Ascent
FORMATION

Microservices with Quarkus

Day 3: Building Resilient & Asynchronous Microservices

Morning Session 1 (09:00 - 10:30)

Topic: Building Resilient Microservices

Activity: Hands-on Lab 6

Lab 6 Objectives

- Apply resilience patterns to the `train-line-service`.
- Handle latency and transient failures from the `station-service`.
- Use `@Timeout` and `@Retry` to meet a 90% success rate objective.
- Implement a `@CircuitBreaker` to prevent cascading failures.
- Use a `@Fallback` to provide a clean response when failures occur.

What is Resilience?

In a distributed system, failures are inevitable.

- Network issues
- Service unavailability
- High latency

Resilience is the ability of a system to gracefully handle these failures and remain functional.

MicroProfile Fault Tolerance

Provides a standard set of annotations to build resilient microservices.

- **Goal**: Isolate and manage failures, preventing them from cascading.
- **Key Annotations**:
  - `@Timeout` : Sets a duration limit for a method execution.
  - `@Retry` : Automatically retries a failed execution.
  - `@CircuitBreaker` : Stops repeated calls to a failing service.
  - `@Fallback` : Provides an alternative result for a failed execution.
  - `@Bulkhead` : Limits concurrent requests to a method.
  - `@RateLimit` : Limit the number of requests over time.
- **Guide**: Fault Tolerance with SmallRye

SmallRye Fault Tolerance

- **Implementation**: Quarkus uses SmallRye to implement the MicroProfile Fault Tolerance specification.
- **Beyond the Spec**: SmallRye provides additional features and fine-grained configuration.
- **Asynchronous Support**: All fault tolerance annotations work with both synchronous and asynchronous (`CompletionStage` , `Uni`) methods.
- **Configuration**: While annotations are easy, all parameters can be configured and overridden in `application.properties` for greater flexibility.

`@Timeout`

- **Problem**: A synchronous call is taking too long, tying up resources.
- **Solution**: Abort the operation if it exceeds a specified duration.

```
@GET
@Path("/{id}")
@Timeout(250) // Fails if execution takes longer than 250ms
public Product getProduct(@PathParam("id") String id) {
    // ... logic that might be slow
}
```

- Throws a `TimeoutException` on timeout.

`@Retry`

- **Problem**: An operation fails due to a transient issue (e.g., temporary network glitch).
- **Solution**: Automatically retry the operation a few times.

```
@GET
@Path("/{id}")
@Retry(maxRetries = 3, delay = 200) // Retry up to 3 times, with 200ms delay
public Station getStationById(@PathParam("id") String id) {
    // ... call to a potentially flaky service
}
```

- Highly configurable (`maxDuration` , `jitter` , `retryOn` , `abortOn`).

`@CircuitBreaker`

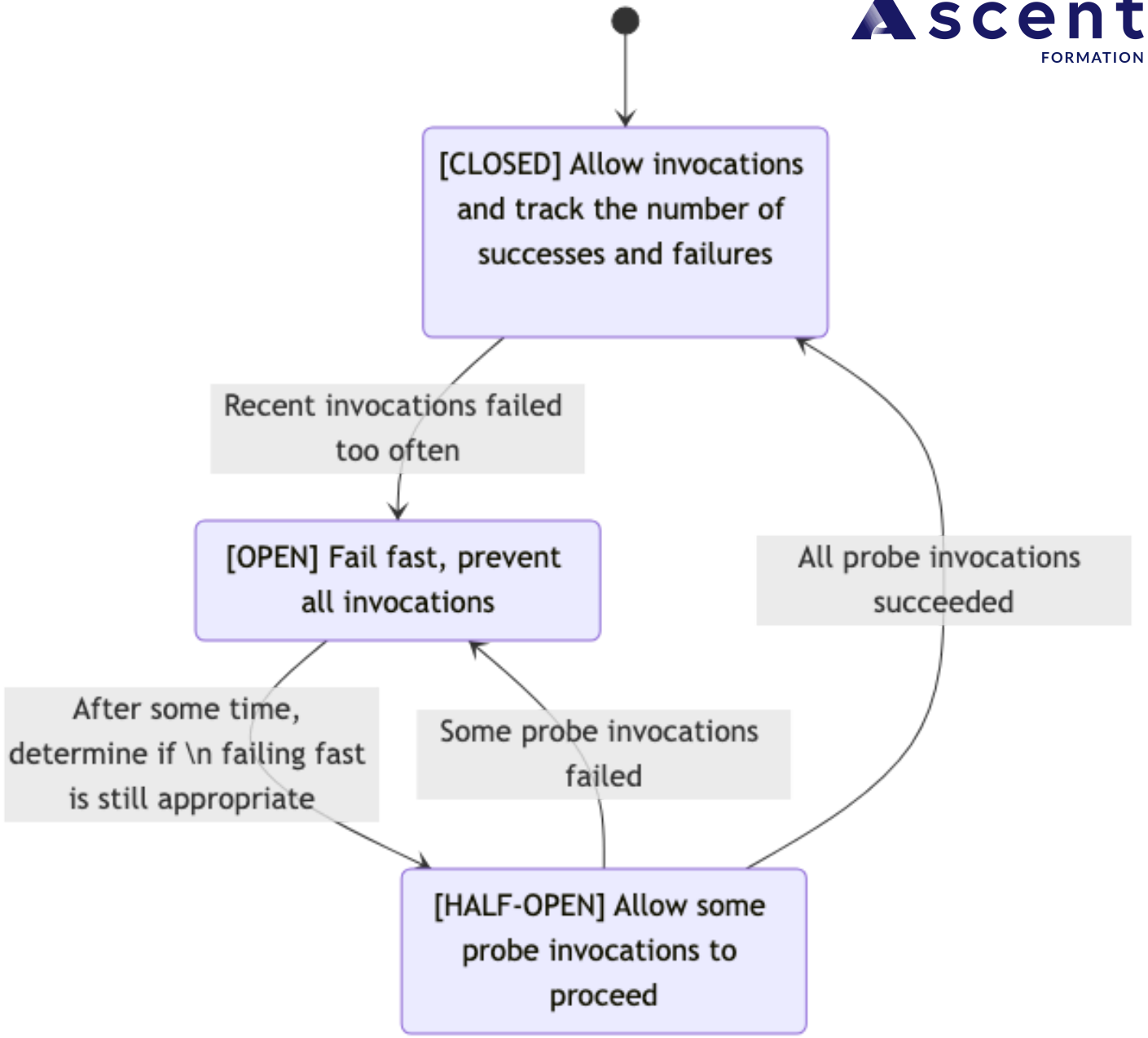
- **Problem**: A downstream service is down. Repeatedly retrying is wasteful and can make recovery harder (thundering herd).
- **Solution**: "Open" a circuit to fail-fast, and periodically check if the service has recovered.

States:

1. **CLOSED**: Operations are executed. If failures exceed a threshold, moves to OPEN.
2. **OPEN**: Operations fail immediately (`CircuitBreakerOpenException`). After a delay, moves to HALF-OPEN.
3. **HALF-OPEN**: A trial request is allowed. If it succeeds, moves to CLOSED. If it fails, moves back to OPEN.

`@CircuitBreaker`

State Machine



`@CircuitBreaker` Example

```
@GET
@Path("/{id}")
@CircuitBreaker(
    requestVolumeThreshold = 10, // in the last 10 requests...
    failureRatio = 0.6,          // ...if 60% fail...
    delay = 5000,                // ...open the circuit for 5s
    successThreshold = 2         // need 2 successes to close
)
public Station getStationById(@PathParam("id") String id) {
    // ... call to a service that might be down
}
```

CircuitBreaker SmallRye Documentation

`@Fallback`

- **Problem**: An operation has failed (after timeouts and retries), but we want to provide a graceful response instead of an exception.
- **Solution**: Specify a method to call to get an alternative result.

```
@GET
@Path("/{id}")
@Retry(maxRetries = 2)
@Fallback(fallbackMethod = "getUnknownStation")
public Station getStationById(@PathParam("id") String id) {
    // ... call to a failing service
}
```

Ascent FORMATION

@Fallback

- The fallback method must have a compatible signature.

```
public Station getUnknownStation(String id) {
    // Return a default or cached value
    return new Station(id, "Unknown Station");
}
```

`@Fallback` Configuration

You can control precisely when the fallback is triggered.

- **`applyOn`** : Specifies an array of exceptions that should trigger the fallback. If empty, all exceptions trigger it.
- **`skipOn`** : Specifies an array of exceptions that should *not* trigger the fallback.

Ascent FORMATION

`@Fallback` Configuration

```
@POST
@Fallback(
    fallbackMethod = "handleCreationFailure",
    applyOn = {WebApplicationException.class}, // Only apply on web exceptions
    skipOn = {IllegalArgumentException.class} // But not for bad arguments
)
public Response create(TrainStop stop) {
    // ... logic that might fail
}
```

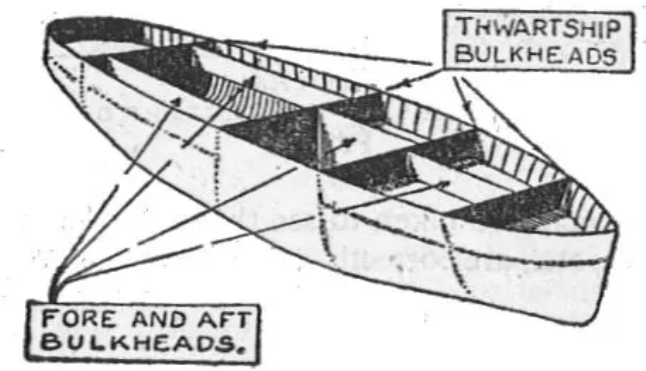
This gives you fine-grained control over your error handling strategy.

SmallRye Fallback Documentation

Ascent FORMATION

@Bulkhead

- **Problem**: A single slow dependency can exhaust all available resources, causing the entire application to become unresponsive.
- **Analogy**: The bulkhead pattern is named after the partitioned sections of a ship's hull. If one compartment floods, the bulkheads prevent the entire ship from sinking.
- **Solution**: Isolate failures in one part of the system from affecting others by limiting the number of concurrent requests to a specific service.



`@Bulkhead` in Quarkus

- **Semaphore-based**: Limits the number of concurrent requests to a method.
- If the limit is reached, subsequent calls will fail immediately with a `BulkheadException`.

```
@GET
@Path("/{id}")
@Bulkhead(5) // Only 5 concurrent requests allowed
public Station getStationById(@PathParam("id") String id) {
    // ... call to a service that can be slow
}
```

- **Thread-pool-based (for async)**: Provides a dedicated thread pool for the annotated method, isolating its execution from other threads.

SmallRye Bulkhead Documentation

`@RateLimit`

- **Problem**: A client is calling an endpoint too frequently, potentially overloading the service or a downstream resource (like a message queue).
- **Solution**: Restrict the number of requests allowed within a specific time window.
- **Implementation**: This is a SmallRye-specific annotation, **not** part of the MicroProfile Fault Tolerance specification.

RateLimit SmallRye Documentation

`@RateLimit` in Quarkus

```
import io.smallrye.faulttolerance.api.RateLimit;
import java.time.temporal.ChronoUnit;

@POST
@Path("/notify")
@RateLimit(
    value = 10,
    window = 1,
    windowUnit = ChronoUnit.MINUTES
) // Allow only 10 requests per minute
public Response notify(String message) {
    // Publish message to a queue
    messageProducer.send(message);
    return Response.accepted().build();
}
```

- If the rate limit is exceeded, a `RateLimitException` is thrown.

Priority of Fault Tolerance Strategies

```
Fallback(
    Retry(
        CircuitBreaker(
            RateLimit(
                Timeout(
                    Bulkhead(
                        ... the guarded method ...
                    )
                )
            )
        )
    )
)
```

Interations with Other Strategies

Lunch Break (12:00 - 13:00)

Afternoon Session 1 (13:00 - 14:30)

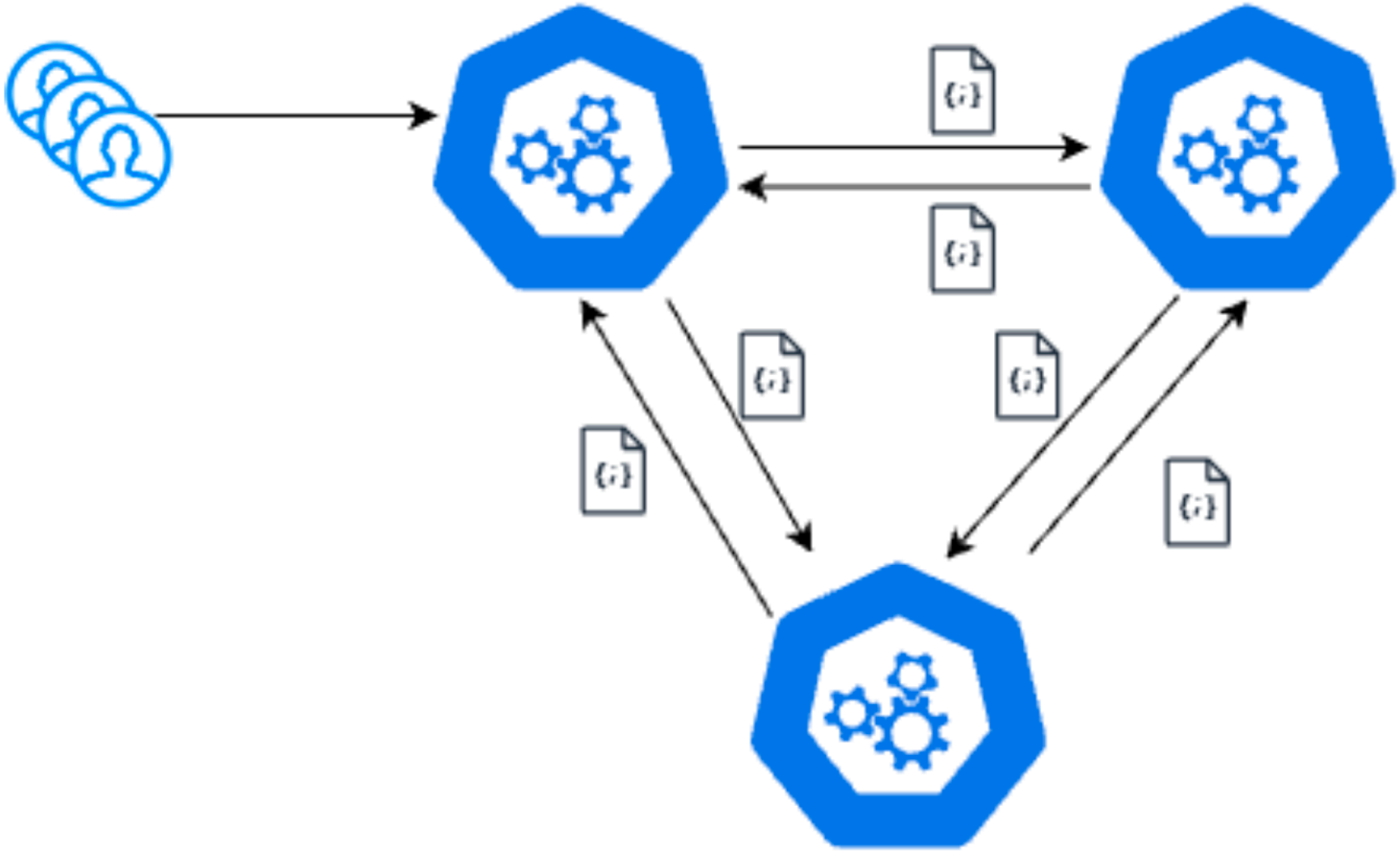
Topic: Asynchronous Messaging

Ascent FORMATION

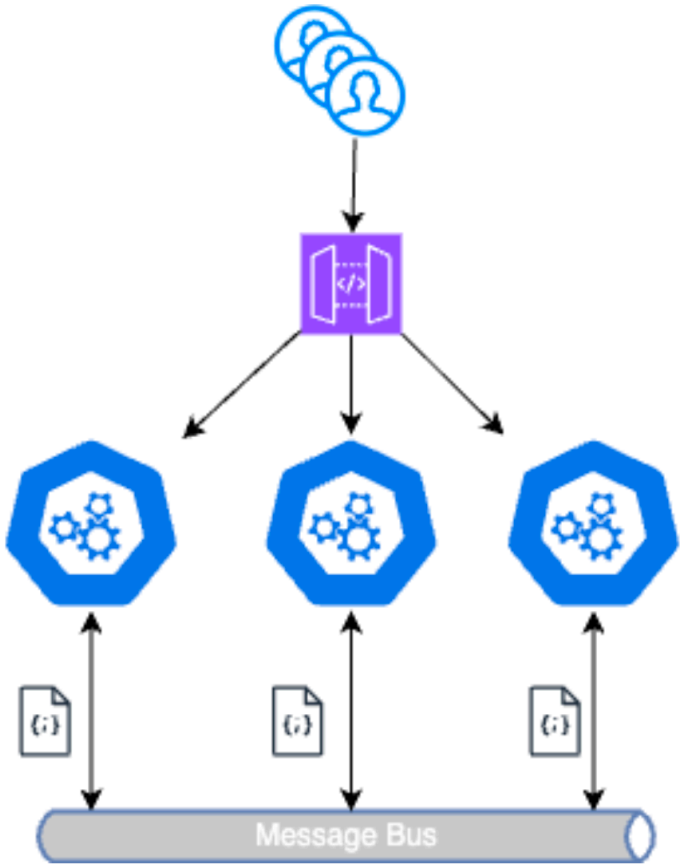
Why Asynchronous Messaging?

- **Decoupling**: Services don't need to know about each other directly. They just produce/consume messages.
- **Resilience**: The system can tolerate temporary unavailability of a consumer. Messages will be processed when it comes back online.
- **Scalability**: You can have multiple instances of a consumer processing messages from a queue in parallel.
- **Responsiveness**: Fire-and-forget. The client doesn't have to wait for the full processing to complete.

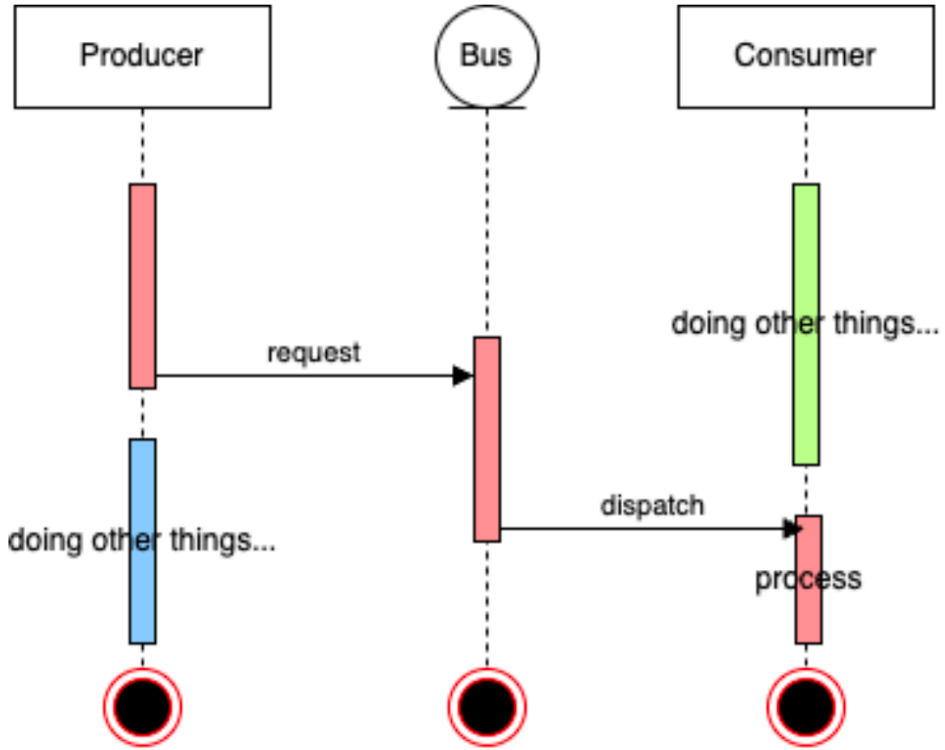
- **Interaction between services via REST APIs**



- **Add a middleware to handle the communication**
- **Decouples the different services**

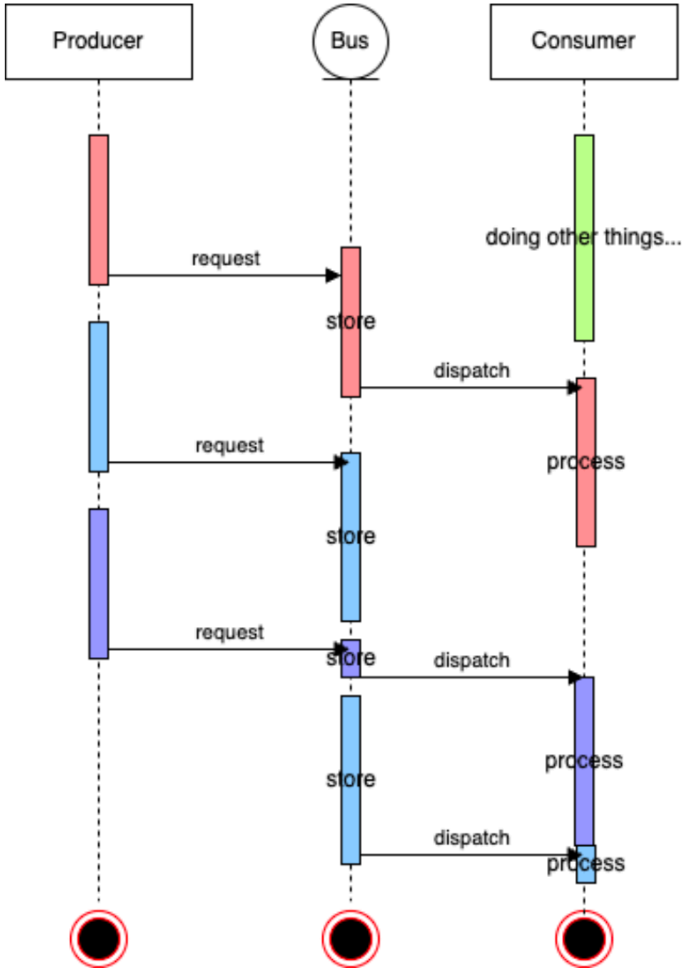


- **Fire and forget**
  - In order for the producer to send a message, there is no need to wait for the receiver to be available



- Store and forward approach
- Message redelivery
- Message broker Redundancy

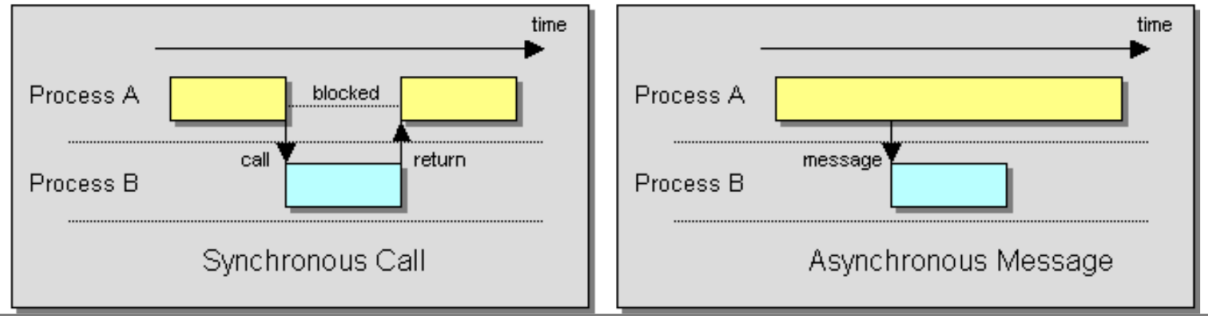
- **Again, fire and forget**
- **Handle multiple requests at the same time**



]

Synchronous vs. Asynchronous

- **Synchronous: Sender waits for a response to the message/request**
  - Request-response, gRPC
  - REST API call (GET, POST, etc)
  - SQL UPDATE
- **Asynchronous: Sender does not wait for receiver**
- **For request-response scenarios the sender provides a "callback"**
  - Javascript Promise/await/async (AJAX for oldschoolers)
  - Java/Guava Threads and Futures
  - C# await/async/Tasks



https://www.enterpriseintegrationpatterns.com/patterns/messaging/Introduction.html

MicroProfile Reactive Messaging

A standard for building event-driven, asynchronous applications.

- **Core Concepts**:
  - **Channel**: A virtual, named destination. Can be in-memory or mapped to a message broker (like Kafka or AMQP).
  - `@Outgoing`: A method that produces messages and sends them to a channel.
  - `@Incoming`: A method that consumes messages from a channel.
  - **Connector**: The "glue" that maps a channel to a specific messaging technology.
- **Guide**: Reactive Messaging

Producer (`@Outgoing`)

A method that produces a stream of messages.

```
@ApplicationScoped
public class MessageGeneratorBean {

    @Outgoing("sink")
    public Multi<String> generate() {
        return Multi.createFrom().items("a", "b", "c");
    }

}
```

Ascent FORMATION

Consumer (`@Incoming`)

A method that is called for each message received from a channel.

```
@ApplicationScoped
public class MessageProcessingBean {

    @Incoming("source")
    public void process(String consumedPayload) {
        // process the payload
        consumedPayload.toUpperCase();
    }

}
```

Ascent FORMATION

Processor (`@Incoming` + `@Outgoing`)

A method that consumes from one channel, transforms the message, and sends it to another channel.

```
    @Incoming("requests")
    @Outgoing("quotes")
    @Blocking
    public Quote process(String quoteRequest) throws InterruptedException {
        // simulate some hard-working task
        Thread.sleep(200);
        return new Quote(quoteRequest, random.nextInt(100));
    }
```

Ascent FORMATION

Connectors & Configuration

Connectors map channels to a message broker. Quarkus has connectors for Kafka, AMQP (RabbitMQ), MQTT, and more.

application.properties

```
amqp-host=amqp
amqp-port=5672
amqp-username=my-username
amqp-password=my-password

mp.messaging.incoming.prices.connector=smallrye-amqp
...
```

Afternoon Session 2 (14:45 - 16:00)

Activity: Lab on Asynchronous Messaging (Optional/Demo)

- https://quarkus.io/guides/amqp
- https://quarkus.io/guides/amqp-reference#configuring-the-amqp-broker-access
- https://quarkus.io/guides/messaging-virtual-threads

End of Day 3

- Recap & Q&A
- Preview of Day 4:
    i. Observabilty
    ii. Metrics
    iii. Azure Service Bus Messaging
    iv. Reactive Programming vs Virtual Threads
    v. Transactions