Building Resilient Data Pipelines

An introduction to Building Data Pipelines in Go on Kubernetes

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PREDIX

Who am I?

Senior Software Engineer

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Organizer for the GE Go User Group

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Climbing + Mountaineering

What we'll cover

1. Industrial IoT and Data @ GE
2. Introduction to Data Pipelines
3. Sample Data Pipeline in Go
4. Resiliency Testing our Data Pipeline
5. Results and takeaways

1. **Industrial IoT and Data @ GE**
2. Introduction to Data Pipelines
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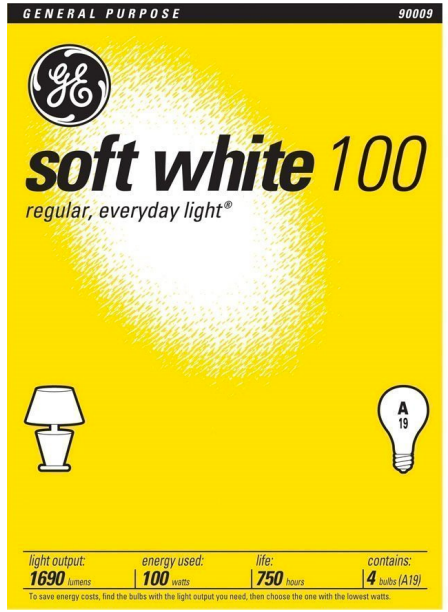
Who here has owned a GE Fridge, Lightbulb, or Microwave?



Actually, we make
HUGE Industrial assets...


2029
GECX
AC MOTORS

Industrial Internet of Things

- GE Assets produce a ton of useful data
- Valuable for gaining insights into these assets
- Asset Performance Management (APM)
- Small percent increase in efficiency saves billions of dollars

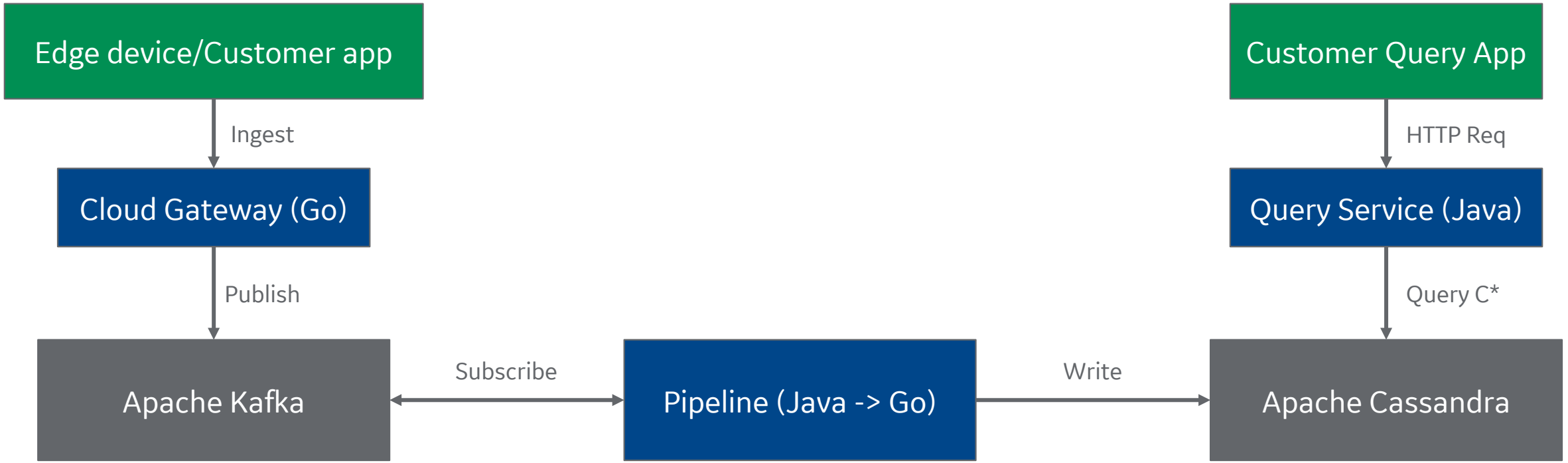
Predix

- Multi-cloud platform for the Industrial Internet of Things
- Many services and applications optimized for industrial data

Some Customers

- Schindler
- Exelon
- Rosneft
- BP
- GE Power
- GE Aviation
- GE Renewables

Monitoring and Diagnostic Architecture

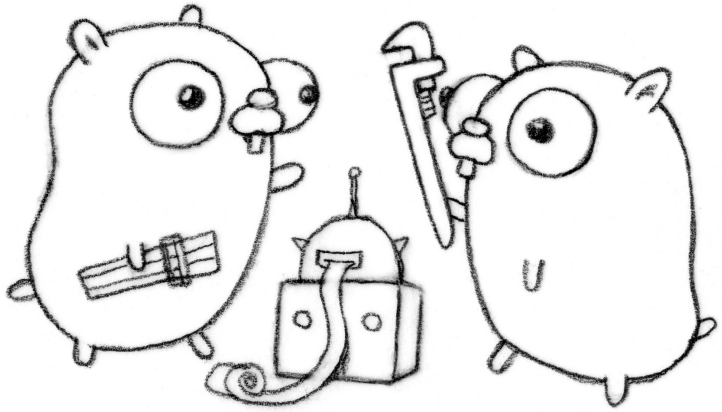


Data Pipeline component (Java version)

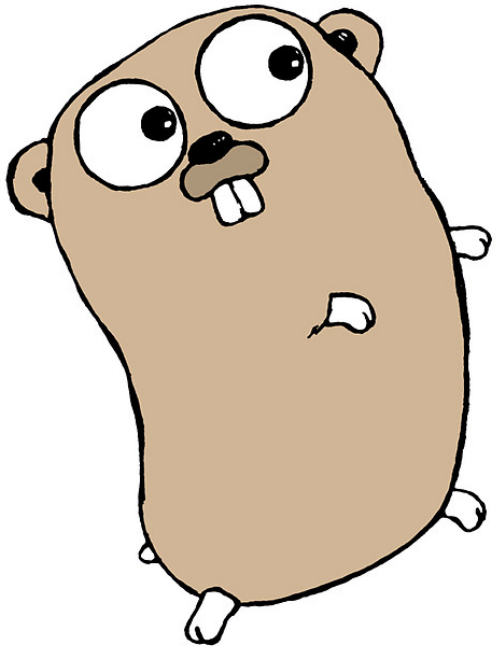
- **Stack:**
  - Stateful Java app
  - Java and Apache Apex
- **Largest deployment (out of several)**
  - 150 Cassandra nodes
  - 30 Kafka nodes
  - 144 Apache Apex containers
- **Results:**
  - 900,000 C* writes/second (peak)

Data Pipeline component (Go version)

- **Stack:**
  - Stateless Go app
  - Kubernetes & Cloud Foundry (prod environment specific)
- **Prod Configuration:**
  - Cloud Foundry application
  - 8+ instances
- **Results:**
  - Similar performance at lower scale (smaller dedicated cluster)
  - Pushing to multiple other dedicated environments soon!



Rewrite motivations



- Change in service vision/purpose
  - Originally – wanted customer specific data models/parsing
  - Now – standard data model, parsing
- Operational cost ($$$)
  - Managing a Hadoop cluster
  - Resources (RAM/CPU/Disk)
- Moving towards Kubernetes
  - Simple Go microservice
- We love Go!

1. Data @ GE
2. **Introduction to Data Pipelines**
3. Sample Data Pipeline in Go
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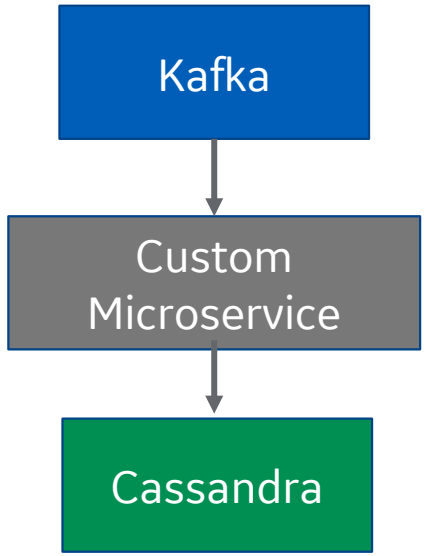
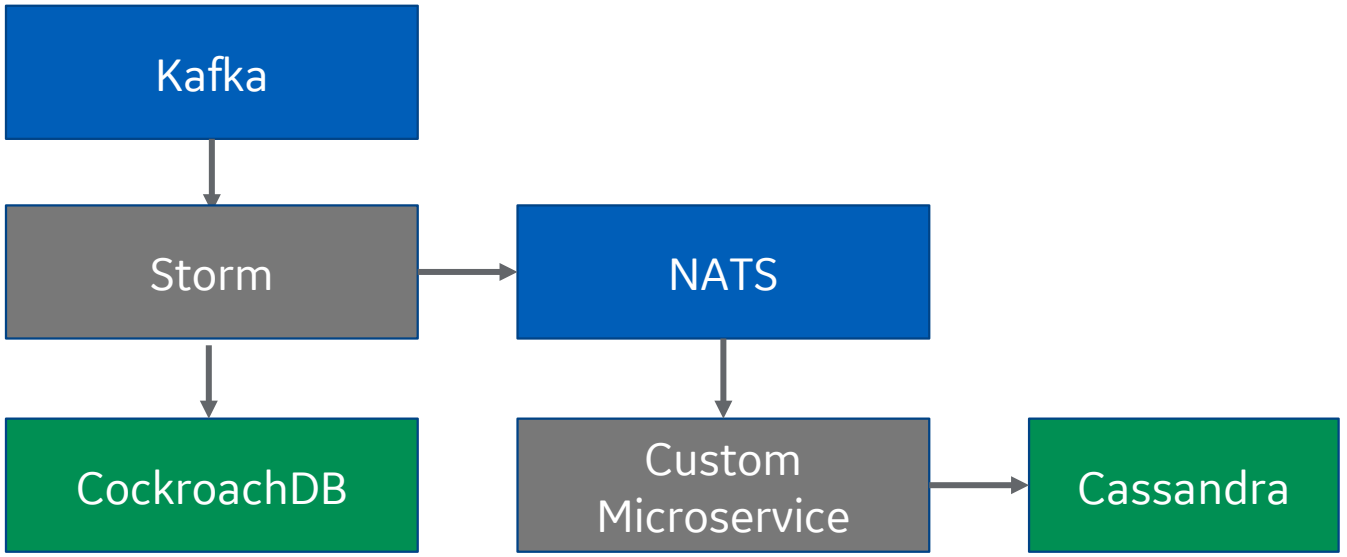
Introduction to Data Pipelines

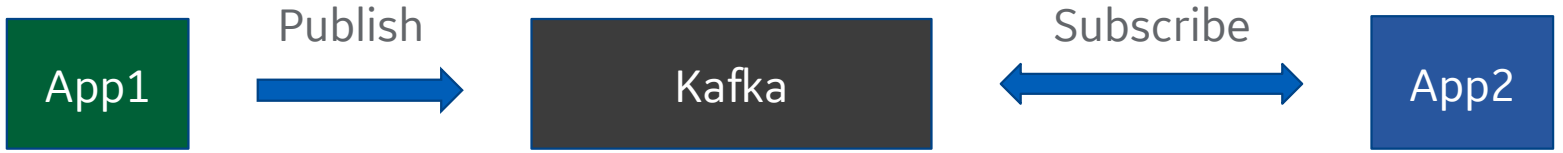
- Move data from one system to another
- Performing transformations and business logic



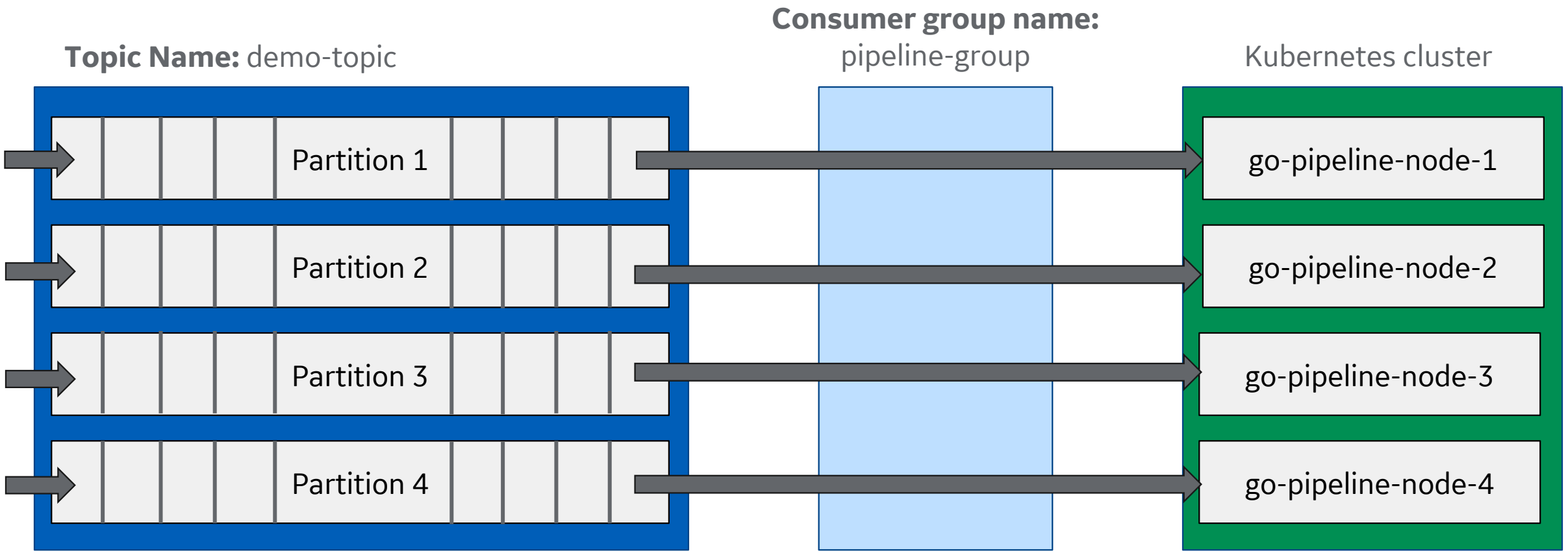


Data source: Apache Kafka

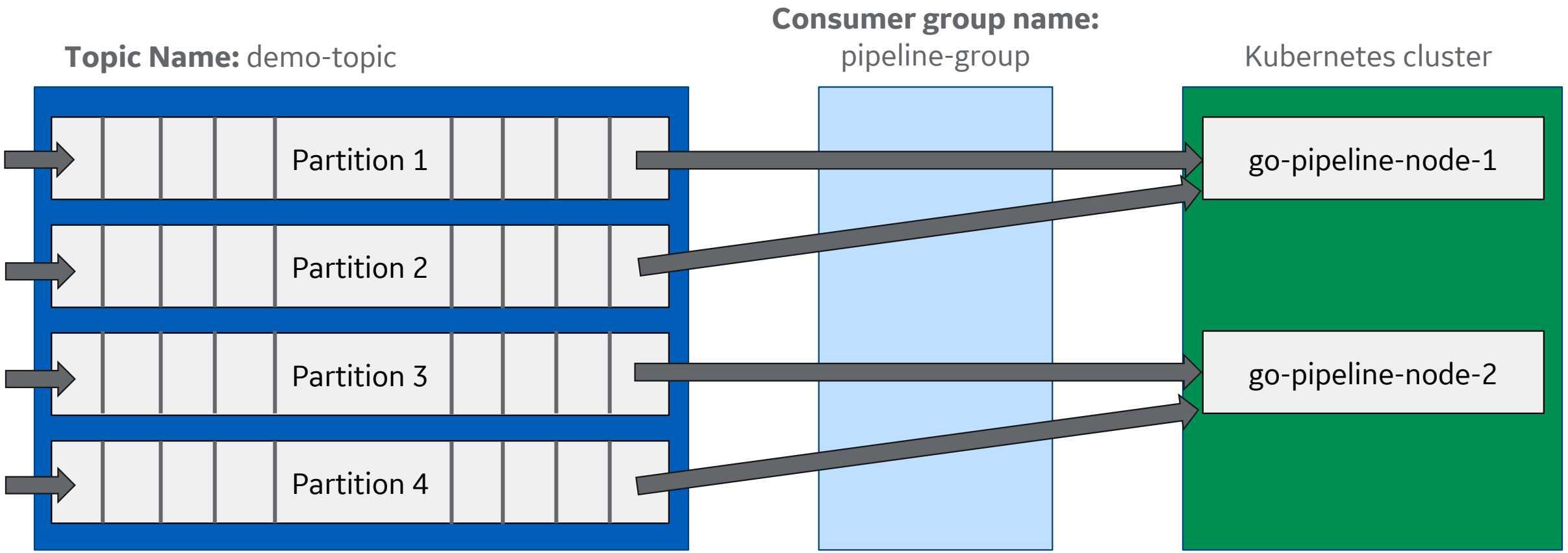
- Publish/Subscribe messaging system
- Parallelized with topic partitions
- High throughput
- Very widely used
- Java, open source - github.com/apache/kafka



Consumer groups Example 1: 1:1



Consumer groups Example: 2:1



Using Kafka with Go

- Many libraries
  github.com/Shopify/sarama + github.com/bsm/sarama-cluster
  github.com/confluentinc/confluent-kafka-go
  github.com/segmentio/kafka-go (June 2017)
- Chose Sarama + Sarama Cluster
  1. No CGo dependency
  2. Most mature library (at the time)
  3. Wrote internal tooling + documentation around it for ease of use
- Pick what works for you

Data store: Apache Cassandra

- Column-oriented database
- Fault Tolerant - replicated
- Scalable
  - Apple: over 75,000 nodes storing over 10 PB of data
  - Netflix: 2,500 nodes, 420 TB, 1 trillion requests
  - GE: 1,250 nodes, find size, find throughput
- Java, open source github.com/apache/cassandra

Go and Cassandra

- github.com/gocql/gocql
- For high performance data bindings:
  - github.com/scylladb/gocqlx

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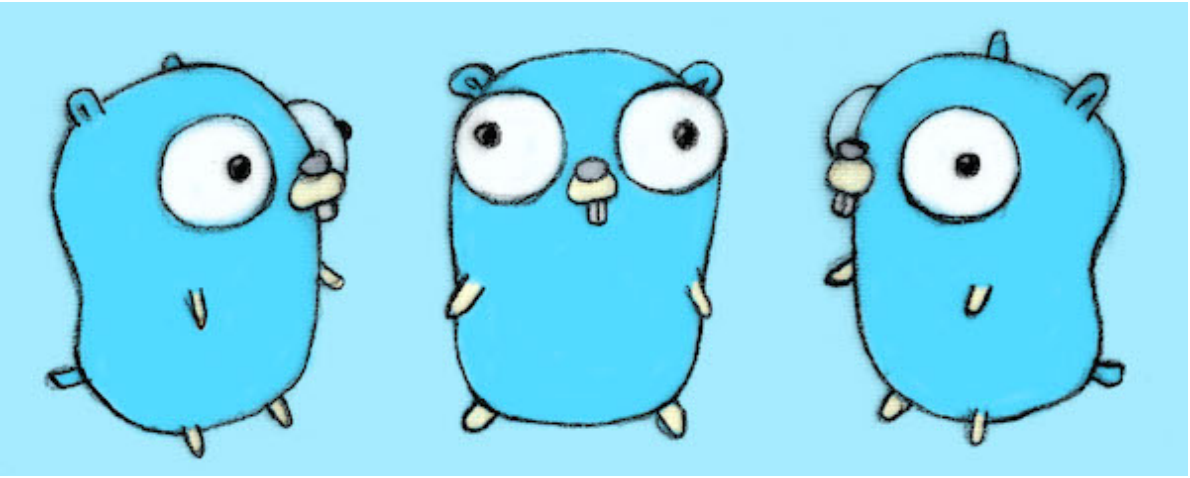
By show of hands...

Who likes the Go Gopher?



I bring to you... Gophers “R” Us

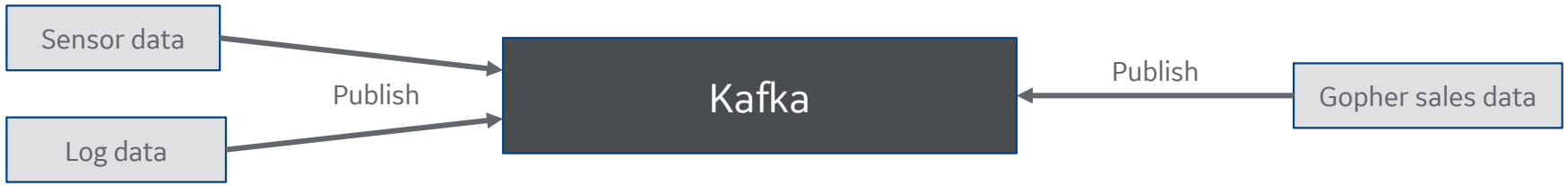
Example: Data Pipeline (Gophers “R” Us)

Gopher sales data

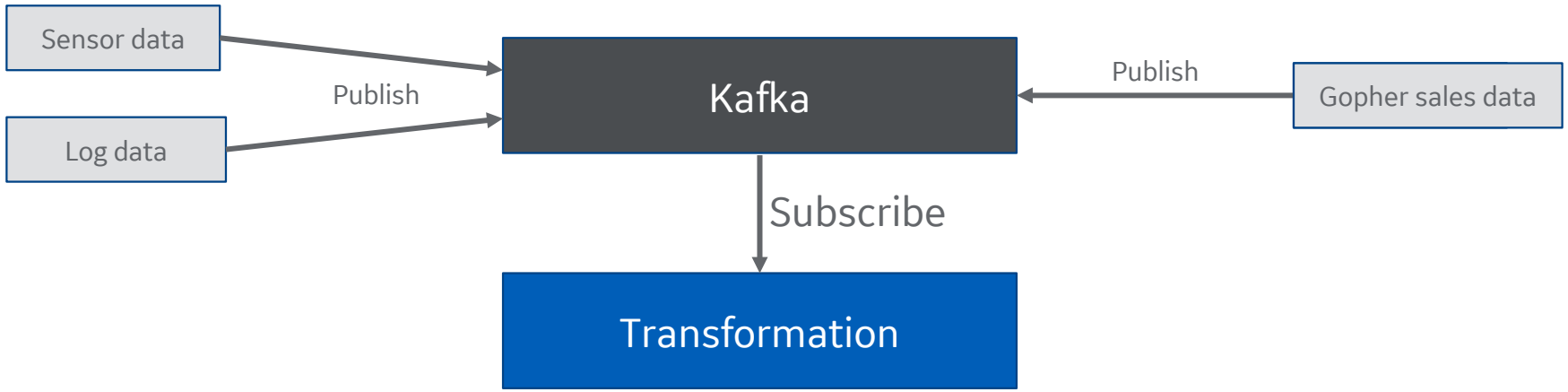
Sensor data

Log data

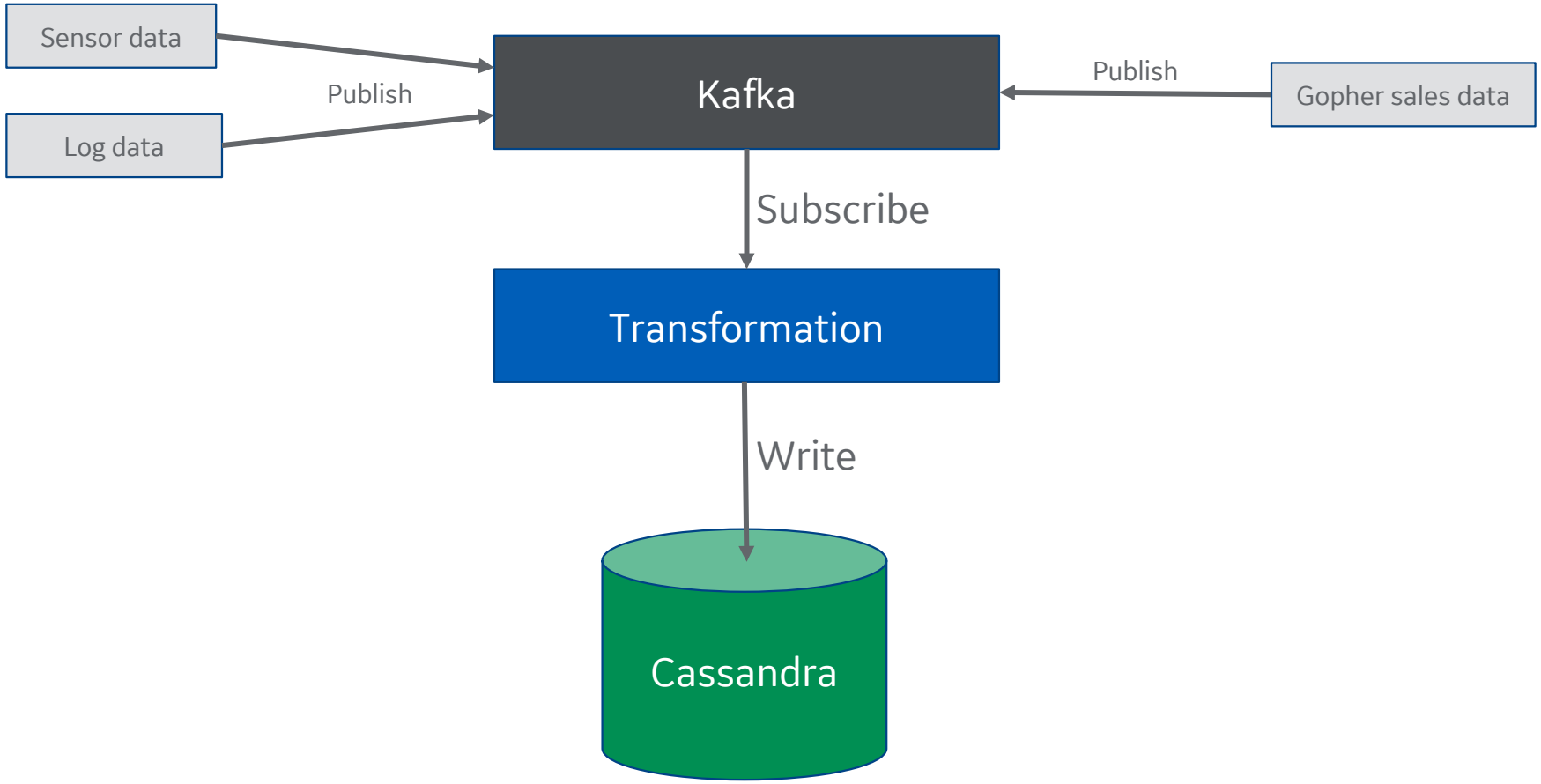
Data pipeline architecture



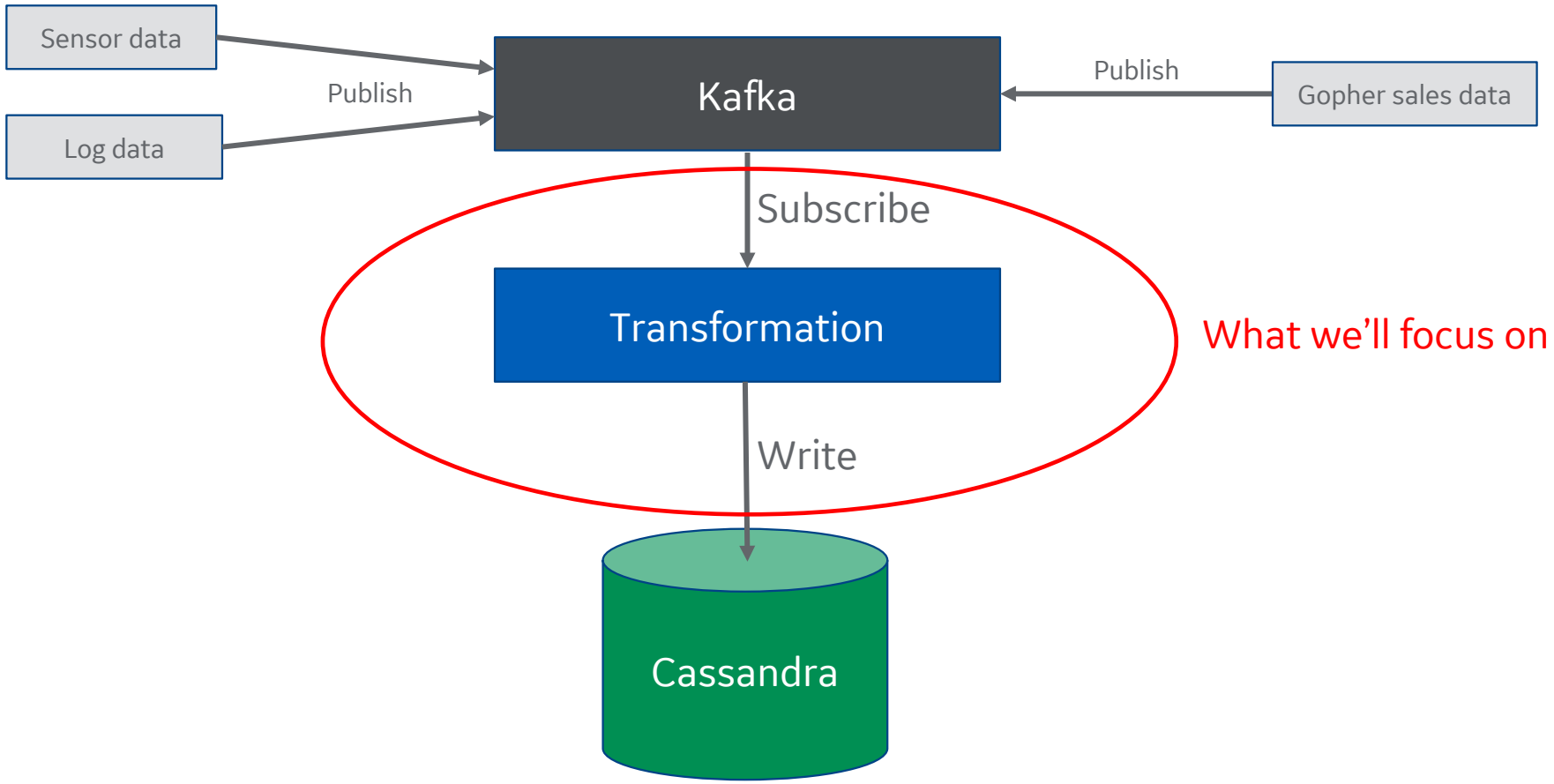
Data pipeline architecture



Data pipeline architecture

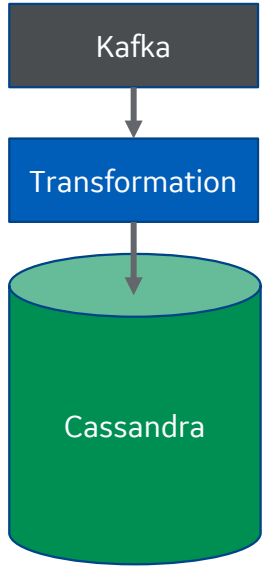


Data pipeline architecture



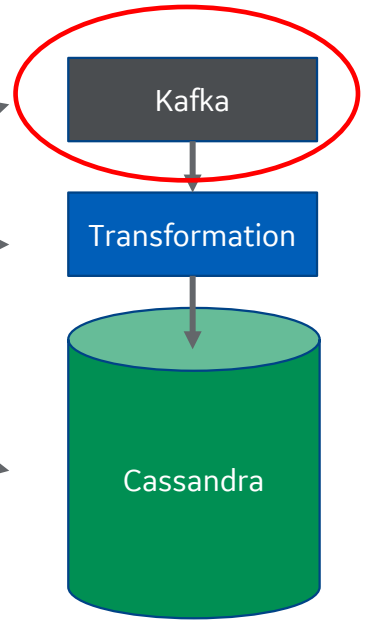
Simplified Application Flow: 3 Easy Steps

```
for {
  select {
    case msg := <-consumer.Messages():
      event := Transform(&msg)
      sink.Write(&event)
  }
}
```



Subscribing to Kafka

```
for {
  select {
    case msg := <-consumer.Messages():
      event := Transform(&msg)
      sink.Write(&event)
  }
}
```



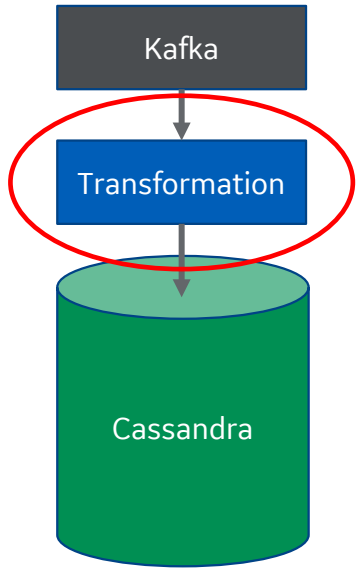
Subscribing to Kafka

```
for {
    select {
    case msg, ok := <-consumer.Messages():
        log.Printf("Messages received: %v", *msg)

    case notification, ok := <-consumer.Notifications():
        log.Printf("Rebalance received: %v", *notification)

    case err, ok := <-consumer.Errors():
        log.Printf("Error received: %s", err.Error())

    }
}
```

1. **Messages channel:** Data from Kafka
2. **Notifications channel:** Rebalance notifications
3. **Errors channel:** Errors in offset management

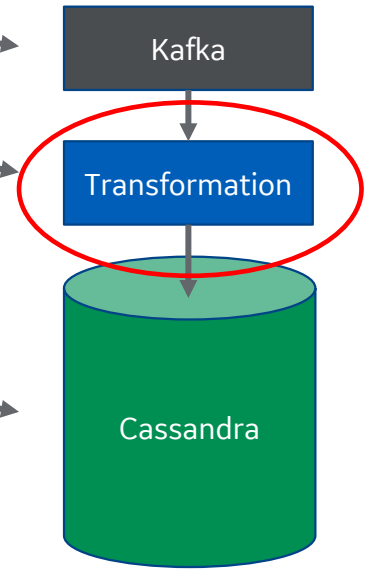
Handling messages

```
for {
  select {
    case msg := <-consumer.Messages():
      event := Transform(&msg)
      sink.Write(&event)
  }
}
```



Handling messages

```
case msg, _ := <-consumer.Messages():
    event, err := Transform(msg)
    if err != nil {
        ...
    }

    if err := sink.Write(event); err != nil {
        ...
    }
    consumer.MarkOffset(msg, "")
```



Transforming our message

Gophers “R” Us complicated business logic

```go
// Transform take a sarama Message and transforms it based
// on our business logic
func Transform(msg *sarama.ConsumerMessage) (*StoreEvent, error) {
    var event StoreEvent
    if err := json.Unmarshal(msg.Value, &event); err != nil {
        ...
    }
    event.AssignDepartment()

    return &event, nil
}
```

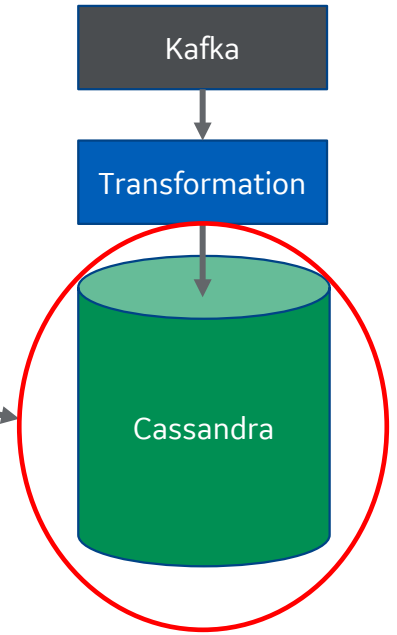
Transforming our message

Gophers “R” Us complicated business logic

```go
// AssignDepartment assigns a deparment for an item based on it's name
func (se *StoreEvent) AssignDepartment() {
    switch se.ItemName {
    case "blue-gopher", "pink-gopher", "purple-gopher":
        se.ItemDepartment = deptGophers

    case "gophercon-us-sticker", "gosf-sticker", "gophercon-uk-sticker":
        se.ItemDepartment = deptStickers

    case "gophercon-us-shirt", "gophercon-uk-shirt":
        se.ItemDepartment = deptClothing

    default:
        se.ItemDepartment = deptMisc
    }
}
```

Writing to Cassandra

```
for {
  select {
    case msg := <-consumer.Messages():
      event := Transform(&msg)
      sink.Write(&event)
  }
}
```



Writing to Cassandra

```go
// Write persists an event to Cassandra
func (cs *CassandraSink) Write(e *StoreEvent) error {
    stmt, names := qb.Insert(fmt.Sprintf("%s.%s", cs.Keyspace, cs.StoreEventTable)).
        Columns("name", "price", "dept").
        ToCql()
    q := gocqlx.Query(cs.Session.Query(stmt), names).Bind(e.ItemName, e.Price, e.ItemDepartment)
    return q.Exec()
}
```

Graceful shutdown

```go
signals := make(chan os.Signal, 1)
for {
    select {
    case sig, _ := <-signals:
        switch sig {
        case syscall.SIGTERM:
            log.Printf("Gracefully shutting down. Goodbye!")
            consumer.Close()
            sink.Session.Close()
            os.Exit(0)
        }
```

1. Setup channel for listening to OS Signals

2. Listen on os signals channel

3. Handle SIGTERM for graceful shutdown
   - k8s sends this signal when containers are stopped, scaled down, etc

4. Grace period (10-30s)
   - Configurable in k8s: *terminationGracePeriodSeconds*
   - Container killed after this period (or you can os.Exit(0) manually)

Deploying to Kubernetes

```yaml
---
kind: Deployment
apiVersion: extensions/v1beta1
metadata:
  name: gophers-r-us-pipeline
spec:
  template:
    metadata:
      labels:
        app: gophers-r-us-pipeline
        id: "1"
    spec:
      containers:
      - name: gophers-r-us-pipeline
        image: ggriffiths/gophers-r-us-pipeline:v1
        ports:
        - containerPort: 8080
      terminationGracePeriodSeconds: 15
```

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Reliability Testing

- Systems fail
  - How does our pipeline behave during times like these?
  - How can we remedy these failures?
  - How can we ensure customer data is not lost?
- Embrace failure scenarios
  - or they will embrace you at 3 AM
- If this interests you: Google SRE Book landing.google.com/sre/book/index.html

Reliability Testing our Data Pipeline

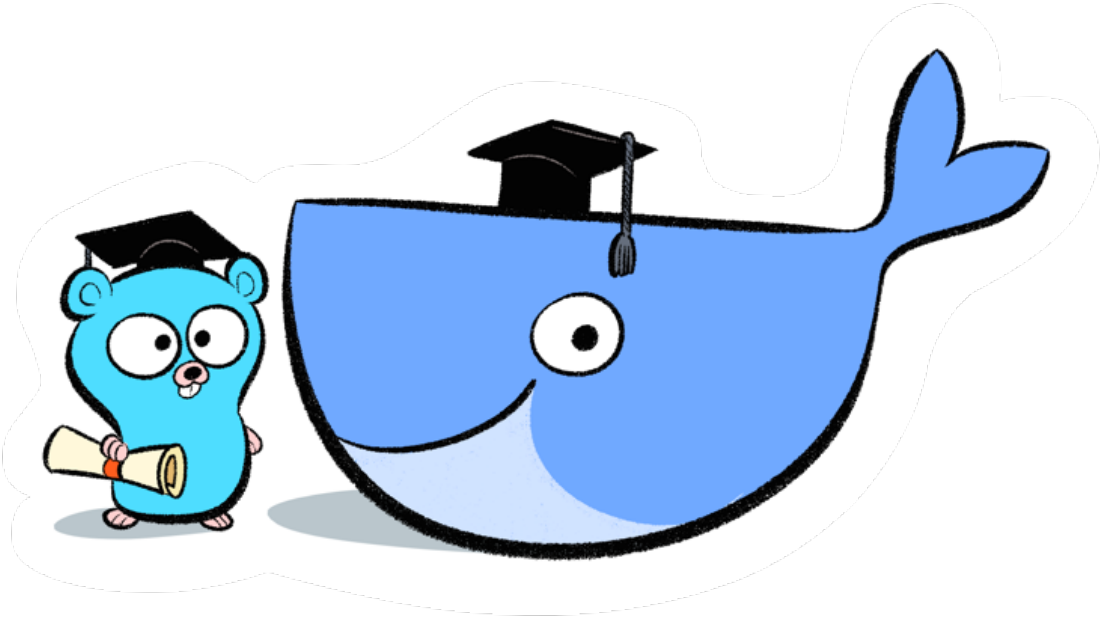
- What can fail?
  - Data pipeline node(s)
  - Kafka node(s)
  - Cassandra node(s)
  - Kubernetes can fail
- How does our pipeline behave when this happens?
  - We can write a test
- How can we remedy these failures?

Reliability Test example

```
Describe("Given our Data pipeline is running successfully, reading from Kafka and writing to C*", func() {
    Context("When our Cassandra cluster goes down", func() {
        It("Then no data should be lost", func() {
            initalCount := cassandraRowCount("keyspace", "item_table")

            desiredMessageCount := 50
            for i := 0; i < desiredMessageCount; i++ {
                pushMessages("demo-topic", 1)

                // Take Cassandra down for 20 seconds
                switch i {
                case 10:
                    pauseDockerImage("cassandra")

                case 30:
                    unPauseDockerImage("cassandra")
                }

                time.Sleep(1 * time.Second)
            }

            finalCount := cassandraRowCount("keyspace", "item_table")
            Expect(finalCount - initalCount).To(Equal(desiredMessageCount))
        })
    })
})
```

Reliability Test example

- What else can we test?
  - Partial cluster failures
  - Full cluster failures
  - Pipeline failures
  - High load
  - etc



- Integration Test with Docker!

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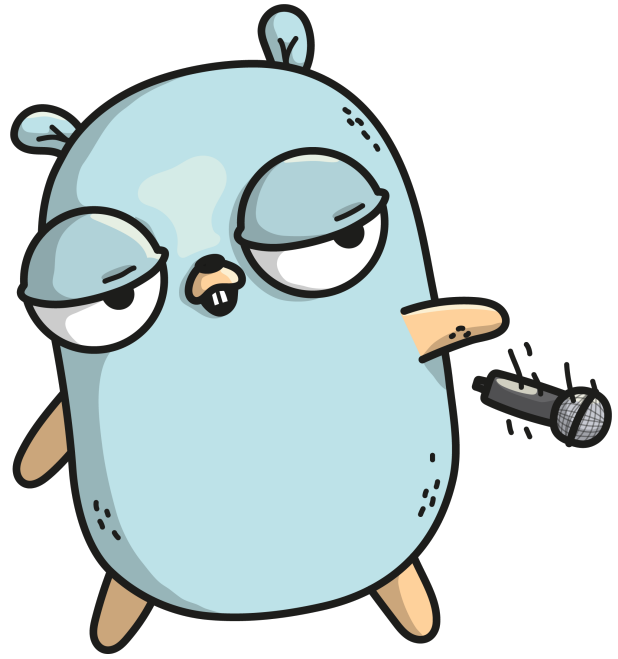
Results & Takeaways

- Building Data Pipelines in Go
  - Simple to get a small app up and running
  - Good enough community support for Kafka, Cassandra, etc
  - Use chan of os.Signals for graceful shutdown
- Reliability testing
  - Use docker to integration/reliability test
  - Understand how your system behaves during failures scenarios
- Go Pipelines at GE Digital
  - Replaced our existing Java pipeline for lower operational cost, simplicity, and performance



We’re hiring!

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Questions?

Or funding for Gophers ”R” Us?

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