The Dataflow Model
A Practical Approach to Balancing Correctness, Latency, and Cost in Massive-Scale, Unbounded, Out-of-Order Data Processing

Tyler Akidau et al.
Outline

Prerequisites
Problem
System
Evaluation
Prerequisites
Event vs Processing Time
Low Watermark

Actual watermark: [Graph showing processing time vs event time]

Ideal watermark: [Graph showing processing time vs event time]
Fixed Windowing
Unaligned Windowing (Tuples)
Unaligned Windowing (Sessions)
Problem
Tracking Video Sessions

- Online/Offline video platform
- Want aggregate stats per user: track sessions
- Pay advertisers per view: must be correct
- Want to adjust bids fast: low latency
- Must scale: distributed system
“A major shortcoming of all the models and systems mentioned above, is that they focus on input data as something which will at some point become complete.”
System
- *What* results are being computed.
- *Where* in event time they are being computed.
- *When* in processing time they are materialized.
- *How* earlier results relate to later refinements.
- **What** results are being computed. ✔
- **Where** in event time they are being computed.
- **When** in processing time they are materialized.
- **How** earlier results relate to later refinements.
Two Primitive Transforms

ParDo( ExpandPrefixes )

GroupByKey
Session Windowing Example

(k1, (v1, 13:02))
(k2, (v2, 13:14))
(k1, (v3, 13:57))
(k1, (v4, 13:20))

(k1, (v1, [13:02, 13:32]))
(k2, (v2, [13:14, 13:44]))
(k1, (v3, [13:57, 14:27]))
(k1, (v4, [13:20, 13:50]))

ParDo
AssignWindows
GroupByKey
MergeWindows
ParDo
MergeWindows
- **What** results are being computed. ✔
- **Where** in event time they are being computed. ✔
- **When** in processing time they are materialized.
- **How** earlier results relate to later refinements.
Triggering
Triggering (end of time)
Triggering (periodically)
Triggering (on input, tuples)
Triggering (on watermark + input)
- What results are being computed. ✔

- Where in event time they are being computed. ✔

- When in processing time they are materialized. ✔

- How earlier results relate to later refinements.
Accumulating
Discarding
Accumulating + Retracting

Event Time
12:01 12:02 12:03 12:04 12:05 12:06 12:07 12:08
Processing Time
12:06 12:07 12:08 12:09
-5 39 -25 -7 25 -10 7 5 3
5 7 3 4 10 -3 12

Actual watermark:
Ideal watermark:
- **What** results are being computed. ✔

- **Where** in event time they are being computed. ✔

- **When** in processing time they are materialized. ✔

- **How** earlier results relate to later refinements. ✔
Evaluation
Evaluation

- Name
- Concepts
- Necessity
- Clarity
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