Welcome!

To the 3rd Community Over Code **Performance Engineering** Track

Track chairs: Paul Brebner, Roger Abelenda

1st New Orleans 2022

Technologies: Lucene, Ozone, Kafka, Cassandra, JMeter, and Spark/ML

2nd Beijing 2023

Technologies: Kafka, JMeter, Arrow, Java profiling, Spark & Flink, Hadoop

3rd Halifax 2023

Technologies: Kafka, Ozone, Cassandra, Camel, JMeter/Selenium, Lucene

And maybe 4th EU 2024

Talks (3 x 2 = 6)

11:20 Paul Brebner
Developing Fast Applications With Open Source Software - Without The Fury (Kafka)

12:10 Duong Nguyen, Tanvi Penumudy, Ritesh Shukla
Design patterns and then the road to realize billions of objects, and exabytes of capacity, while preserving performance in Apache Ozone

--- LUNCH

2:20 German Eichberger, Pallavi Iyengar
Performance measurement and tuning of Cassandra 5.0 transactions on Cloud infrastructure

3:10 Otavio Piske
Hunting Performance Monsters on the Back of a Camel

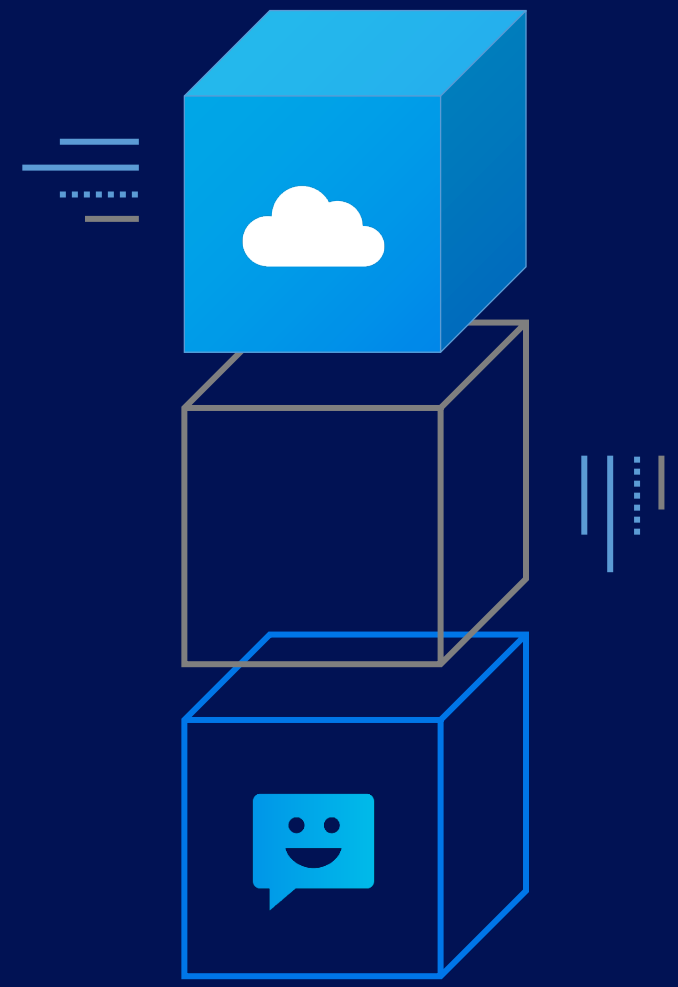
--- COFFEE

4:10 Roger Abelenda
Quick load testing from Selenium scripts

5:00 Stefan Vodita
Lessons Learned from Benchmarking Amazon’s E-commerce Search Engine

instaclustr
Now part of Spot by NetApp

Fast Open Source Software — Without The Fury



Paul Brebner - Open Source Technology Evangelist
www.instaclustr.com/paul-brebner/

Community Over Code Halifax October 2023

Fast *Cars*?!

“NetApp helps Aston Martin F1 use data to go faster”

instaclustr

Massive amounts of data is captured and used to gain milliseconds of performance improvements on race-days

Using NetApp Cloud and Storage Technologies

Fast *Cars*?! “Fast & Furious”

instaclustr

“Fast & Furious” Cars for my Grandson

(unopened as they are “collectables”)

Fast Open Source Software

(Source: wikimedia.org)

Enabled by Scalable Big Data Technologies (e.g. Apache Kafka®)

(Source: wikimedia.org)

And Cloud Infrastructure

Cars run on roads
S/W runs on H/W

(Source: wikimedia.org)

Without the Fury

(Source: Shutterstock)

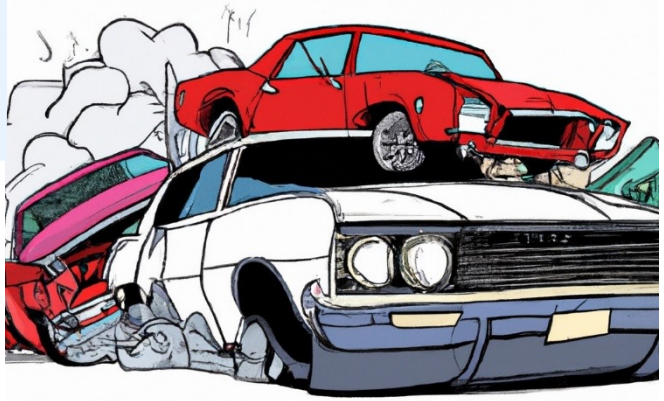
Fury 1 Too Many Kafka Topics

Fury 2 Slow Consumers

Fury 3 Too Many Kafka Partitions

Fury 4 Single Threaded Consumers—concurrency limited by partitions

Fury 5 Operational Problems

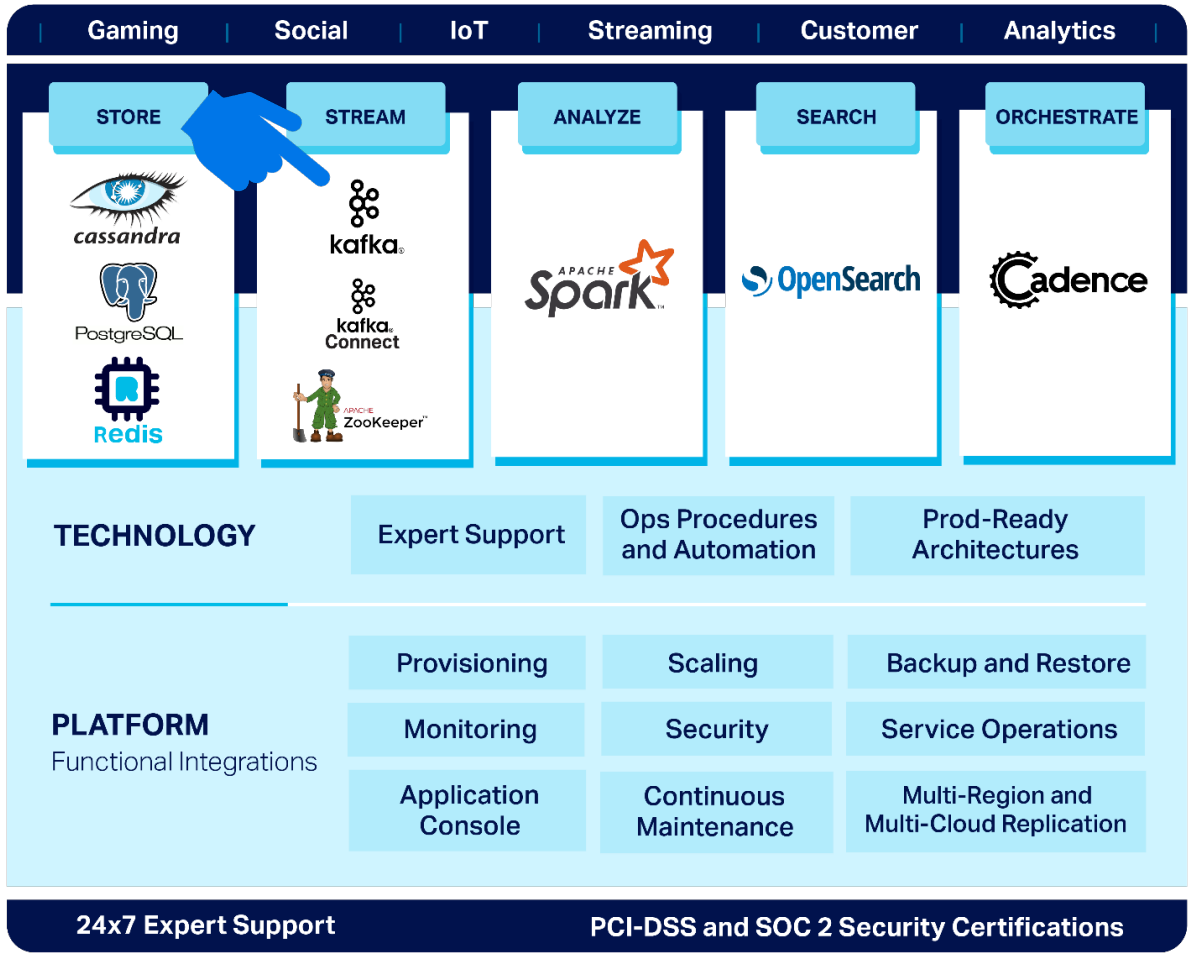


(Source: Shutterstock)

Instaclustr Managed Platform

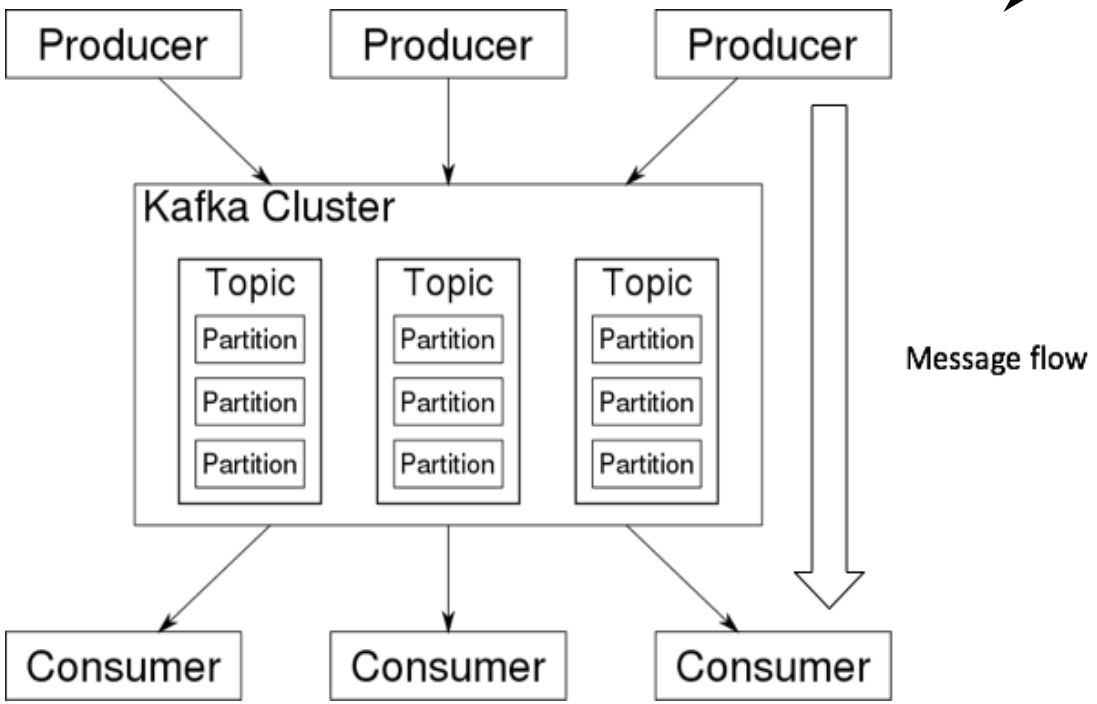
Cloud Platform for Big Data Open Source Technologies

Focus of this talk is on Apache Kafka®

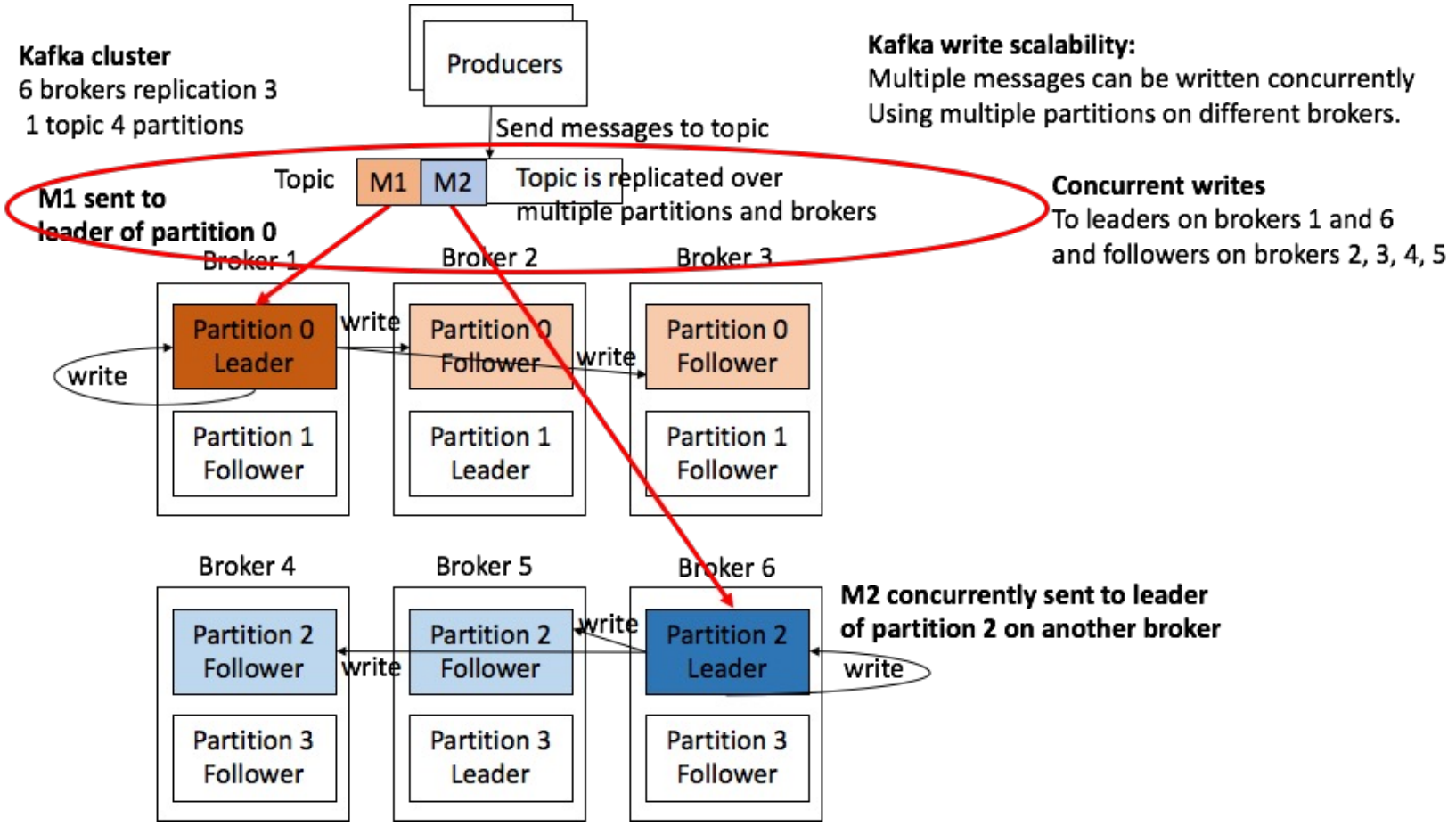


What is Kafka?

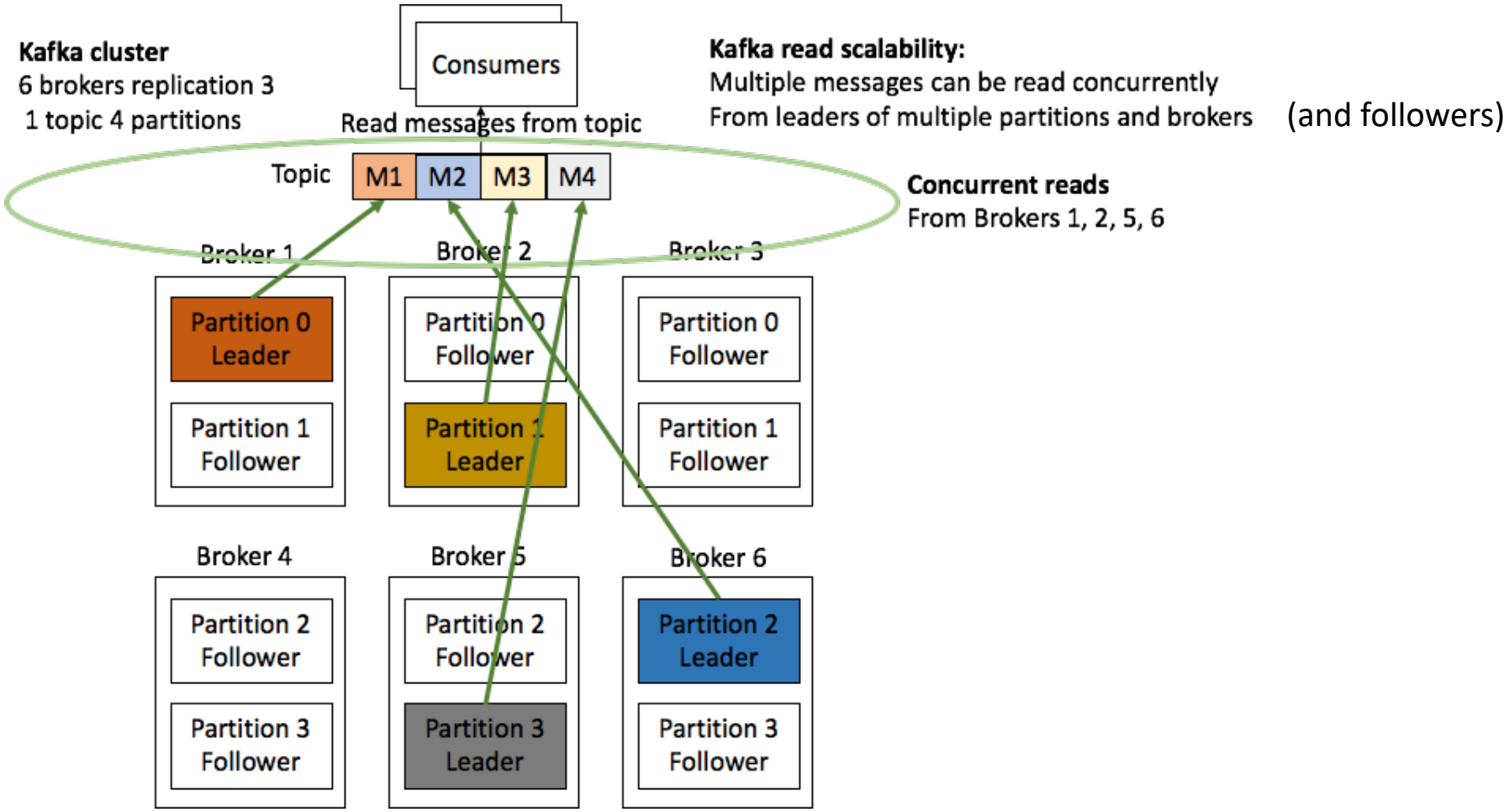
Kafka is a distributed streams processing system—it allows distributed producers to send messages to distributed consumers via a Kafka cluster.



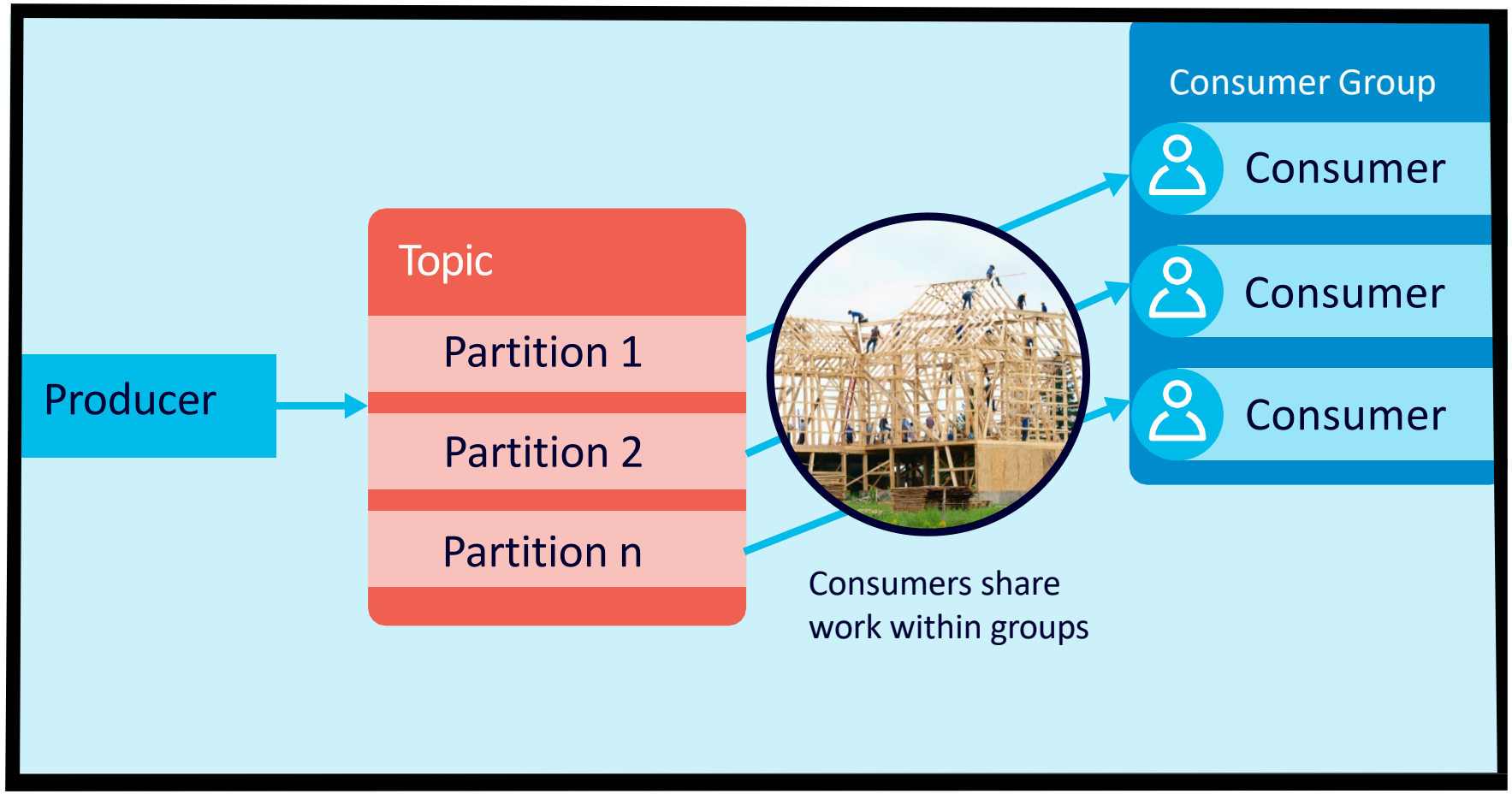
Partitions Enable Concurrency: Cluster and Producers



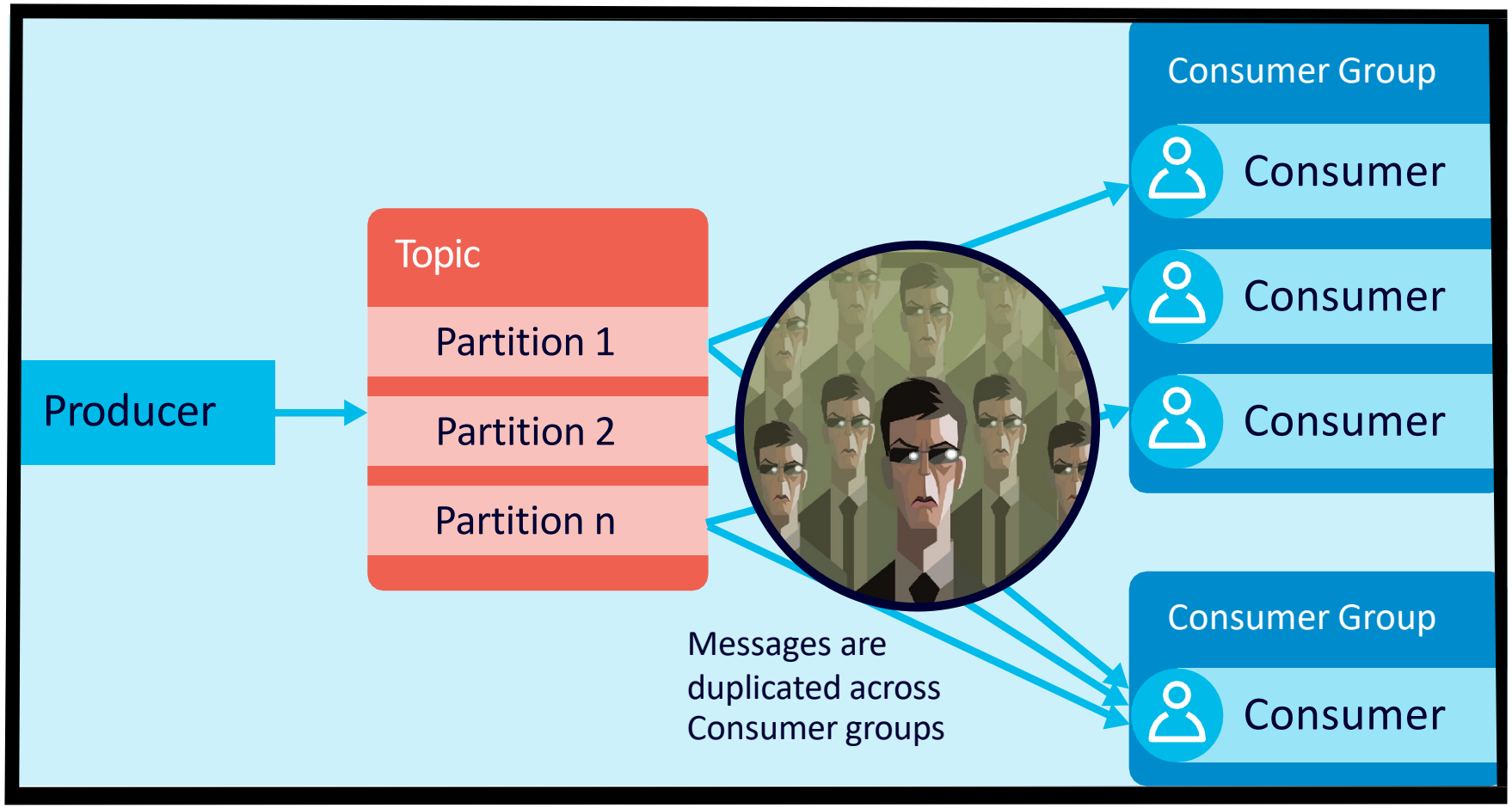
Partitions Enable Concurrency: Cluster and Consumers



Partitions enable Consumers to share work (c.f. Amish Barn raising) within a consumer group

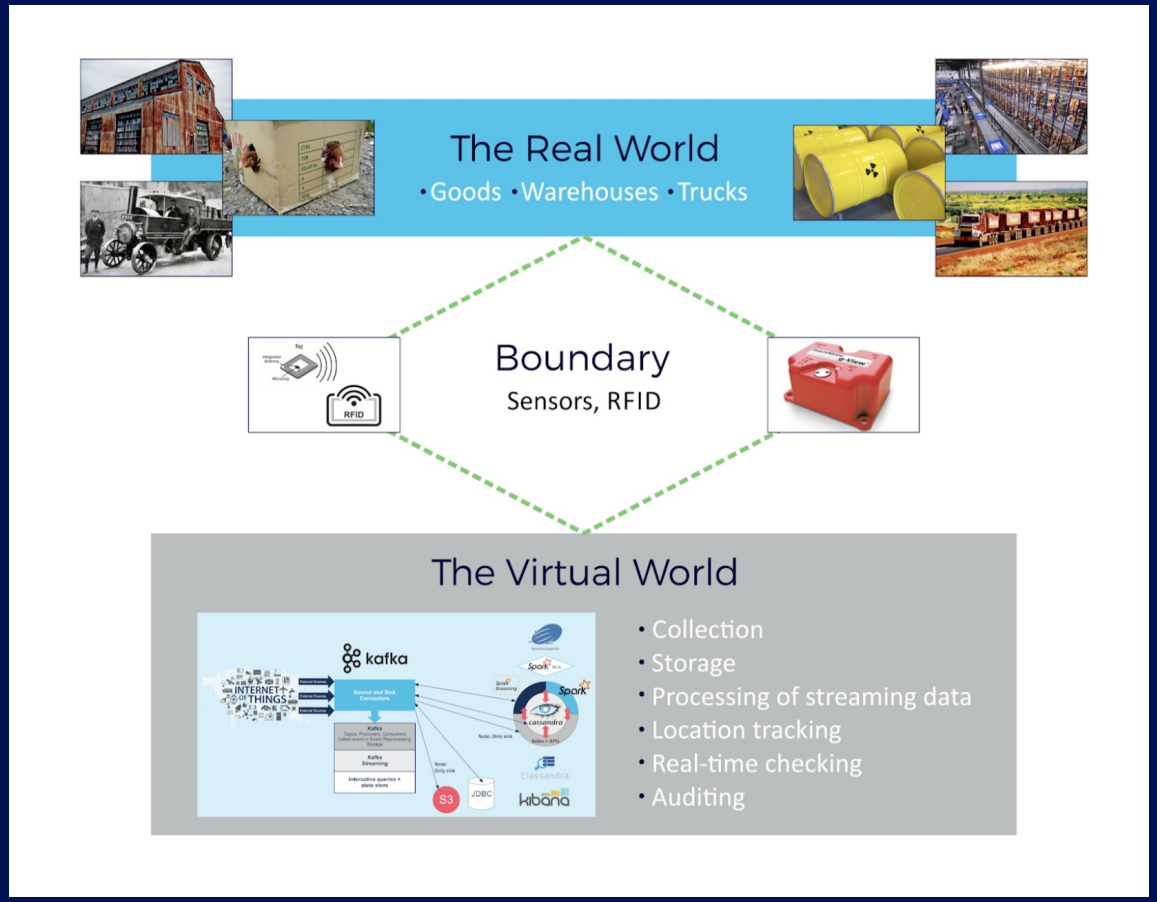


Multiple Groups Enable Message Broadcasting



Messages are duplicated (c.f. clones) across groups, as each consumer group receives a copy of each message

Fury 1: Too Many Kafka Topics



"Kongo" Logistics IoT Application

Design Choices: Many vs. One Topic?

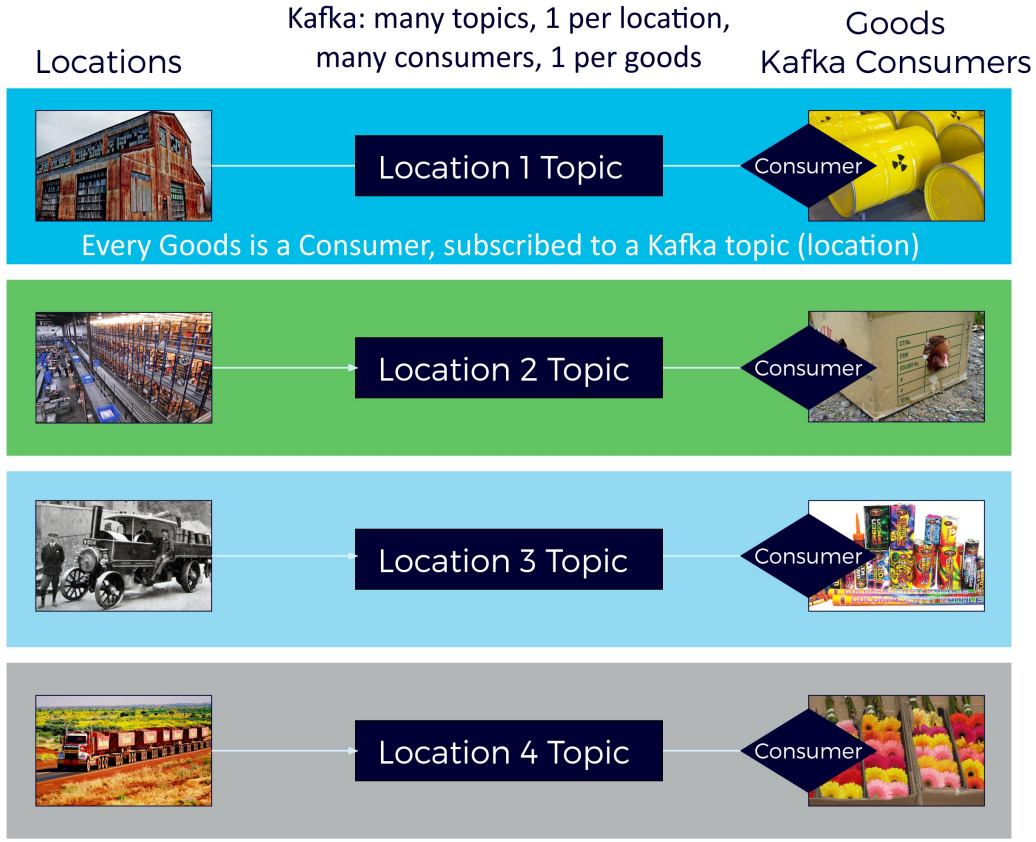
instaclustr

1. Many (100s) of Topics

- 100s of locations (Warehouses, Trucks)
- Each location has a topic and multiple consumer groups (so all the Goods in a location receive relevant events)

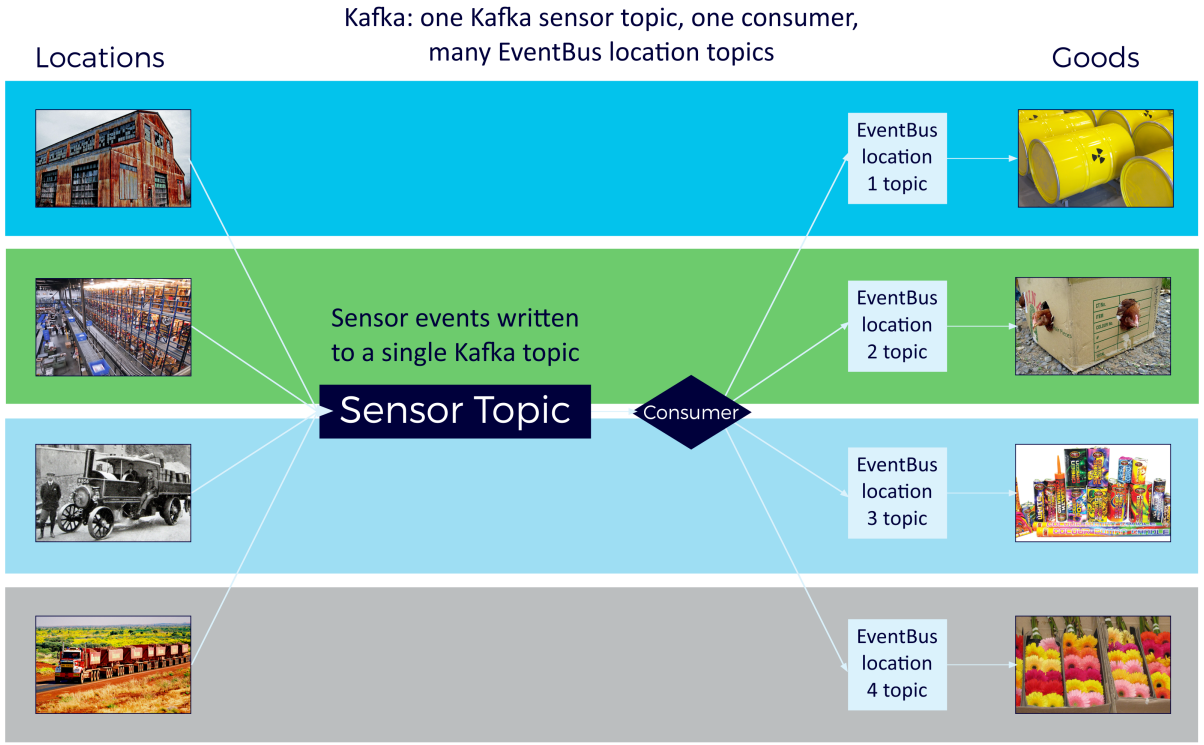
Option 1:

- Many topics
- Many consumer groups per topic -> high fan-out

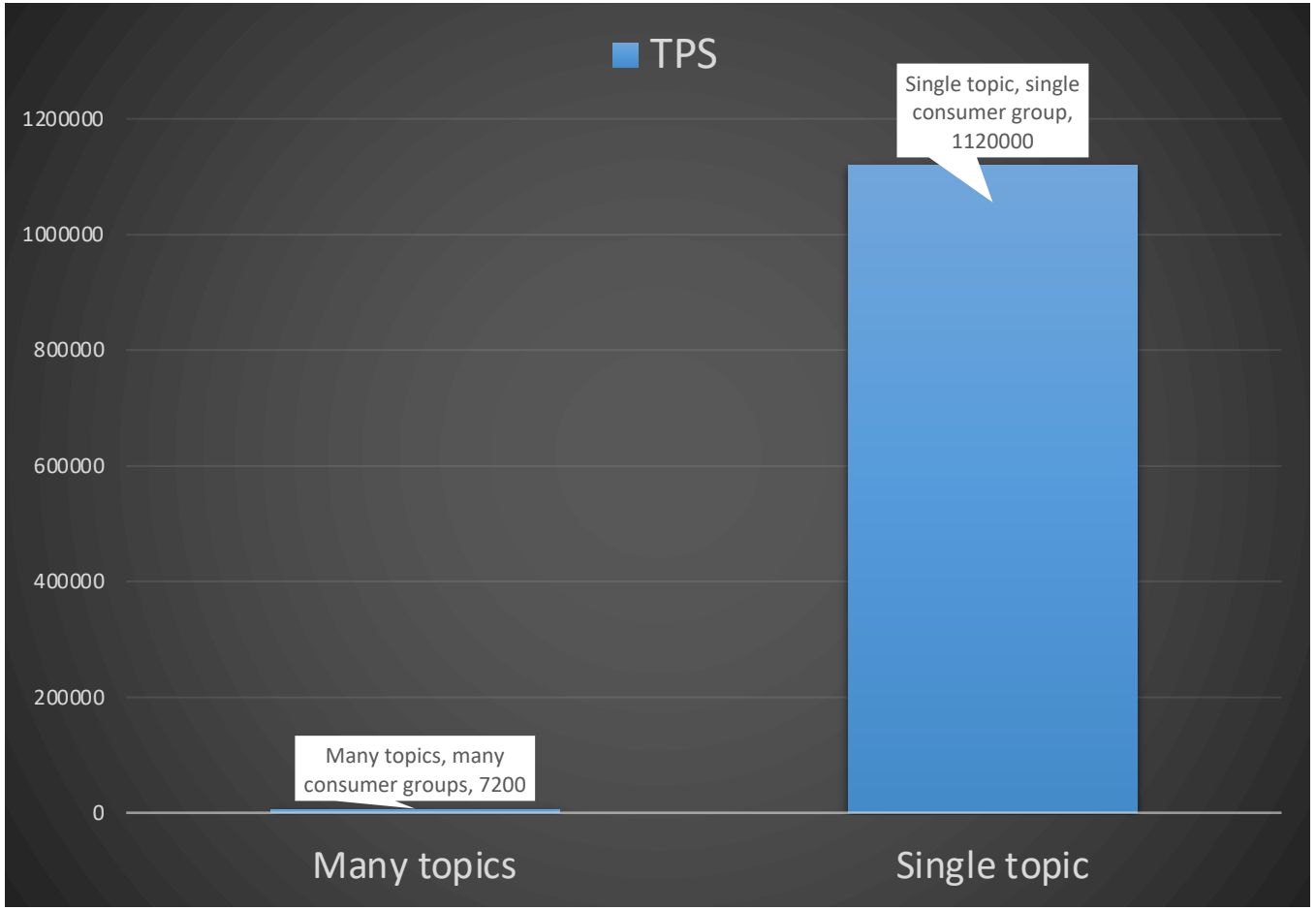


2. One Topic, One Consumer Group

- One topic for all locations
- Using an external notification mechanism for event broadcasting (Guava Event Bus)



Single Topic/Single Consumer Group Wins



155 times better!

But why?

Trains Are More Scalable Than Cars

Train in the Canadian Rockies *(Source: Getty Images)*

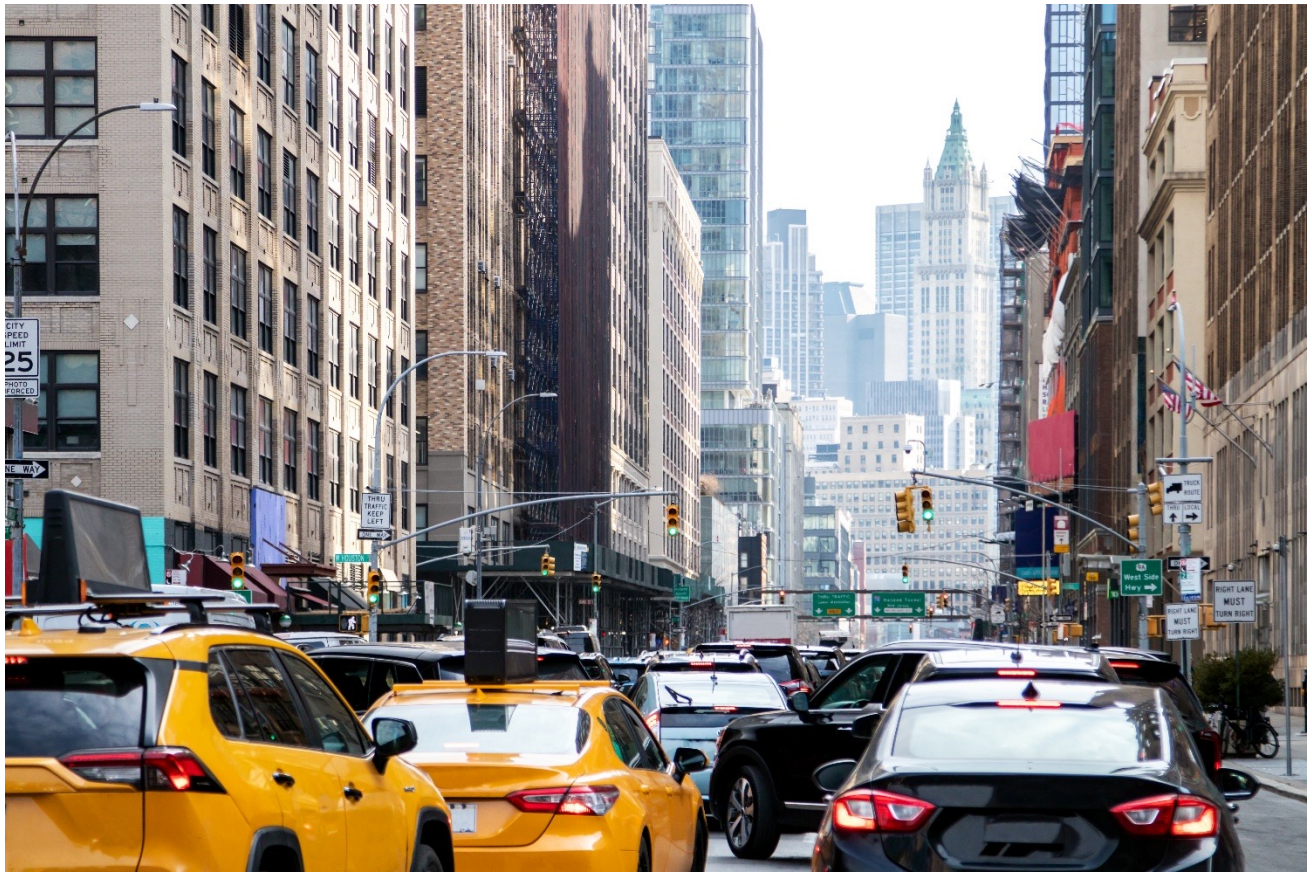
High Fan-Out = Lots of On/Off Ramps

Explanation: High fan-out = lots of output data and many consumer groups (resource intensive)

(Source: Shutterstock)

Many Topics = Traffic Jam

Explanation:
More topics → more partitions



(Source: Shutterstock)

But Kafka Is Scalable! Bigger Clusters

instaclustr

Vertical/Scale-up Increase Node Sizes

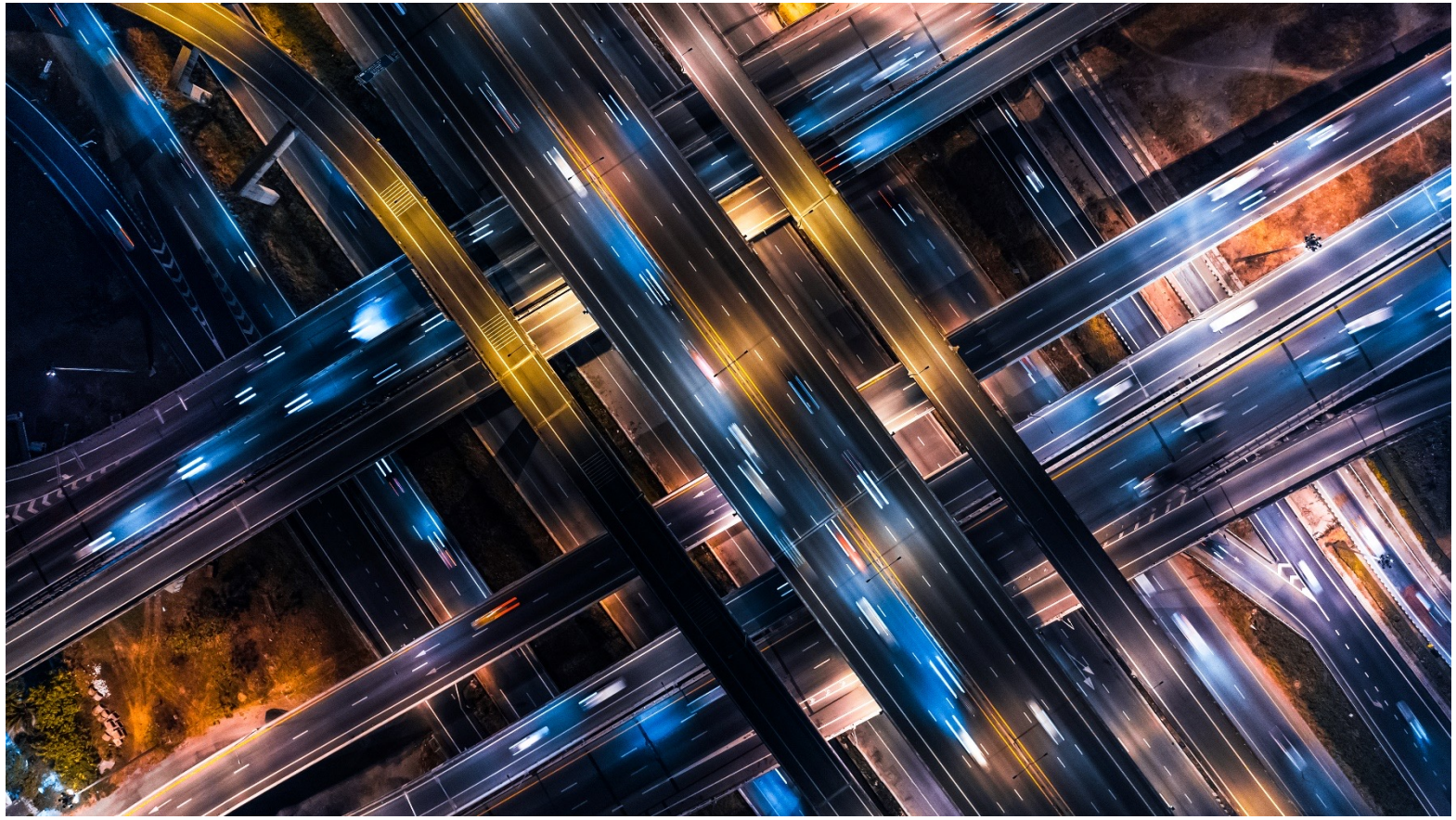
Add more lanes! ➡

(Source: Wikimedia)

Horizontal/Scale-Out
Add More Nodes

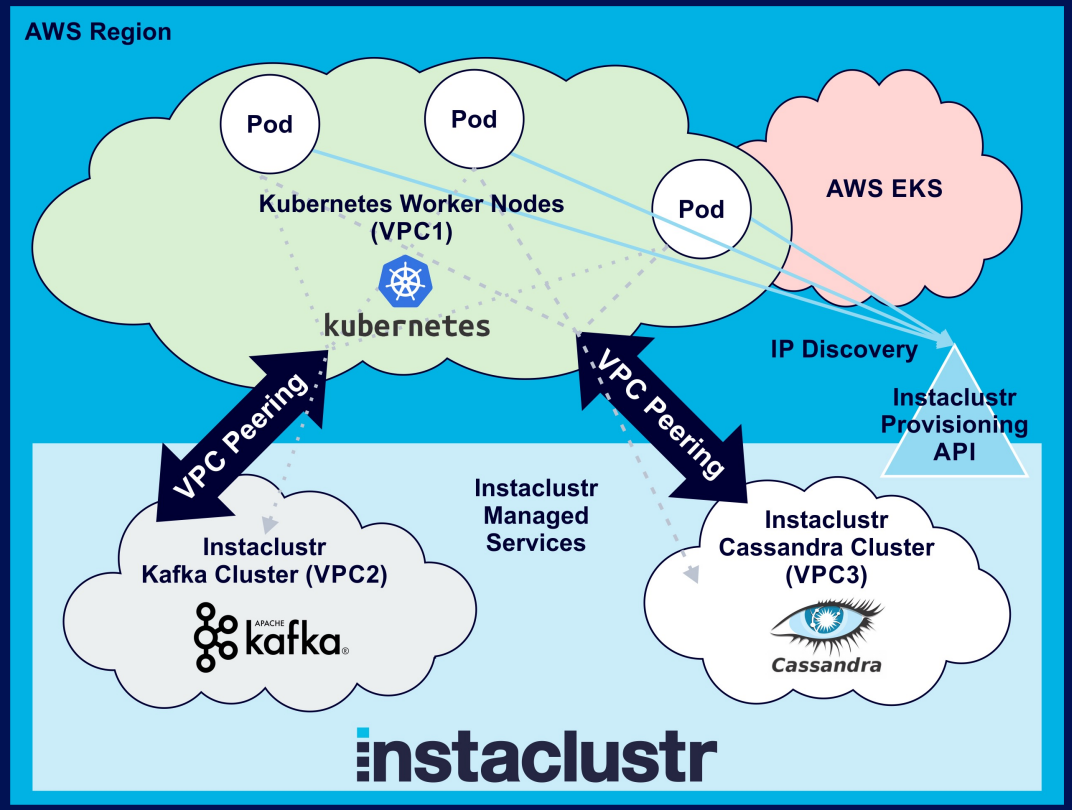
instaclustr

Add more roads!



(Source: Shutterstock)

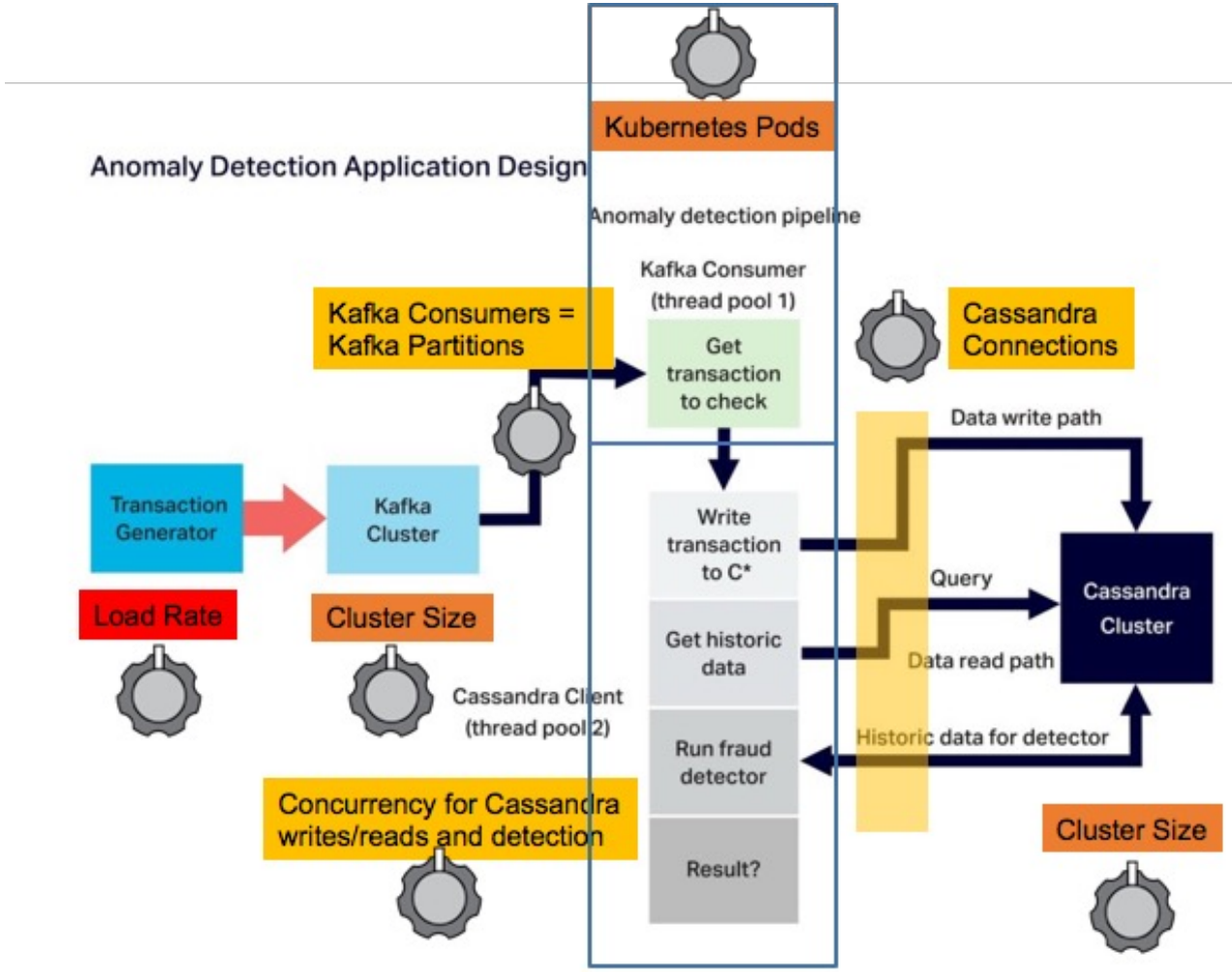
Fury 2: Slow Consumers Kafka+Cassandra Anomaly Detector Application



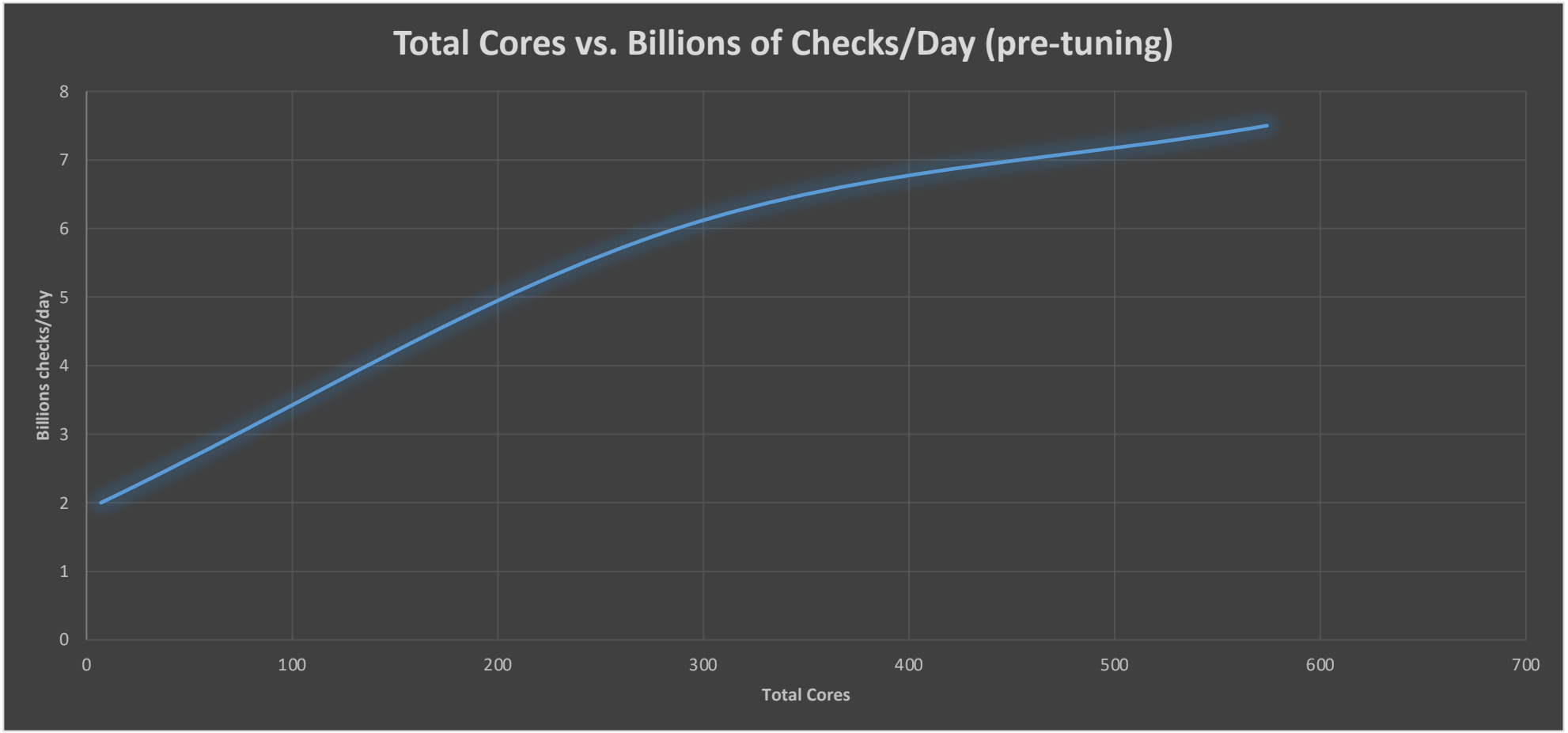
Massively Scalable Anomaly Detection: Tuning Knobs (Orange h/w, Yellow s/w)

- Initially just increased h/w resources
- Scaling was “easy” with Kubernetes
- Easy to create lots of consumers (100s)

- Initially single threaded Kafka consumer (no thread pools)



But Scalability Not Great:
Scaling Is Too Easy—Scalability Harder



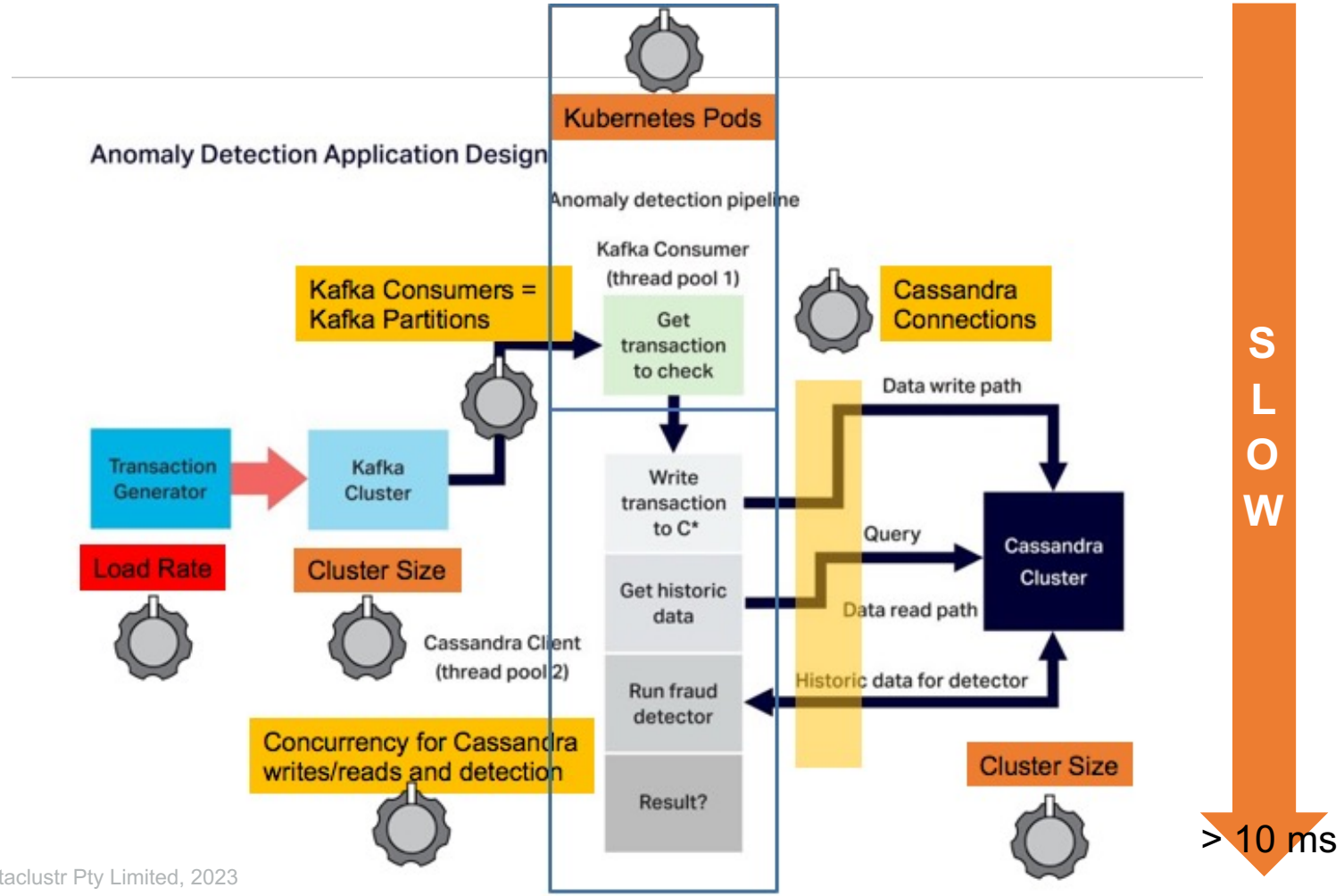
Slow Kafka Consumers Problem

Default Kafka consumers:

- Are single-threaded
- If the processing is “slow” then queuing occurs—as the thread is blocked—reducing throughput
- Solutions include speed up the processing, or increase the number of consumers
- But more consumers → more partitions
- As each consumer needs 1 or more partitions

(Source: Getty Images)

Single Threaded Kafka Consumers And Slow Processing = Slow Consumers



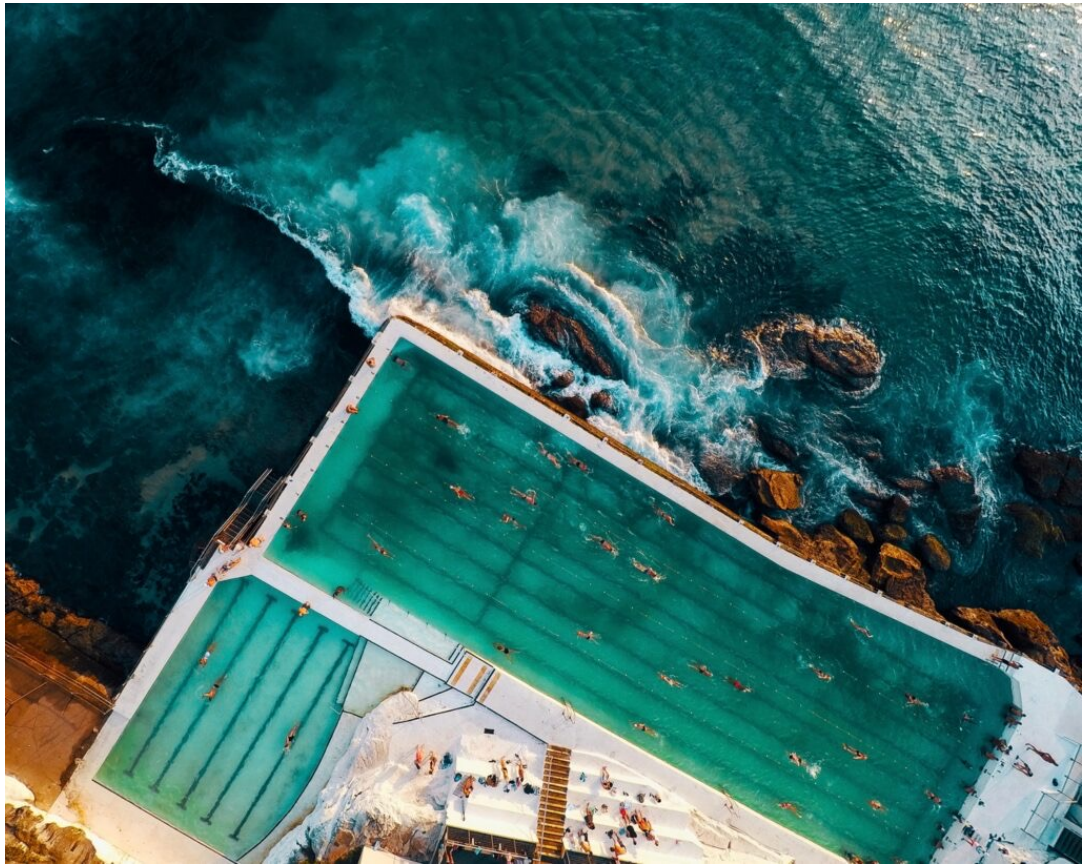
- Slow consumers → need more consumers and also more partitions for higher throughput
- But more consumers is slow, try speeding them up

We Need Some Car Mods (Hacks)

(Source: Getty Images)

Multi-Threaded/Two Pool Consumers

The famous Bondi Ocean Pool
(in Sydney, Australia) has 2 pools

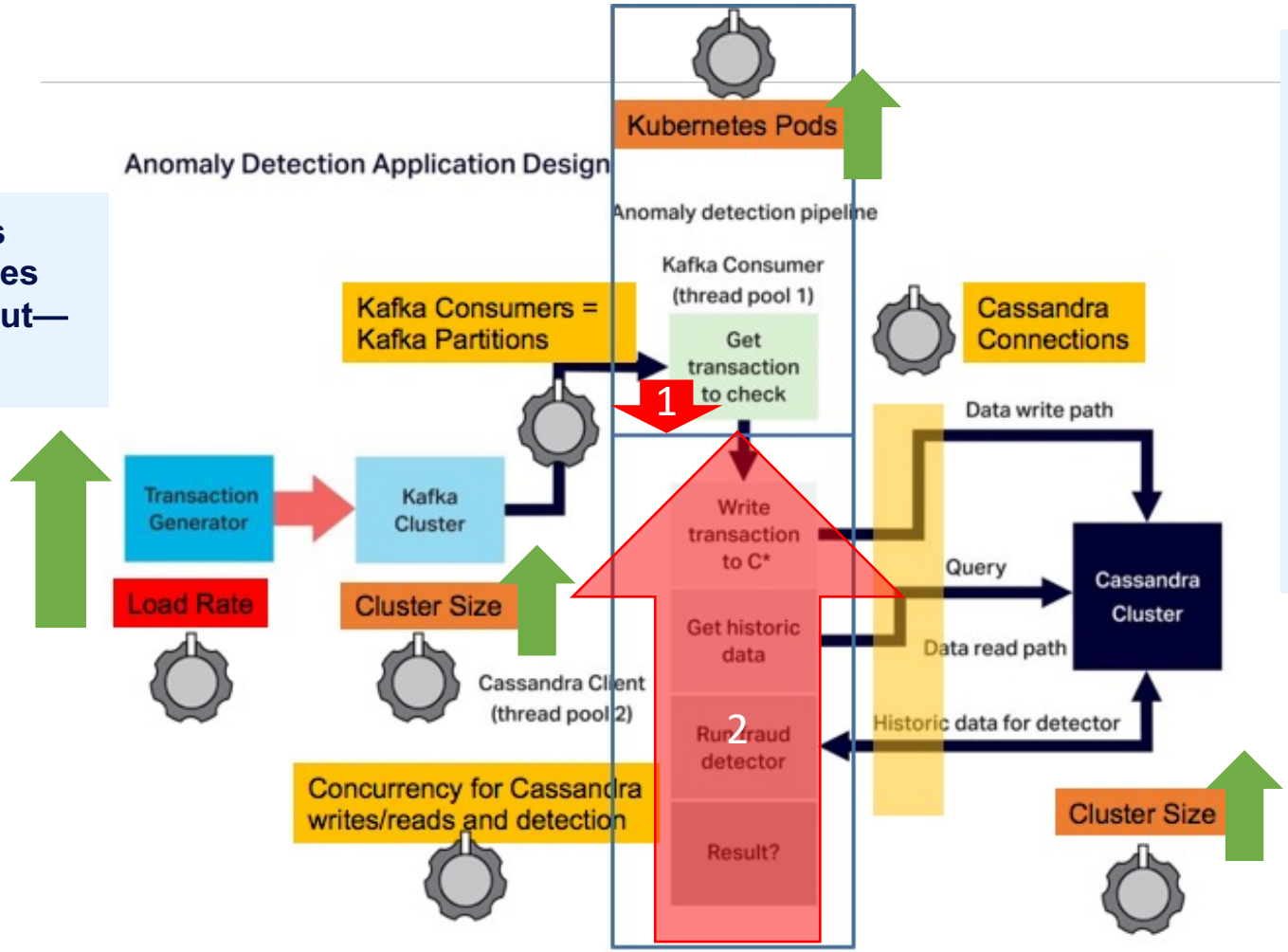


(Source: Shutterstock)

Tuning: Optimize Consumer Speed/ Concurrency Using 2 Stage Pipeline

instaclustr

Less consumers (around 100) gives higher throughput—a surprise!

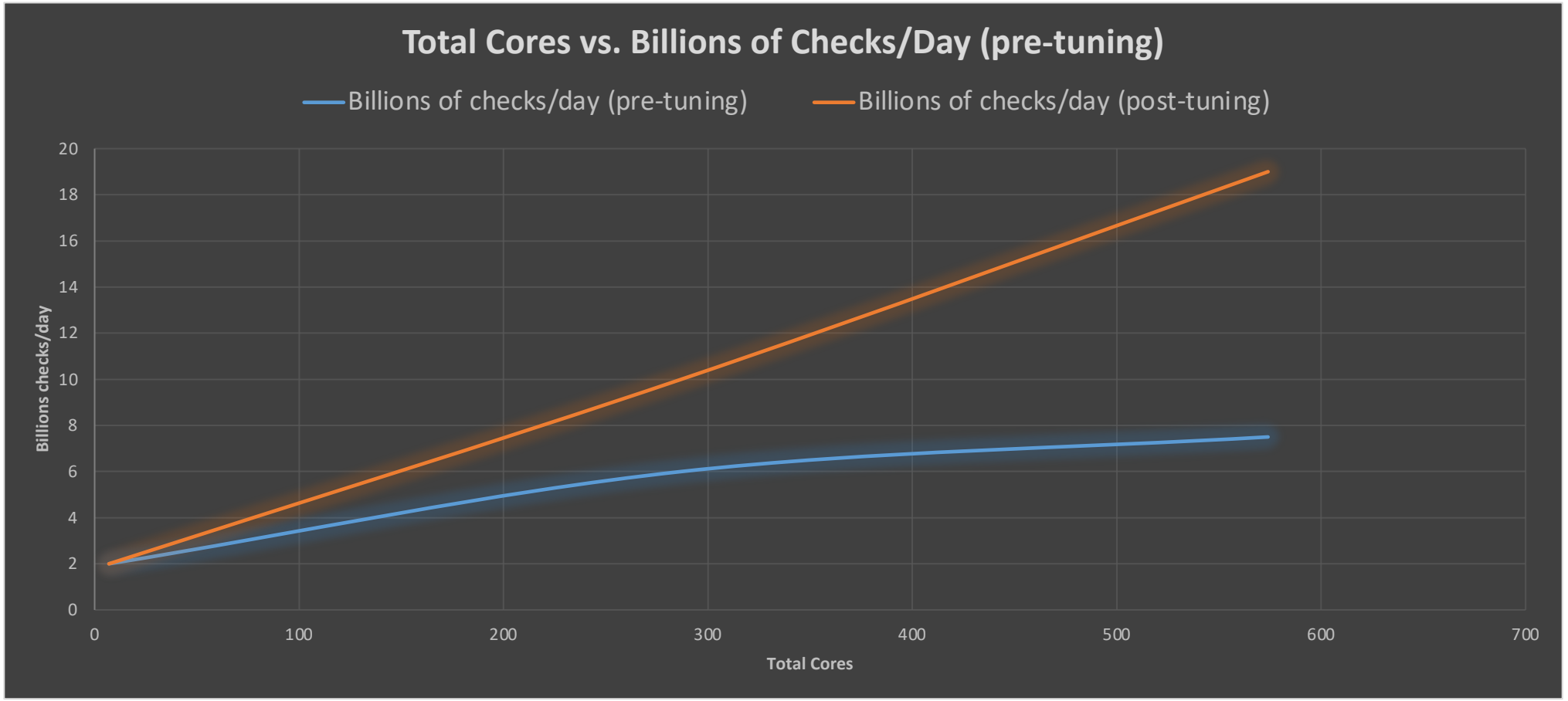


1. Speed up polling (thread pool 1)
2. Maximize anomaly detector concurrency (thread pool 2)

Result—Reduces the number of consumers and therefore partitions needed and gives higher throughput—why?

Don't more partitions give higher throughput?! Answer in part 3.

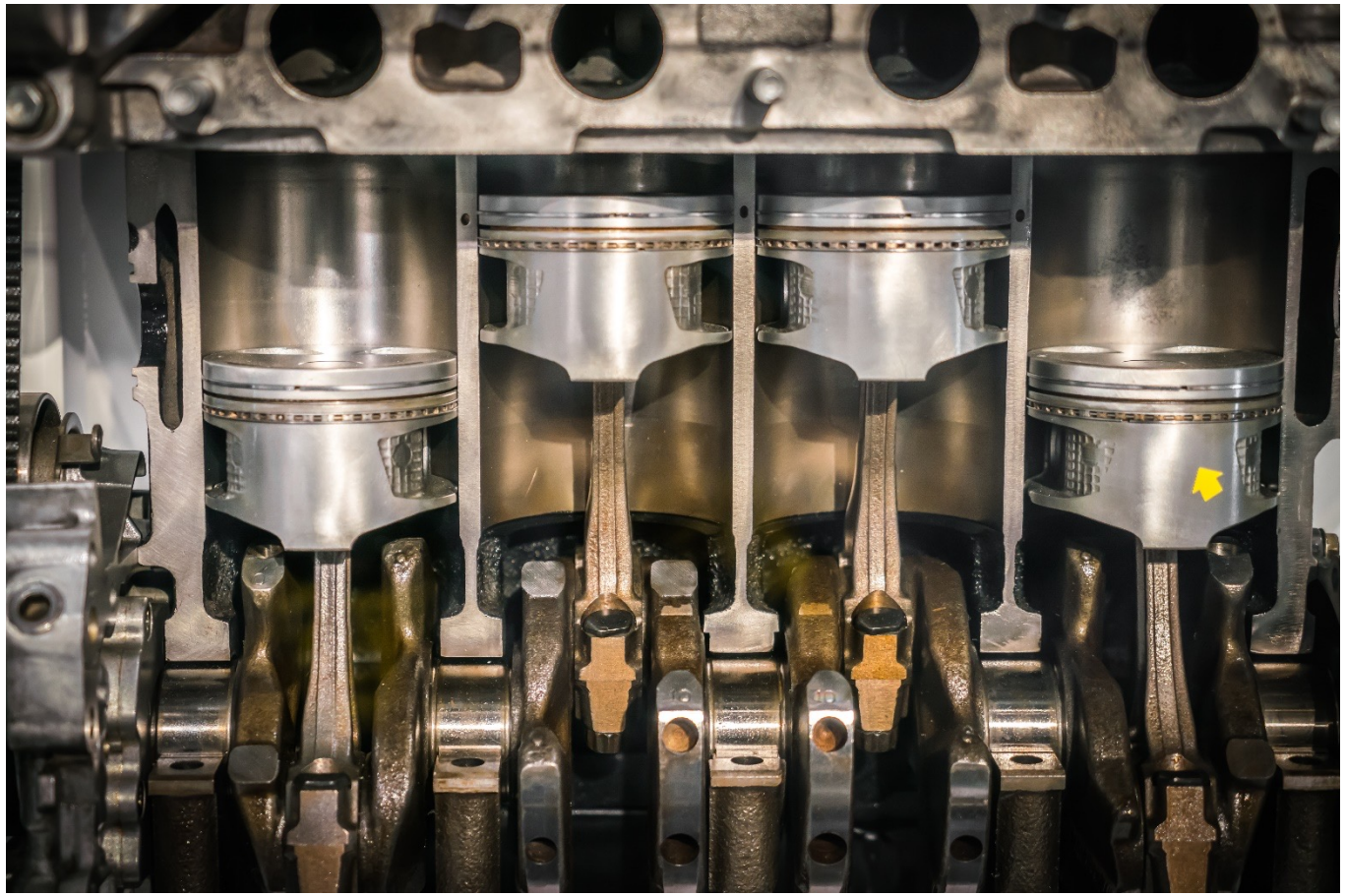
Scalability Post-Tuning—7.5 to 19 Billion Checks/Day—2.5 Times Improvement



Fury 3: Too Many Partitions
What's really going on under the Kafka Bonnet?

(Source: Adobe Stock)

Partitions = Pistons (Cylinders)



(Source: Getty Images)

But How Many?

1 piston isn't very powerful:
Isetta (bubble car) single-cylinder, 10HP, top speed 55MPH

Isetta 1-cylinder car
(Source: Wikimedia)

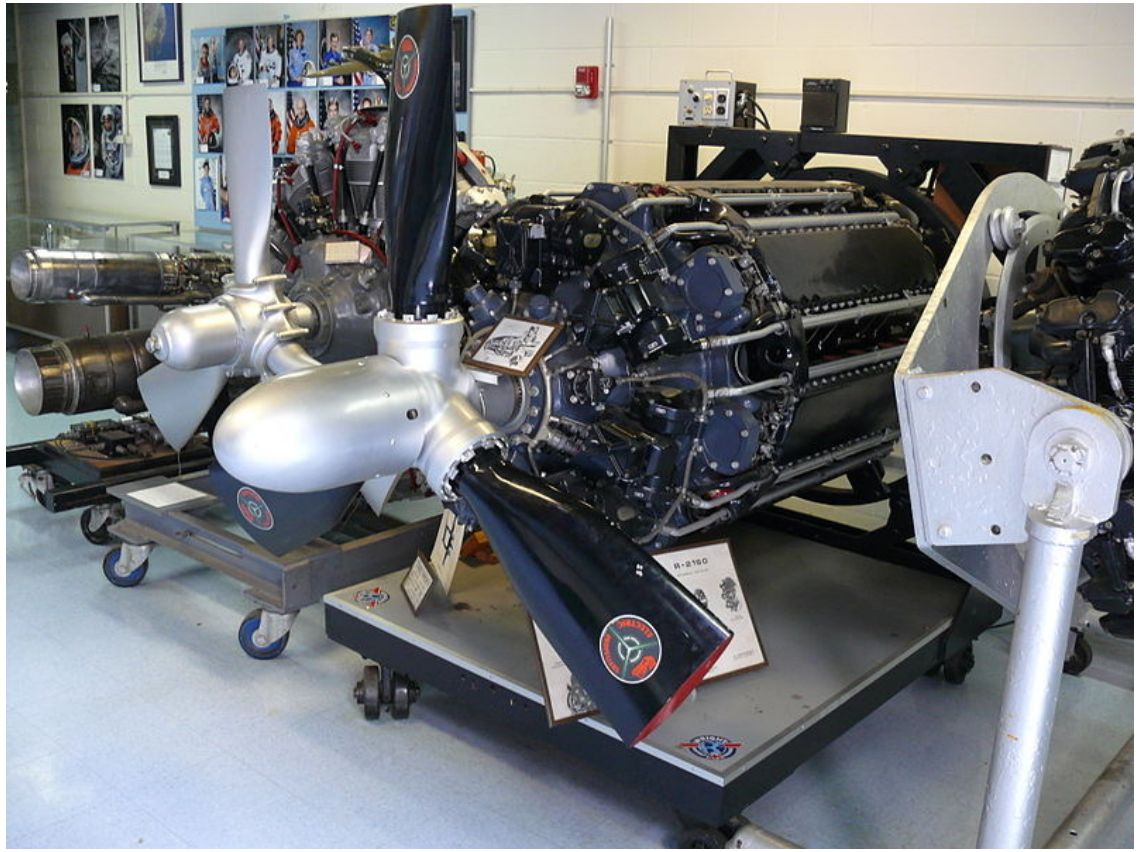
…16 Pistons Is a Lot!

Cadillac V-16
175HP,
100 MPH!

Can You Have “Too Many”?

YES!

Experimental 42-cylinder 2,350 hp (plane) engine!

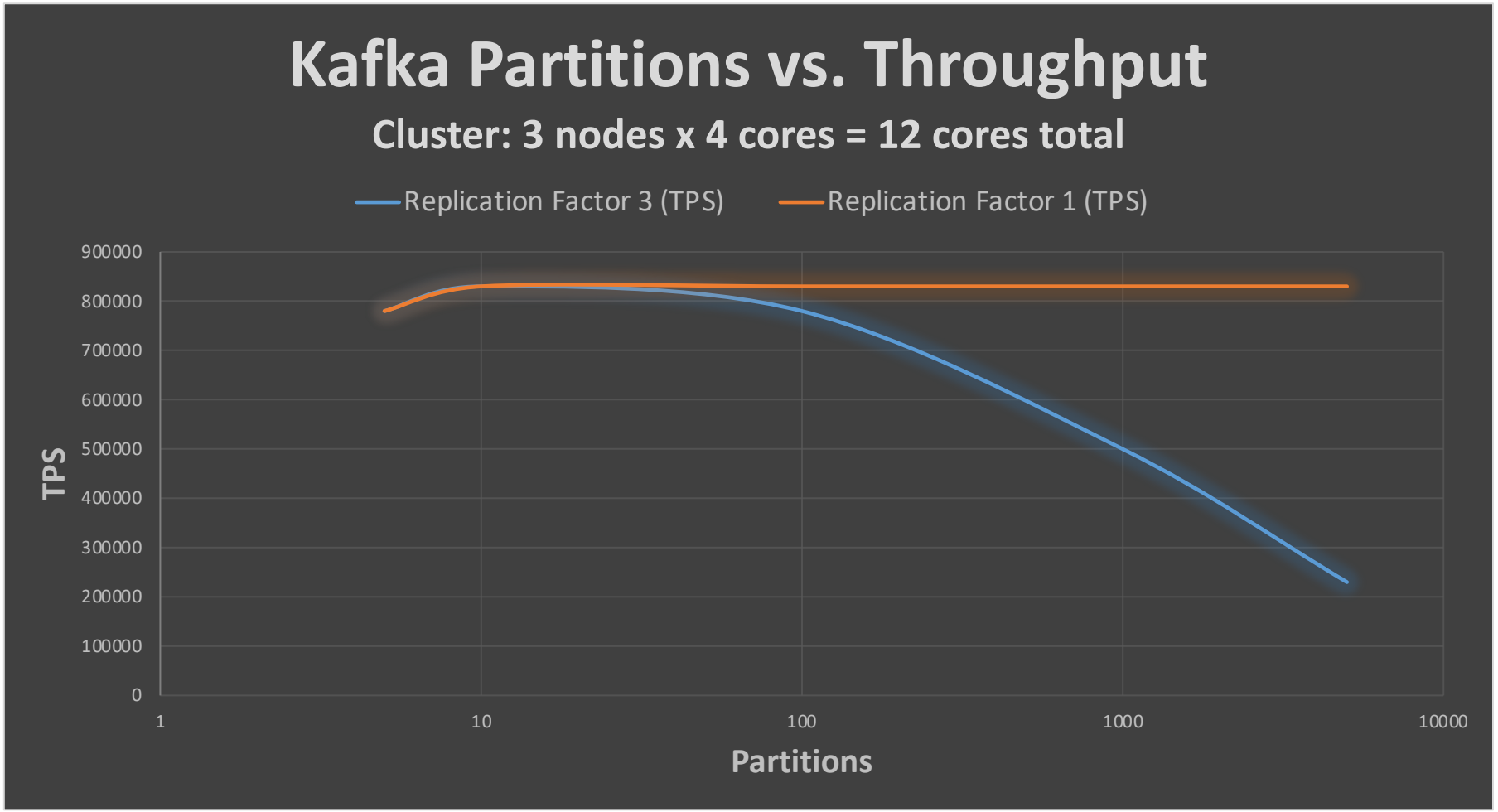


Source: Wikimedia

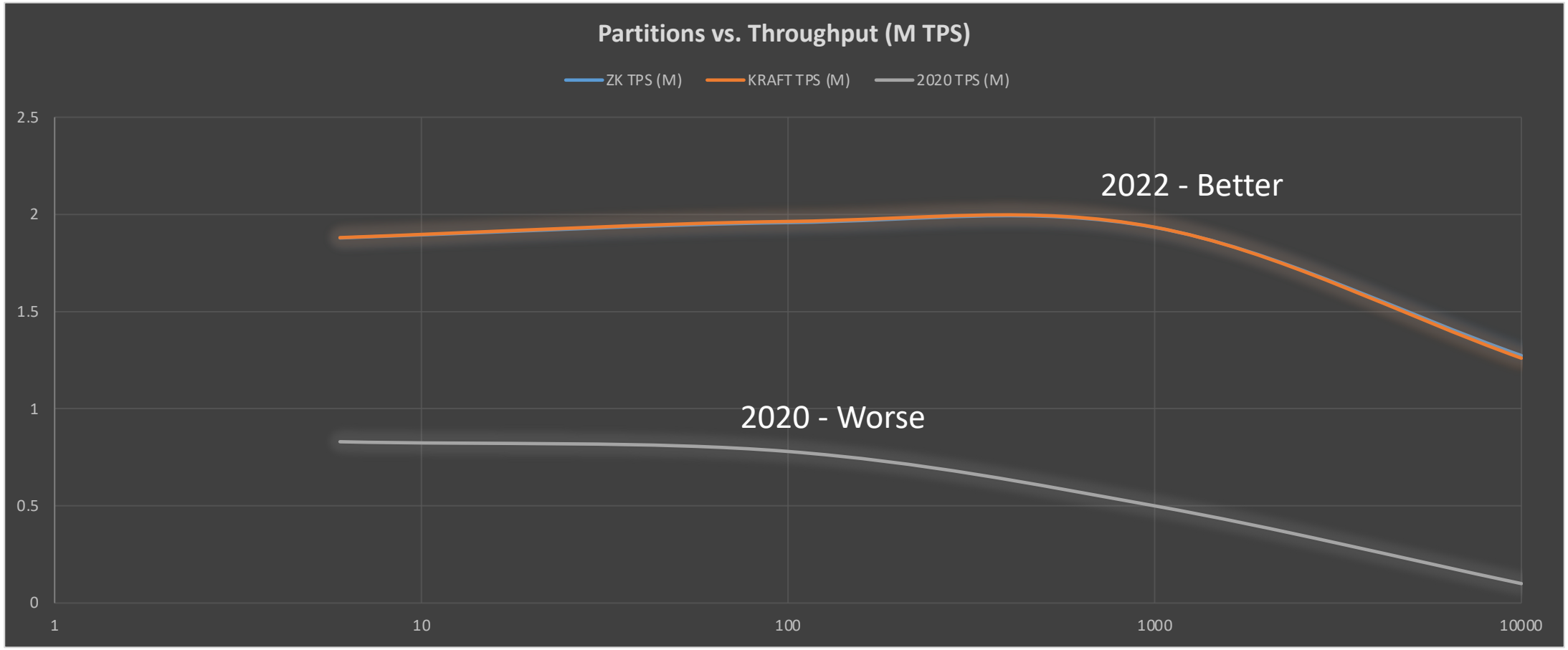
Benchmarking (2020): Partitions and Replication Factor Are the Culprits

instaclustr

**You need sufficient partitions to benefit from the cluster concurrency—
And not too many that the replication overhead impacts overall throughput**



2022 Kraft/Zookeeper Modes vs. 2020 Results Better, 1000 Partitions Is Ok

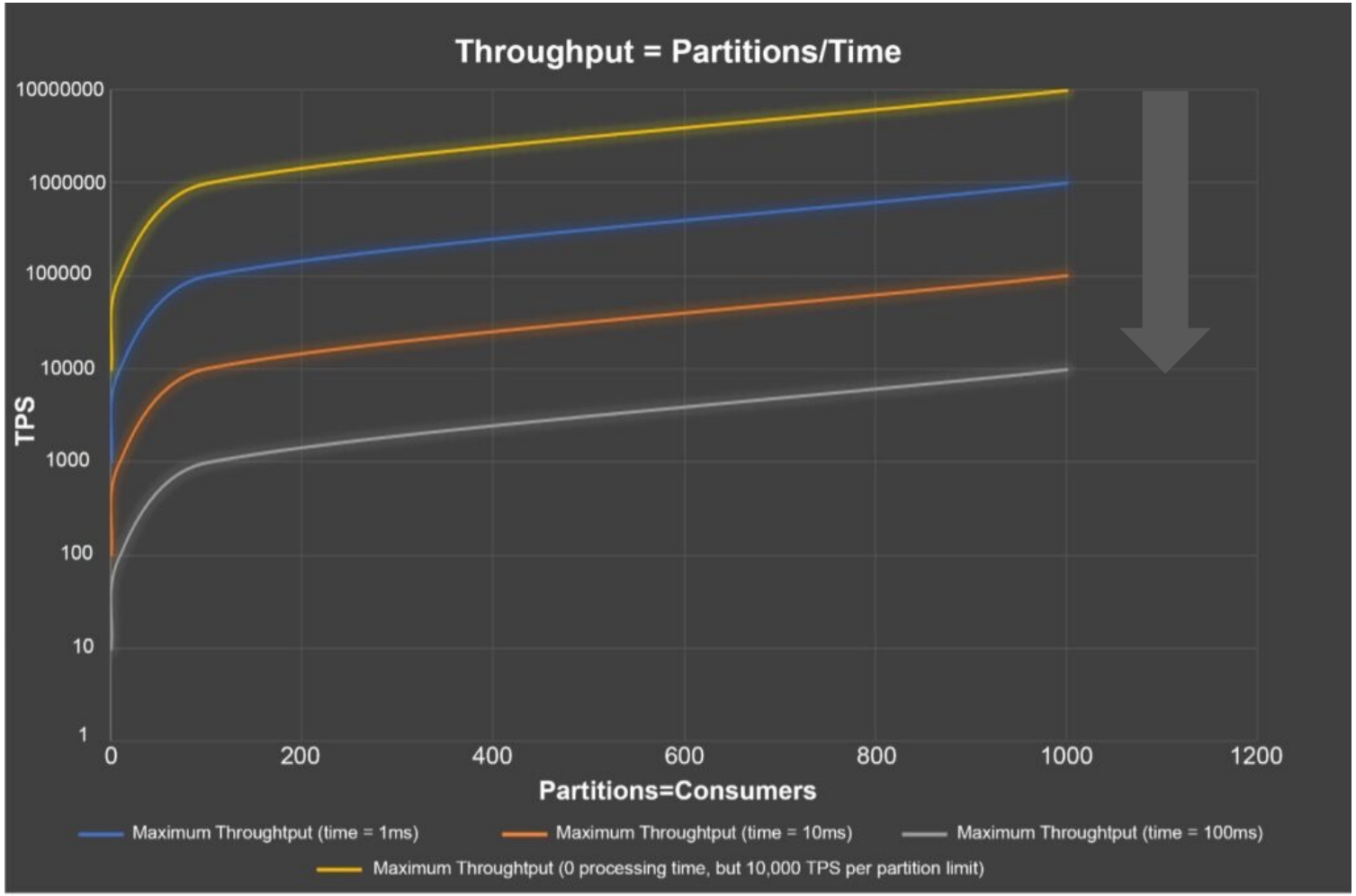


Fury 4: Single Threaded Consumers What's New? Kafka Parallel Consumer = A New Engine!

"La Jamais Contente", first car to reach 100 km/h in 1899 – 68hp electric!
(Source: Wikimedia)

Rimac Nevera – Electric "Hypercar"
4 Engines, 1,888 HP, 0-400KM/H in 29s
(Source: Wikimedia)

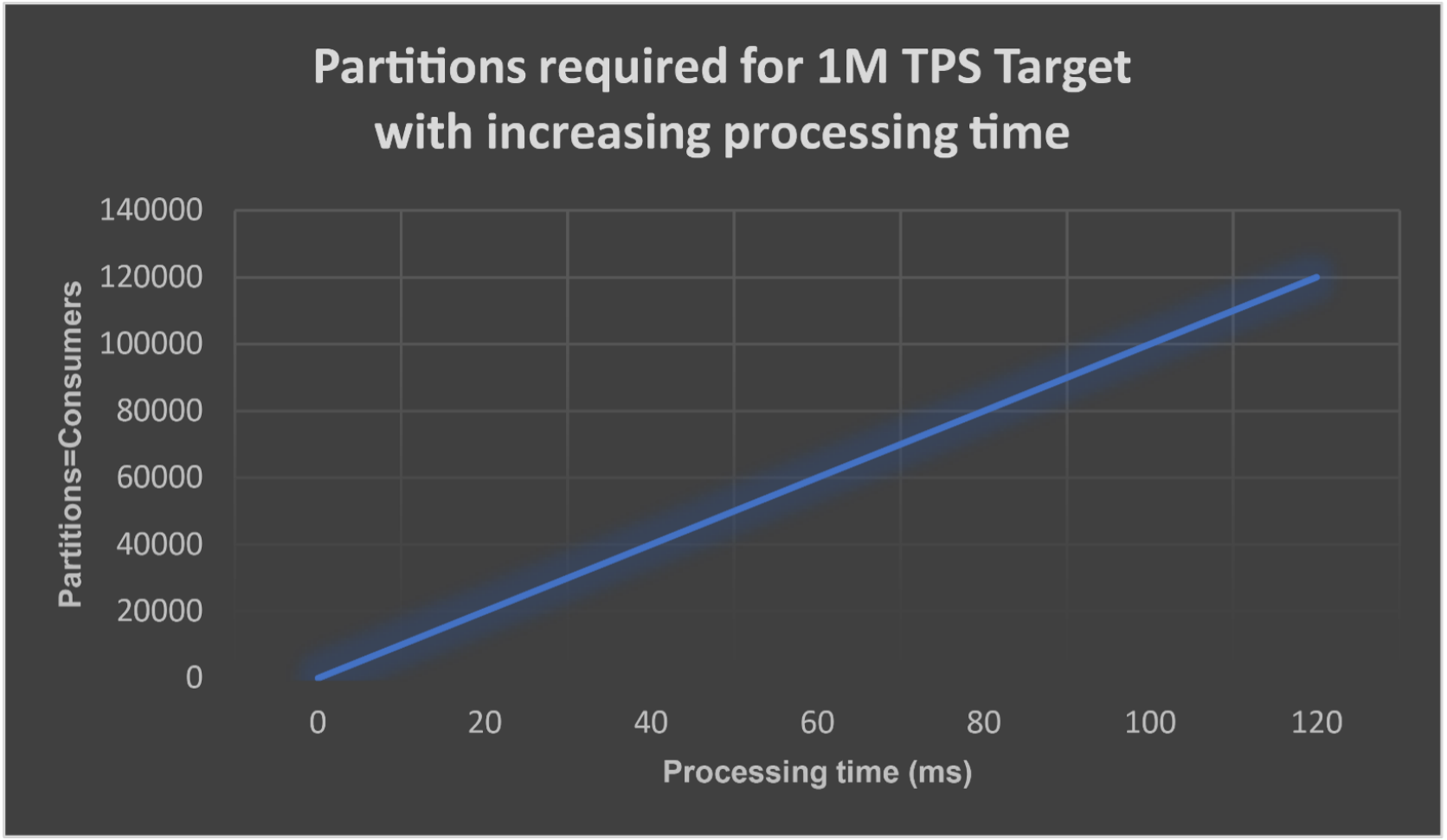
Theory: Little's Law: Concurrency = Throughput x Time



Rearranged:

- **Throughput = Concurrency/Time**
- **Concurrency is Partitions = Consumers**
- **Using default consumer the throughput drops with increasing time**
- **Only solution is to increase partitions**

For Given Target Throughput (1M TPS) Increasing Partitions With Increasing Time



Order in Kafka Is Partition Based—
So How To Increase Consumer Concurrency?

instaclustr

(Source: Adobe Stock)

Kafka Parallel Consumers: Multi-Threaded Consumer

instaclustr

- Multiple ordering options—c.f. default Kafka only guarantees order within partitions!

  PARTITION → KEY → UNORDERED

  Increasing concurrency →

- Concurrency from 1 to lots —depends on client resources, and Partitions/Key space sizes
- KEY has higher concurrency than Partition and is ordered by KEY—reasonable compromise
- UNORDERED is unordered

Kafka Parallel Consumers
Multi-Threaded Consumer = Buses

instaclustr

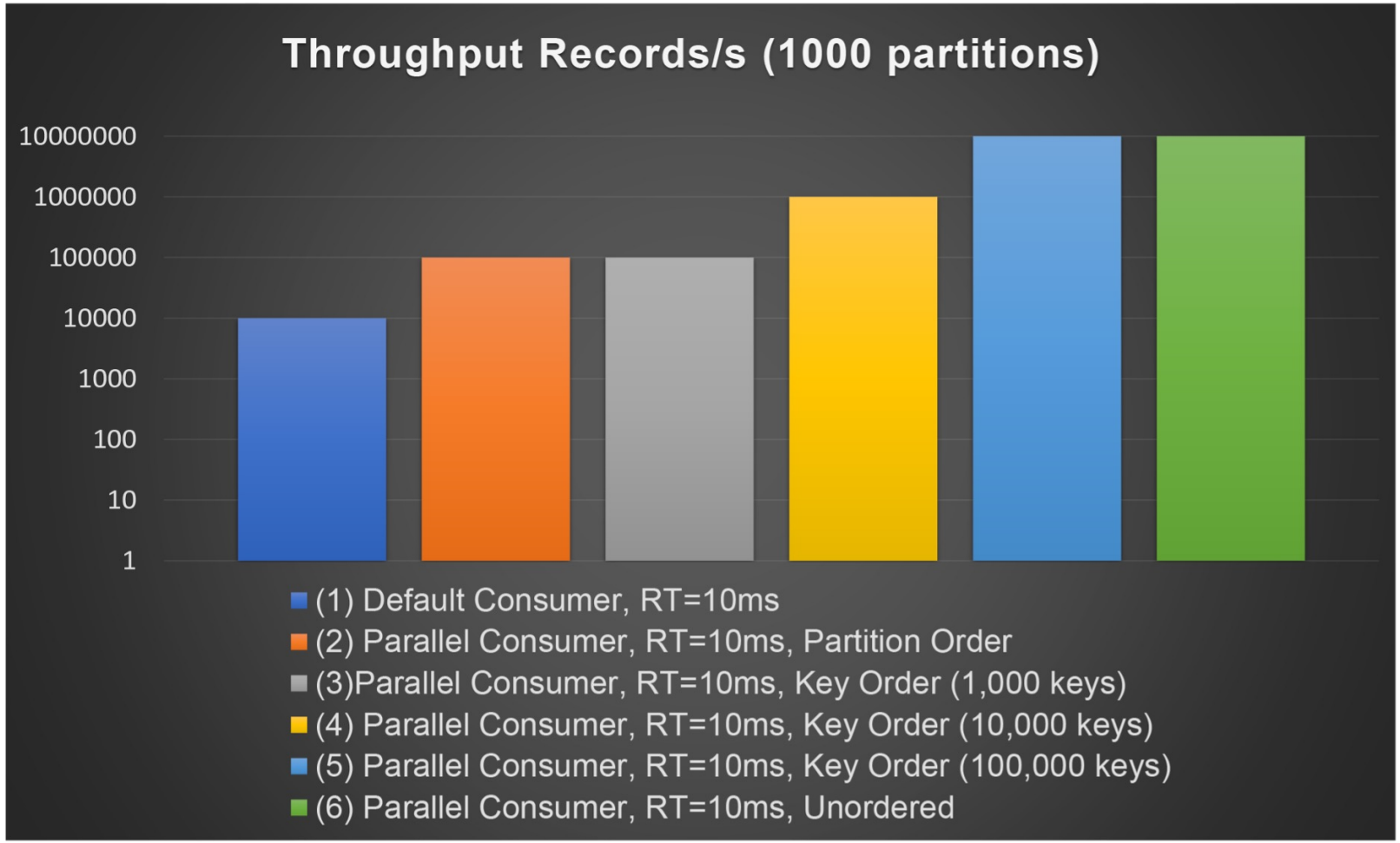
(Source: Getty Images)

Theoretical Improvement for Each Mode – max 3 orders of magnitude

instaclustr

1,000 partitions

100 consumers max



Experimental Results:

3, 50, and 200 times improvement, unordered best

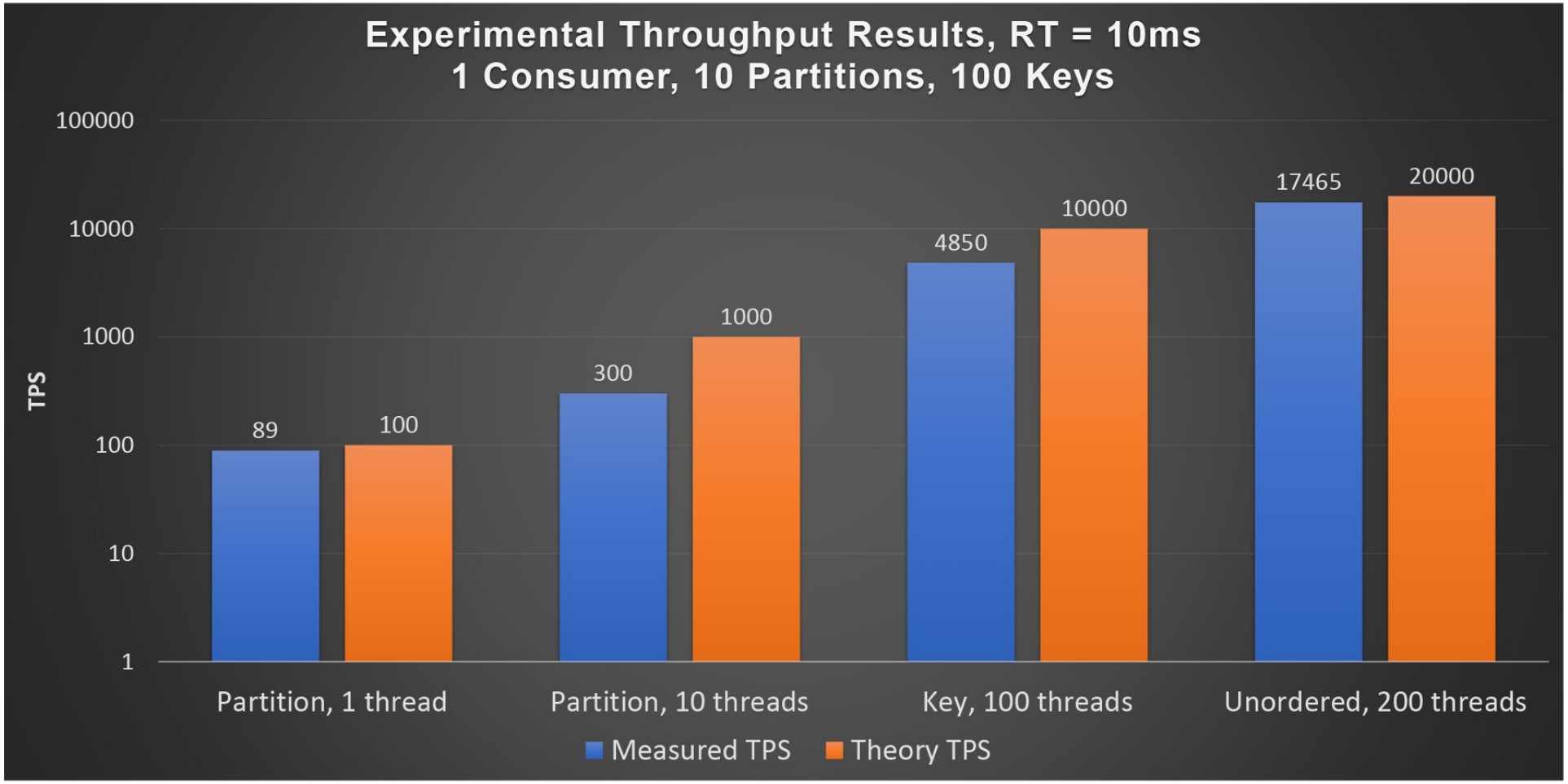
instaclustr

1 consumer

10 partitions

100 keys

10ms latency

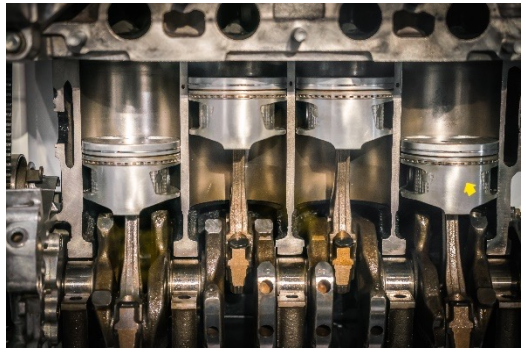


Watch Out for the Kafka Furies

Too many topics
(= too many partitions)

Too many consumer groups

Slow consumers
(= too many partitions)



Insufficient/
too many partitions

Single threaded
consumer
(= too many partitions)

instaclustr

Speed can be achieved with train-buses

Track + Buses

Minimize Topics and Partitions = Tracks
- Buses are fast & self-driving on tracks

Minimize Consumer Groups = Interchanges
- At interchanges, buses fan out onto roads, reducing passenger transfers

Maximize Consumer Concurrency = Buses
- Multiple passengers, integrated with road system

Adelaide's O-Bahn Busway train-bus system

Source: Wikimedia

Fury 5: Operational Problems

Pit Stop Performance Penalties (Source: Getty Images)

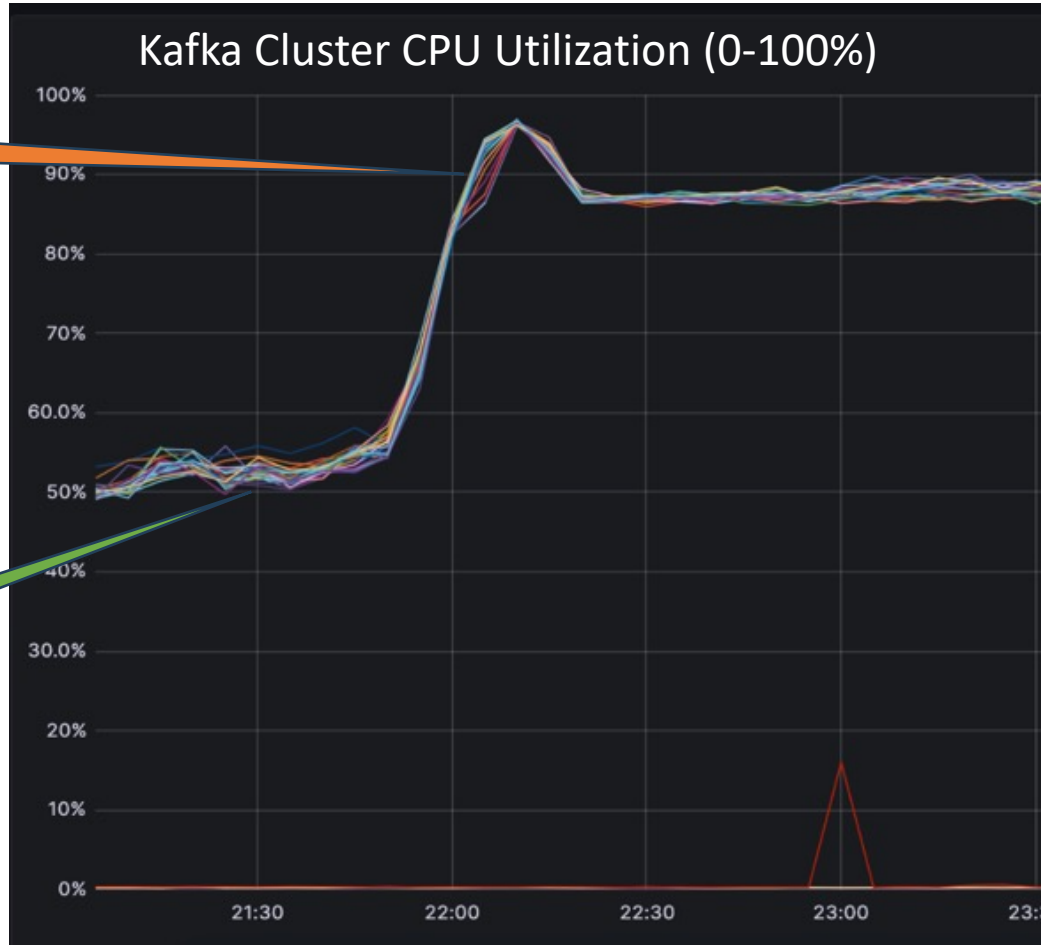
Even well designed Kafka Applications occasionally have operational performance problems

instaclustr

Abnormal

Normal

This was the only example of a Kafka performance problem in our Post-Incident Reviews



Rapid increase in CPU Utilization from normal of 50% to lots

What's going on?

Has the workload increased?

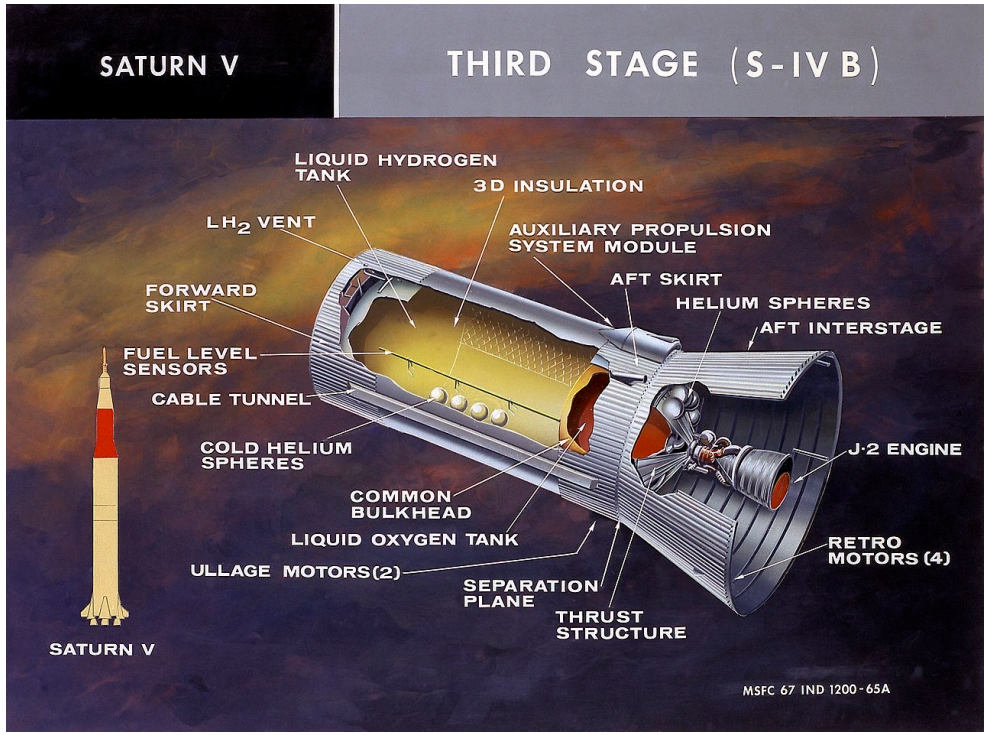
No.

Has the cluster capacity decreased? (e.g. lost some brokers)

No.

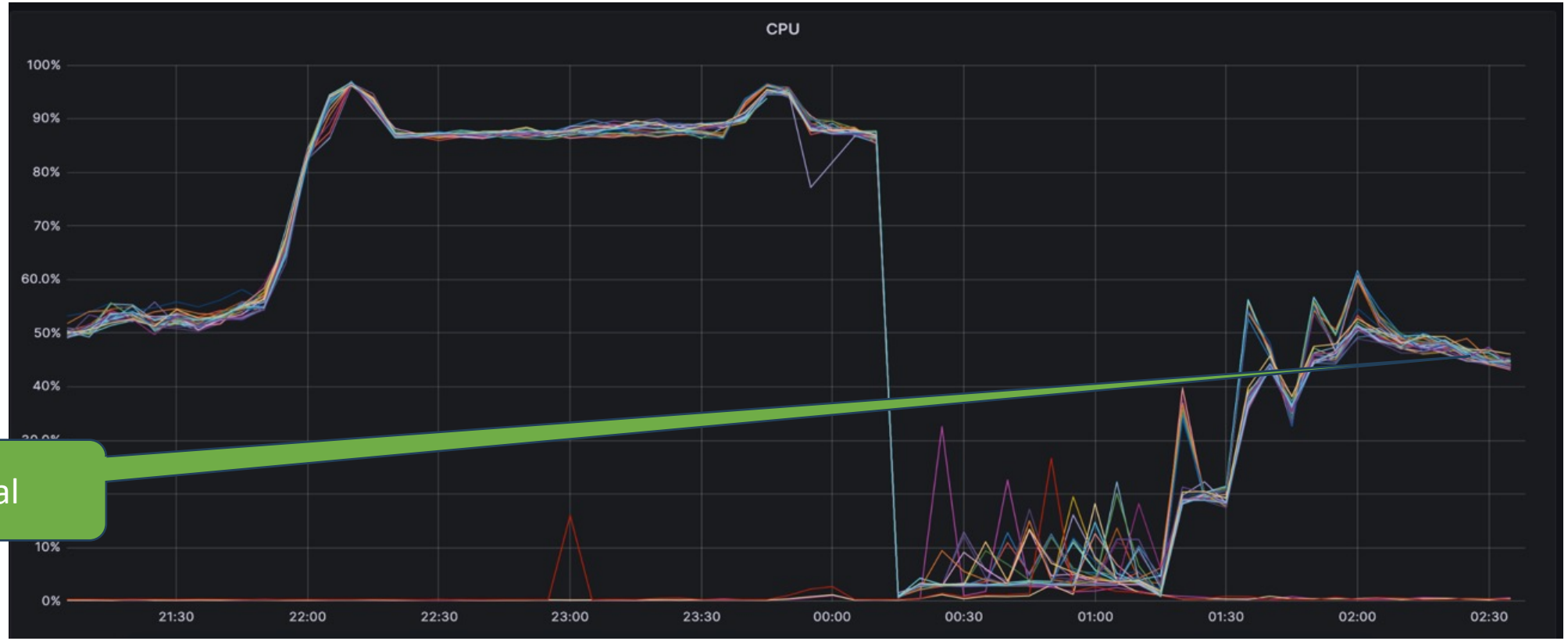
Remediation

- Attempt 1: Replace 1 broker at a time
  - Didn't work – problem reappeared when new broker took over partition leadership
  - (A broker restart is what triggered the problem)
- Attempt 2: Stop all customer clients (producers/consumers)
  - Perform a rolling restart of Kafka cluster
  - Restart clients, hold breathe…



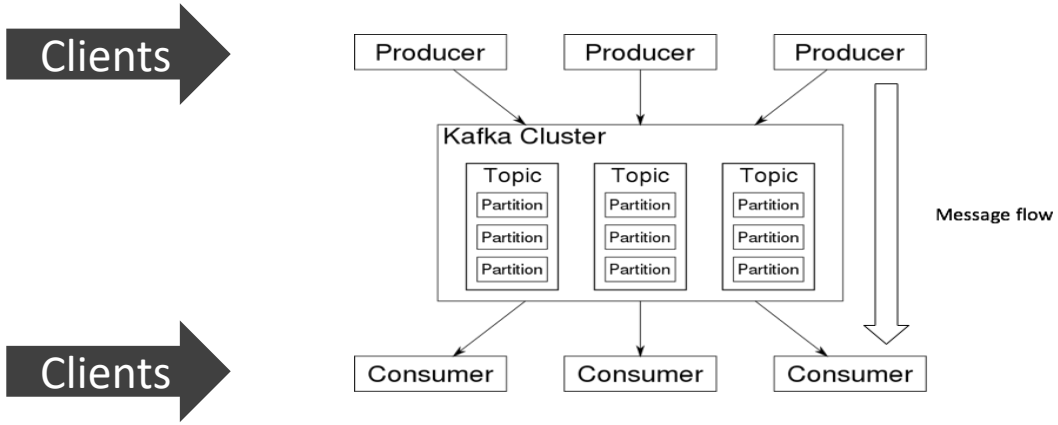
Apollo 3rd stage J-2 Engines (13,000,000 HP) were designed to restart – but failed to restart in uncrewed Apollo 6 (Source: NASA)

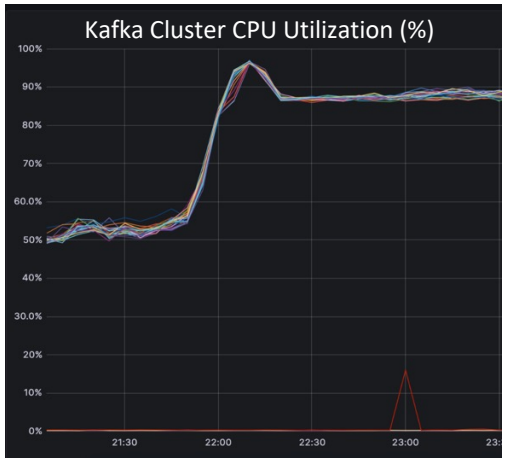
Back to normal

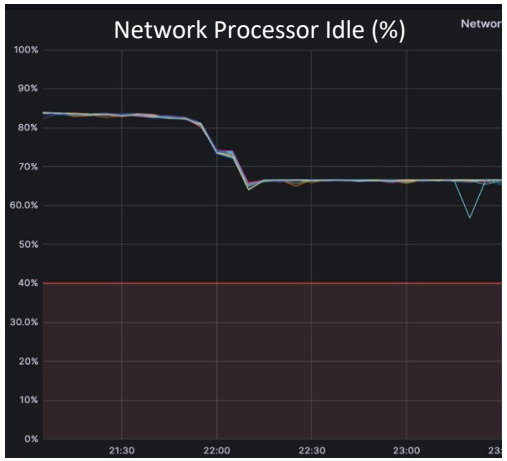


Diagnosis: Kafka is a distributed system

Kafka clients are also a critical part of the system







Kafka Network Processor Threads handle client network data

Network Processor Idle % has decreased (more is better, less is worse)

The client load had increased.

Why? Further Clues and Causes

instaclustr

- Kernel Error
  - TCP: request_sock_TCP: Possible SYN Flooding …
- Decreased Network Processor Idle % was a symptom
  - Of repeated Kafka producer connection attempts
  - TCP congestion control and window size dropped to very small and inconsistent values between producers and broker
  - Making it impossible to reconnect producers to brokers after a broker restart
- Cause?
  - Broker restart triggered the problem
  - Permanent fix required Linux Kernel and Kafka version upgrades
  - And different settings for SYN cookie options
  - Probably related to KAFKA issues 9648 and 764

And Back to the Start (Aston Martins)
Thank You and Goodbye (Eject)

instaclustr

Aston Martin DB5
(Source: Wikimedia)

"Ejector seat? You're joking."
My now "collectable" but played with Corgi DB5 *(Source: Paul Brebner)*

instaclustr
Now part of Spot by NetApp

www.instaclustr.com

info@instaclustr.com

@instaclustr

www.instaclustr.com/paul-brebner/

THANK YOU!

instaclustr
Now part of Spot by NetApp

www.instaclustr.com

info@instaclustr.com

@instaclustr