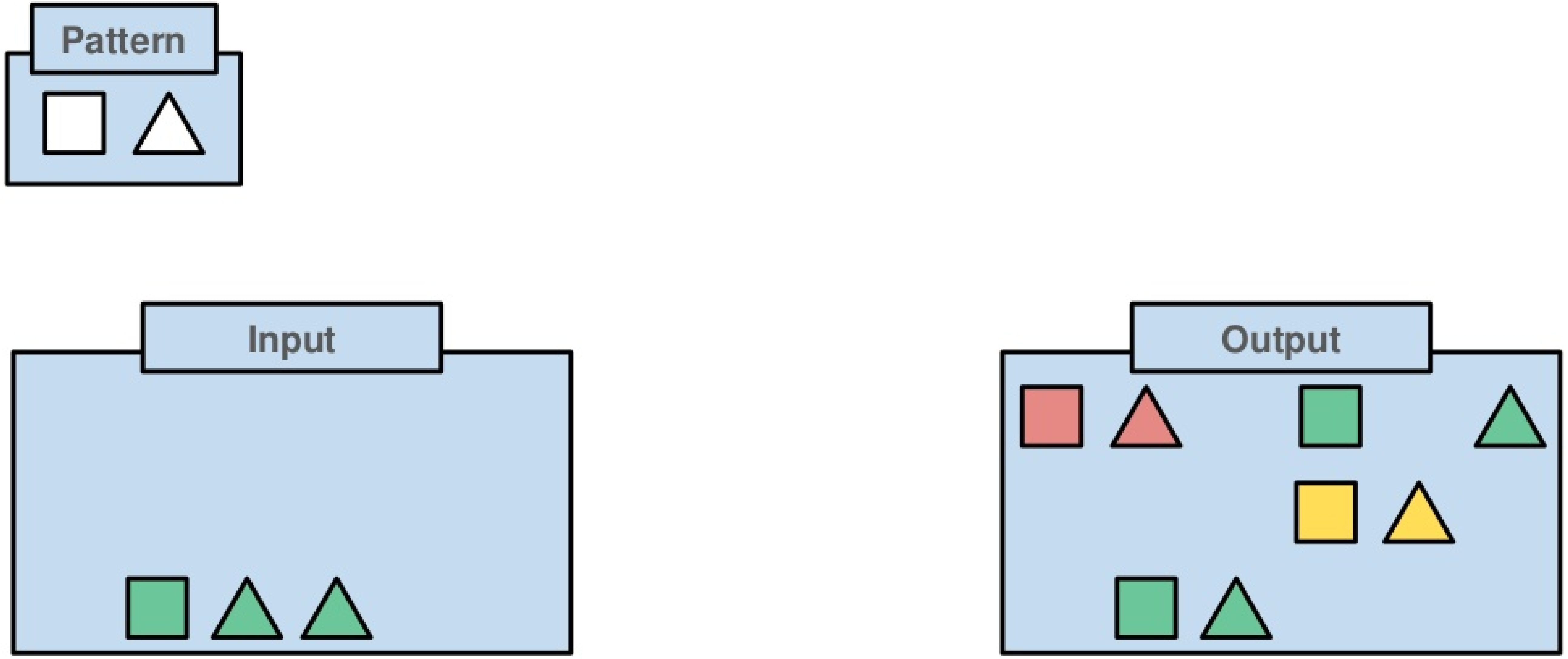


Relaxed Contiguity

- non-matching events to simply be ignored



FlinkCEP Contiguity Conditions



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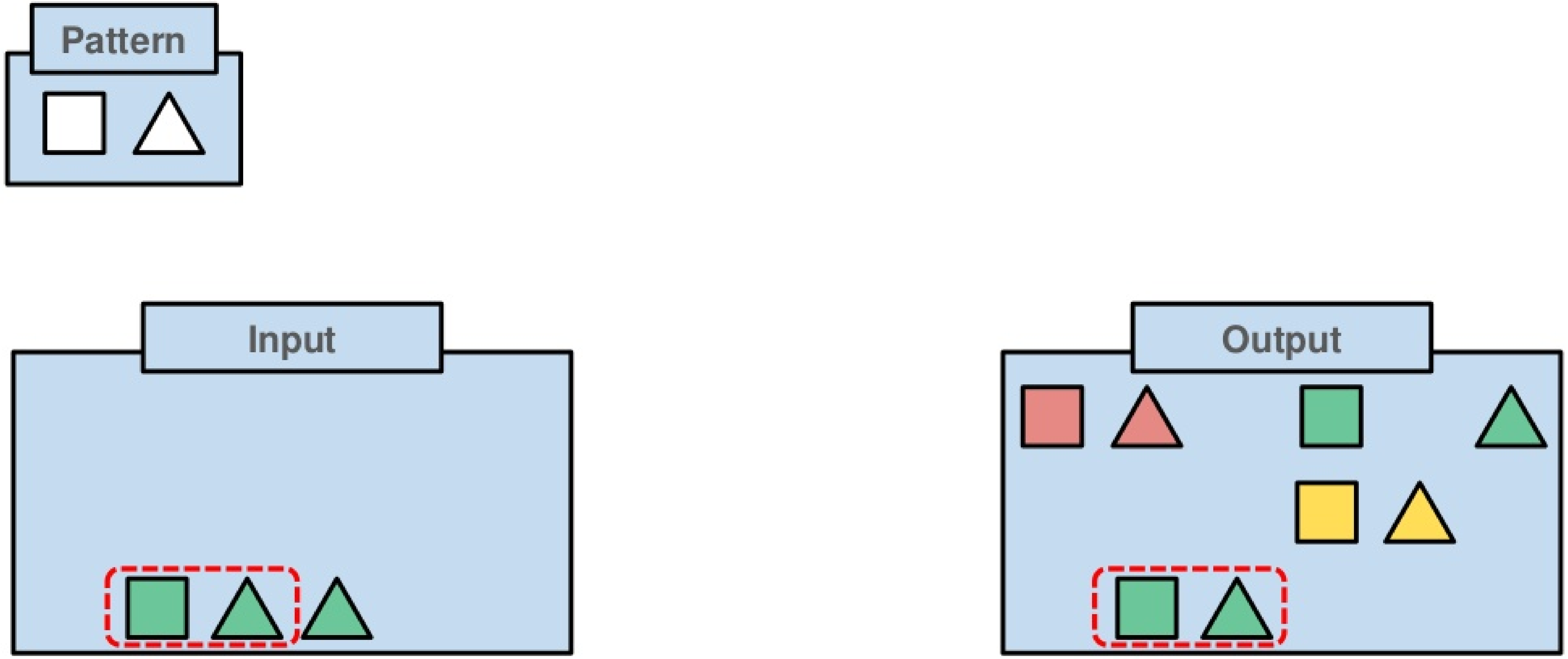

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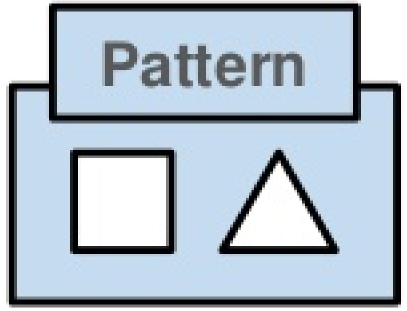
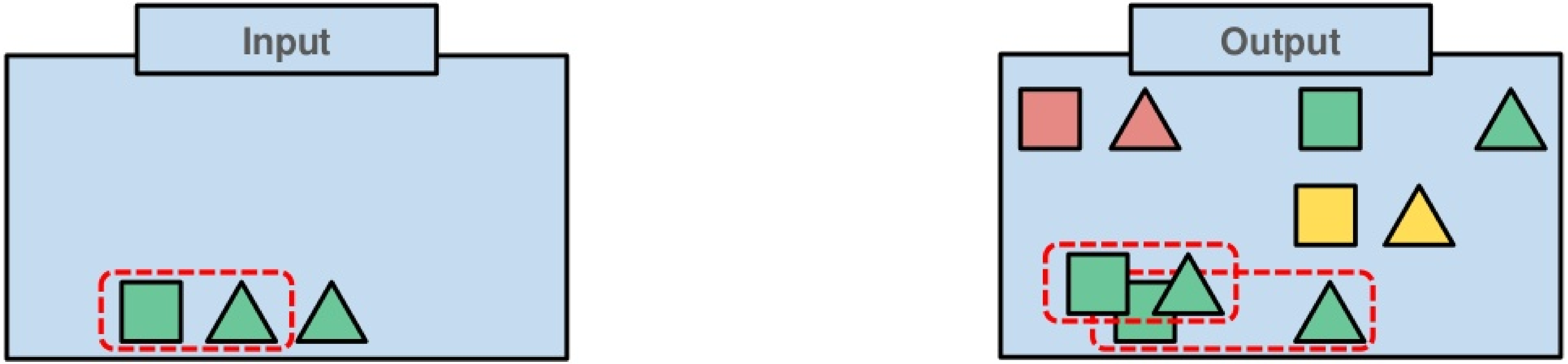
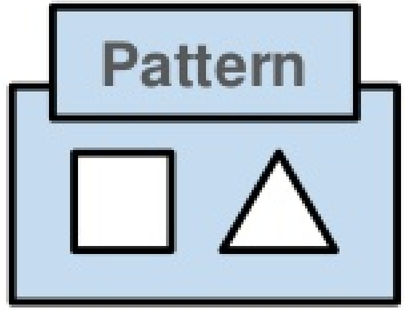


Non-Deterministic Relaxed Contiguity

- allows non-deterministic actions on relevant events

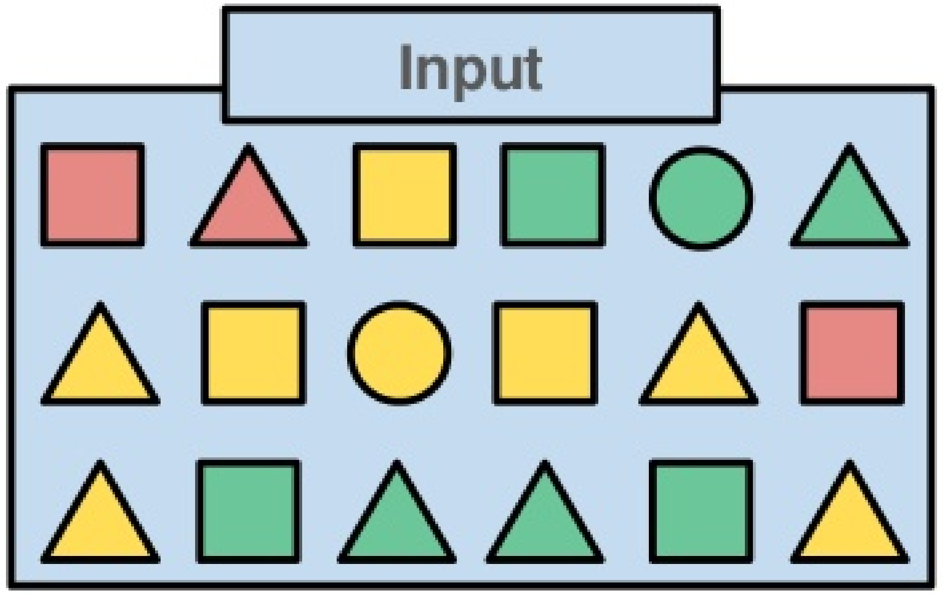


FlinkCEP Contiguity Conditions



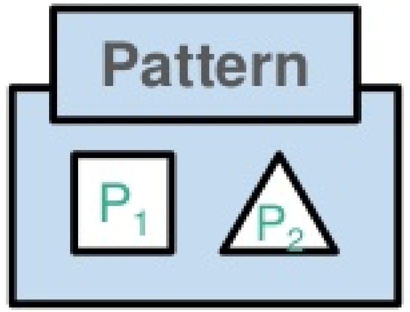
NOT patterns:

- for strict and relaxed contiguity
- for cases where an event should invalidate a match



FlinkCEP Grouping Patterns

- Define Individual Patterns



- Combine them into Complex Patterns

- Can we combine …Complex Patterns ?

FlinkCEP Grouping Patterns

Grouping Patterns are for CEP what parenthesis are for mathematical expressions.

FlinkCEP Grouping Patterns

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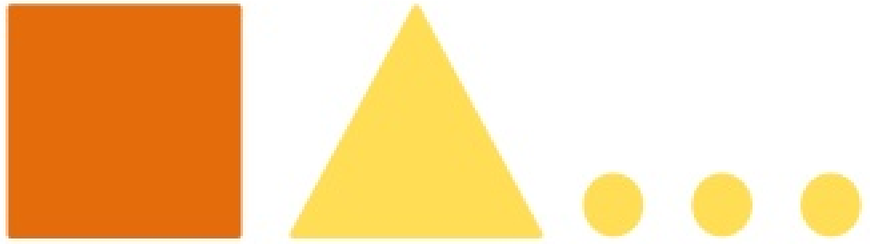

FlinkCEP Grouping Patterns

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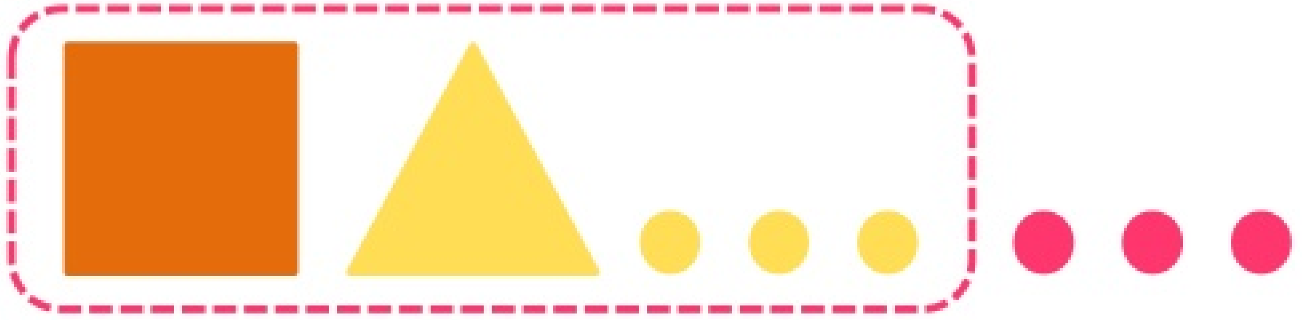

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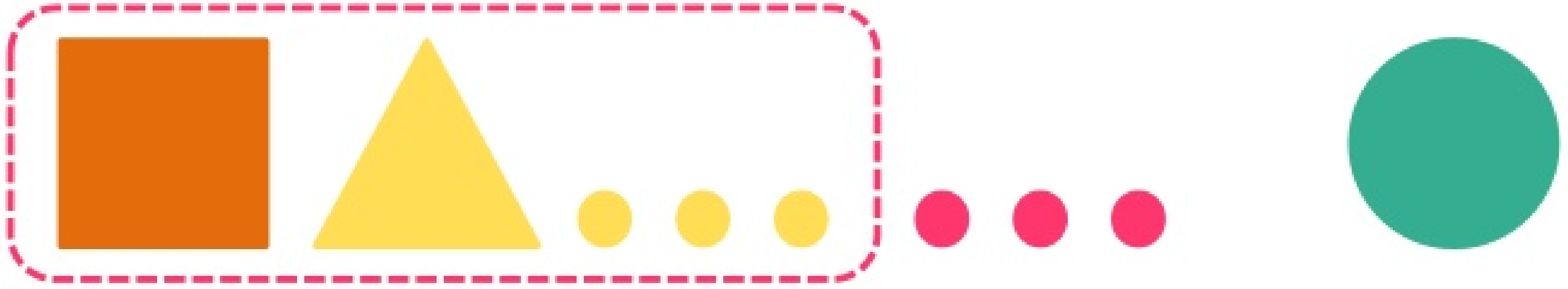


FlinkCEP Summary

- Quantifiers oneOrMore(), times(), optional()
- Conditions Simple, Iterative, Stop
- Time Constraints Event and Processing time
- Contiguity Constraints

  Strict, relaxed, non-deterministic relaxed, NOT
- Grouping Patterns

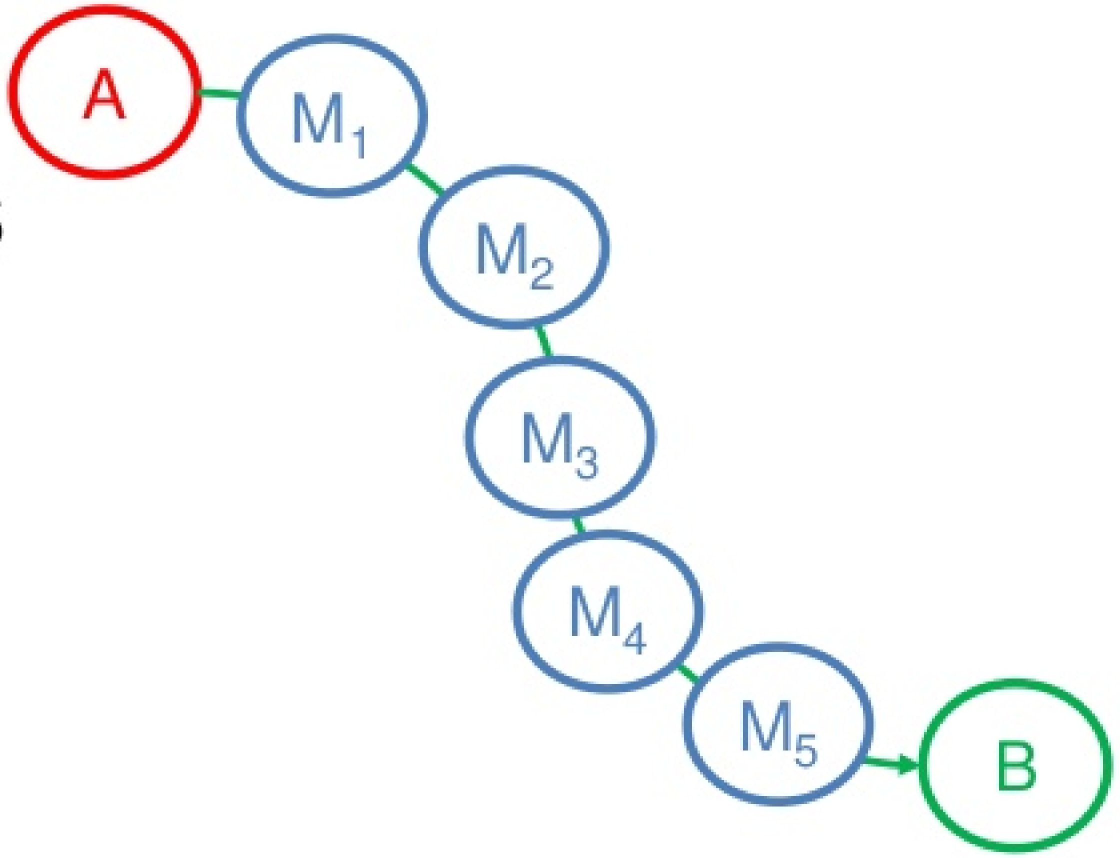
FlinkCEP Integration with SQL

- Flink already supports **SQL**:
  - match_recognize clause in SQL:2016
  - ongoing effort with a lot of interest from the community

Example

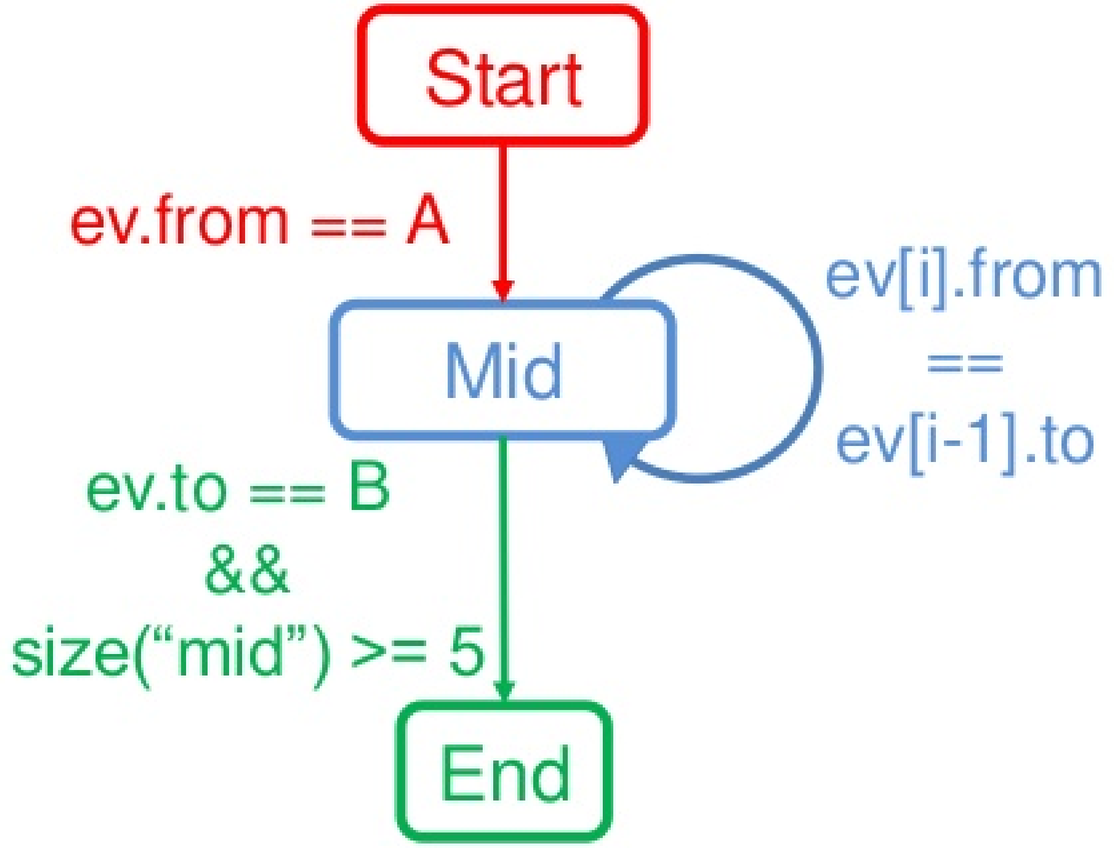
Running Example: retailer

- Trace all shipments which:
  - start at location A
  - have at least 5 stops
  - end at location B
  - within the last 24h



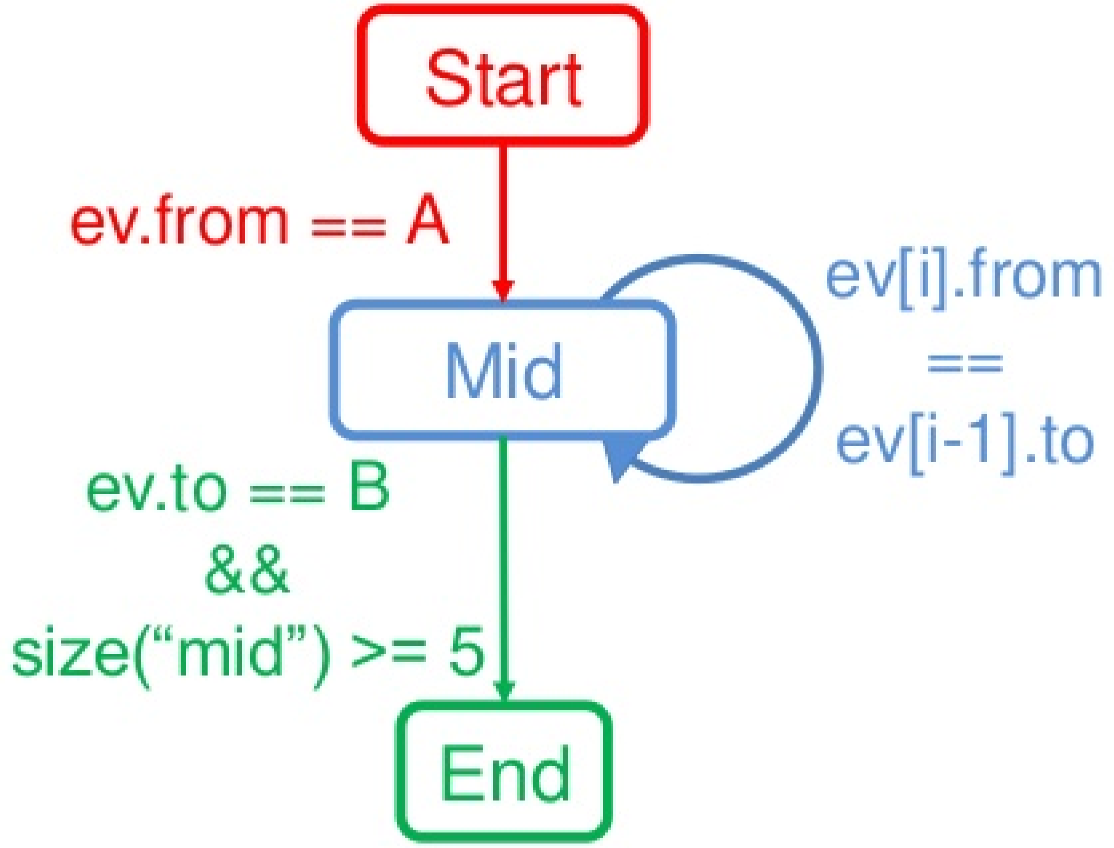
Observation A Individual Patterns

- Trace all shipments which:
  - start at location A
  - have at least 5 stops
  - end at location B
  - within the last 24h



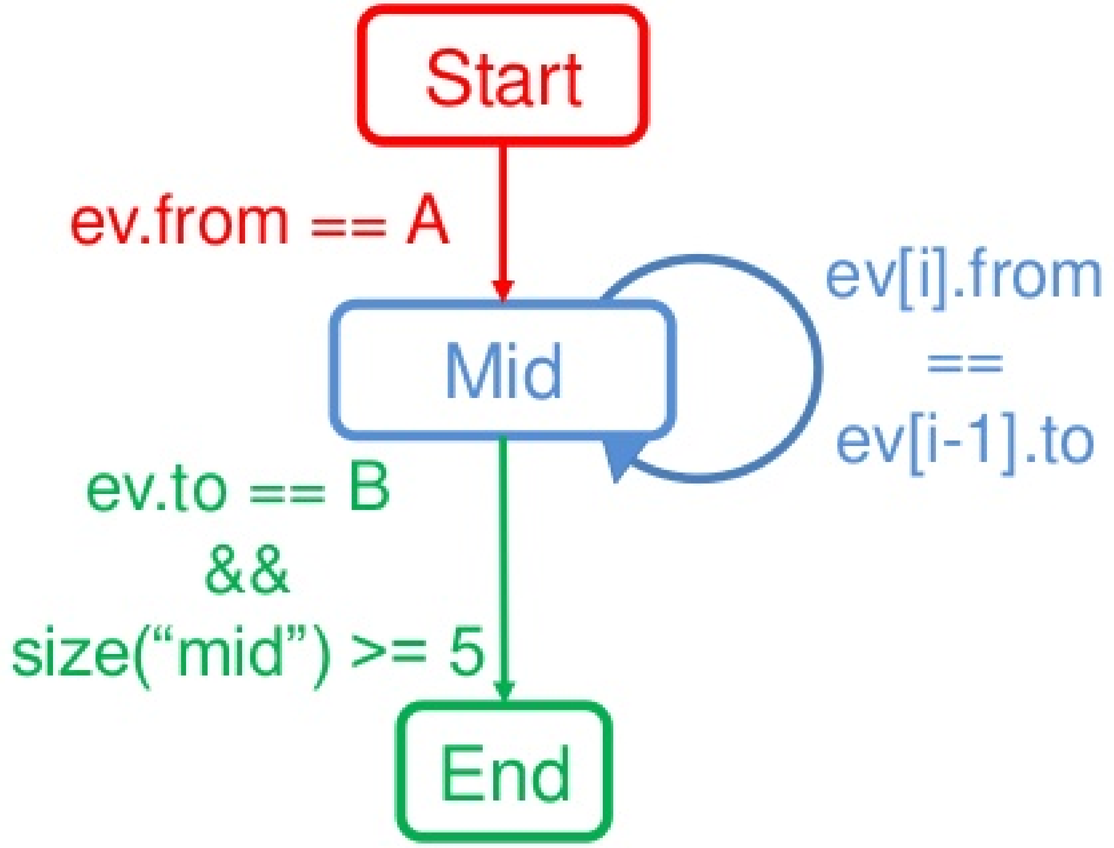
Observation B Quantifiers

- Start/End: single event
- Middle: multiple events
  - .oneOrMore()



Observation C Conditions

- Start -> Simple
  - properties of the event
- Middle/End -> Iterative
  - Depend on previous events



Observation D Time Constraints

- Trace all shipments which:
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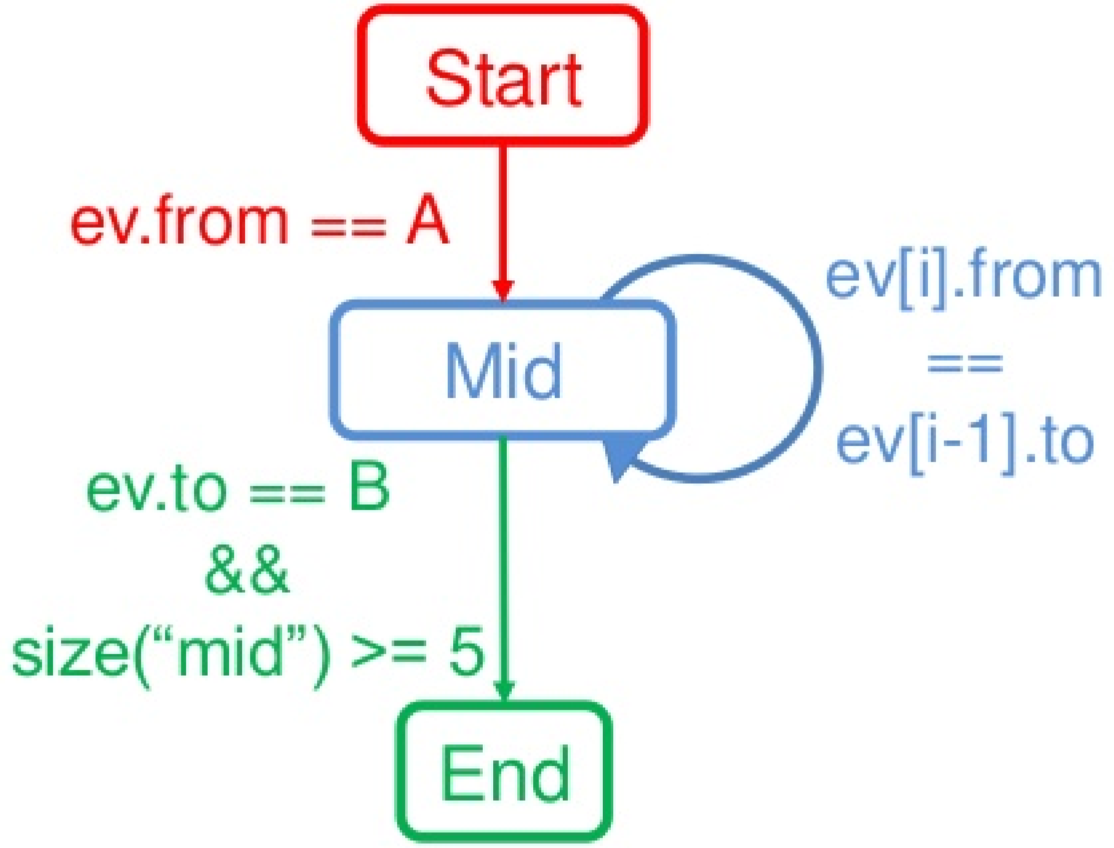
  - have at least 5 stops
  - end at location B
  - within the last 24h



Observation E Contiguity

- We opt for relaxed continuity

Running Example Individual Patterns

```
Pattern<Event, ?> pattern = Pattern
    .<Event>begin("start")
        .where(mySimpleCondition)
    .followedBy ("middle")
        .where(myIterativeCondition1)
        .oneOrMore()
    .followedBy ("end”)
        .where(myIterativeCondition2)
    .within(Time.hours(24))
```

Start

Middle

End

Running Example Quantifiers

```
Pattern<Event, ?> pattern = Pattern
          .<Event>begin("start")
                    .where(mySimpleCondition)
          .followedBy ("middle")
                    .where(myIterativeCondition1)
                    .oneOrMore()
          .followedBy ("end")
                    .where(myIterativeCondition2)
          .within(Time.hours(24))
```

Start

Middle

End

Running Example Conditions

```
Pattern<Event, ?> pattern = Pattern
    .<Event>begin("start")
        .where(mySimpleCondition)           Start
    .followedBy ("middle")
        .where(myIterativeCondition1)       Middle
        .oneOrMore()
    .followedBy ("end")                     End
        .where(myIterativeCondition2)
    .within(Time.hours(24))
```

Running Example Time Constraint

```
Pattern<Event, ?> pattern = Pattern
      .<Event>begin("start")
            .where(mySimpleCondition)              Start
      .followedBy ("middle")
            .where(myIterativeCondition1)          Middle
            .oneOrMore()
      .followedBy ("end”)
             .where(myIterativeCondition2)         End
      .within(Time.hours(24))
```

Running Example Pattern Integration

```
Pattern<Event, ?> pattern = ...

PatternStream<Event> patternStream = CEP.pattern(input, pattern);

DataStream<Alert> result = patternStream.select (
    new PatternSelectFunction<Event, Alert>() {
        @Override
        public Alert select(Map<String, List<Event>> pattern)  {
        return parseMatch(pattern);
        }
);
```

Running Example Pattern Integration

```
Pattern<Event, ?> pattern = ...

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Documentation

- FlinkCEP documentation:

FlinkCEP 1.3: https://ci.apache.org/projects/flink/flink-docs-release-1.3/dev/libs/cep.html
FlinkCEP 1.4: https://ci.apache.org/projects/flink/flink-docs-release-1.4/dev/libs/cep.html

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