Quarkus Basics

Training

PUZZLE ITC
changing IT for the better

Nice to meet you

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Agenda - Day 1

- Microservices architecture
- Quarkus introduction
- MicroProfile specification
- RESTful microservices with Quarkus

Agenda - Day 2

- 8 fallacies of distributed computing
- Cloud patterns
- Continuous integration and delivery
- Event driven architecture and messaging
- Observability – Metrics and Tracing
- Writing your own Quarkus extension

Day 1

Agenda - Day 1

- Microservices architecture
- Quarkus introduction
- MicroProfile specification
- RESTful microservices with Quarkus

Microservices

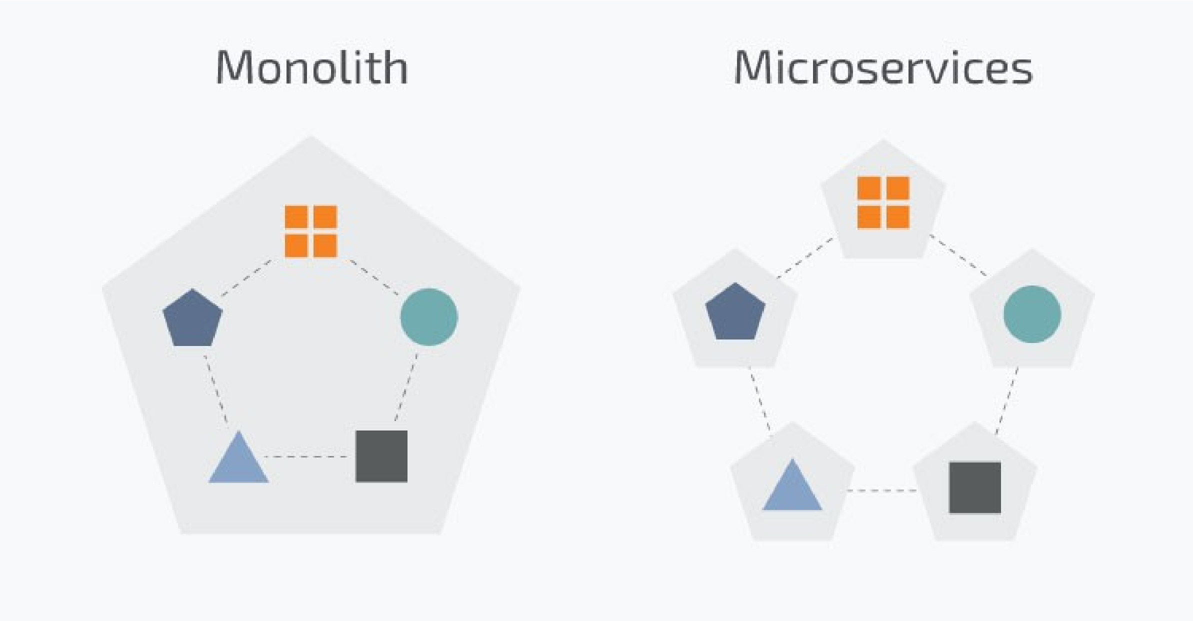
- What are microservices
- Why and when to use them
- Advantages / Disadvantages
- Approach to migrate

Monolithic Architecture

Monolithic Architecture

- Single code-base
- Single unit deployable
- Independent from other applications
- All domains or business processes in one application

Microservices Architecture



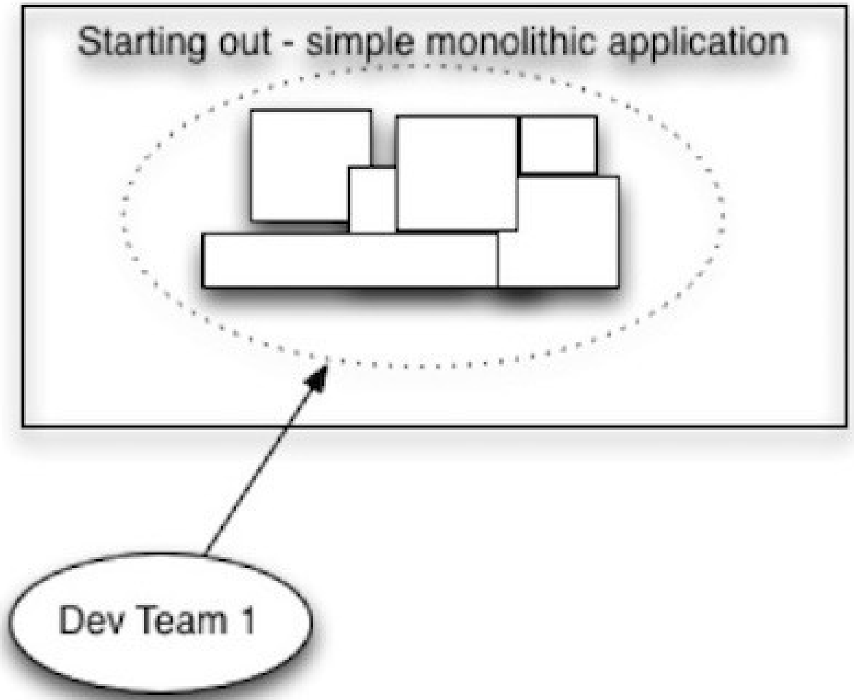
Microservices Architecture

- Small autonomous applications
- Independent life cycles
- Microservice for single responsibility / domain
- Loosely coupled
- Code base per domain / business process

Microservices Architecture

- When to choose which architecture?

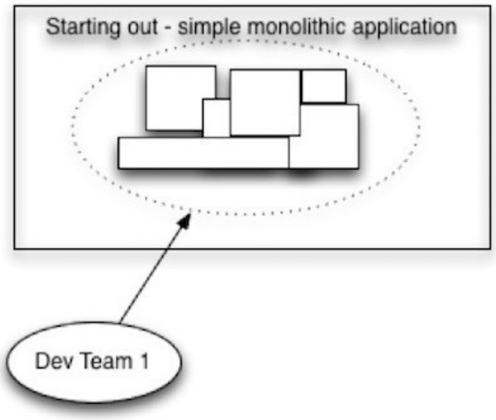
New Application



Advantages of monoliths

Simple architecture

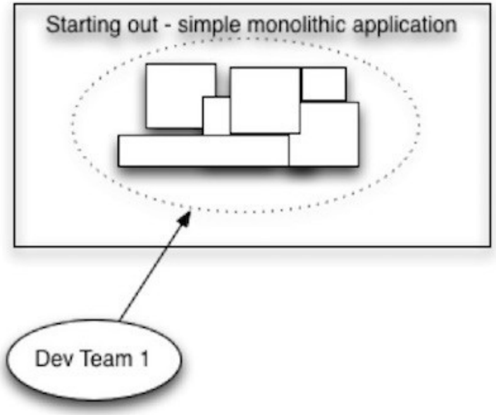
- Everything is local
- High productivity
- Limited attack vectors
- Easy testing
- Performance matches requirements



Advantages of monoliths

Team

- Dedicated team
- Independent releasing
- Features can be released fast
- No dependencies to other teams
- Devs have strong application knowledge



But then...

- Application is a big success
- Users increase
- Traffic increases dramatically
- New features
- Dev team grows

Application and complexity grows

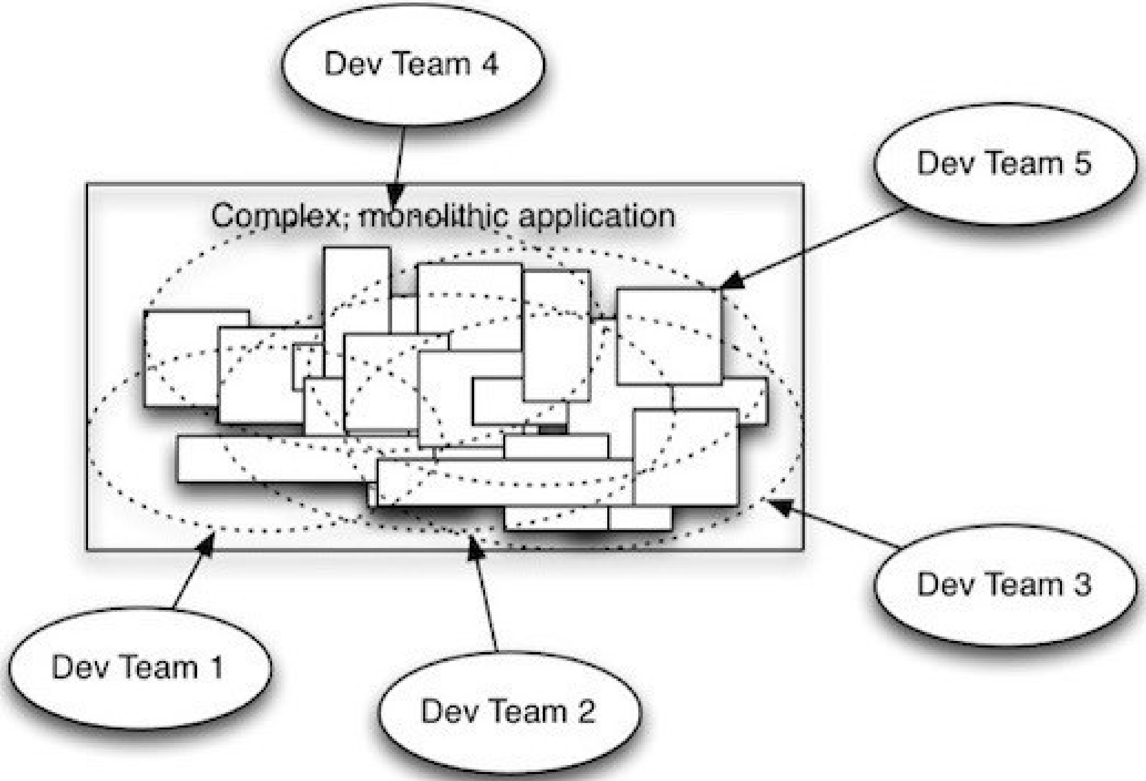
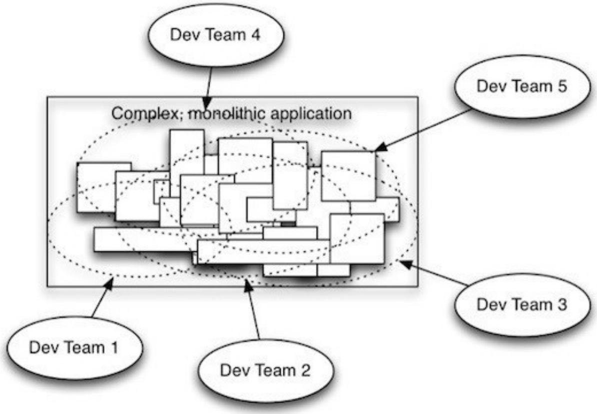


Image source: linkedin.com

Disadvantages of monoliths

Complex architecture

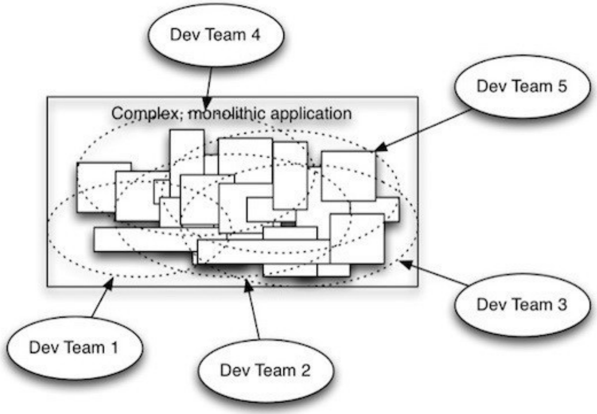
- Architectural changes are difficult
- Impact of code change are hard to estimate
- Keeping up code quality needs extra effort
- Newer technologies are hard to pickup



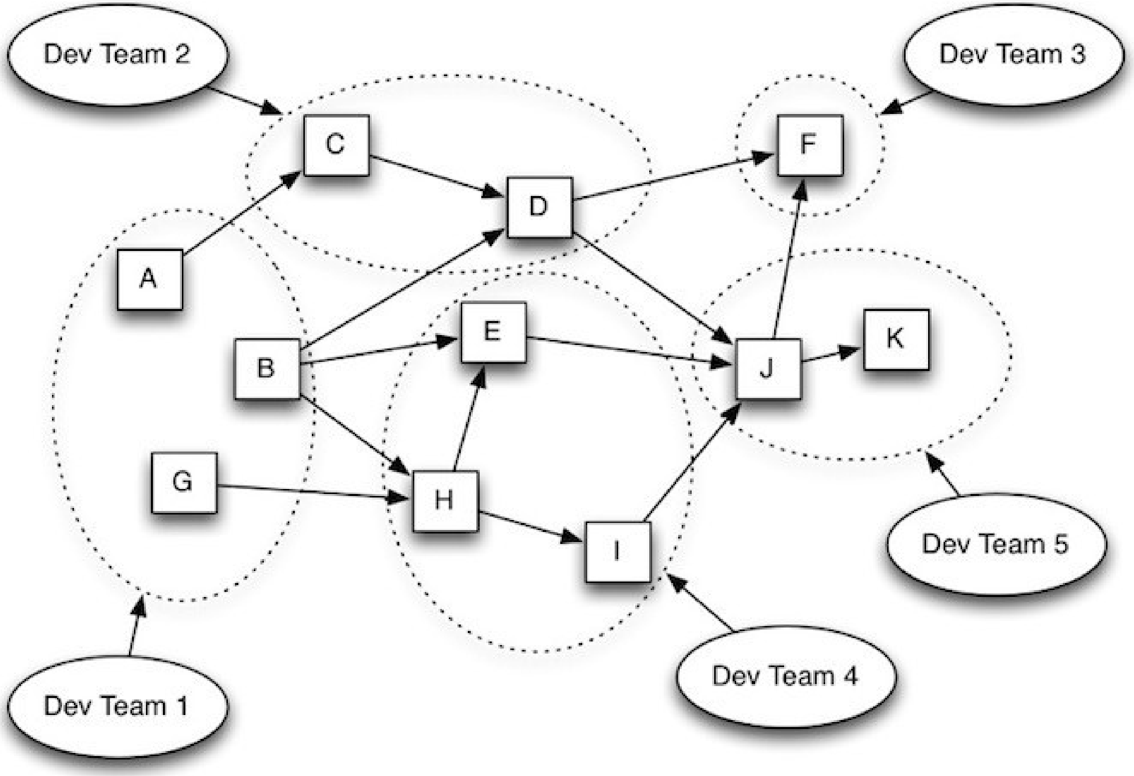
Disadvantages of monoliths (cont.)

Team

- Teams need to be coordinated
- Code changes may collide
- Release planning required
- Feature freeze and test cycles
- Devs have limited knowledge
- Productivity drops



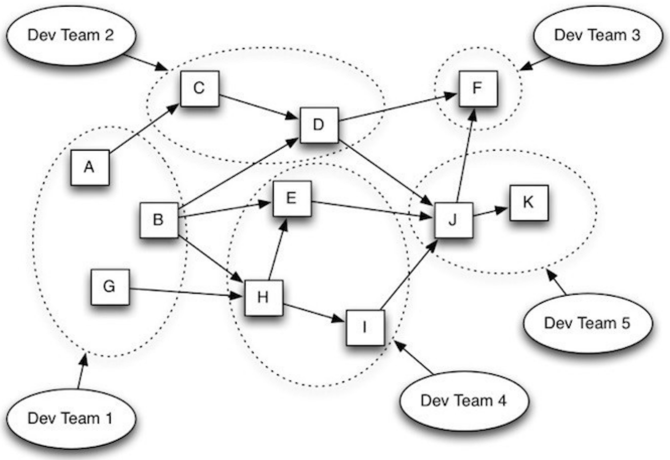
Ok, now what?


Dev Team 2
C
D
F
Dev Team 3
A
E
K
B
J
G
H
I
Dev Team 5
Dev Team 1
Dev Team 4

Advantages of microservices

Architecture

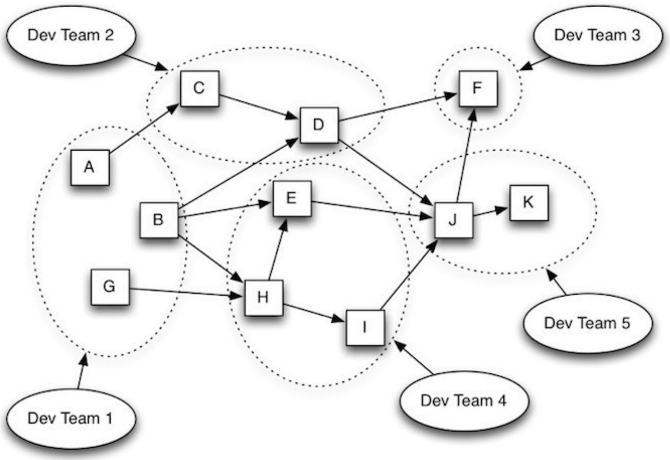
- Independent modules
- Defined boundaries (APIs, Events)
- Loosely coupled (if done right)
- Polyglot (what best fits the task)



Advantages of microservices

Team

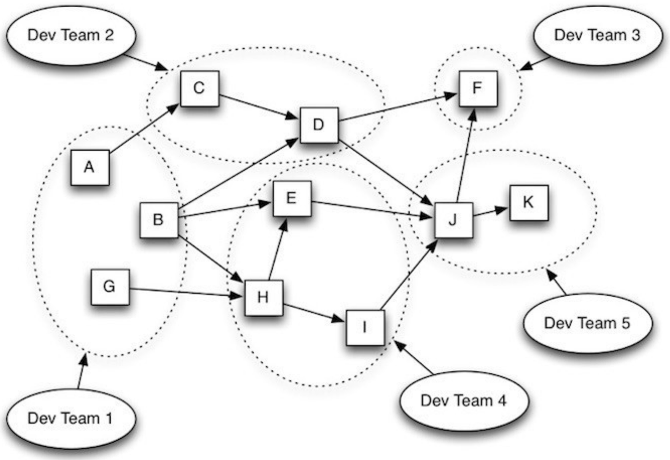
- Teams work independently
- Need to agree to defined boundaries
- Independent within their microservice
- Easier onboarding due limited scope



Advantages of microservices

Deployment and Runtime

- Deploy independently
- Easier scaling of single components
- Bugs may be local only



But ...

Image source: turnoff.us

Disadvantages of microservices

Architecture

- Everything is local does not hold anymore
- Data is distributed, no foreign keys across boundaries
- Keeping data consistent needs extra effort
- Communication and error handling needs extra effort
- Changing the agreed boundaries may be hard

Disadvantages of microservices (cont.)

Deployment and Runtime

- Harder troubleshooting with multiple instances
- Root cause detection can be hard
- More attack vectors

Short Recap

Microservices

- Lead to modularity
- Developers are enforced to respect boundaries
- Enable teams to work and release independently
- Can be replaced as long as boundary is untouched

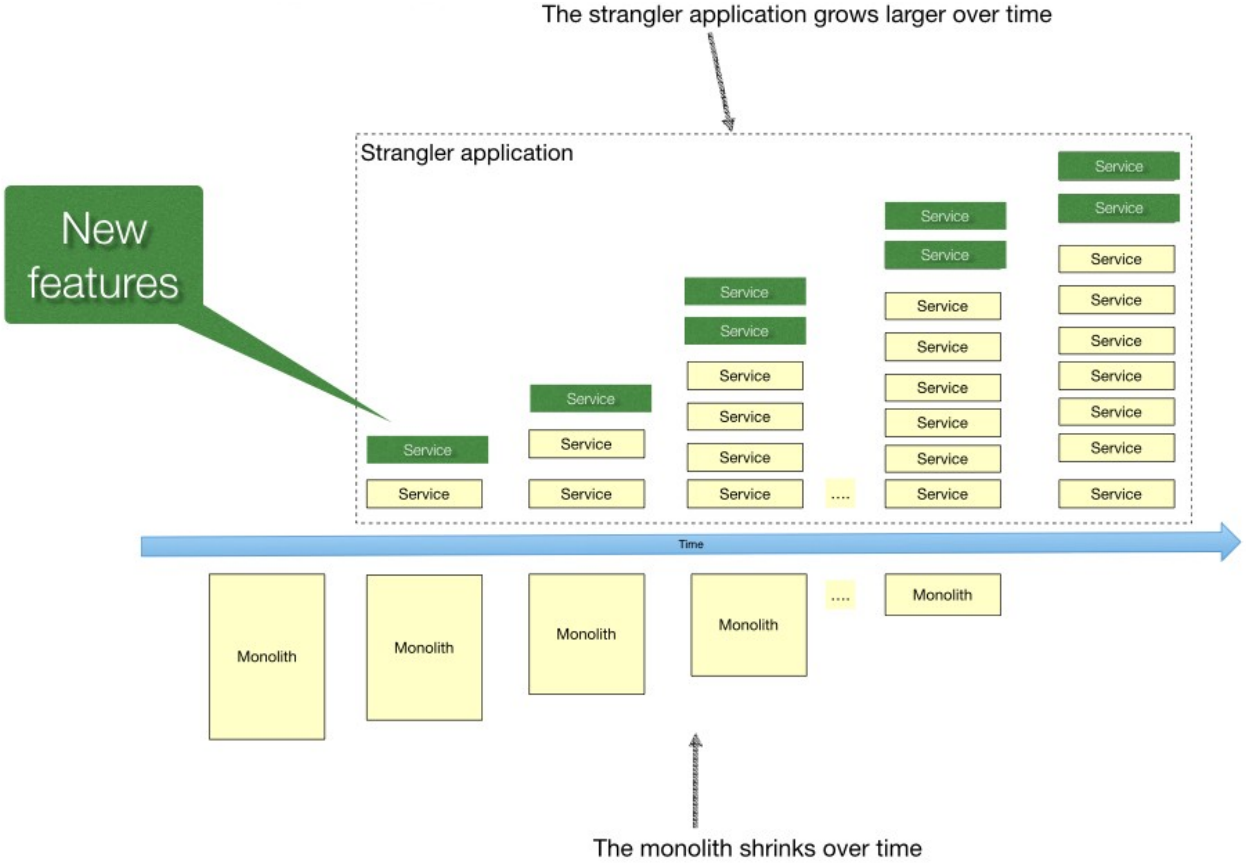
But they introduce technical complexity

Microservices Architecture

- How to migrate from monolithic application?

Strangler pattern

Strangler pattern



Agenda - Day 1

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- MicroProfile specification
- RESTful microservices with Quarkus

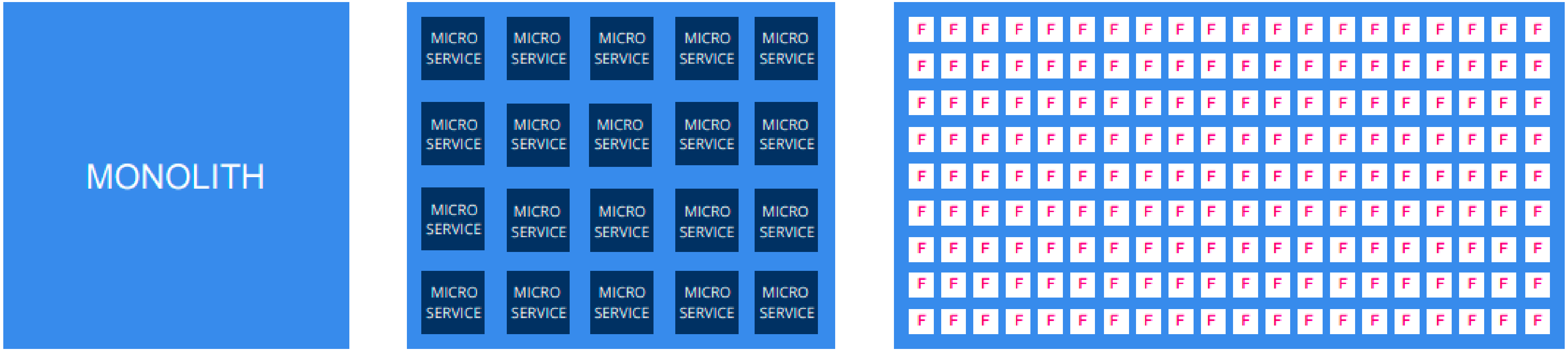
What is Quarkus?

«Full-stack, Kubernetes-native Java framework made for JVM and native compilation», Red Hat

«Toolkit and Framework for writing Java, Kotlin and Scala applications», Peter Palaga 2020

«Build time augmentation Toolkit», Peter Palaga 2021

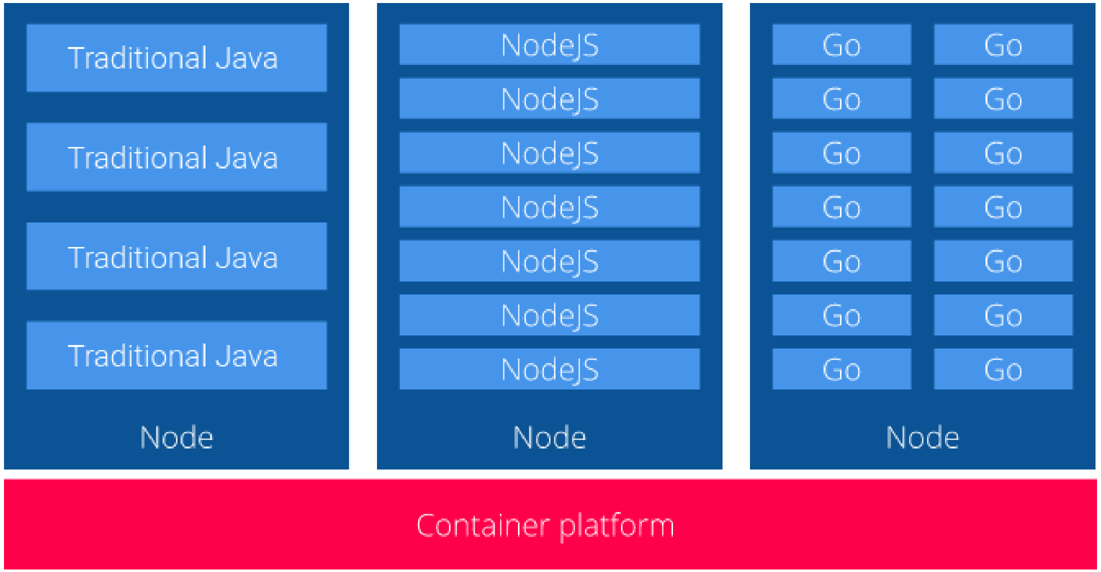
Why Quarkus?



- 1 monolith → 20 Microservices → 200 functions
- Big → Small
- Long living → short living

Image source: Red Hat

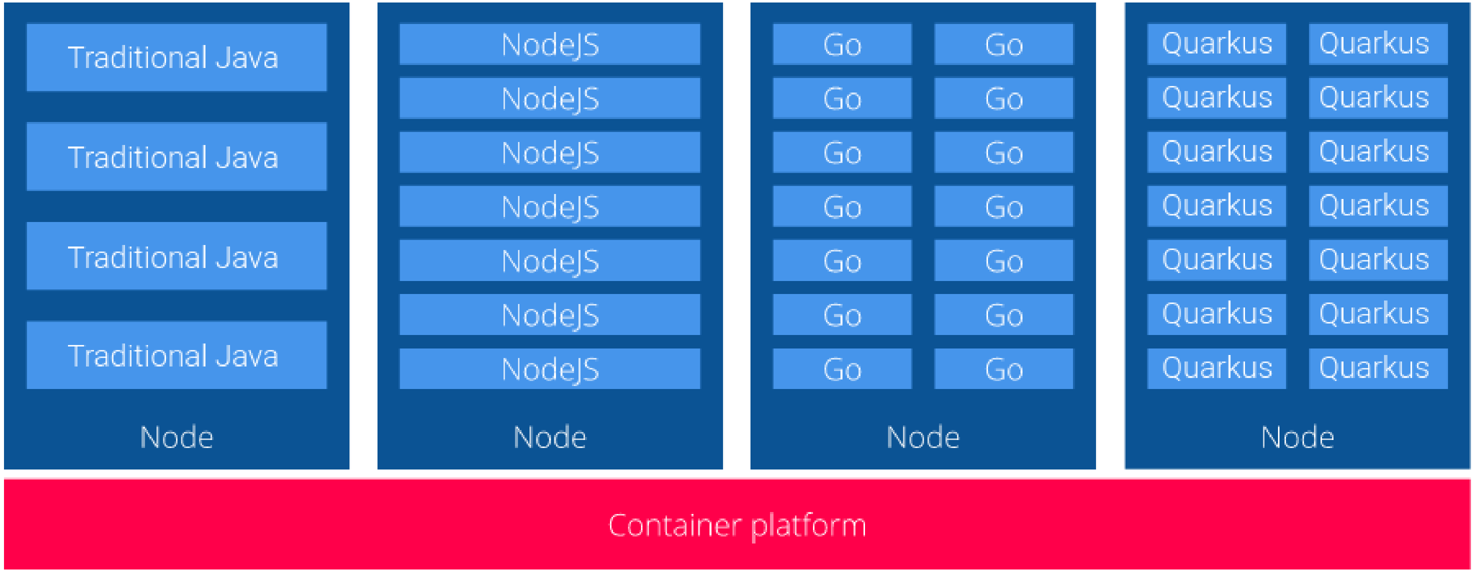
Why Quarkus? – Java and containers



- Startup overhead
- Resource overhead

Image source: Red Hat

Why Quarkus?



- Optimizing Java for containers
- Enabling Java to become an effective platform for serverless, cloud and Kubernetes environments

Image source: Red Hat

Show me numbers!

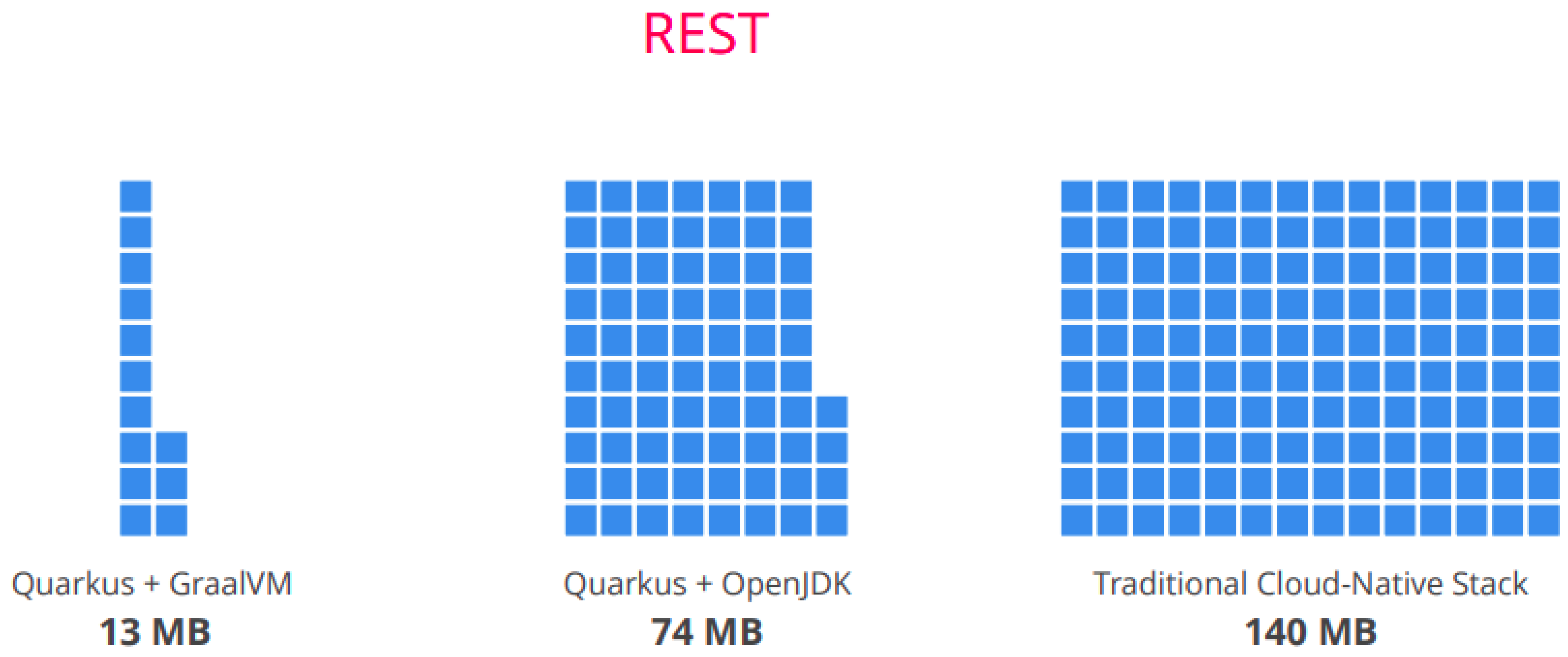


Image source: Red Hat

Show me numbers!

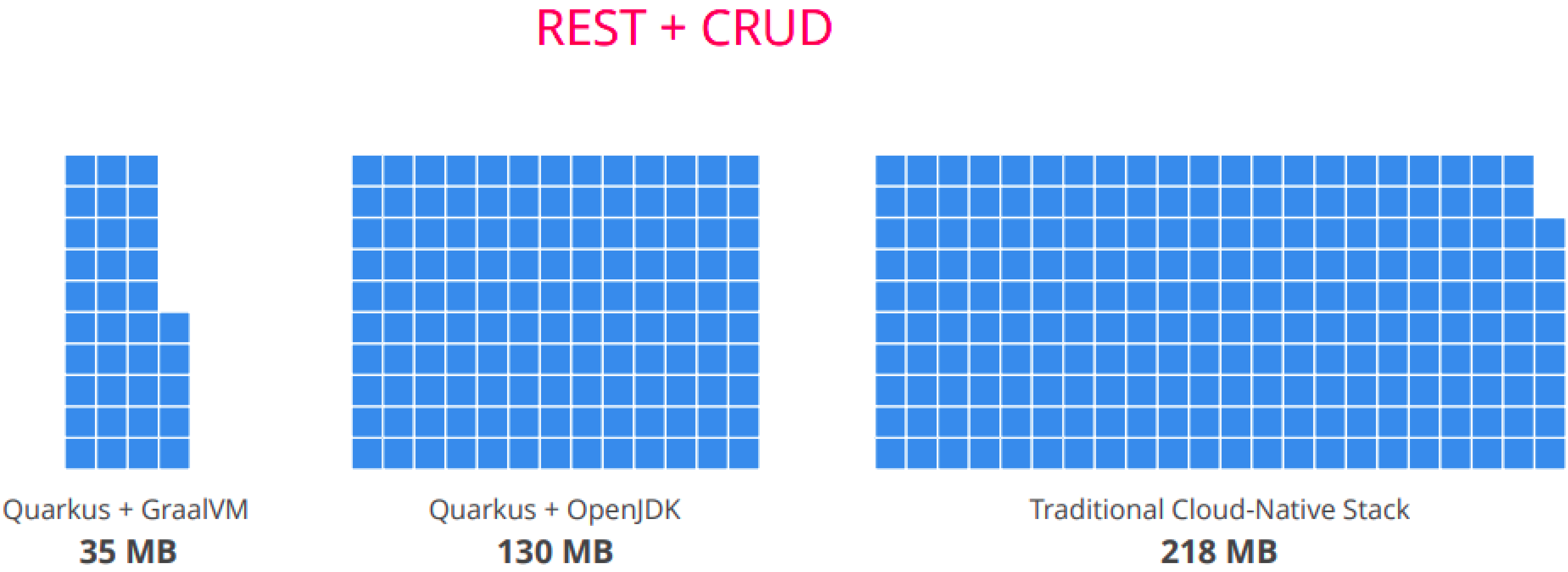


Image source: Red Hat

Show me numbers!

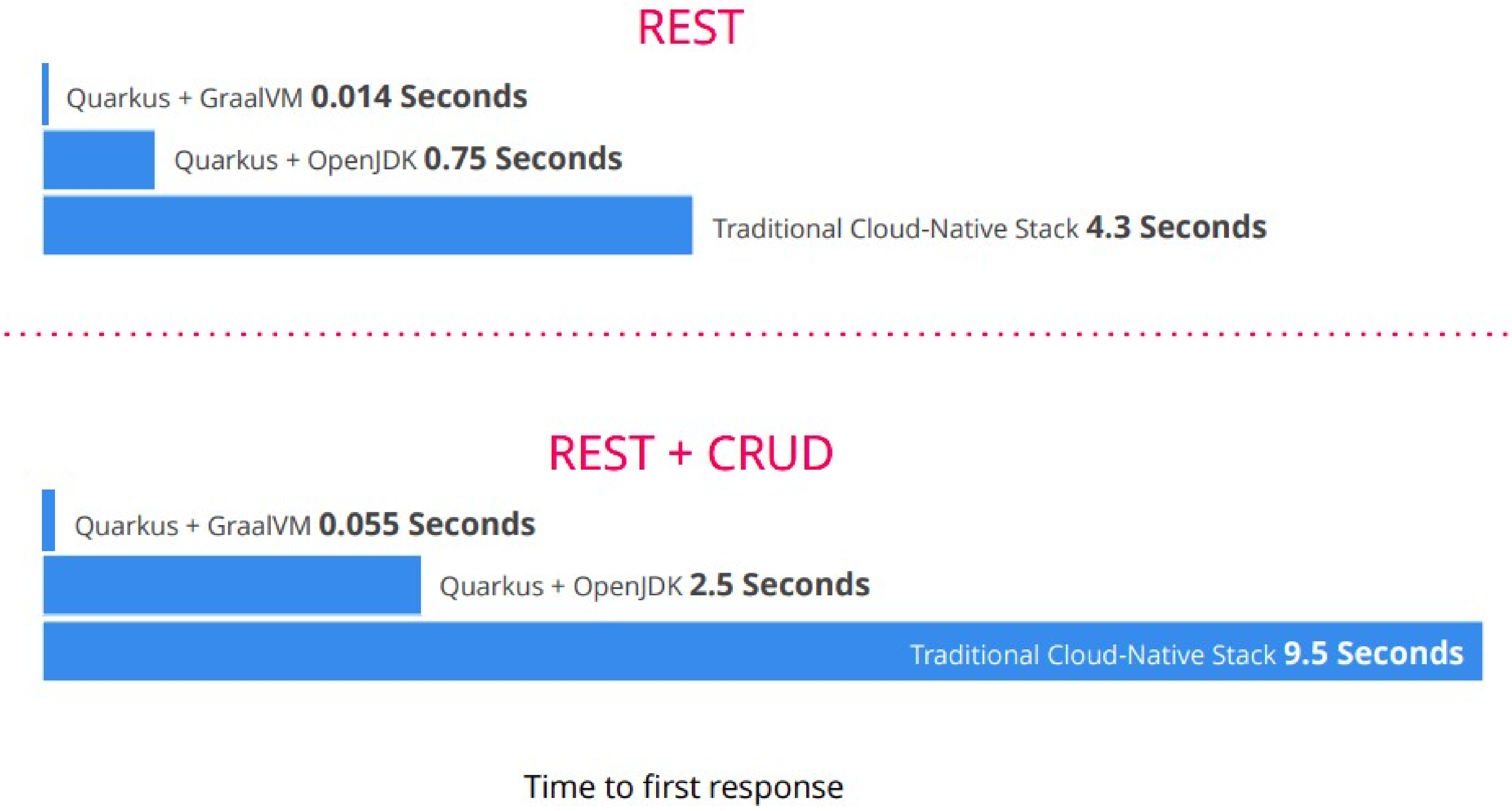
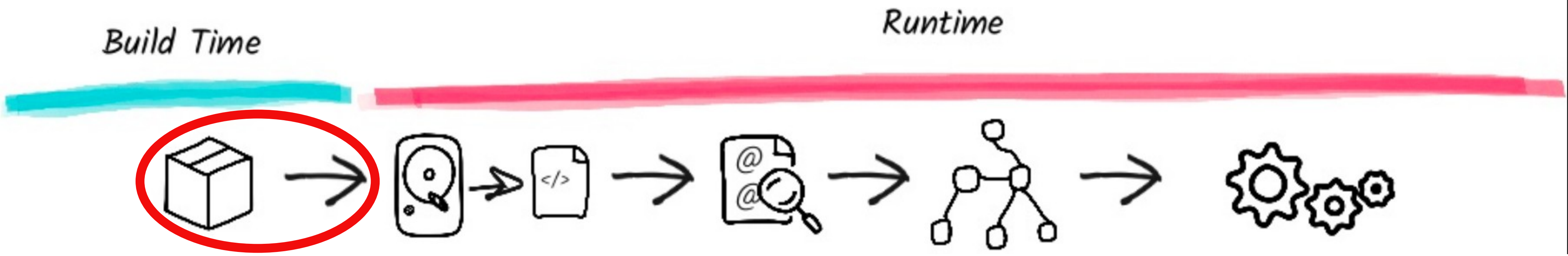


Image source: Red Hat

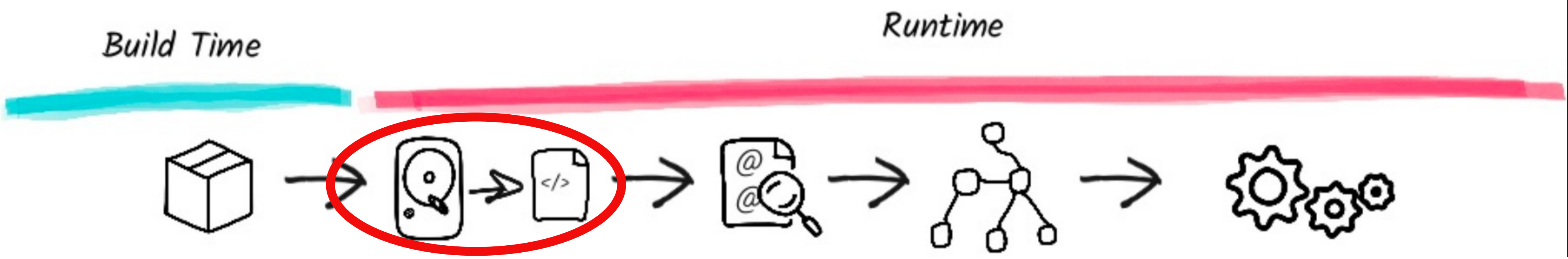
How a framework starts



Package Application
(maven, gradle, ...)

Image source: Red Hat

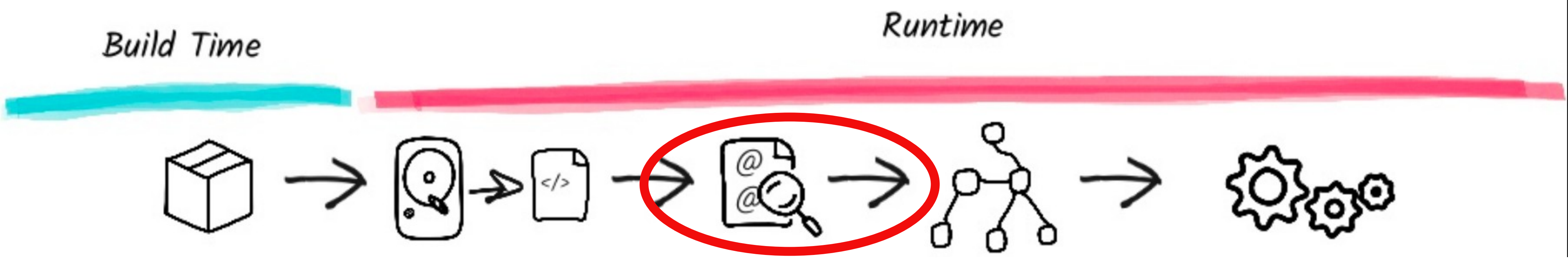
How a framework starts



Load config files
(parse it, ...)

Image source: Red Hat

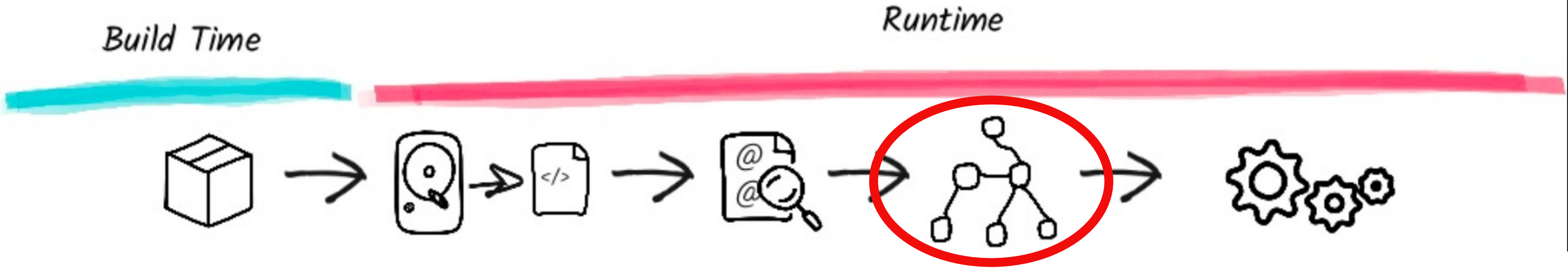
How a framework starts



Scan classpath for annotations
(load classes, enable/disable features, ...)

Image source: Red Hat

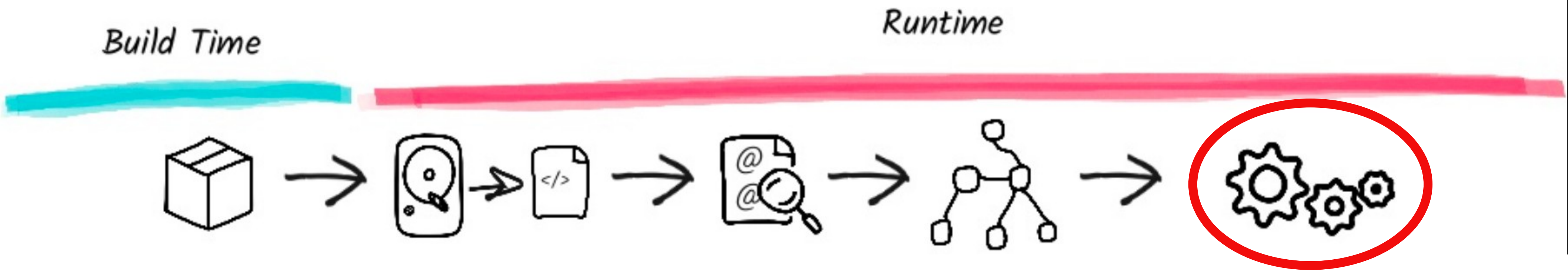
How a framework starts



Build its model of the world

Image source: Red Hat

How a framework starts



Start Application
(threads, pools, ...)

Image source: Red Hat

How Quarkus does it

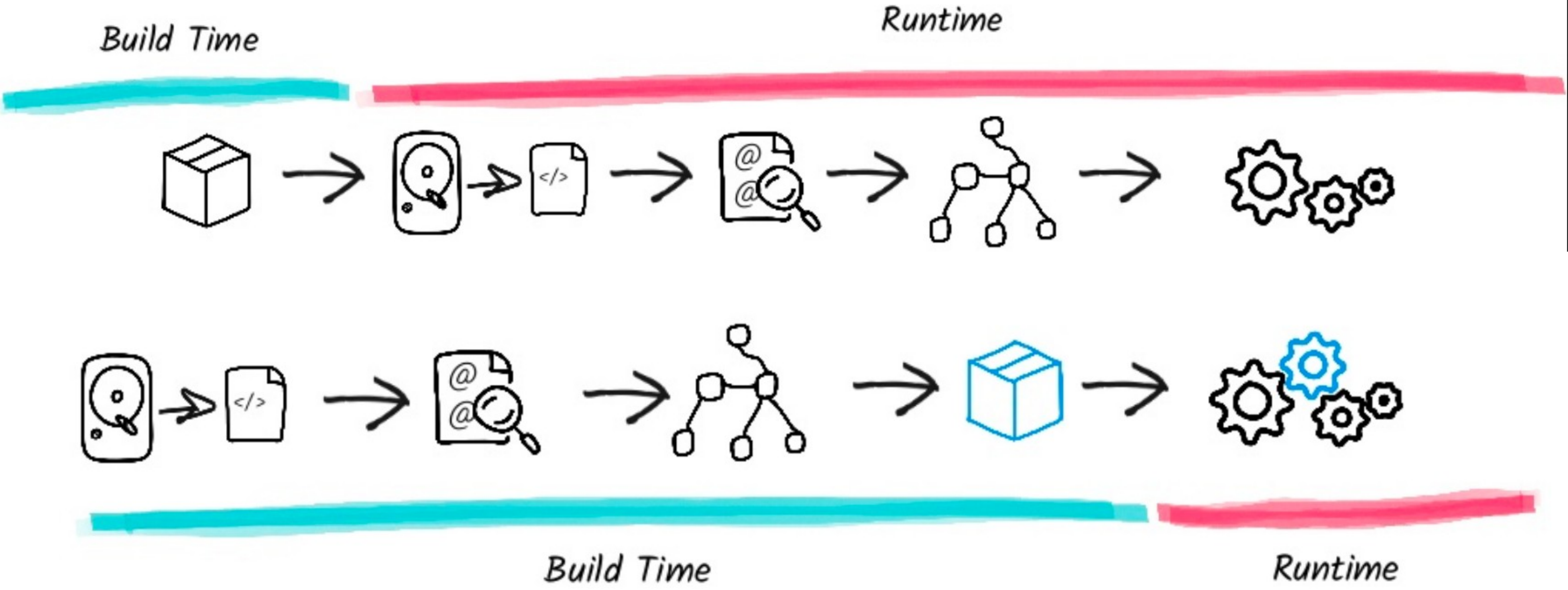


Image source: Red Hat

Traditional vs Quarkus

Traditional

- Many classes only run during boot
  - Xml parsers, annotation lookup, …
  - Later unused and occupy memory

Quarkus

- Built time approach
- As much work as possible during build
- Built time augmentation
  - Extensions
- Output: recorded wiring bytecode

Quarkus Build

«The end result of a Quarkus build should be just enough bytecode to start the services that your application requires»

Edson Yanaga, Red Hat

Configuration phases

- Quarkus needs to make decisions at build time

- Different config phases
  - Build time
  - Build and runtime fixed
  - Bootstrap
  - Run Time

Configuration phases

- Not all properties may be changed at runtime
- Some properties will need a rebuild
- Check «All Configuration Options» of Quarkus

Datasource configuration	Type	Default
🔒 `quarkus.datasource.db-kind` The kind of database we will connect to (e.g. h2, postgresql...).	string	
🔒 `quarkus.datasource.health.enabled` Whether or not an health check is published in case the smallrye-health extension is present. This is a global setting and is not specific to a datasource.	boolean	`true`
🔒 `quarkus.datasource.metrics.enabled` Whether or not datasource metrics are published in case a metrics extension is present. This is a Show more	boolean	`false`
`quarkus.datasource.username` The datasource username	string	
`quarkus.datasource.password` The datasource password	string	

Quarkus structure

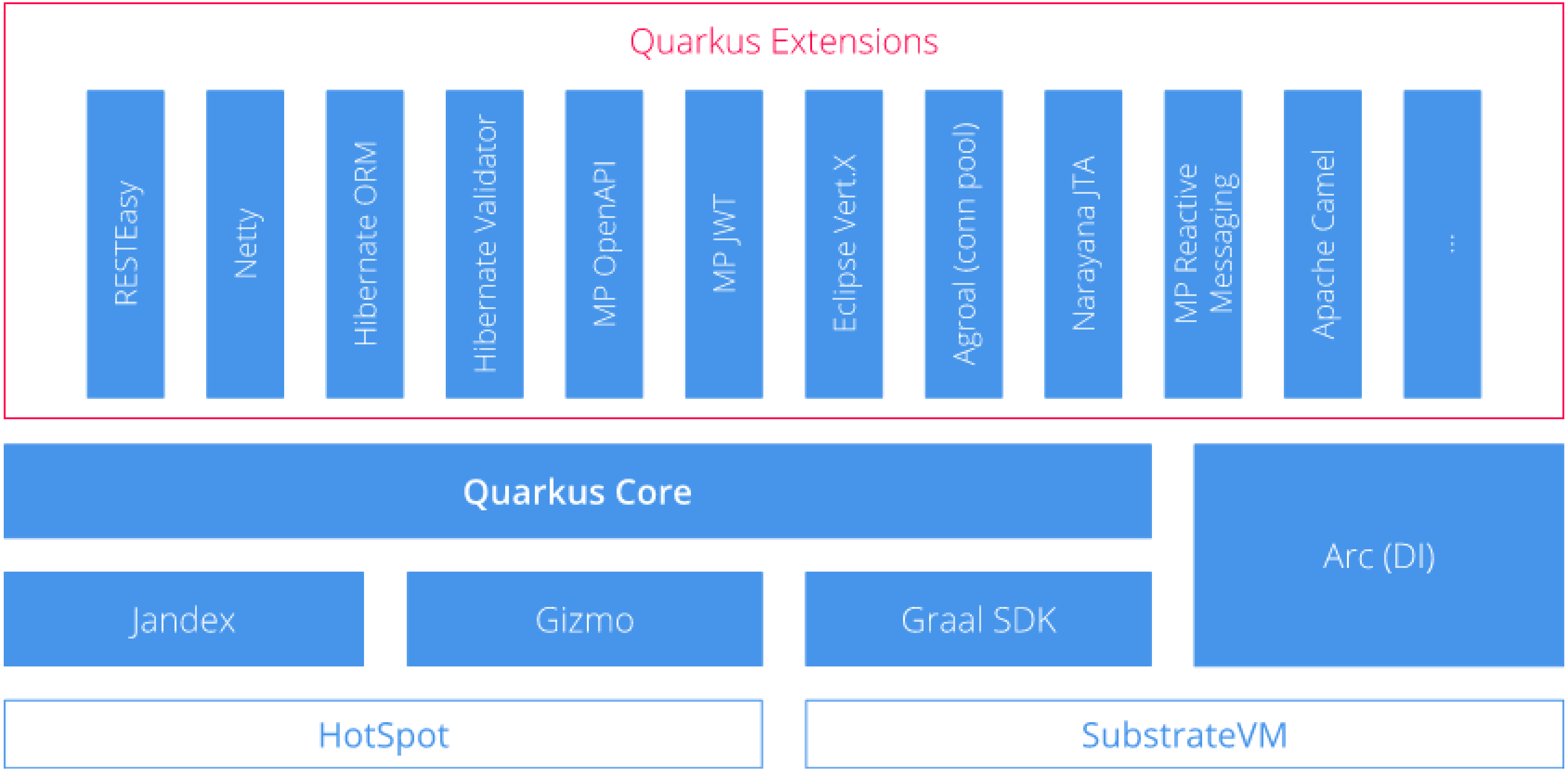
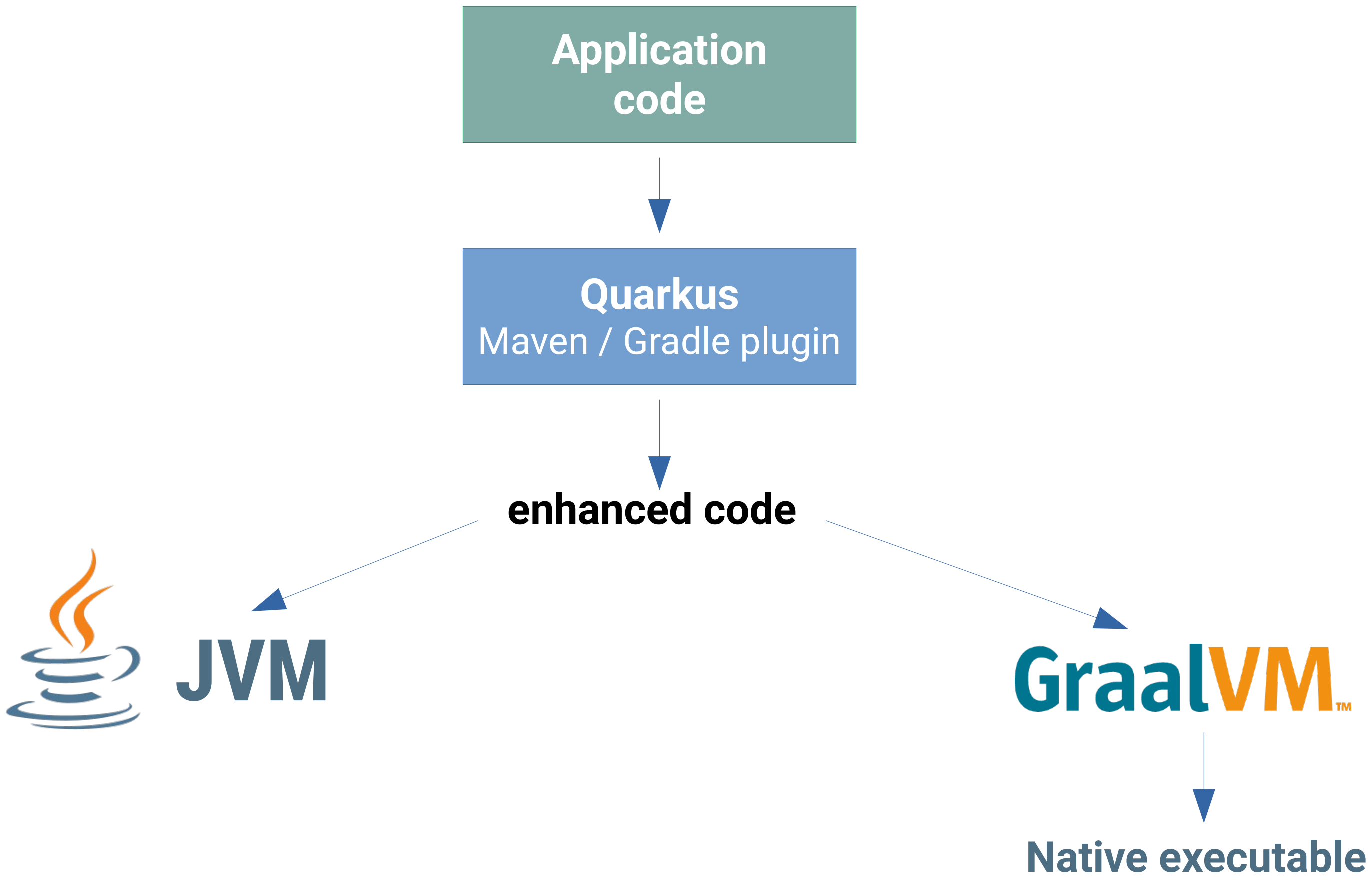


Image source: Red Hat

Quarkus modes



Downside of GraalVM

- Closed world assumption
  - Everything has to be known at build-time
- No dynamic classloading
- No native VM Interfaces (JVM tool Interface, Java Management Extensions JMX)
- No agents (Profilers, Traceing, …)
- No Java debugger
  - Native debugger GDB

https://www.graalvm.org/22.1/reference-manual/native-image/Limitations/

Downside of GraalVM

- Require Registration
  - Reflection limited (@RegisterForReflection, reflection-config.json)
  - Dynamic Proxies (Proxy Config files)
  - Resources (resources-config.json)
- Static Inits
  - Bytecode recorded at build time
  - Stored in executable
  - No file handles, sockets, threads

https://www.graalvm.org/22.1/reference-manual/native-image/Limitations/

Extensions and standards

Extend Quarkus framework with custom functionality

Standards

Java EE (Servlet, JAX-RS, CDI, JPA, Bean Validation, ...)
MicroProfile (Health, Metrics, Rest Client, Fault-Tolerance, …)
Spring (Web, Boot, Data, Scheduled,...)

Databases & Tooling

PostgreSQL, MySQL, MariaDB, MS SQL Server, H2, MongoDB, Neo4j, Flyway, Liquibase …

3rdParty libraries and frameworks

Netty, Vert.x, Apache Camel, Caffein, Keycloak, Elasticsearch, Infinispan, Debezium, ...

Extensions and standards

Quarkus Core Repository

github.com/quarkusio (~150 extensions)

Independent sources

github.com/apache/camel-quarkus

github.com/datastax/cassandra-quarkus

github.com/debezium/debezium-quarkus-outbox

...

Quarkiverse: Incubator & Community extensions

logging-json, cxf, github-api, freemarker, google-cloud-services, …

code.quarkus.io provides a big list of extensions

Developer Joy

Easy to start & fast bootstrap

```
mvn io.quarkus:quarkus-maven-plugin:3.4.3:create \
    -DprojectGroupId=ch.puzzle \
    -DprojectArtifactId=quarkus-getting-started \
    -DclassName="ch.puzzle.quarkustechlab.GreetingResource" \
    -Dpath="/hello"

cd quarkus-getting-started

mvn quarkus:dev

curl localhost:8080/hello
Hello from RESTEasy Reactive
```

Developer Joy

Live Reload

```
mvn quarkus:dev

curl localhost:8080/hello
Hello from RESTEasy Reactive

sed -i -e 's/RESTEasy/QuarkusTraining/g' \
.../GreetingResource.java \
&& curl localhost:8080/hello
Hello Quarkus


-> Live reload total time: 0.638s
```

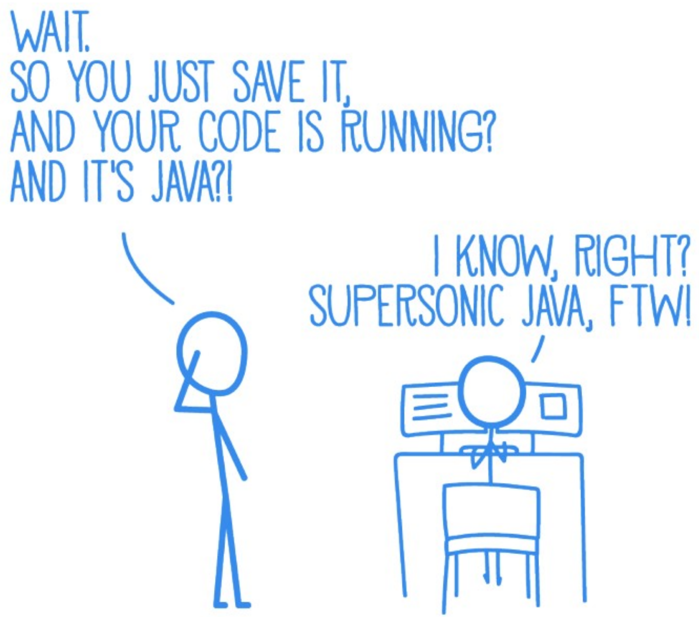
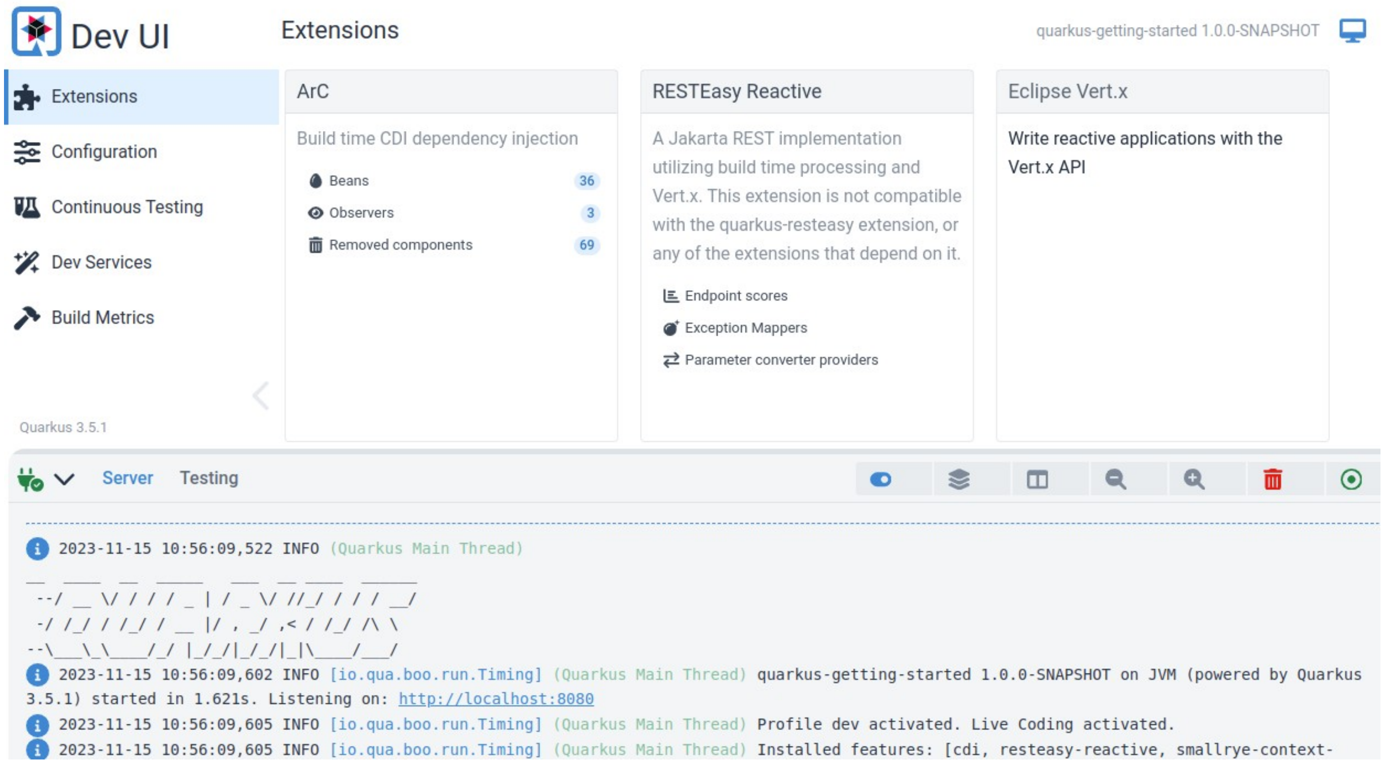


Image source: Red Hat

Developer Joy – Dev UI

http://localhost:8080/q/dev … or hit «d» in your quarkus:dev console



Developer Joy - DevServices

- Spins up required services
  - Most common Databases, Kafka, OIDC (Keycloak)
  - Enabled when testing or running in dev mode
  - Zero configuration required
  - Quarkus uses TestContainers (docker required)
  - For Kafka Services Quarkus uses Redpanda (Kafka API compatible → ~1sec startup time)
- How do we get this?
  - Add relevant extension (database type, kafka or OIDC)
  - Do not configure a database url, kafka.bootstrap.servers or auth-server-url for dev profile

→ Quarkus does the magic for you

Developer Joy – Quarkus CLI Tooling

- Quarkus CLI
  - Replacement for maven or gradle commands
  - Create or add extensions, build and start application
  - Installation using jbang (See CLI-Tooling Guide)

```
$ quarkus create app ch.puzzle.quarkustechlab:quarkus-cli-tooling-demo

$ quarkus extension list --installable --search rest-client
Current Quarkus extensions available:

✬ ArtifactId                                               Extension Name
✬ quarkus-rest-client                                      REST Client Classic


$ quarkus extension add quarkus-rest-client
[SUCCESS]     Extension io.quarkus:quarkus-rest-client has been installed

$ quarkus dev
```

Developer Joy

- Fast start (easy bootstrap)
- Live reload
- Easy Configuration
- Documentation & Guides
- Development UI
  - Change configurations, Console log, Extension Integration
- DevServices
- Quarkus CLI

Agenda - Day 1

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- MicroProfile specification
- RESTful microservices with Quarkus

What is MicroProfile?

«MicroProfile is an open-source community specification for Enterprise Java microservices», microprofile.io

«A community of individuals, organizations, and vendors collaborating within an open source Eclipse Foundation Working Group to bring microservices to the Enterprise Java community», microprofile.io

Why MicroProfile?

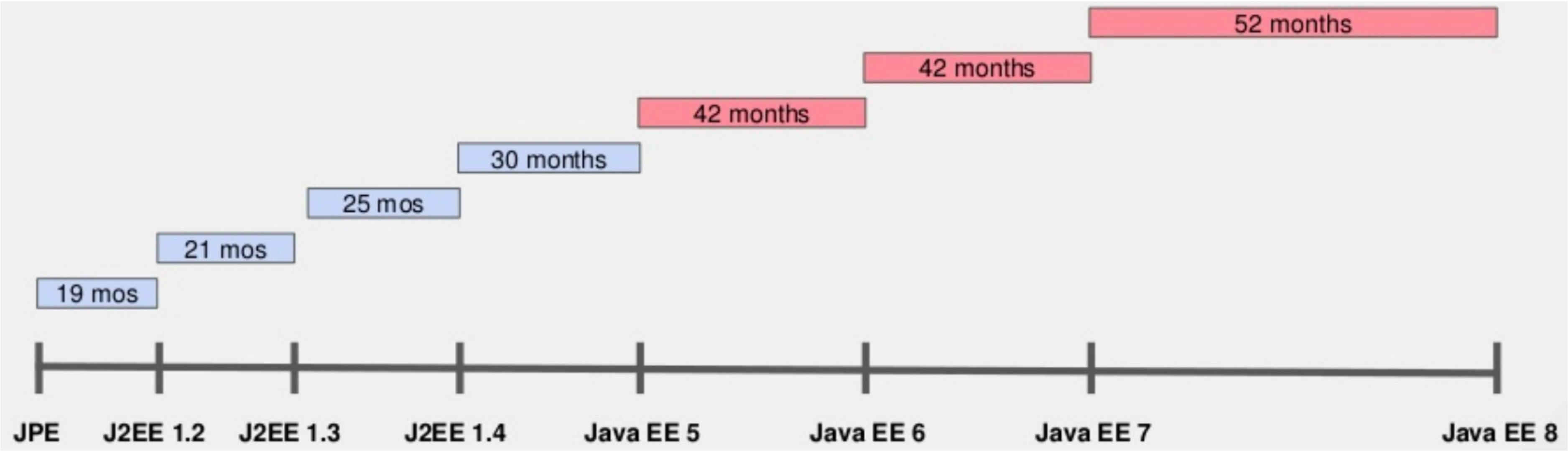


Image source: Red Hat

MicroProfile 1.0 ...

September 2016

CDI 1.2 | JSON-P 1.0 | JAX-RS 2.0

MicroProfile 1.0

10 releases

February 2020

Open Tracing 1.3	Open API 1.1	Rest Client 1.4	Config 1.4
Fault Tolerance 2.1	Metrics 2.3	JWT Propagation 1.1	Health 2.2
CDI 2.0	JSON-P 1.1	JAX-RS 2.1	JSON-B 1.0

MicroProfile 3.3

= New
= Updated
= No change from last release (MicroProfile 3.2)

MicroProfile 6.1 (Current)

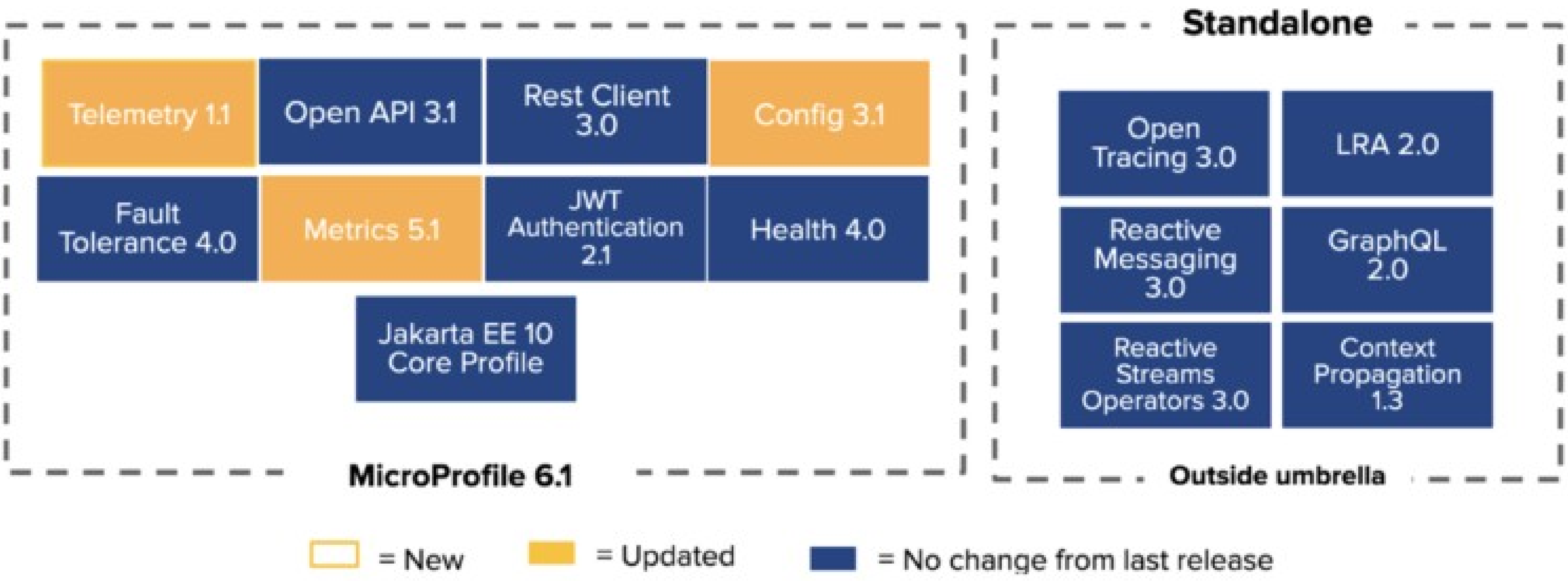
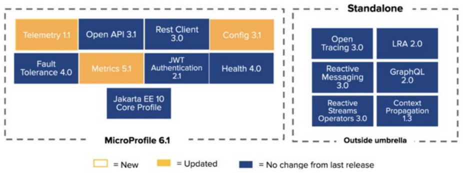


Image source: microprofile.io

MicroProfile Configuration

- Easy and flexible way for application config
- Extendable (write your own config provider)
- Order (highest priority first)
  - System properties
  - Environment variables
  - File named .env in working directory
  - File application.properties placed in $PWD/config
  - File application.properties (from src/main/resources)
  - File META-INF/microprofile-config.properties
- Details about configuration? → MP Config 3.1

MicroProfile Configuration



Injection @ConfigProperty

```
@Inject @ConfigProperty(name = "greeting.suffix", defaultValue="!")
String suffix;
```

Programatically

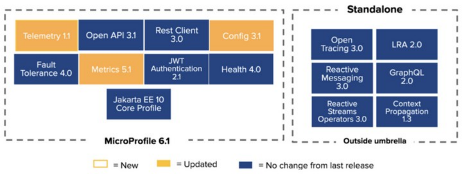
```
ConfigProvider.getConfig().getValue("greeting.suffix", String.class);
```

With @ConfigProperty

```
@ConfigProperties(prefix = "greeting")
public interface GreetingConfiguration {

    @ConfigProperty(defaultValue = "!")
    String getSuffix();
}
```

MicroProfile Rest Client



- Make typesafe calls to Rest APIs
- Defined as Java Interface
- Details about configuration? → Rest Client 3.0

```
@RegisterRestClient(configKey="my-client")
public interface MyServiceClient {
    @GET
    @Path("/greet")
    Response greet();
}
```

With @ConfigProperty

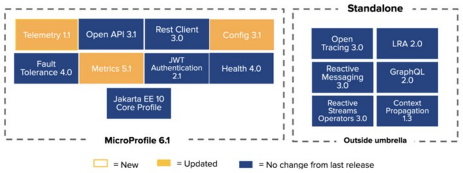
```
my-client/mp-rest/url=https://my-greeting-service/rest
my-client/mp-rest/readTimeout=xy
my-client/mp-rest/proxyAddresses=xy (MP 4.0)
```

MicroProfile Metrics

- Add monitoring endpoint /metrics
  - OpenMetrics (text/plain), JSON (application/json)
- Expose metrics from application
- Details about configuration? → MP Metrics 5.1.0

```
@Counted(name = "processing-counter", absolute = true, tags={"tag1=value1"})
@Timed(name = "processTimer", description = "execution time", unit = MetricUnits.MILLISECONDS)
public void processMessage() { }
```

MicroProfile Health

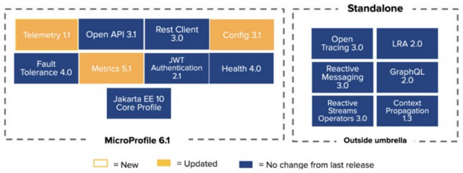


- Validate status and availability of application
- Machine to machine M2M focused
  - Replace unhealthy instances with new health instances
  - Monitored by container platforms
- Provide «Liveness», «Readiness» and «Startup» endpoints */health{/ready,/live,/started}*
- Details about configuration? → MP Health 4.0

```
@ApplicationScoped
@Liveness
@Readiness
public class MyCheck implements HealthCheck {

    public HealthCheckResponse call() {
        [...]
    }
}
```

MicroProfile Fault Tolerance



- Toolkit for resilient applications
  - Timeout, Retry, Fallback, Circuit Breaker, Bulkhead
- Designed to separate execution logic from execution
- Details about configuration? → MP Fault Tolerance 4.0

```
public interface MyServiceClient {
    @GET
    @Path("/greet")
    // timeout is 400ms
    @Timeout(400)
    // 0 - 400ms delay, max 10
    @Retry(delay = 400, maxDuration= 3200, jitter = 400, maxRetries = 10)
    // Specify fallback handler class
    @Fallback(GreetingStringFallbackHandler.class)
    // Scenario: Success, Failure, Success, Success, Failure, CurcuitBreakerOpenException
    @CircuitBreaker(successThreshold = 10, requestVolumeThreshold = 4, failureRatio=0.5, delay = 1000)
    // maximum 10 concurrent requests allowed
    @Bulkhead(10)
    Response greet();
}
```

MicroProfile Telemetry

- Replaces Open Tracing
- Trace request flow across service boundaries
  - Support for JDBC, Kafka or MongoDB available
- Focused on easy instrumentation of services
- RESTful Web Services (server and client) are automatically traced.
  - Annotate methods with @WithSpan to generate custom spans
- Details about configuration? → MP Telemetry 1.1

```
@ApplicationScoped
public class GreetingService {

    @WithSpan("helloSpan")
    public String sayHello() {
        return "hello";
    }
}
```

SmallRye

«APIs and implementations tailored for Cloud development, including but not limited to, Eclipse MicroProfile», smallrye.io

Implementation currently used by:

- Quarkus
- WildFly
- Thorntail
- Open Liberty

SMALLRYE

Resources

Eclipse MicroProfile Developer Resources

https://projects.eclipse.org/projects/technology.microprofile/developer

MicroProfile Specifications available at Github (e.g. Reactive Messaging):

https://github.com/eclipse/microprofile-reactive-messaging

SmallRye MicroProfile Implementation Documentation:

https://smallrye.io/docs/index/index/index.html

SmallRye Reactive Messaging Documentation:

https://smallrye.io/smallrye-reactive-messaging

MicroProfile 6.1 Release Presentation:

https://drive.google.com/drive/folders/1NpSIxyEa4jtA1c-gVqexuY07ij8SHnJb

Agenda - Day 1

- Microservices architecture
- Quarkus introduction
- MicroProfile specification
- RESTful microservices with Quarkus

RESTful microservices with Quarkus

Build two microservices with a RESTful endpoint and a RESTful client

Data Producer

- Implement RESTful endpoint /data with JSON data
- Produce random SensorMeasurement

Data Consumer

- Consumes SensorMeasurement from producers REST endpoint /data
- Implement RESTful client for /data endpoint

Hint: use the quarkus dev mode while developing. Enjoy.

RESTful microservices with Quarkus

Add resiliency with MicroProfile fault-tolerance to our microservices

- Add some random errors
- Slow down the producing of the SensorMeasurement

How can the Data Consumer be more resilient to errors on the producer?

- Try fault-tolerance features retry and timeout

RESTful microservices with Quarkus

Implement microservices in a reactive way

- Stream the data with ServerSentEvents
- Use Reactive JDBC for database calls

Image source: quarkus.io

Day 2

Agenda - Day 2

- 8 fallacies of distributed computing
- Cloud patterns
- Continuous integration and delivery
- Event driven architecture and messaging
- Observability – Metrics and Tracing
- Writing your own Quarkus extension

Questions Day 1?

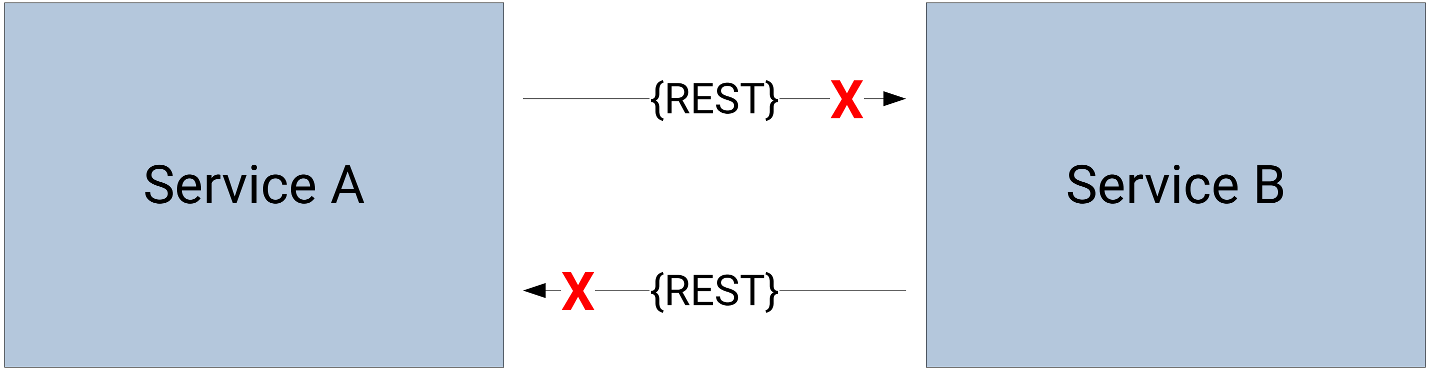
Agenda - Day 2

- 8 fallacies of distributed computing
- Cloud patterns
- Continuous integration and delivery
- Event driven architecture and messaging
- Observability – Metrics and Tracing
- Writing your own Quarkus extension

8 fallacies of distributed computing

1. The network is reliable
2. Latency is zero
3. Bandwidth is infinite
4. The network is secure
5. Topology doesn't change
6. There is one administrator
7. Transport cost is zero
8. The network is homogeneous.

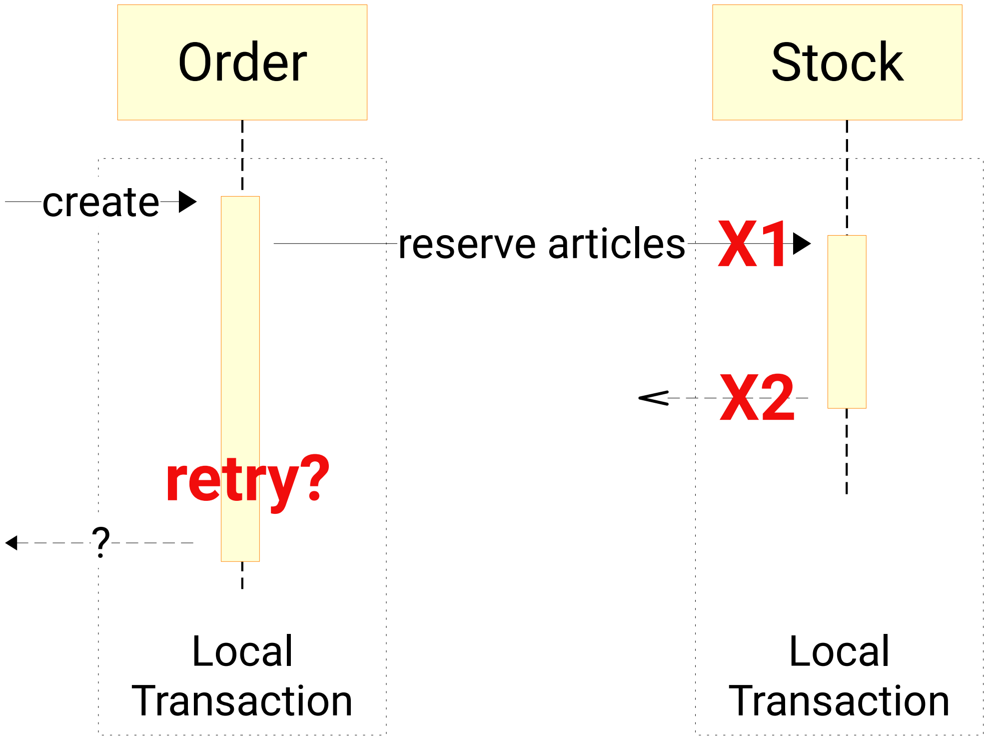
1. The network is reliable



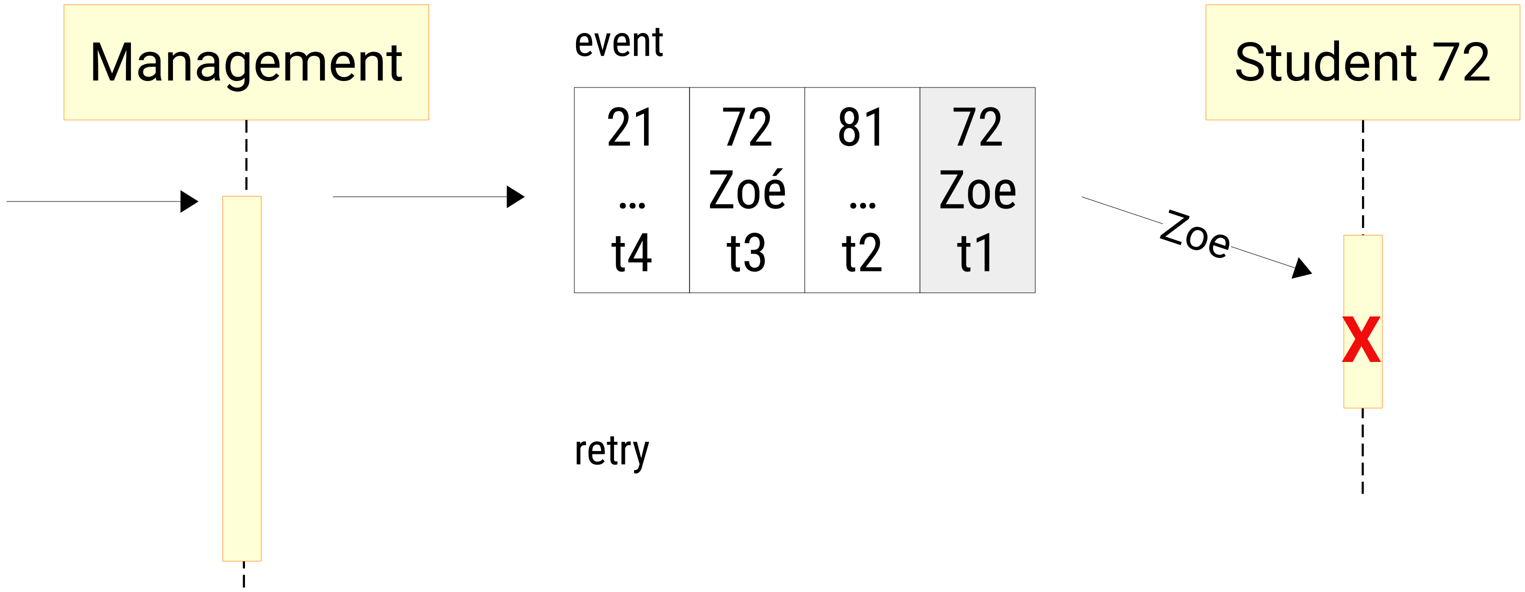
Problem: The network is not reliable. Requests will fail.

Options: Automatic Retries, Message Queues, Timeouts, Circuit-Breaker

Error Handling #1 - REST



Error Handling #2 - Events



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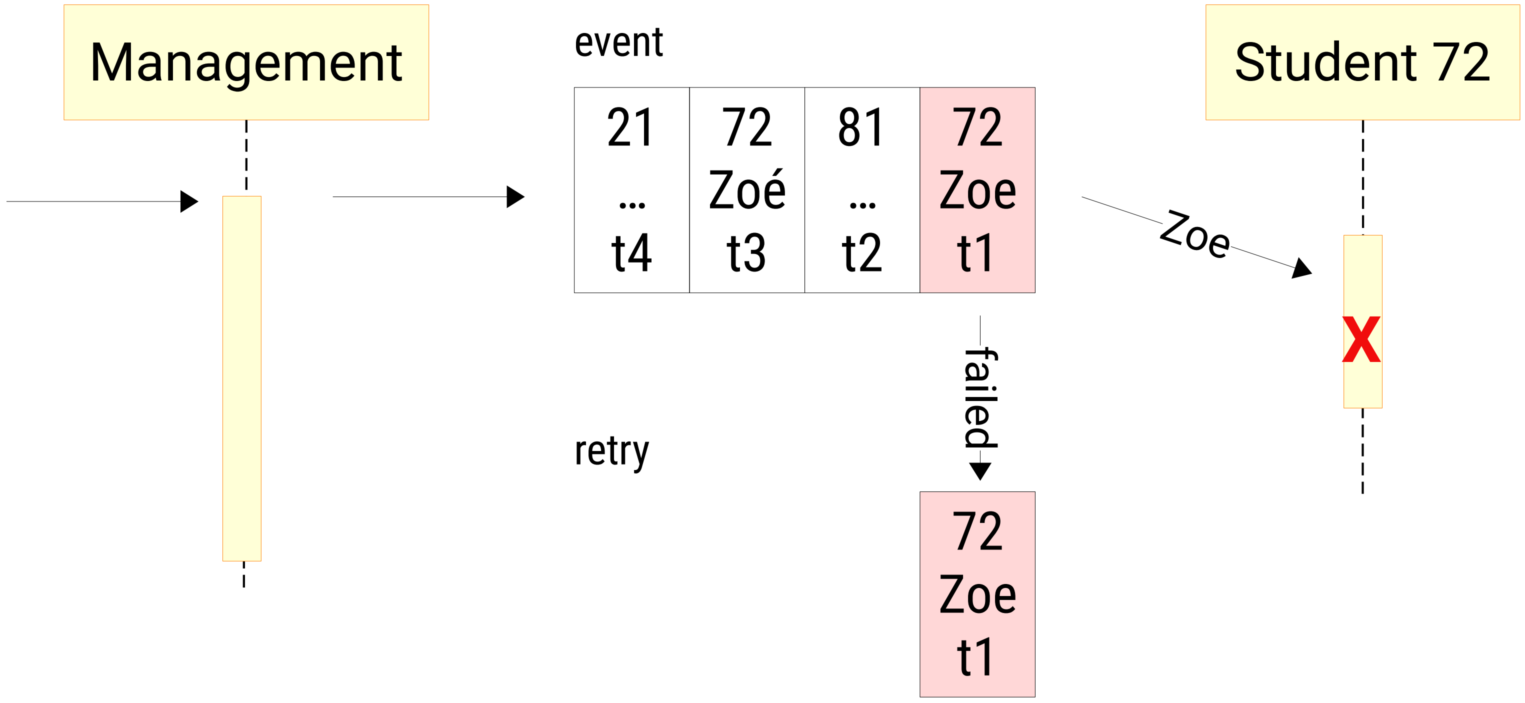

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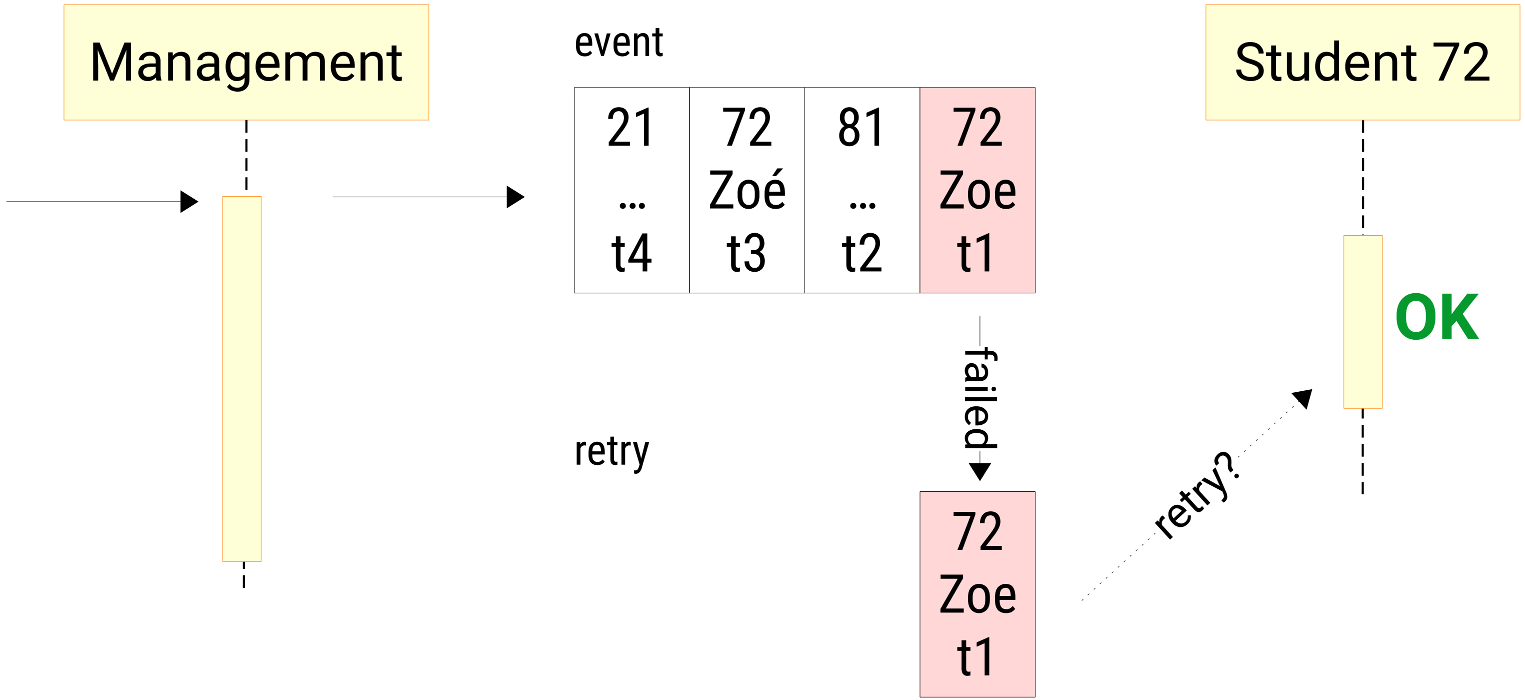
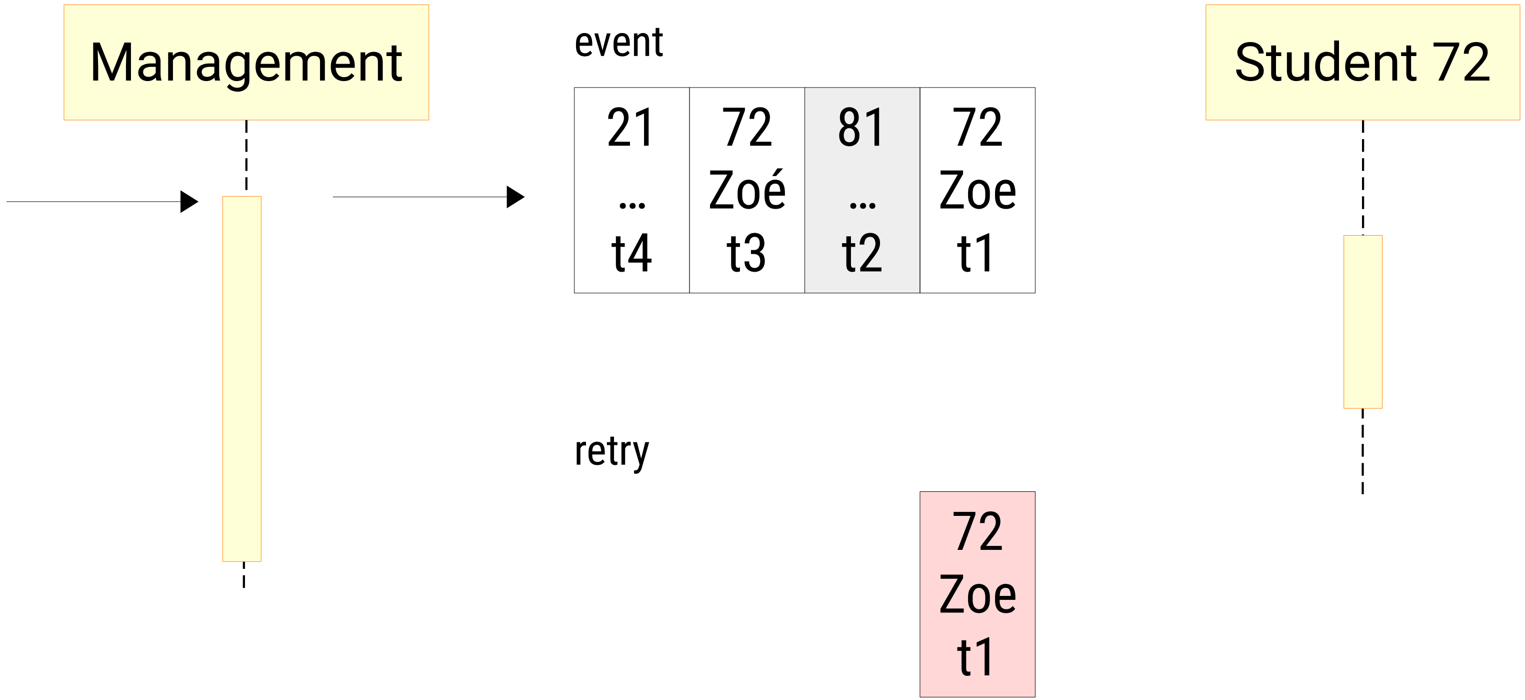


Error Handling #2 - Events



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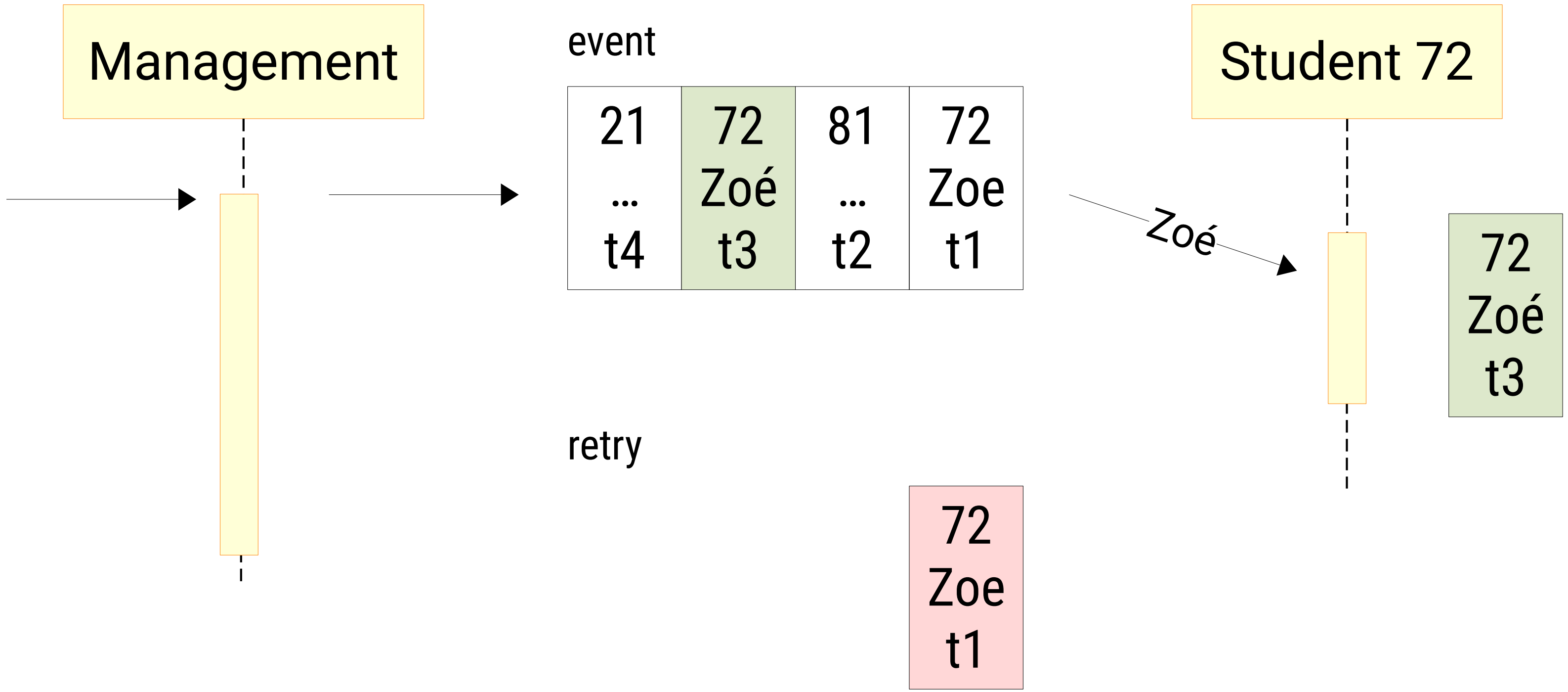

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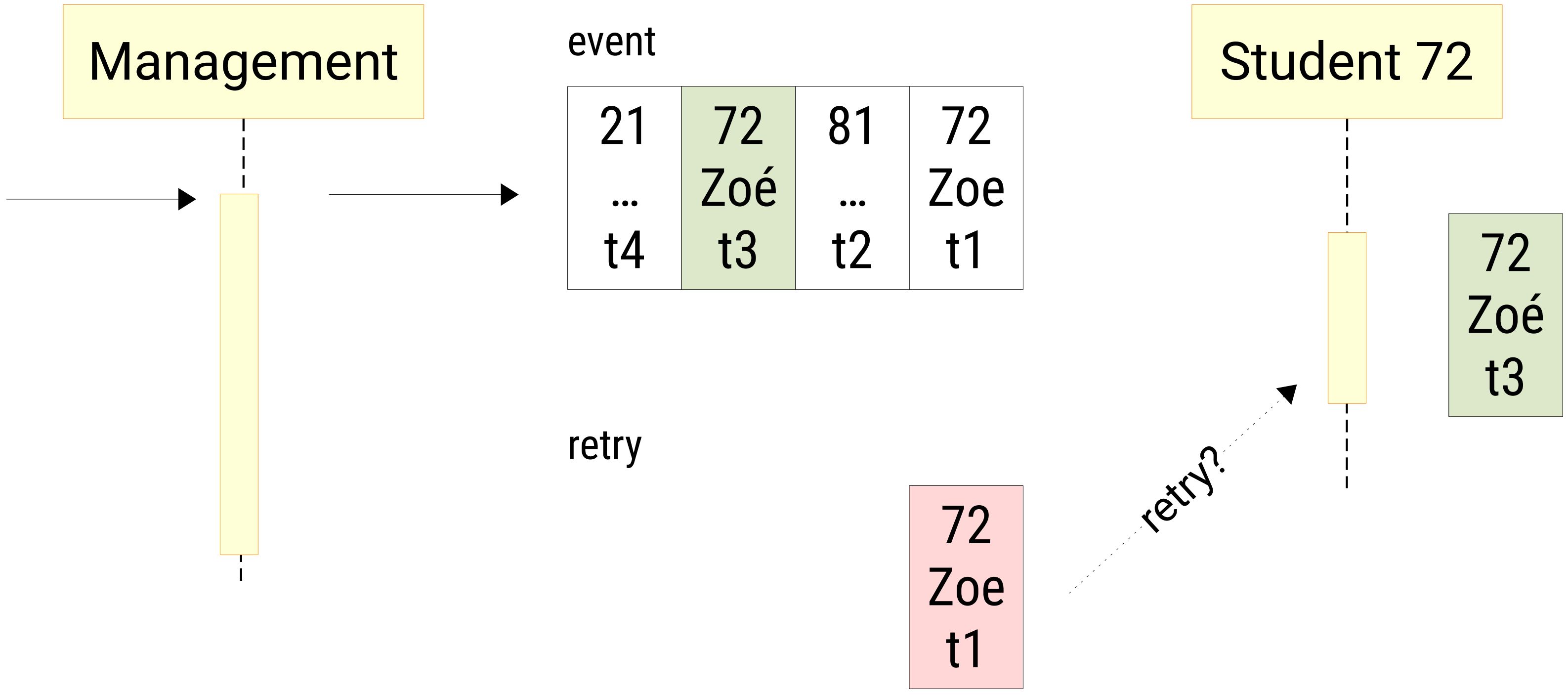
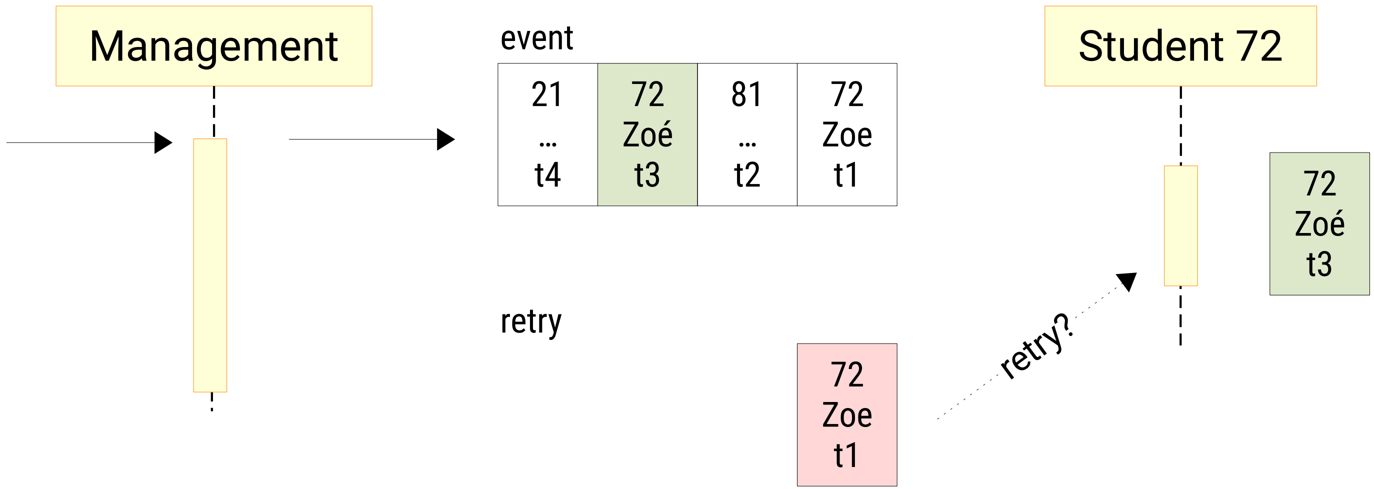


Error Handling #2 - Events



Can ignore event
Name change

T1 < T3 → Drop

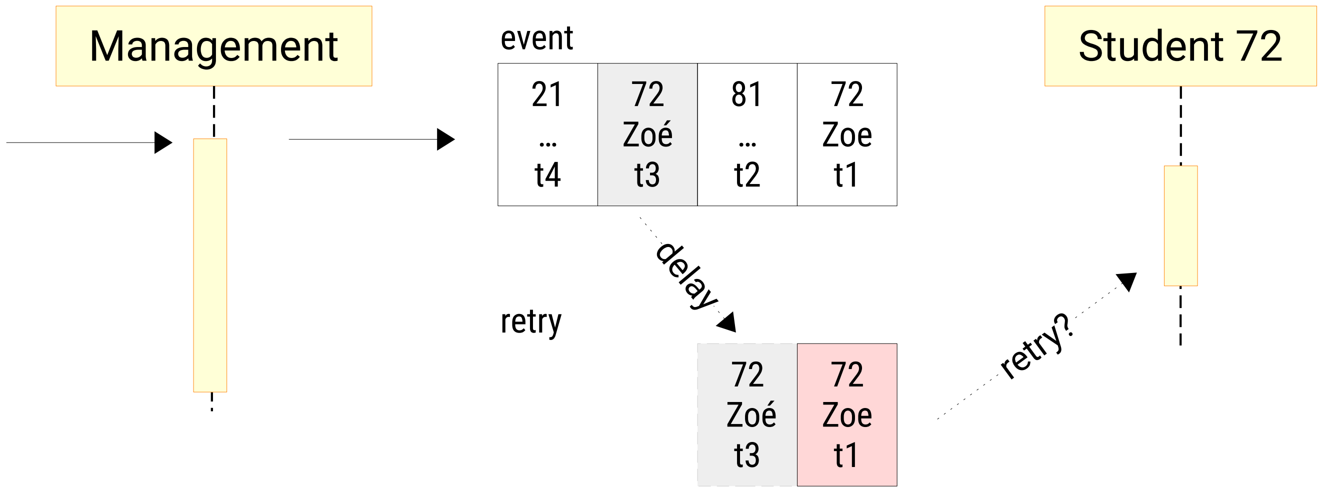
Order does not matter
Coffee order

→ Just retry/apply

Order matters
Bank account (overdraft penalty)

T3 → retry behind T1

Error Handling #2 - Events



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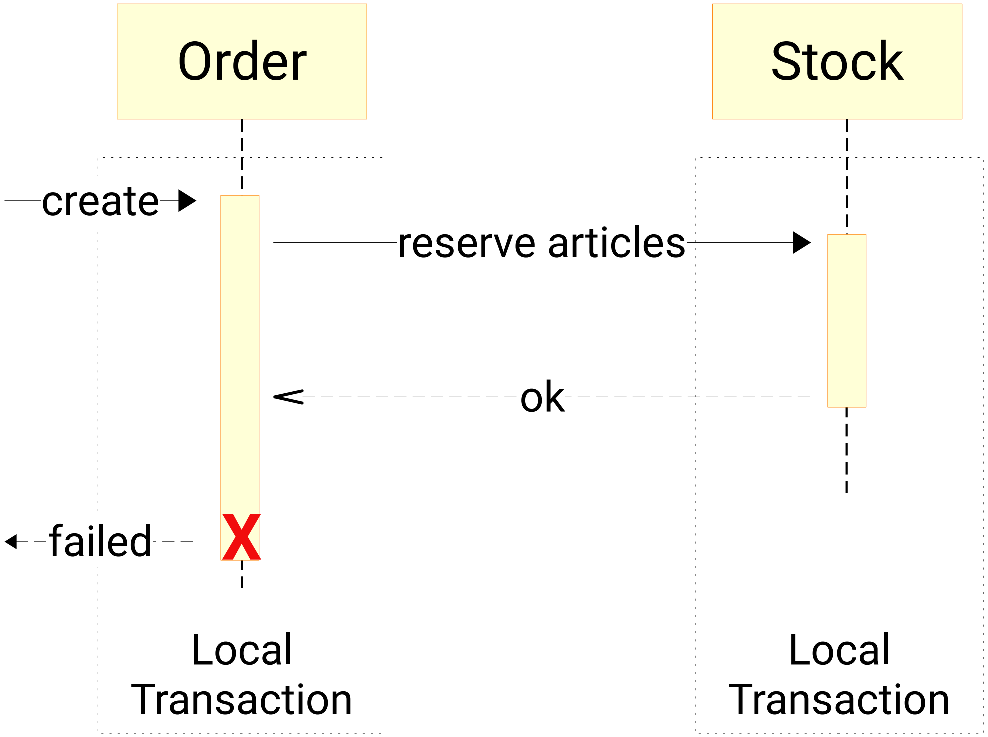
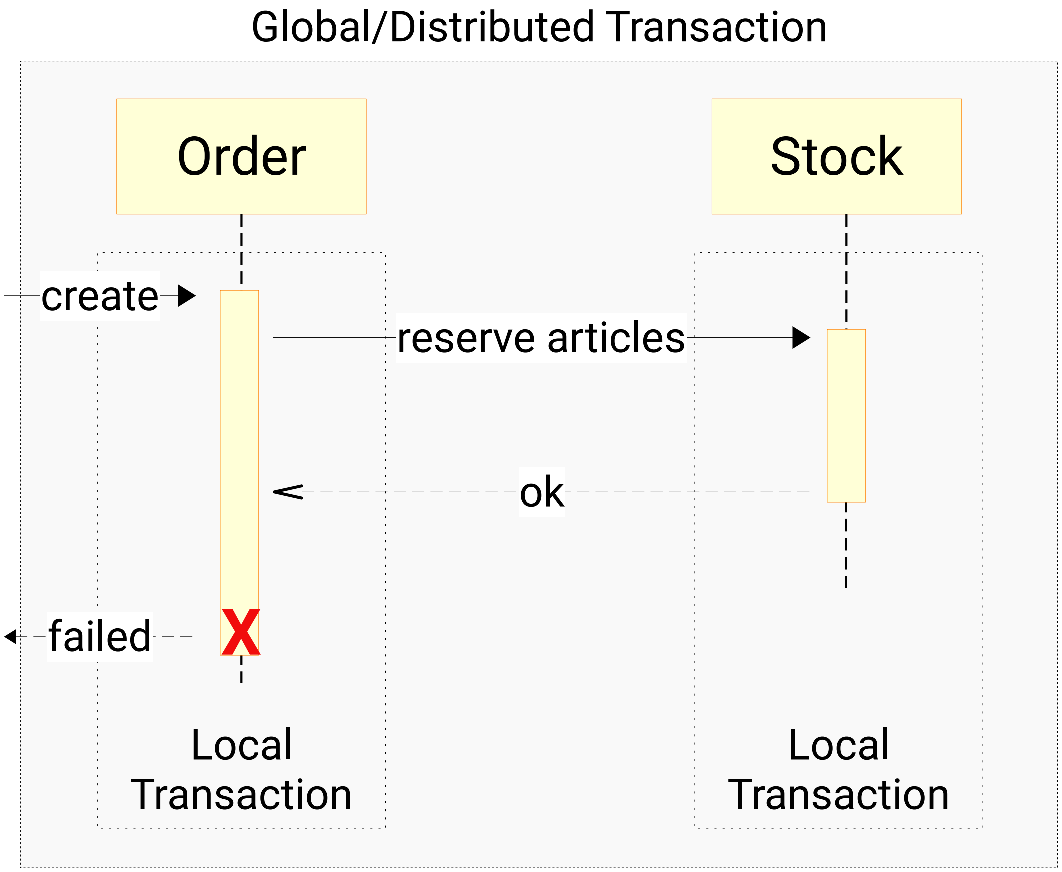
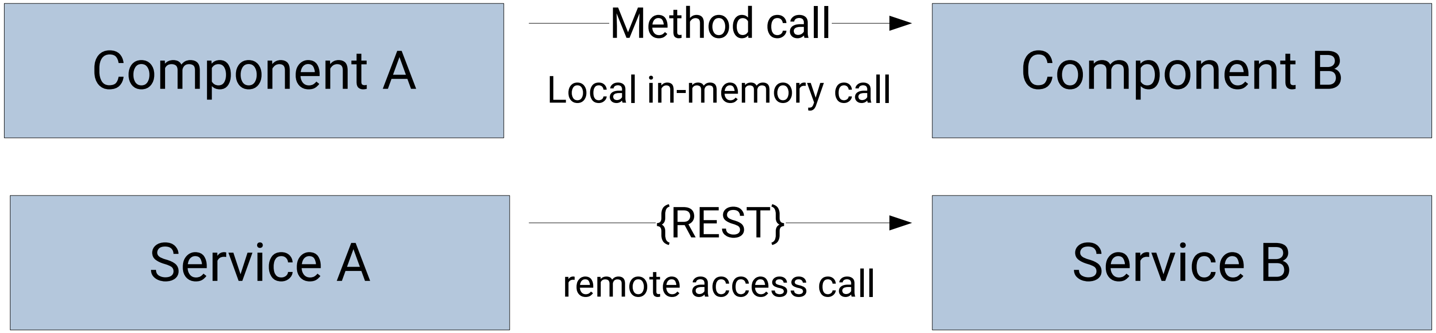
Data Consistency - Transactions



Data Consistency - Transactions



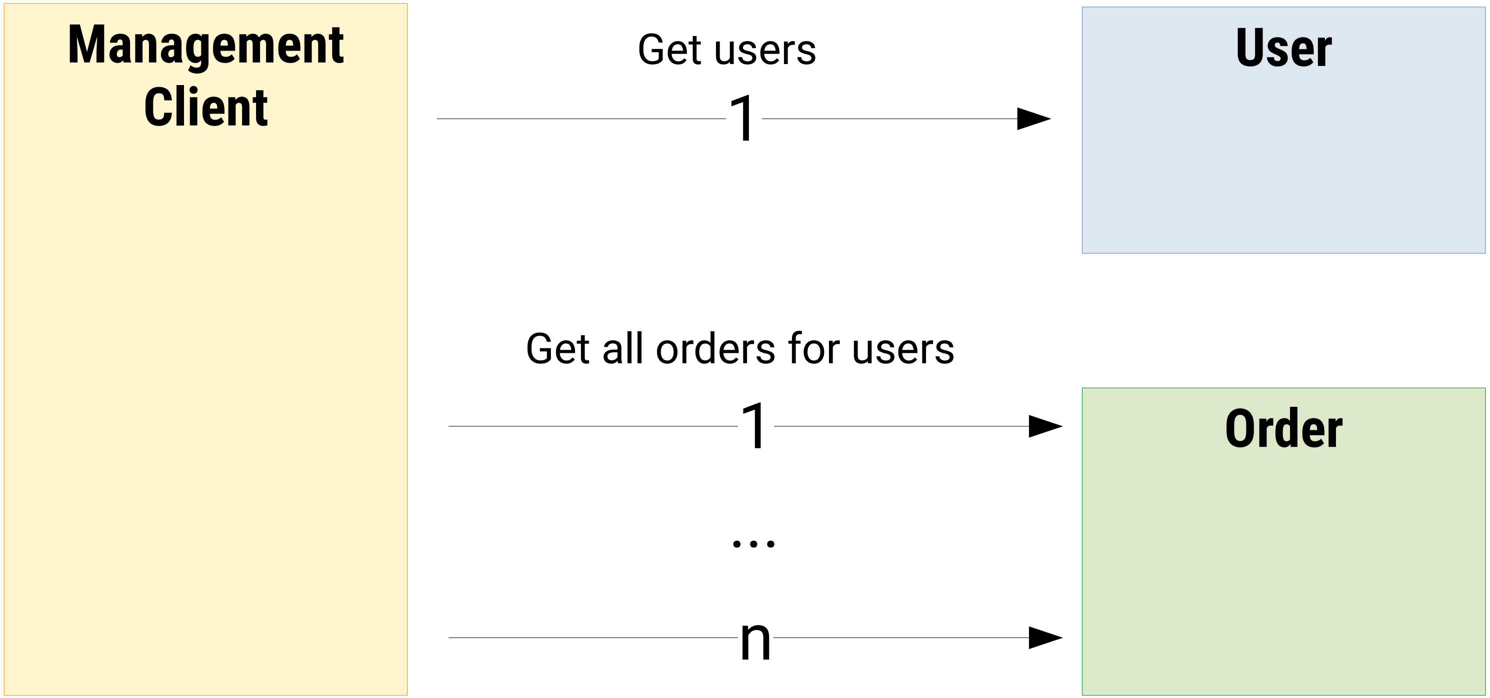
2. Latency is zero



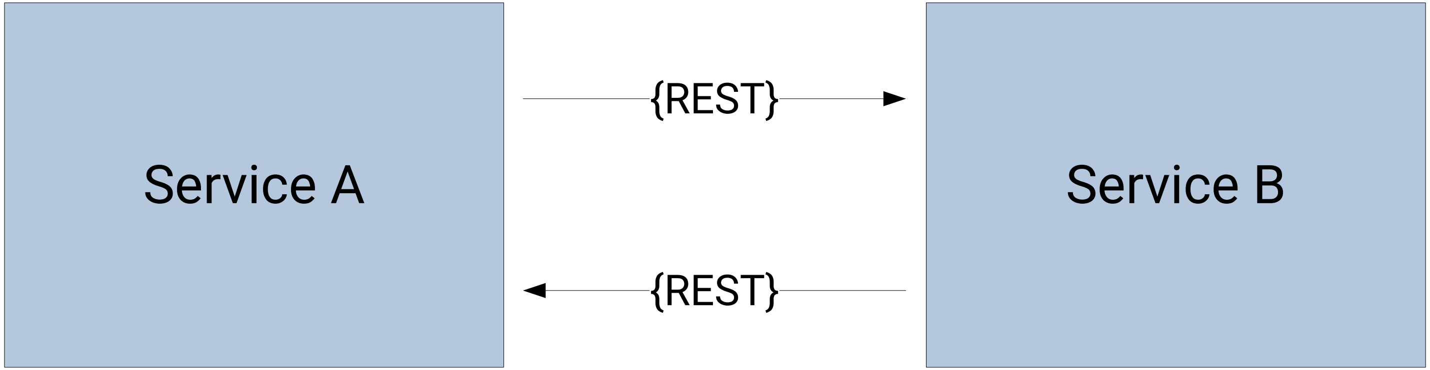
Problem: Network calls are orders of magnitude slower than in-memory calls

Options: Caching, Bulk Requests, Availability Zones

Select N+1 Problem



3. Bandwidth is infinite



Problem: Bandwidth and also amount of connections is not infinite

Options: Small payloads, Optimized data formats, DTOs, Throttling

Bandwidth

Shop

Wishlist

- Table
- Chair
- Mousepad

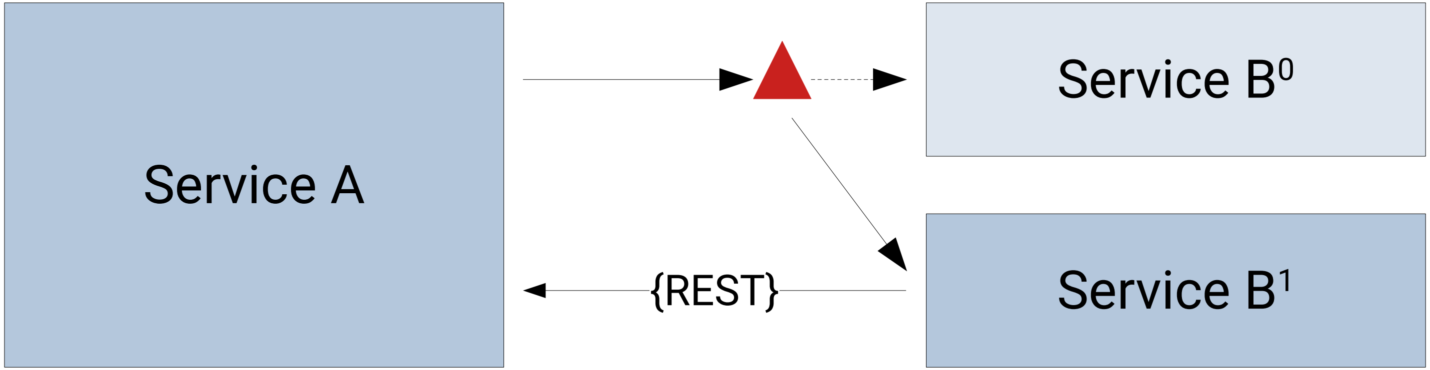
Wishlist

Product[]
(500kb)

Wishlists is called 2000 times per second
*Traffic: 2000 * 500kb = 1gb*

Wishlist renders name only (200 bytes)
*Traffic required: 2000 * 200 bytes = 400kb*

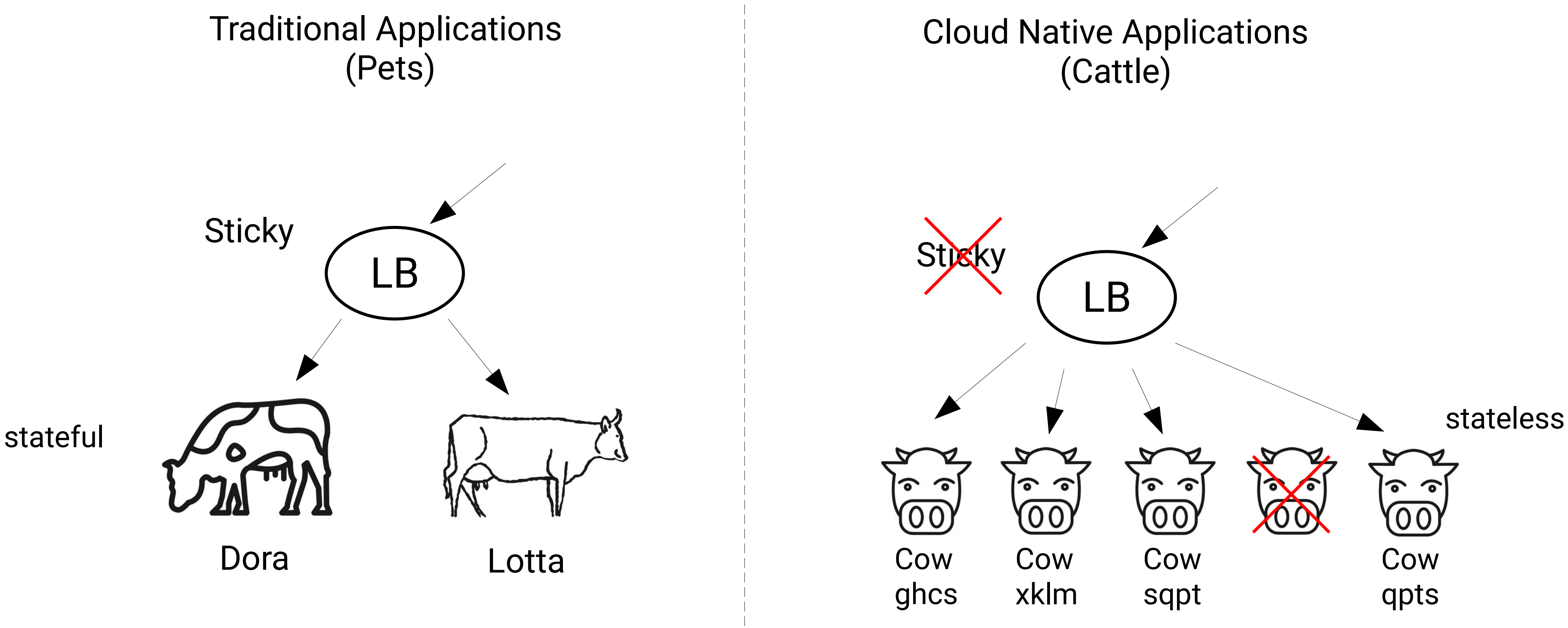
5. Topology does not change



Problem: Topology changes constantly. Service die and restart.

Options: Rely on DNS, No IP hardcoding, Service Discovery

Pets vs. Cattle



Agenda - Day 2

- 8 fallacies of distributed computing
- Cloud patterns
- Continuous integration and delivery
- Event driven architecture and messaging
- Observability – Metrics and Tracing
- Writing your own Quarkus extension

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Cloud patterns

- The Twelve-Factor App
- Design for Failure (Retry, Timeout, Circuitbreaker)
- Microservice Communication
- Orchestration vs. Choreography
- Event Driven Architecture
- Transaction management

12 factor application

«The Twelve-Factor App methodology is a methodology for building software-as-a-service applications. These best practices are designed to enable applications to be built with portability and resilience when deployed to the web.[1]»

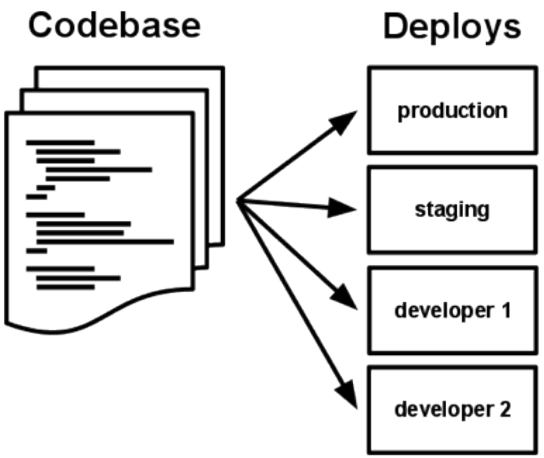
Hofmann, Michael; Schnabel, Erin; Stanley, Katherine (13 March 2017). Microservices Best Practices for Java. IBM Redbooks. pp. 2–3. ISBN 9780738442273.

12 factor application

- I. Codebase - One codebase tracked in revision control, many deploys
- II. Dependencies - Explicitly declare and isolate dependencies
- III. Config - Store config in the environment
- IV. Backing services - Treat backing services as attached resources
- V. Build, release, run - Strictly separate build and run stages
- VI. Processes - Execute the app as one or more stateless processes
- VII. Port binding - Export services via port binding
- VIII. Concurrency - Scale out via the process model
- IX. Disposability - Maximize robustness with fast startup and graceful shutdown
- X. Dev/prod parity - Keep development, staging, and production as similar as possible
- XI. Logs - Treat logs as event streams
- XII. Admin processes - Run admin/management tasks as one-off processes

I. Codebase

- One codebase for a single deployed service
- Each microservice might have seperated codebase
- One codebase many deployments
- Deployments should differ in config



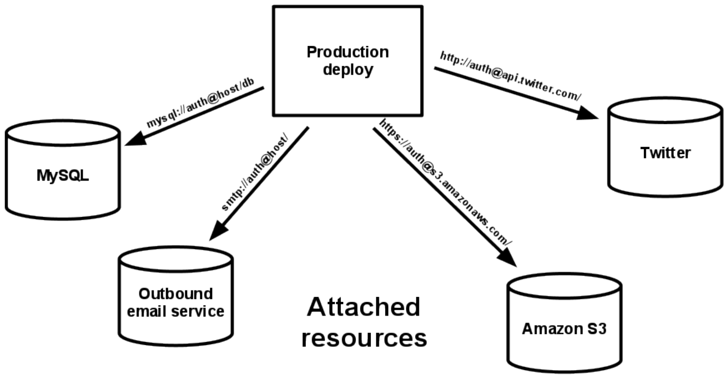
III. Config

- Seperation of config from code
- Environment variables define deployments
- Modern frameworks support this approach

```yaml
order:
  image: kafka-order:latest
  ports:
    - 8080:8080
  networks:
    - kafka
  depends_on:
    - order-db
    - kafka
  environment:
    - QUARKUS_HTTP_PORT=8080
    - QUARKUS_DATASOURCE_JDBC_URL=jdbc:tracing:postgresql://order-db:5432/admin
    - KAFKA_BOOTSTRAP_SERVERS=kafka:9092
```

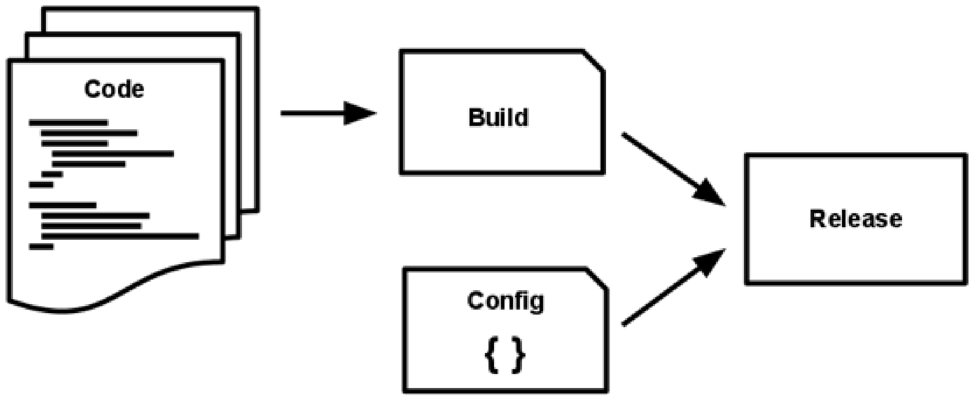
IV. Backing services

- Make backing services (Databases, message brokers, etc) attachable resource
- Loosely coupled even with third party services
- Attach and detach or substitute with ease



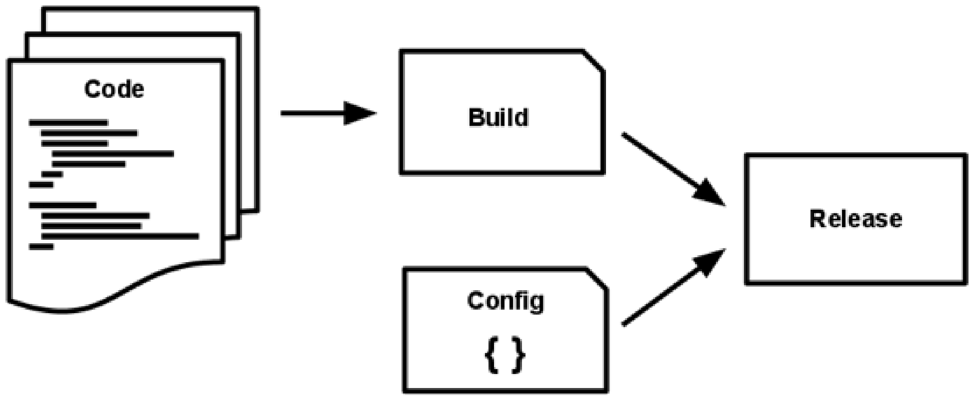
V. Build, release, run

- Transform codebase into deploy with three stages
- Use the same artifact (Docker image) for all environments
- Use a single pipeline to track all steps



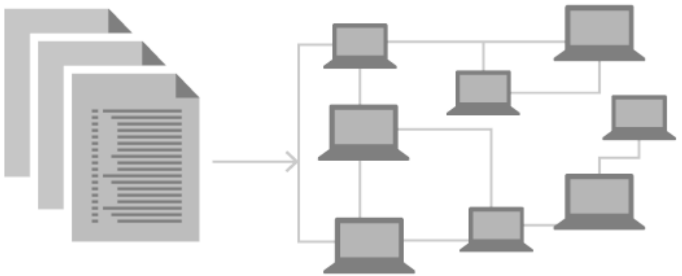
V. Build

- Use automated pipelines to build and test codebase
- Create single deployable for all deployment environments
- Prepare your deployable to be parameterized for each deployment



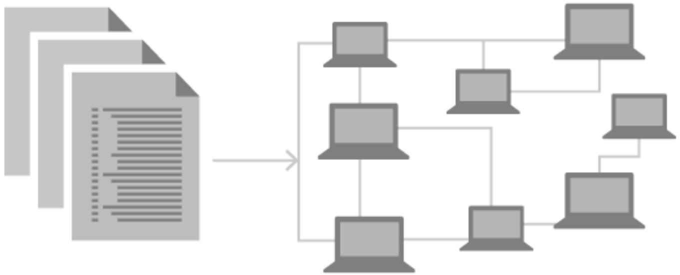
V. Release

- Deliver the parameterizable deployable to environment
- Use environment variables to fill parameters to your needs
- Release fast and often
- Best practice: Infrastructure as code



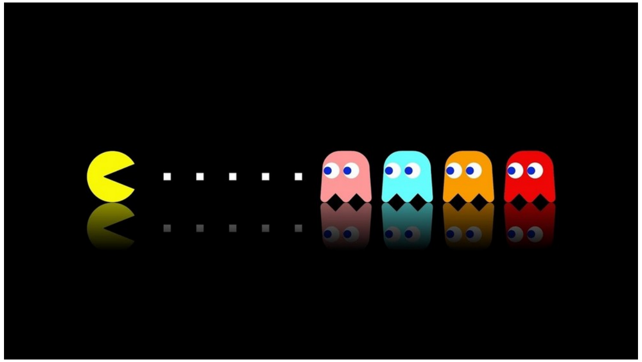
V. Run

- Delivered deployable should run on each environment
- Tag and track deployed applications via build or release ids



IX. Disposability

- Scalable applications should have low startup times
- Stopped and started with low cost
- Robustness against sudden death



X. Dev/Prod parity

- Environments (dev/prod) should use same deployable
- As similar as possible
- Difference in environment variables preferably via code
- Tests will have meaning

Cloud patterns

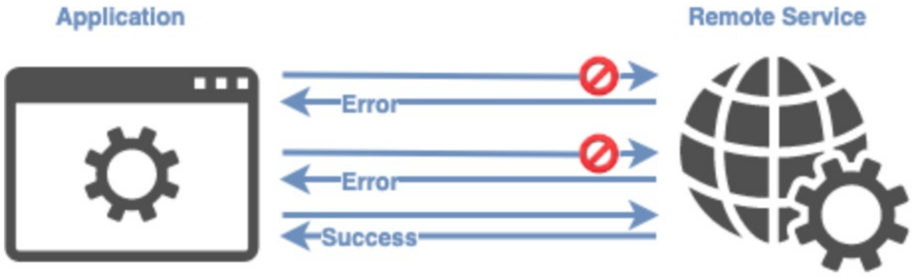
- The Twelve-Factor App
- Design for Failure (Retry, Timeout, Circuitbreaker)
- Microservice Communication
- Orchestration vs. Choreography
- Event Driven Architecture
- Transaction management

Design for failure

- Microservices need a lot of communication
- Communication brings external coupling
- External coupling will vulnerable to failure
- Use patterns to create robustness

Retry

- Microservice A calls a remote service B
- B is not available (can and will happen)
- Call from Microservice A will be retried after a short delay and will hopefully succeed

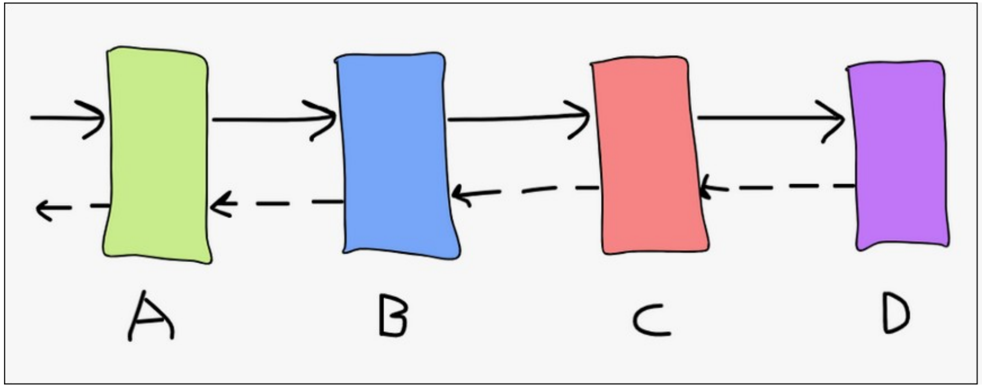


Timeout

- Microservice A calls a remote service B
- B experiences a lot of load and has longer response time
- A defines a timeout period to wait until the remote call will be dismissed
- Careful with combining retries and timeouts

Retry storms

- Number of retries = 3
- A calls B, B calls C, C calls D
- D responses with 100% errors
- B will face 300% load, C 900% load, D 2700% load



Fallback

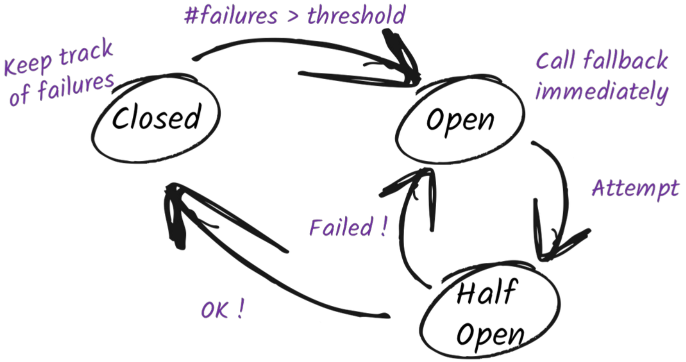
- Fallbacks can be defined when alternatives are available
- Whenever a remote source fails, repeat on fallback
- Example: Use last cached result instead of new query
- Careful compromise between robustness and vulnerability and loss of consistency

Circuit Breaker

- Real world analogy to electrical circuit breaker
- Resources that fail often in a defined period of time will open a circuit breaker
- Continue operation without failure cascading through entire system

Circuit Breaker

- Failures will trigger circuit breaker to open
- If circuit breaker is open, calls will fail immediately, fallback will handle
- After succession, circuit breaker will be half open and retry
- If request succeeds circuit breaker will close and operation will continue normally



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Cloud patterns

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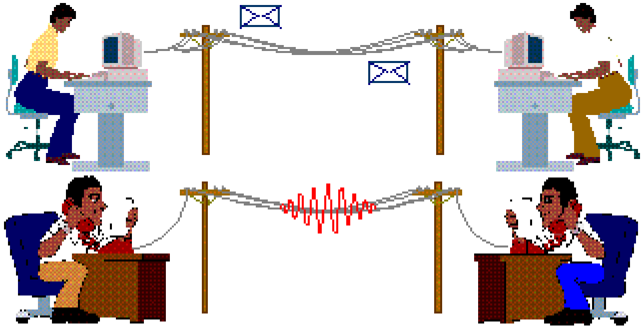
Microservice Communication

- Microservice heavily reliant on communication
- More distribution brings more communication
- Synchronous / Asynchronous protocols

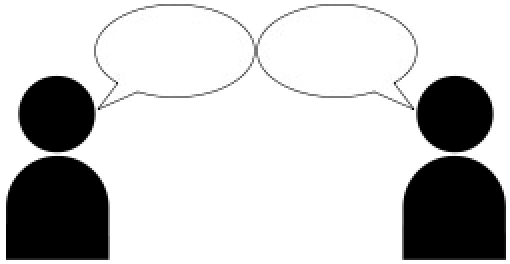
Synchronous vs Asynchronous

- Synchronous – Telegraph
- Asynchronous - Email



Synchronous communication

- Well known
- Easy implemented
- Hard to scale



Synchronous: REST (HTTP)

- REST communication simple and efficient
- Transition from monolithic approach easy
- Fault tolerance patterns widely supported
- Brings tighter coupling
- Blocking operations

Asynchronous: Messaging

- Loose coupling
- Non-blocking operations
- Simple to scale
- Responsibility shift to broker

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Cloud patterns

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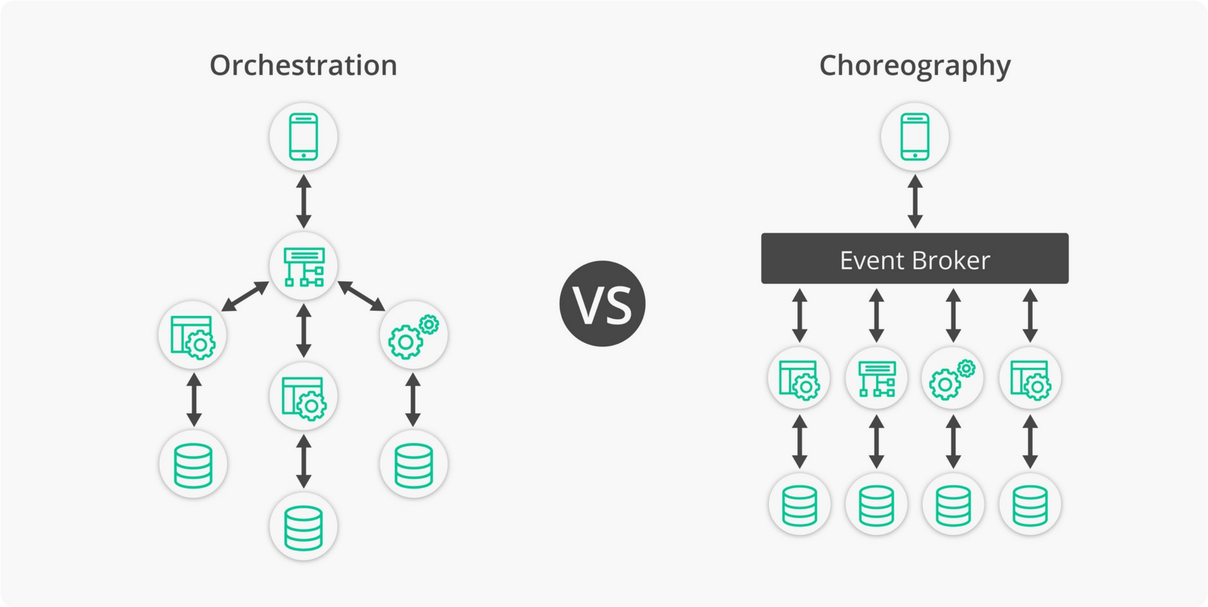
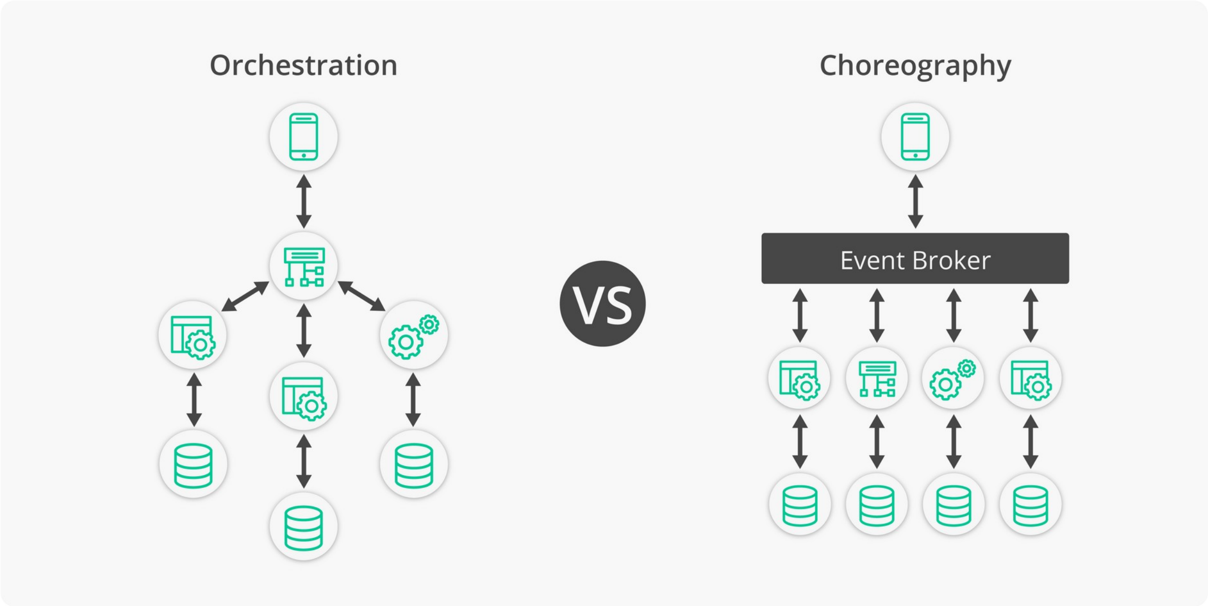
Orchestration vs. Choreography

- Different approach for communication
- Responsibility question



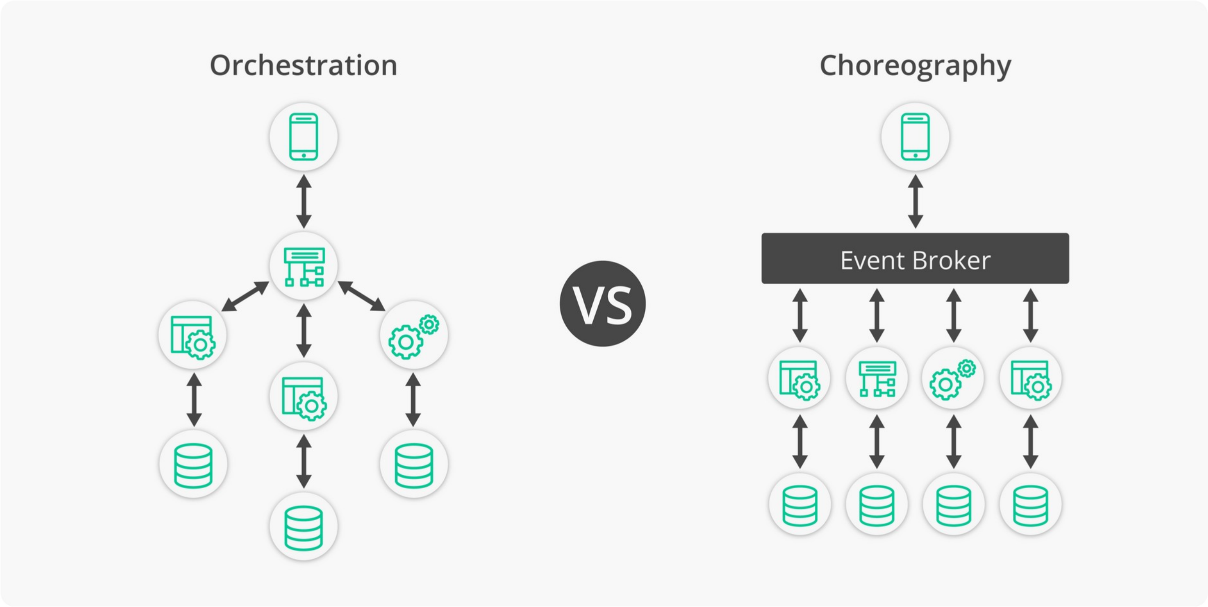
Choreography

- Each part knows it's responsibility
- Microservice knows the workflow



Orchestration

- Central orchestrator has responsibility
- Controls general workflow within the system



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Event Driven Architecture

- Design tends to be imperative
- Creates coupling direct between services
- Services need to know their communication partner

Event Driven Architecture

```
+------------+                    +------------+                    +--------------+
| shop       |       create order | order      |    process payment |   payment    |
| component  +------------------->+ component  +------------------->+   component  |
+------------+                    +------------+                    +--------------+
```

Event Driven Architecture

- Take a look from another perspective
- Call from Shop to Order can be viewed as an event
- Workflow becomes reactive instead of imperative
- Central broker takes responsibility for delivering events
- Single source of truth in event bus

Event Driven Architecture

```
              +------------------+                +-----------------+
      +------->     orders       |---+        +---> payment request +-----+
      |       +------------------+   |        |   +-----------------+     |
      |                              |        |                           |
+-------------+                    +-v----------+                     +---v----------+
| shop        |                    | order      |                     |   payment    |
| component   |                    | component  |                     |   component  |
+-------------+                    +------------+                     +--------------+
```

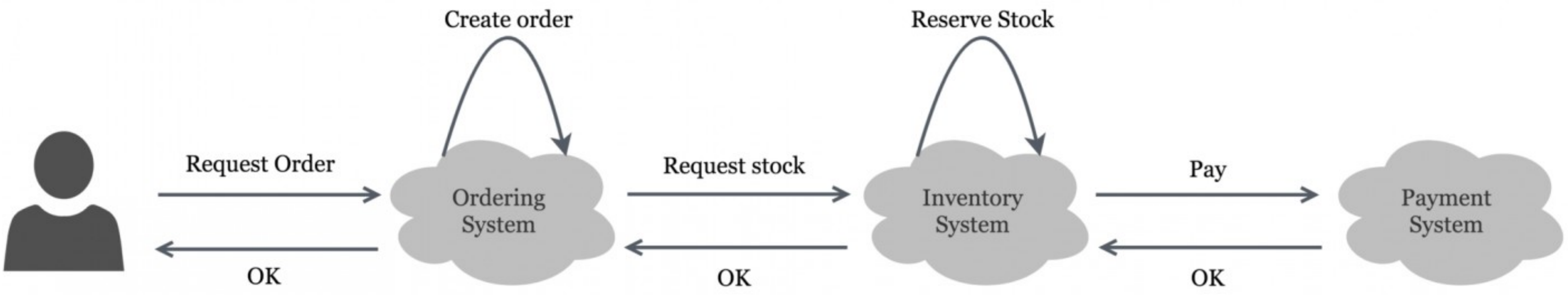
Transaction management

- What are distributed transaction?
- Patterns for distributed transactions
- Saga pattern

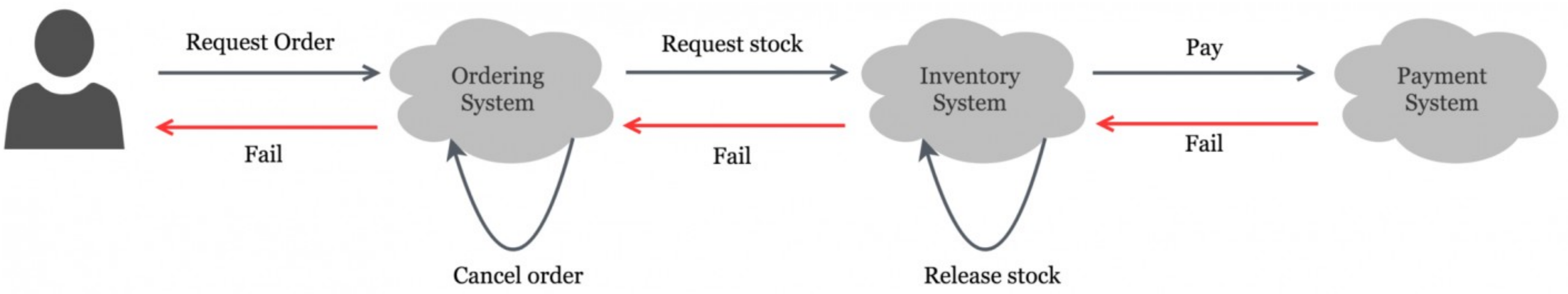
Transaction management

- Decentralization from workflow generates problem
- ACID (atomicity, consistency, isolation, durability)
- Several patterns how to manage transactions
- Best practice: Database per service

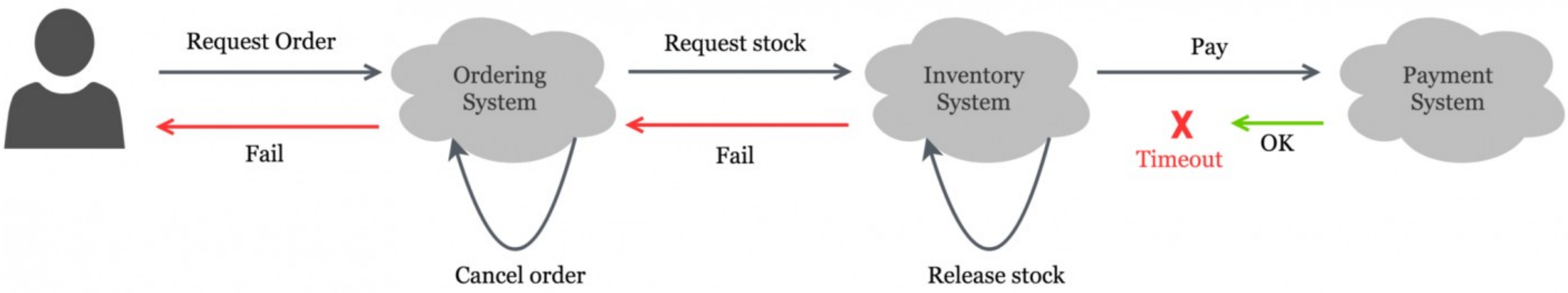
Transaction management



Transaction management



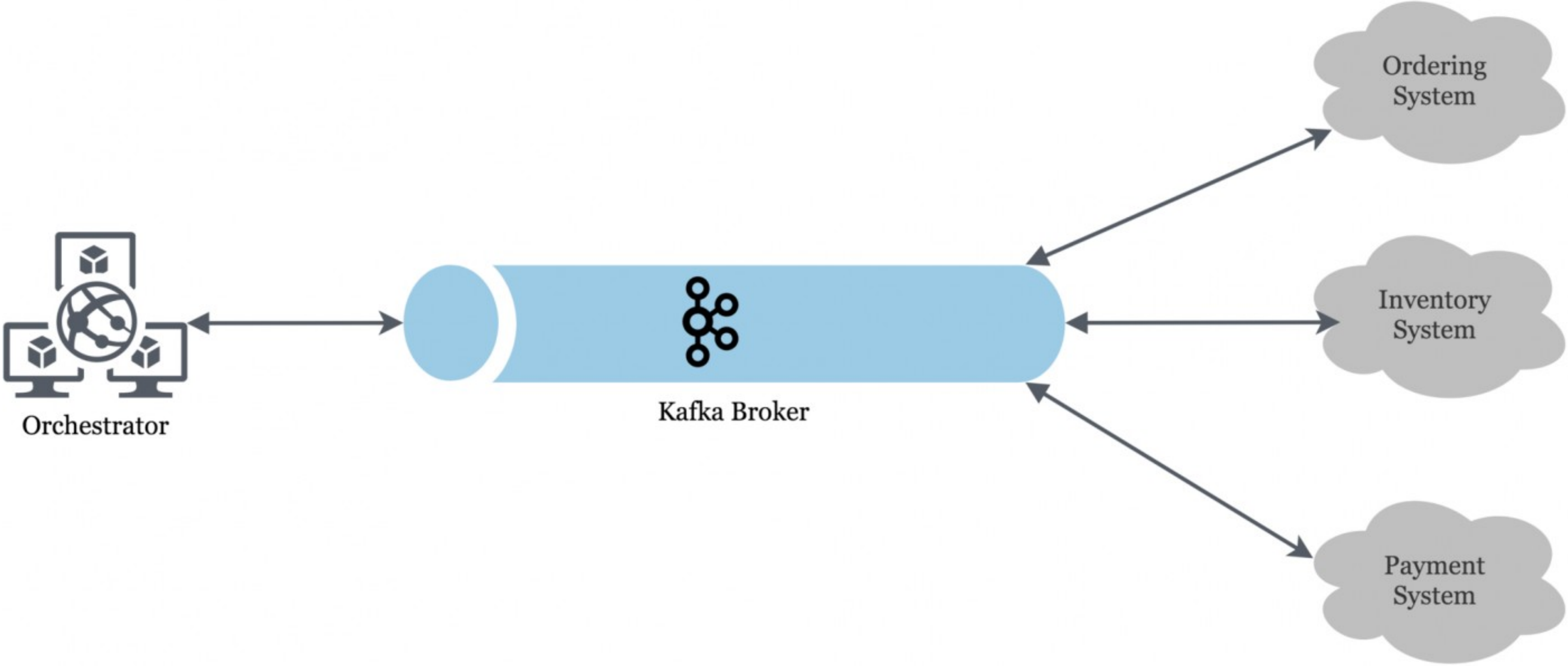
Transaction management



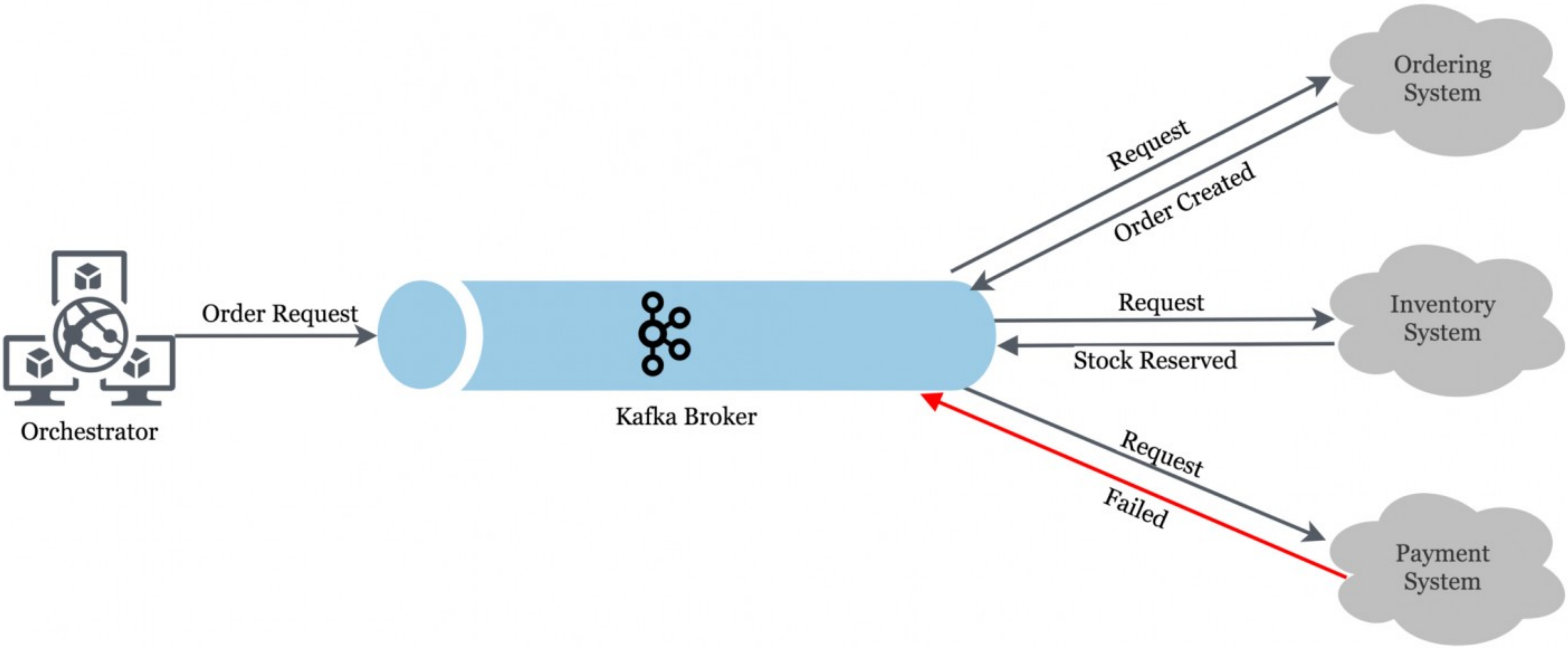
Saga Pattern

- Global distributed transactions as series of local ACID transactions
- Compensations as rollback mechanism
- Global state depends of local transaction executions
- Orchestration / Choreography

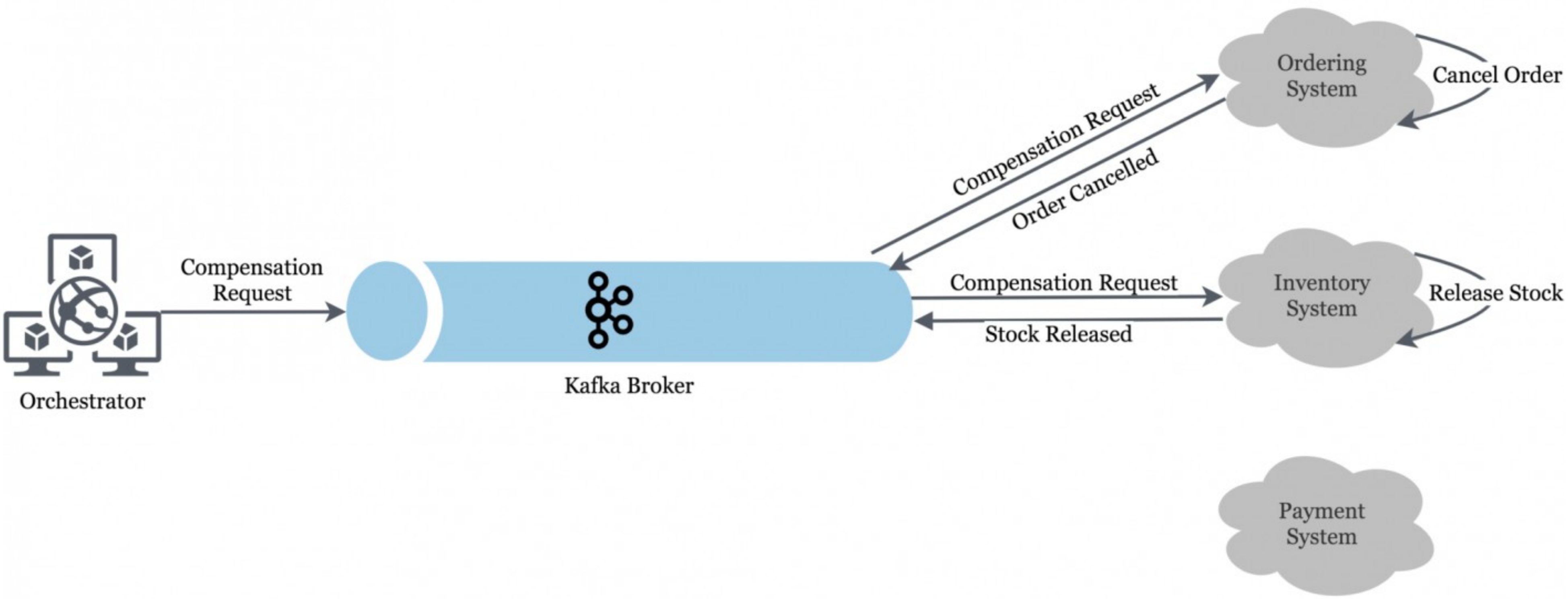
Saga Pattern



Saga Pattern

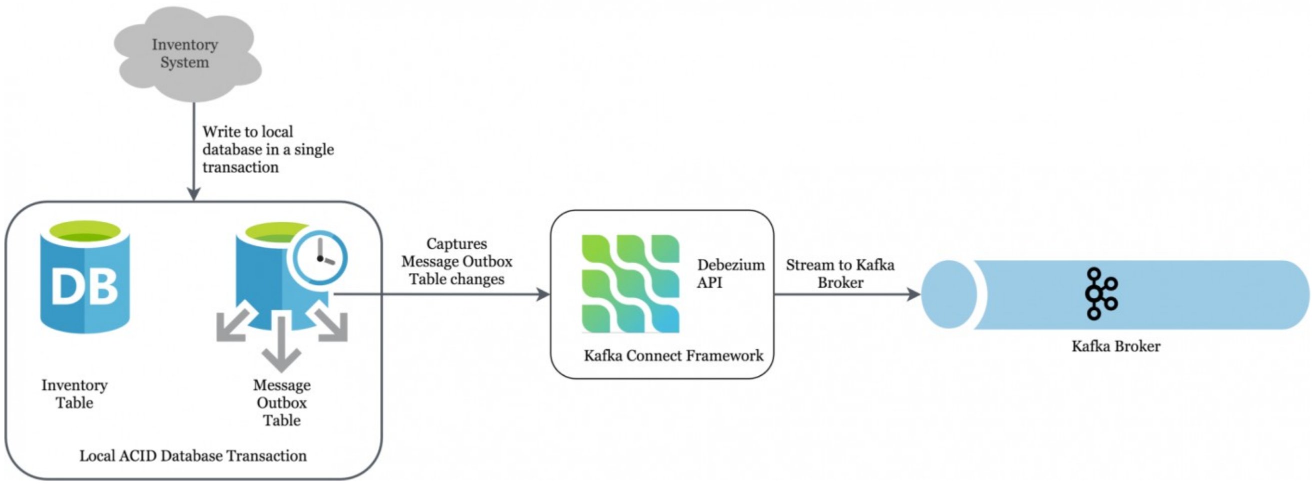


Saga Pattern



Transactional outbox pattern

- Database operations will atomically inserted to outbox table in the same transaction
- Outbox table will then produce events to publish transactions



Agenda - Day 2

- 8 fallacies of distributed computing
- Cloud patterns
- Continuous integration and delivery
- Event driven architecture and messaging
- Observability – Metrics and Tracing
- Writing your own Quarkus extension

20.11.2023

Deployment automation

- DevOps culture
- Applications can be rolled out independently
- Continuous Integration and Delivery is crucial
- Build and Deploy often
- Automate as much as possible

DevOps

DevOps

«DevOps is the combination of cultural philosophies, practices, and tools that increases an organization’s ability to deliver applications and services at high velocity: evolving and improving products at a faster pace than organizations using traditional software development and infrastructure management processes.»

https://aws.amazon.com/devops/what-is-devops/

DevOps

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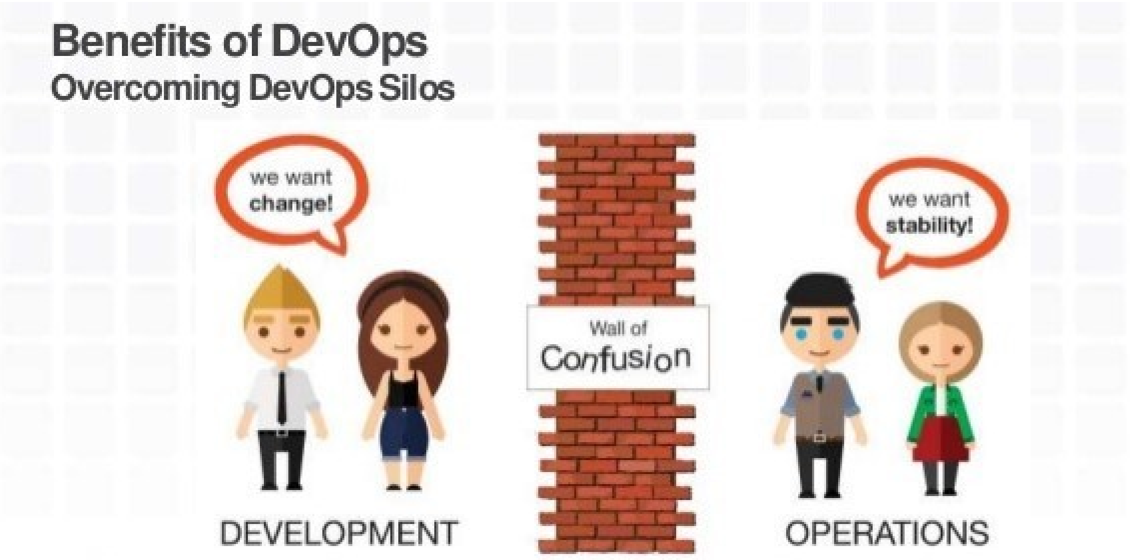
DevOps

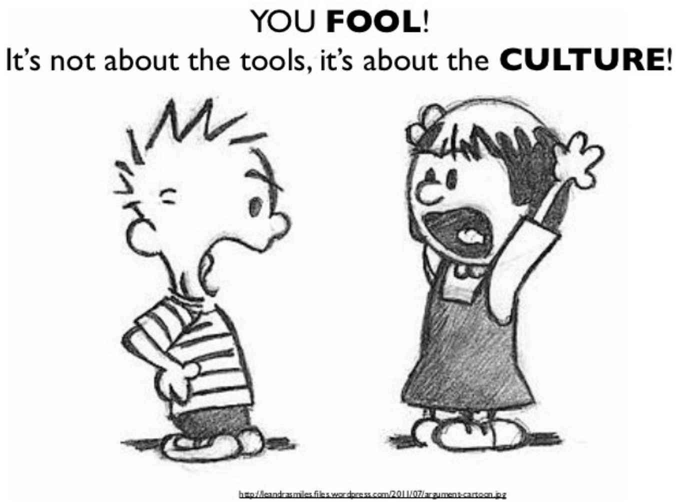


Benefits of DevOps
Overcoming DevOps Silos
we want change!
Wall of Confusion
we want stability!
DEVELOPMENT
OPERATIONS

DevOps - Before

- Classical split Devs and Ops
- Dev develops application
- Application thrown over fence
- Ops should operate unknown application
- Big knowledge gap

DevOps culture

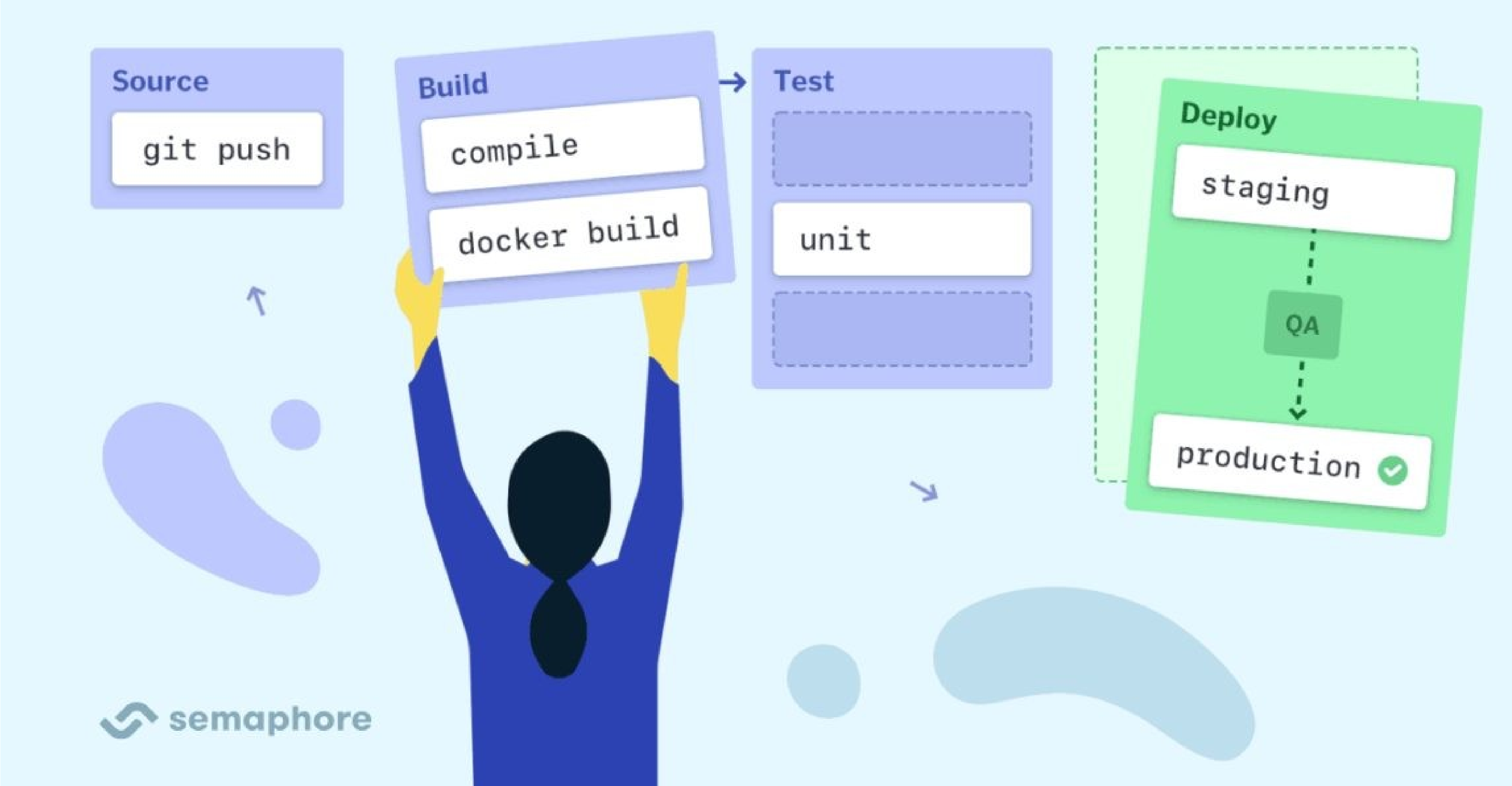


- Tear down wall of confusion
- Enable Devs to be Ops
- Integrate Operations to daily development
- Mindset should develop

Infrastructure as Code (IaC)

- Infrastructure objects defined in code
- Development process involves infrastructure
- Infrastructure gets detachable
- Fast creation of new environments

Deployment automation



Deployment automation

- Automated pipelines for build, test, release
- Deploy fast and often
- «Handle every commit on master as deployable»
- Feedback-Loop gets faster

Deployment automation

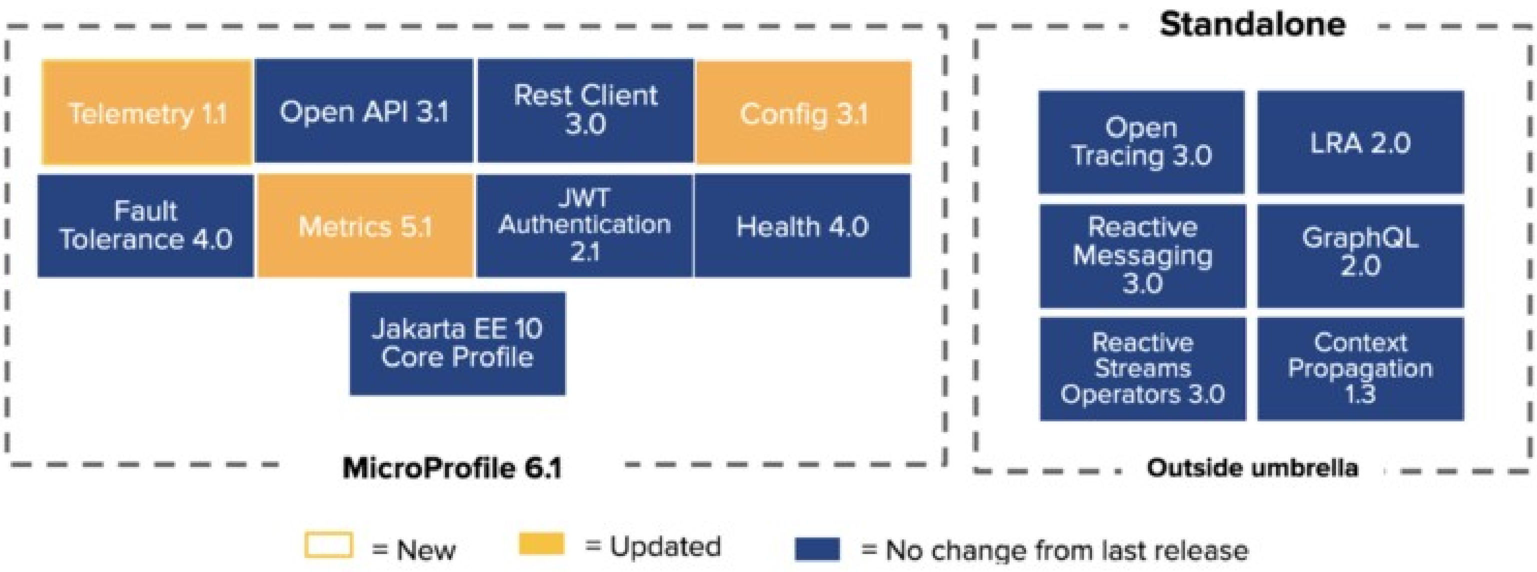
- API changes need to be categorized
- Non-breaking changes deployed fast
- Breaking changes need to deploy all dependent services
- Communication is key

Agenda - Day 2

- 8 fallacies of distributed computing
- Cloud patterns
- Continuous integration and delivery
- Event driven architecture and messaging
- Observability – Metrics and Tracing
- Writing your own Quarkus extension

Reactive Messaging

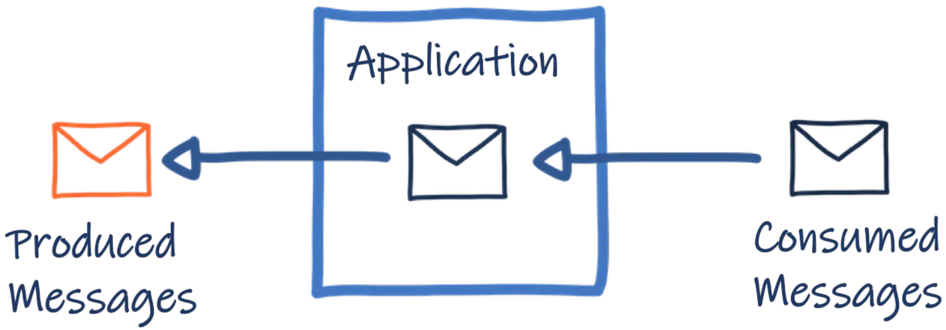
«Framework for building event-driven, data streaming and event sourcing applications using CDI», smallrye.io



Reactive Messaging Concepts

Message, Payload, Metadata

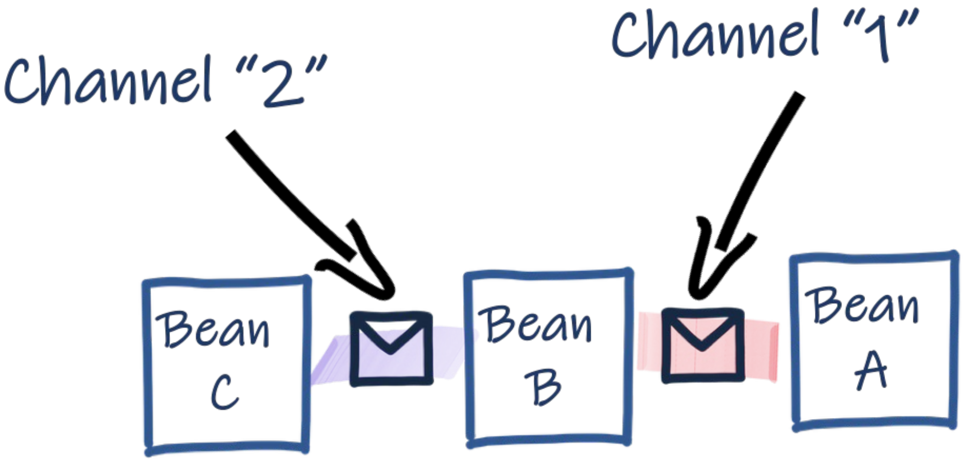
- Application receives, processes and send messages
- Message is an envelop around payload
- Messages can contain metadata (e.g tracing context)



Reactive Messaging Concepts

Channels and Streams

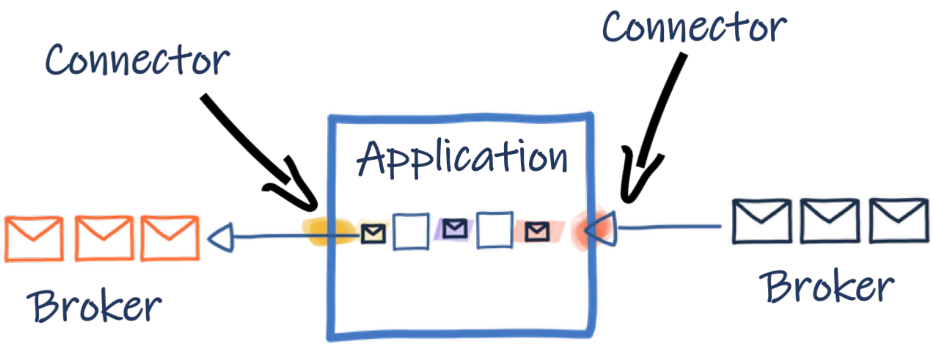
- Messages transit on channels
- Virtual destination (identified by name)



Reactive Messaging Concepts

Connectors

- Connect to broker
- Poll or write messages
- Map messages to channels
- Dedicated to a technology (e.g. Kafka)



Reactive Messaging

Connector Support

- Kafka Connector
- AMQP Connector
- MQTT Connector
- HTTP Connector
- Camel Connector (SmallRye Camel Quarkus)
- In Memory (for testing)

Reactive Messaging Example

Application Class

```java
/**
 * A bean consuming data from the "prices" Kafka topic and applying some conversion.
 * The result is pushed to the "my-data-stream" stream.
 */
@ApplicationScoped
public class PriceConverter {

    private static final double CONVERSION_RATE = 0.88;

    @Incoming("prices")
    @Outgoing("my-data-stream")
    public double process(int priceInUsd) {
        return priceInUsd * CONVERSION_RATE;
    }
}
```

Reactive Messaging Example

Application Configuration (Serializer/Deserializer properties omitted)

```
# Configure the SmallRye Kafka connector
kafka.bootstrap.servers=localhost:9092
```

kafka address

```
# Configure the Kafka source (we read from it)
mp.messaging.incoming.prices.connector=smallrye-kafka
mp.messaging.incoming.prices.topic=prices-raw
```

connector type

```
# Configure the Kafka sink (we write to it)
mp.messaging.outgoing.my-data-stream.connector=smallrye-kafka
mp.messaging.outgoing.my-data-stream.topic=prices-converted
```

channel

kafka topic

Reactive Messaging

Documentation

- SmallRye Reactive Messaging

View supported Method Signatures

- They affect the acknowledgement strategies

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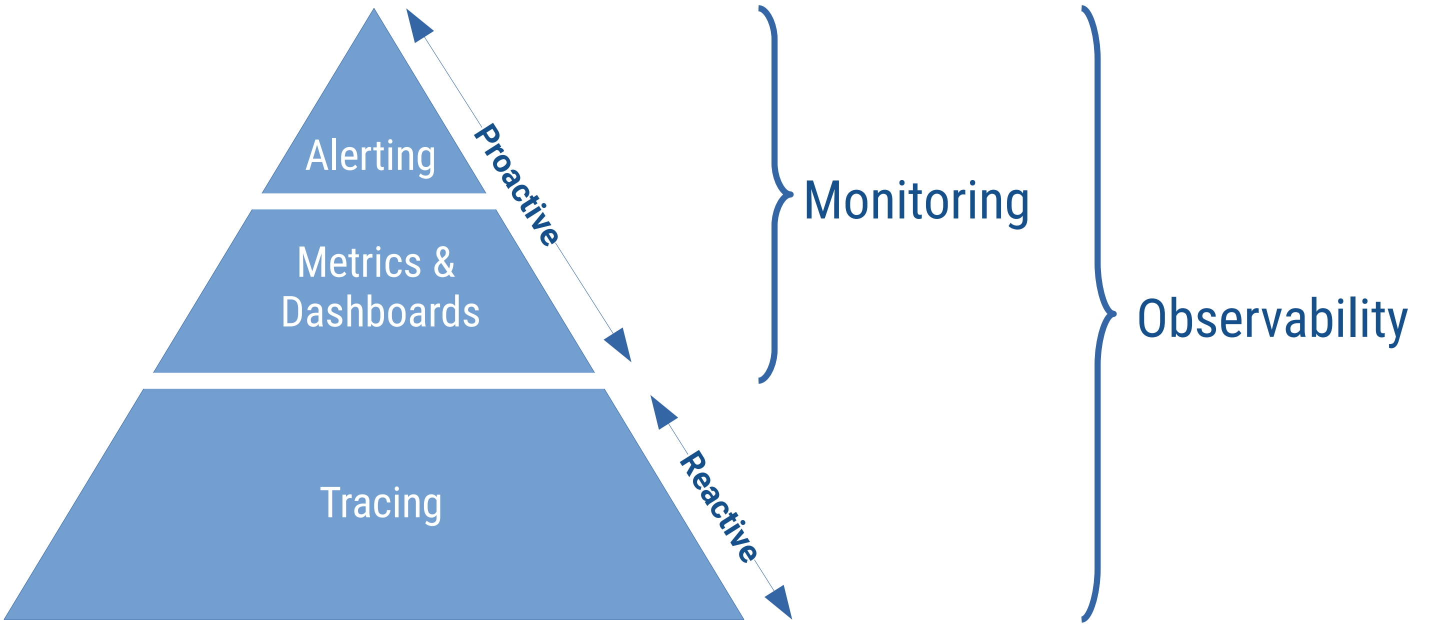
Observability extends Monitoring

«Monitoring tells you whether a system is working, observability lets you ask why it is not working.», Baron Schwartz 2017



Why do we need it?

- More complexity
- More diverse problems
- Runtime issues
- Request path may vary
- 1:n communication
- Monitoring: targets known problems
- Tracing: Instrumentation for problems we dont know yet

Three pillars of observability

source: dynatrace.com

Metrics

```
number of orders created:23
number of failed invocations of /order:3
response time of /order:823ms
```

- Capture system state at given time
- Visualize and analyze metrics with dashboards
- History might be useful
- Send alerts based on metrics

Logs

```
2020-07-12 11:45:34 Transaction id 12398 failed on update
2020-09-23 19:23:11 POST /order - status:201 - response_ms:21
```

- Collect logs centrally
- Analyze logs in case of problem
- What happens at this time
- Find application misbehaviour and exceptions

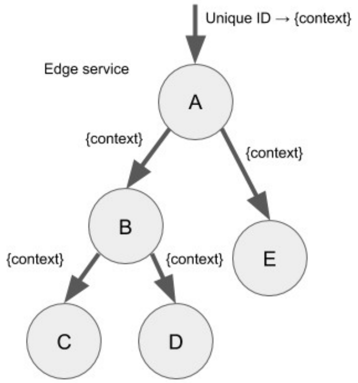
Tracing - Terminology

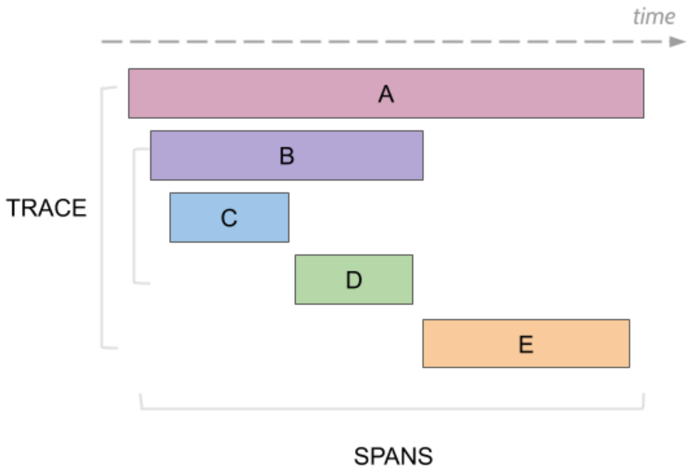
Trace: Execution path through the system

- Acyclic graph of spans

Span: Logical unit of work

- Name, Start-Time and Duration
- Could be nested, ordered





Tracing

```
request with id 98183 took 62ms
  - service a took 22ms
  - service b took 40ms
```

- Sample real requests
- Find erroneous components
- Find bottlenecks

Observability Example

Observability – Example

Logs

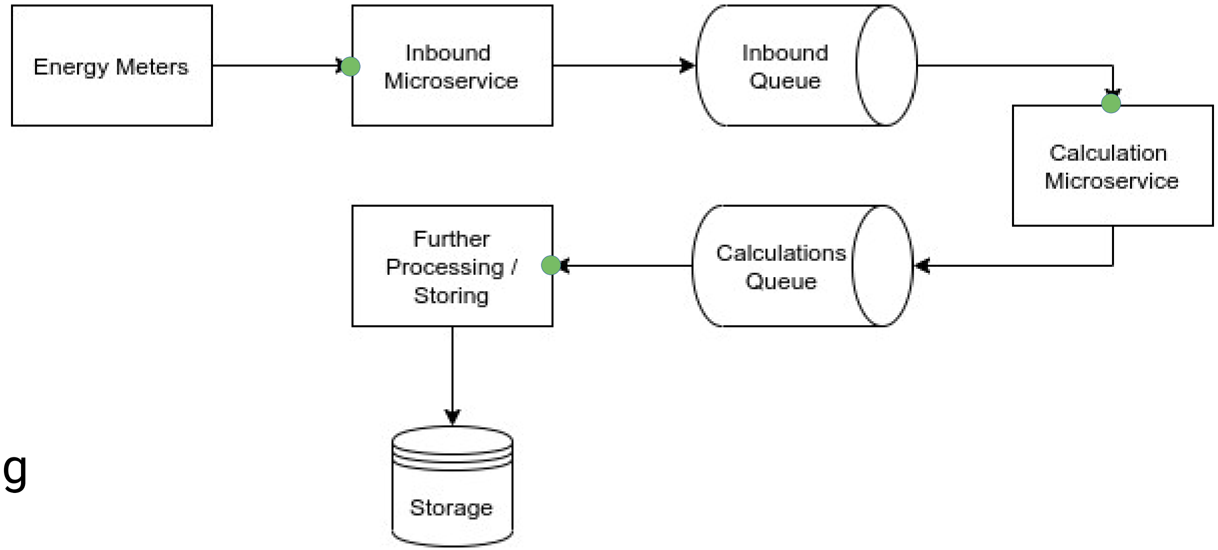
- Centralized logs

Metrics

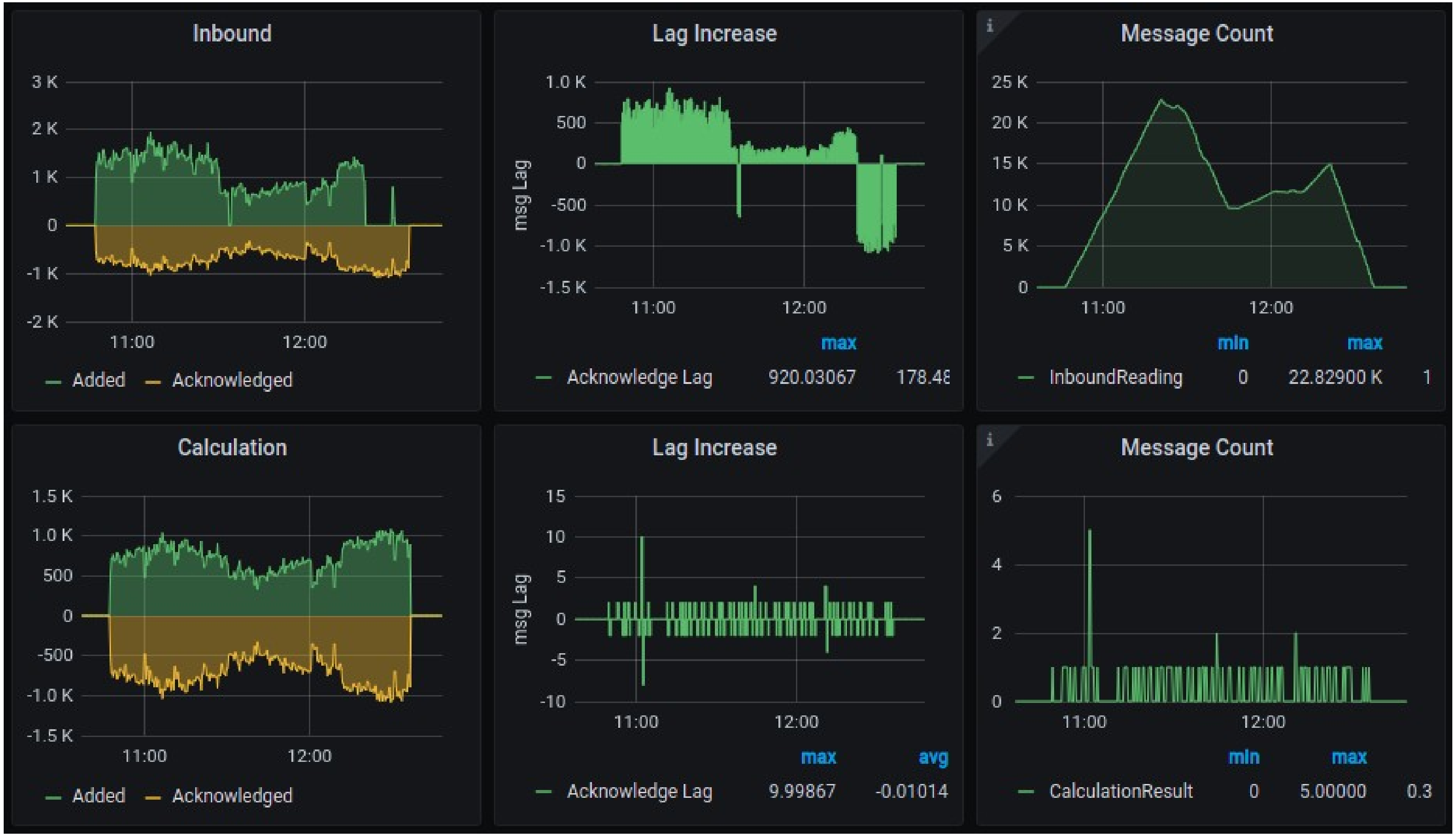
- JVM Metrics Microservices
- System metrics
- Network metrics
- Message Brokers
- Storage
- Duration of message processing

Alerts

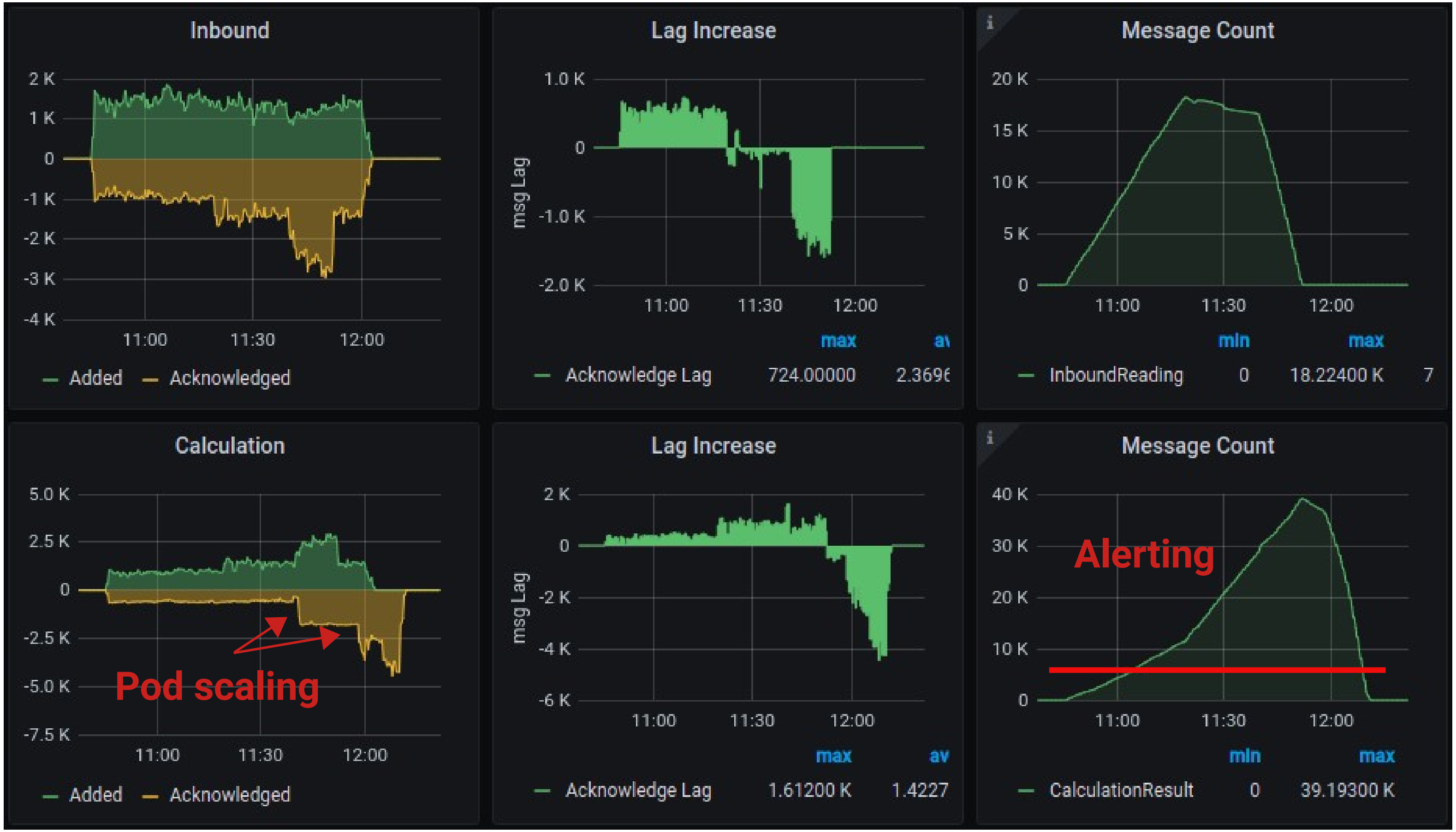
- Queue size
- ...



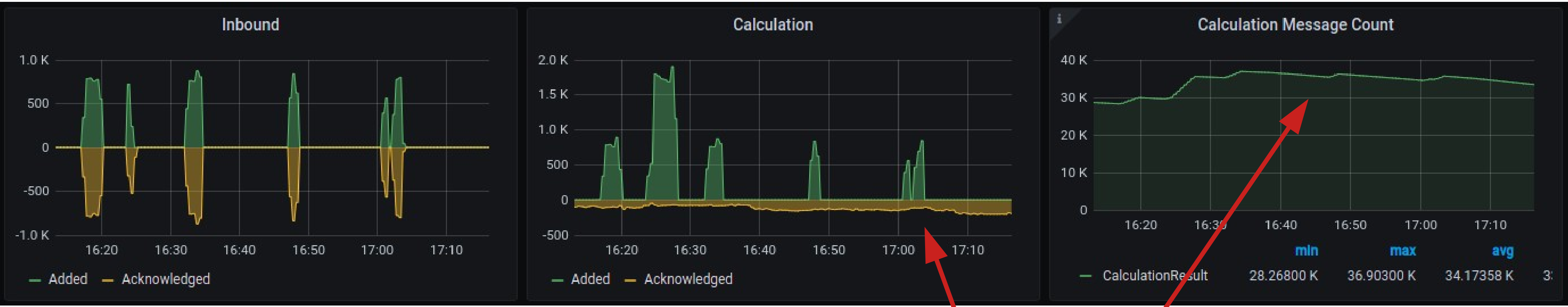
Observability – Example



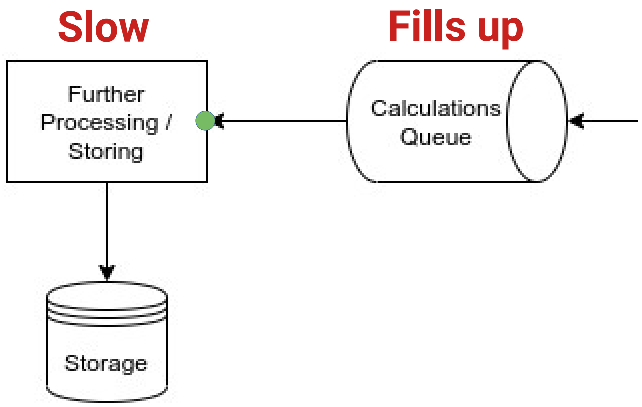
Observability – Example



Observability – Example



Observability – Example



Time to investigate ...

1. Log: what happend at that time?
2. Metrics: processing is slow
3. Metrics: network, system does not show any problems

Observability – Example

Results from Tracing

- Huge amount of repeated spans
- Three-fourths of time in foreach
- «complex» calls db & services
- Select n + 1 problem
- Increasing size of data[] increases request count

```
processCalculations(Message message) {
    Data[] data = message.data;

    // handle data
    data.foreach({
        // complex
    });

    store(data);
}
```

Observability – Example

Optimization

- Prefetch data once (as batch)
- Less interaction in foreach
- Code runs 10x faster
- Increasing data[] does not increase request count

```
processCalculations(Message message) {
    Data[] data = message.data;

    // prefetch required data once
    fetchData();

    // handle data
    data.foreach({
        // less complex
    });

    store(data);
}
```

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Quarkus structure

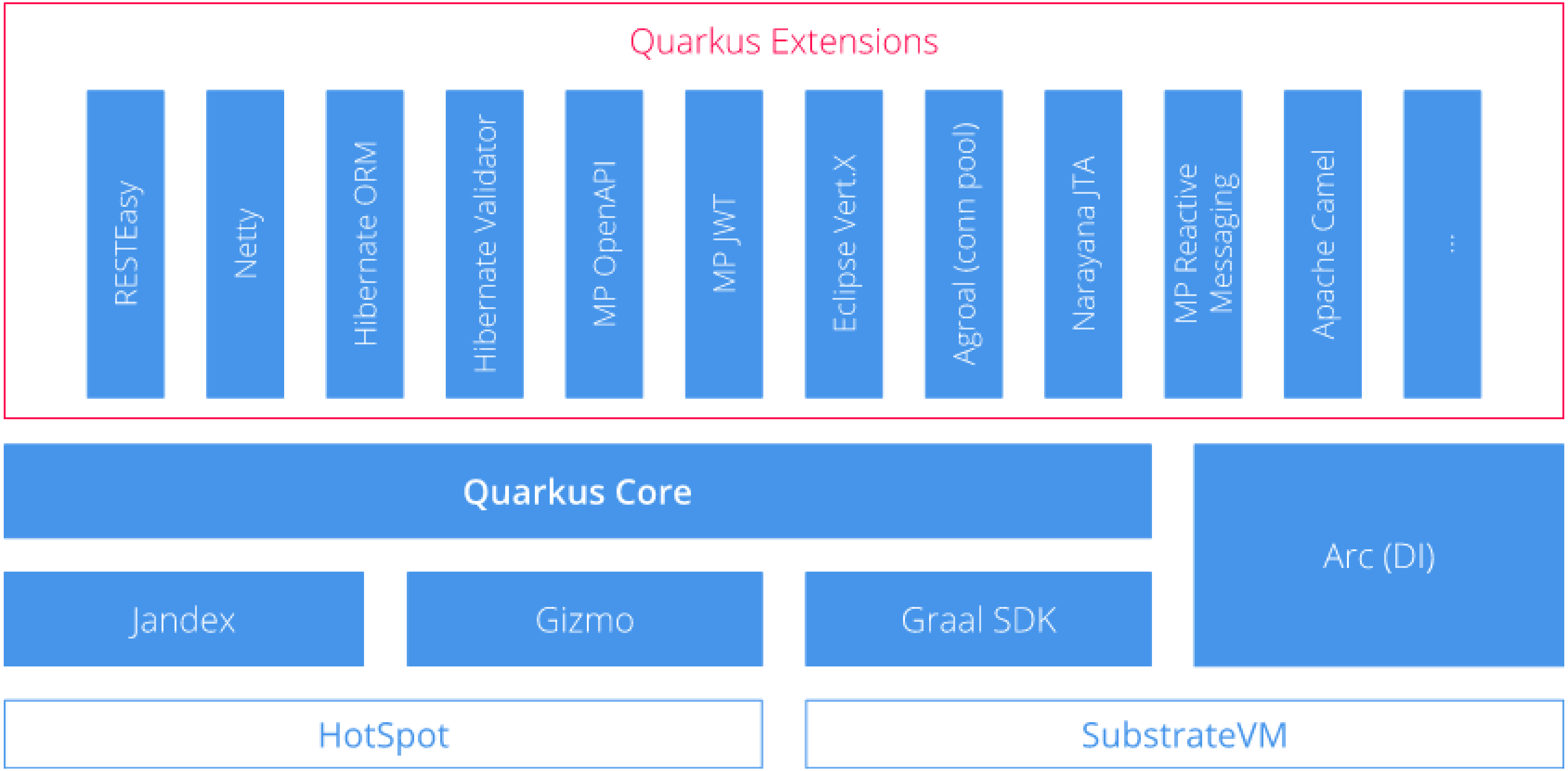


Image source: Red Hat

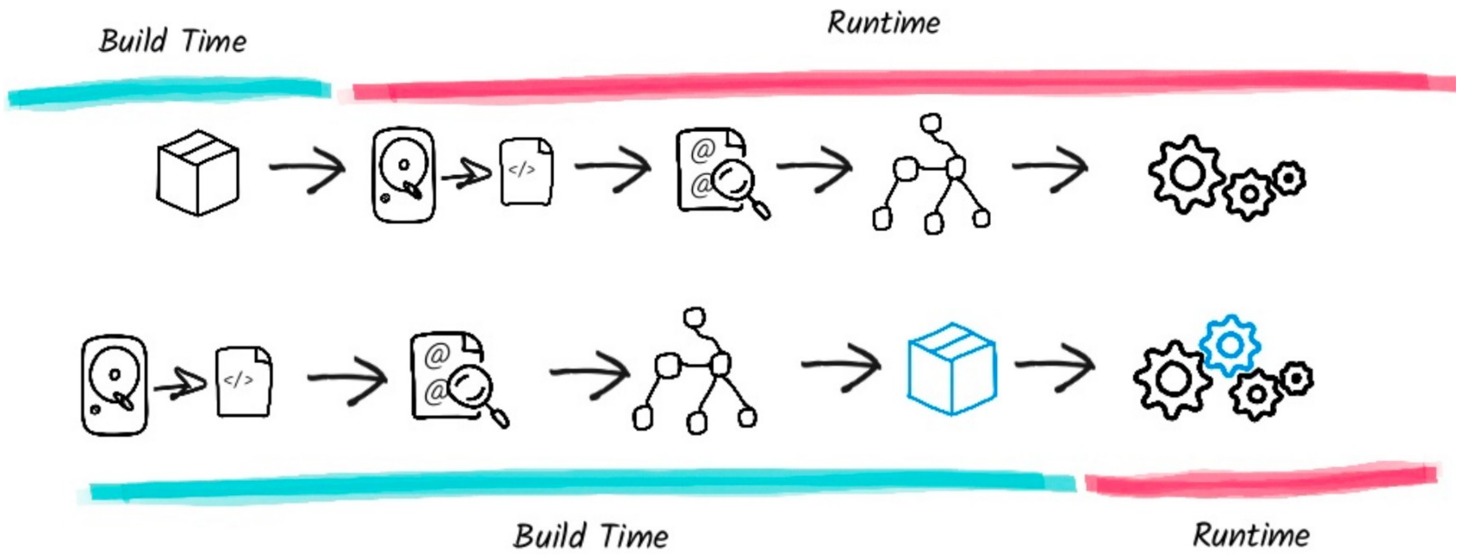
Extensions

- Extend Quarkus framework
  - With custom functionality
  - Adopting libraries or frameworks to the Quarkus world
- Maven multi-module project
  - Deployment
  - Runtime

Extensions

Adopting libraries or frameworks to the Quarkus world

- Third party libraries might or might not work out of the box



Deployment Module

- How to deploy the extension code
- Processing done with @BuildSteps which run at build time
- Has dependency to extension runtime module
- Dev UI integration

Deployment Module - @BuildStep

- Produce and consume BuildItems
- Are ordered by dependencies
- A BuildStep is run when all dependencies are available
- Can record invocations by using recorders from runtime module

Deployment Module - @BuildStep

Example: Find classes ending with MessageConverter and register for CDI

- Jandex Access → CombinedIndexBuildItem
- Register additional beans for CDI → AdditionalBeanBuildItem

```
@BuildStep
void messageConvertersAsBean(CombinedIndexBuildItem index,
                             BuildProducer<AdditionalBeanBuildItem> additionalBeans) {

    List<String> converters = index.getIndex().getKnownClasses().stream()
            .filter(ci -> !Modifier.isAbstract(ci.flags()))
            .map(ci -> ci.name().toString())
            .filter(c -> c.startsWith("my.dependency.package."))
            .filter(c -> c.endsWith("MessageConverter"))
            .collect(Collectors.toList());

    additionalBeans.produce(new AdditionalBeanBuildItem.Builder()
            .addBeanClasses(converters)
            .setUnremovable()
            .setDefaultScope(DotNames.APPLICATION_SCOPED)
            .build());
}
```

Deployment Module - @BuildStep

Example: Add an undertow servlet

- Access to current LaunchMode of Quarkus → LaunchModeBuildItem
- Access build configuration → Custom defined MyBuildConfig
- Add Servlet → ServletBuildItem

```
@BuildStep
void createServlet(LaunchModeBuildItem mode,
                   MyExtConfig config,
                   BuildProducer<ServletBuildItem> servlets) {

    if(mode.getLaunchMode().isDevOrTest() && config.enabled) {
        servlets.produce(ServletBuildItem.builder(config.basePath, MyExtServlet.class.getName())
                                         .addMapping(config.basePath)
                                         .build();
    }
}
```

Runtime Module

- Runtime features (extension code, configuration)
- Application depends on this extension module
- Contains recorders

```
@Recorder
class HelloRecorder {

  public void sayHello(String name) {
    System.out.println("Hello" + name);
  }
}
```

@BuildStep (deployment module)

```
@Record(RUNTIME_INIT)
@BuildStep
public void helloBuildStep(HelloRecorder recorder) {
    recorder.sayHello("World");
}
```

Exposing Configuration

- Extensions can expose configuration
  - Remember different configuration phases

```
@ConfigRoot(name = "my-ext", phase = ConfigPhase.BUILD_TIME)
public final class MyExtConfig {

    @ConfigItem(defaultValue = "true")
    public boolean enabled;

    @ConfigItem(defaultValue = "/myext")
    public String basePath;
}
```

application.properties

```
quarkus.my-ext.enabled=false
```

Extension Resources

Writing your own extension

https://quarkus.io/guides/writing-extensions

Building my first extension

https://quarkus.io/guides/building-my-first-extension

How to write Quarkus extensions

https://peter.palaga.org/presentations/210407-quarkus-insights-how-to-write-quarkus-extensions

Quarkus core extensions

https://github.com/quarkusio/quarkus/tree/main/extensions

Quarkus community extensions (quarkiverse)

https://github.com/quarkiverse

Goodbye

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