State and Timers

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Agenda

Course Intro

Beam Concepts Review

Windows, Watermarks, and Triggers

Sources and Sinks

Schemas

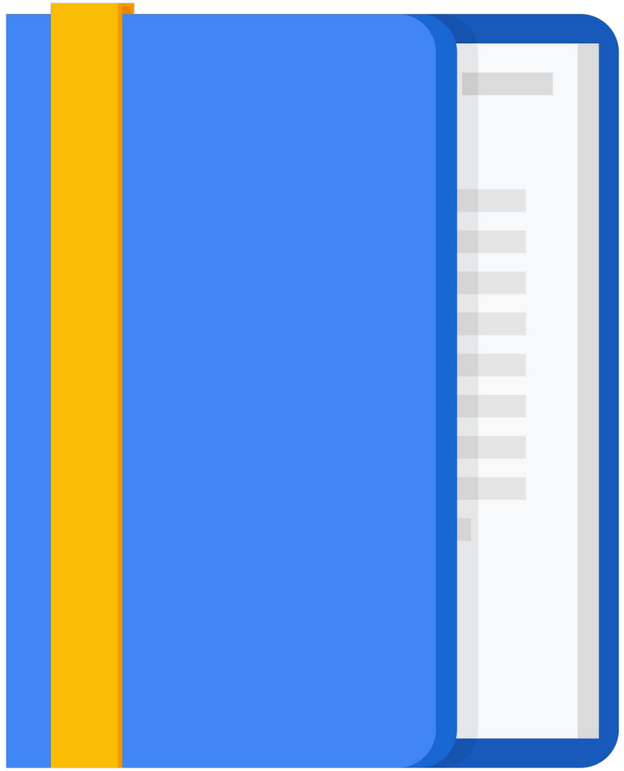
State and Timers

Best Practices

Dataflow SQL and DataFrames

Beam Notebooks

Summary



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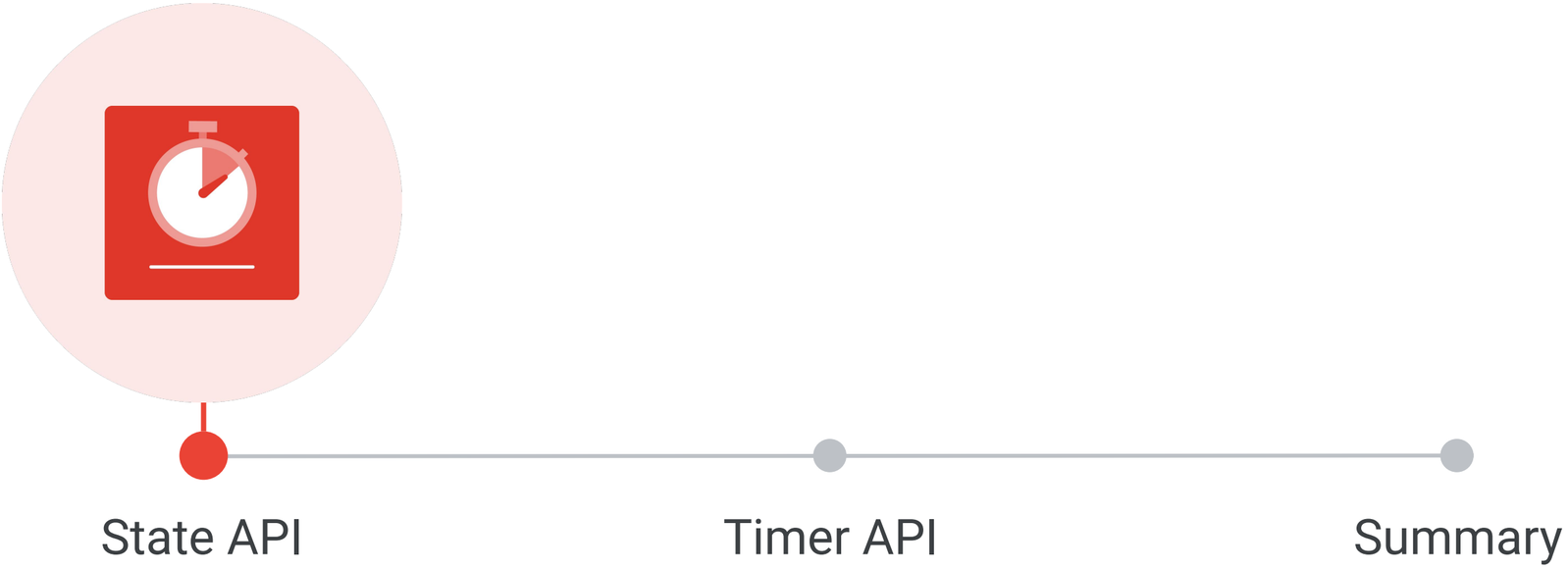
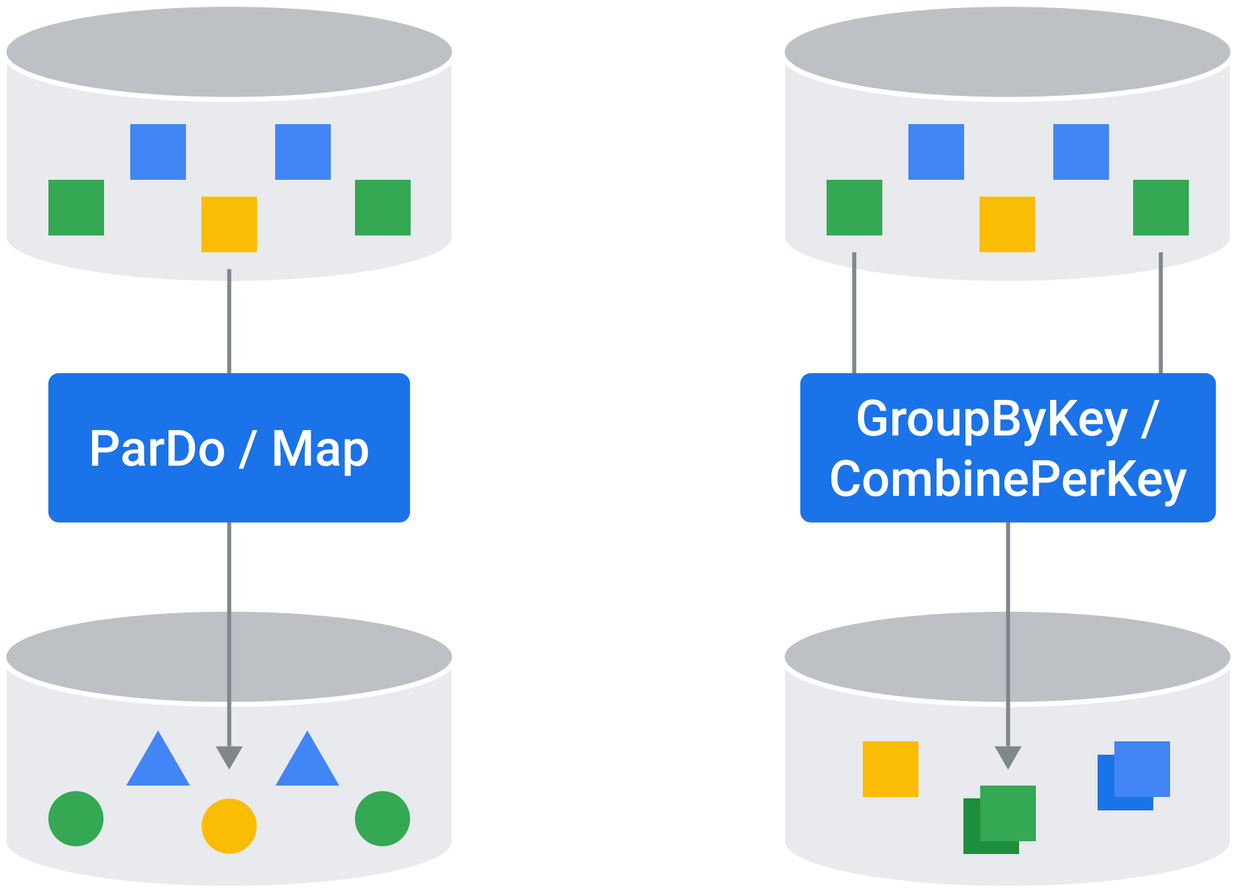
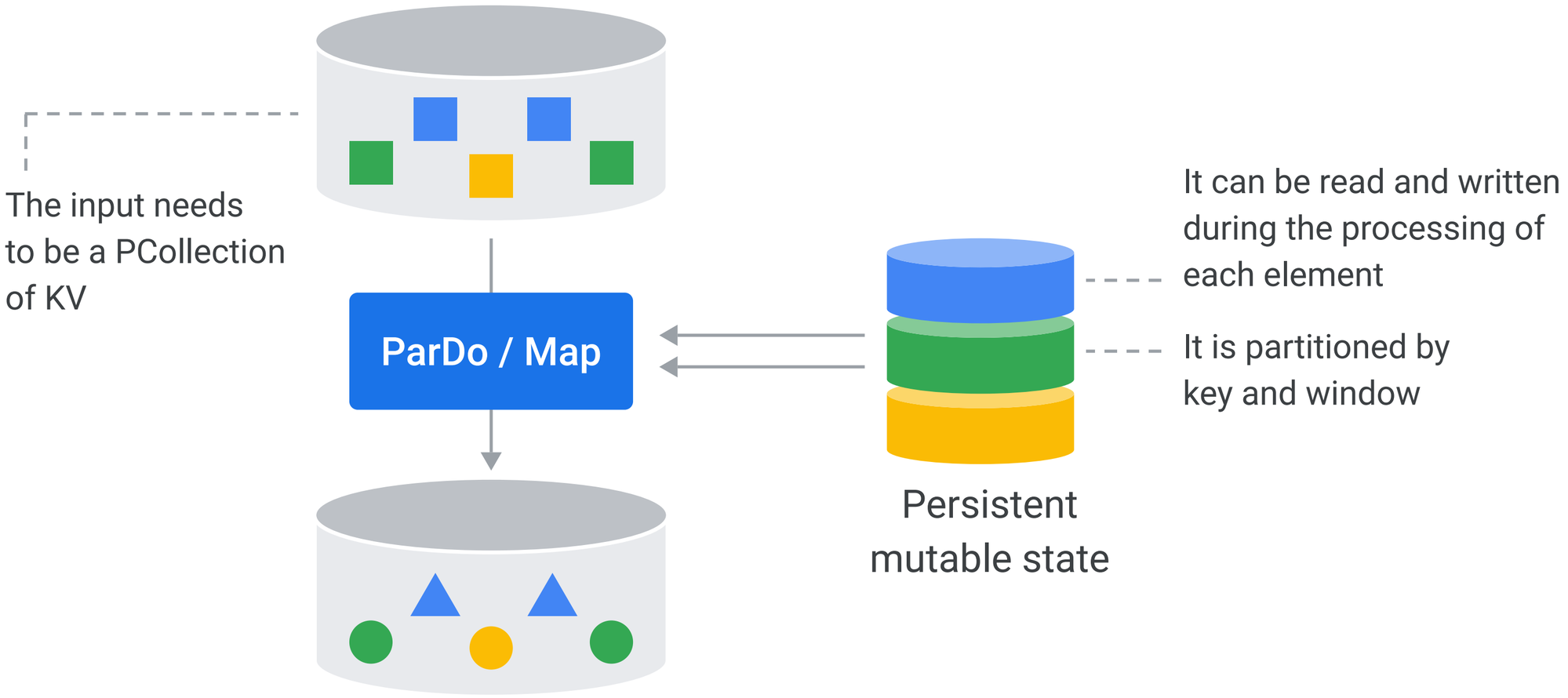


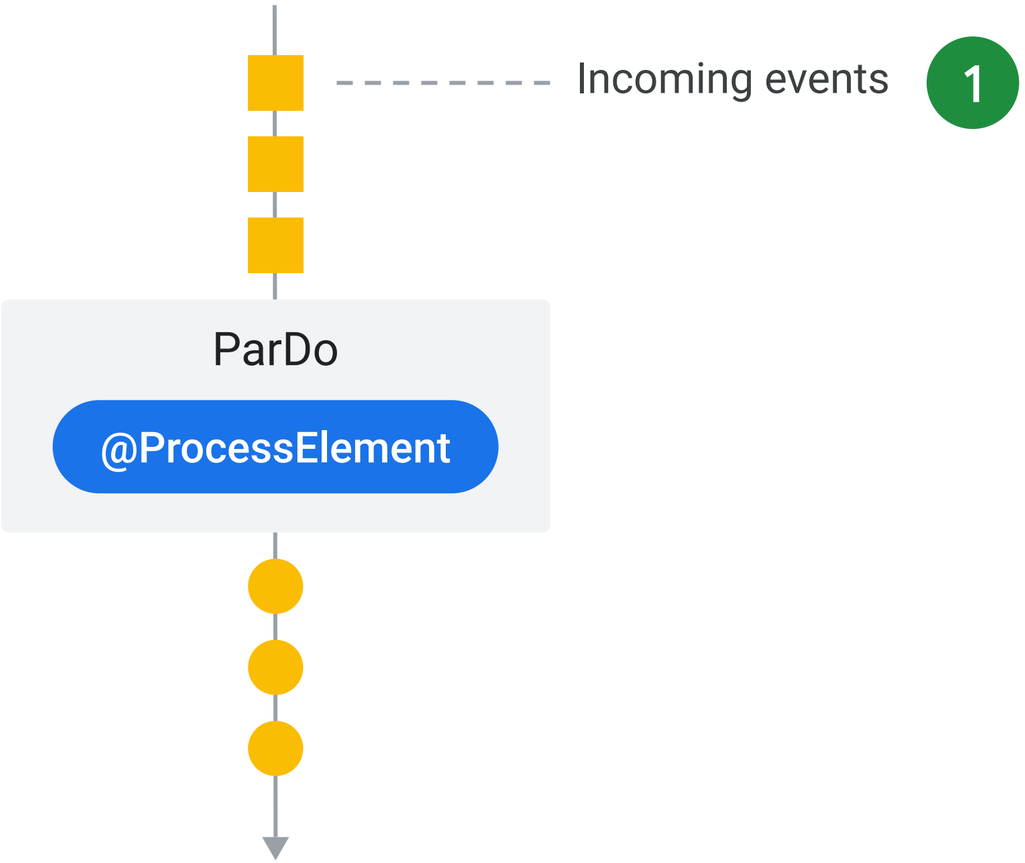
How to aggregate data in Apache Beam



Introducing stateful ParDo



How does it work?



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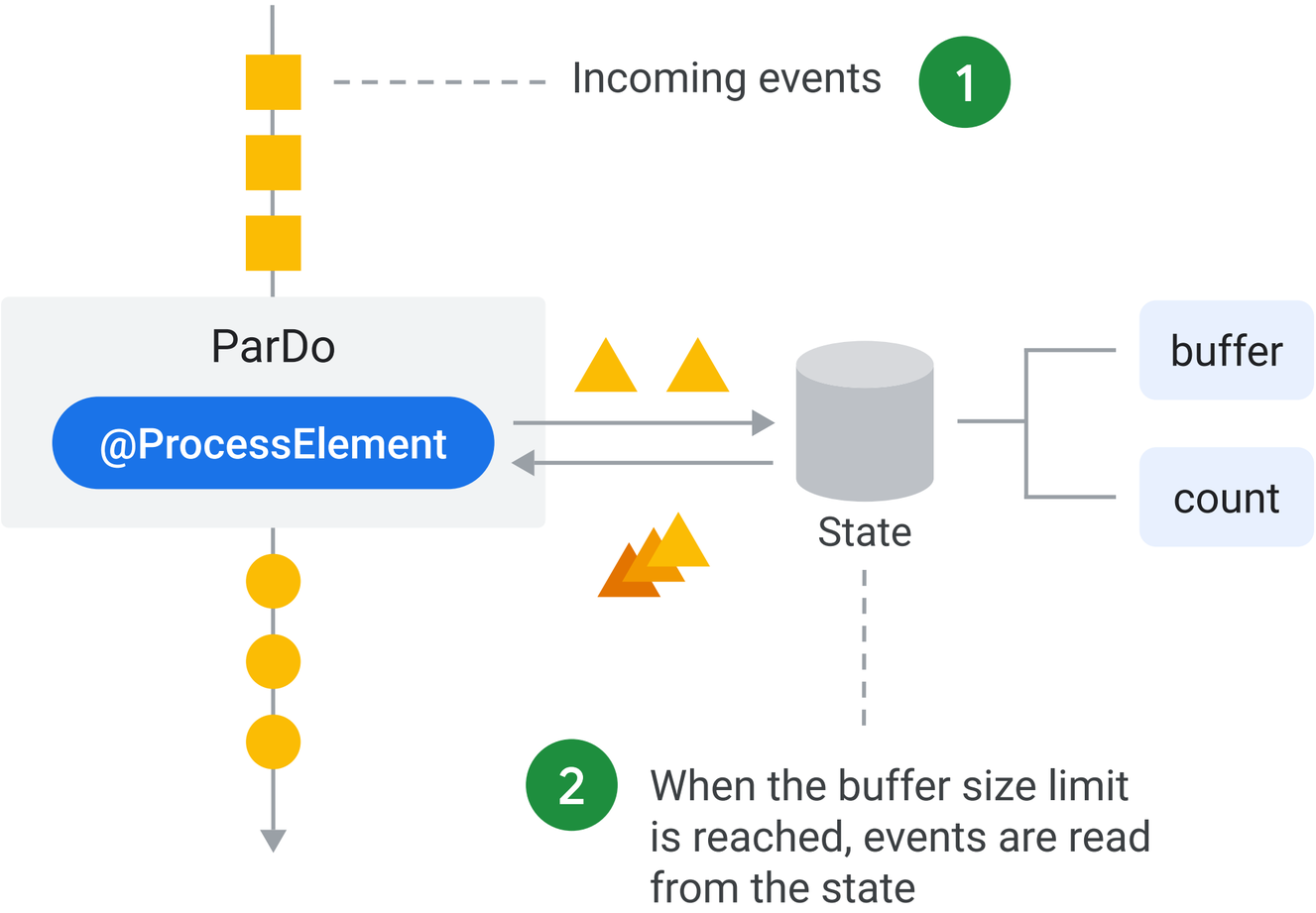

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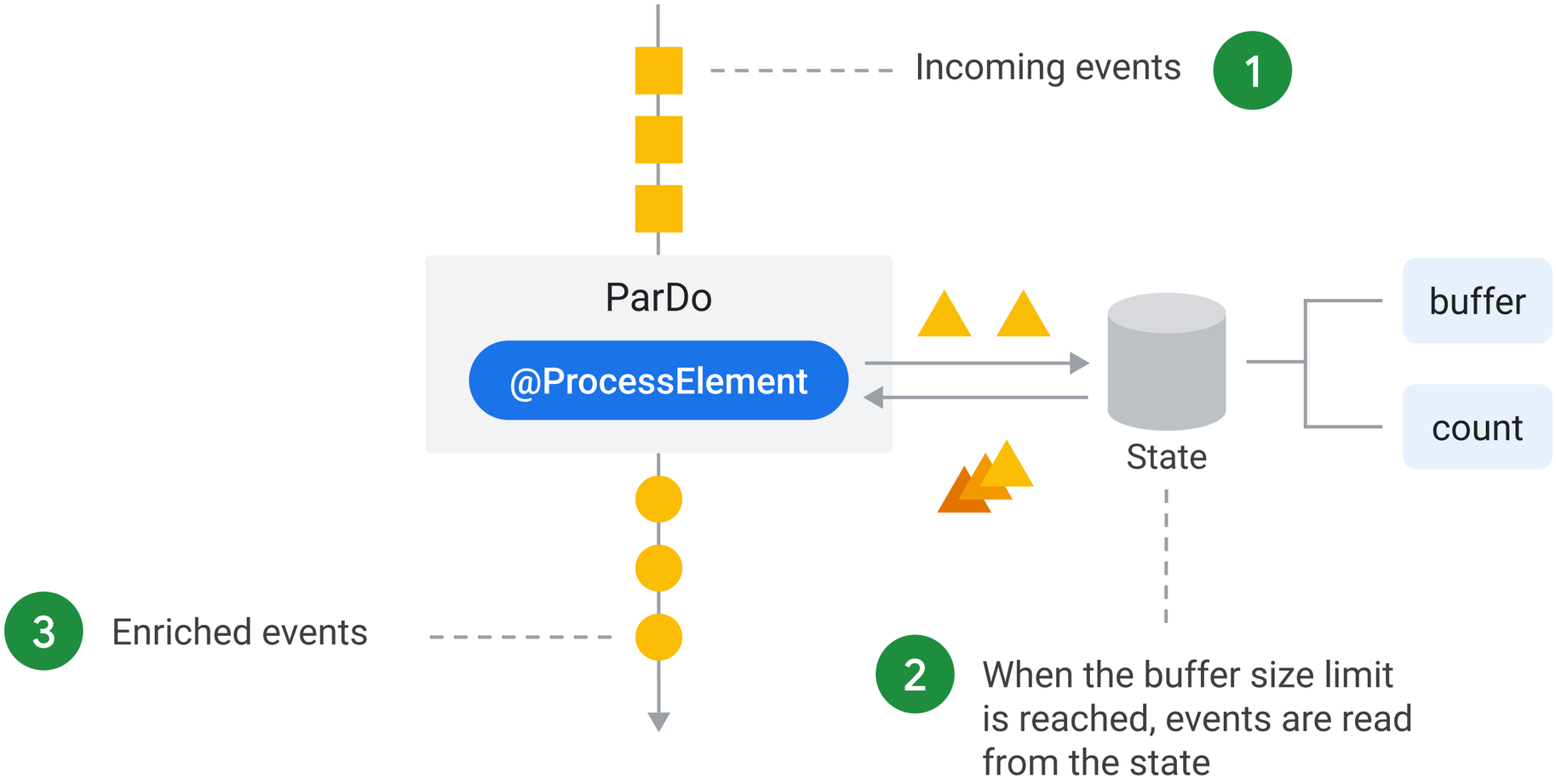
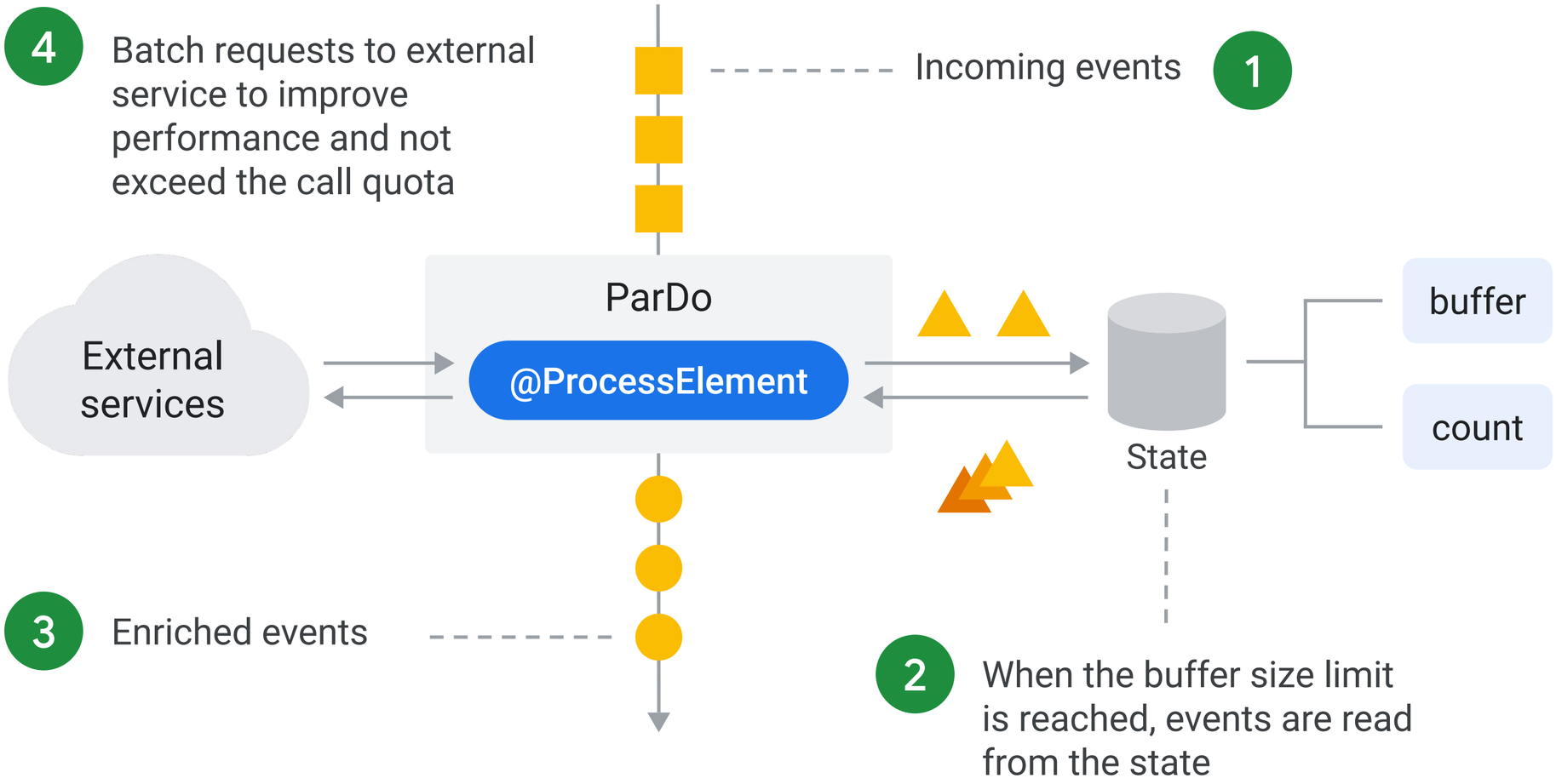


What is it useful for?



Python

```
class StatefulBufferingFn(beam.DoFn):
  MAX_BUFFER_SIZE = 500;
  BUFFER_STATE = BagStateSpec('buffer', EventCoder())
  COUNT_STATE = CombiningValueStateSpec('count',
                                        VarIntCoder(),
                                        combiners.SumCombineFn())
  def process(self, element,
              buffer_state=beam.DoFn.StateParam(BUFFER_STATE),
              count_state=beam.DoFn.StateParam(COUNT_STATE)):
    buffer_state.add(element)
    count_state.add(1)
    count = count_state.read()
    if count >= MAX_BUFFER_SIZE:
      for event in buffer_state.read():
        yield event
      count_state.clear()
      buffer_state.clear()
```

Increment count and add element to buffer

When buffer size limit is reached, a request is sent to the external service

Java

```java
new DoFn<Event, EnrichedEvent>() {
  private static final int MAX_BUFFER_SIZE = 500;
  @StateId("buffer") private final StateSpec<BagState<Event>> bufferedEvents = StateSpecs.bag();
  @StateId("count")  private final StateSpec<ValueState<Integer>> countState = StateSpecs.value();

  @ProcessElement
  public void process(ProcessContext context,
      @StateId("buffer") BagState<Event> bufferState,
      @StateId("count") ValueState<Integer> countState) {
    int count = firstNonNull(countState.read(), 0);
    count = count + 1; countState.write(count);
    bufferState.add(context.element());
    if (count >= MAX_BUFFER_SIZE) {
      for (EnrichedEvent enrichedEvent : enrichEvents(bufferState.read())) {
        context.output(enrichedEvent);
      }
      bufferState.clear();
      countState.clear();
    }
  }
  ...
}
```

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State and Timers

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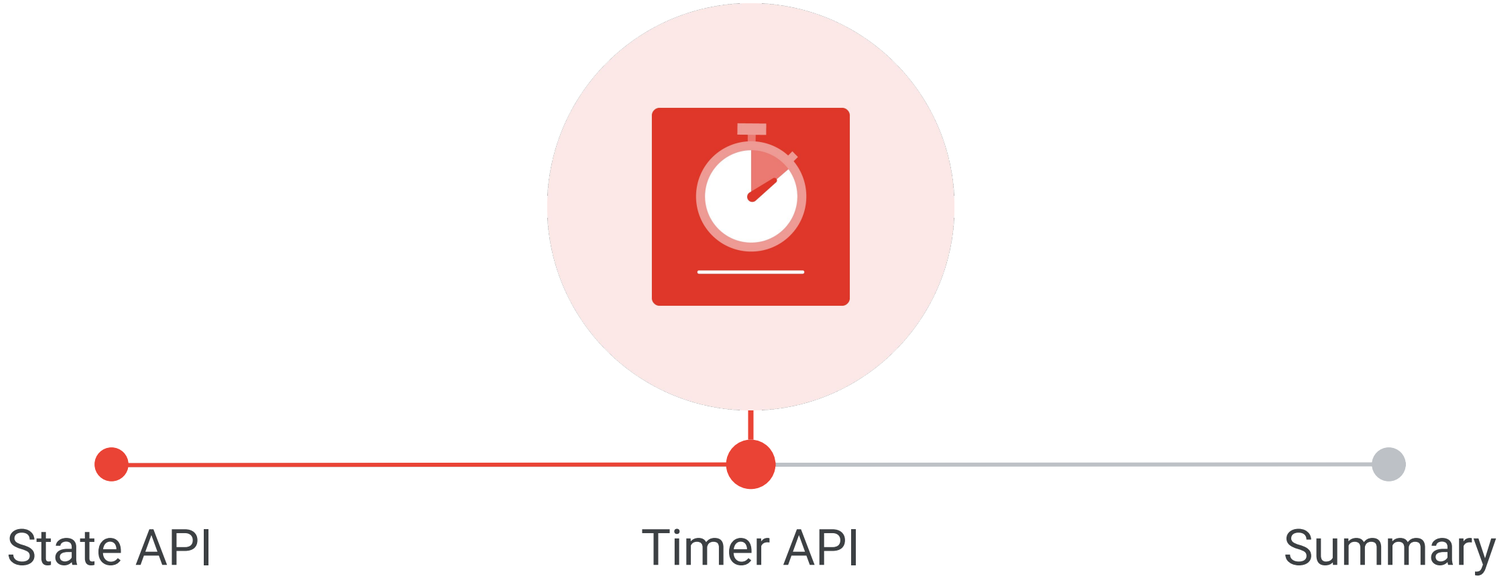

Timers

Event-time timers

Callback when the watermark reaches some threshold.

Processing-time timers

Callback after a certain amount of time has elapsed.

Python

```
class StatefulBufferingFn(beam.DoFn):
  …
  EXPIRY_TIMER = TimerSpec('expiry', TimeDomain.WATERMARK)
  def process(self, element,
              w=beam.DoFn.WindowParam,
              …
              expiry_timer=beam.DoFn.TimerParam(EXPIRY_TIMER)):
    expiry_timer.set(w.end + ALLOWED_LATENESS)
    … same logic as on previous code slide…

  @on_timer(EXPIRY_TIMER)
  def expiry(self,
             buffer_state=beam.DoFn.StateParam(BUFFER_STATE),
             count_state=beam.DoFn.StateParam(COUNT_STATE)):
    events = buffer_state.read()
    for event in events:
      yield event
    buffer_state.clear()
    count_state.clear()
```

Added an event time timer so that when the window expires, any events remaining in the buffer are processed.

Java

```
new DoFn<Event, EnrichedEvent>() {
  …
  @TimerId("expiry") private final TimerSpec expirySpec = TimerSpecs.timer(TimeDomain.EVENT_TIME);
  …
  @ProcessElement
  public void process(ProcessContext context, BoundedWindow window, …
   @TimerId("expiry") Timer expiryTimer) {
    expiryTimer.set(window.maxTimestamp().plus(allowedLateness));
    … same logic as on previous code slide…
 }

 @OnTimer("expiry")
 public void onExpiry(OnTimerContext context,
  @StateId("buffer") BagState<Event> bufferState) {
    if (!bufferState.isEmpty().read()) {
      for (EnrichedEvent enrichedEvent : enrichEvents(bufferState.read())) {
        context.output(enrichedEvent);
      }
      bufferState.clear();
    }
  }
}
```

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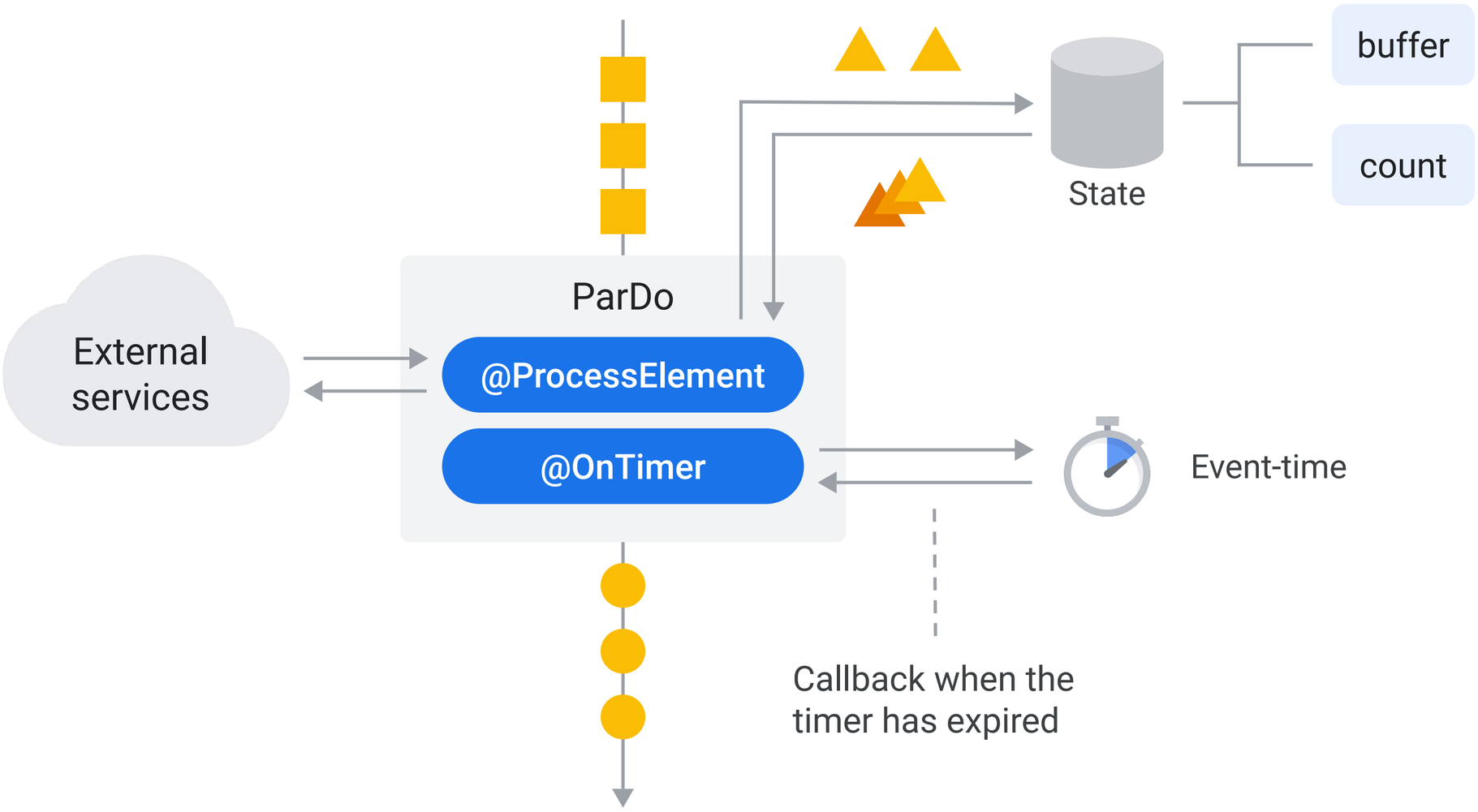
Stateful DoFn with state and timers



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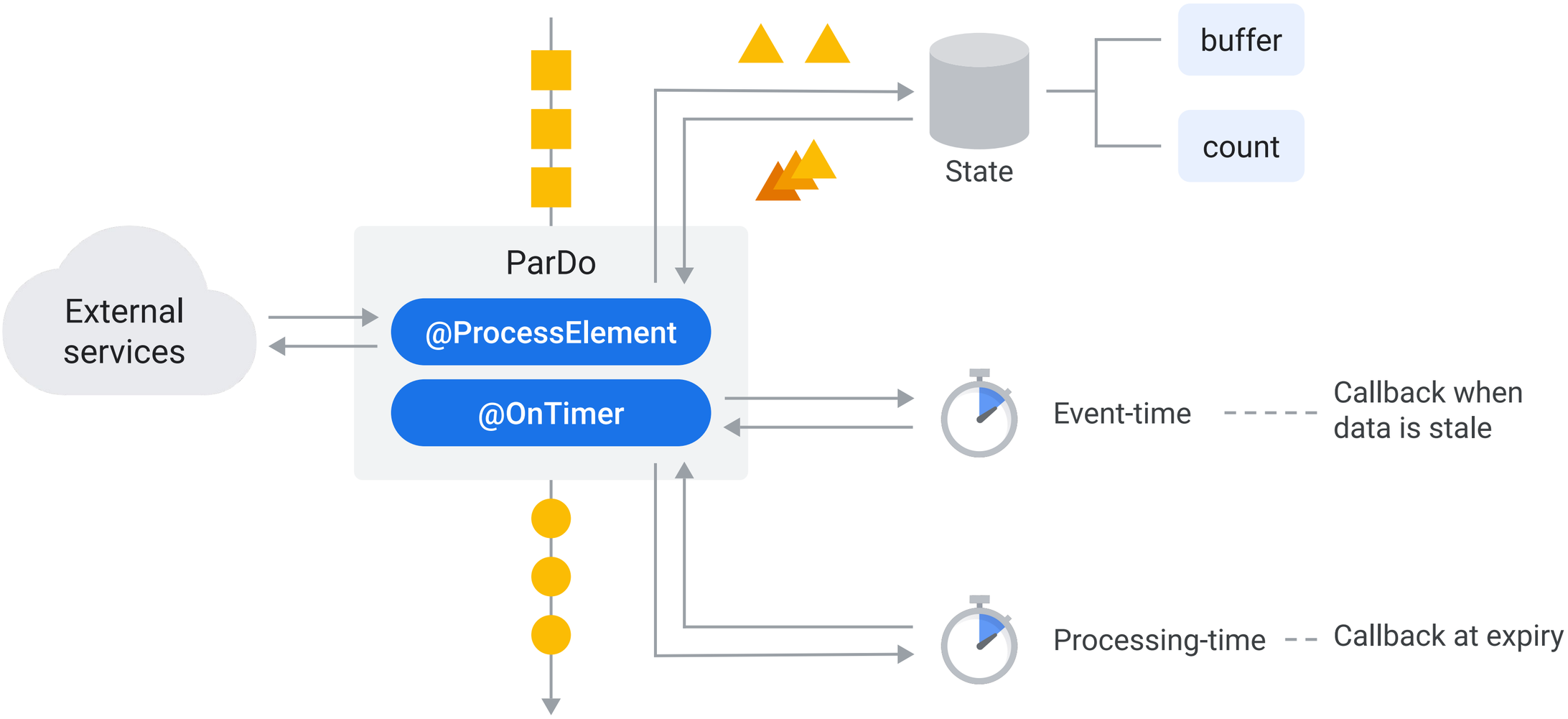

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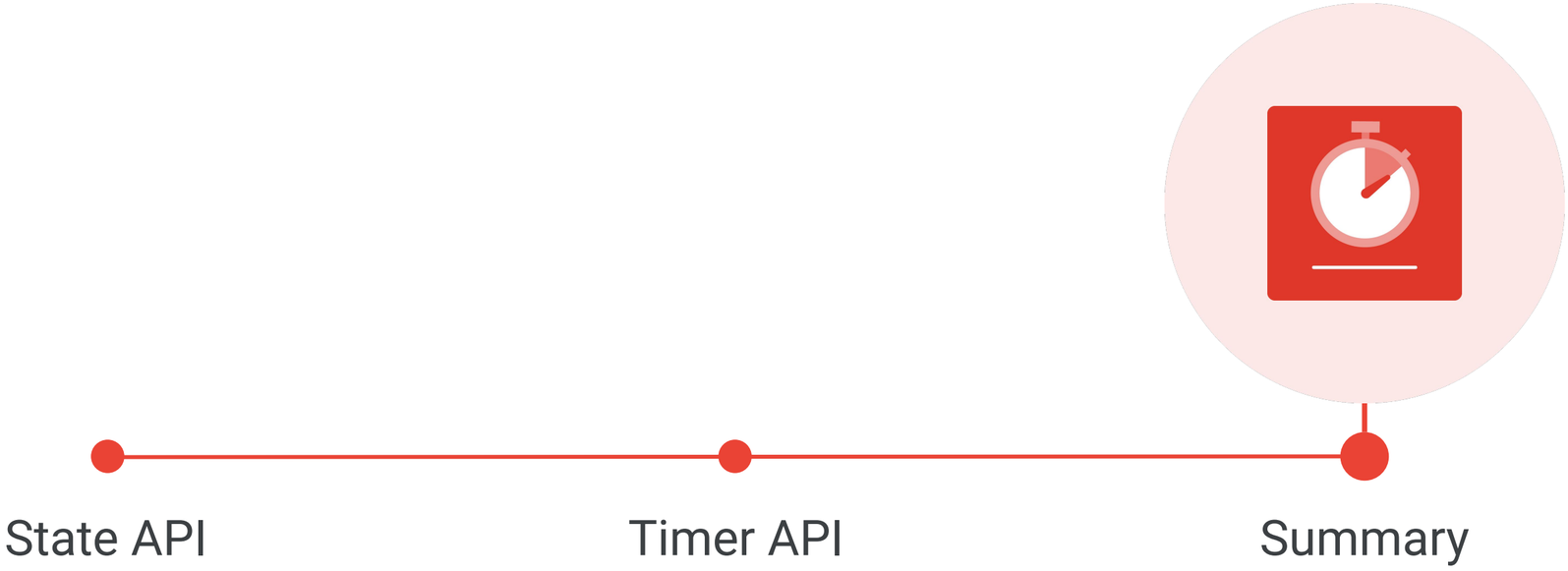

Summary: Types of timers

Processing time

Event time

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Event time

- Output based on completeness of input data
- Absolute times ("when the data is complete up to 5:00am")
- Final/authoritative outputs
- Don't leave data behind in state!

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Map	**Read/write just keys you specify**	✓

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Map	Read/write just keys you specify	✓
Set	Membership checking	✗

What can you do with state and timers?

- **Domain-specific triggering** ("output when five people who live in Seattle have checked in")
- **Slowly changing dimensions** ("update FX rates for currency ABC")
- **Stream joins** ("join-matrix" / "join-biclique")
- **Fine-grained aggregation** ("add odd elements to accumulator A and event elements to accumulator B")
- **Per-key workflows** (like user sign up flow w/ reminders & expiration)