Beam for Real-time Manufacturing Data Analysis

Jeswanth Yadagani - Oden Technologies

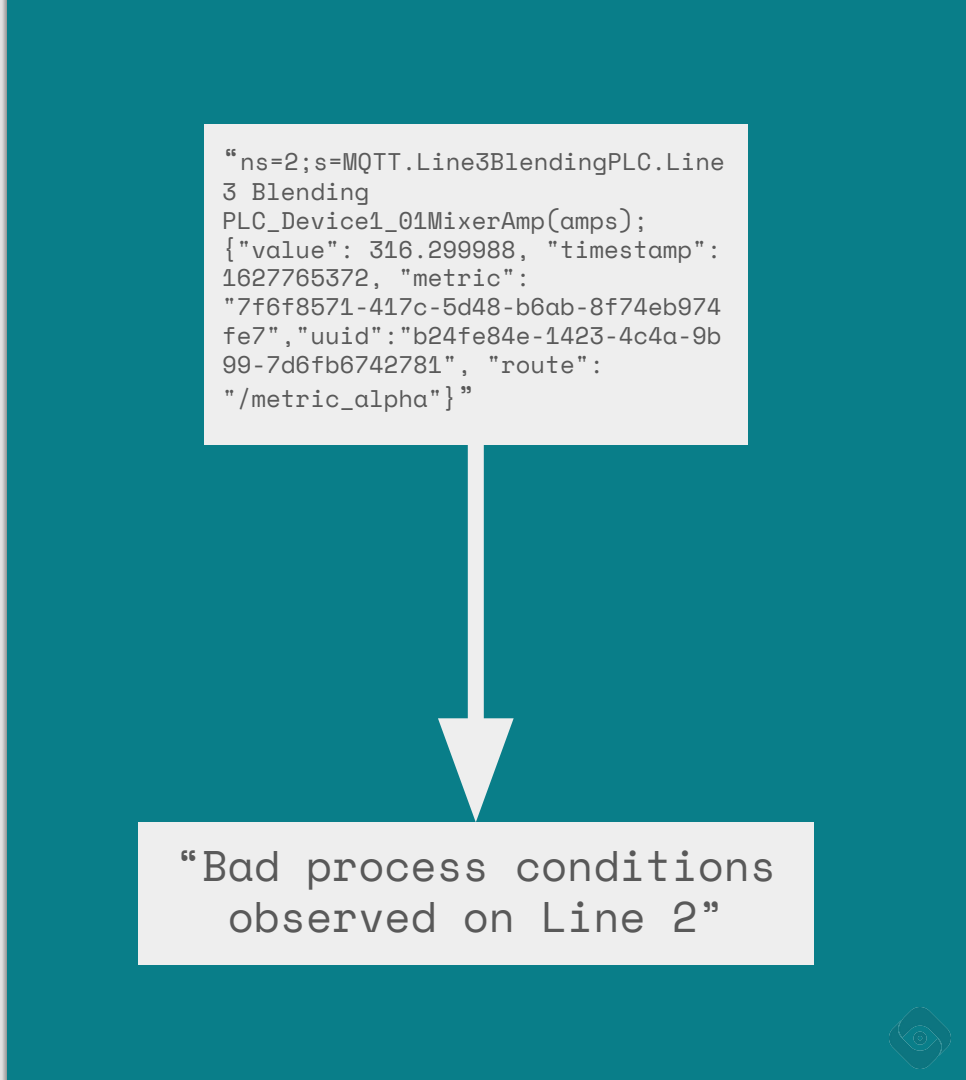
Jeswanth Yadagani

ML Engineer
Oden Technologies

Outline of this talk

- Oden and its customers
- Second bullet goes here
- Slide No. 10
- Fourth point is very important
- Fifth one is a secret! Don’t share
- blah blah blah.....
- This is an application of the third point
- The animations and flow charts
- Beam it is!
- Classic THANK YOU slide

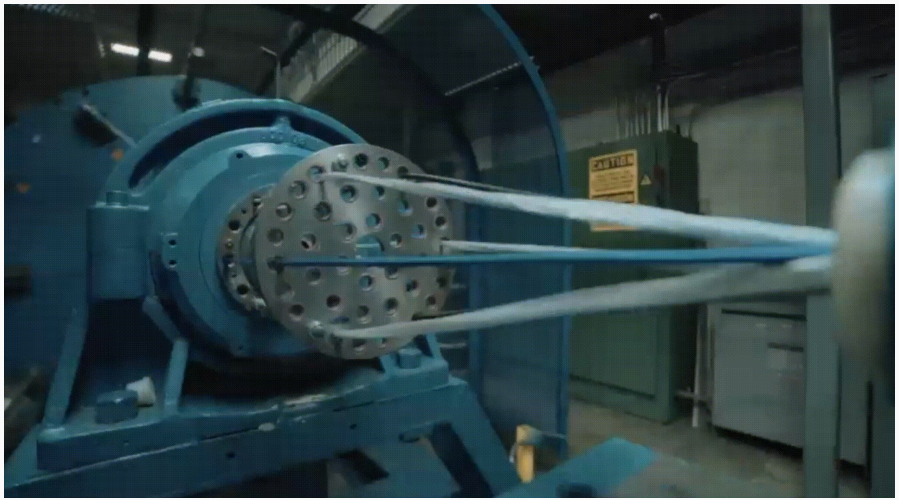
Outline of this talk



Oden Technologies

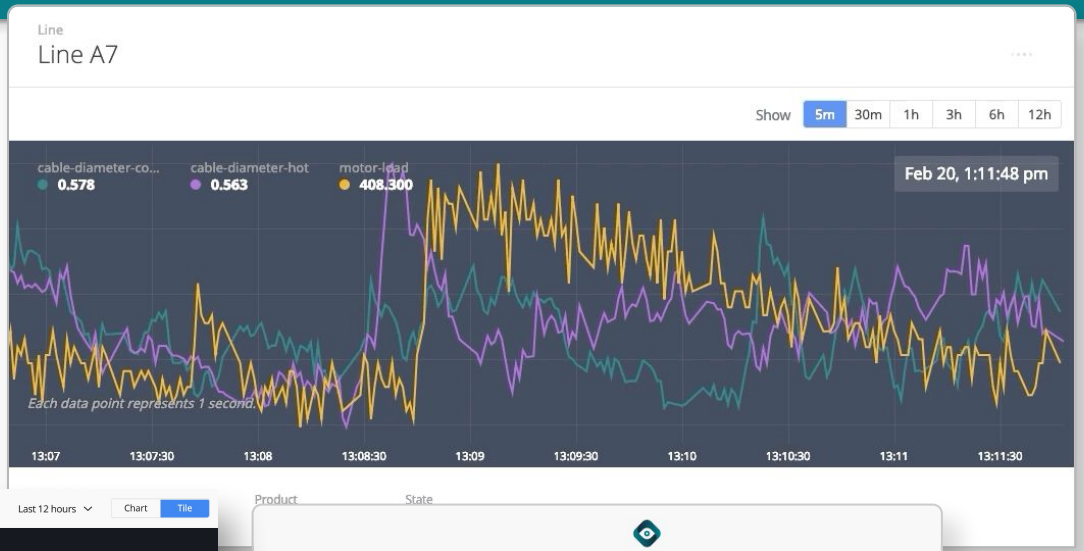
Oden's Customers

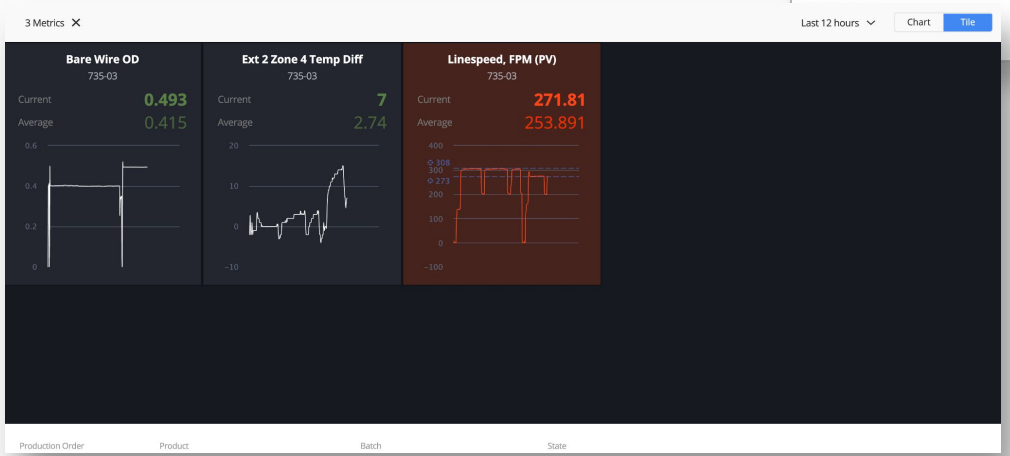
Medium to Large scale industries manufacturing wires & cables, pipes, chemical resins, paper and pulp

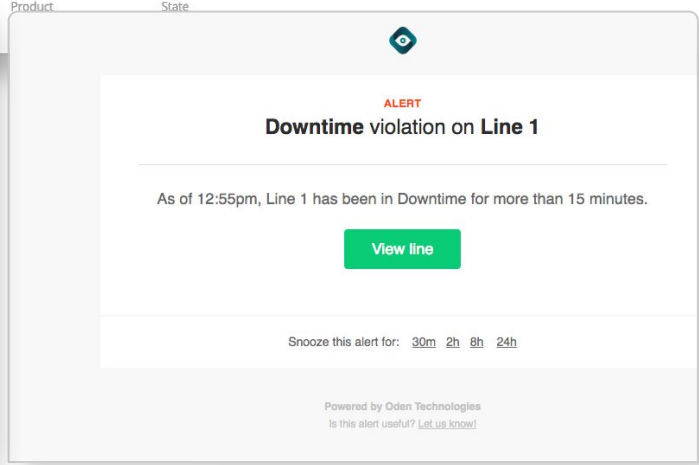


Our Product - Live Data and Alerting

- Metrics Streaming at a second resolution
- Real-time status indication of the process
- Real-time intelligent alerts

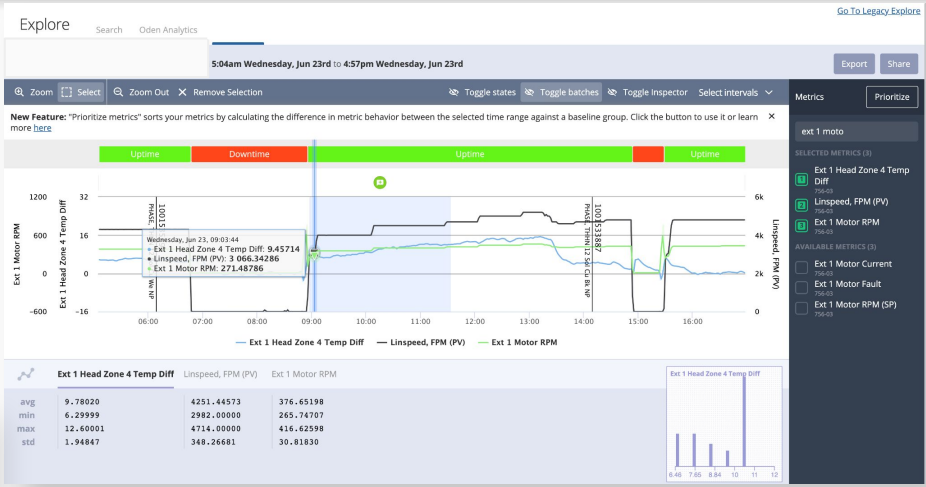


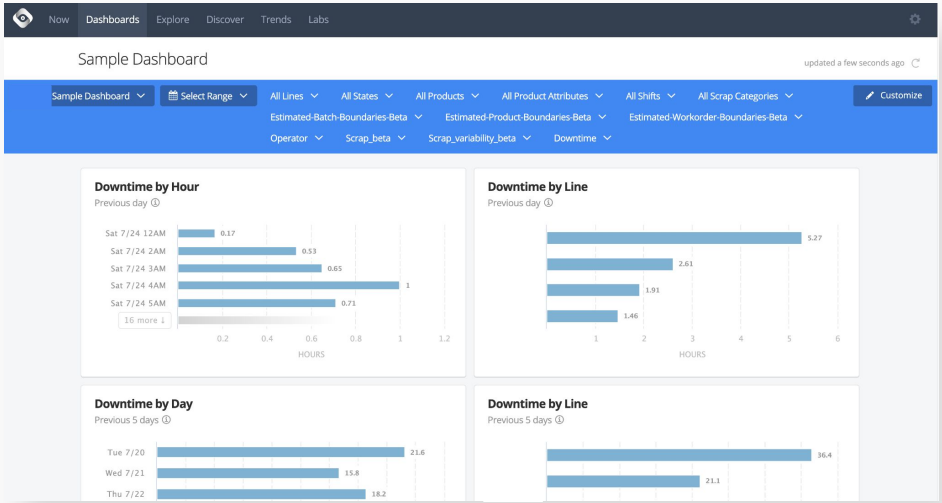




Our Product - Historic Analytics

- Centralize and compare metrics for root cause analysis.
- Custom dashboards indicating performance indexes of interest for comparison.





How do we Ingest Data into our Platform?

Data Ingestion Architecture

Sensor Readings

Operator Logs

OPC-UA Server

Google Cloud

Data Ingestion Architecture

Sensor Readings

Operator Logs

OPC-UA Server

Google Cloud

Cloud IoT Core

Data Ingestion Architecture

Sensor Readings

Operator Logs

OPC-UA Server

Google Cloud

Cloud IoT Core

Streaming Calculations

Pub Sub

Dataflow

Data Ingestion Architecture

Sensor Readings

Operator Logs

OPC-UA Server

Google Cloud

Cloud IoT Core

Streaming Calculations

Pub Sub

Dataflow

Storage

Cloud Big Table

Heroic Timeseries

Data Ingestion Architecture

Sensor Readings

Operator Logs

Data Maps

Metadata

Process Targets

OPC-UA Server

Google Cloud

Cloud IoT Core

API

Streaming Calculations

Pub Sub

Dataflow

Storage

Cloud Big Table

Heroic Timeseries

Data Ingestion Architecture

Sensor Readings

Operator Logs

Data Maps

Metadata

Process Targets

OPC-UA Server

Google Cloud

Cloud IoT Core

API

Streaming Calculations

Pub Sub

Dataflow

Storage

Cloud Big Table

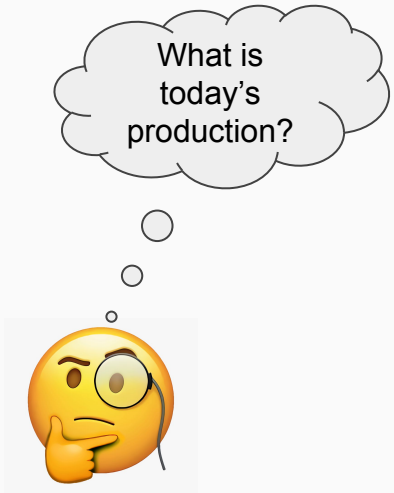
Heroic Timeseries

Cloud SQL

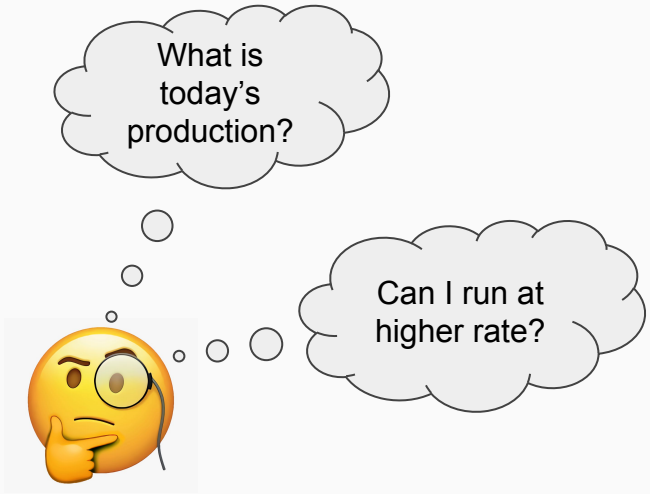
Postgres

Customer Questions/Requirements

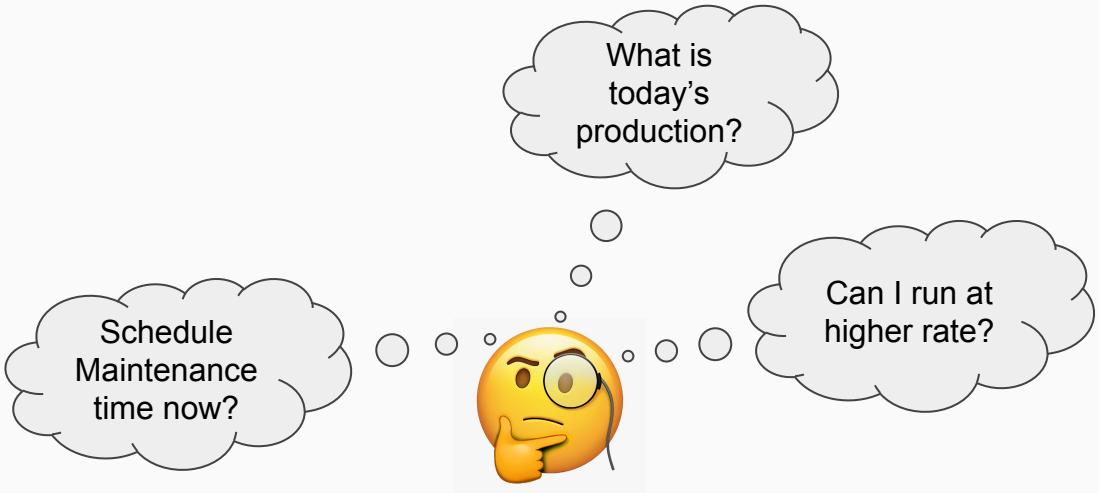
Questions! Questions! Questions!



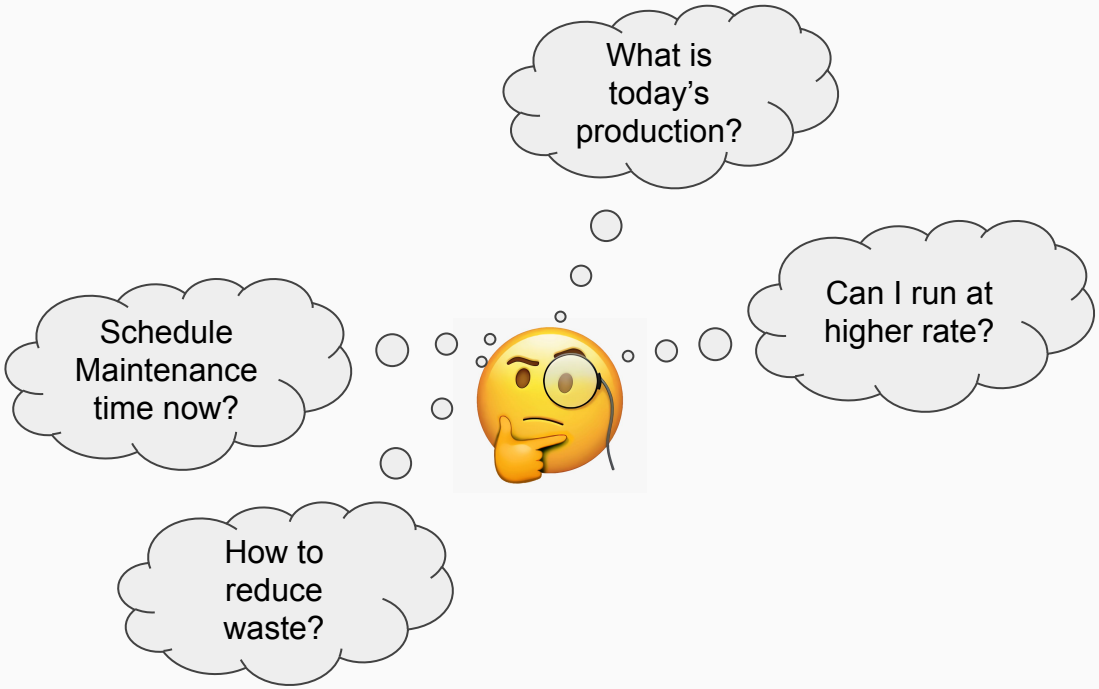
Questions! Questions! Questions!



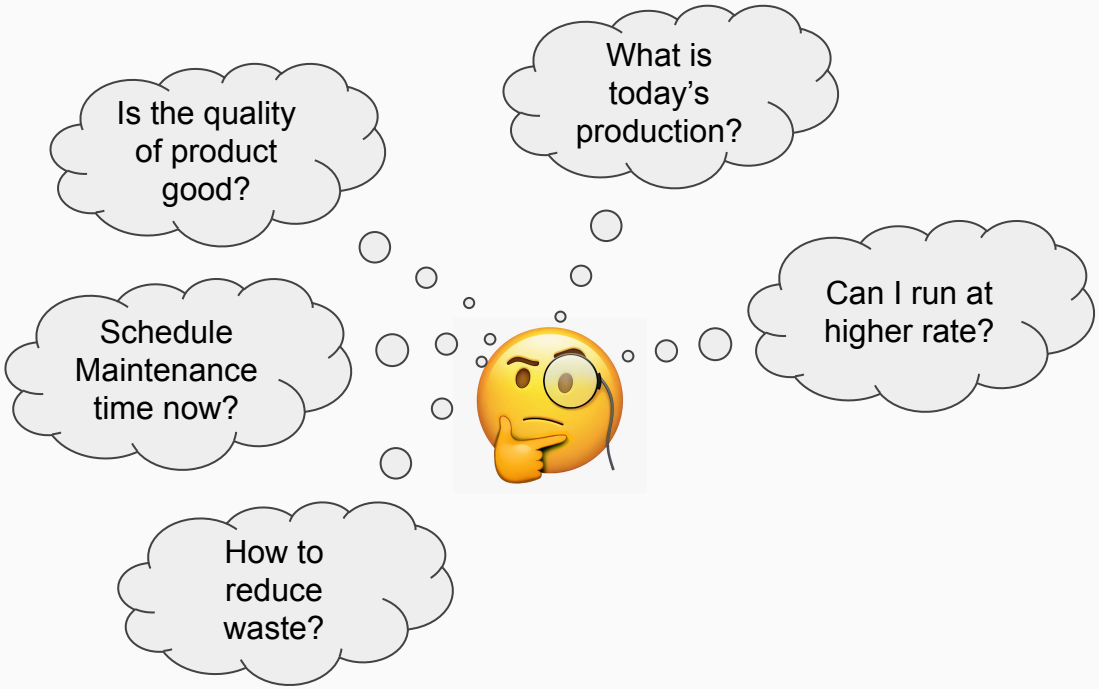
Questions! Questions! Questions!



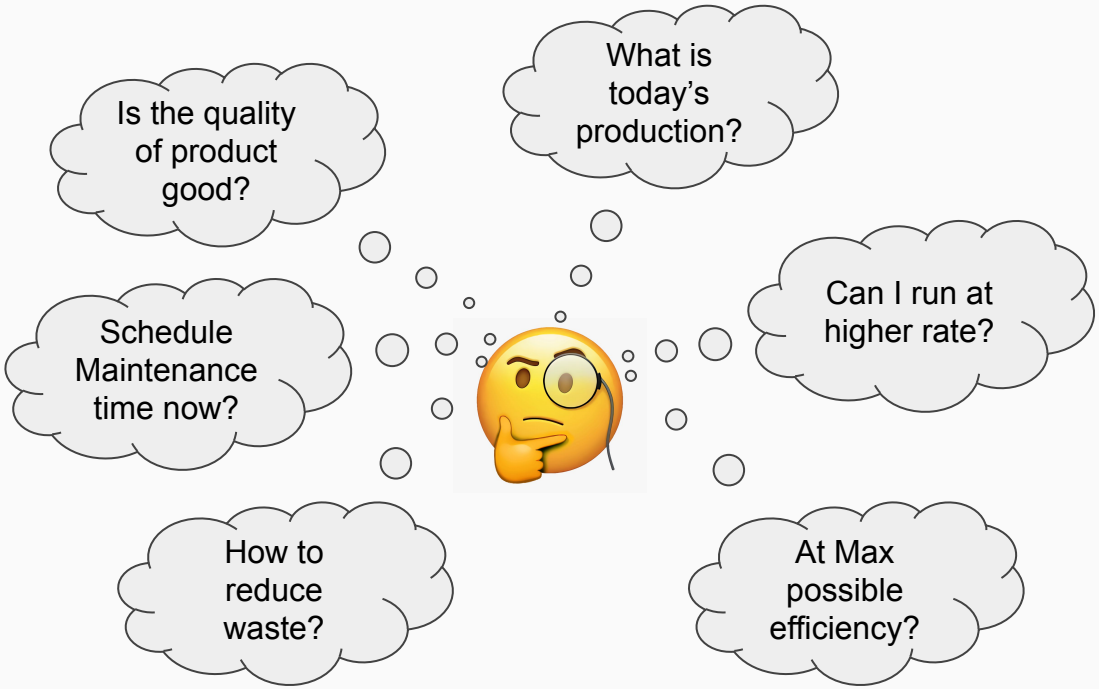
Questions! Questions! Questions!



Questions! Questions! Questions!



Questions! Questions! Questions!



Questions! Questions! Questions!

Streaming Metric Calculations with Apache Beam

THE LOOPS

BEAM! BEAM! BEAM!

Streaming Calculations

Pub Sub

Dataflow

THE LOOPS

BEAM! BEAM! BEAM!

Streaming Calculations

Pub Sub

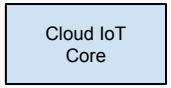
Dataflow

Stateless Calculation

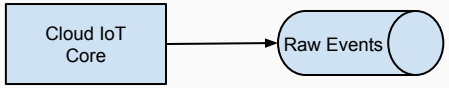
Windowed Calculation

Stateful Calculation

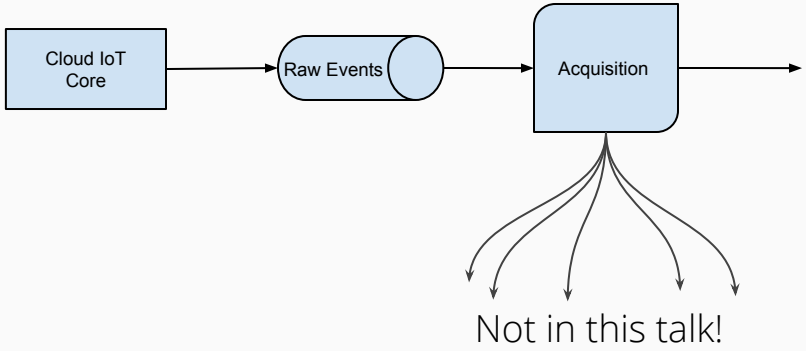
THE LOOPS



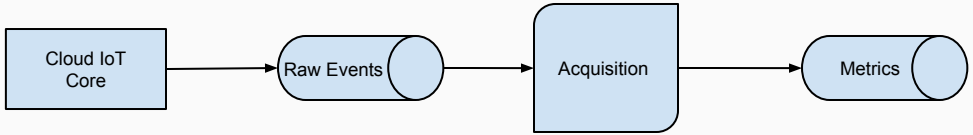
THE LOOPS



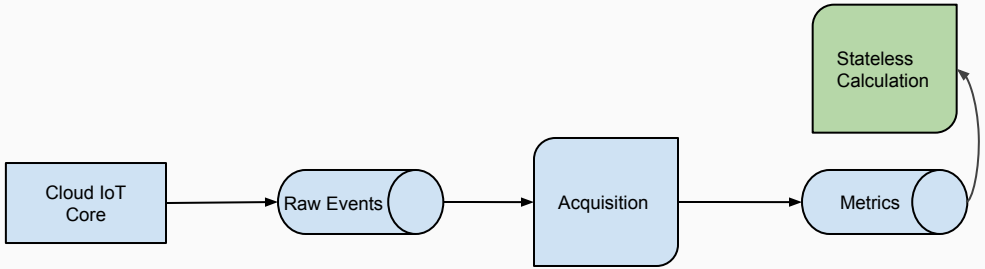
THE LOOPS



THE LOOPS



THE LOOPS



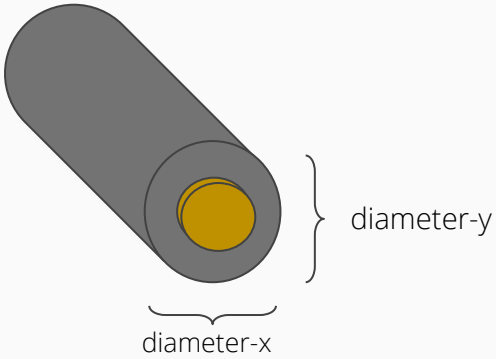
Operations on the data that is streaming in the present moment

Stateless Calculation

diameter_x

diameter_y

Raw streams: diameter-x and diameter-y



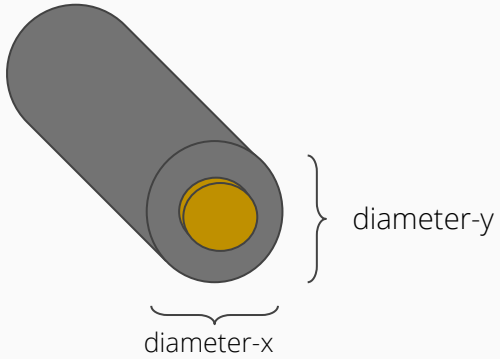
Stateless Calculation

diameter_x

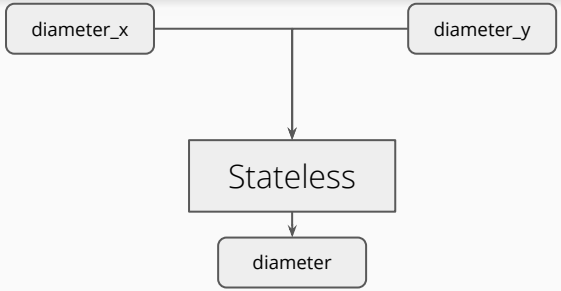
diameter_y

Raw streams: diameter-x and diameter-y

User Requirement: What is the diameter of cable that is being produced?



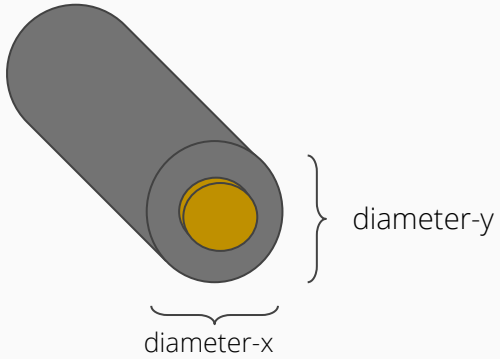
Stateless Calculation



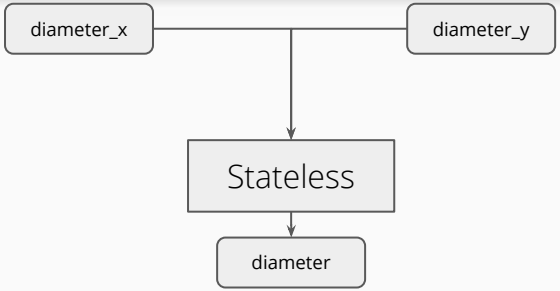
Raw streams: diameter-x and diameter-y

User Requirement: What is the diameter of cable that is being produced?

diameter = Stateless(diameter-x,
diameter-y,
function = mean)



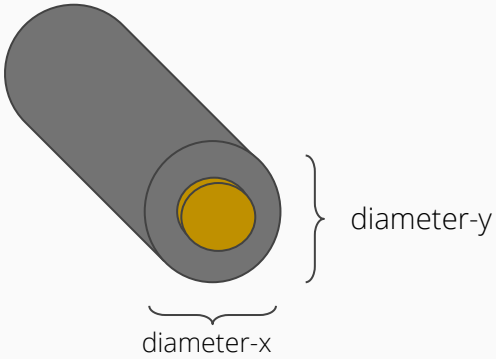
Stateless Calculation

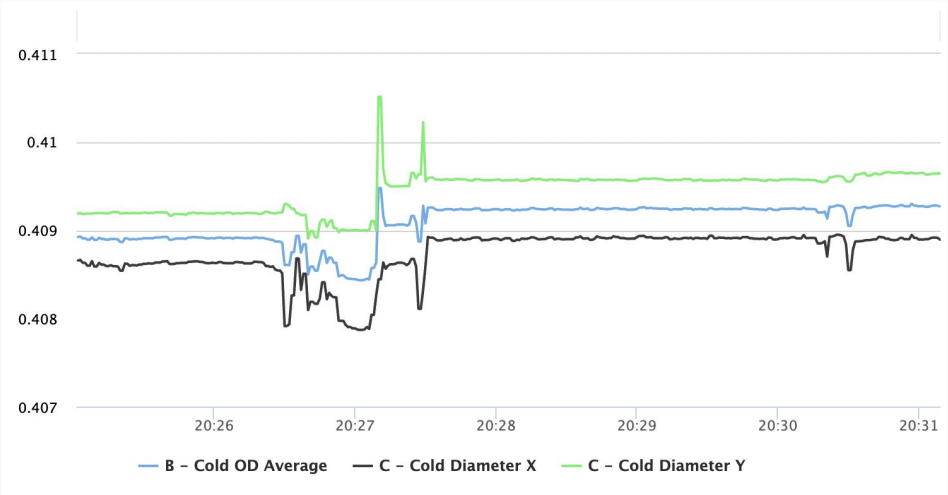


Raw streams: diameter-x and diameter-y

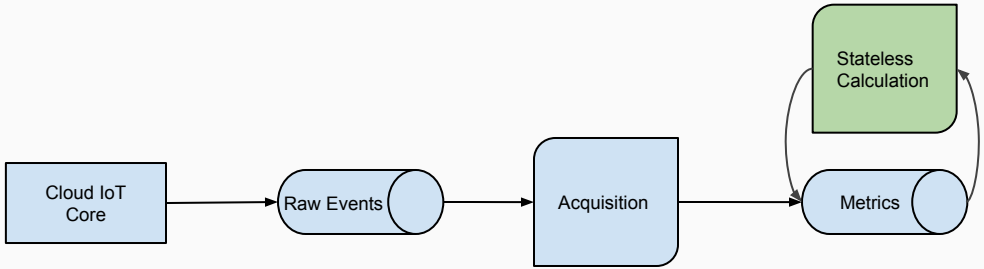
User Requirement: What is the diameter of cable that is being produced?

diameter = Stateless(diameter-x,
diameter-y,
function = mean)

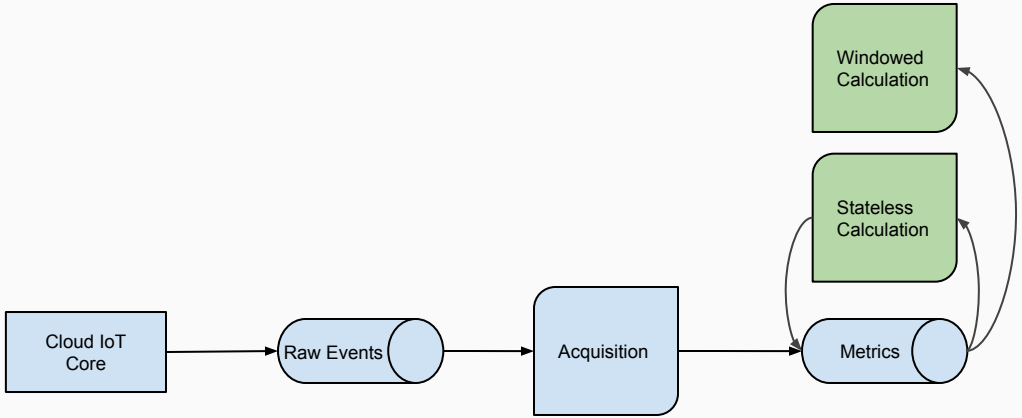




THE LOOPS

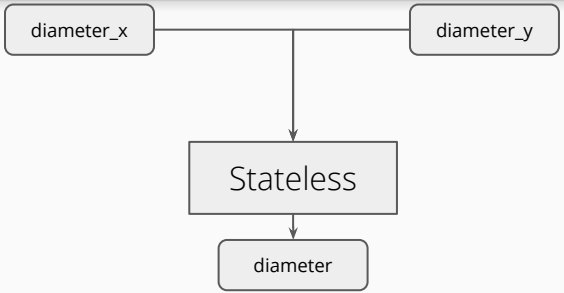

Stateless
Calculation
Cloud IoT
Core
Raw Events
Acquisition
Metrics

THE LOOPS



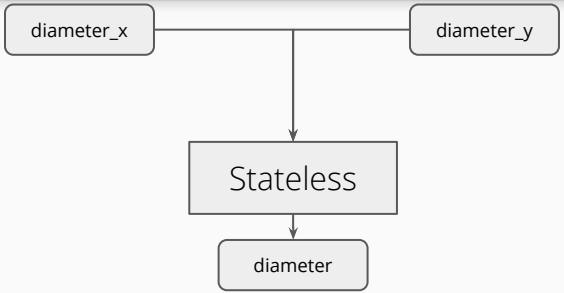
Operations on the data that is gathered into a window of predefined size

Windowed Calculation



Raw streams: diameter-x and diameter-y
Specifications: diameter-USL and diameter-LSL

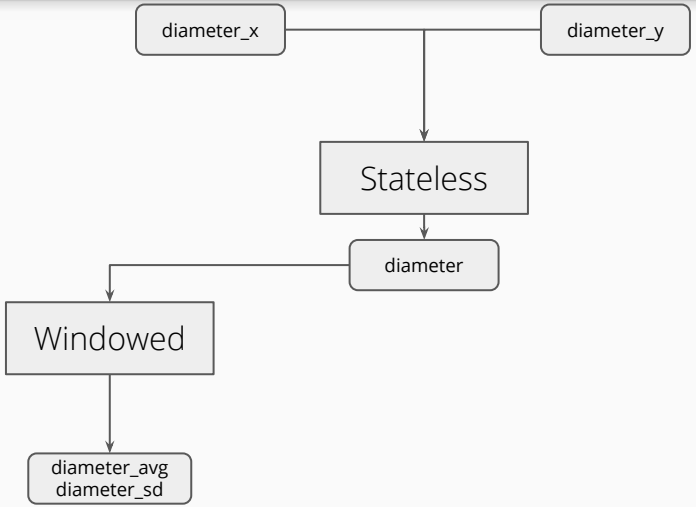
Windowed Calculation



Raw streams: diameter-x and diameter-y
Specifications: diameter-USL and diameter-LSL

User Requirement: Is diameter under specification limits?

Windowed Calculation

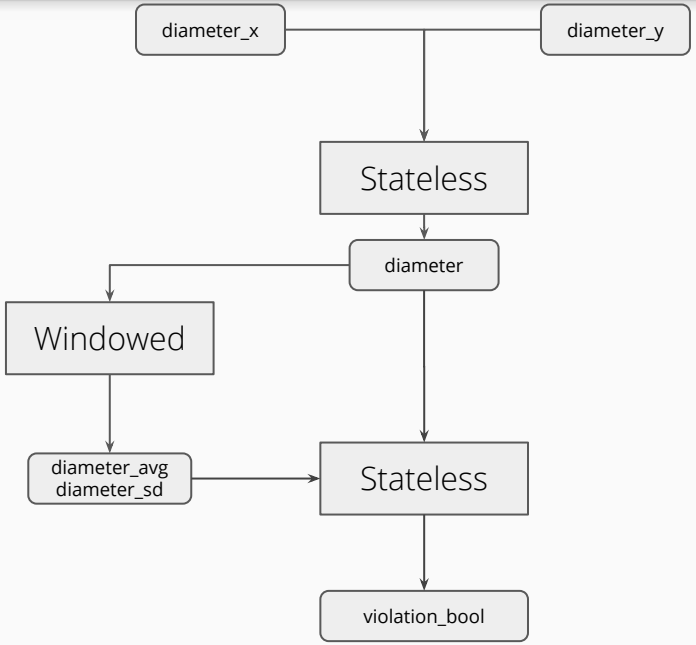


Raw streams: diameter-x and diameter-y
Specifications: diameter-USL and diameter-LSL

User Requirement: Is diameter under specification limits?

```
diameter_avg, diameter_sd = Window(diameter,
                                   functions = [avg, sd],
                                   size = 60s,
                                   slide = 5s)
```

Windowed Calculation



Raw streams: diameter-x and diameter-y
Specifications: diameter-USL and diameter-LSL

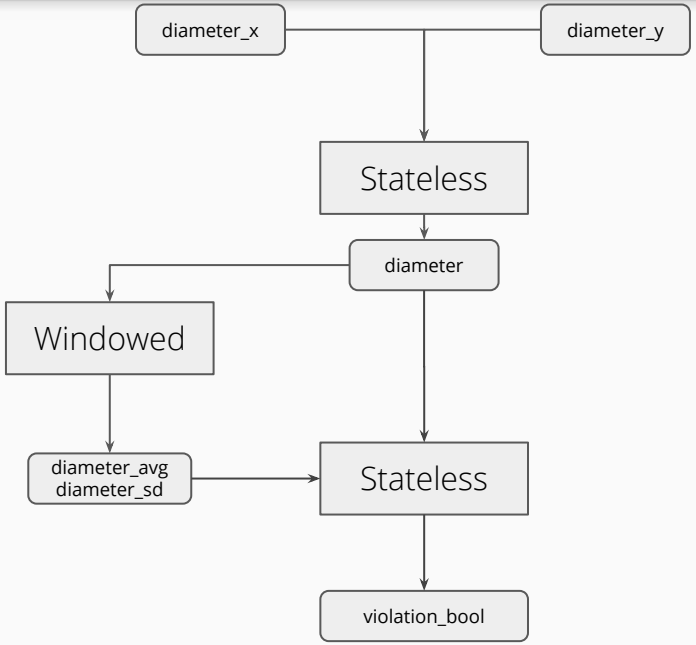
User Requirement: Is diameter under specification limits?

diameter_avg, diameter_sd = Window(diameter,
functions = [avg, sd],
size = 60s,
slide = 5s)

limit_bool = diameter-USL > diameter_avg > diameter-LSL

stability_bool = diameter_avg - 3*diameter_sd > diameter > diameter_avg + 3*diameter_sd

Windowed Calculation



Raw streams: diameter-x and diameter-y
Specifications: diameter-USL and diameter-LSL

User Requirement: Is diameter under specification limits?

diameter_avg, diameter_sd = Window(diameter,
functions = [avg, sd],
size = 60s,
slide = 5s)

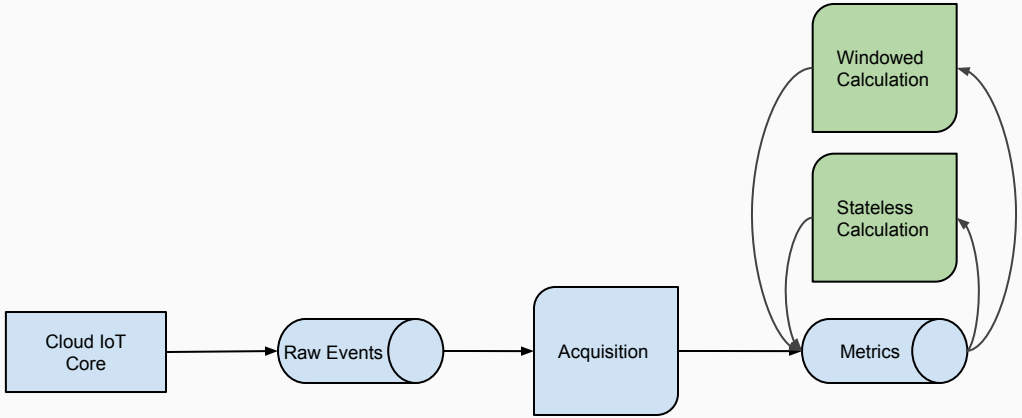
limit_bool = diameter-USL > diameter_avg > diameter-LSL

stability_bool = diameter_avg - 3*diameter_sd > diameter > diameter_avg + 3*diameter_sd

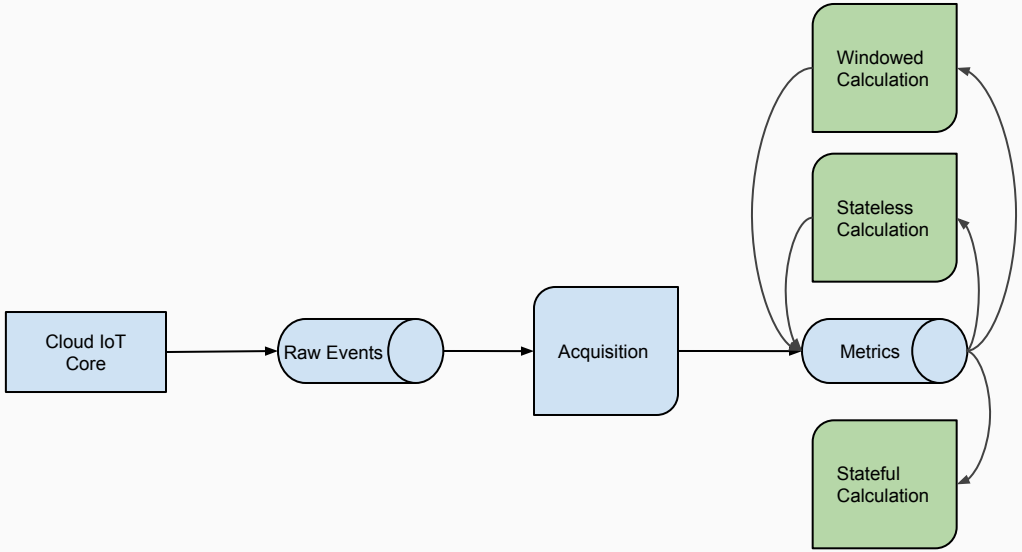
violation_bool = ~(limit_bool AND stability_bool)

This stream tells us if diameter is off specs

THE LOOPS

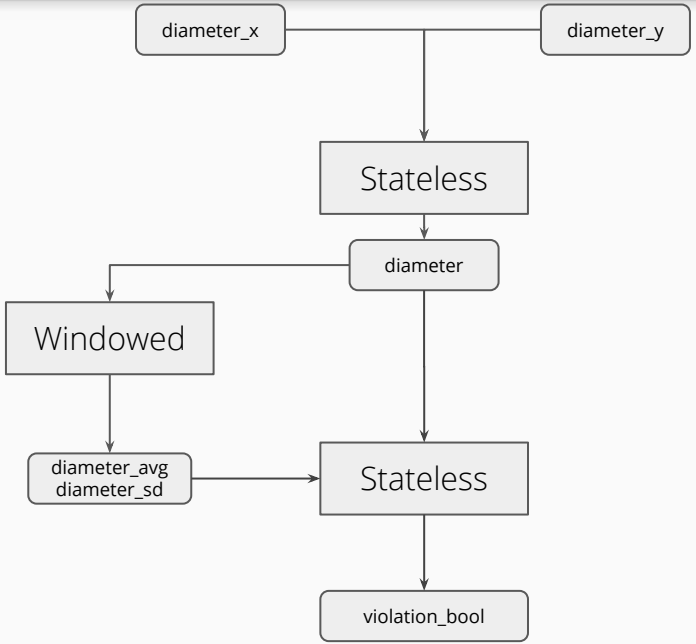

Windowed Calculation
Stateless Calculation
Cloud IoT Core
Raw Events
Acquisition
Metrics

THE LOOPS



Operations that leverage advantages of maintaining memory and are custom reset upto certain events of interest

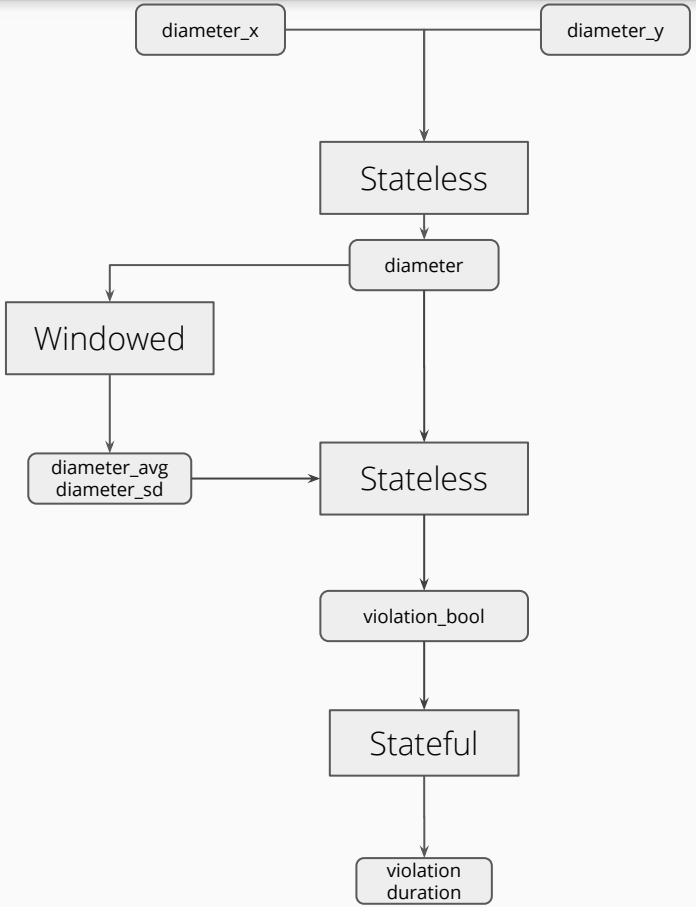
Stateful Calculation



Raw streams: diameter-x, diameter-y and **linespeed**
Specifications: diameter-USL and diameter-LSL

User Requirement: How much of the cable is off specs in this batch?

Stateful Calculation

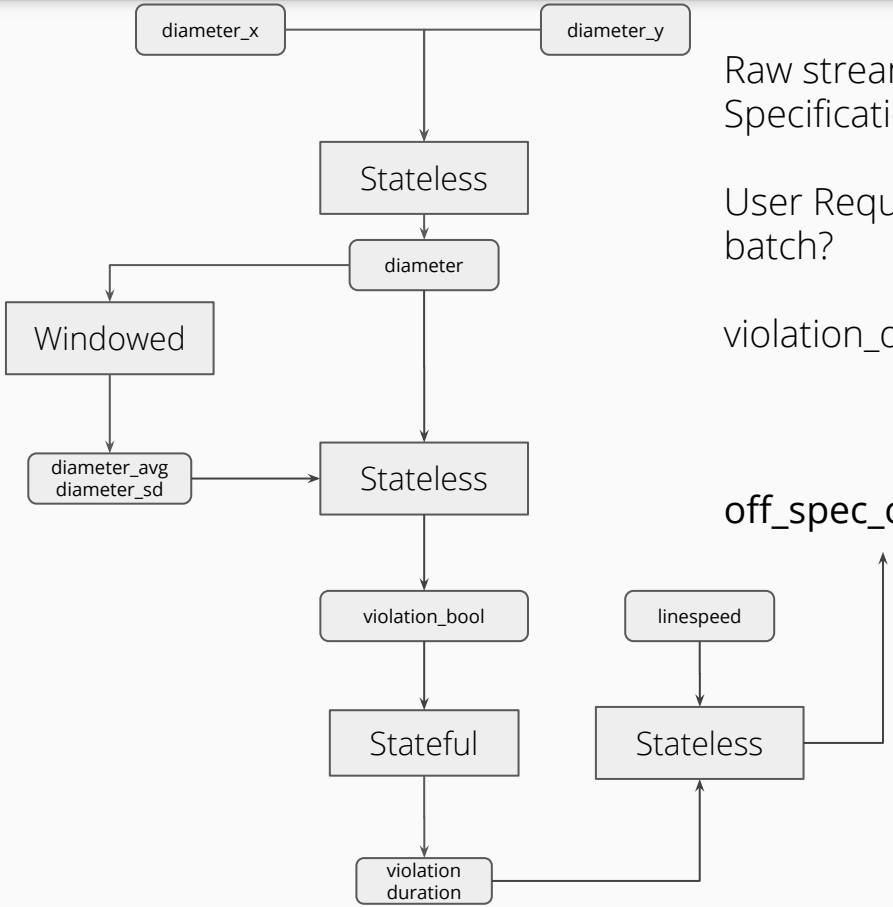


Raw streams: diameter-x, diameter-y and **linespeed**
Specifications: diameter-USL and diameter-LSL

User Requirement: How much of the cable is off specs in this batch?

violation_duration = Stateful(violation_bool,
function = time_aggregate,
reset_on = new batch)

Stateful Calculation



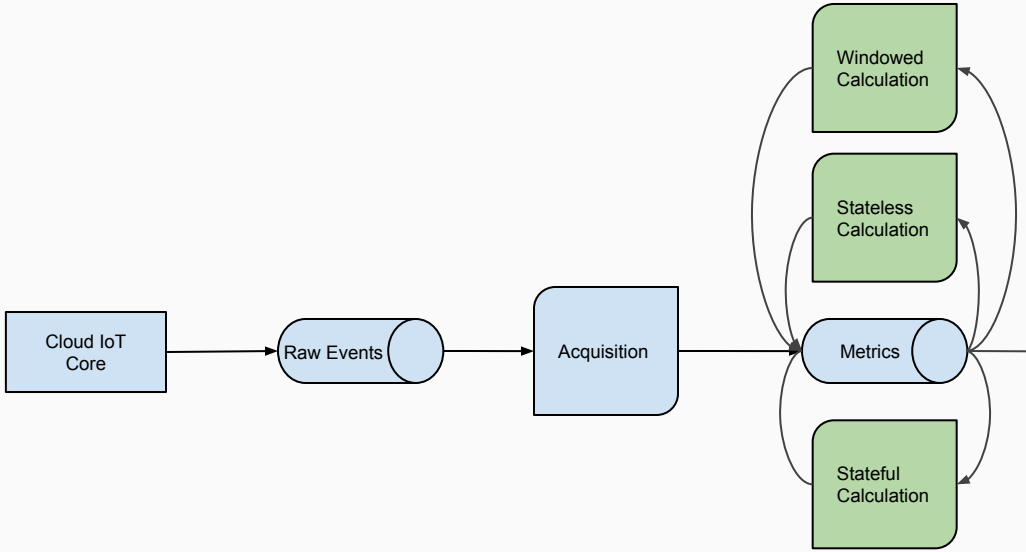
Raw streams: diameter-x, diameter-y and **linespeed**
Specifications: diameter-USL and diameter-LSL

User Requirement: How much of the cable is off specs in this batch?

violation_duration = Stateful(violation_bool,
function = time_aggregate,
reset_on = new batch)

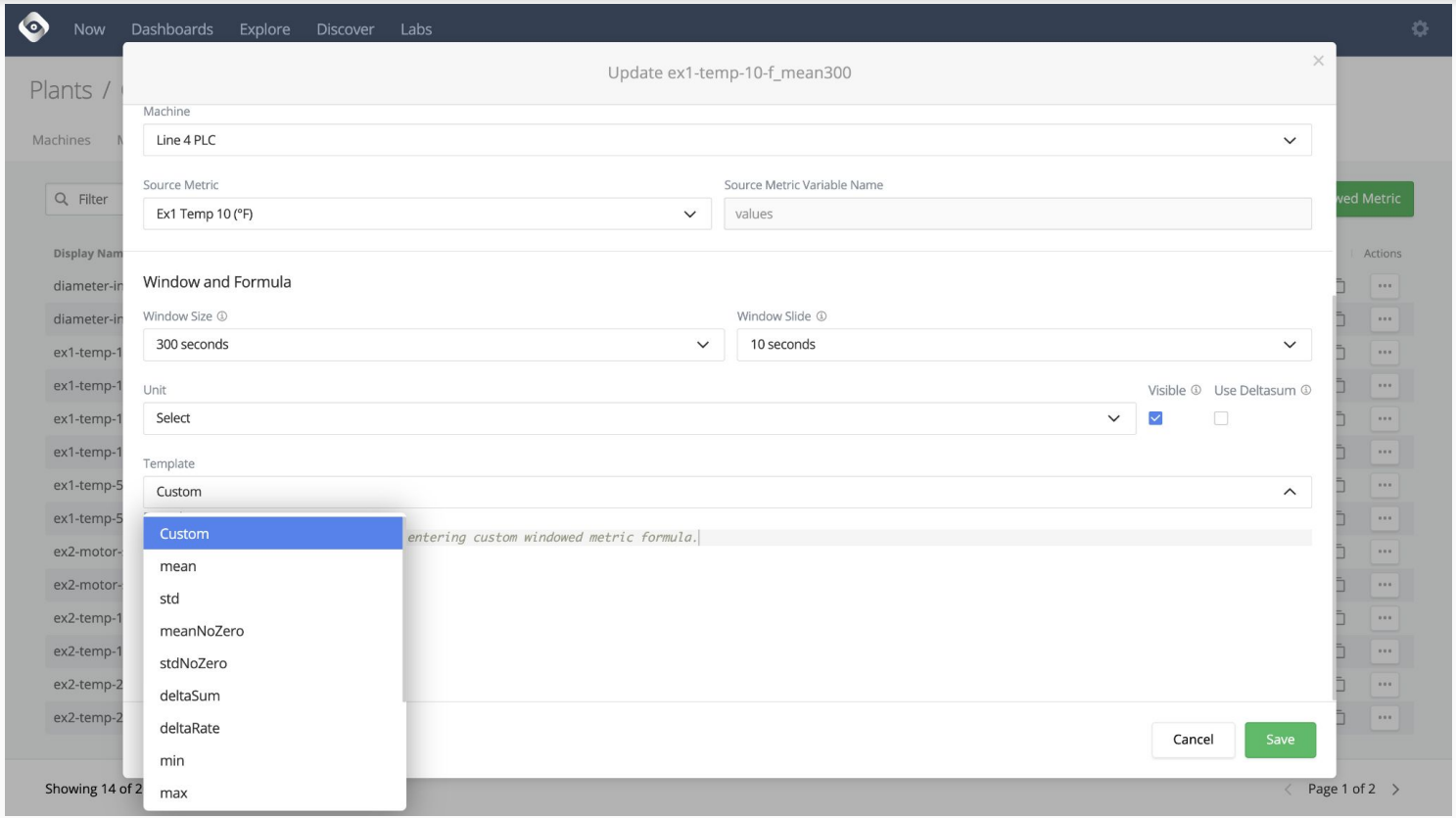
off_spec_cable = Stateless(linespeed, violation_duration
function = multiply)

THE LOOPS



Algebra of streaming analysis: LOOPS allow us to create arbitrary combinations of these three calculations to address any customer requirement

THE LOOPS

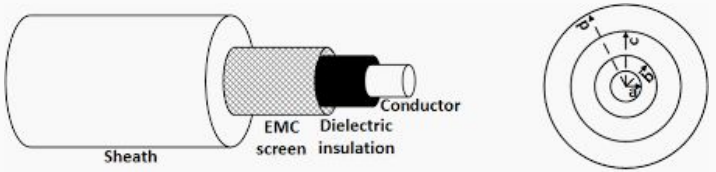


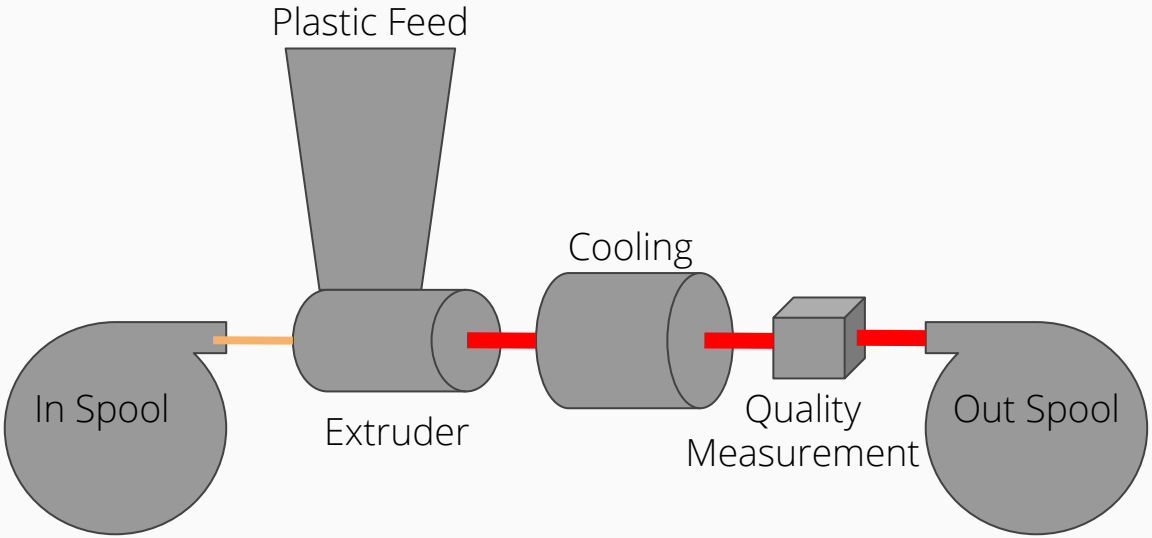
Rhino JS interpreter embedded within beam ParDos

Alerting on Bad Process Conditions

Cable Manufacturing

- Copper is pulled from an in-spool into an extruder.
- Plastic is melted over the copper to make wire.
- Wire is cooled.
- Wire is pulled into an out-spool.

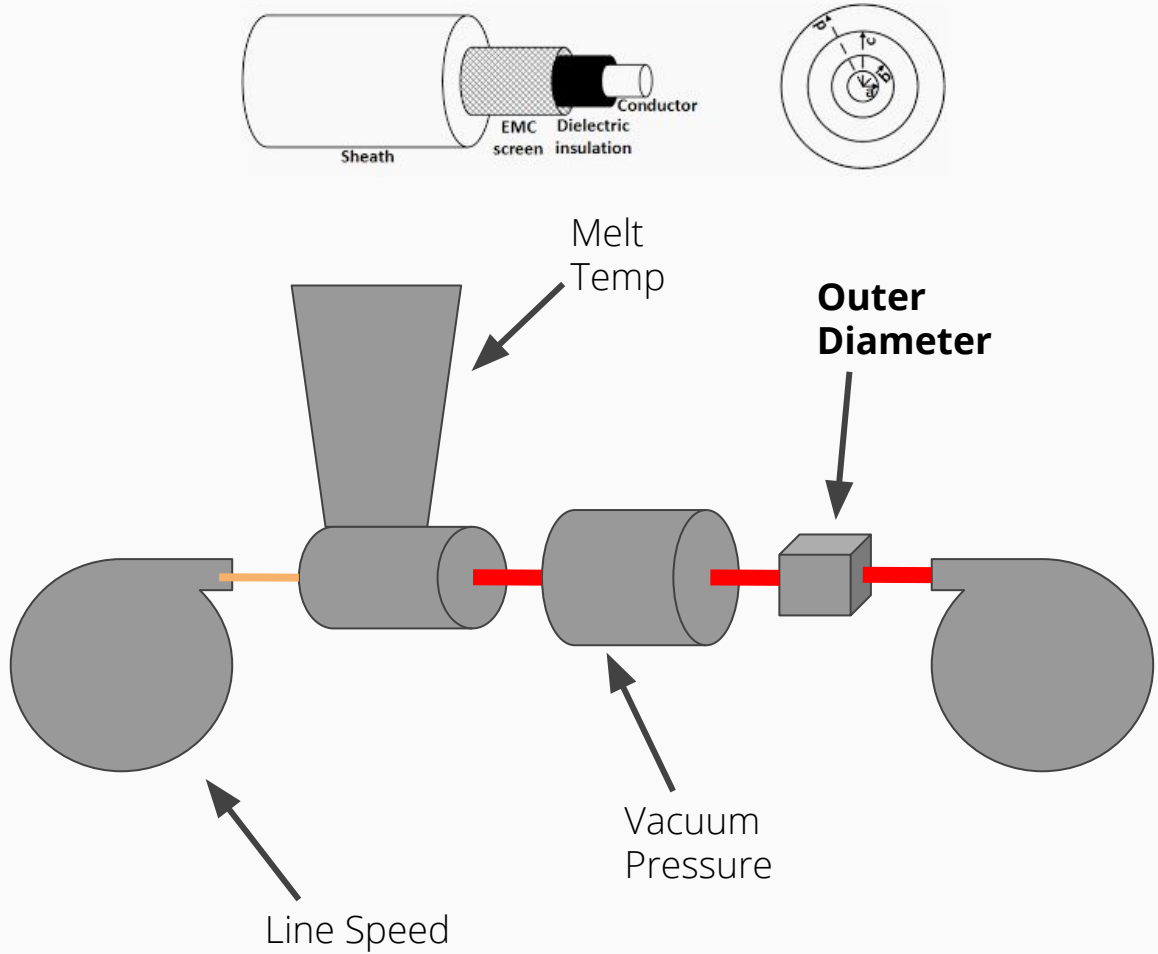




Cable Manufacturing

- Copper is pulled from an in-spool into an extruder.
- Plastic is melted over the copper to make wire.
- Wire is cooled.
- Wire is pulled into an out-spool.

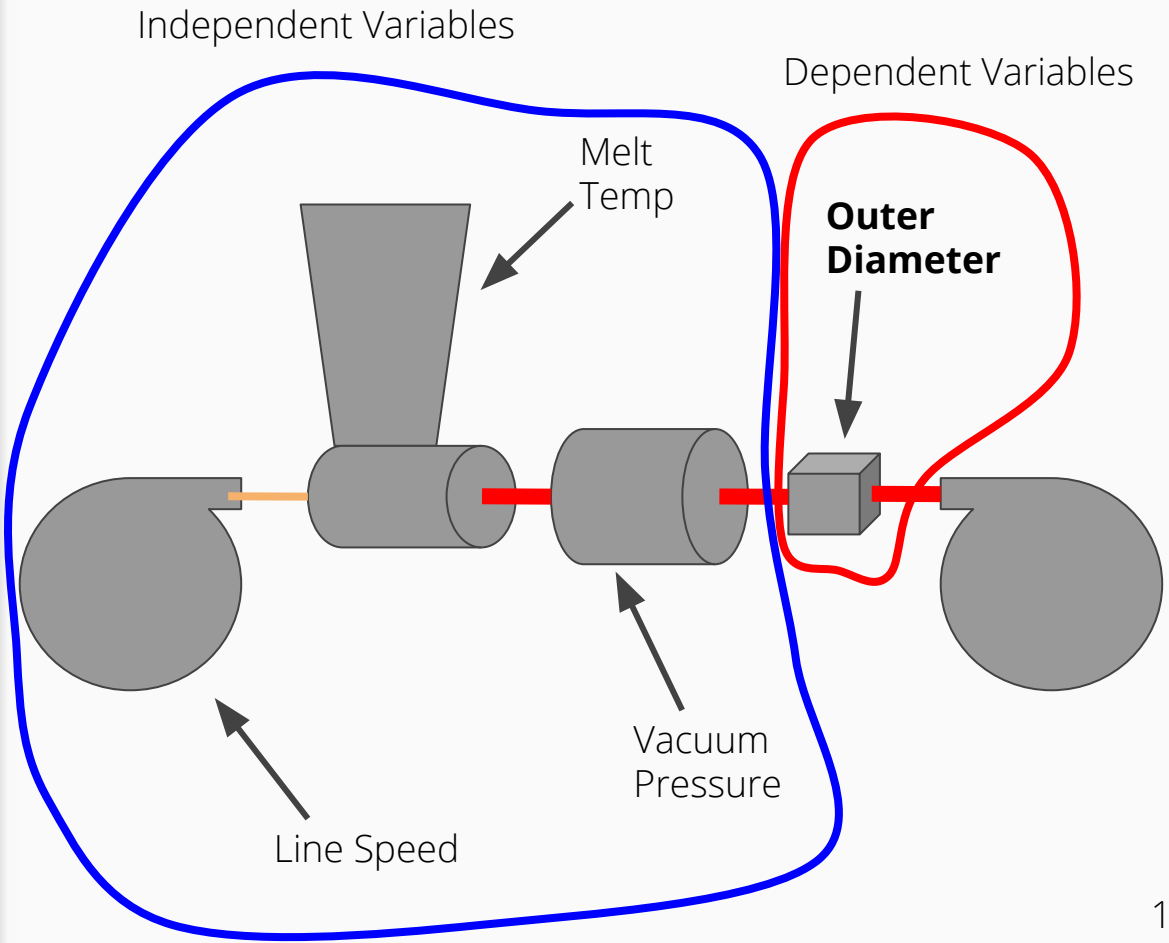
- A laser measures the diameter of the wire to monitor its closeness to spec.



Cable Manufacturing

- Copper is pulled from an in-spool into an extruder.
- Plastic is melted over the copper to make wire.
- Wire is cooled.
- Wire is pulled into an out-spool.

- A laser measures the diameter of the wire to monitor its closeness to spec.



Process Alerts with streaming pipeline

Decision trees are trained on historic data to extract rules corresponding to bad and good production.

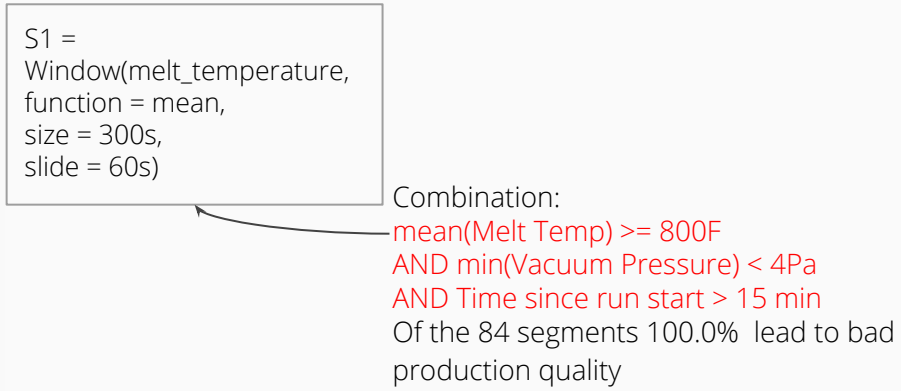
Process Alerts with streaming pipeline

Decision trees are trained on historic data to extract rules corresponding to bad and good production.

Combination:
mean(Melt Temp) >= 800F
AND min(Vacuum Pressure) < 4Pa
AND Time since run start > 15 min
Of the 84 segments 100.0% lead to bad production quality

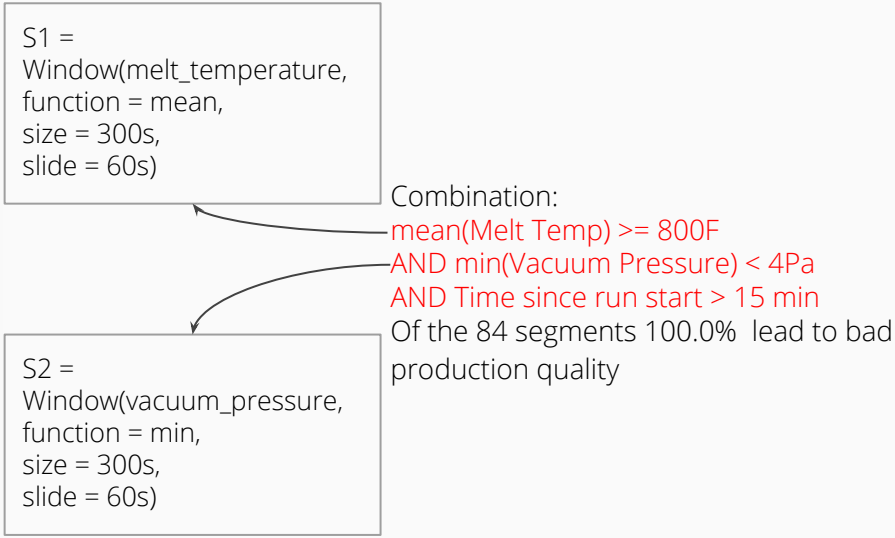
Process Alerts with streaming pipeline

Decision trees are trained on historic data to extract rules corresponding to bad and good production.



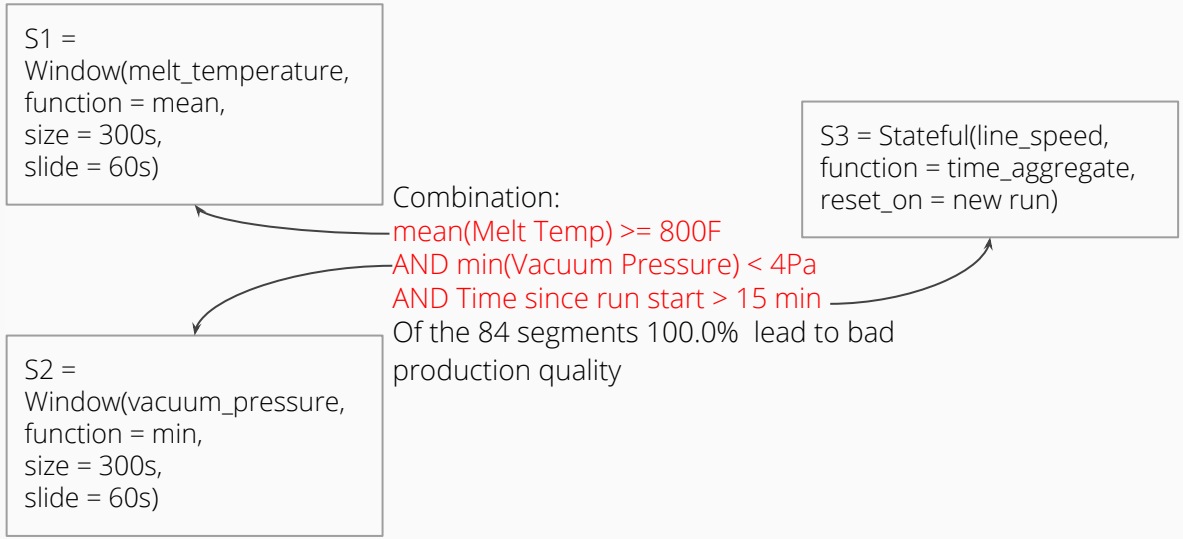
Process Alerts with streaming pipeline

Decision trees are trained on historic data to extract rules corresponding to bad and good production.



Process Alerts with streaming pipeline

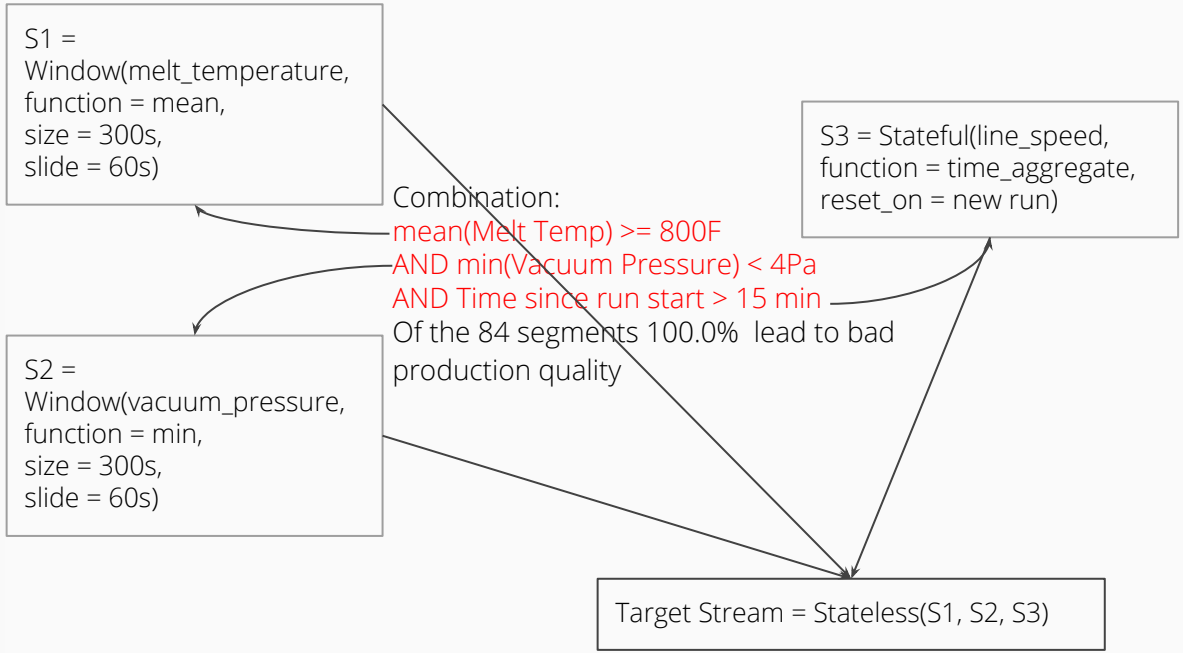
Decision trees are trained on historic data to extract rules corresponding to bad and good production.



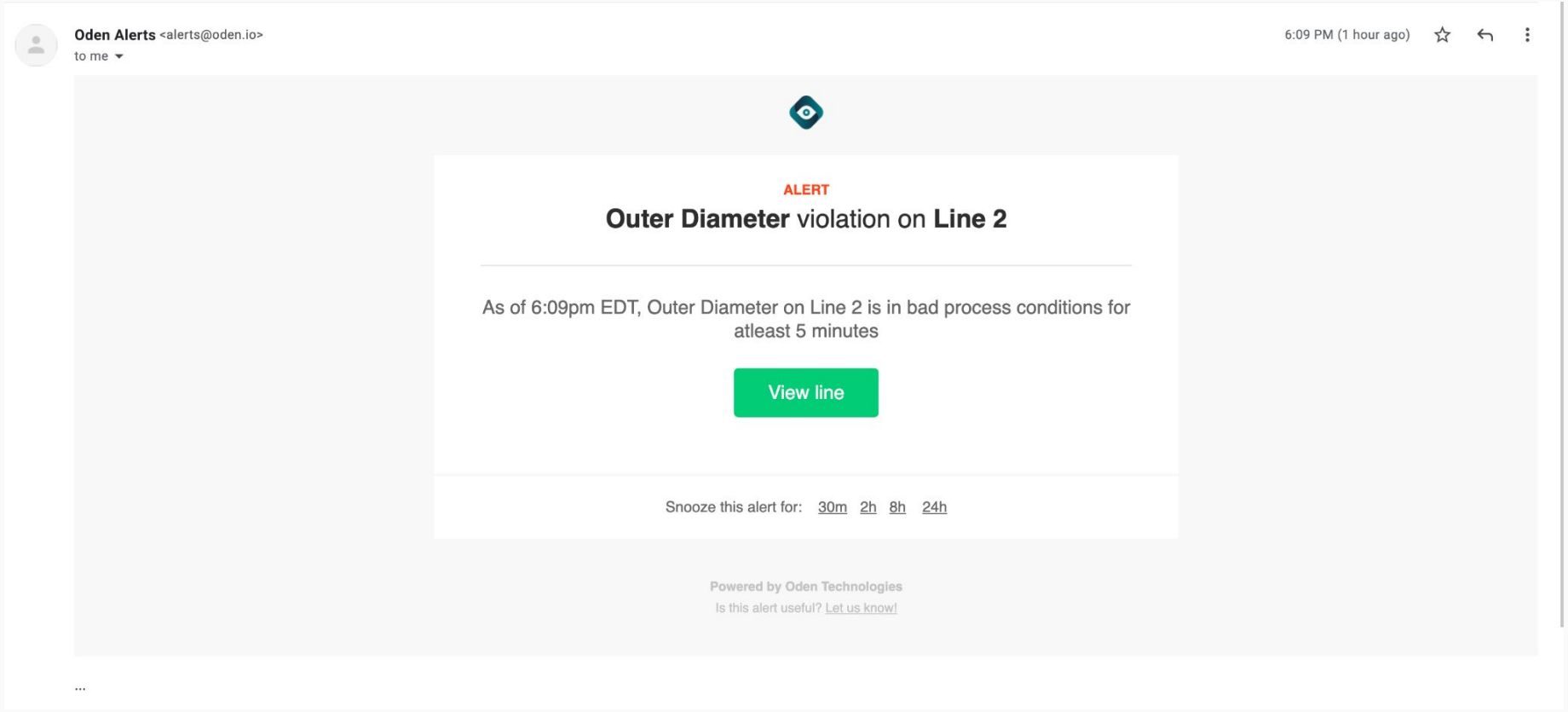
Process Alerts with streaming pipeline

Decision trees are trained on historic data to extract rules corresponding to bad and good production.

Alerts are configured to notify operators on factory floor when process goes into bad production conditions.



Alert!!!


Oden Alerts <alerts@oden.io>
to me
6:09 PM (1 hour ago)
ALERT
Outer Diameter violation on Line 2
As of 6:09pm EDT, Outer Diameter on Line 2 is in bad process conditions for atleast 5 minutes
View line
Snooze this alert for: 30m 2h 8h 24h
Powered by Oden Technologies
Is this alert useful? Let us know!
...

That concludes the journey
Raw data from factory →
Alerting on meaningful process conditions


beam

What we Love!

What we Love!

- 

What we Love!

- 
- Compatible with dataflow on GCP

What we Love!

- 

- Compatible with dataflow on GCP
- Watermarks, windows, triggers, State API

What we Love!

- 

- Compatible with dataflow on GCP
- Watermarks, windows, triggers, State API

Workarounds!

What we Love!

- 

- Compatible with dataflow on GCP
- Watermarks, windows, triggers, State API

Workarounds!

- Custom watermark function using state API for per key functionality to deal with late data.

What we Love!

- 

- Compatible with dataflow on GCP
- Watermarks, windows, triggers, State API

Workarounds!

- Custom watermark function using state API for per key functionality to deal with late data.
- Clogging of pipeline due to late data as a result of the LOOPS is addressed in another talk by Devon.

What we Love!

- 

- Compatible with dataflow on GCP
- Watermarks, windows, trigger, State API

Workarounds!

- Custom watermark function using state API for per key functionality to deal with late data.
- Clogging of pipeline due to late data as a result of the LOOPS is addressed in another talk by Devon.

Late Data Recoveries with Batch-Mode
Aug 6th 2pm EST

Devon Peticolas

Principal Engineer

>>Alert: End of Stream found!

We are hiring!
https://oden.io/careers/