

Microservice





Somkiat Puisungnoen

Somkiat Puisungnoen

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Intro
Software Craftsmanship

Software Practitioner at สยามชัมนาภิกิจ พ.ศ. 2556

Agile Practitioner and Technical at SPRINT3r

Somkiat Puisungnoen 15 mins · Bangkok · ⚙️

Java and Bigdata





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<https://github.com/up1/course-microservice-testing>



Module 1 : Design

Cloud Native Application

Evolution of architecture

Microservice architecture

How to decompose app to Microservice

Communication between service

Data consistency

Workshop



Module 2 : Testing

Recap Microservice

Properties of Microservice

How to develop Microservice ?

How to test Microservice ?

Workshop



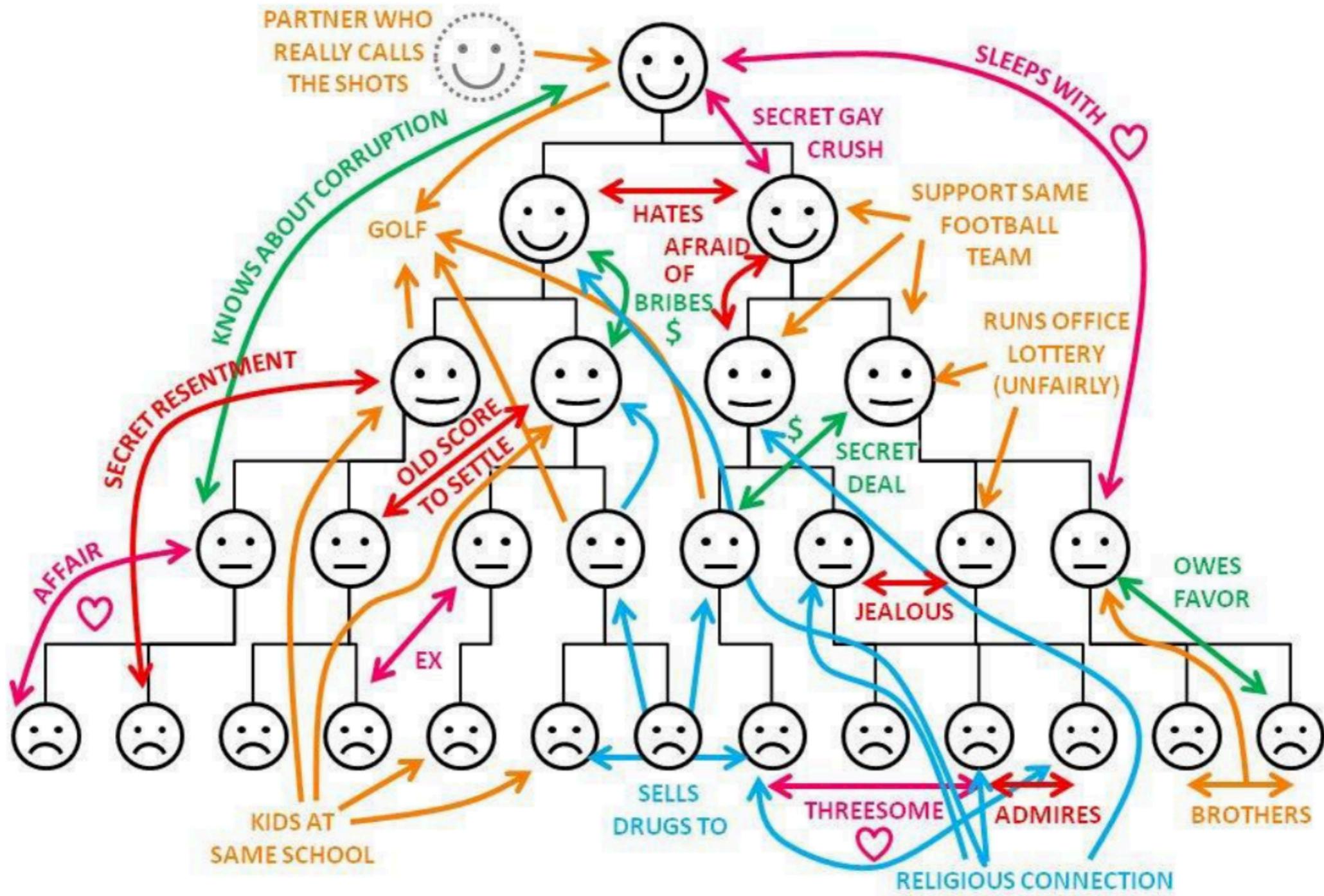
Module 1 : Design

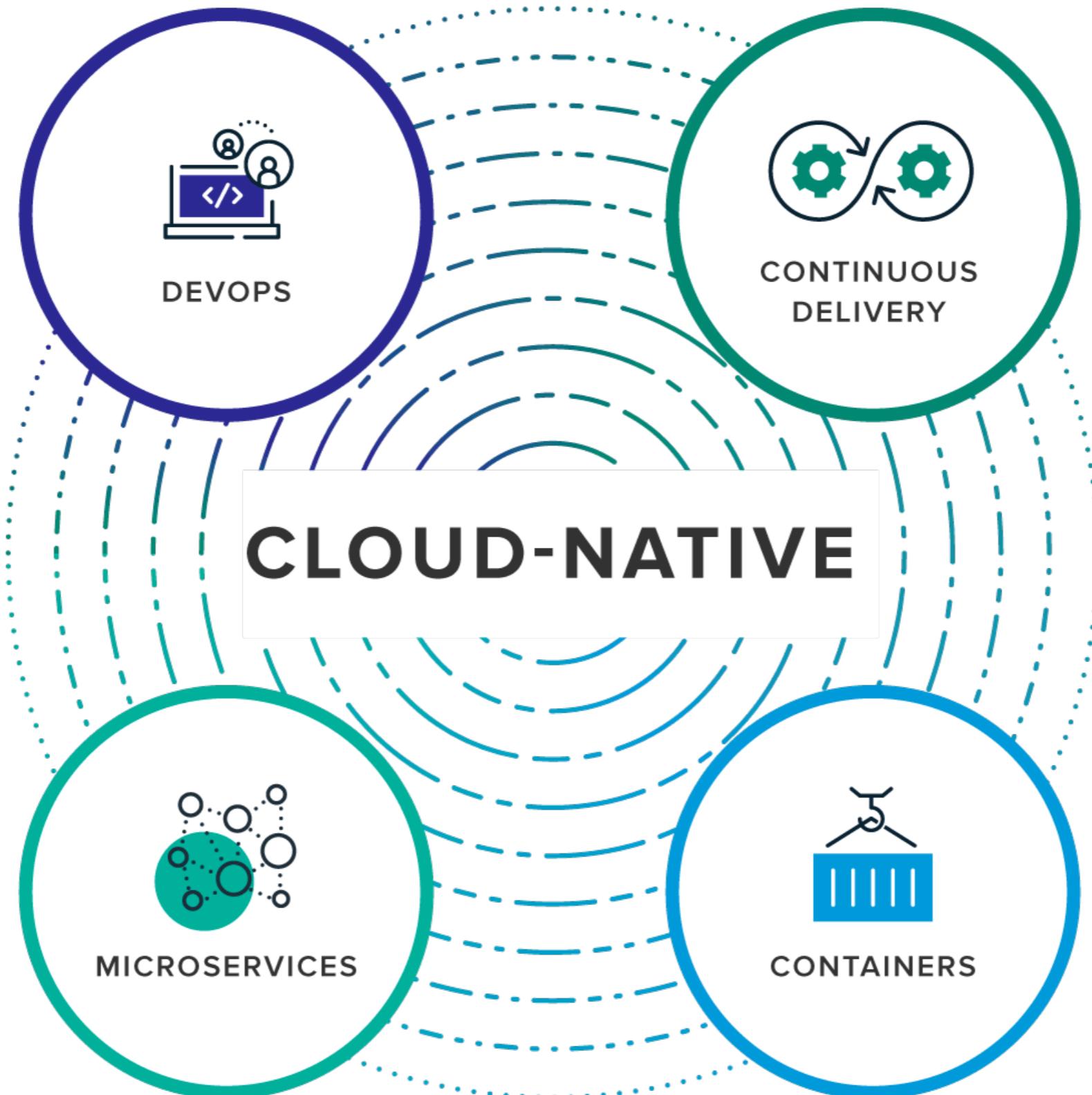


"organizations which design systems ... are constrained to produce designs which are copies of the communication structures of these organizations"

- *Melvin Conwey, 1968* -







<https://pivotal.io/cloud-native>



Evolution of Architecture

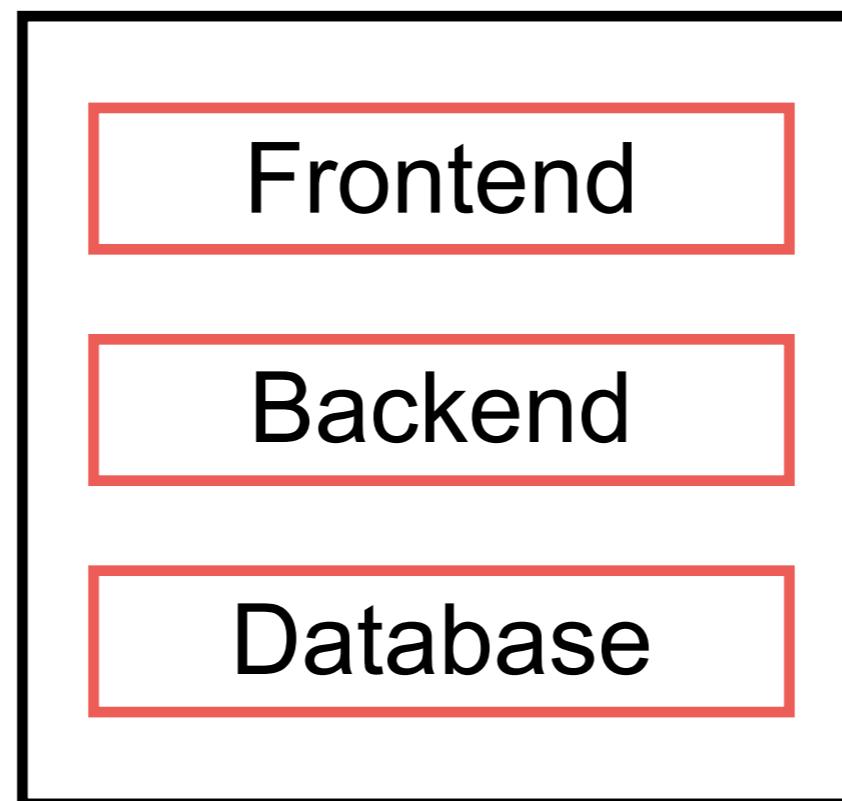


Monolith

App



Layer

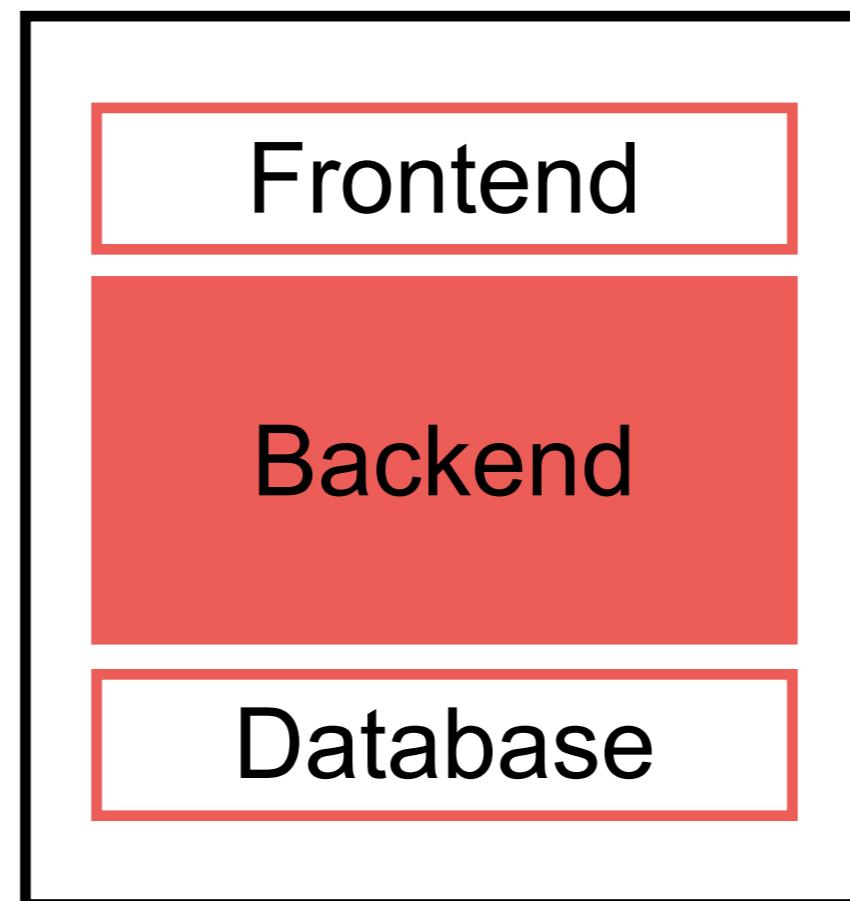


Monolith

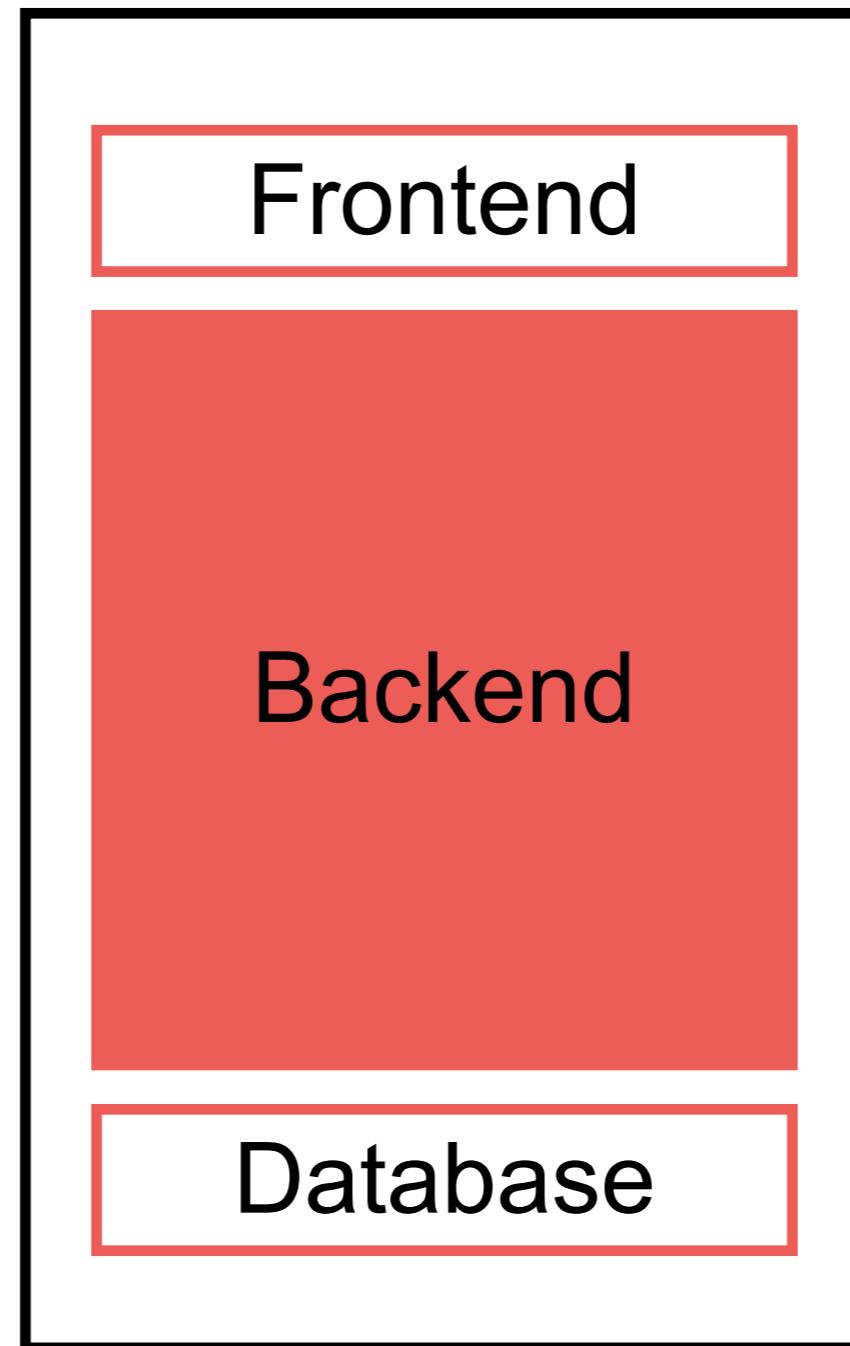
Easy to develop
Easy to change
Easy to testing
Easy to deploy
Easy to scale



More features ...



More features ...



More features ...

Frontend



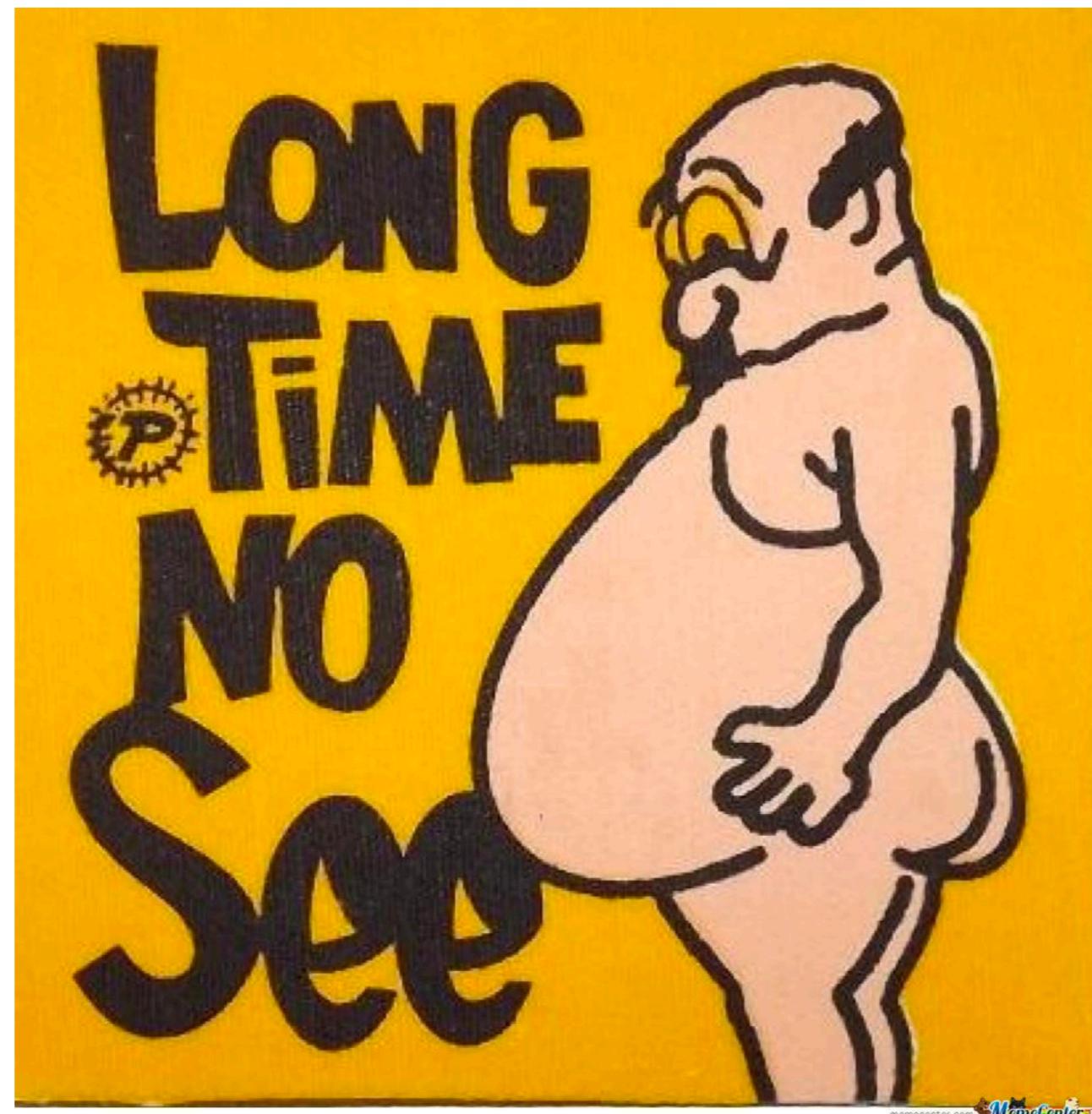
In spaghetti code, the relations between the pieces of code are so tangled that it is nearly impossible to add or change something without unpredictably breaking something somewhere else.

Database

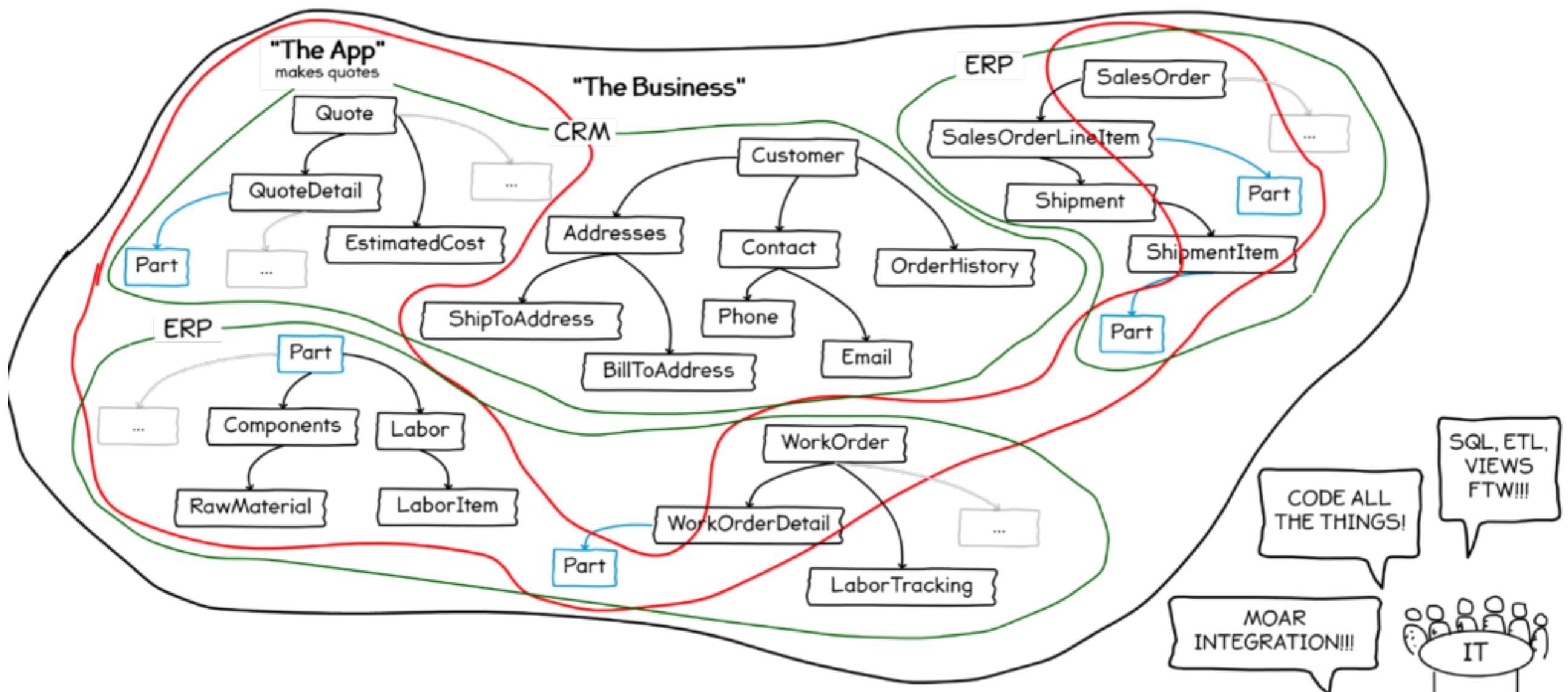


More features ...





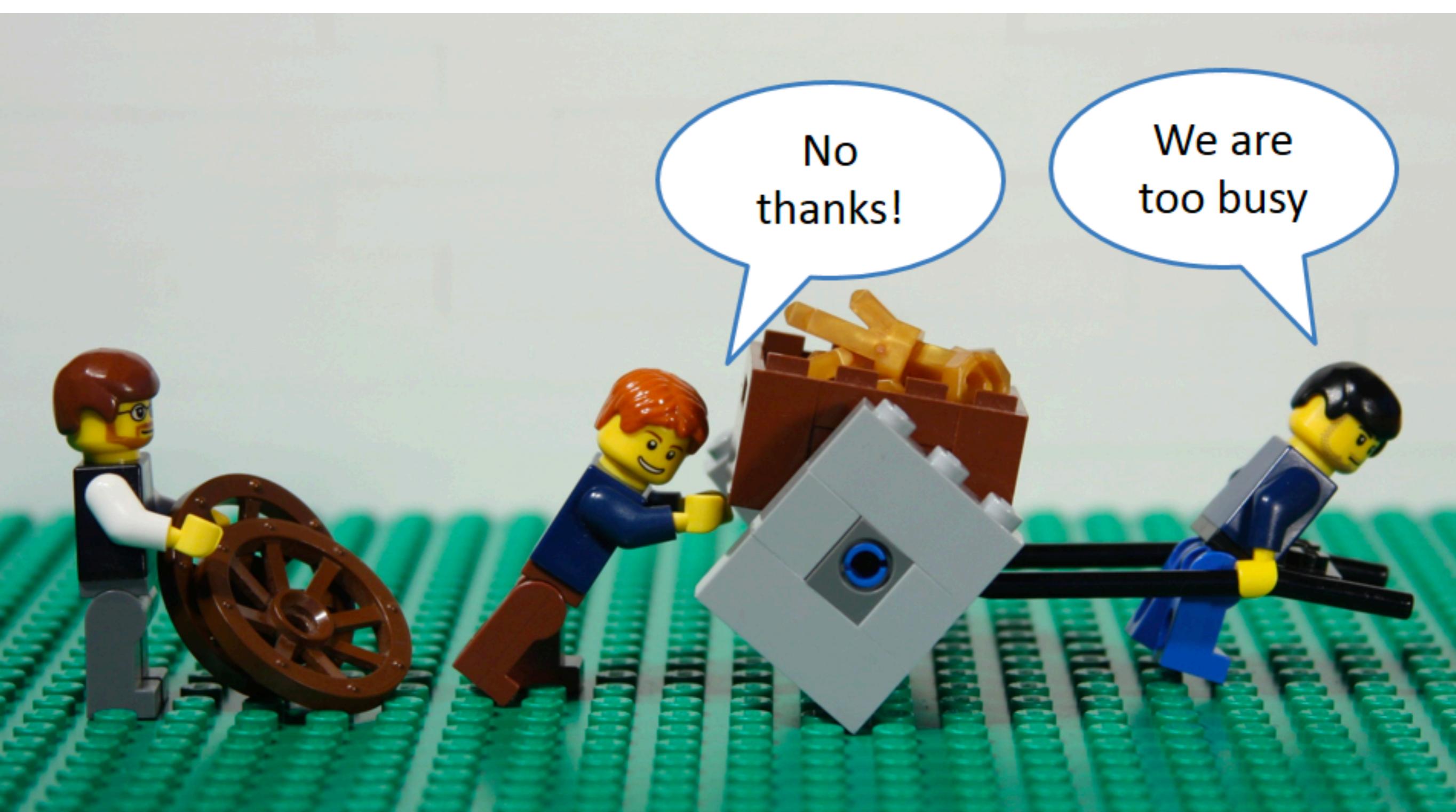
Monolith Hell



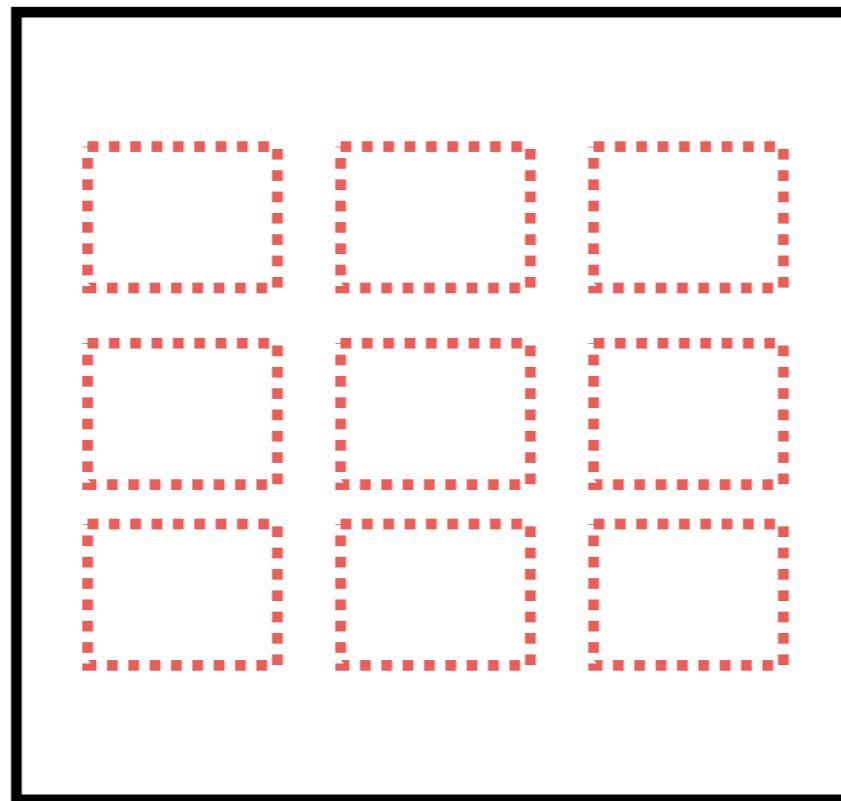
We need to improve

We need to get better

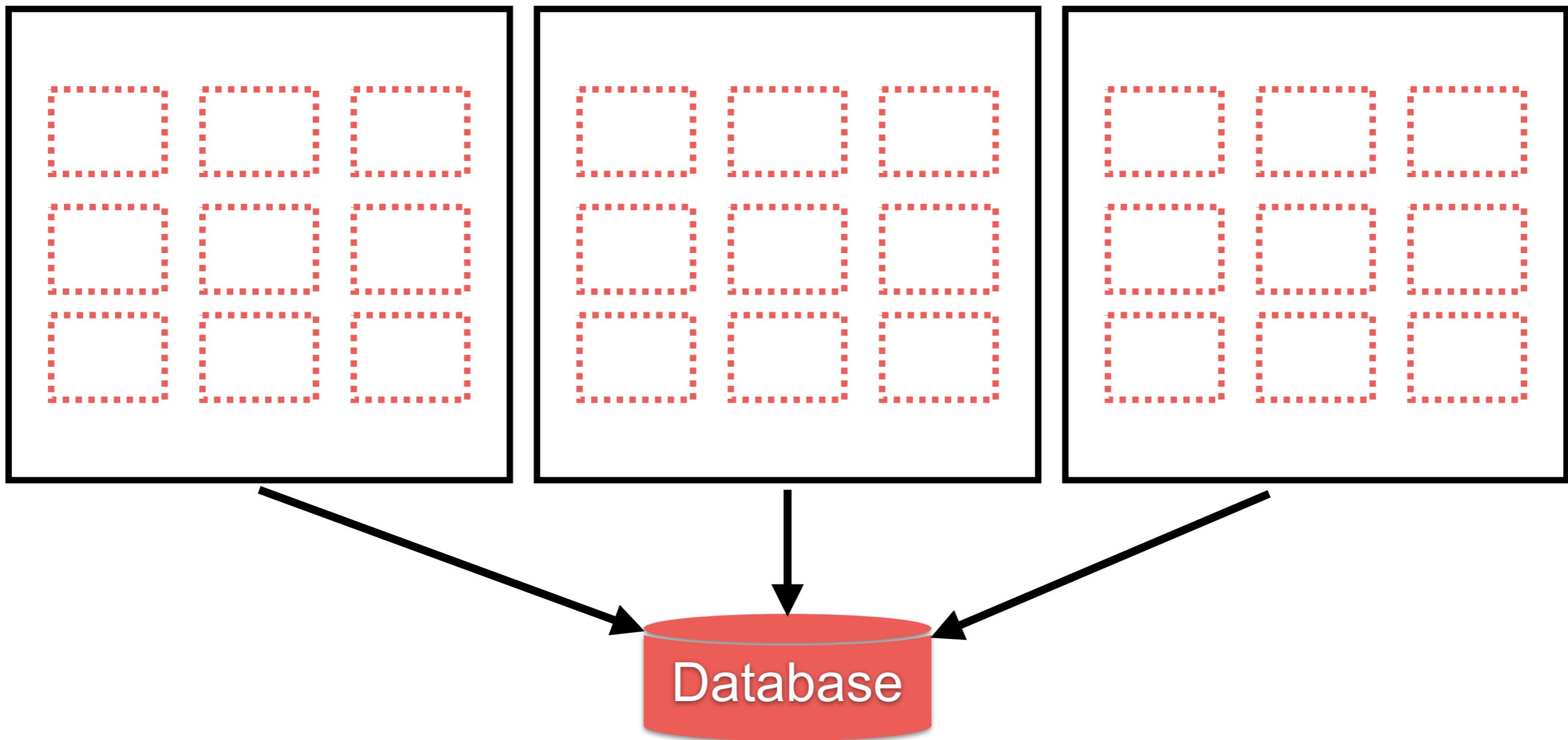




Modules



How to scale ?



What happens when we need more servers ?



What if we don't use all modules equally ?



How can we update individual models/database ?



Do all modules need to use the same Database, Language and Runtime ... ?



We need to improve

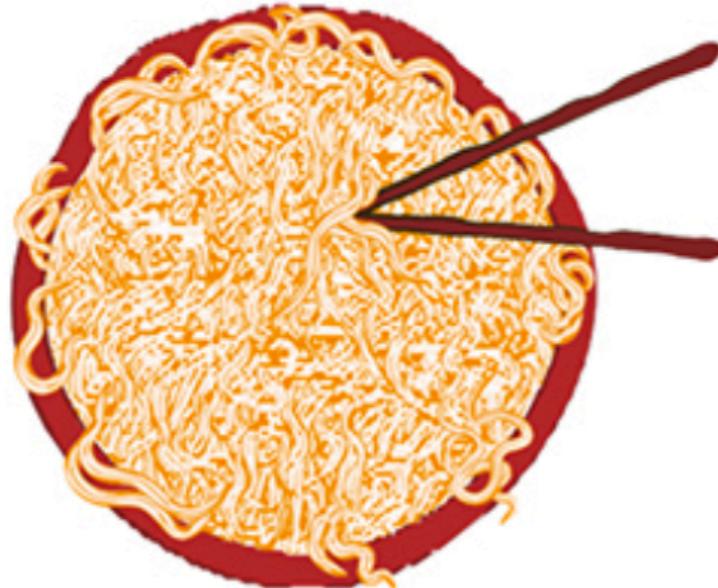
We need to get better



SOA

1990s and earlier

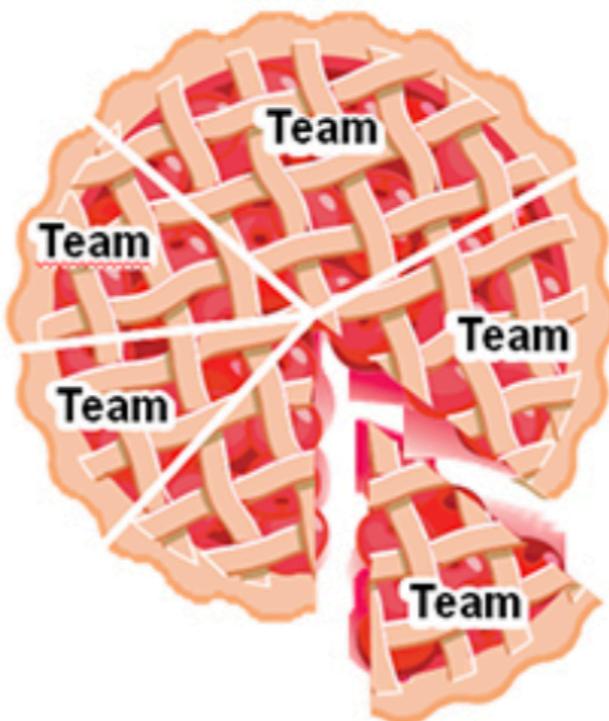
Pre-SOA (monolithic)
Tight coupling



For a monolith to change, all must agree on each change. Each change has unanticipated effects requiring careful testing beforehand.

2000s

Traditional SOA
Looser coupling



Elements in SOA are developed more autonomously but must be coordinated with others to fit into the overall design.

2010s

Microservices
Decoupled



Developers can create and activate new microservices without prior coordination with others. Their adherence to MSA principles makes continuous delivery of new or modified services possible.



Service-Oriented Architecture

SOA Manifesto

Service orientation is a paradigm that frames what you do.
Service-oriented architecture (SOA) is a type of architecture
that results from applying service orientation.

We have been applying service orientation to help organizations
consistently deliver sustainable business value, with increased agility
and cost effectiveness, in line with changing business needs.

<http://www.soa-manifesto.org/>



Service-Oriented Architecture

Through our work we have come to prioritize:

Business value over technical strategy

Strategic goals over project-specific benefits

Intrinsic interoperability over custom integration

Shared services over specific-purpose implementations

Flexibility over optimization

Evolutionary refinement over pursuit of initial perfection

<http://www.soa-manifesto.org/>



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Microservices

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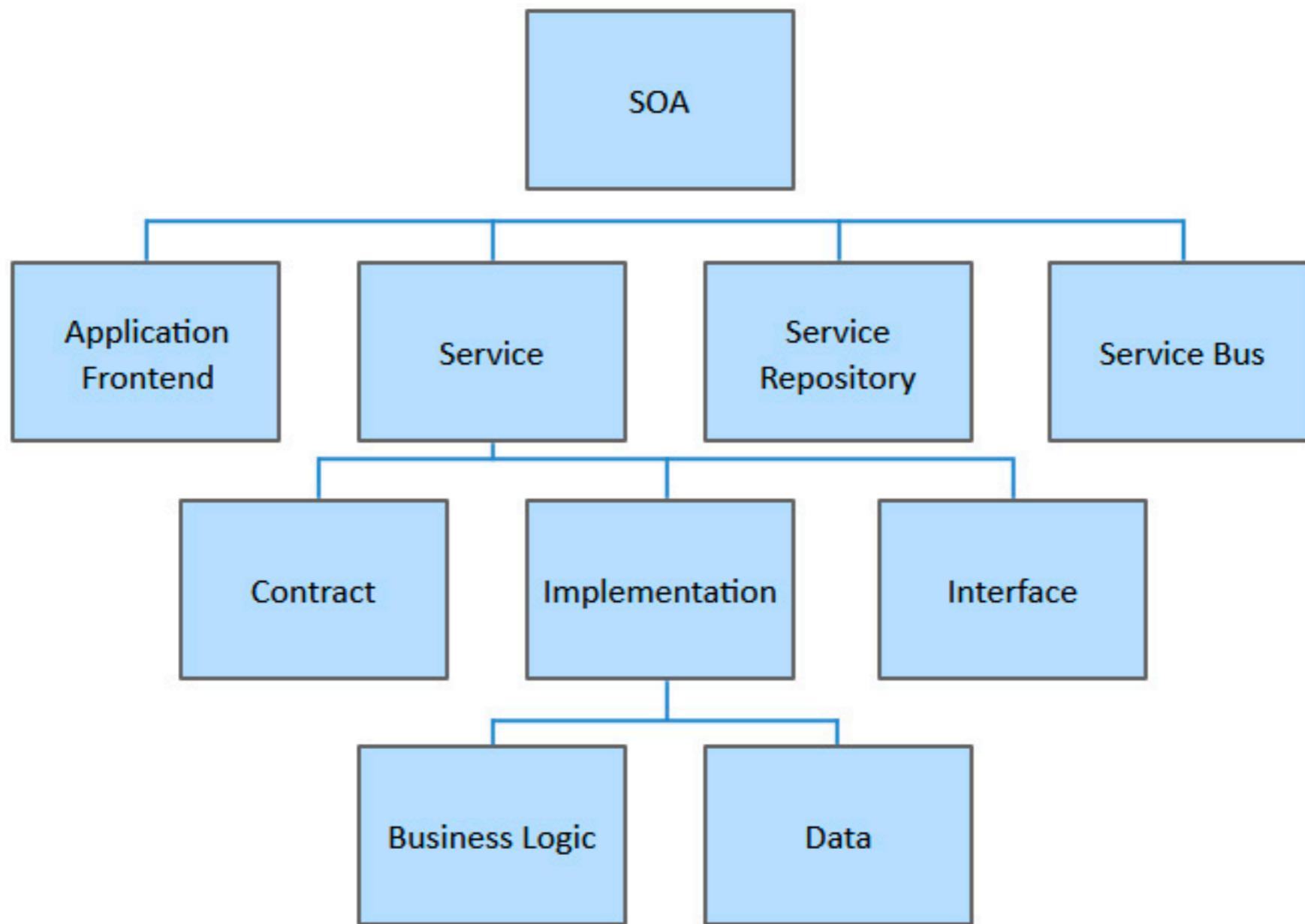
Flexibility over optimization

Evolutionary refinement over pursuit of initial perfection

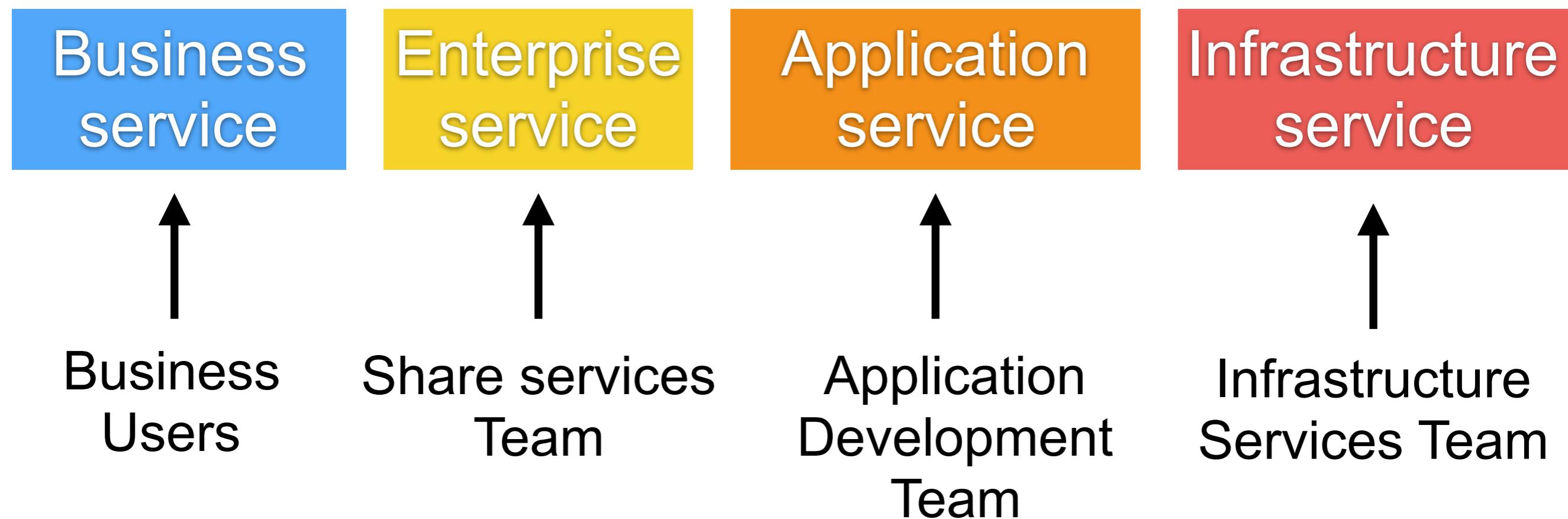
<http://www.soa-manifesto.org/>



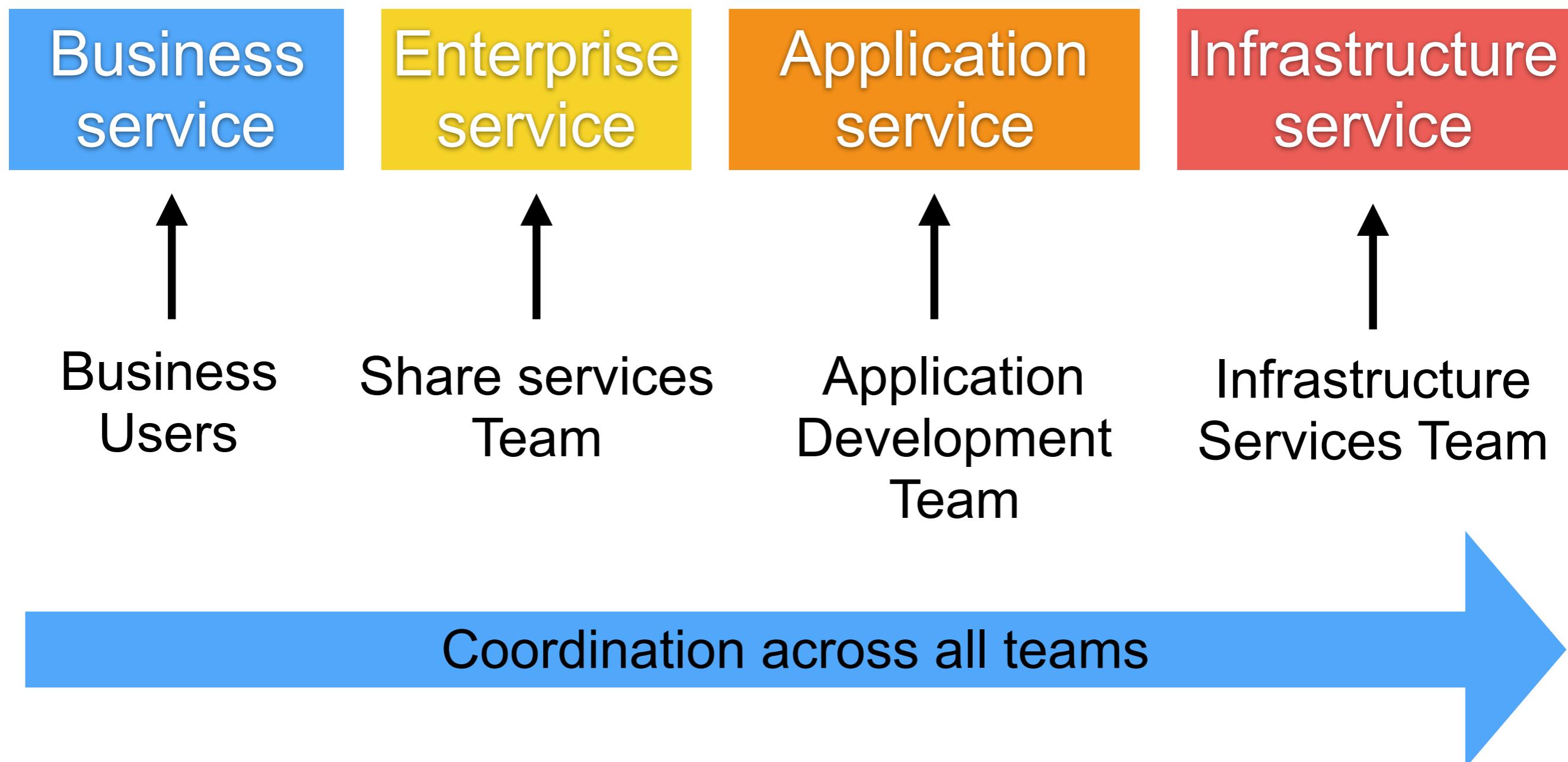
Service-Oriented Architecture



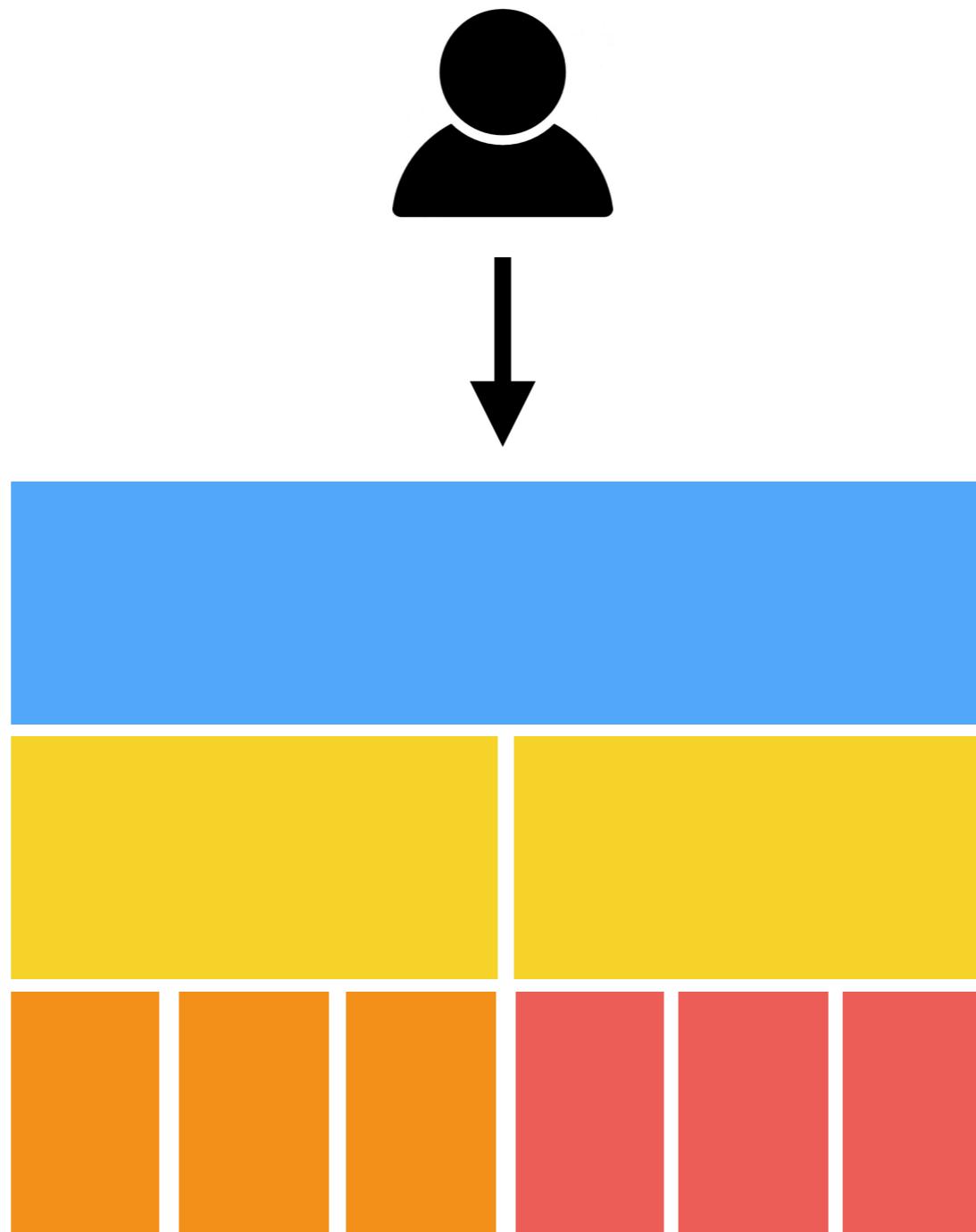
Service-Oriented Architecture



Service-Oriented Architecture



Service-Oriented Architecture



SOA promise

Simpler system

Lowering integration cost

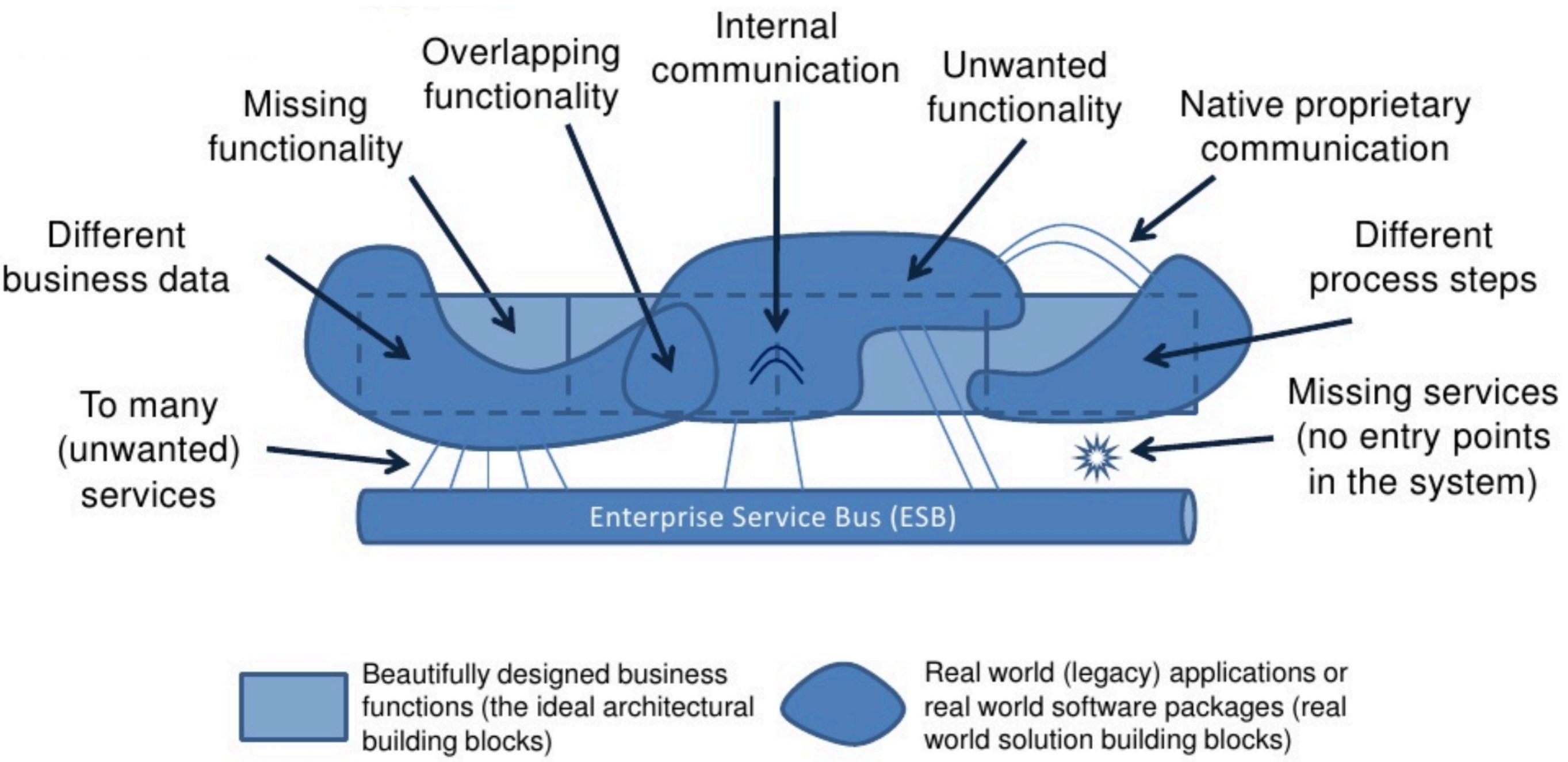
Lowering maintenance cost

Enhancing architectural flexibility

Becoming more agile



Real World



SOA promise

Simpler system

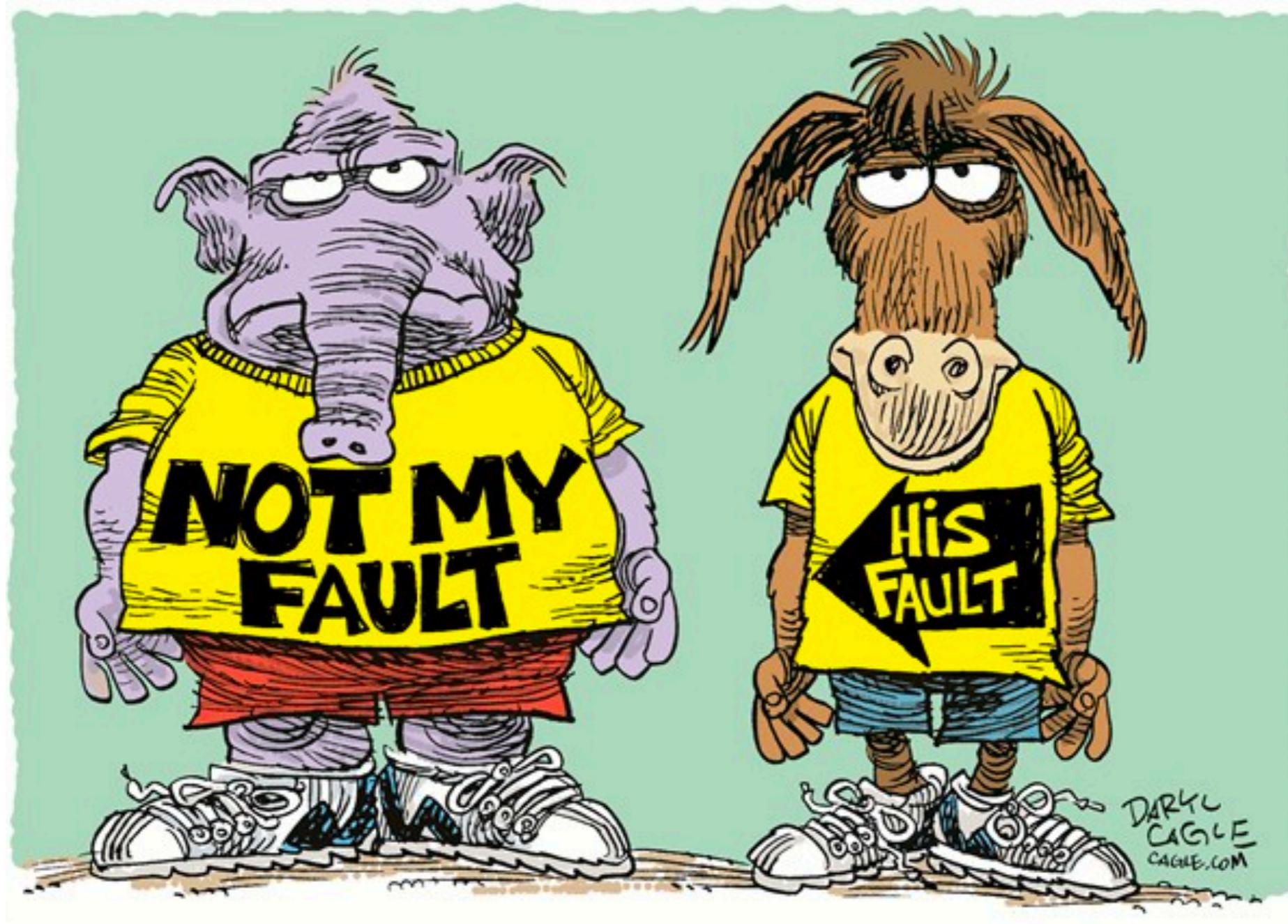
Lowering integration cost

Lowering maintenance cost

Enhancing architectural flexibility

Becoming more agile





We need to improve

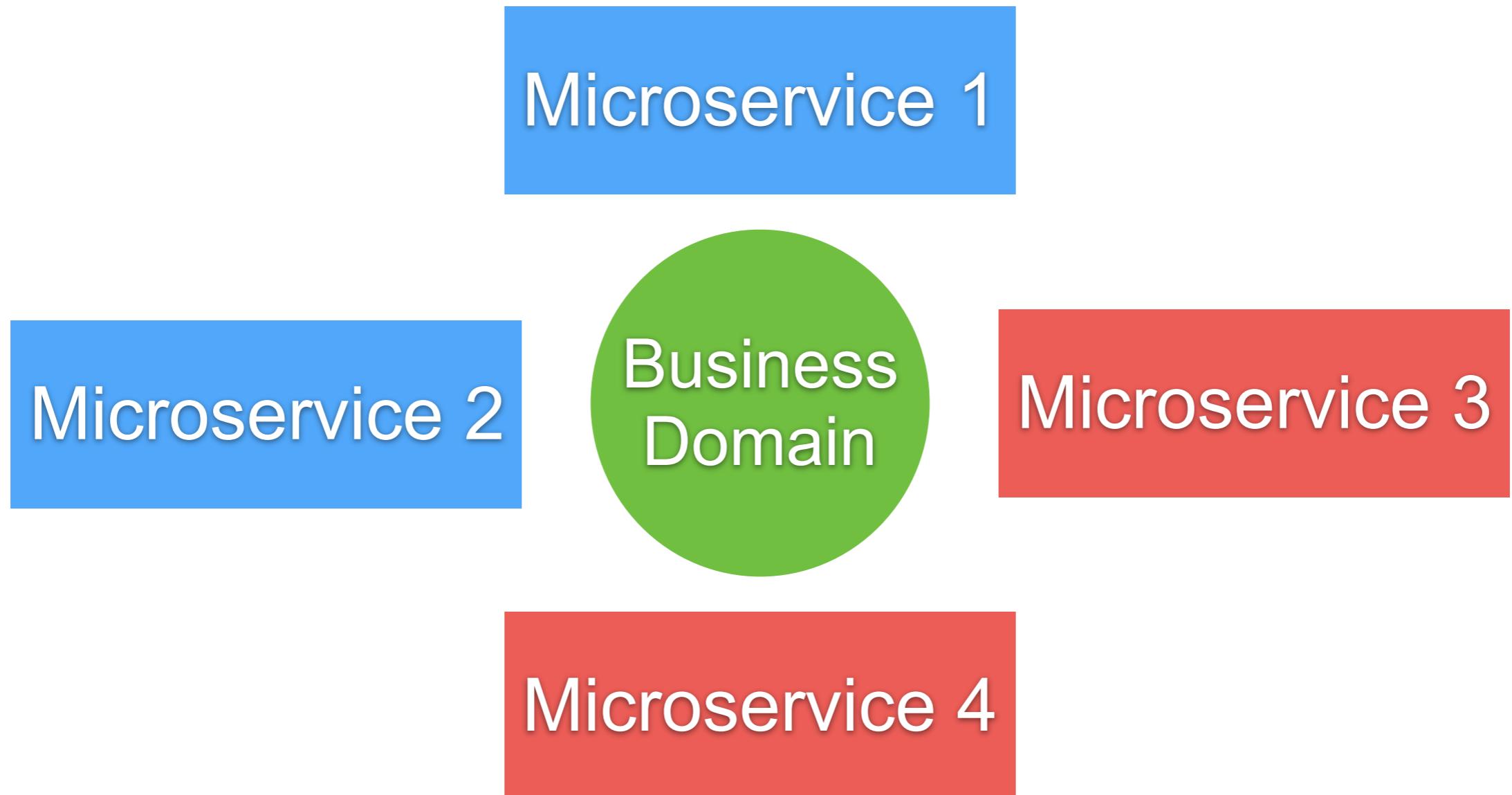
We need to get better



Microservice



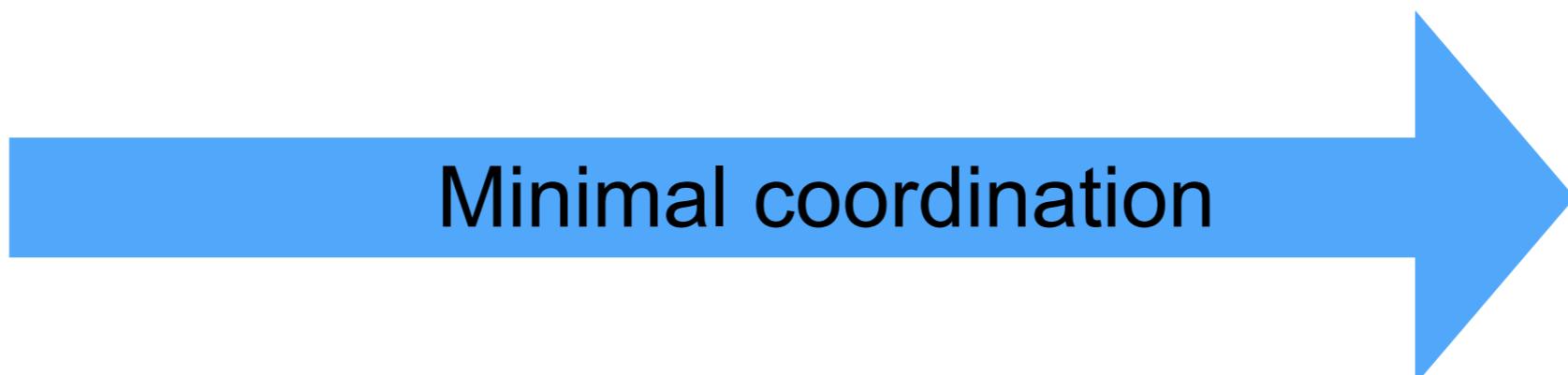
Microservice



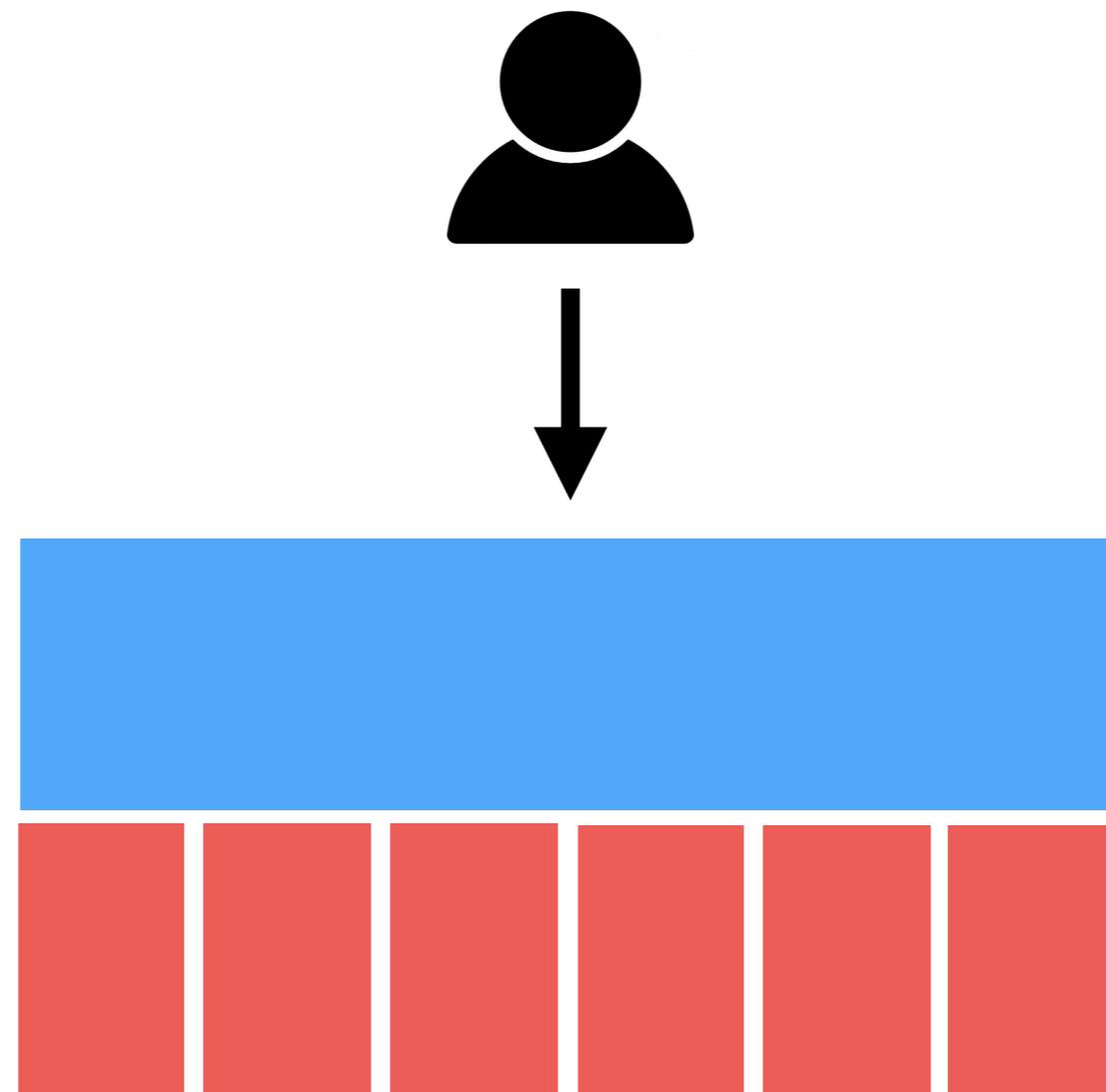
Microservice



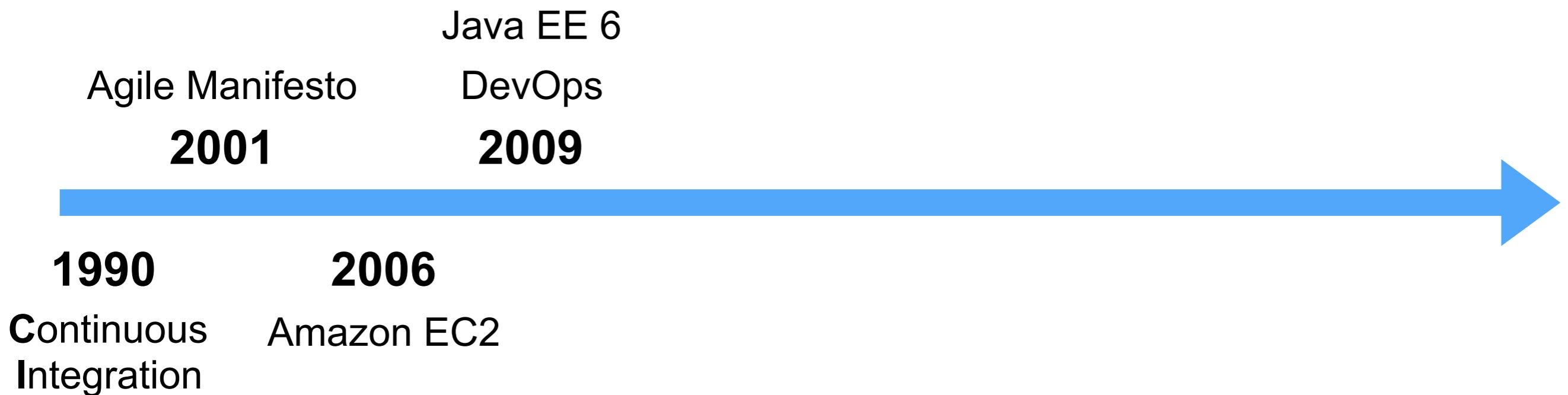
Application Development Team



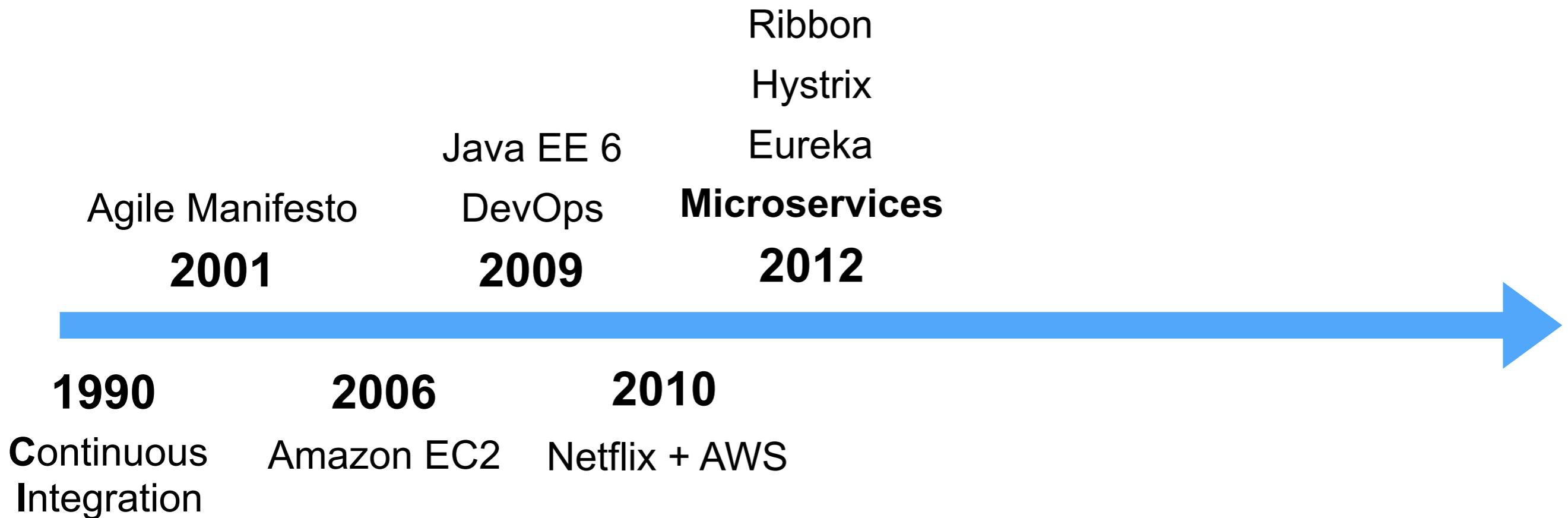
Microservice



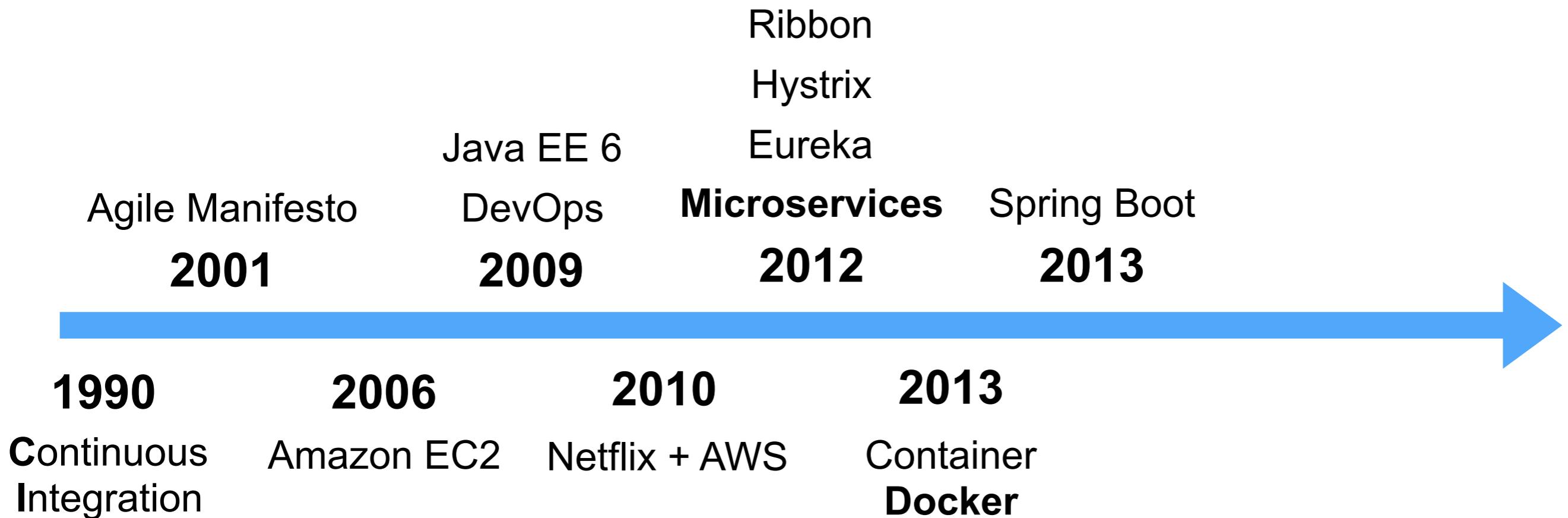
Microservice history



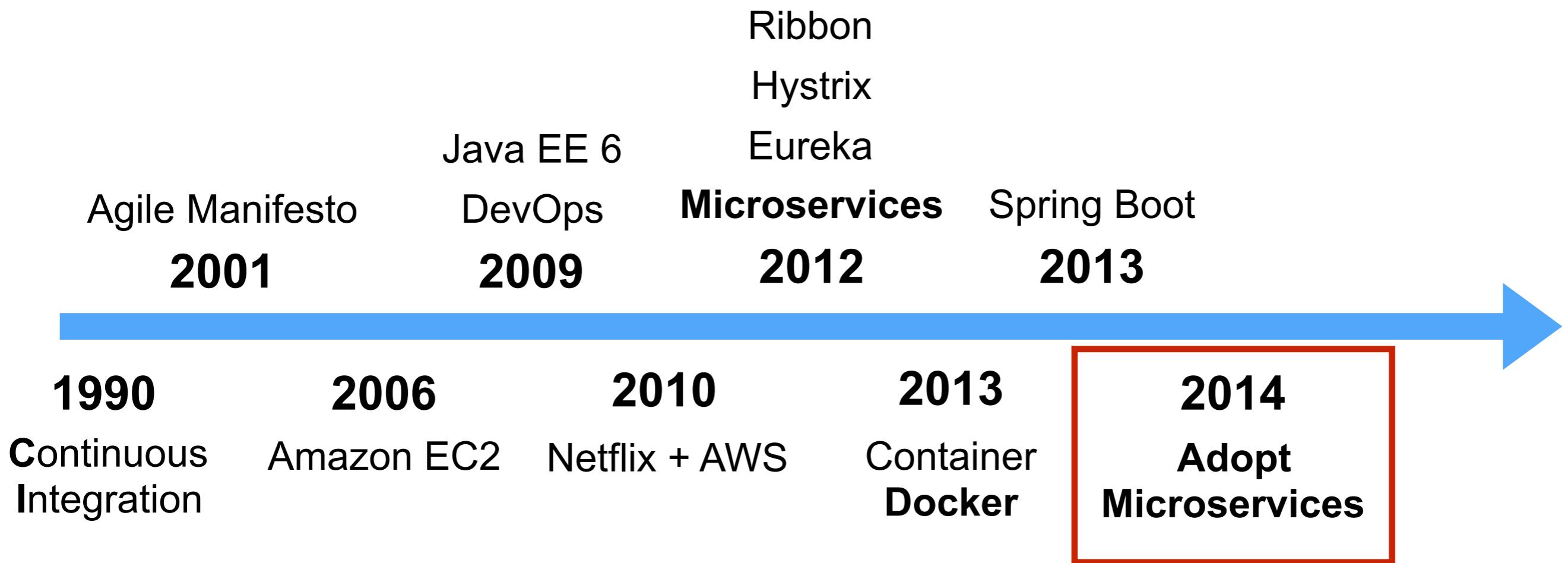
Microservice history



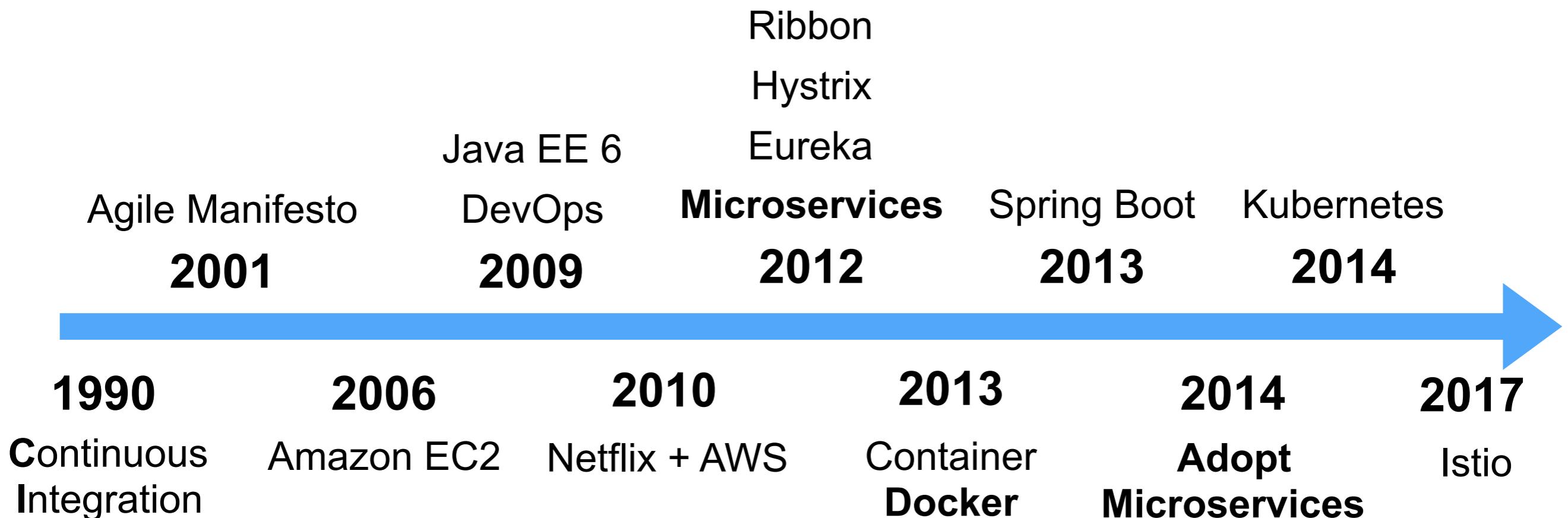
Microservice history



Microservice history



Microservice history



Microservice

Small, Do one thing (Single Responsibility)

Modular

Easy to understand

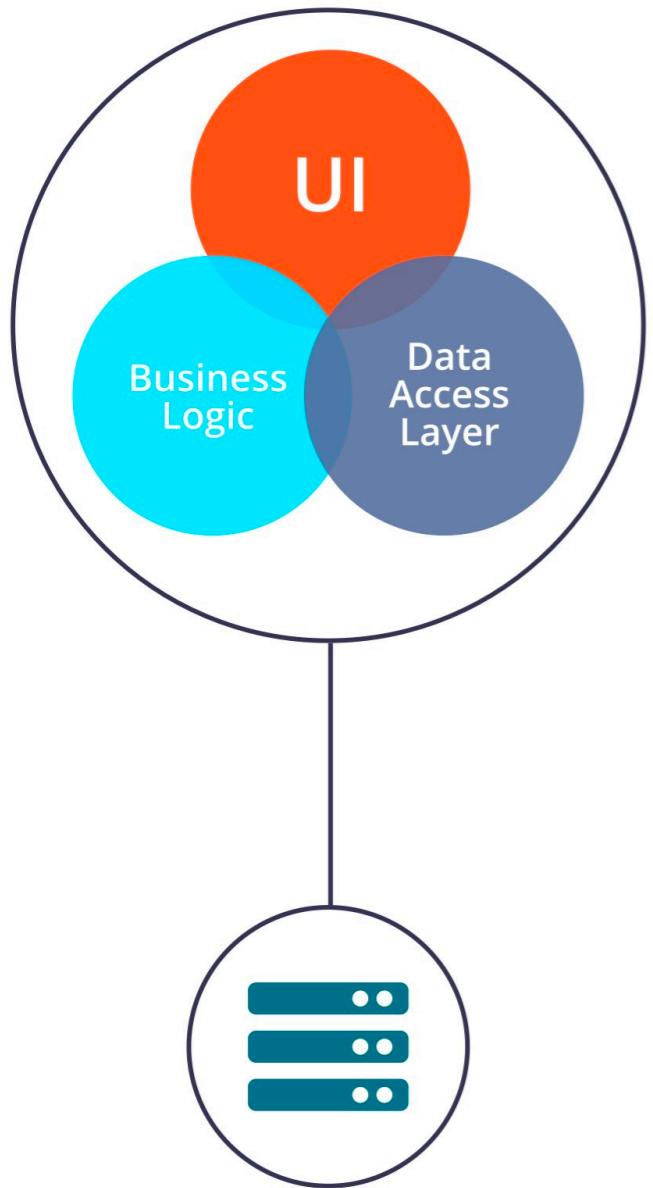
Easy to develop

Easy to deploy

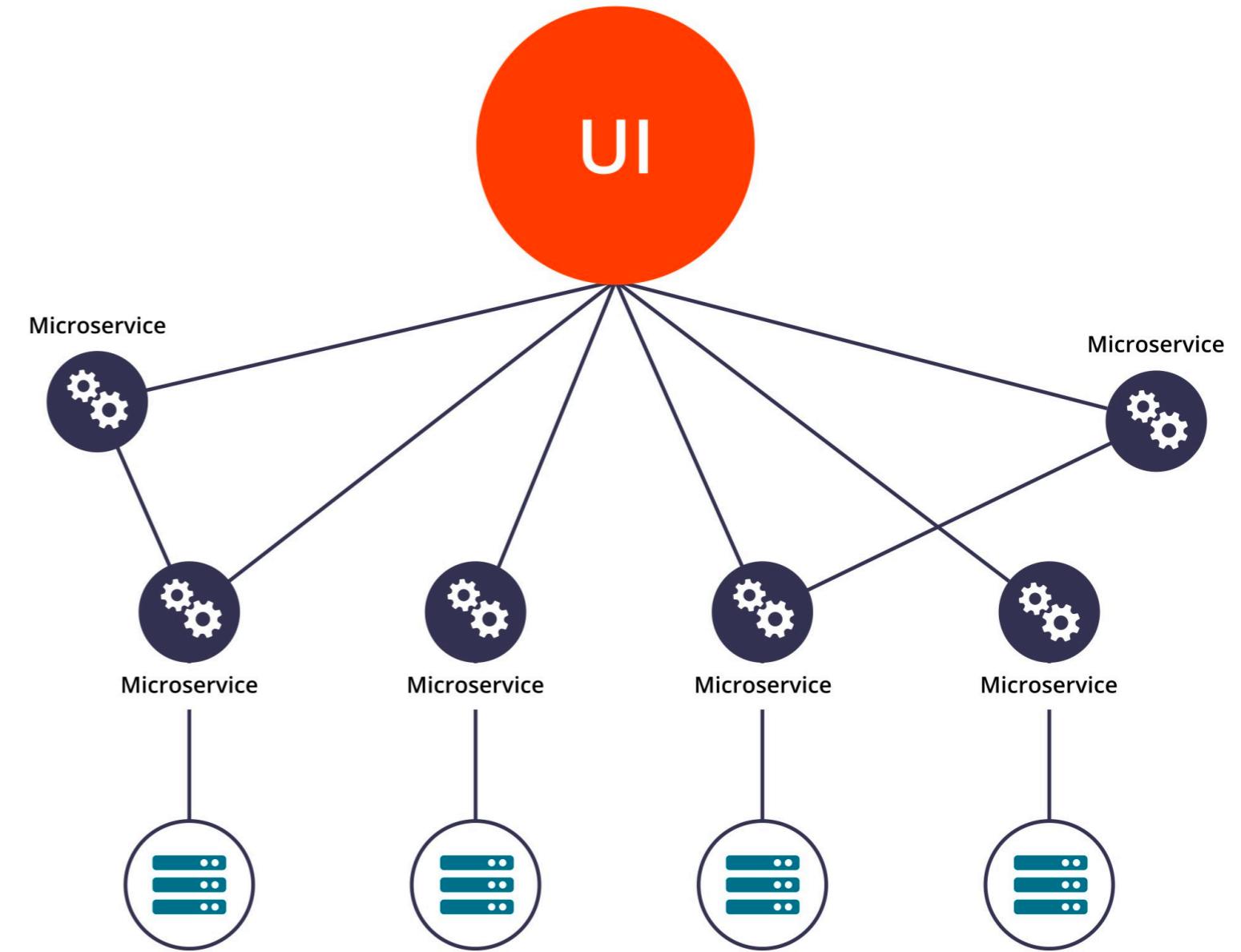
Easy to maintain

Scale independently





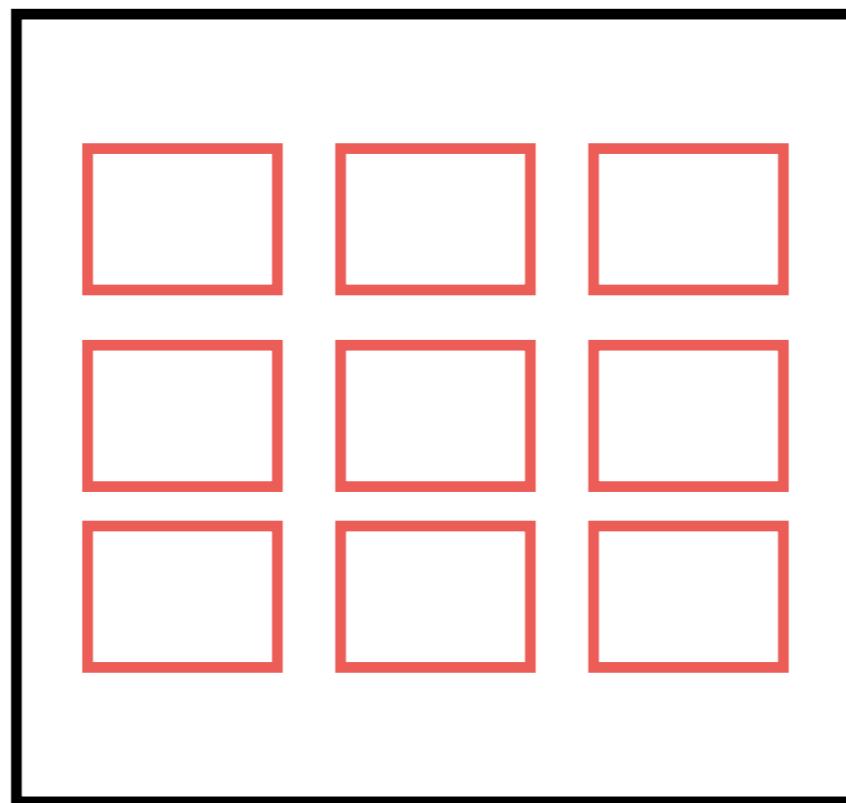
Monolithic Architecture



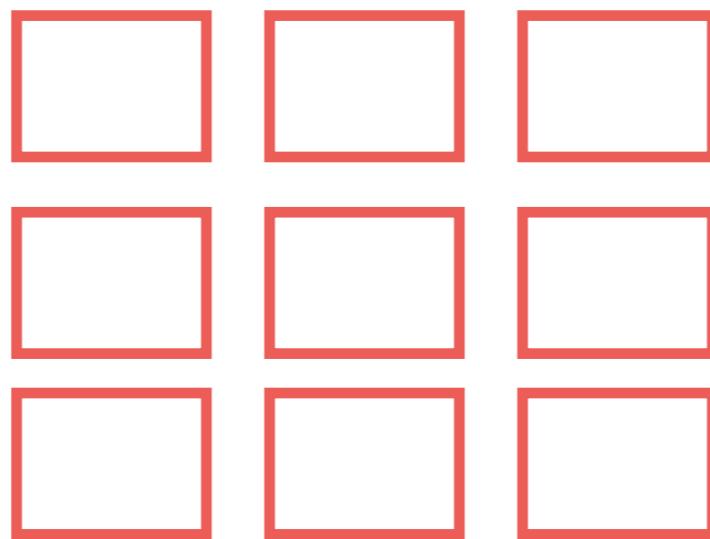
Microservice Architecture



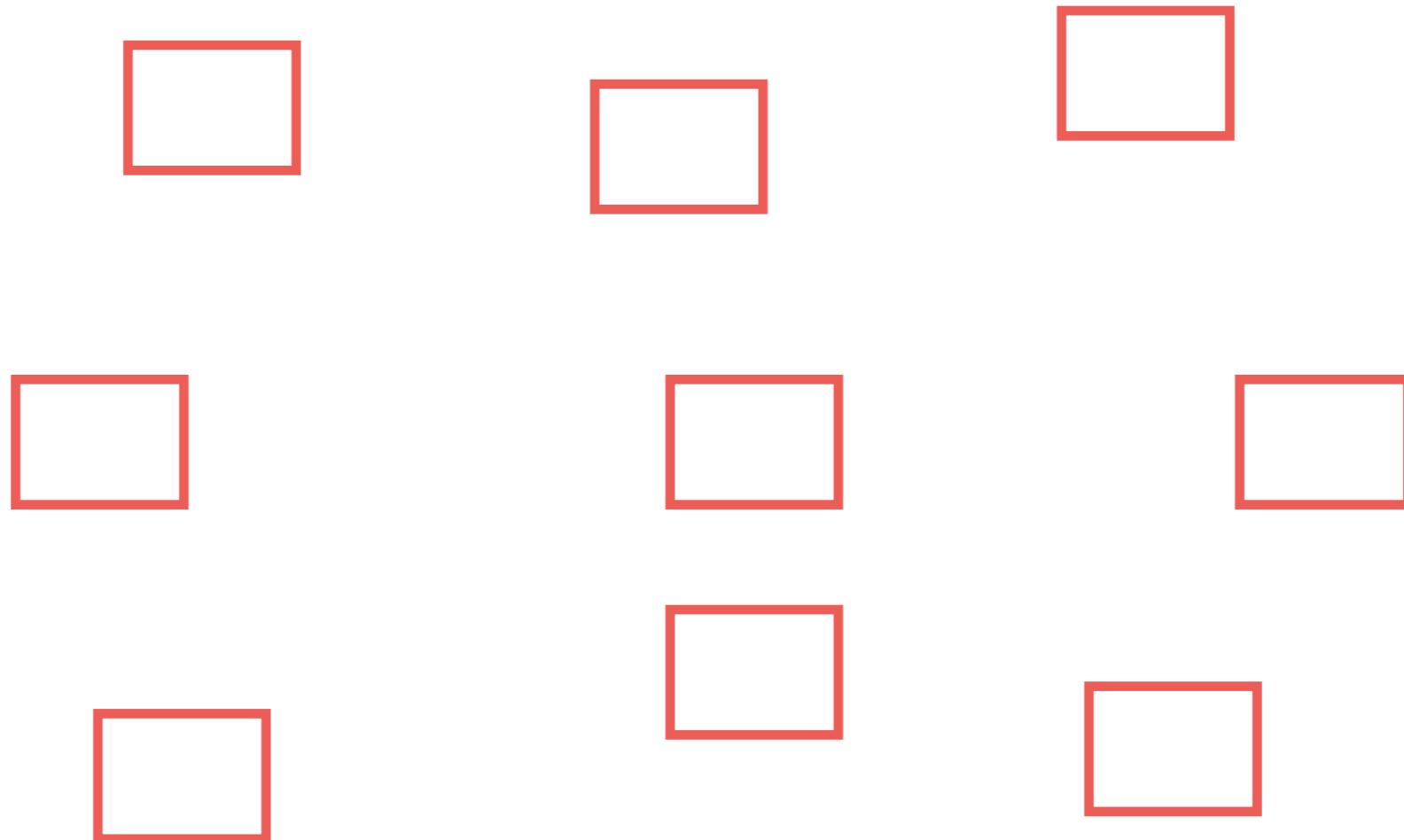
Microservice



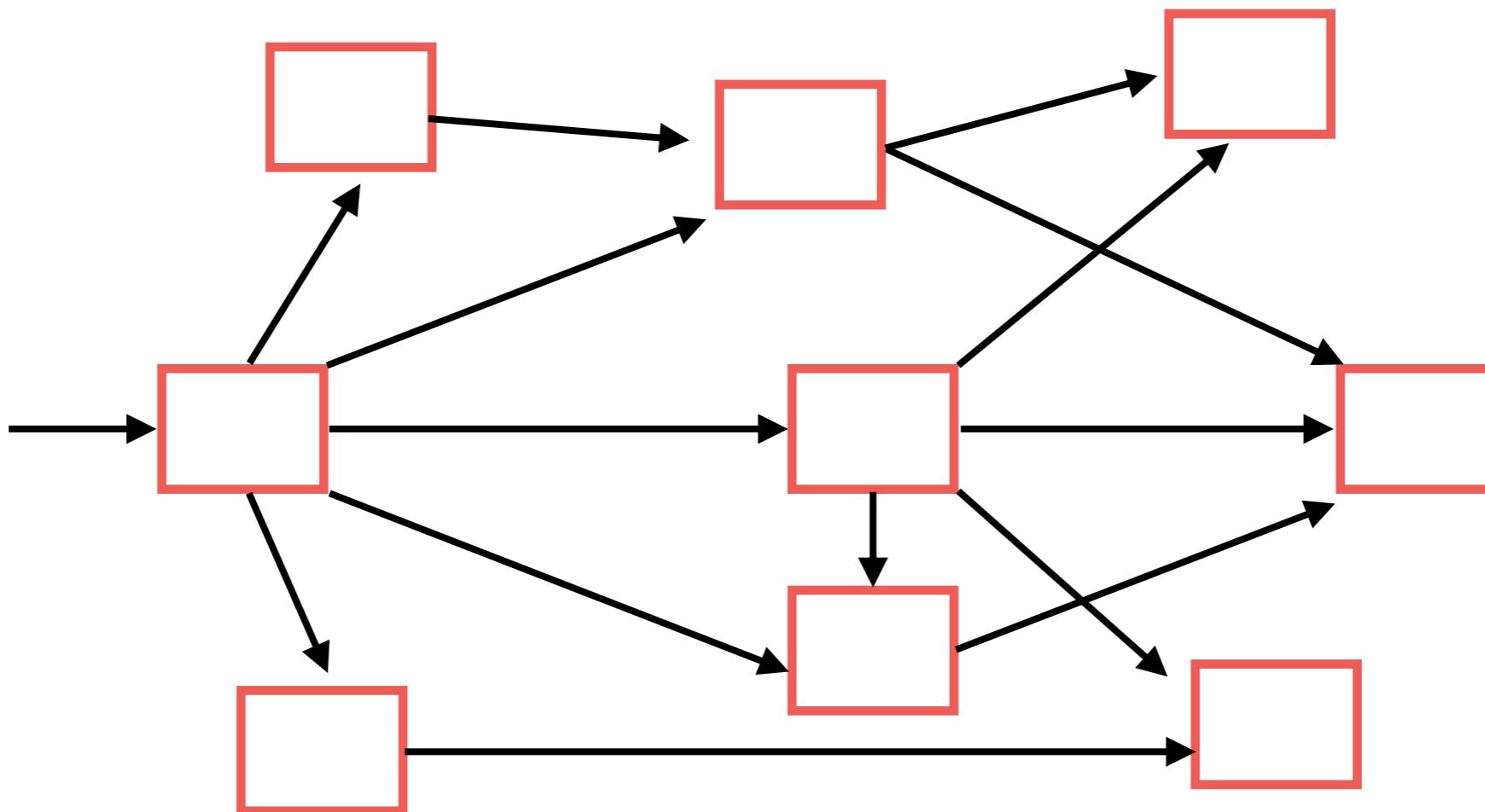
Microservice



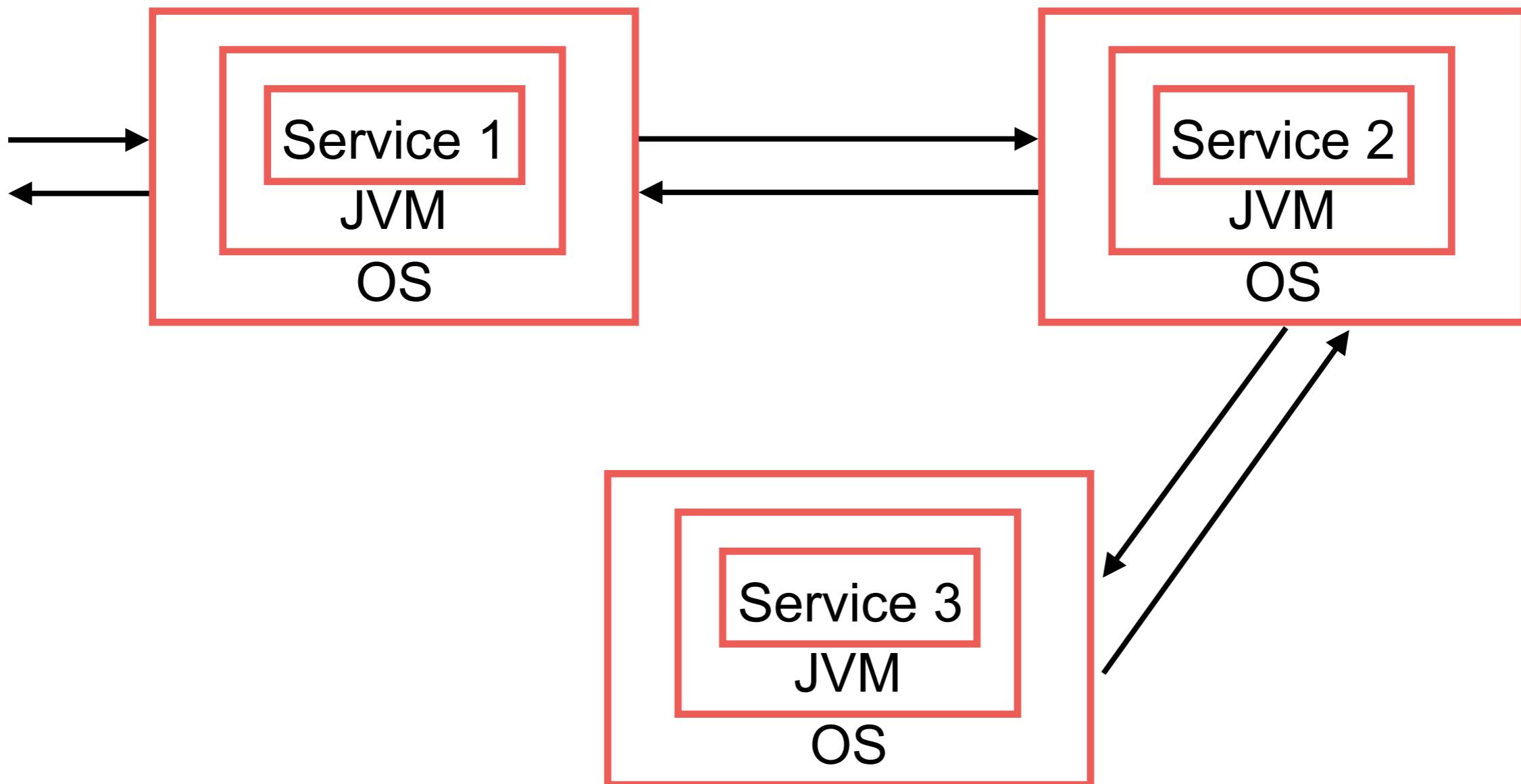
Microservice



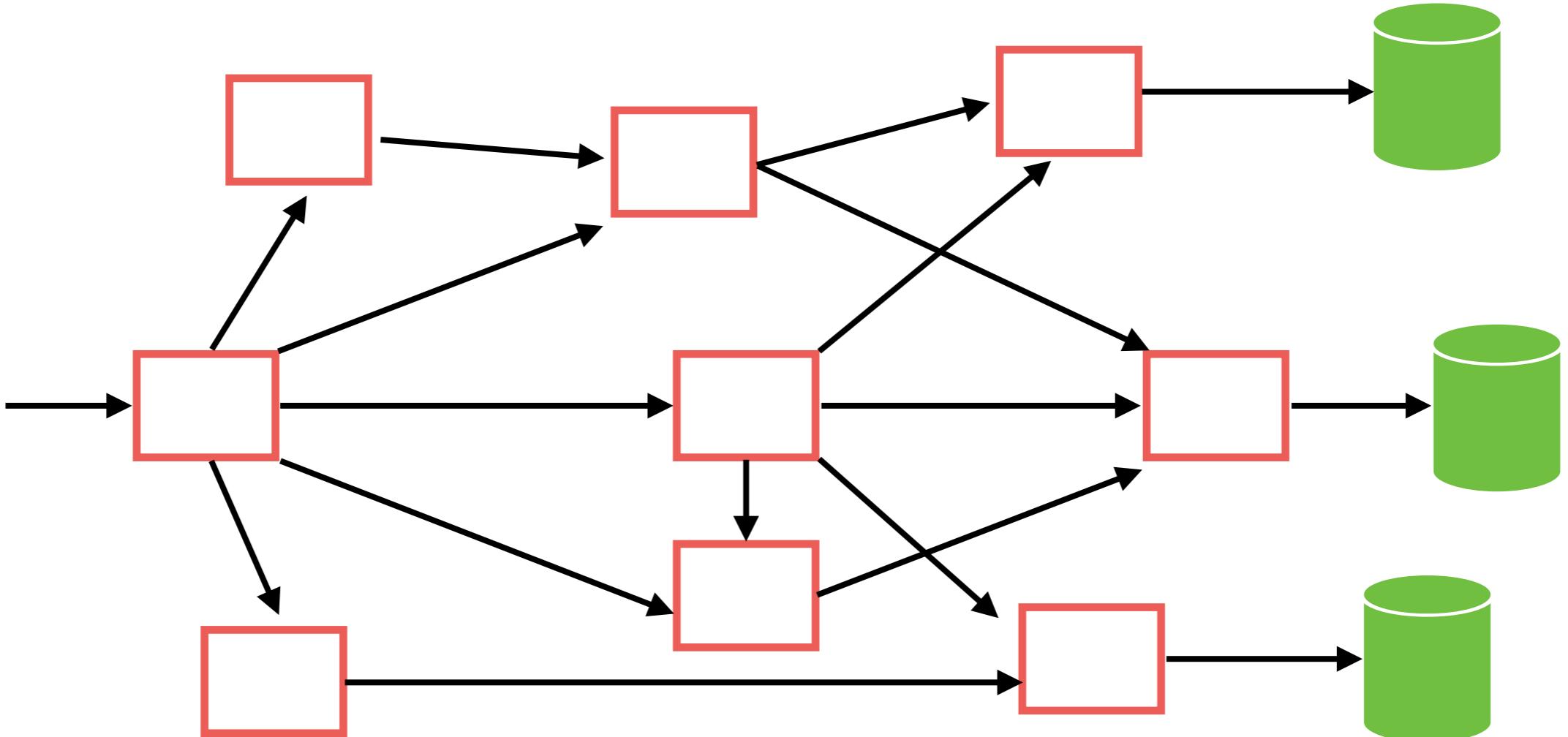
Microservice == Distributed



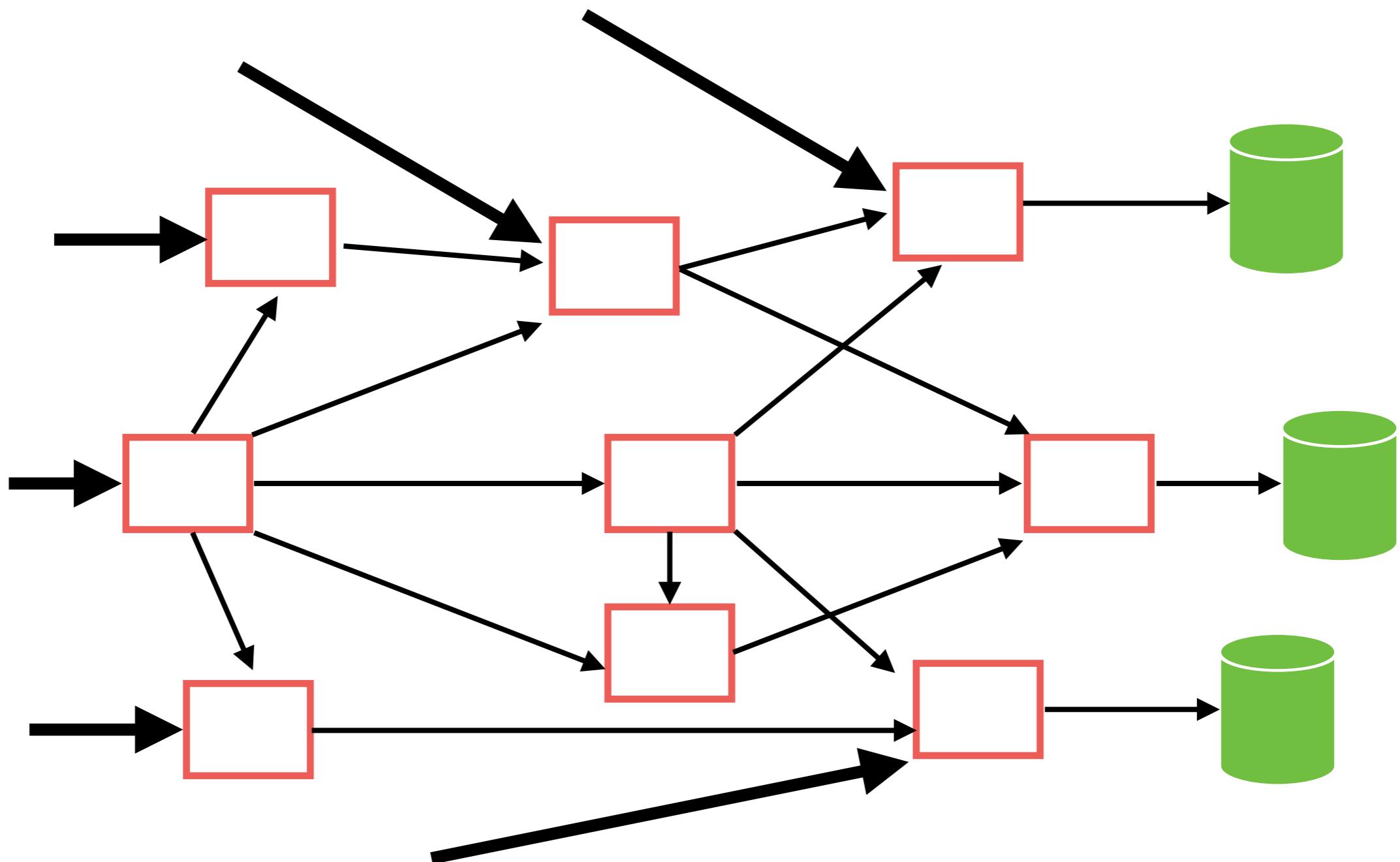
Network of services



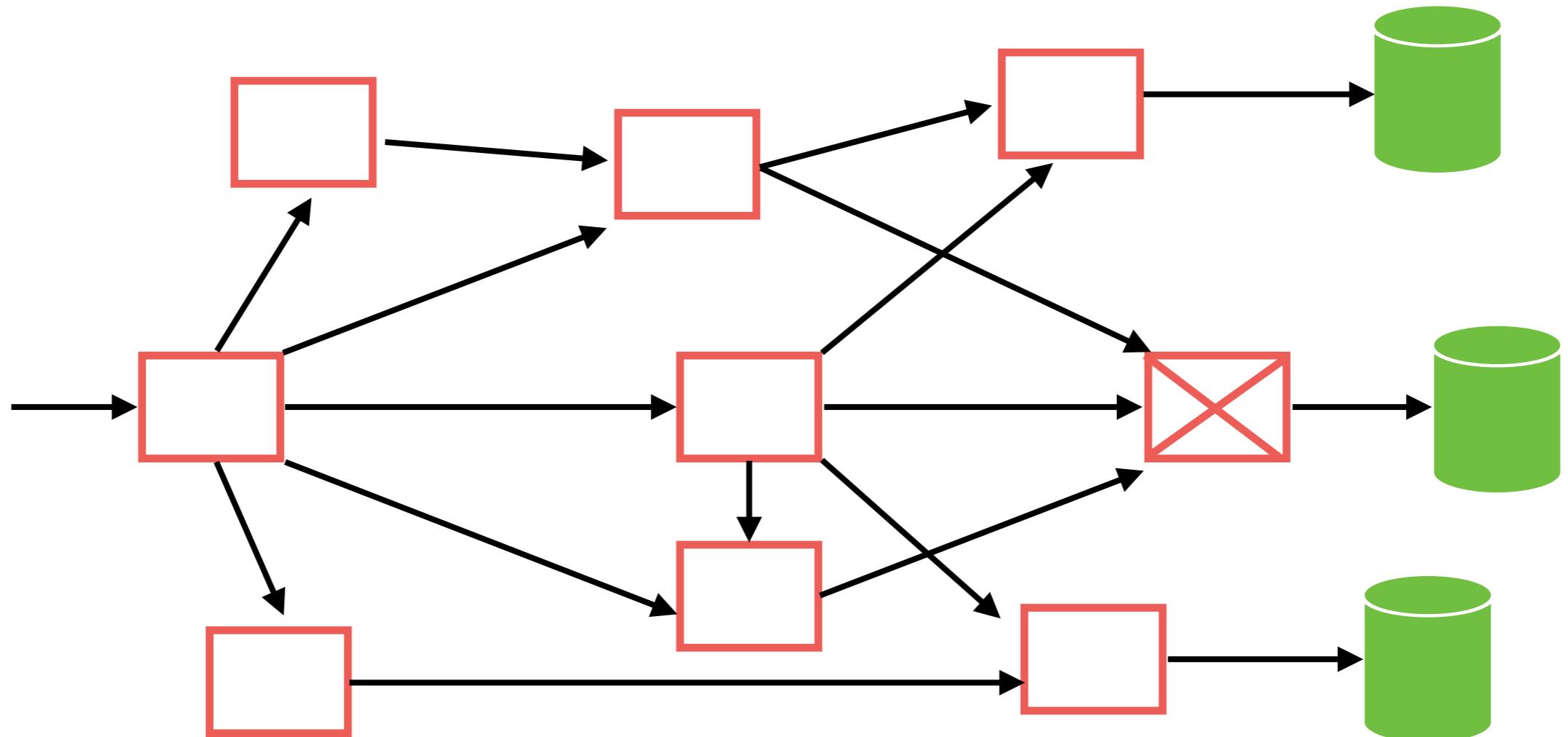
Own data



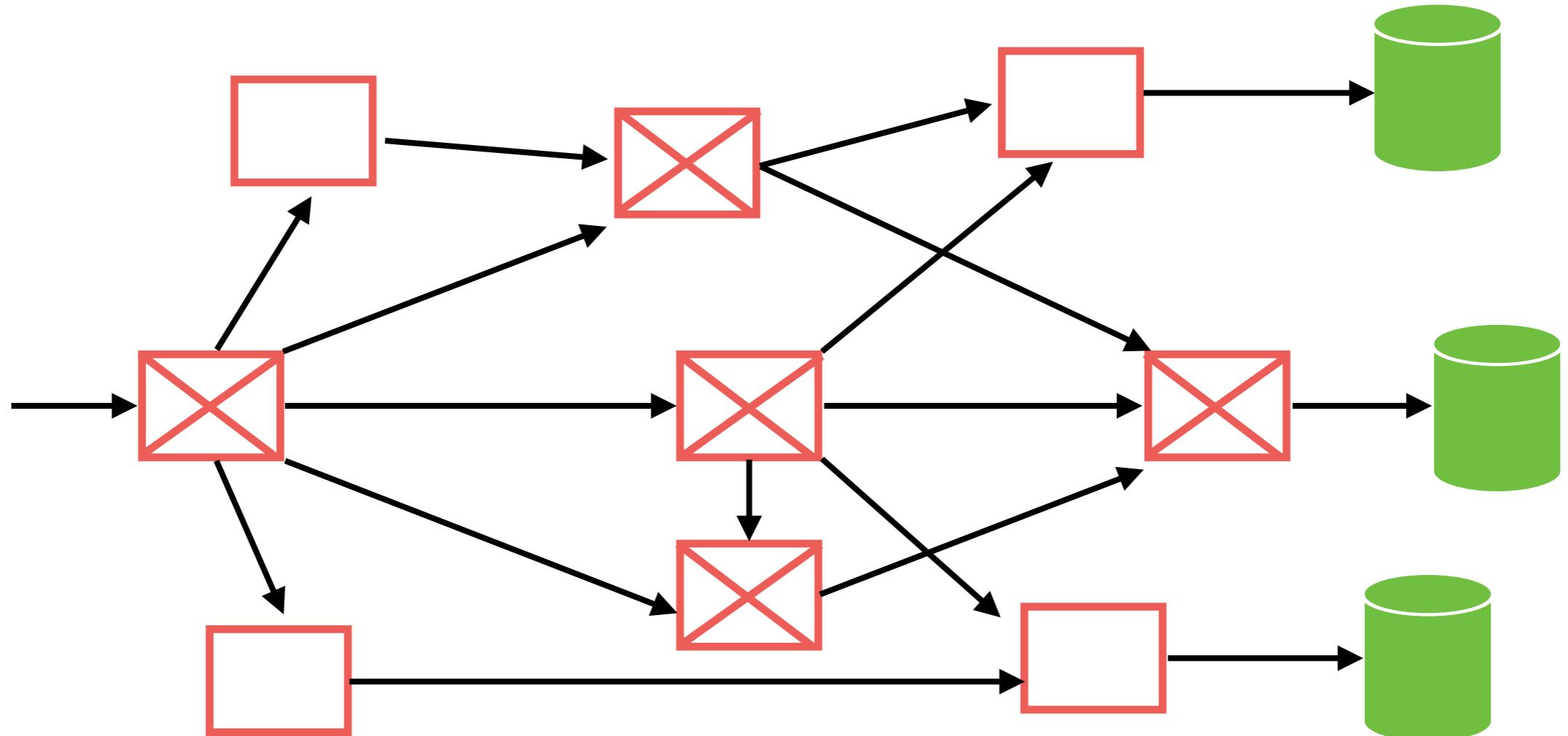
Multiple entry points



Failure !!



Cascading Failure !!

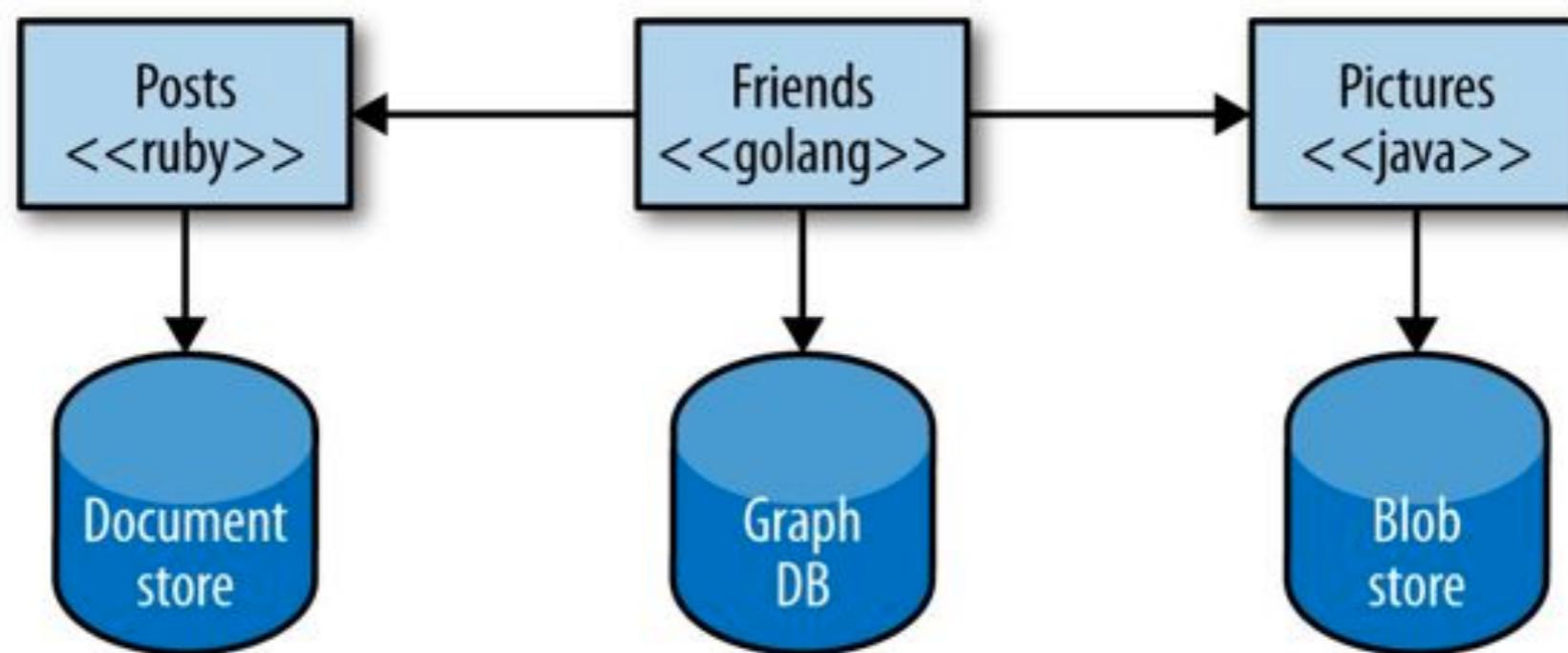


Key Benefits

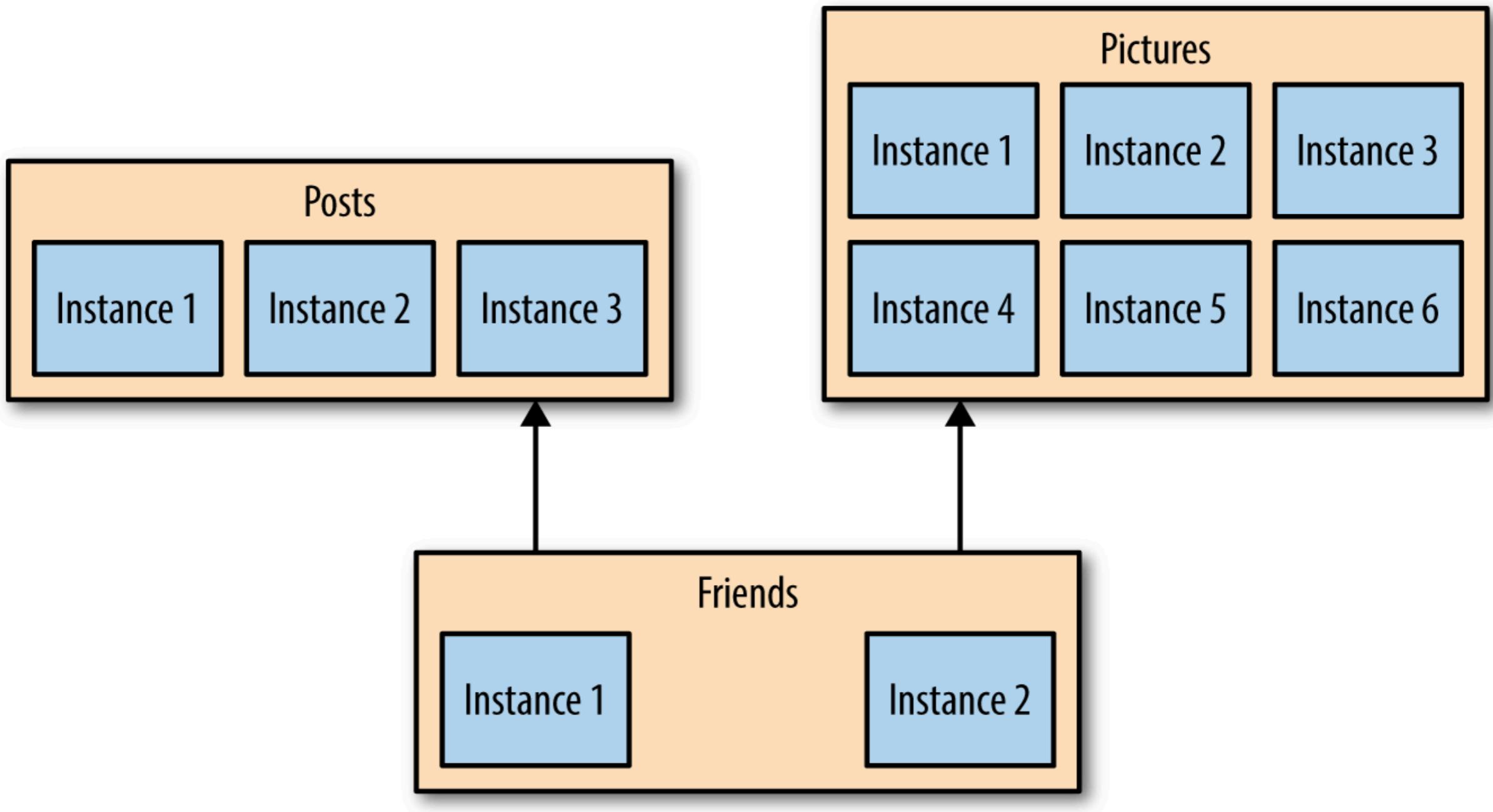


1. Technology heterogeneous

The right tool for each job
Allow easy experimenting and adoption of new technology

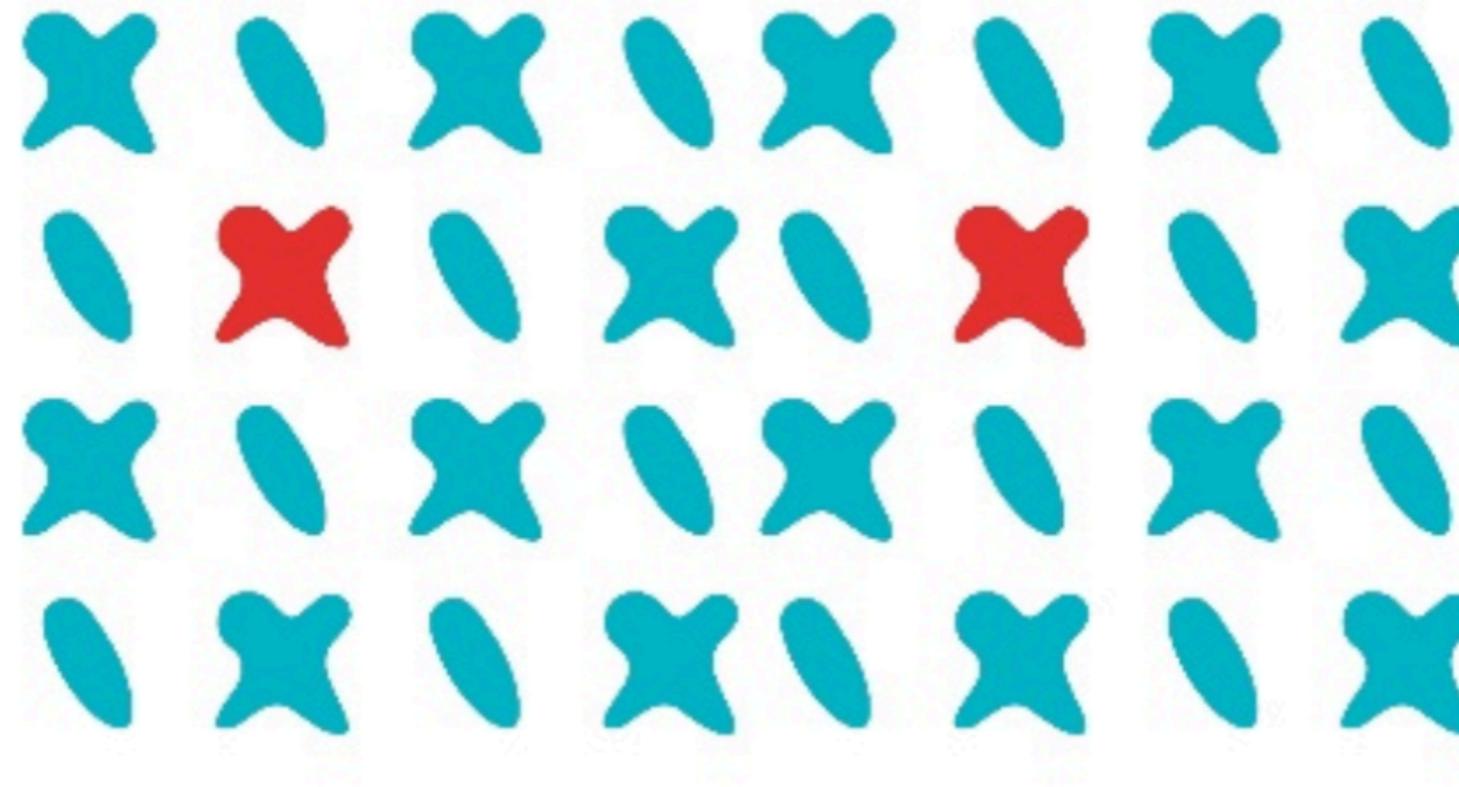


2. Scaling

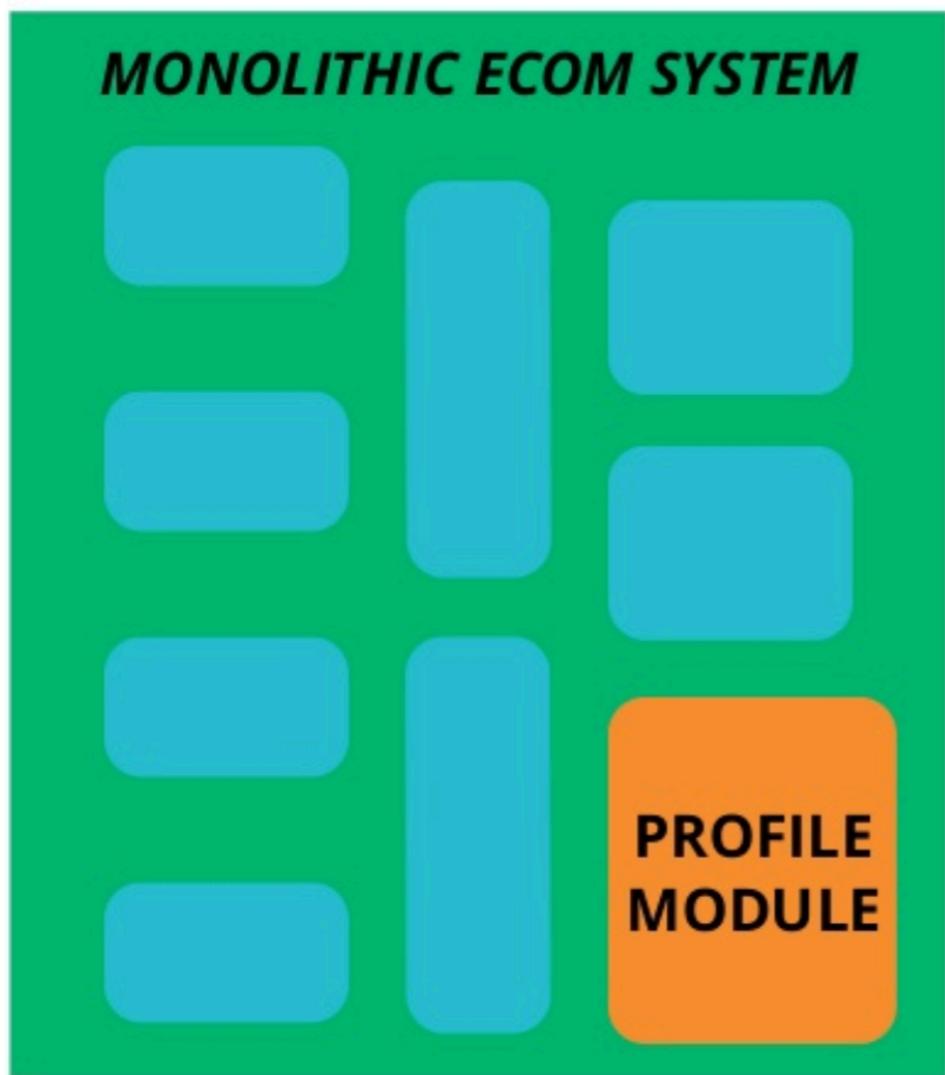


3. Ease of deployment

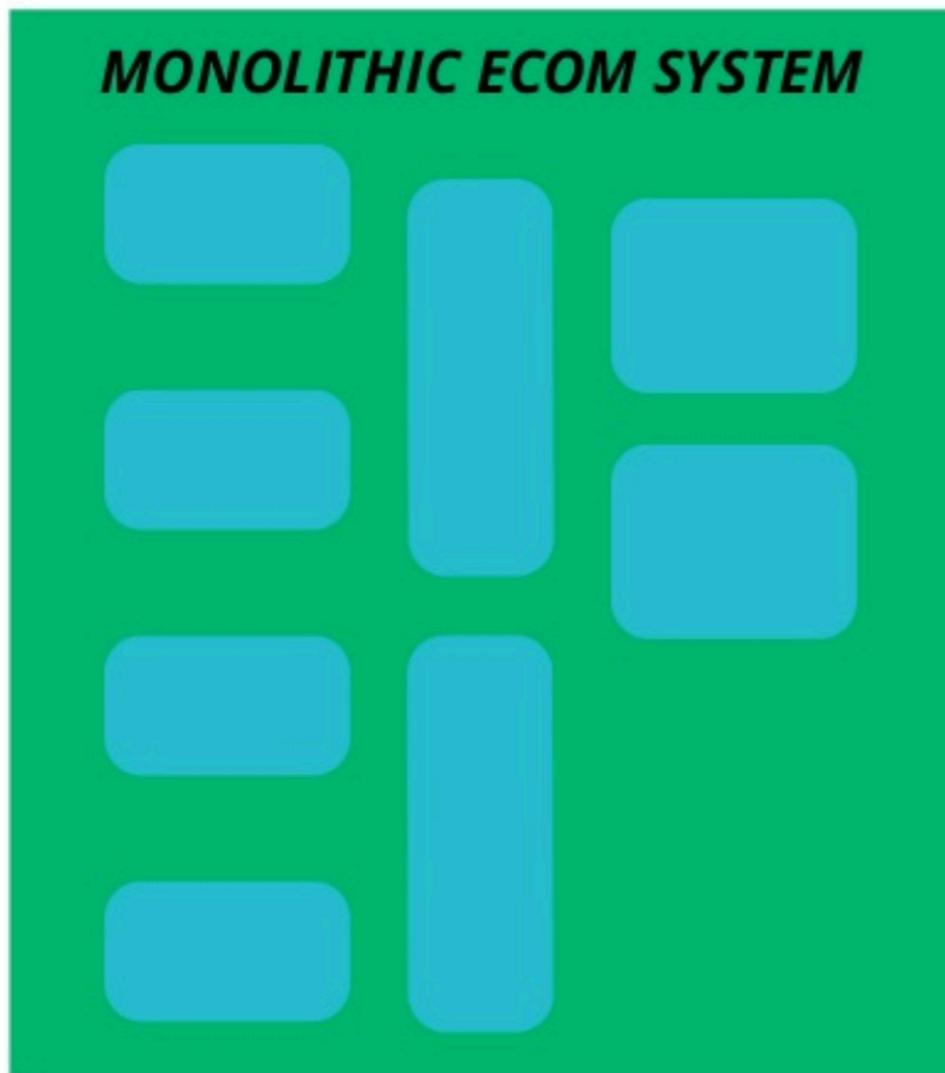
Deploys are faster, independent and problems can be isolated more easily



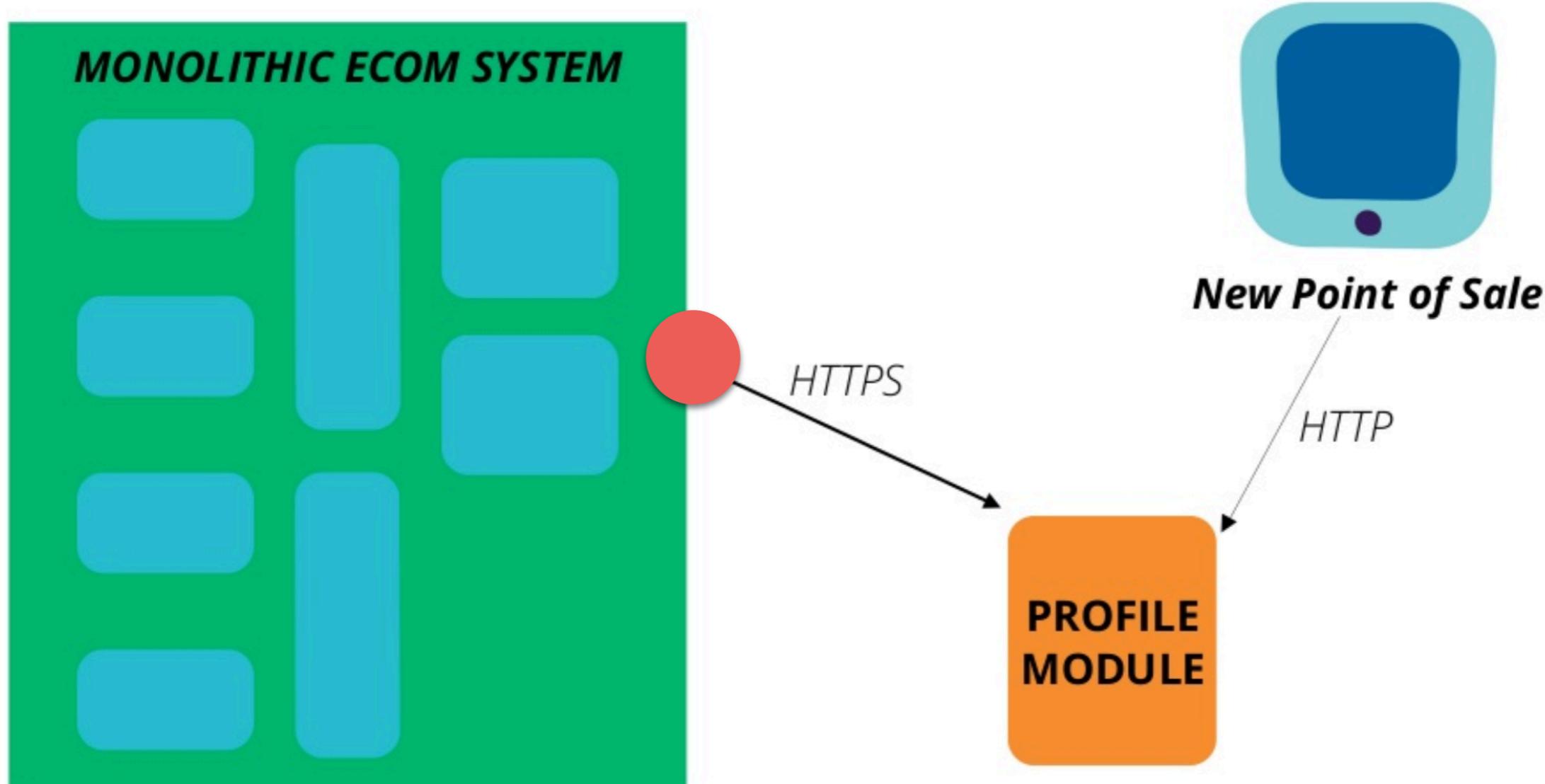
4. Composability and replaceability



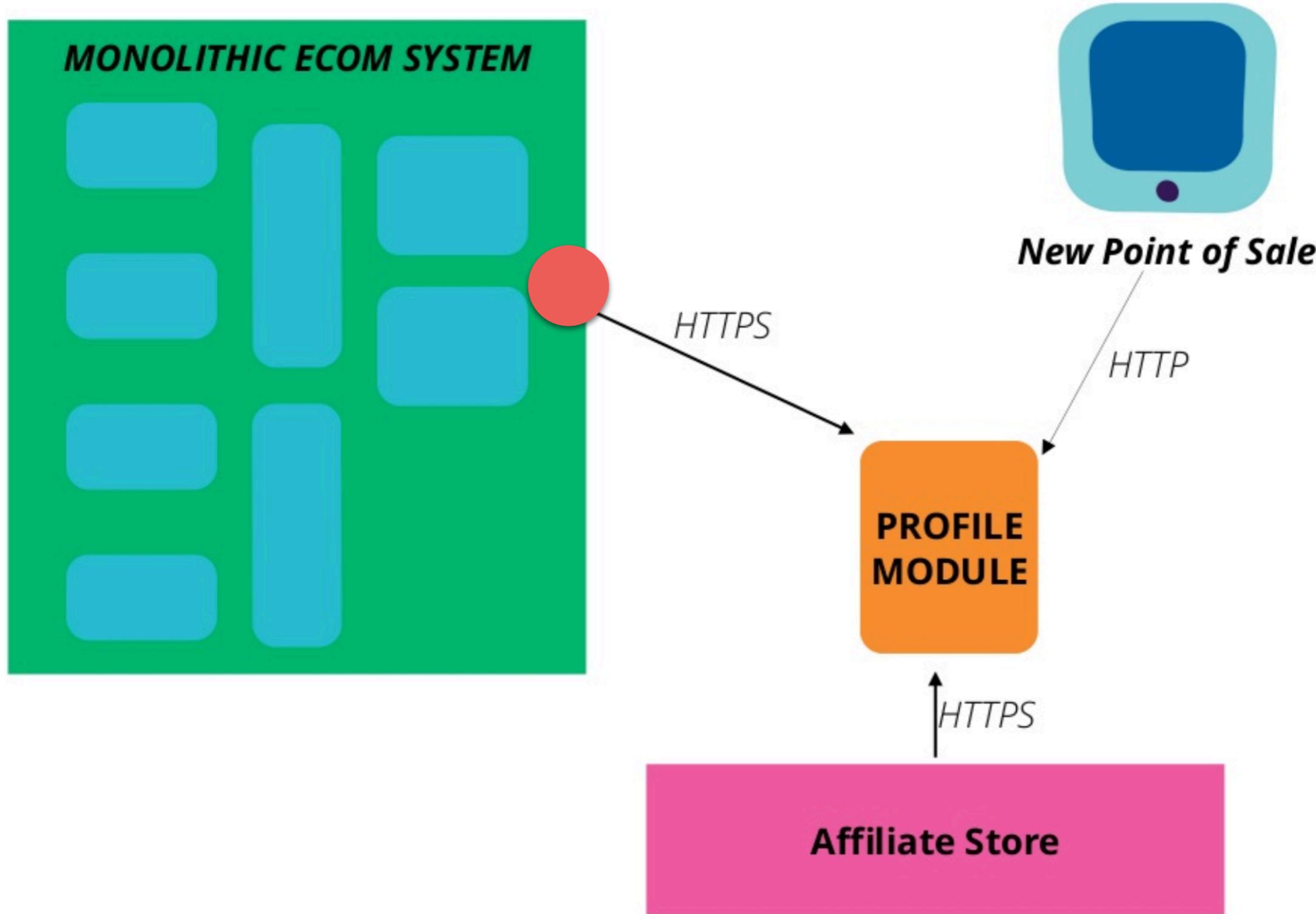
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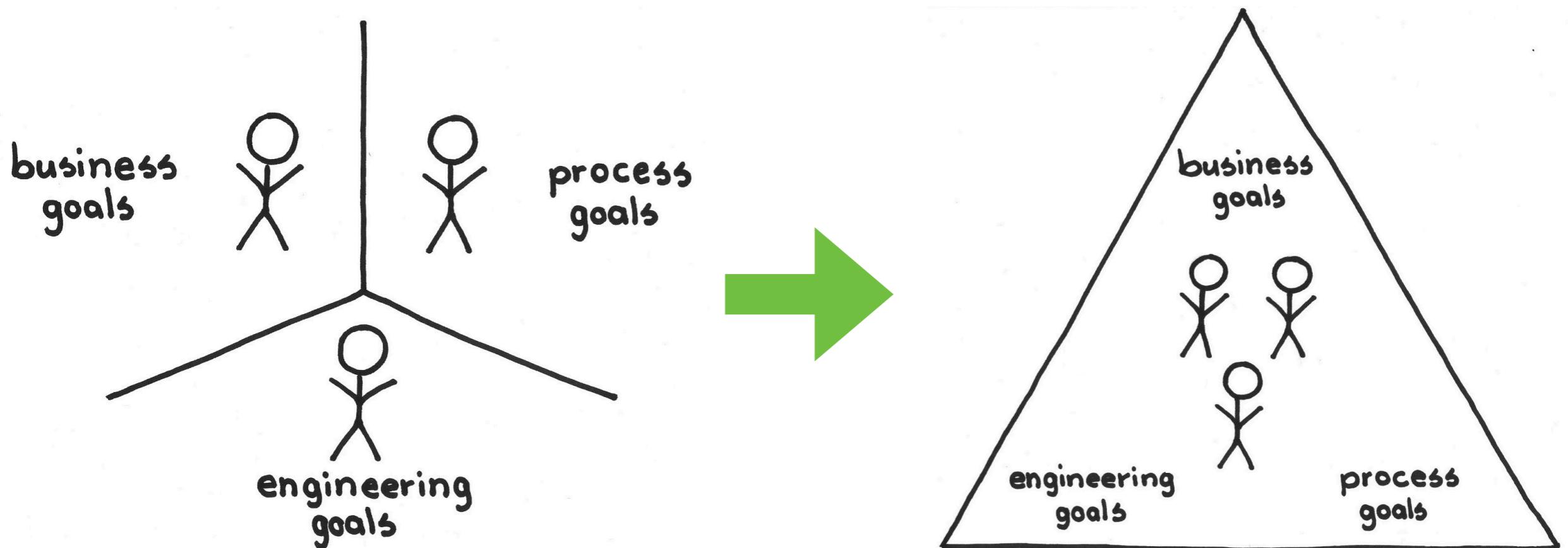


5. Organization alignment

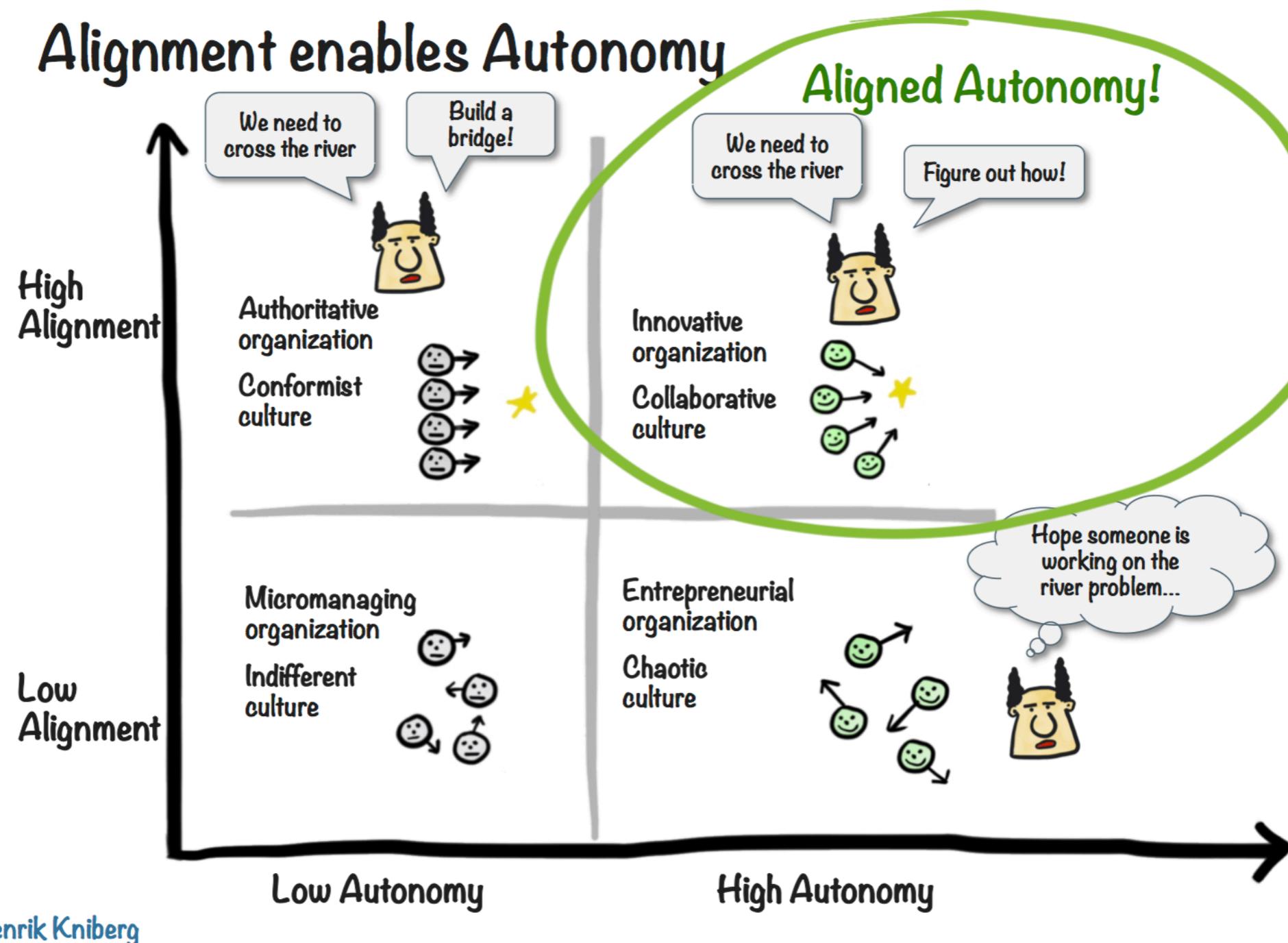
Small teams and smaller codebases



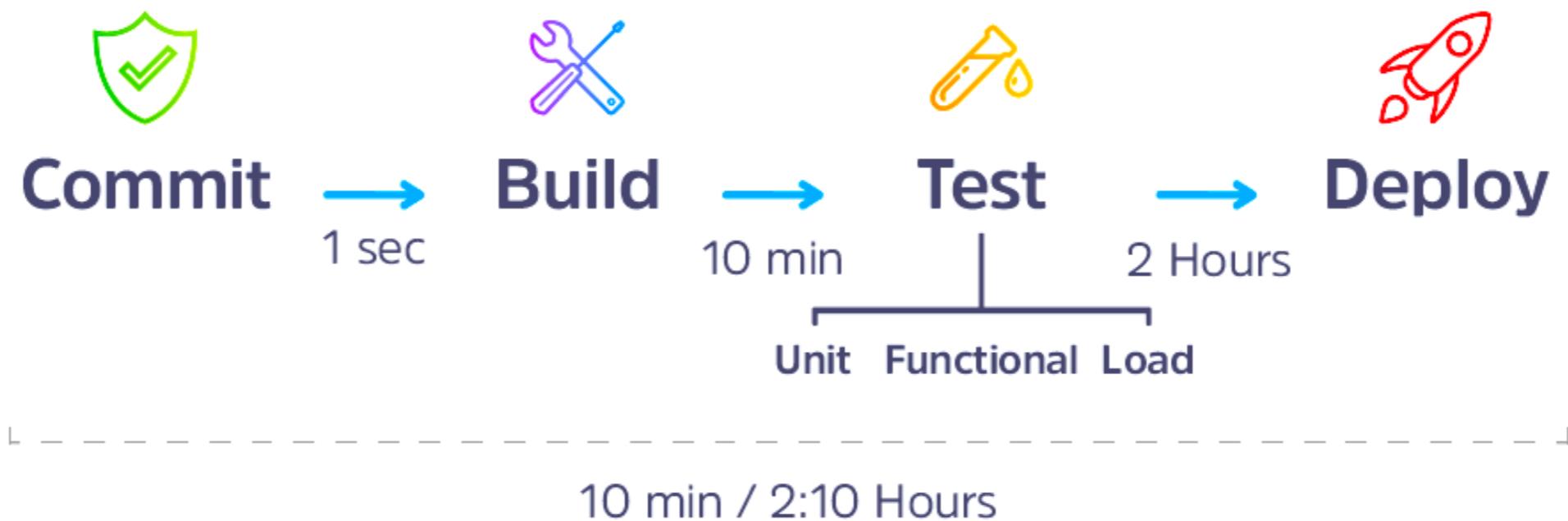
Autonomous team



Autonomous team



Autonomous team



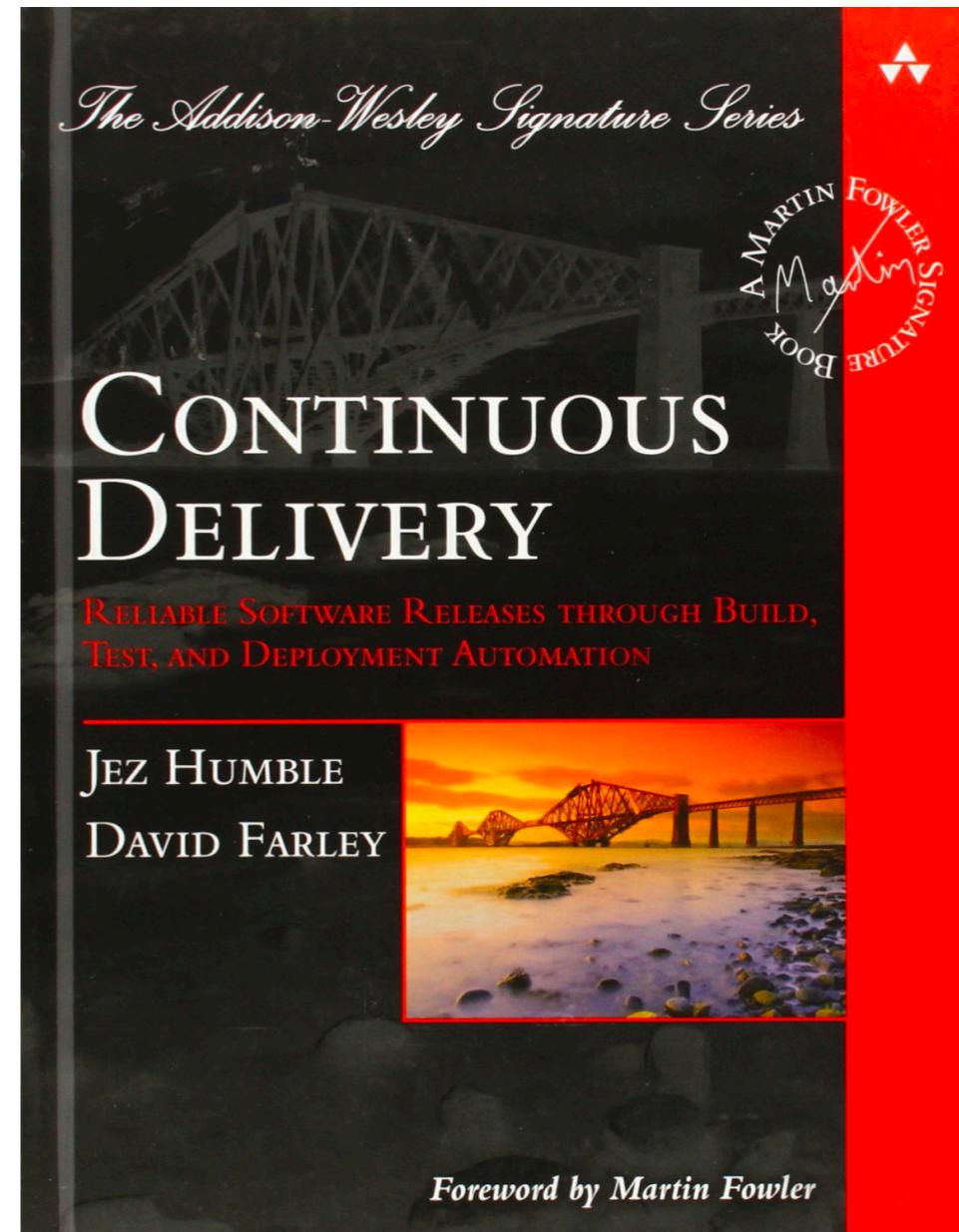
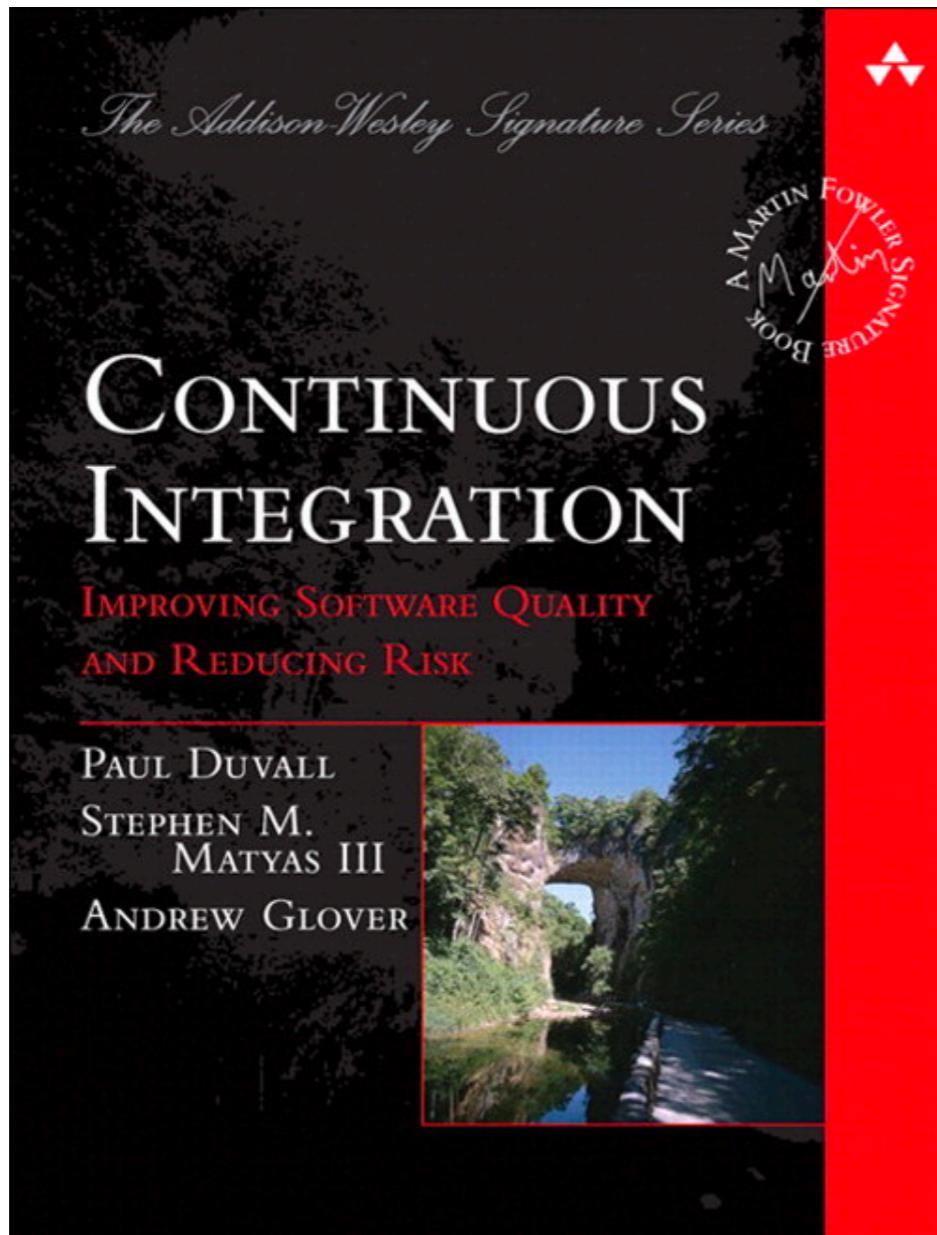
6. Enable Continuous Delivery

A part of DevOps

Set of practices for the **rapid, frequent and reliable delivery** software



Continuous Delivery/Deployment



Microservices

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Continuous Delivery/Deployment

Testability
Deployability
Autonomous team and loose coupling



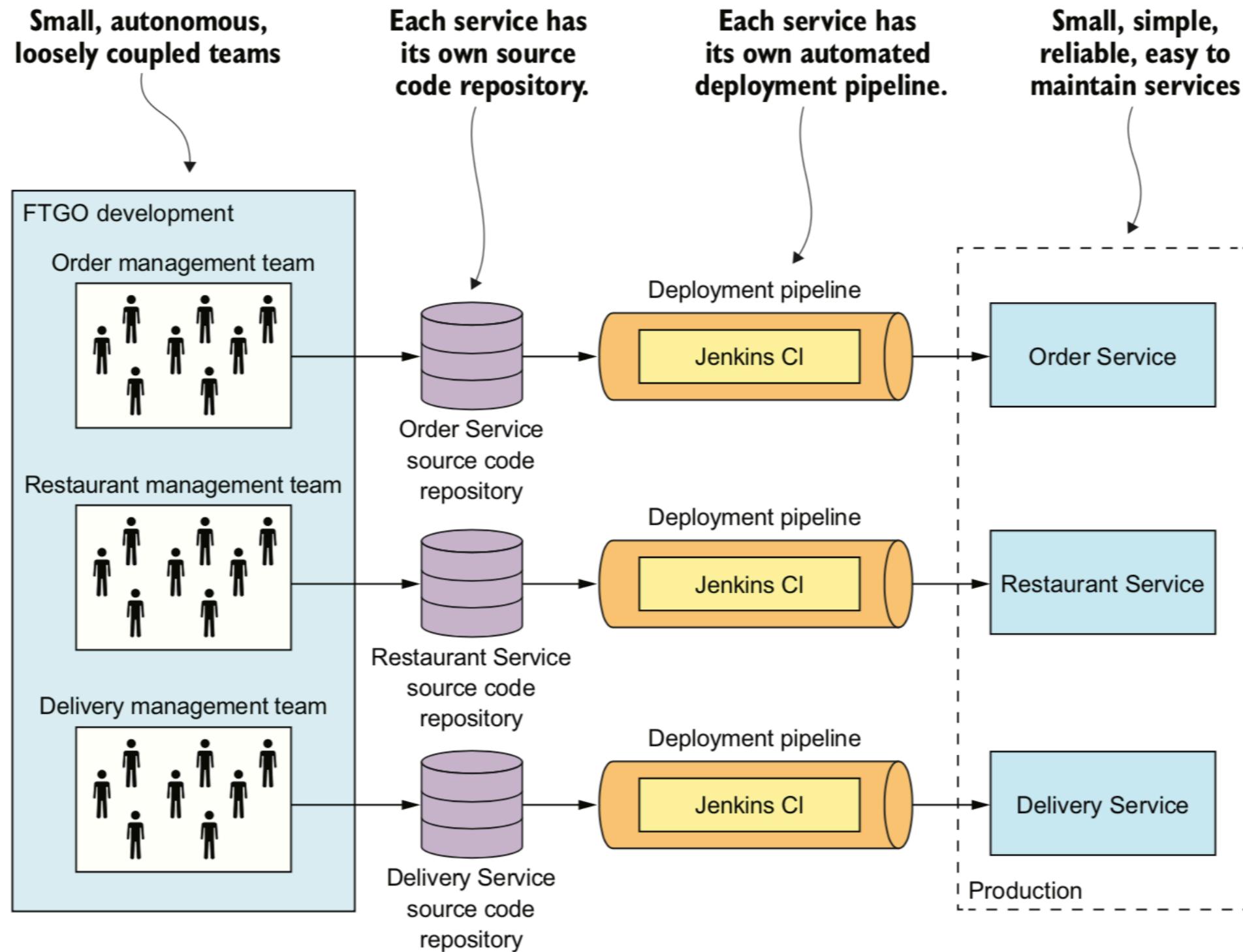
Benefits of Continuous Delivery

Reduce time to market

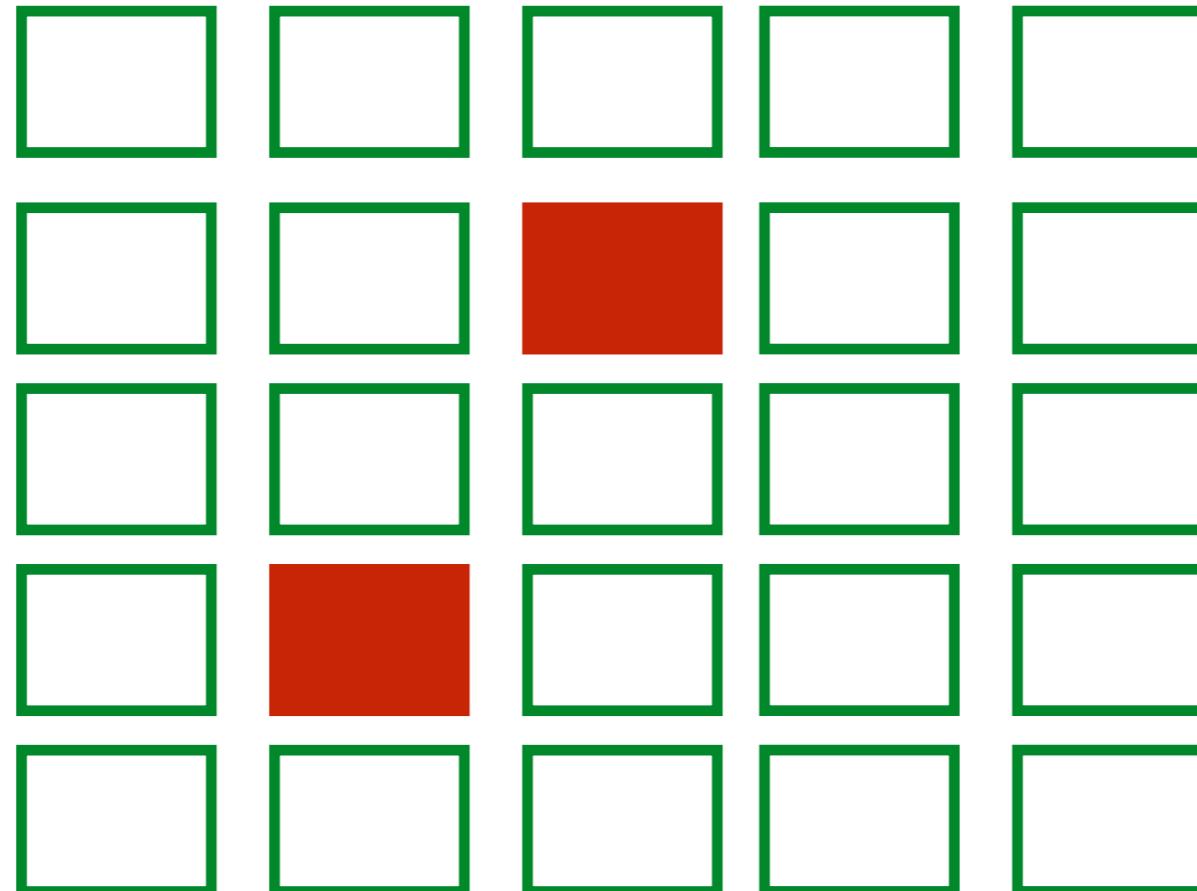
Enable **business** to provide reliable service
Employee satisfaction is higher



Continuous Delivery for service



7. Better Fault isolation



Drawbacks of Microservice



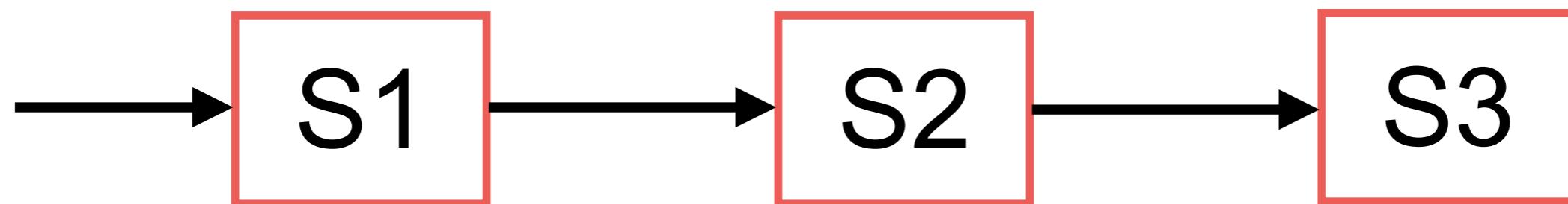
Drawbacks of Microservice

Find the right set of services
Distributed systems are complex
How to develop, testing and deploy ?



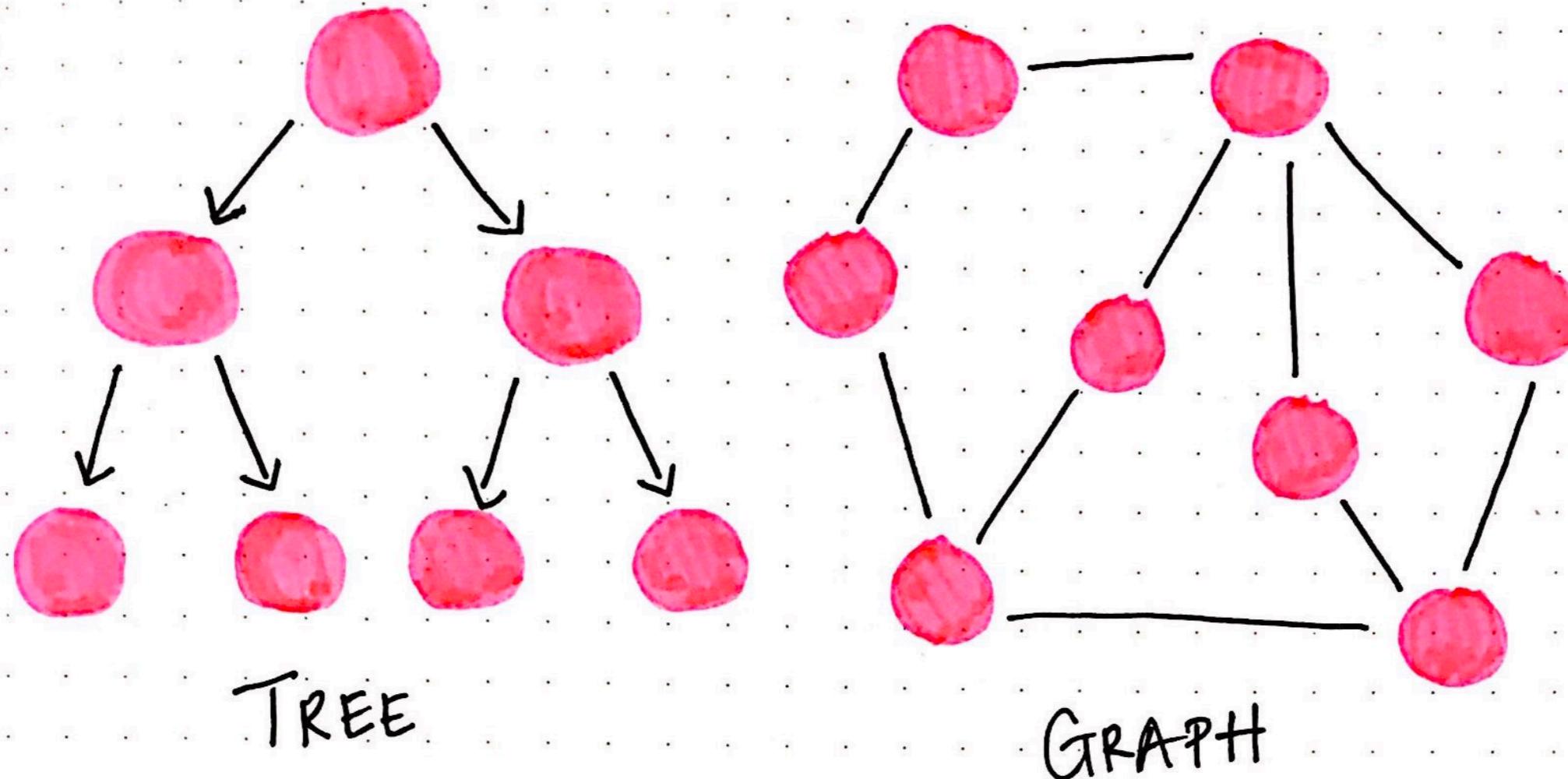
Drawbacks of Microservice

Deploy feature that required multiple service ?



Service Principles

Minimize the depth of the service call-graph

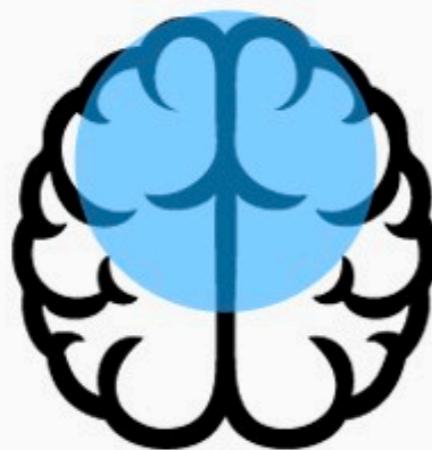


<https://github.com/Yelp/service-principles>

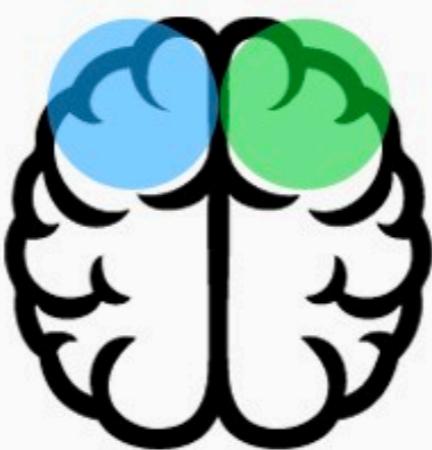


Service Principles

Minimize the number of services owned by your team

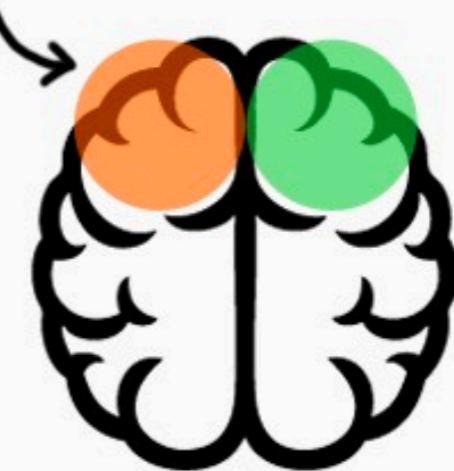


SINGLE TASK



TWO TASKS

THE 3RD TASK IS REPLACING ONE OF THE 3 TASKS



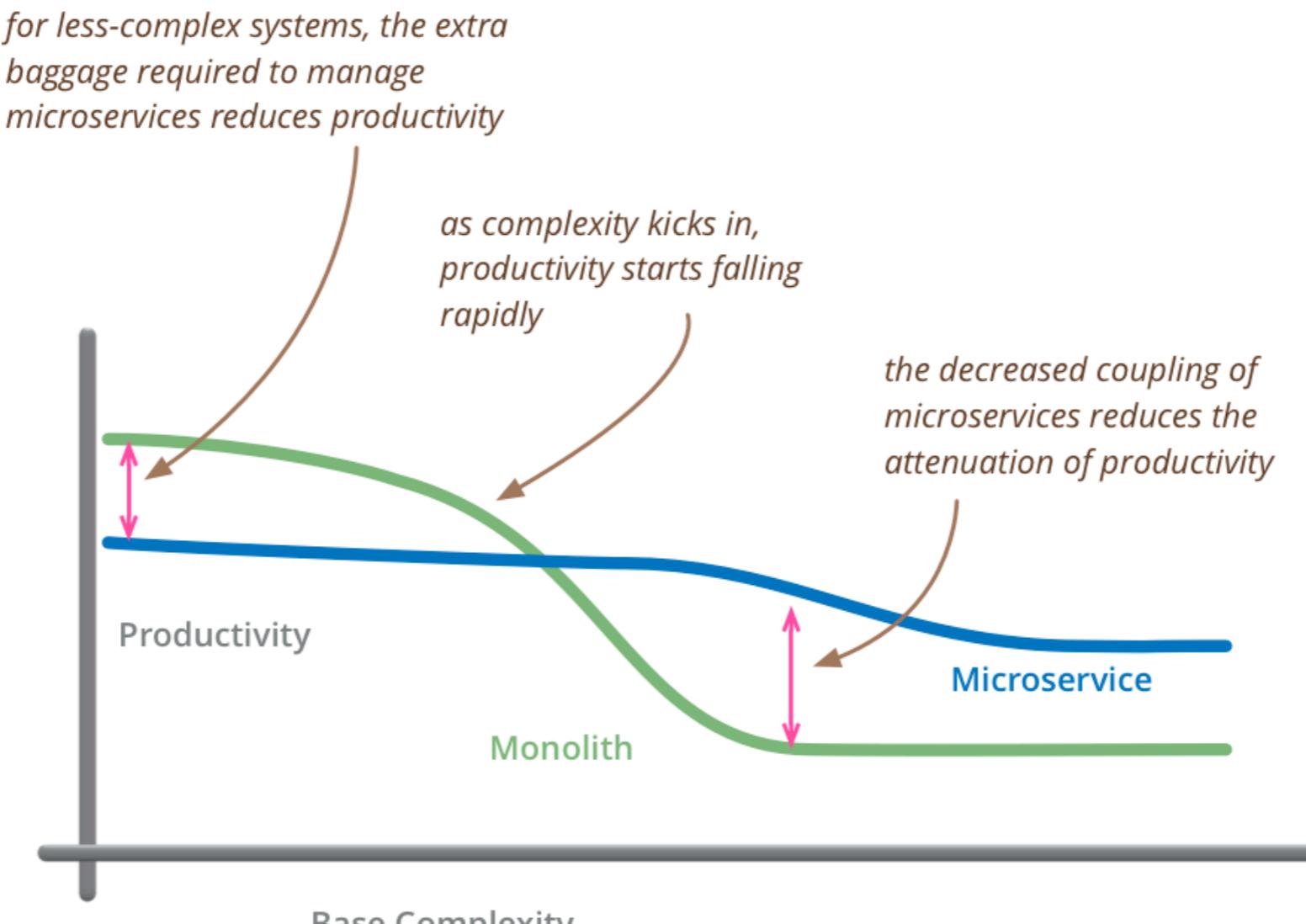
THREE TASKS

<https://github.com/Yelp/service-principles>



Drawbacks of Microservice

Decide to use when adopt is difficult !!



but remember the skill of the team will outweigh any monolith/microservice choice



Microservice architecture patterns

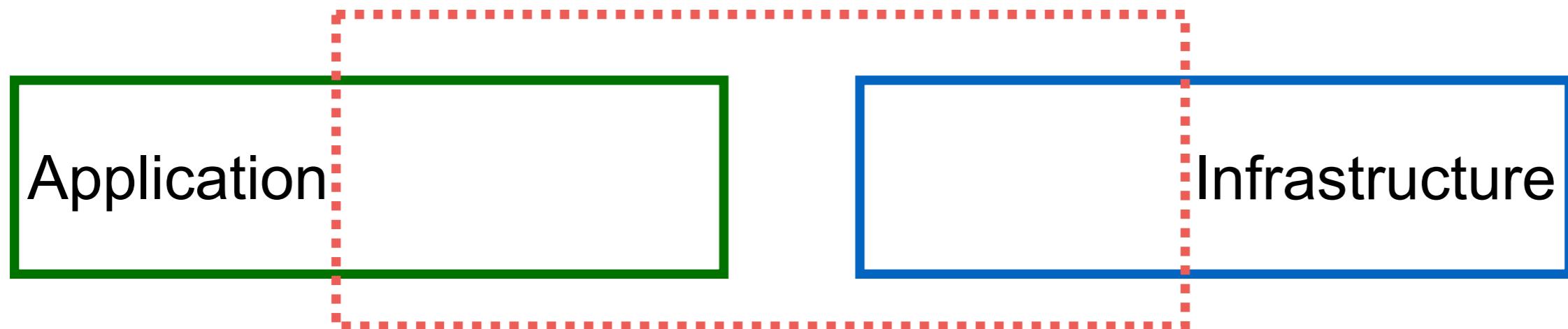


3 Layers of service patterns

Application patterns

Application infrastructure pattern

Infrastructure pattern



Patterns for Microservice

Decompose application into services

 Communication patterns

 Data consistency patterns

 Service deployment patterns

 Observability patterns

 Automated testing of services

 Security patterns



Decompose application into services



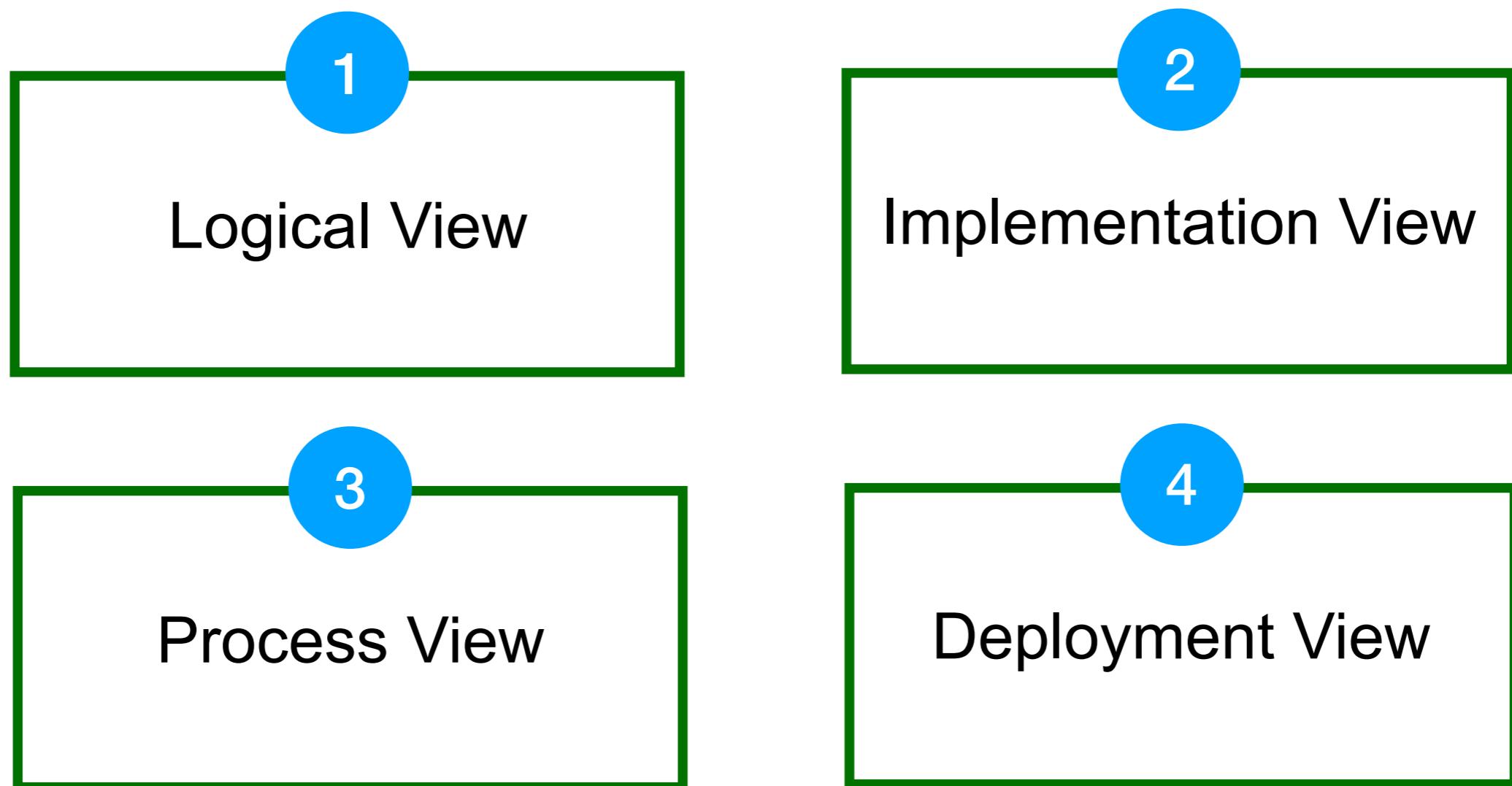
Premature splitting is the root of
all evil.



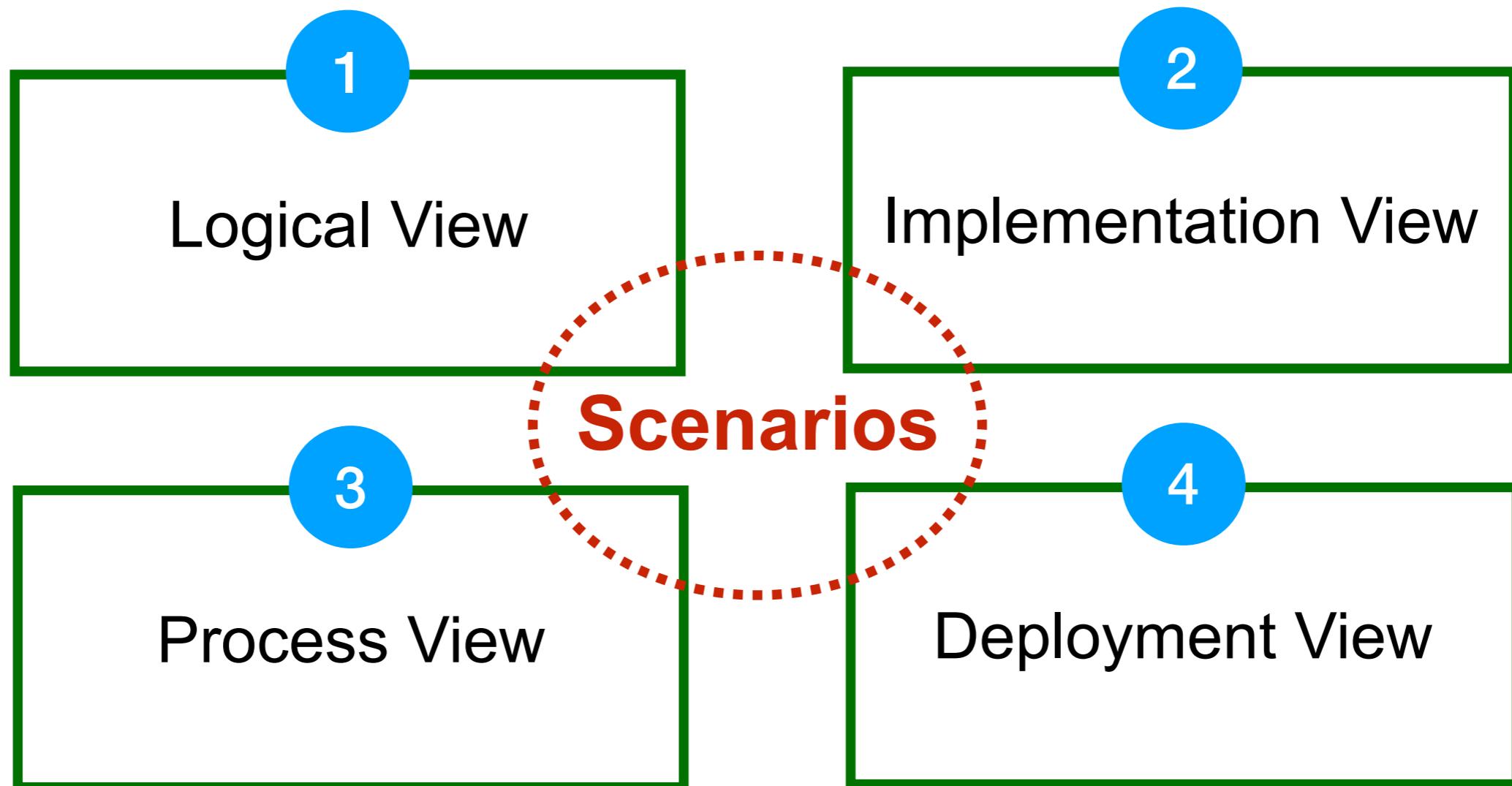
Every time you make the decision
to split out a new microservice,
there's a **risk** of ending up with a
bloated app.



4 View model of Software Architecture



4 View model of Software Architecture



What is service ?

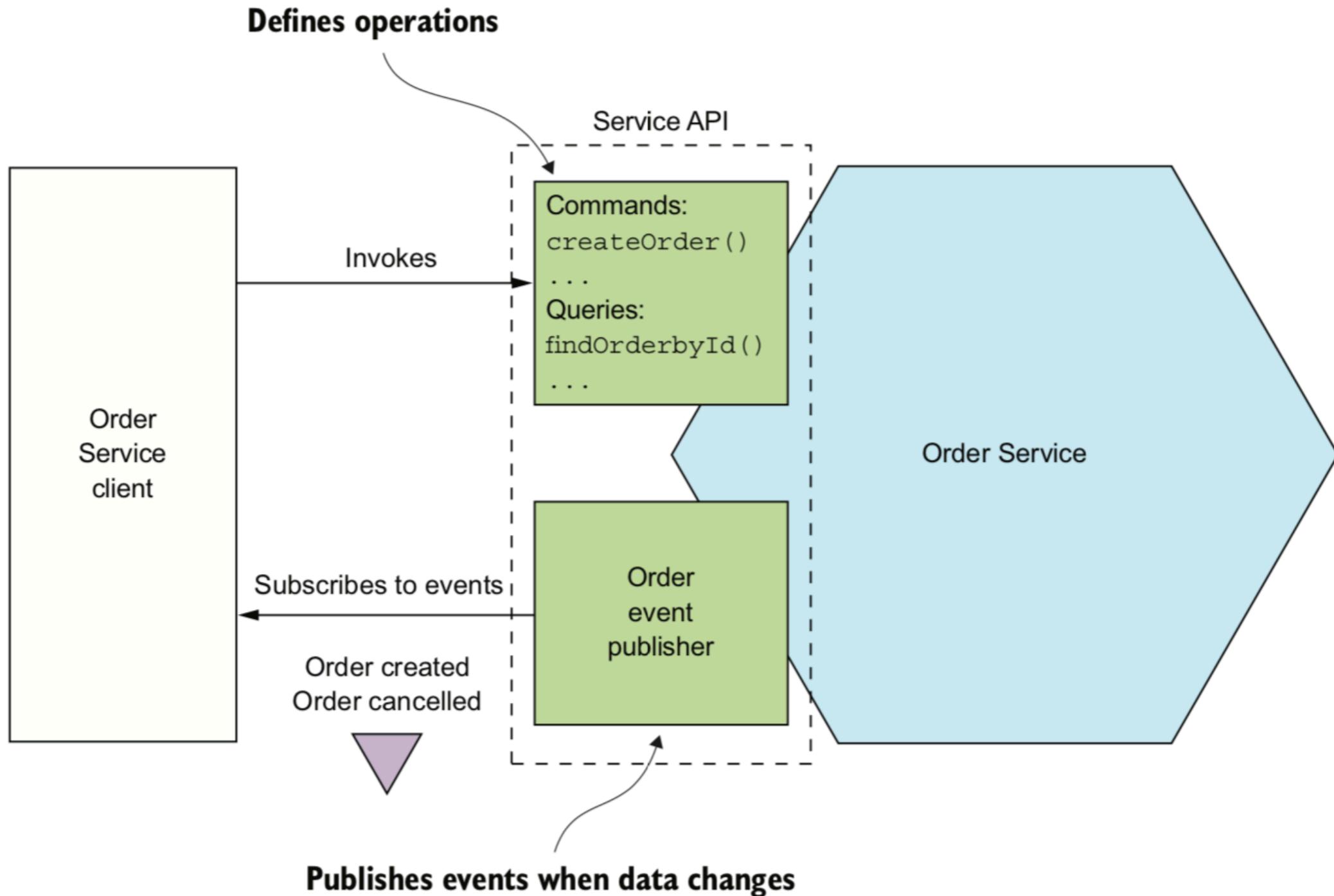
Standalone and loosely couple

Independently deployable software component

Implement some useful functionality



Example of service



Decompose application into services

By business capability ?
By subdomain/technical ?



Step to define services

1. Identify system operations
2. Identify services
3. Define service APIs and collaboration

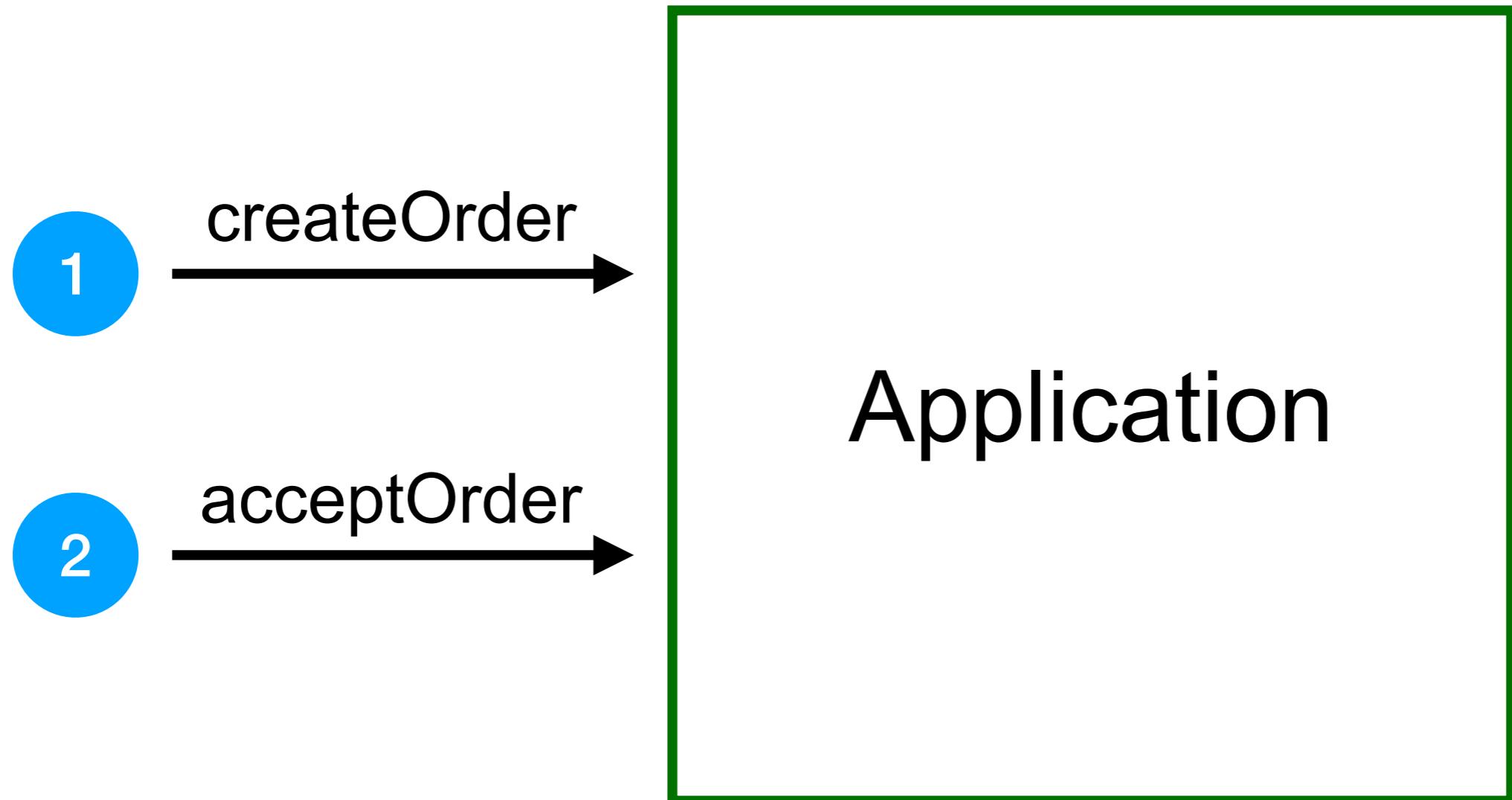


1. Identify system operations

Start with functional requirements
User story



1. Identify system operations



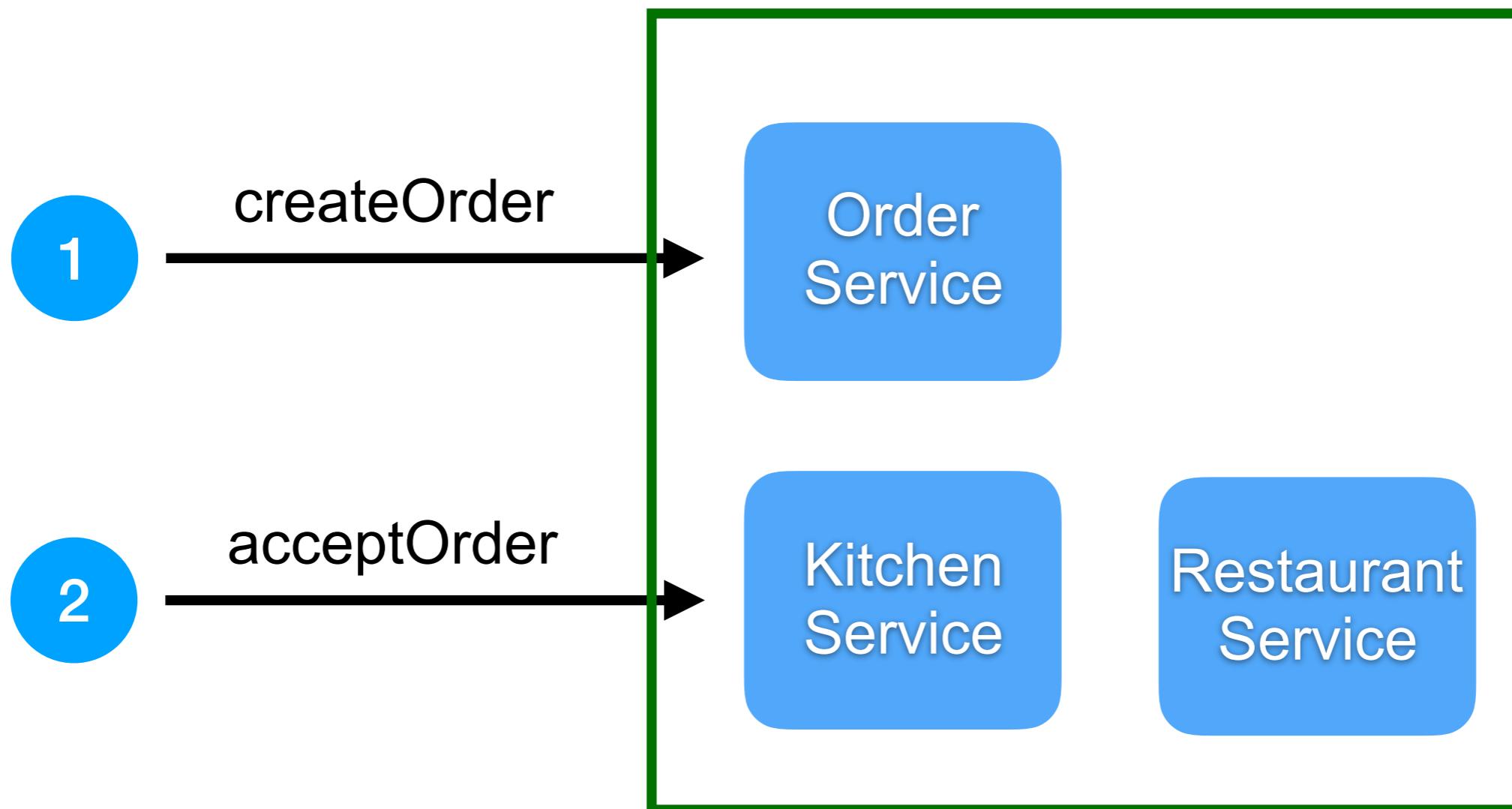
2. Identify services

Try to decomposition into services

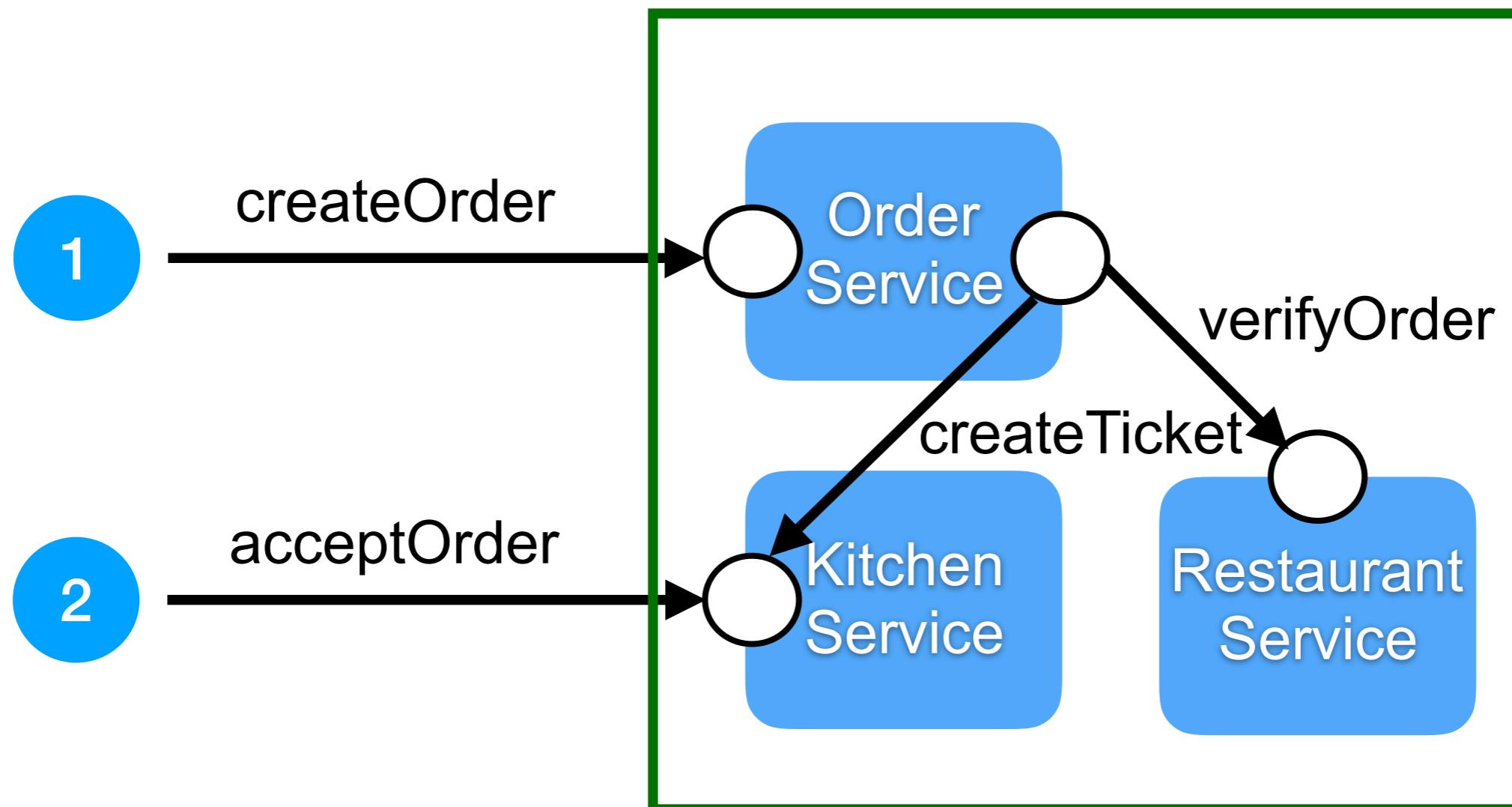
Business > Technical concept
What > How



2. Identify services



3. Define service APIs and collaborations



Workshop



Problems when decompose services ?

Network latency

Reliability of communication (sync)

Maintain data consistency

God classes



Communication between services



Communication patterns

Communication style

Discovery service

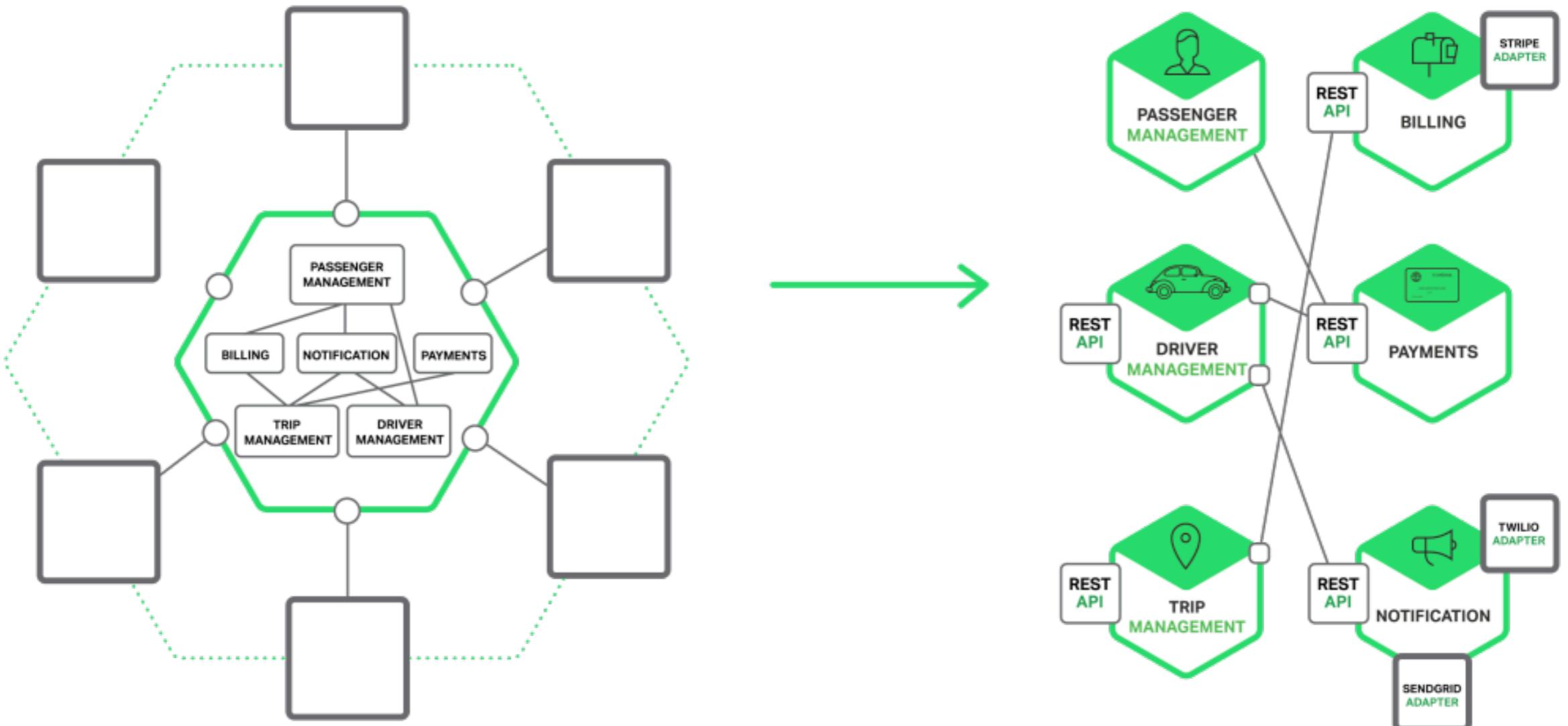
Reliability of communication

Transactional messaging

External API



Inter Process Communication (IPC)



<https://www.nginx.com>

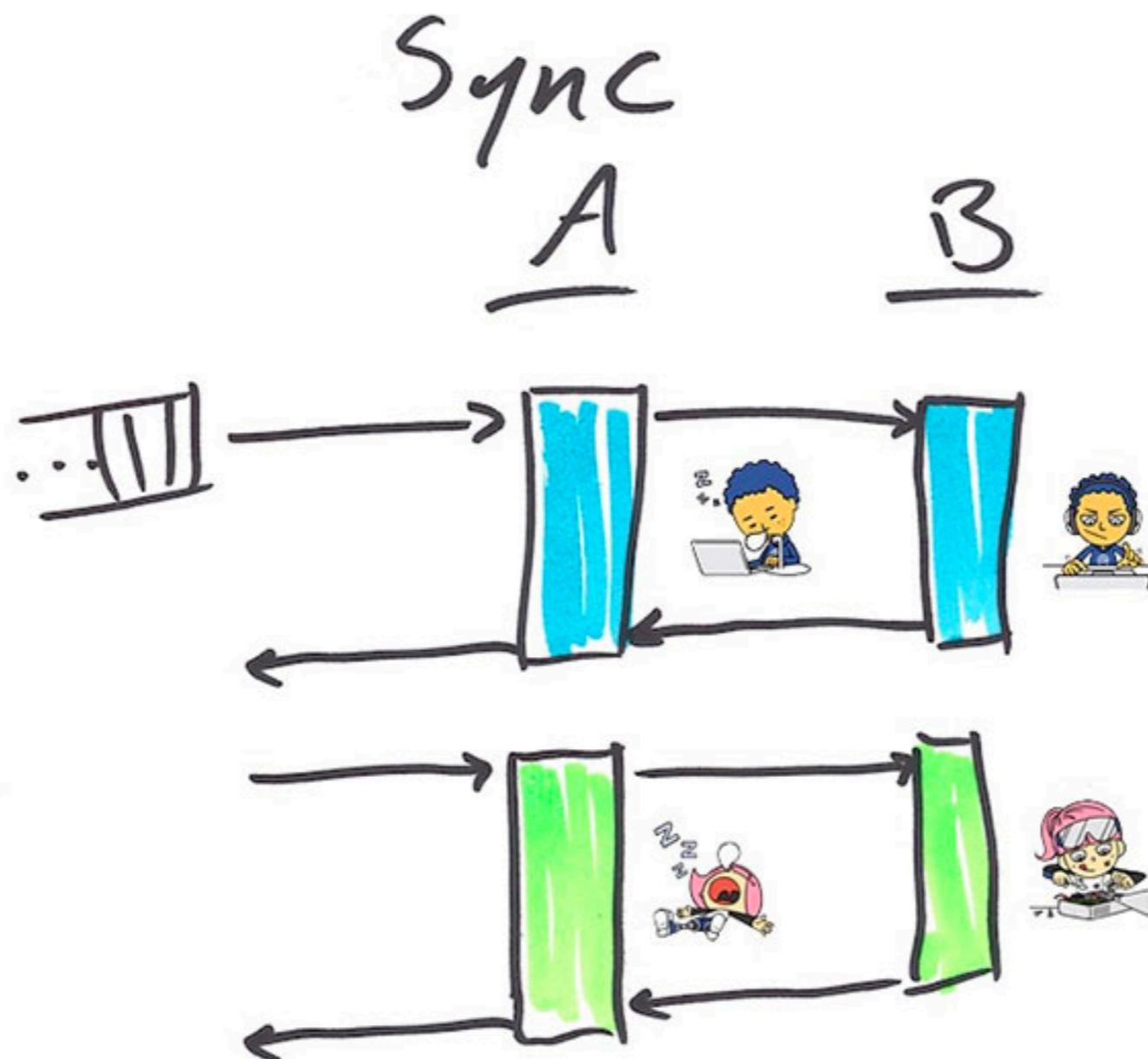


Interaction Styles

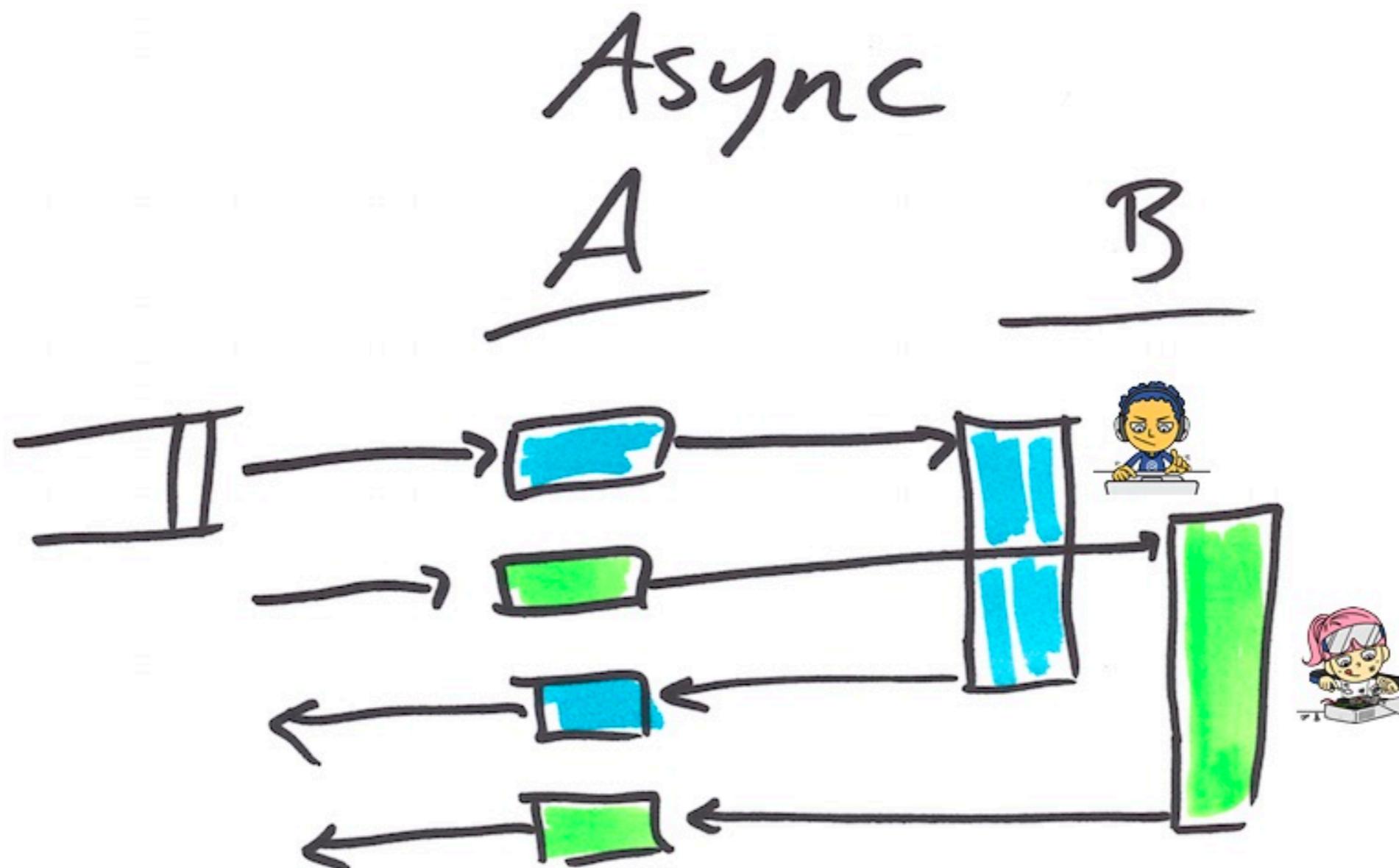
	One-to-one	One-to-many
Synchronous	Request/response	-
Asynchronous	Async request/response	Publish/subscribe
	Notification	Publish/async response



Synchronous



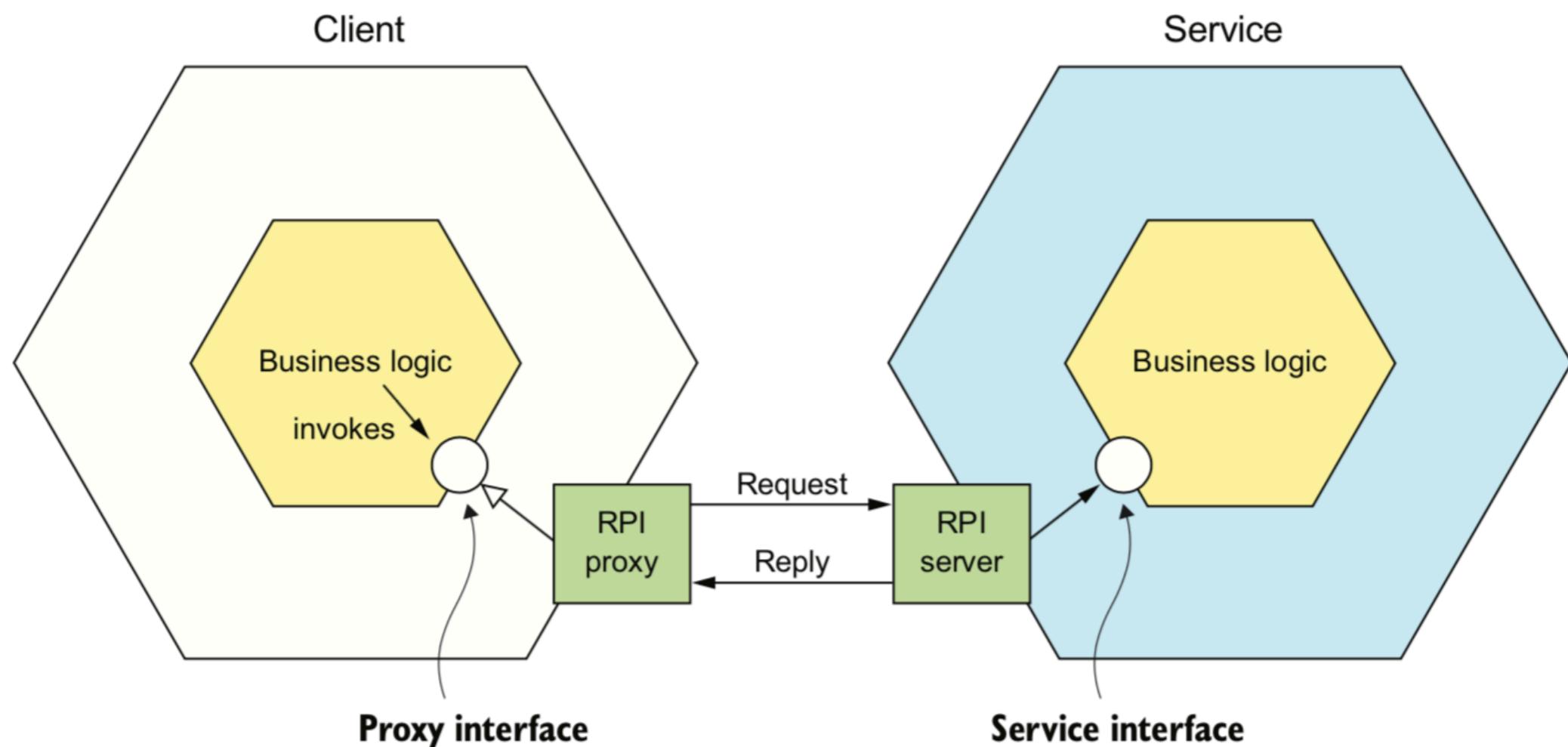
Asynchronous



Synchronous Remote Procedure Invocation



Synchronous Remote Procedure Invocation



Synchronous Remote Procedure Invocation

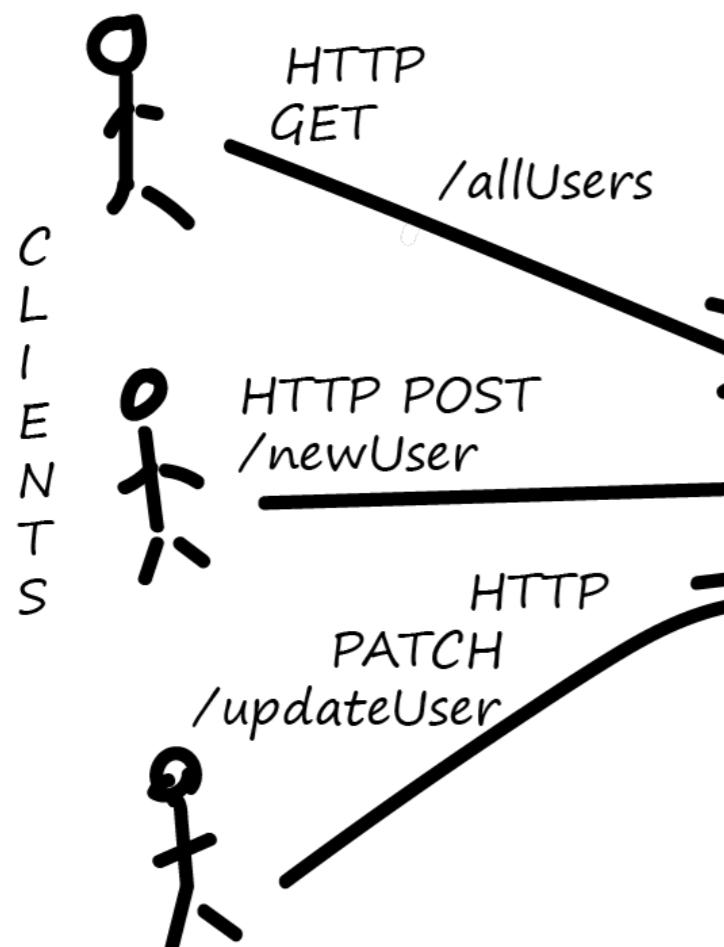
REST
gRPC

Handling failure with Circuit breaker
Service discovery



REpresentational State Transfer

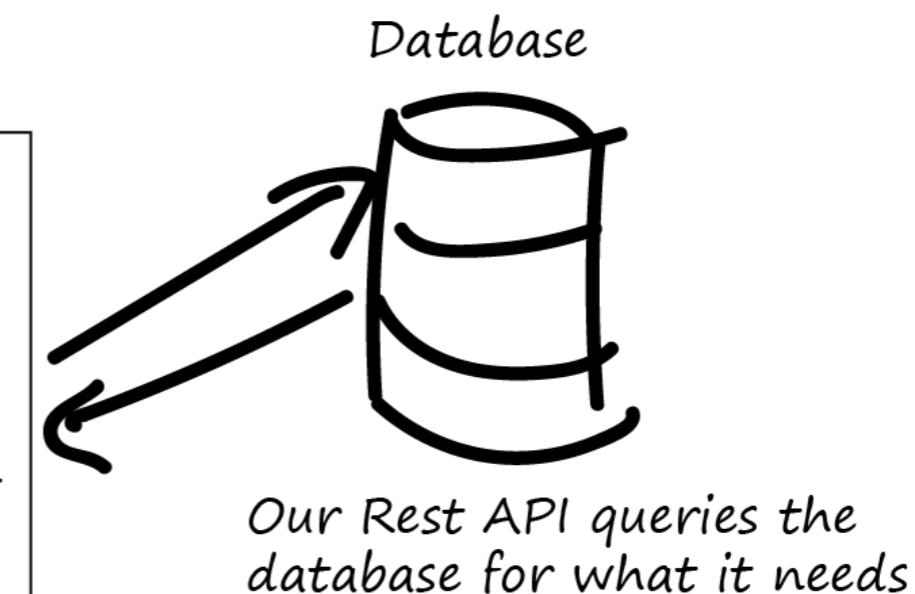
Rest API Basics



Our Clients, send HTTP Requests and wait for responses

Rest API
Receives HTTP requests from Clients and does whatever request needs. i.e create users

Typical HTTP Verbs:
GET → Read from Database
PUT → Update/Replace row in Database
PATCH → Update/Modify row in Database
POST → Create a new record in the database
DELETE → Delete from the database



Response: When the Rest API has what it needs, it sends back a response to the clients. This would typically be in JSON or XML format.

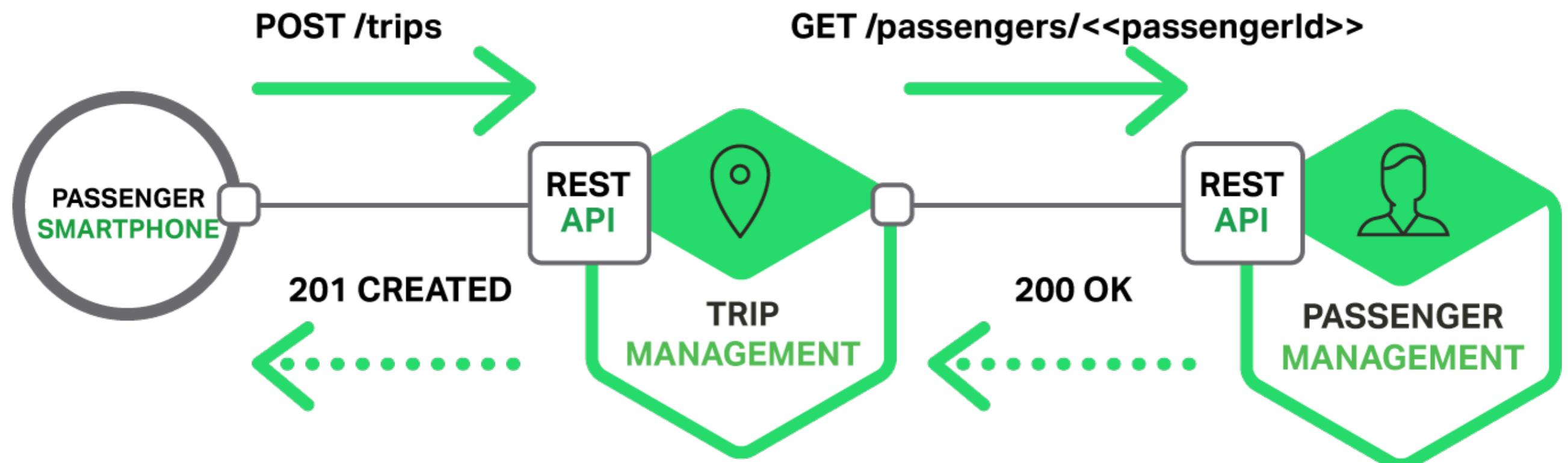


REST :: mapping with HTTP verbs

Activity	HTTP Method
Retrieve data	GET
Create new data	POST
Update data	PUT
Delete data	DELETE



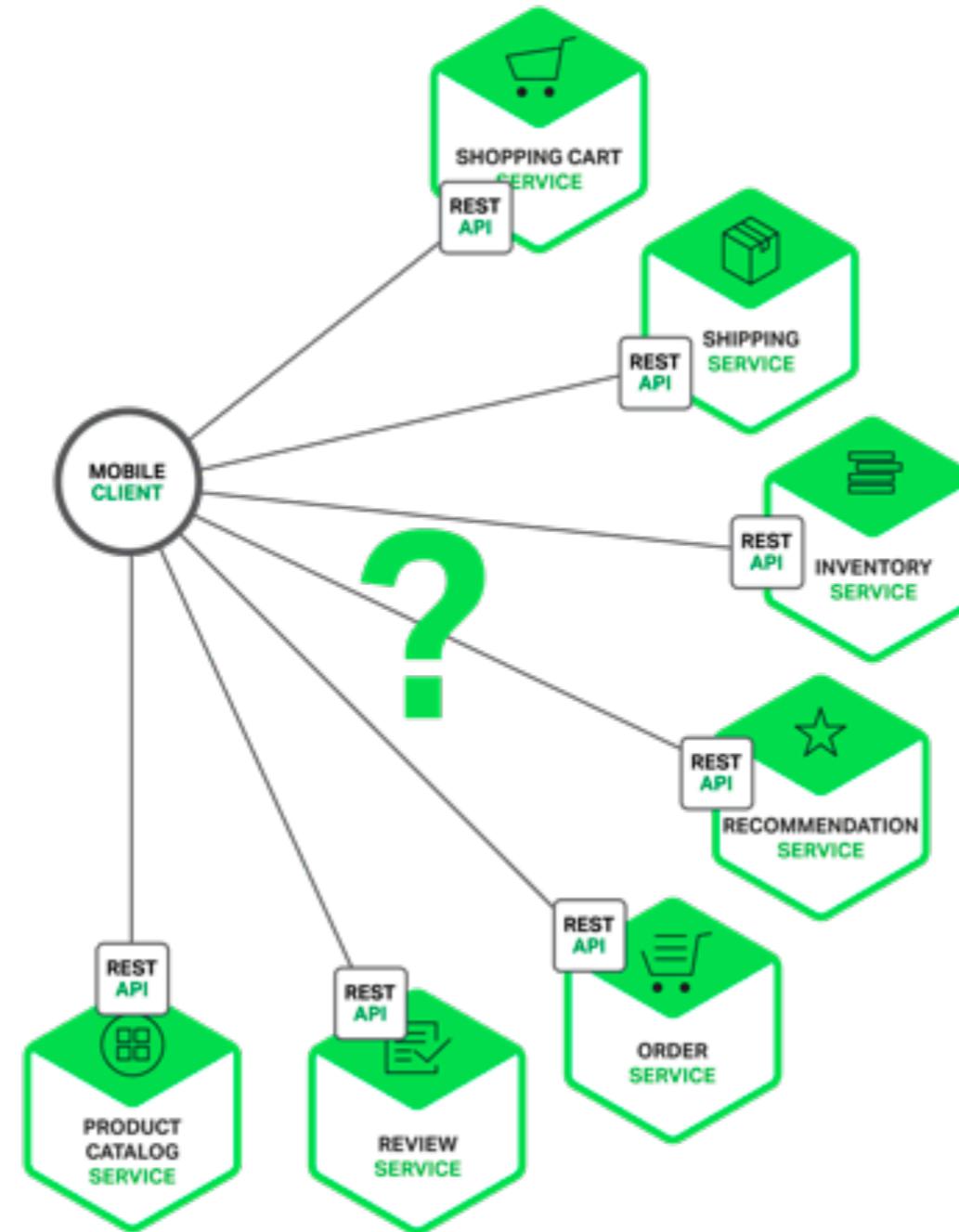
Request and response format



<https://www.nginx.com>



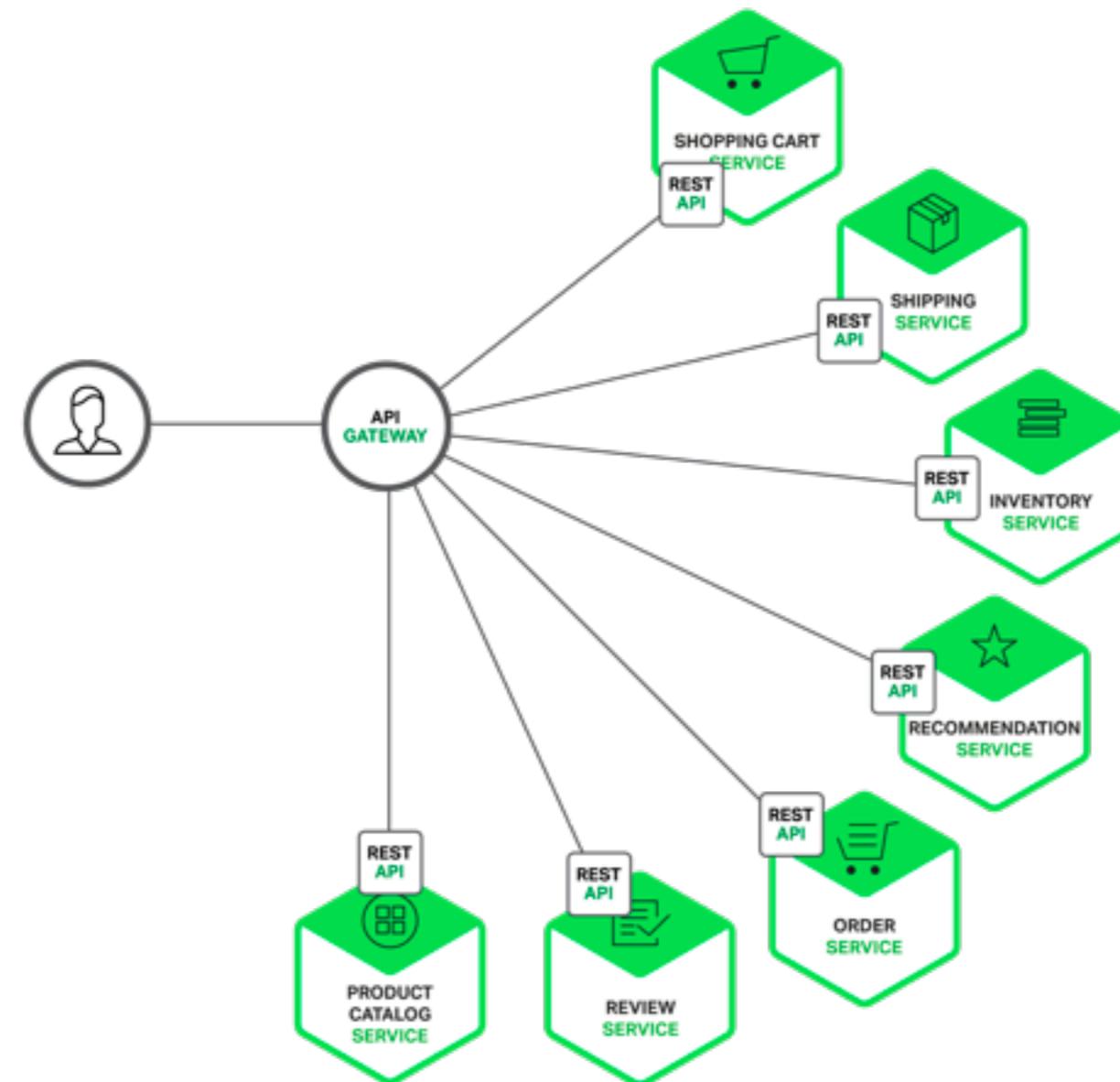
Direct communication !!



<https://www.nginx.com>



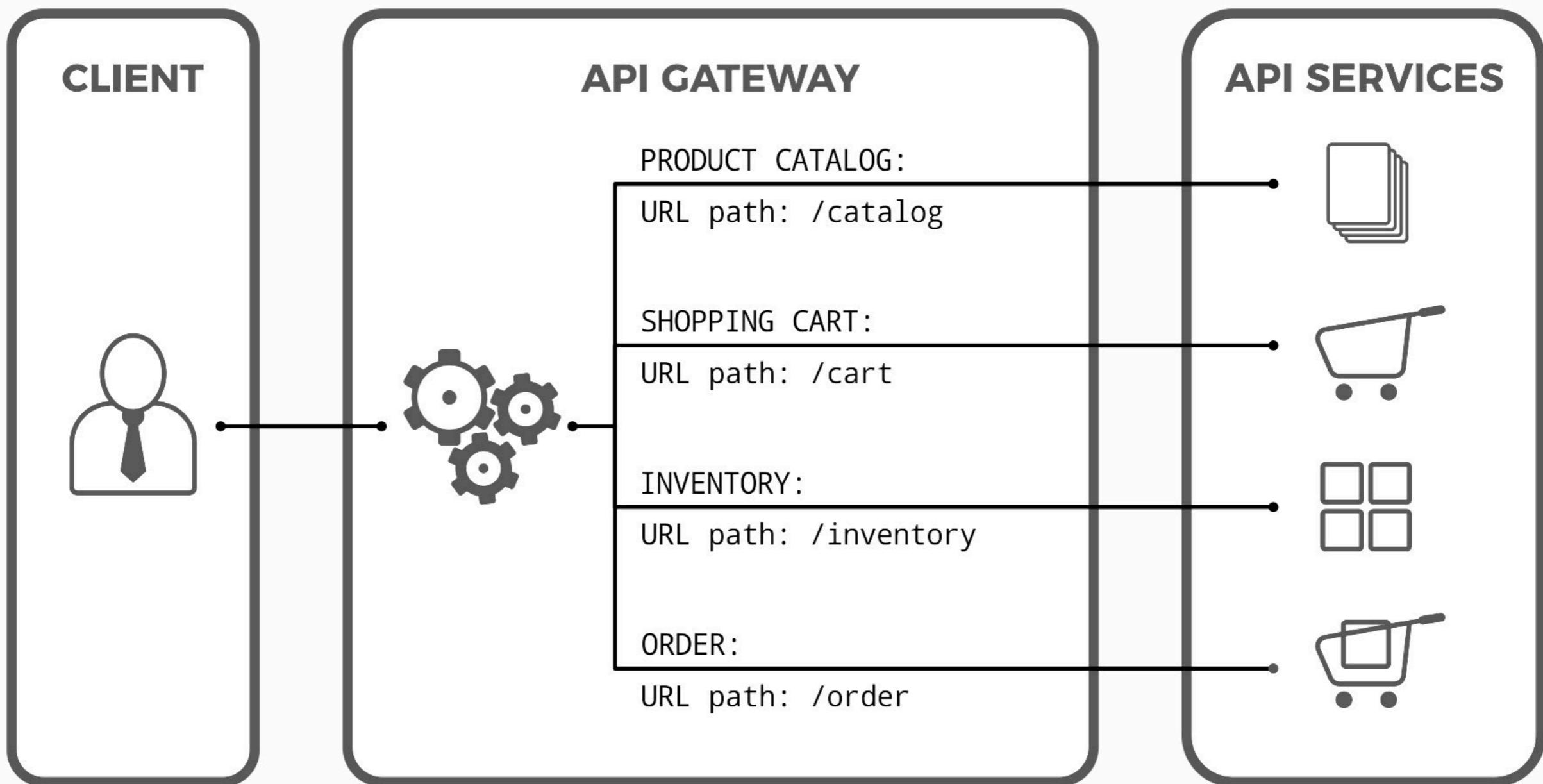
Working with API gateway



<https://www.nginx.com>



Working with API gateway



Functions of API gateway

Authentication

Authorization

Rate limiting

Caching

Metrics collection

Request logging

Load balancing

Circuit breaking



Benefits

Encapsulation interface structure

Client talk to service via gateway

Reduce round trip between service



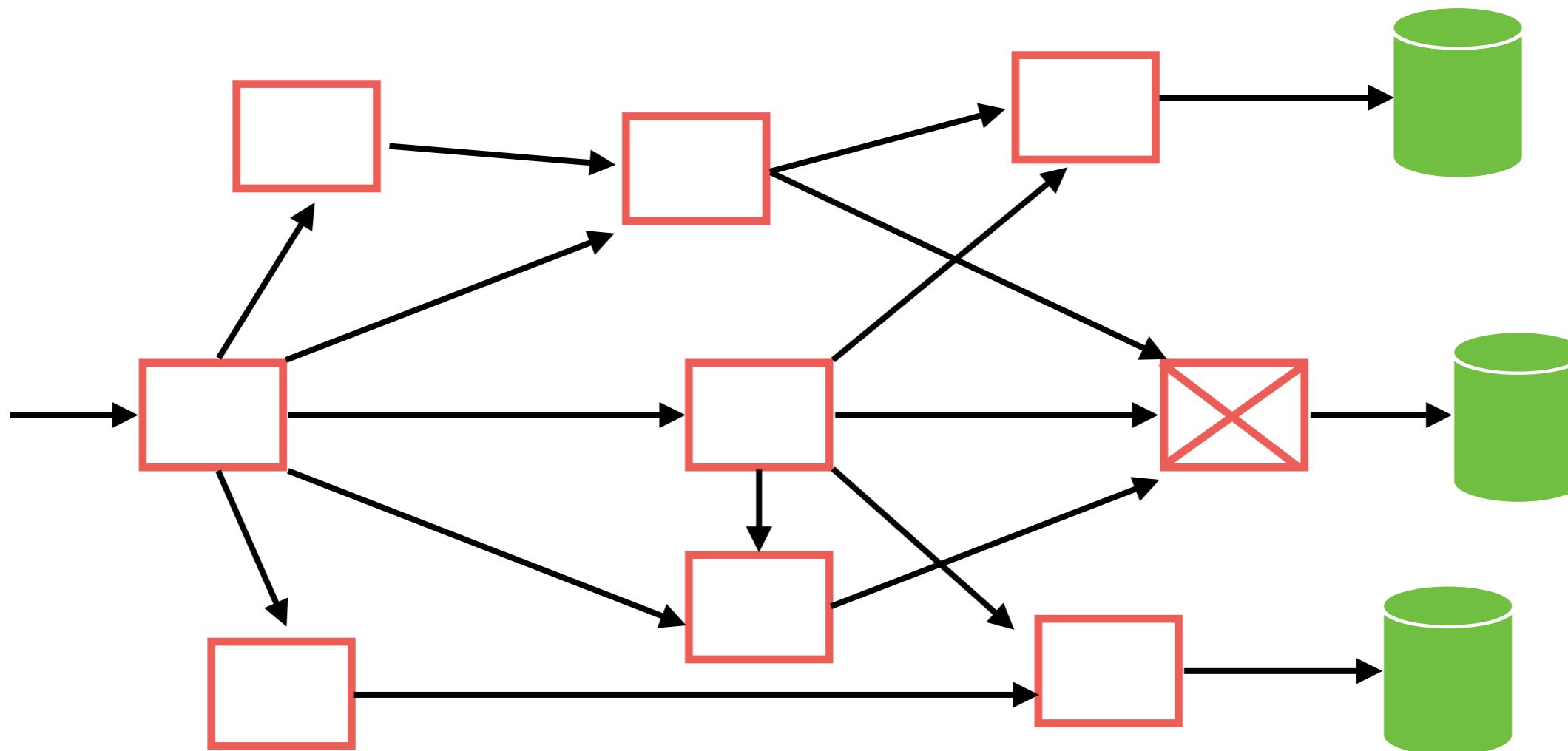
Drawbacks

Development/Performance bottleneck
Single point of failure
Waiting for update data in gateway



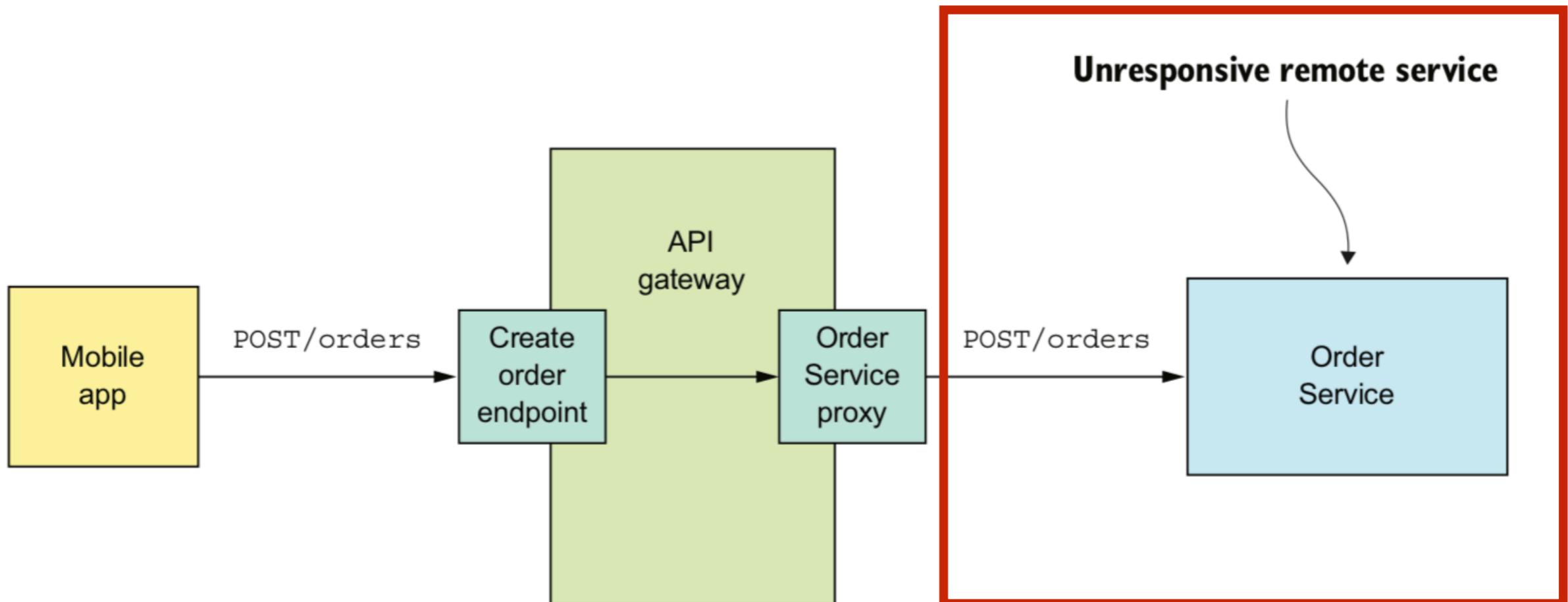
Circuit Breaker pattern

How to handling partial failure ?



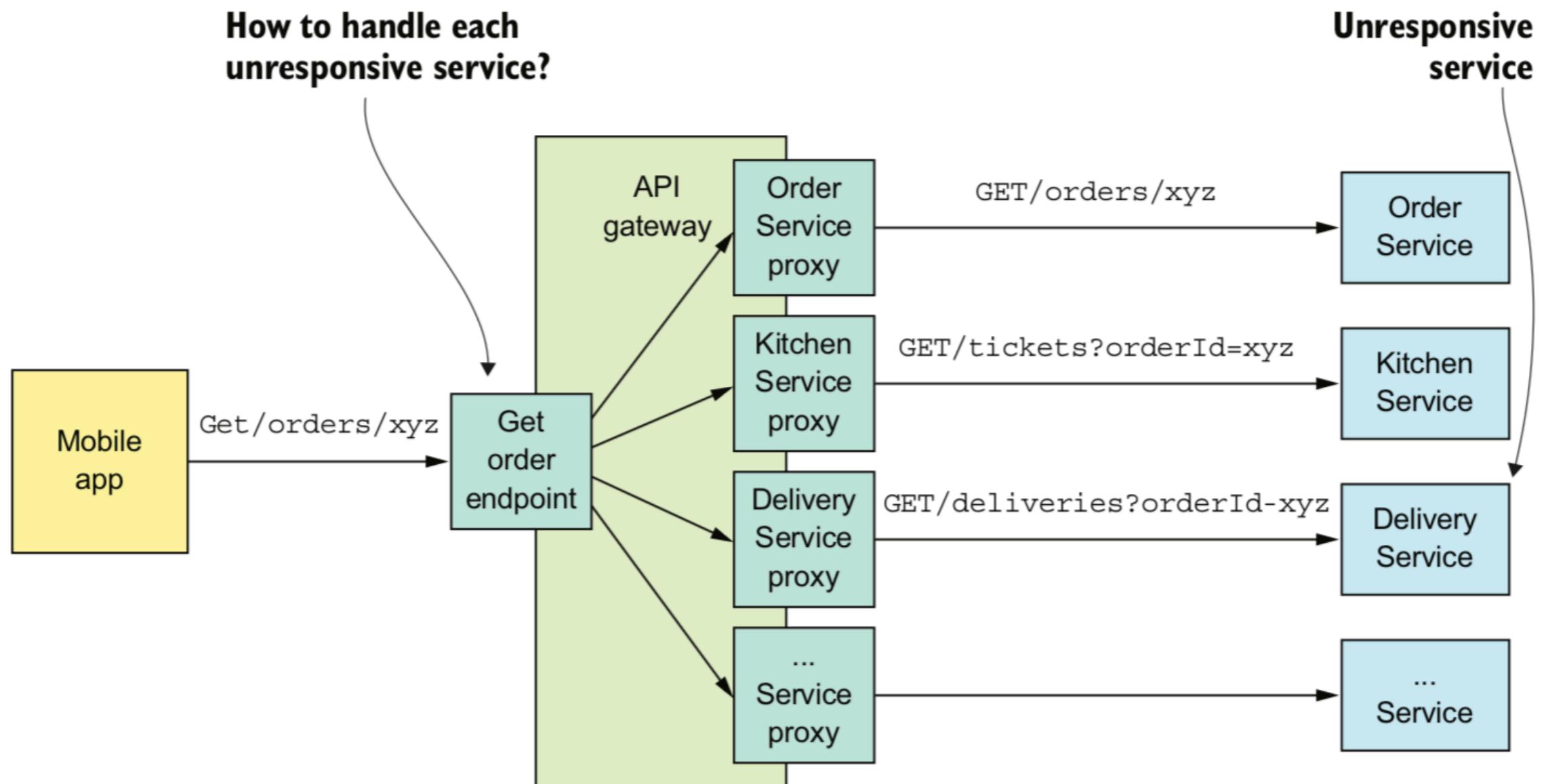
Circuit Breaker pattern

How to handling partial failure ?



Circuit Breaker pattern

How to handling partial failure ?



Develop robust patterns

Network timeout

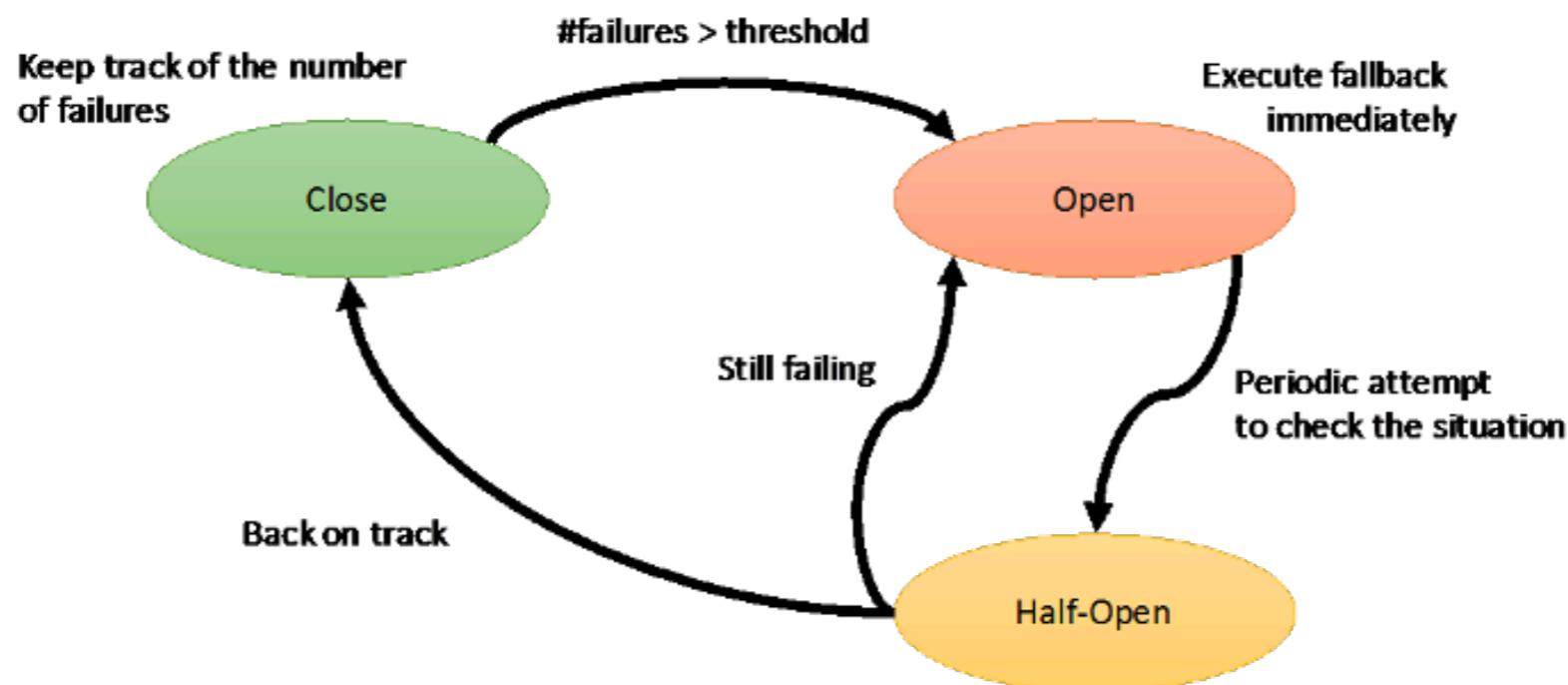
Limit request from client to service
Circuit breaker pattern



Circuit Breaker pattern

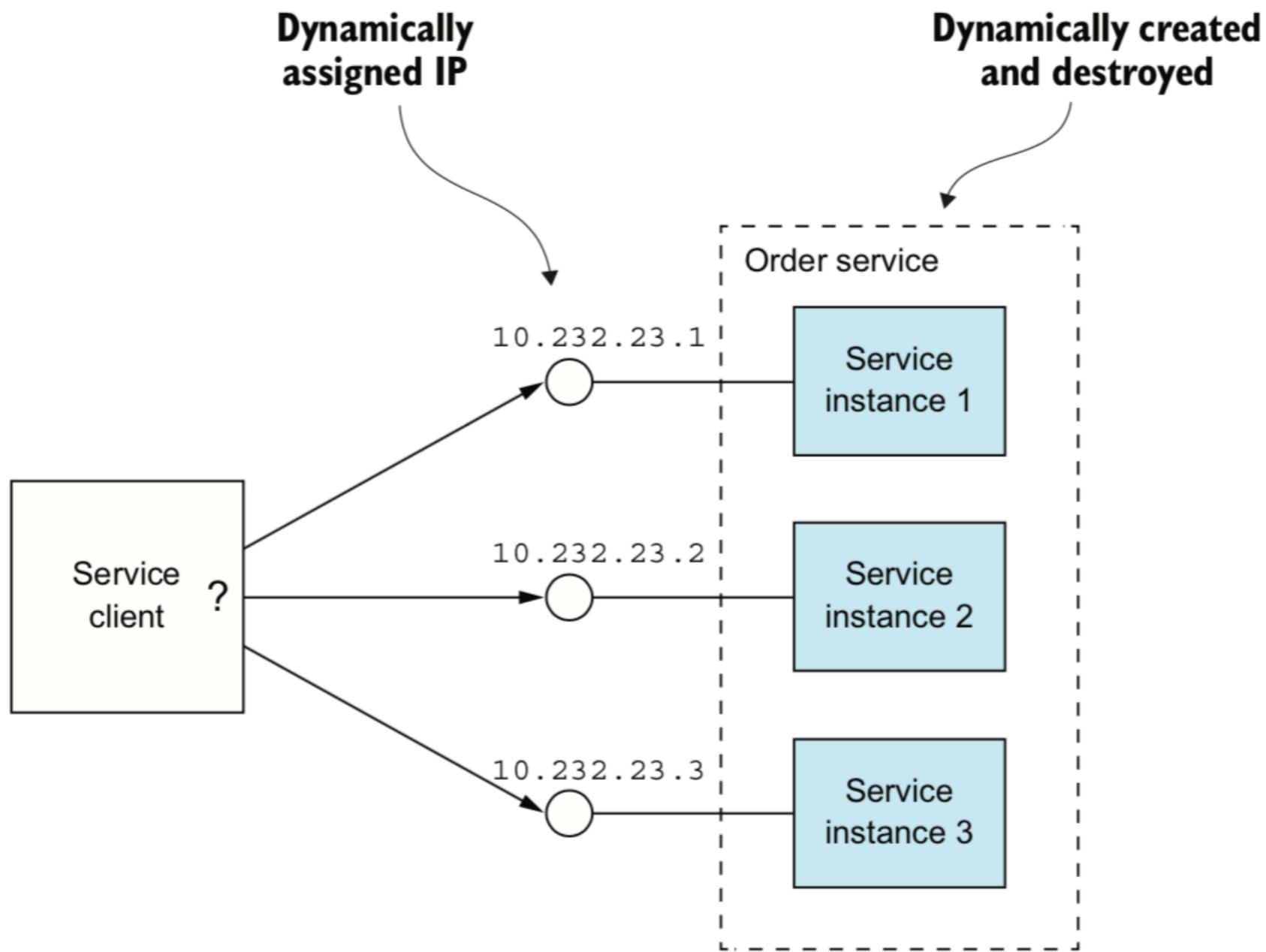
Track the number of success and failure

***If error rate exceed some threshold
then enable circuits breaker***

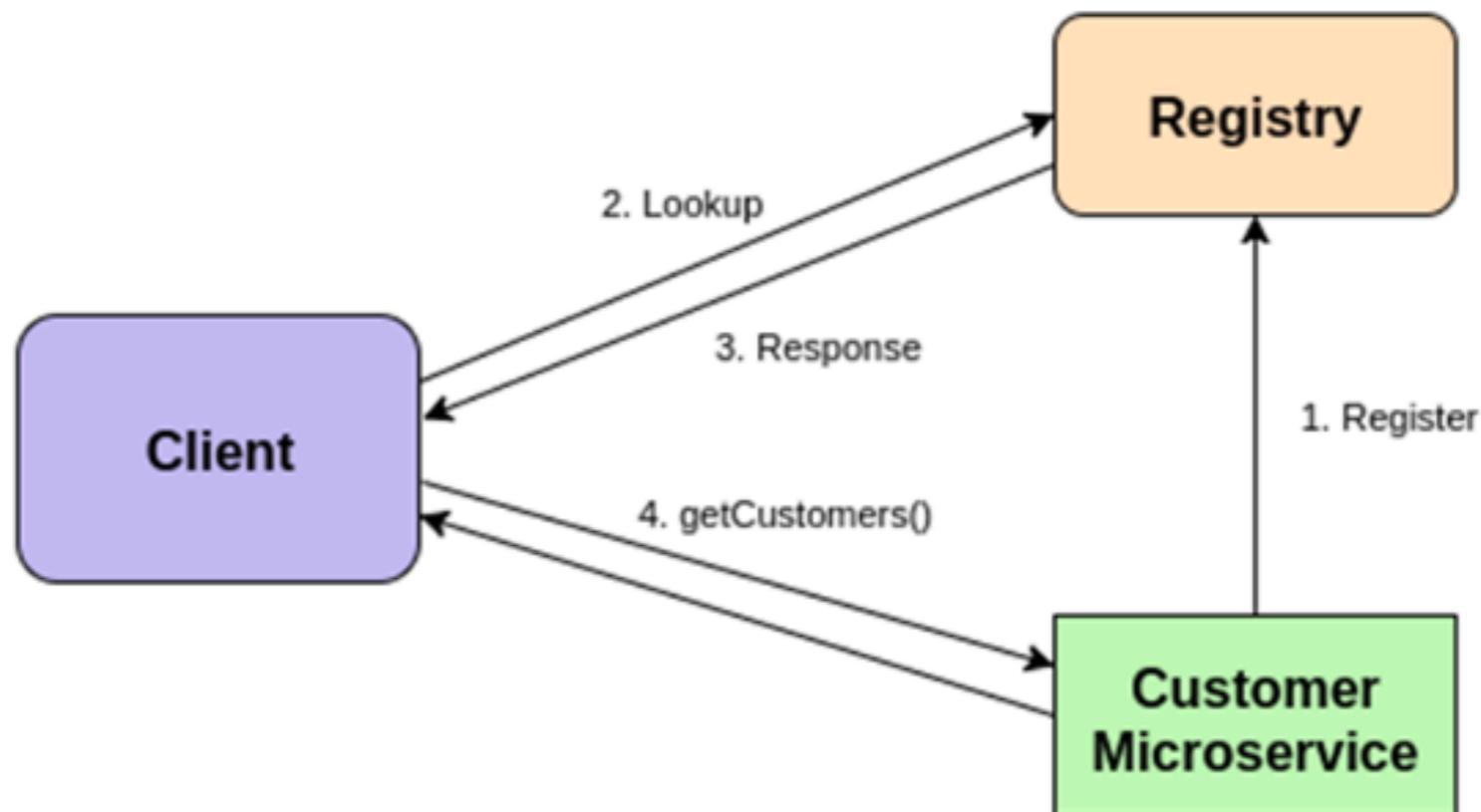


Service Discovery

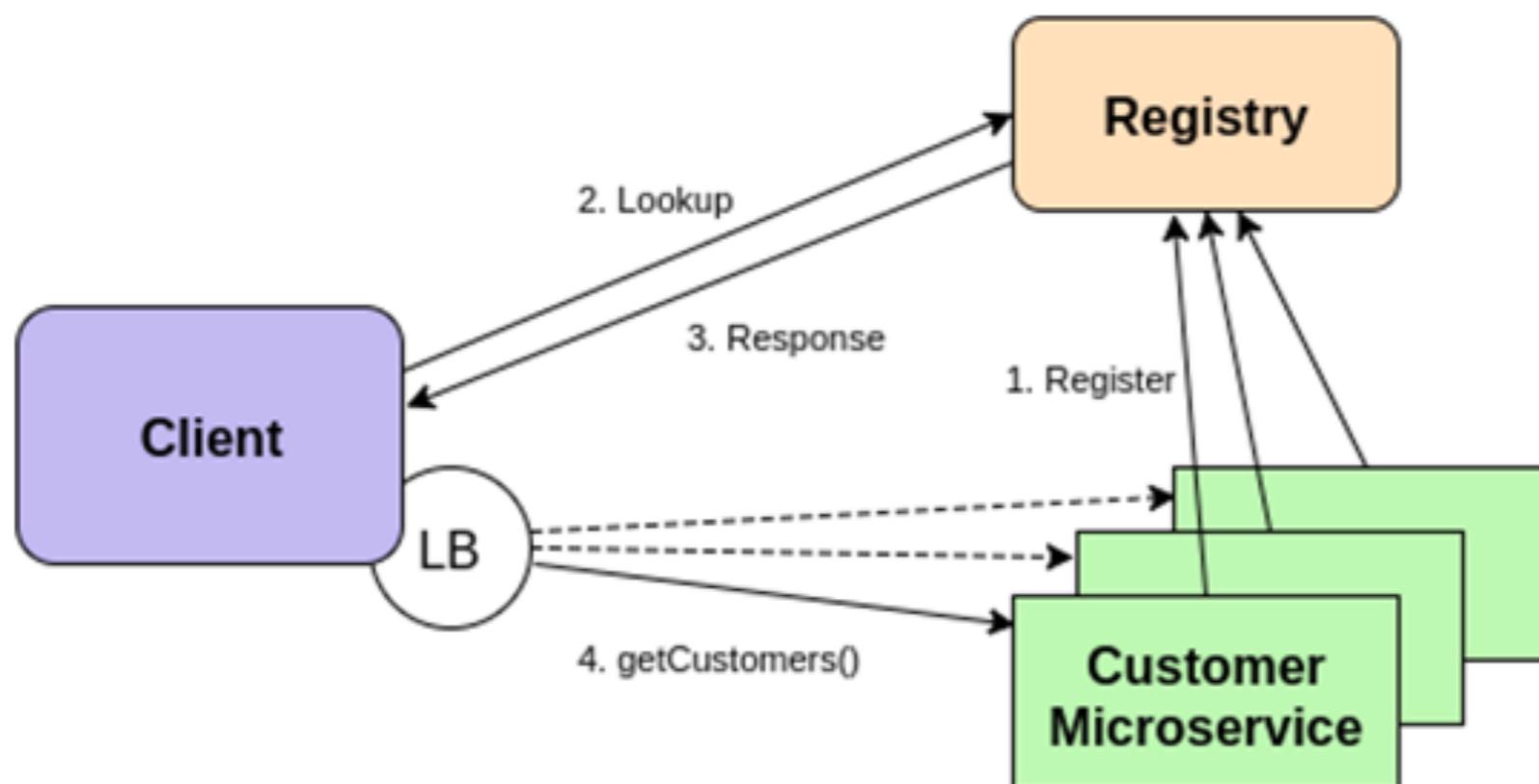
How to call another services ?



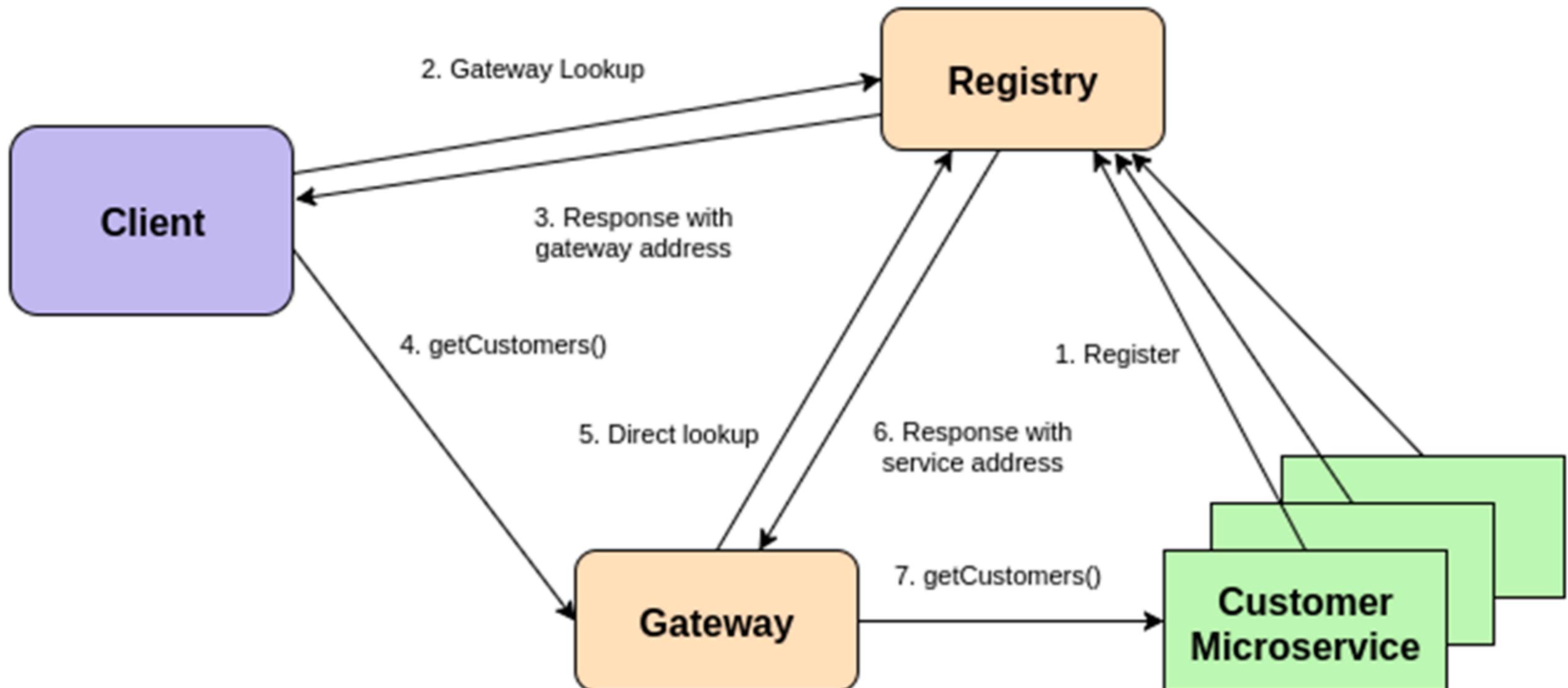
Service Discovery



Service discovery with Load balance



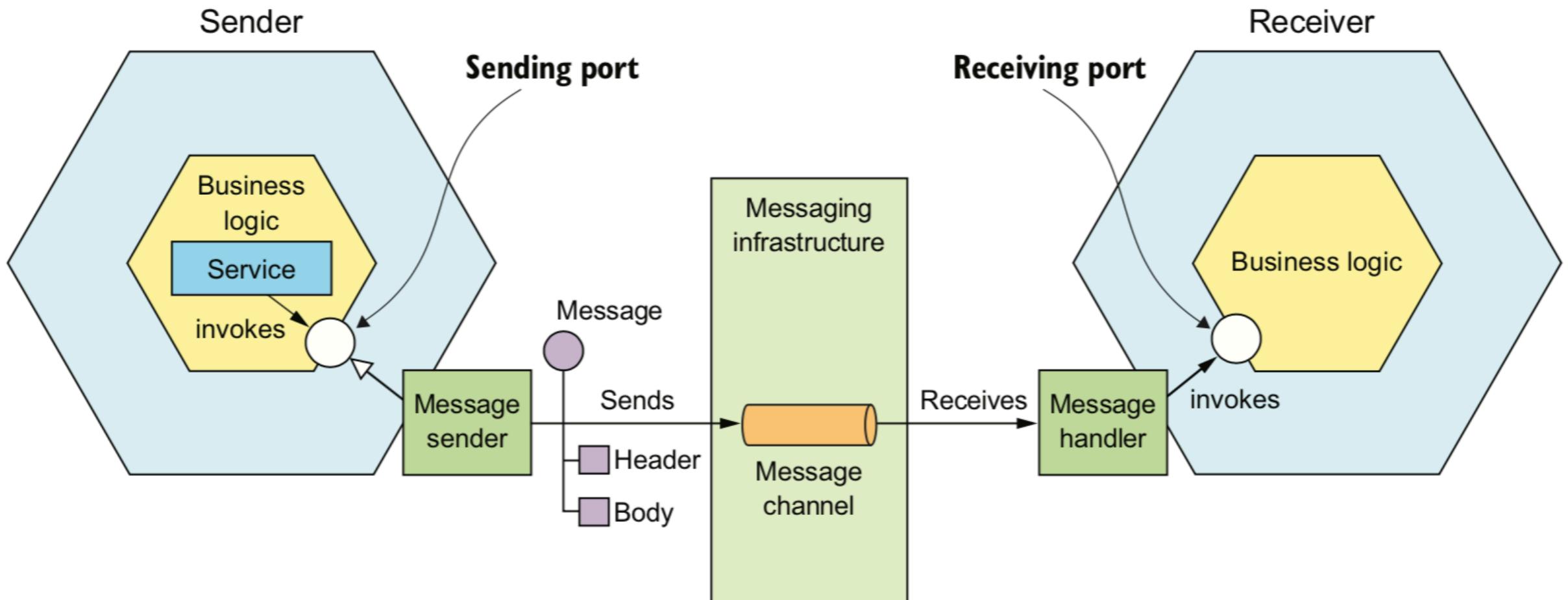
Service discovery with API gateway



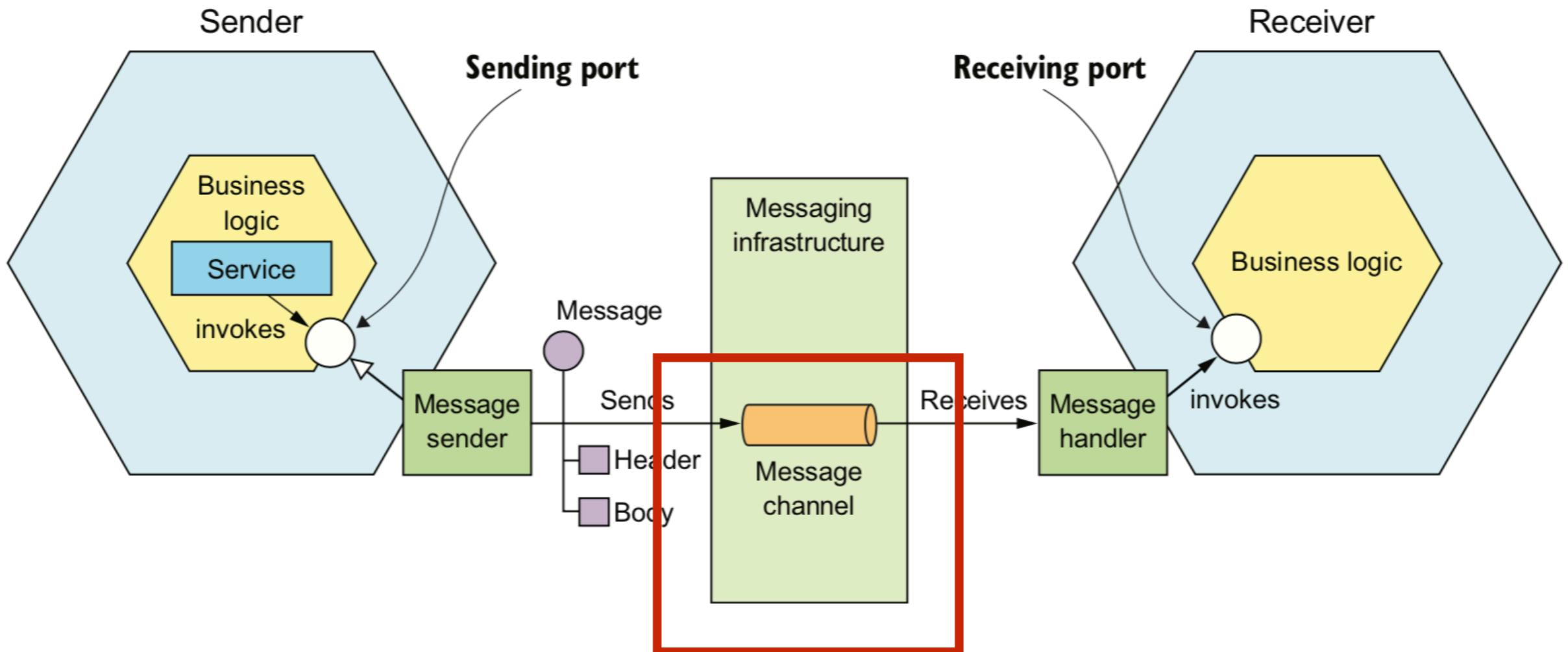
Asynchronous messaging pattern



Asynchronous messaging pattern

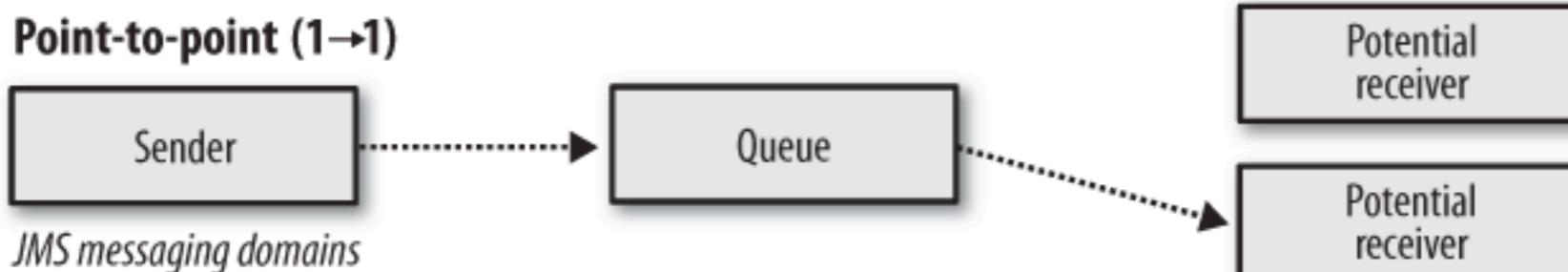
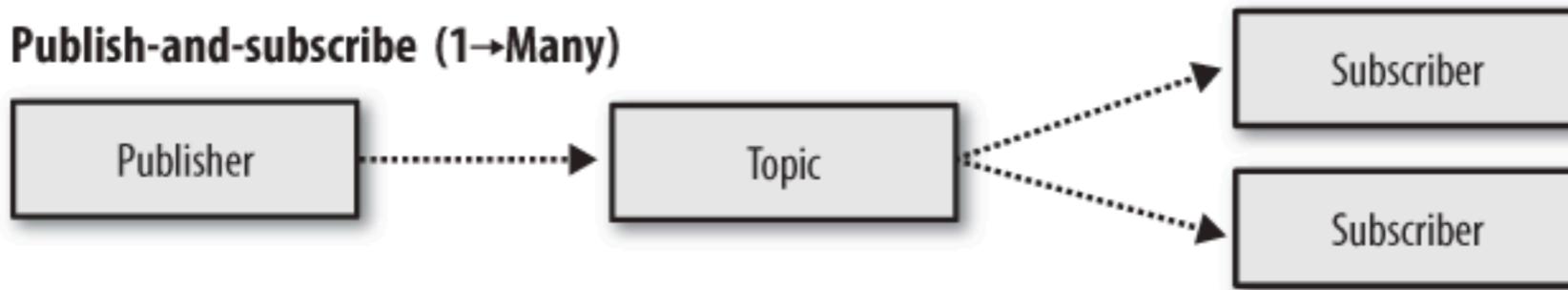


Asynchronous messaging pattern



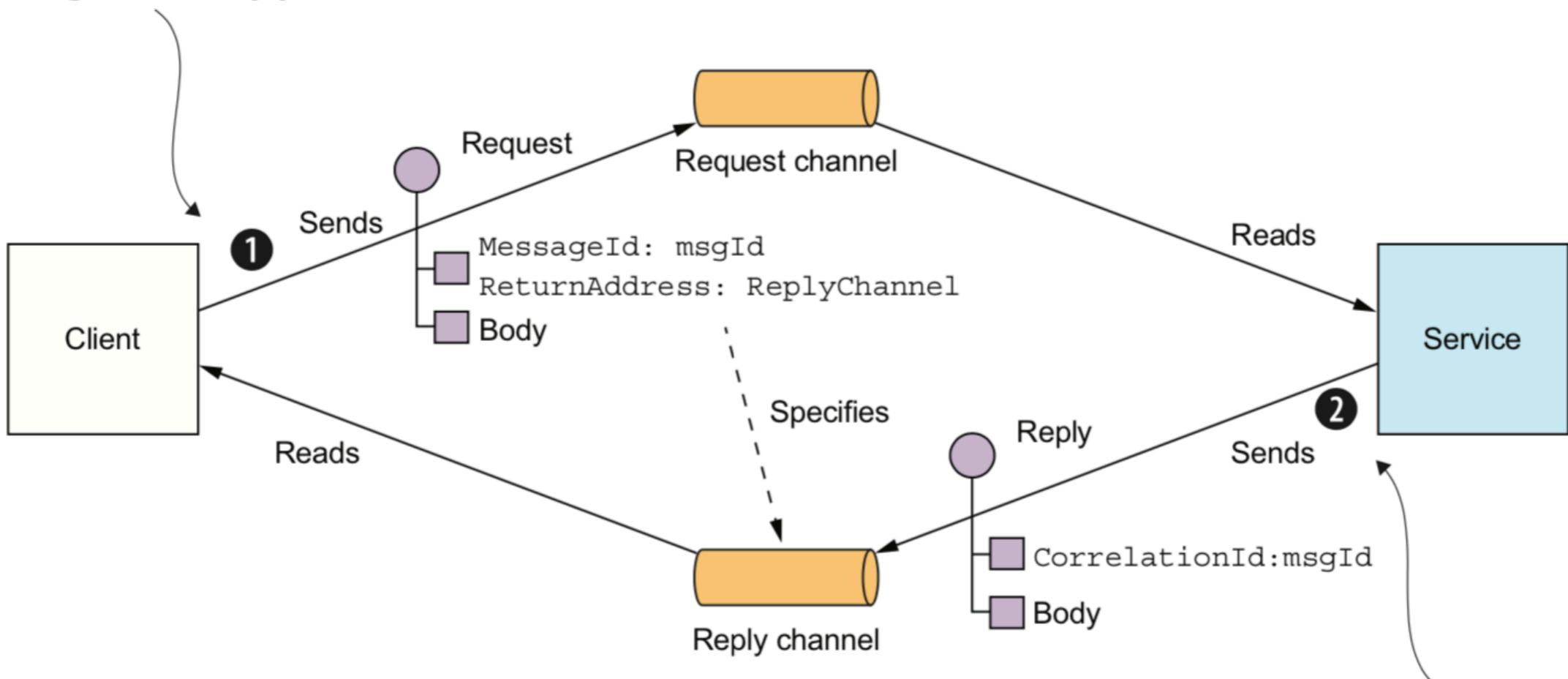
Messaging channels

Point-to-point Publish-subscribe



Async request/response (1)

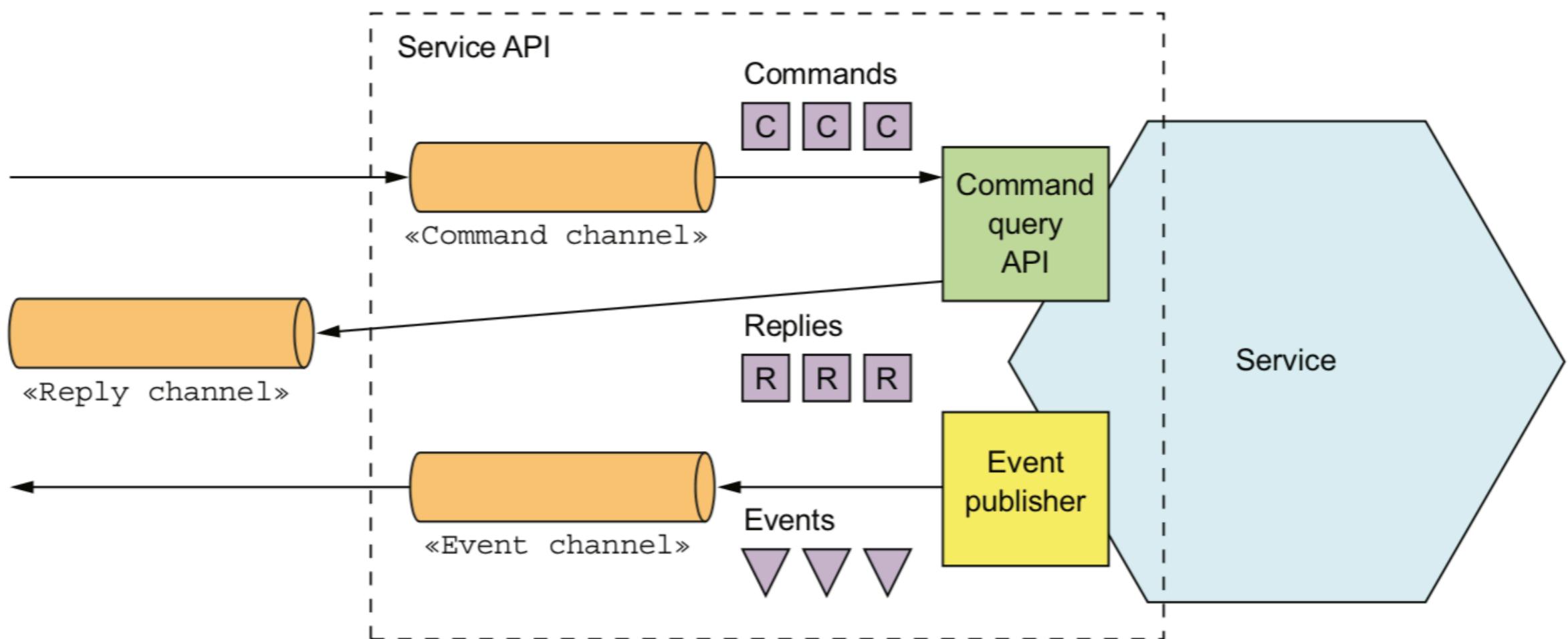
Client sends message containing msgId and a reply channel.



Service sends reply to the specified reply channel. The reply contains a correlationId, which is the request's msgId.

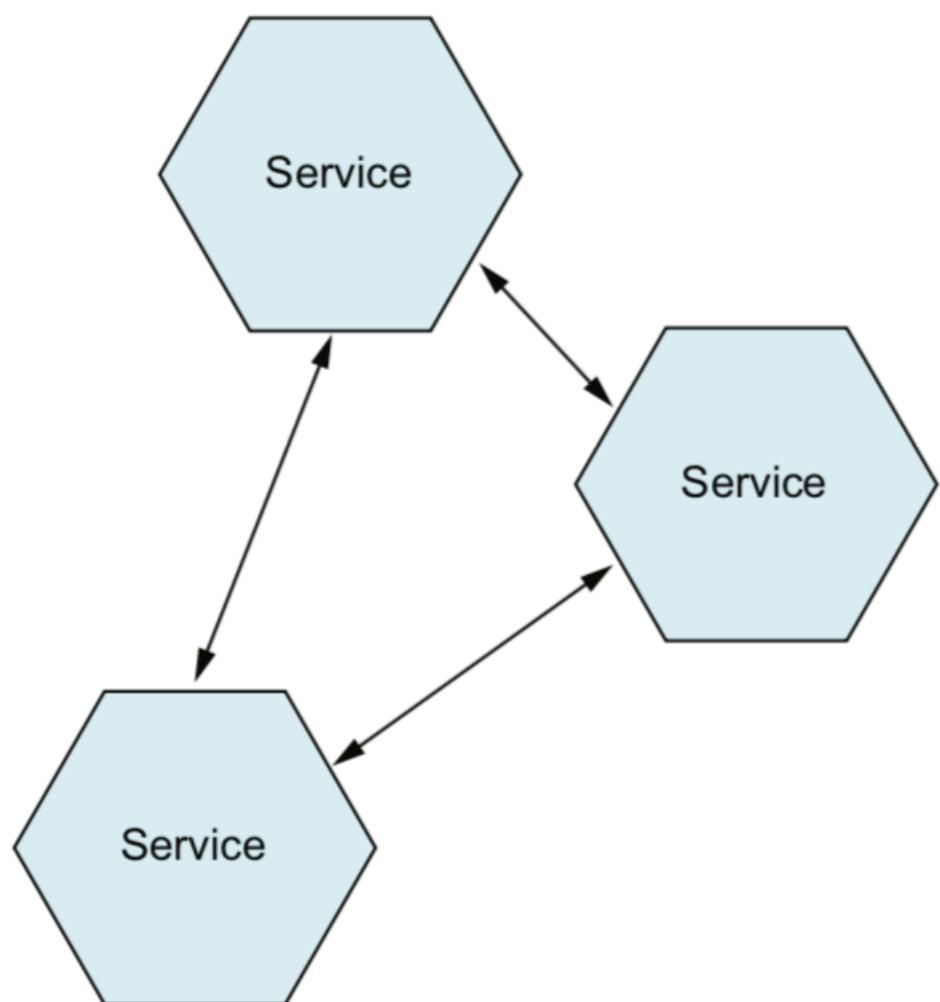


Async request/response (2)

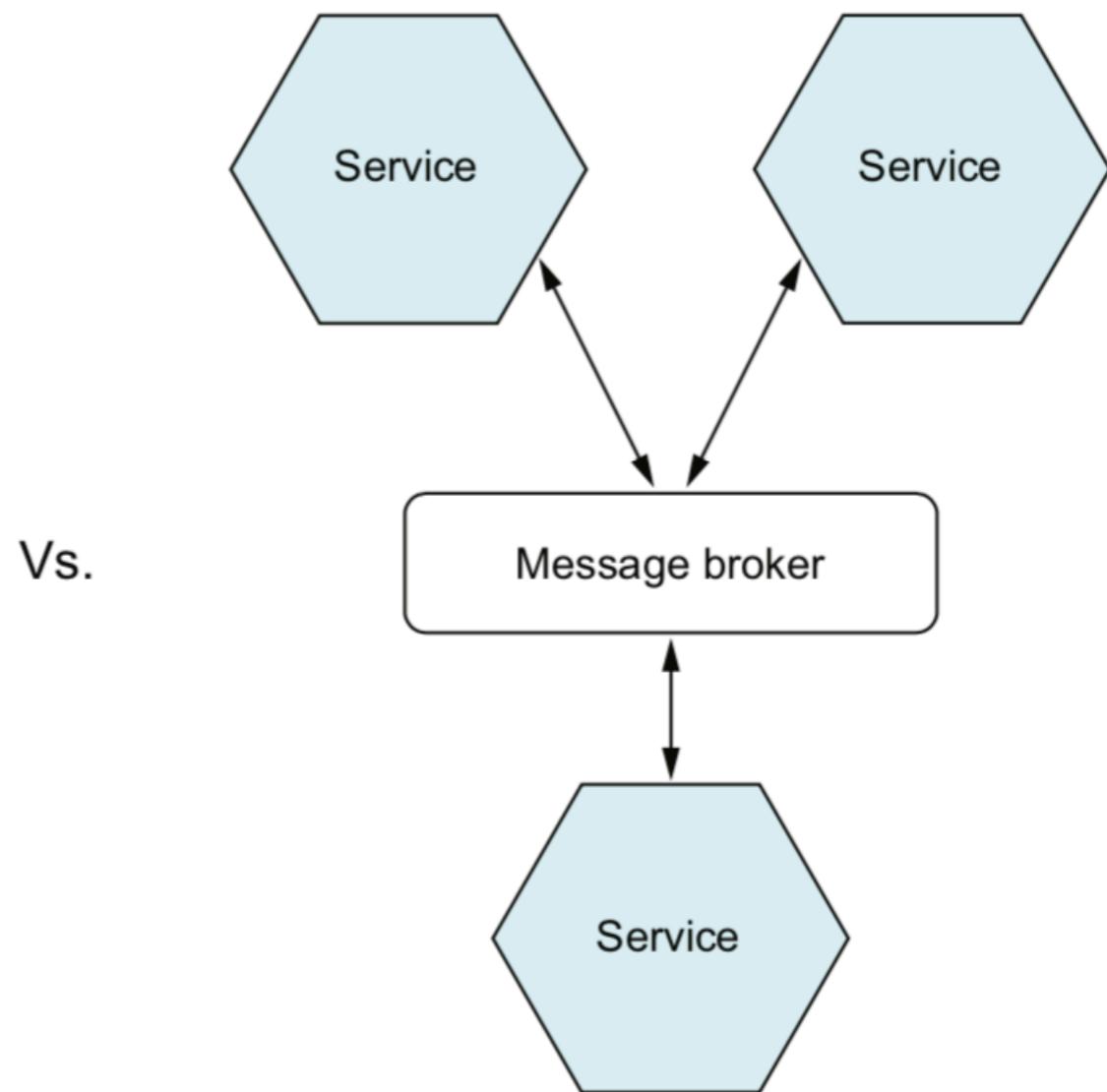


Messaging-based use message broker

Brokerless architecture



Broker-based architecture



Vs.



Message brokers



Benefits

Loose-coupling
Message buffer
Flexible communication



Drawbacks

Performance bottleneck
Single point of failure
Operational complexity

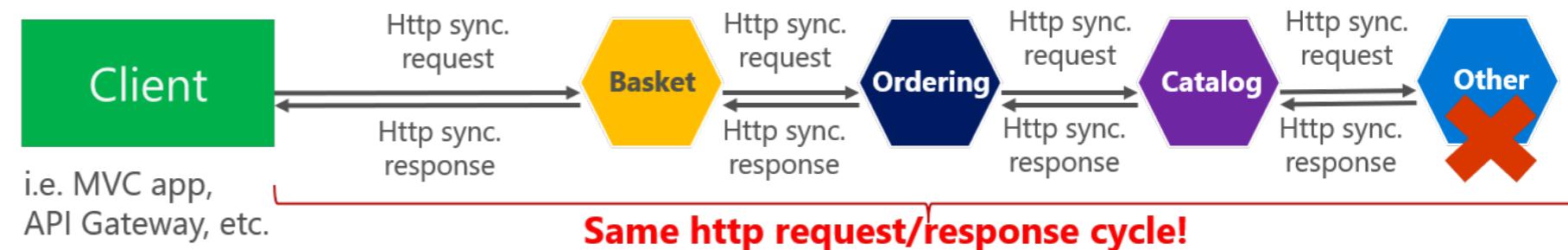


Communication

Synchronous vs. async communication across microservices

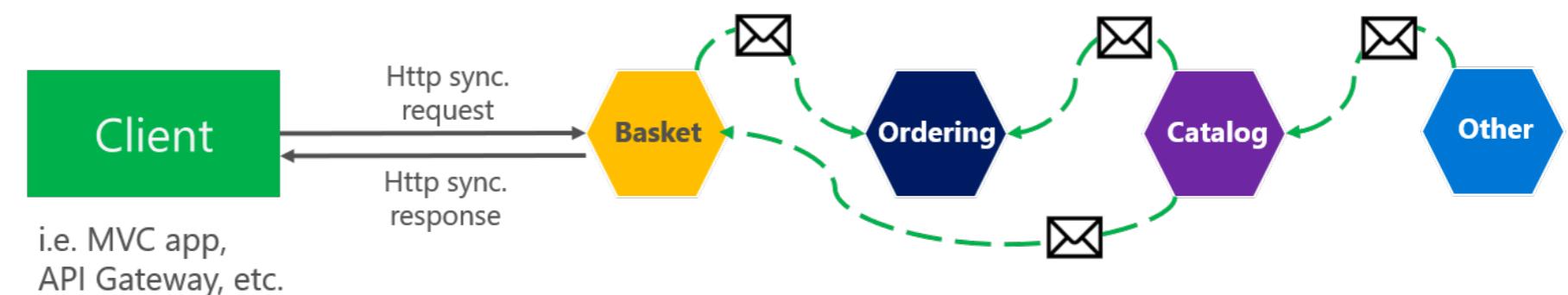
Anti-pattern

Synchronous
all req./resp. cycle



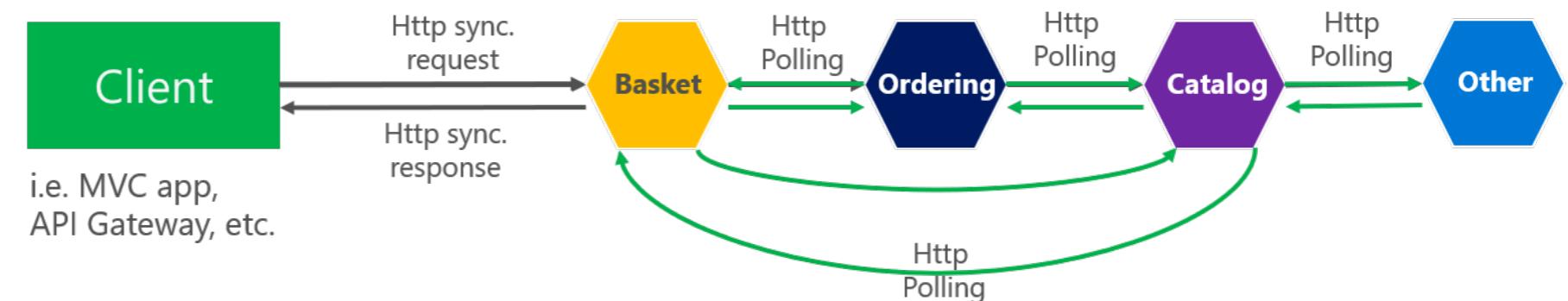
Asynchronous

Comm. across
internal microservices
(EventBus: i.e. **AMQP**)

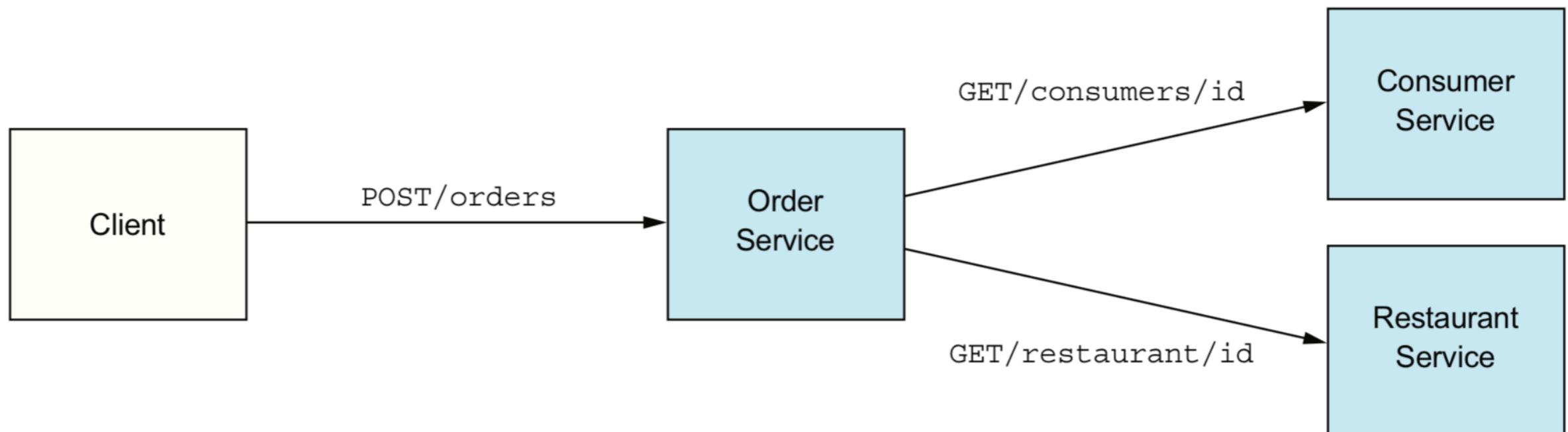


"Asynchronous"

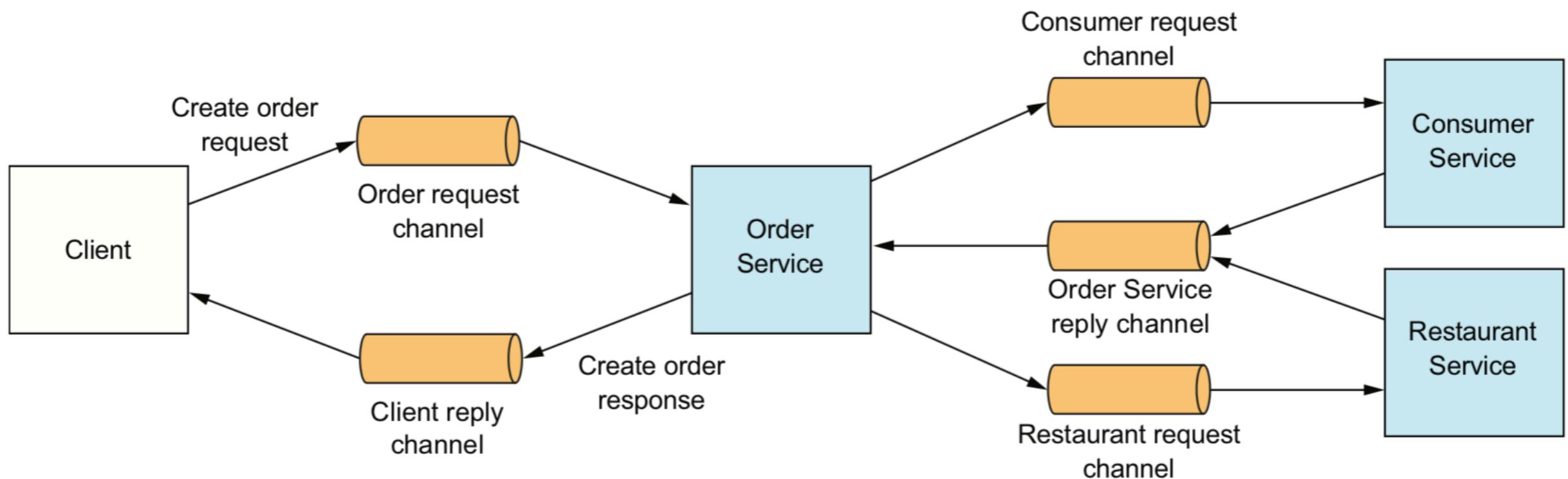
Comm. across
internal microservices
(Polling: **Http**)



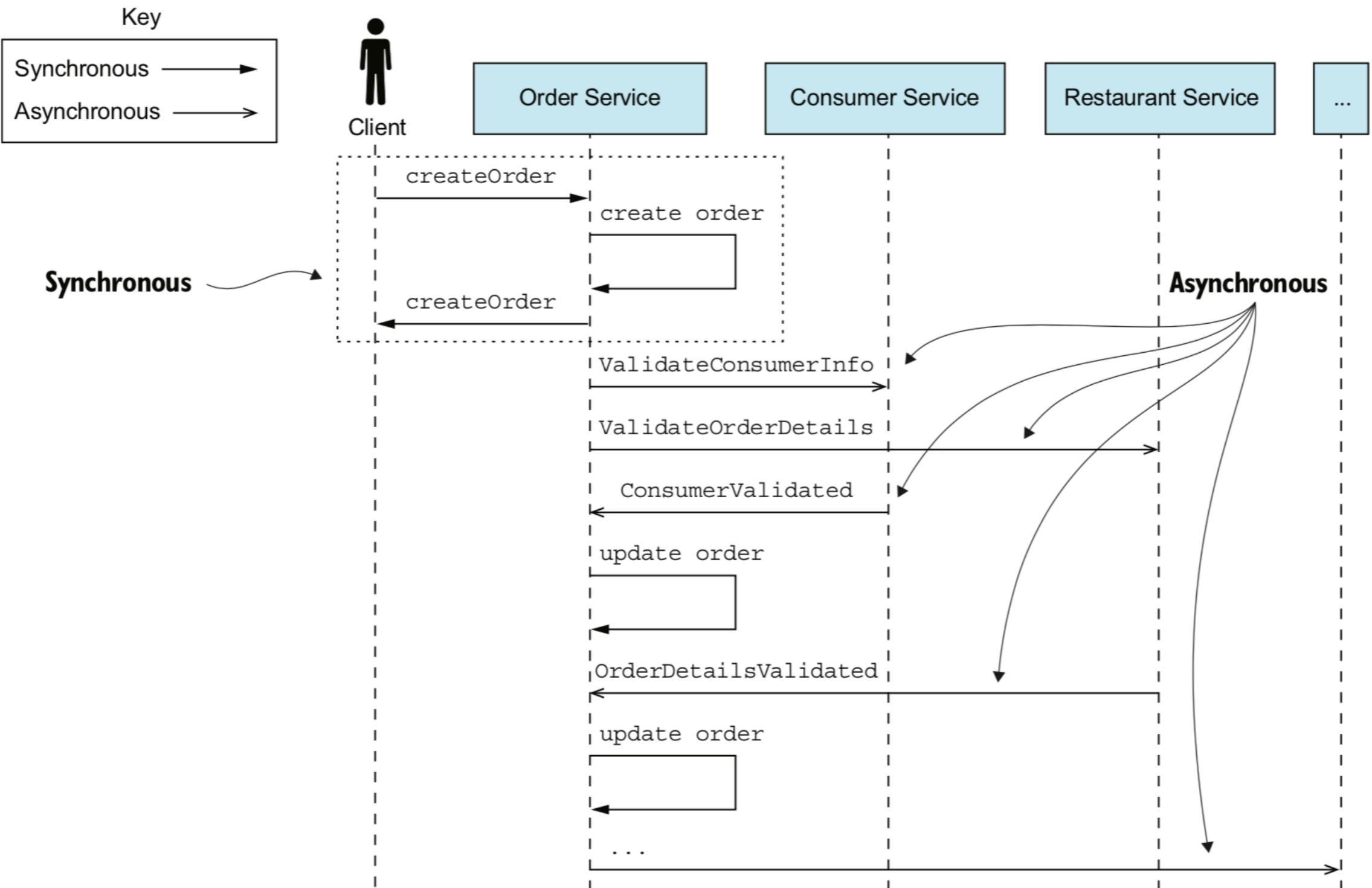
Synchronous reduce availability



Replace with asynchronous (1)



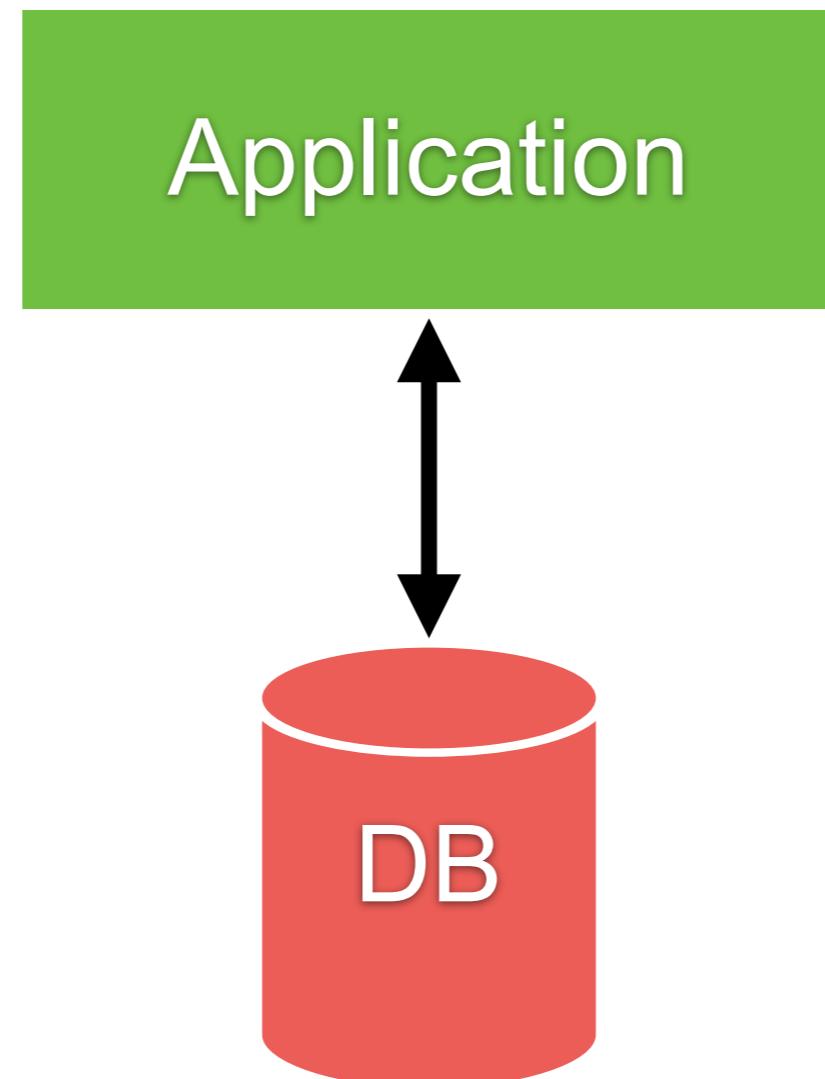
Replace with asynchronous (2)



Manage data consistency

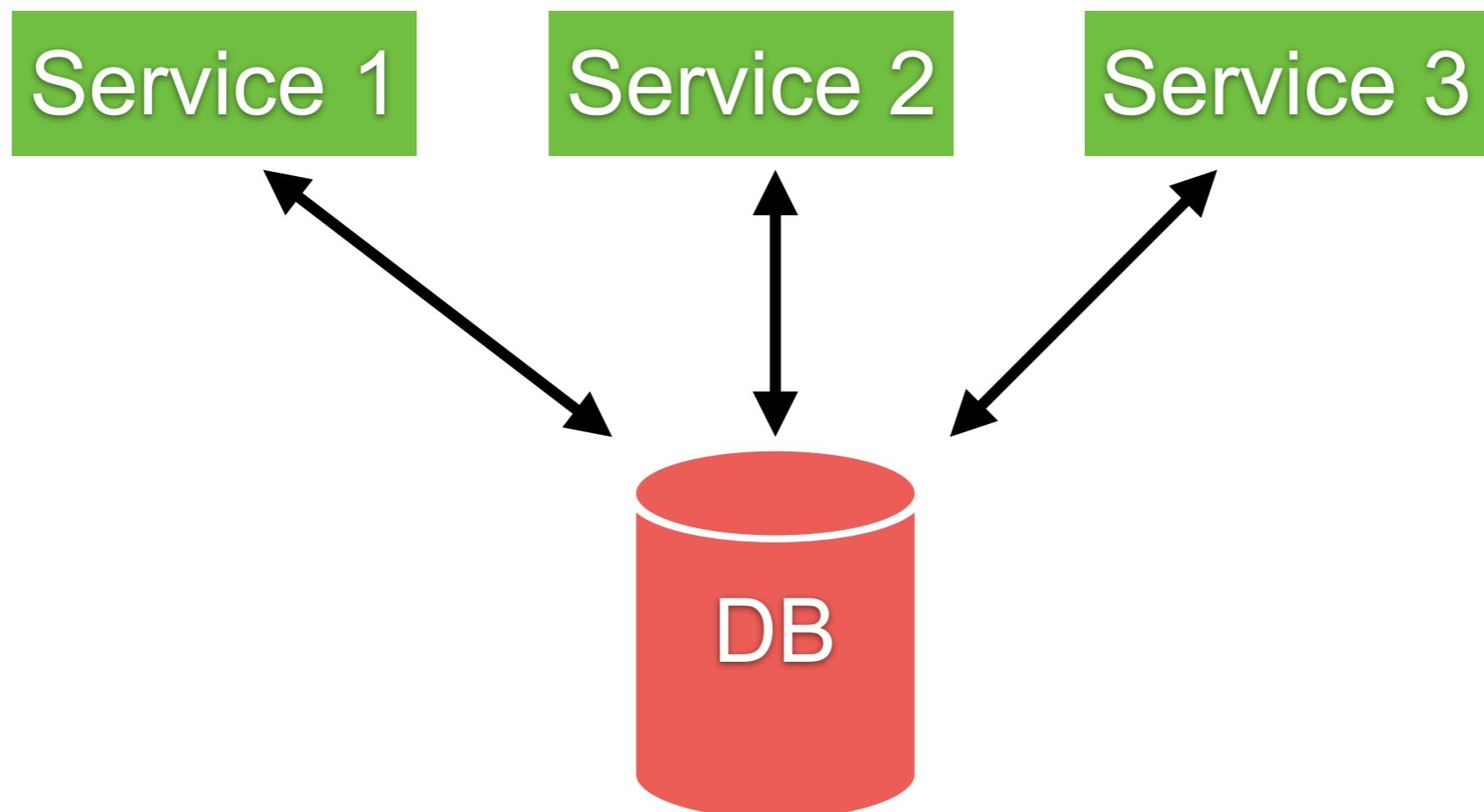


Monolithic



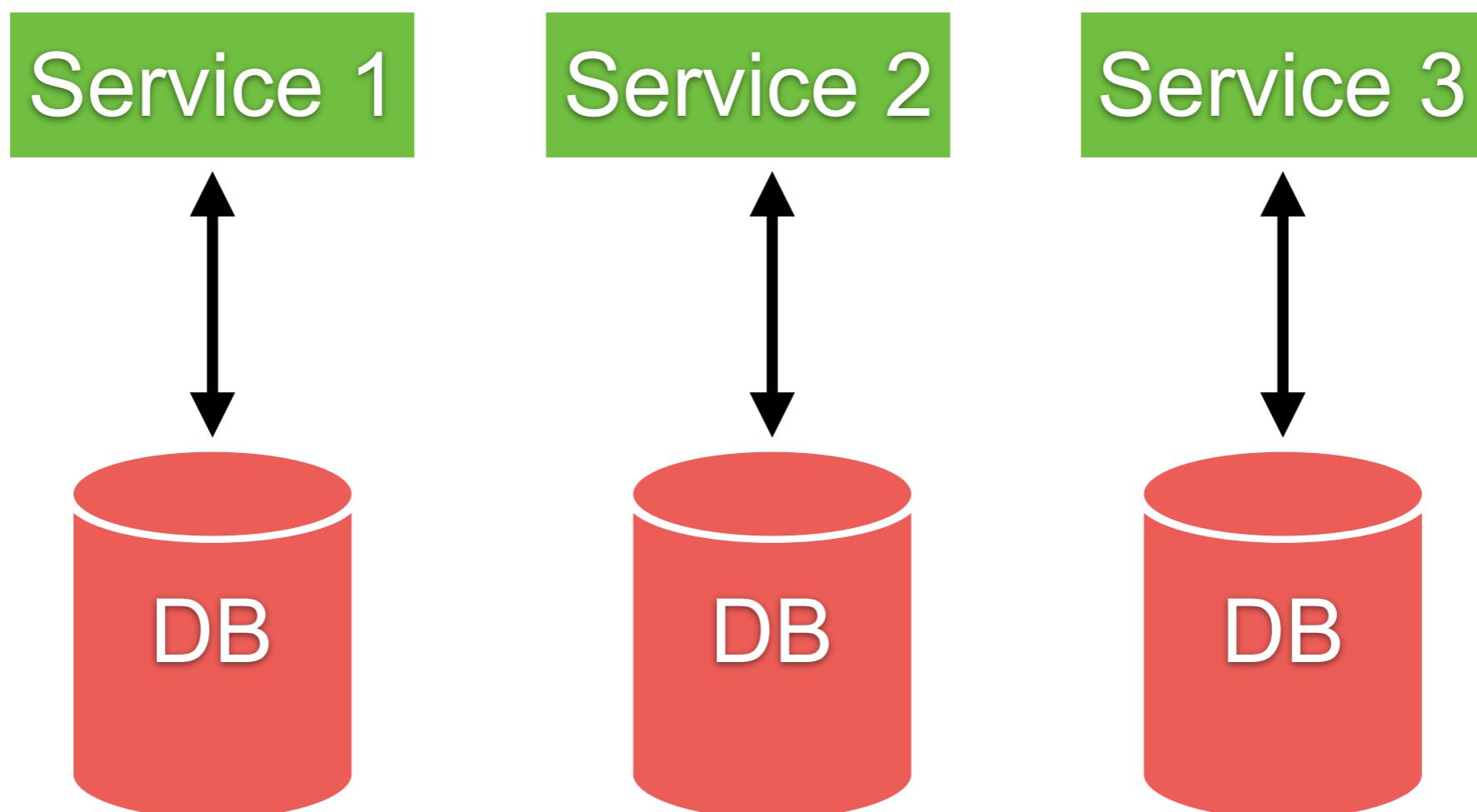
Microservices

Shared database

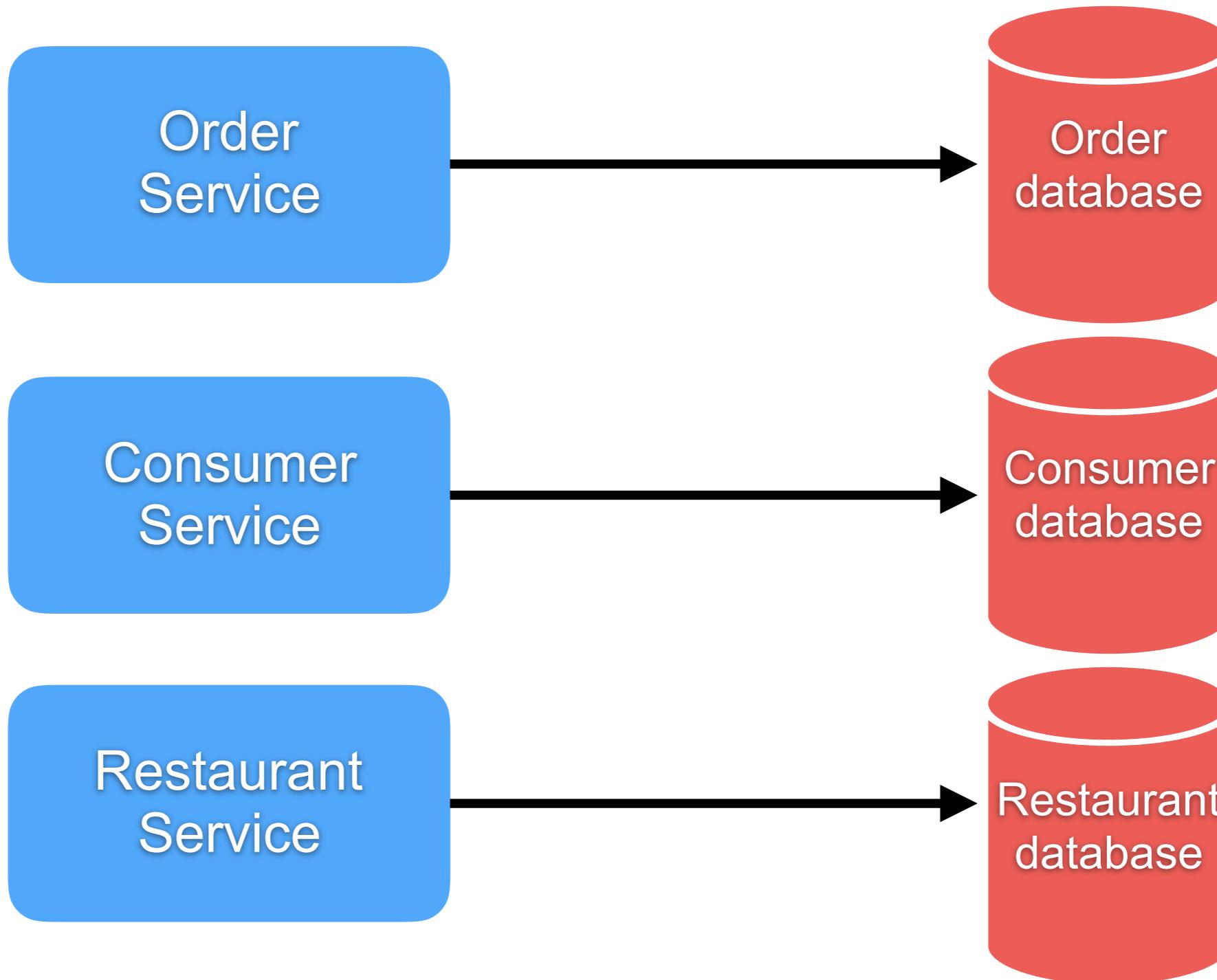


Microservices

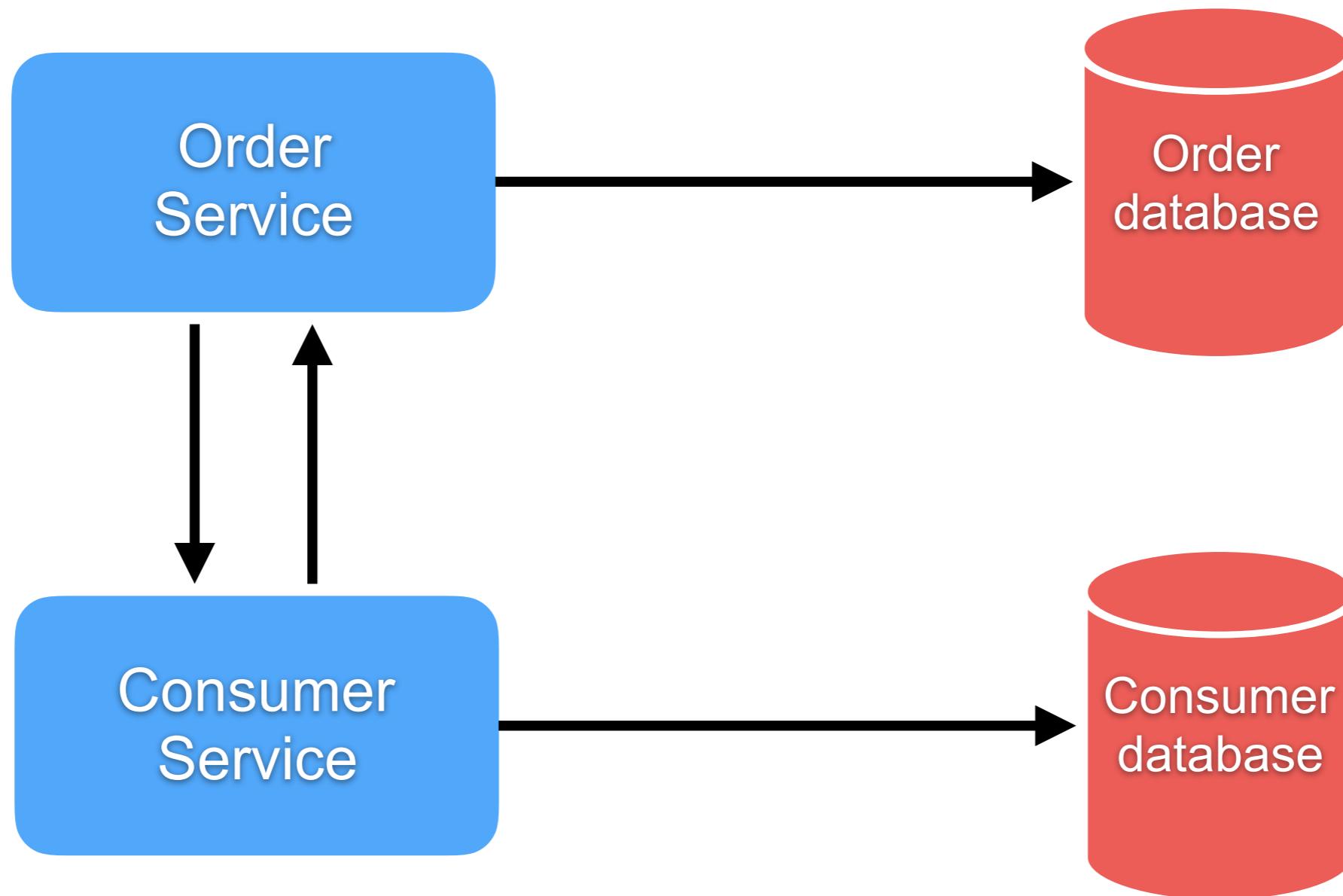
Database per service



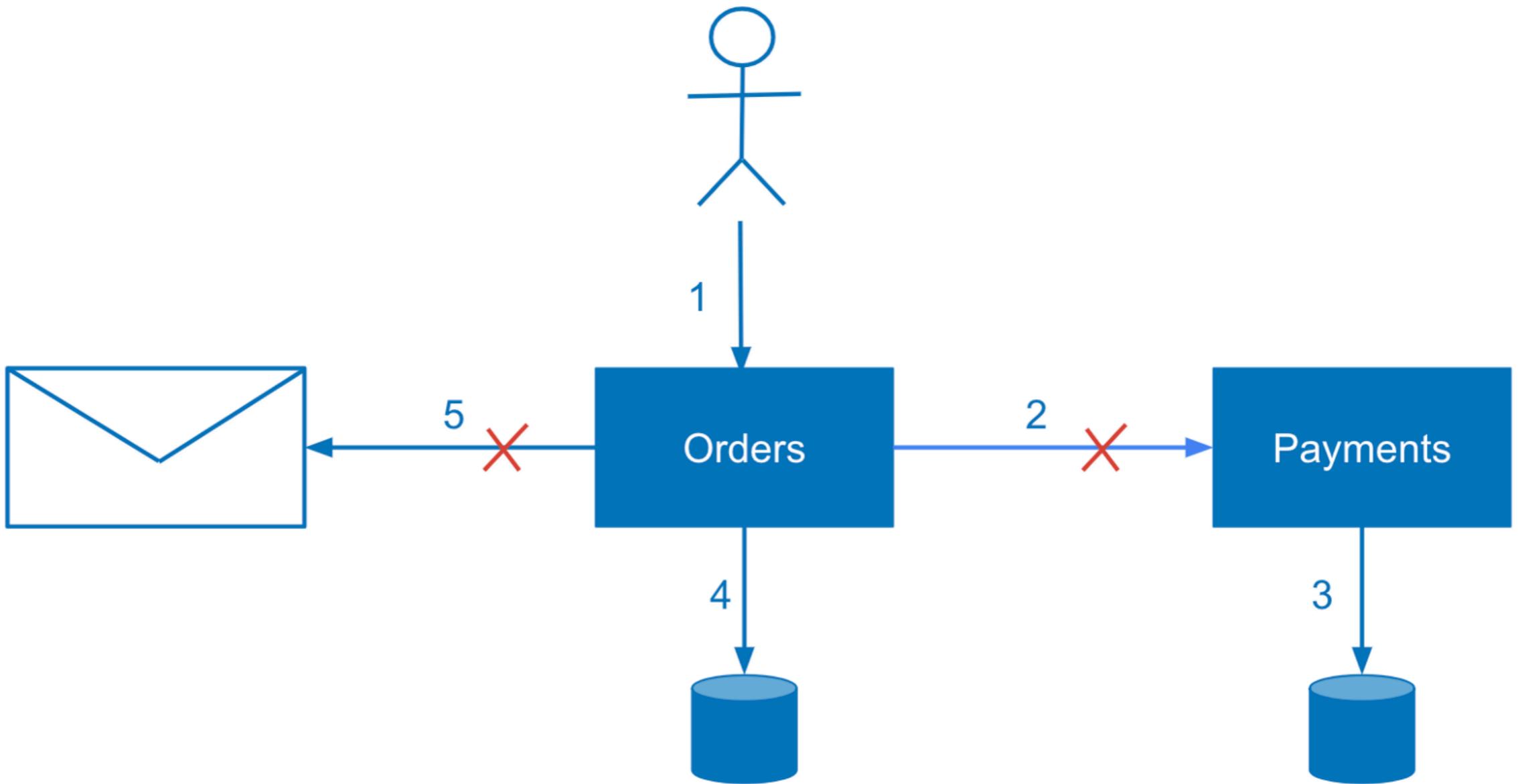
Database per service



Loose coupling = encapsulation data

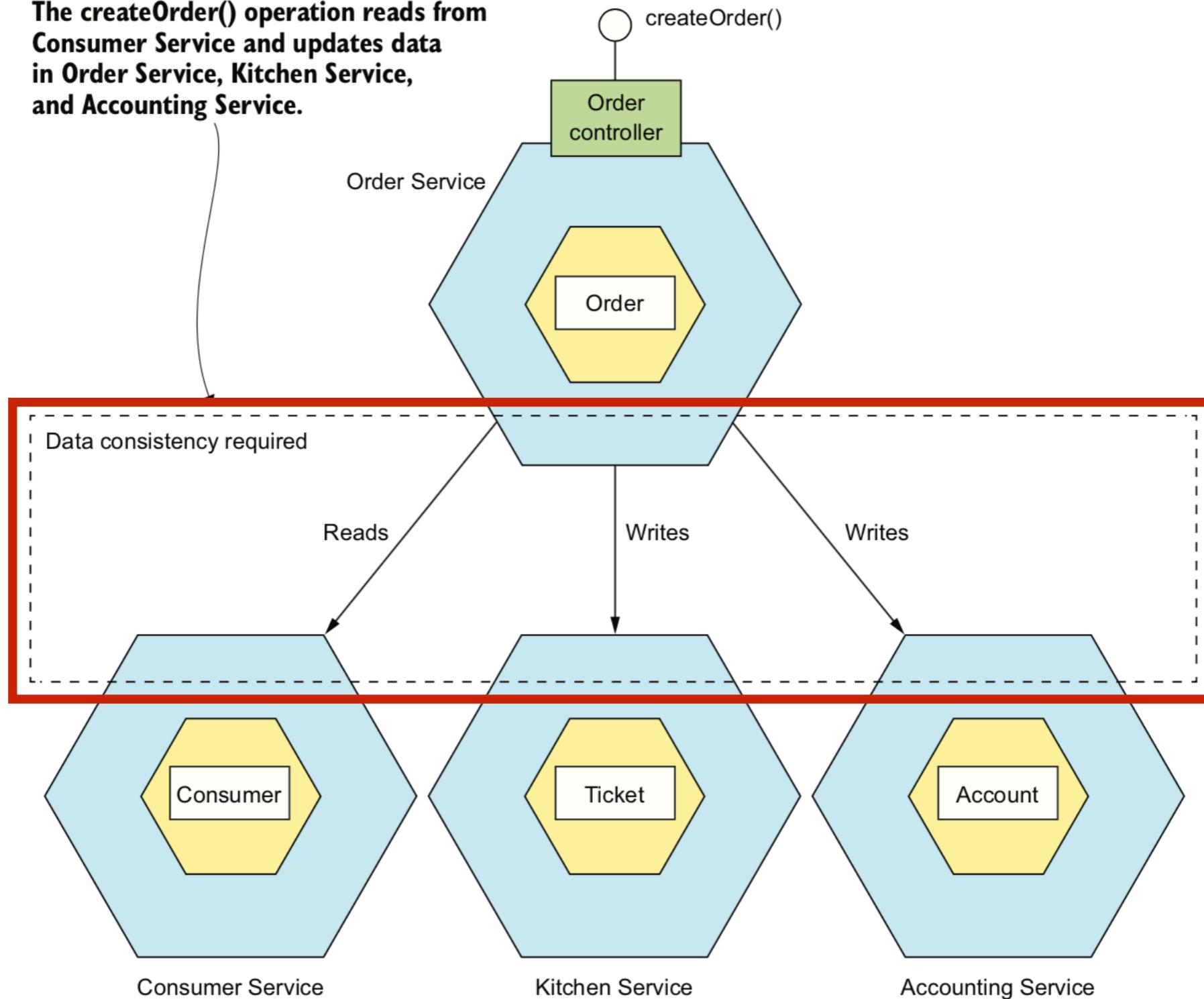


Distributed process failure !!



Problem ?

The **createOrder()** operation reads from Consumer Service and updates data in Order Service, Kitchen Service, and Accounting Service.



Can't use **ACID** transaction !!



A - Atomicity

All or Nothing Transactions

C - Consistency

Guarantees Committed Transaction State

I - Isolation

Transactions are Independent

D – Durability

Committed Data is Never Lost

(c) <http://blog.sqlauthority.com>

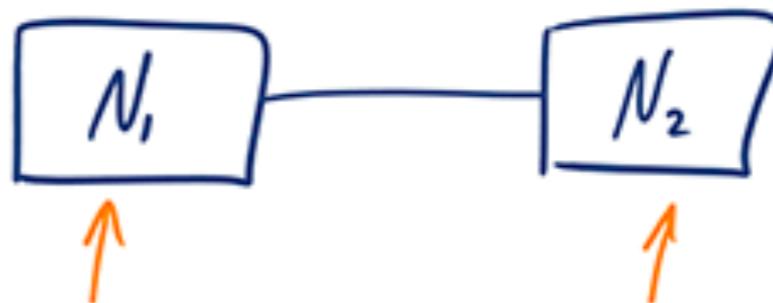


CAP Theorem

Consistency



Availability



Partition Tolerance



<http://robertgreiner.com/2014/08/cap-theorem-revisited/>



Database per service

High complexity

Query data across multiple databases

Challenge “How to join data ?”

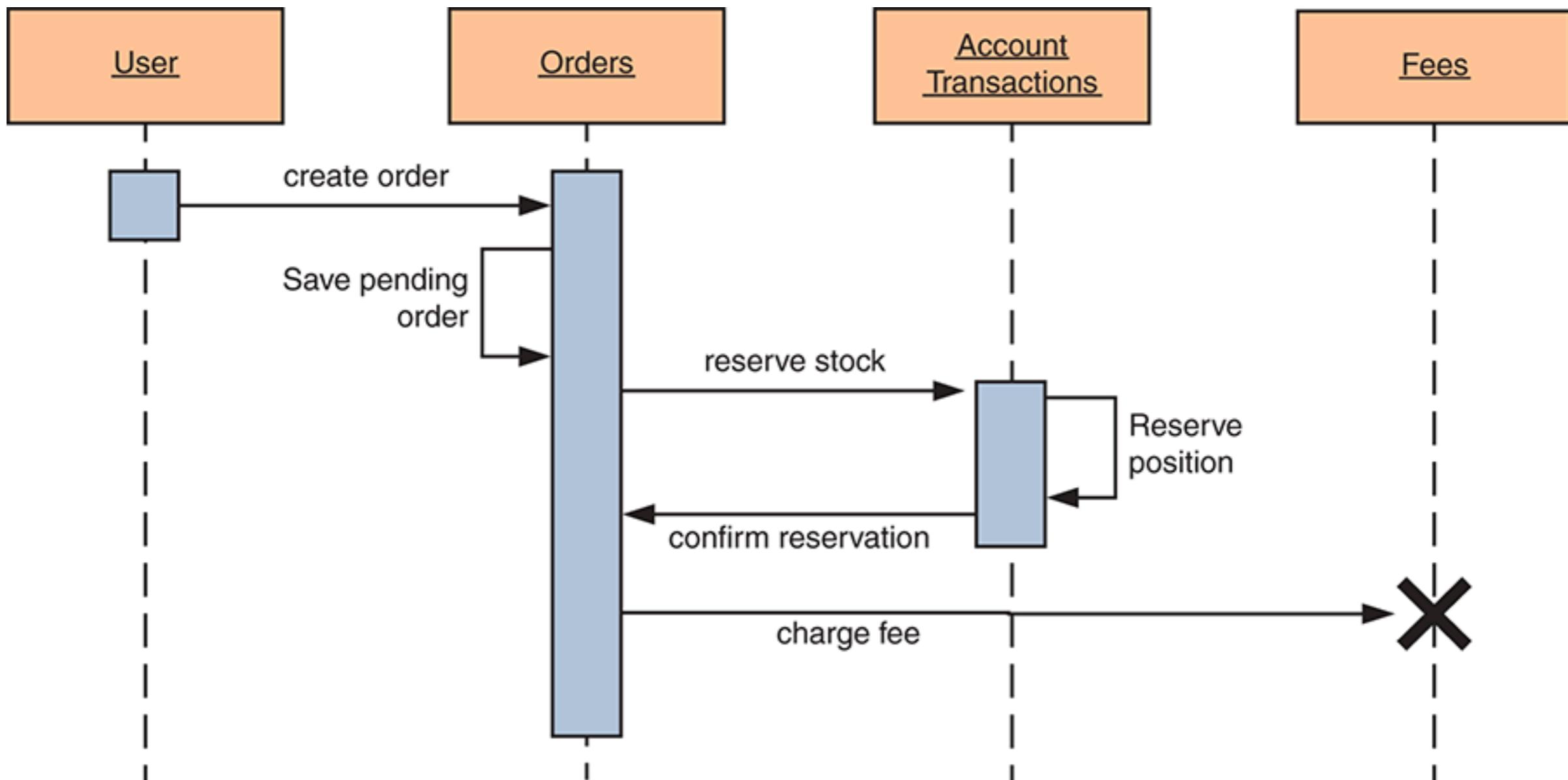
Maintain database consistency



How to maintain data consistency across services ?



Problem



Distributed transaction

Common approach is Two-phase commit(2PC)

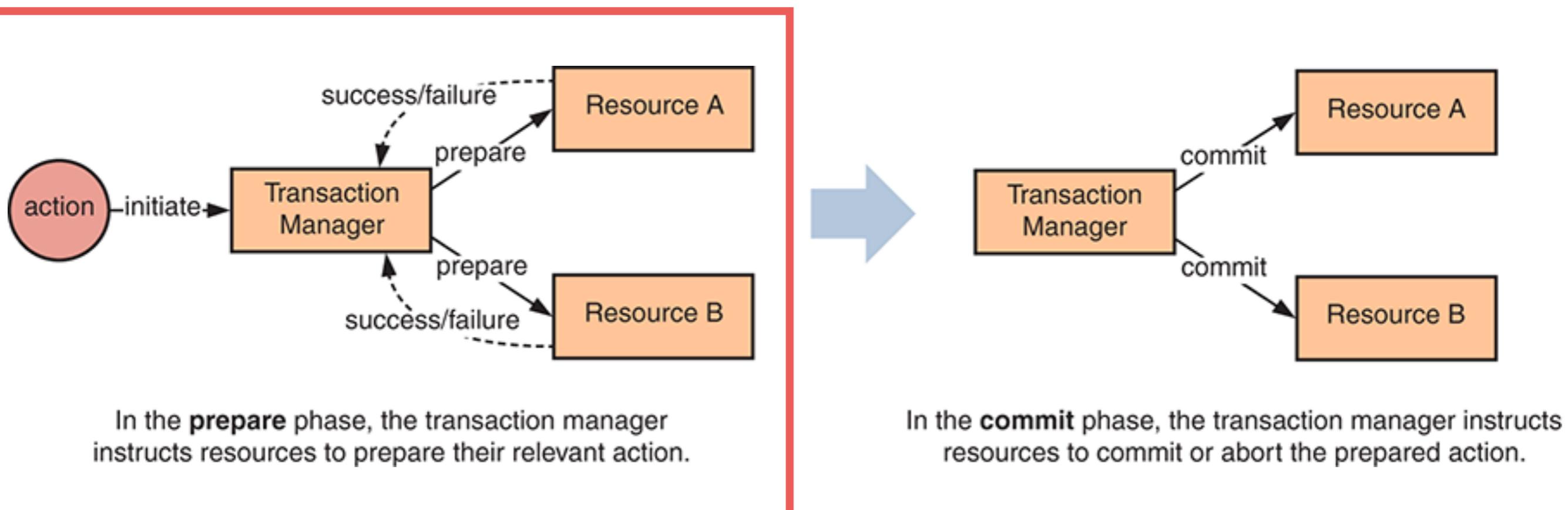
Use transaction manager to split operations across multiple resources in 2 phases

1. *Prepare*
2. *Commit*



Two-phase commit

Phase 1: prepare

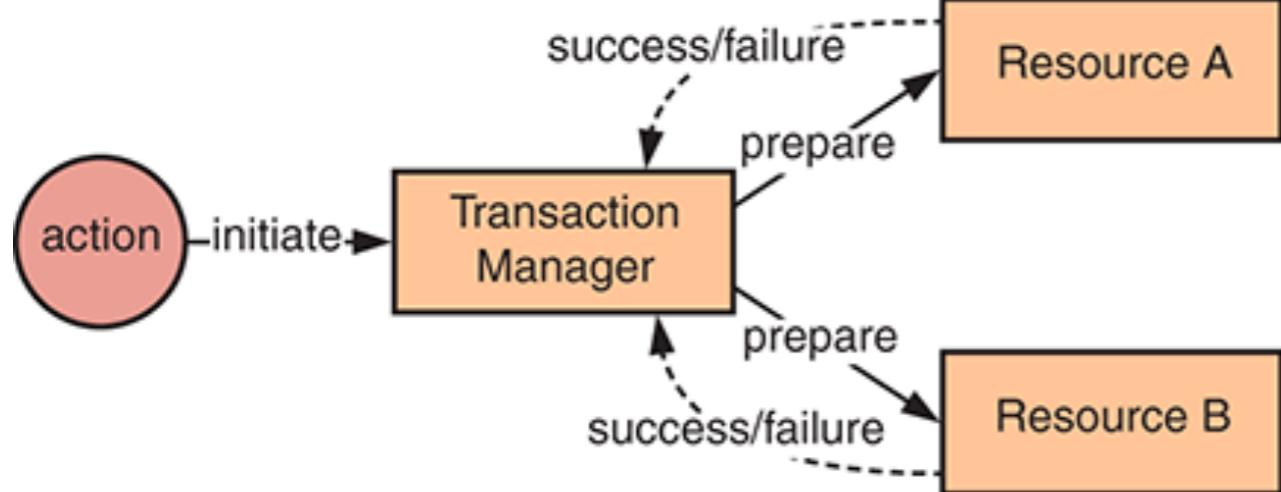


https://en.wikipedia.org/wiki/Two-phase_commit_protocol

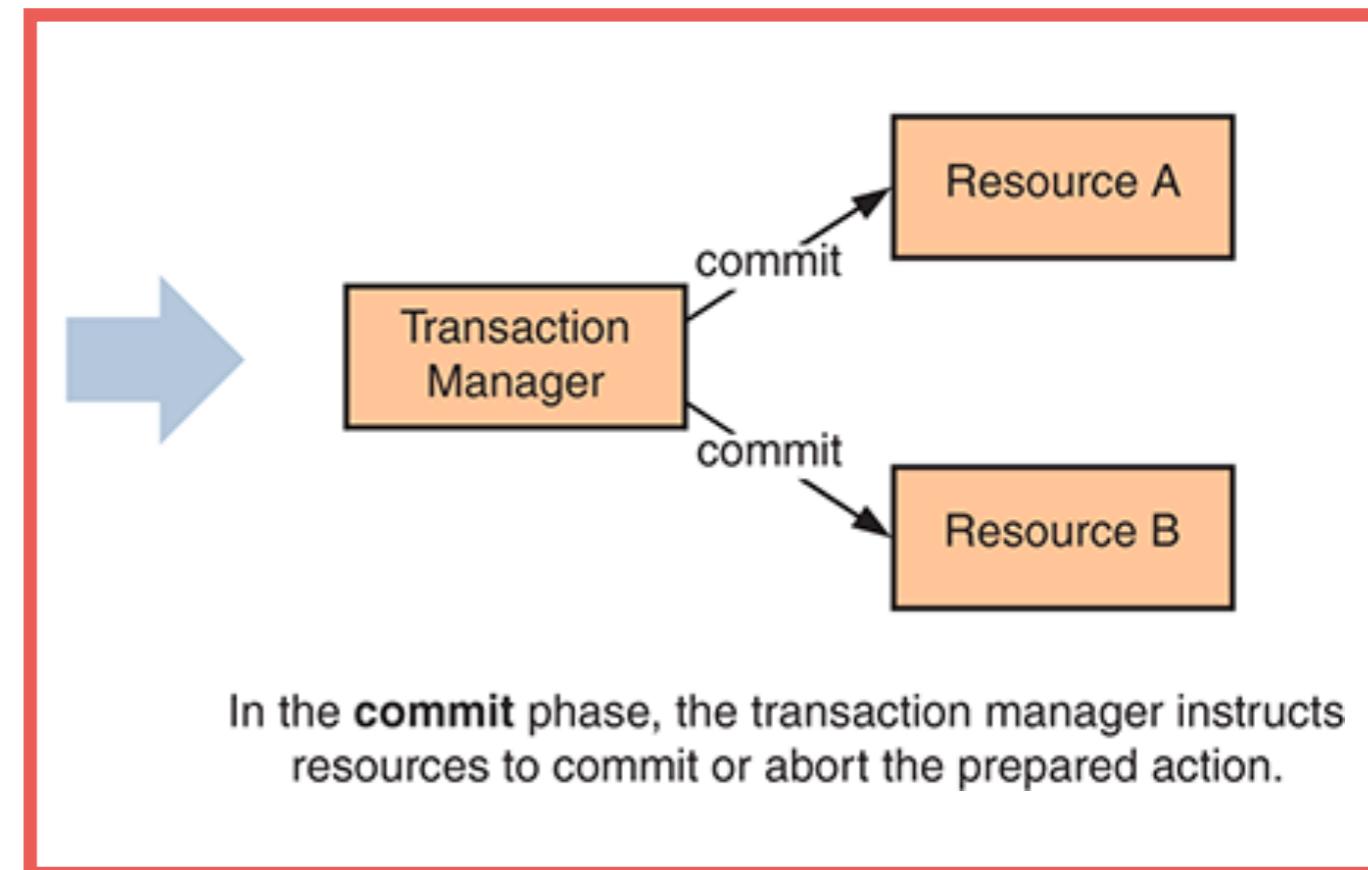


Two-phase commit

Phase 2: commit



In the **prepare** phase, the transaction manager instructs resources to prepare their relevant action.



In the **commit** phase, the transaction manager instructs resources to commit or abort the prepared action.

https://en.wikipedia.org/wiki/Two-phase_commit_protocol



**Distributed transaction places
a lock on resources under
transaction to ensure isolation**



Inappropriate for long-running operations



Increase risk of contention and deadlock

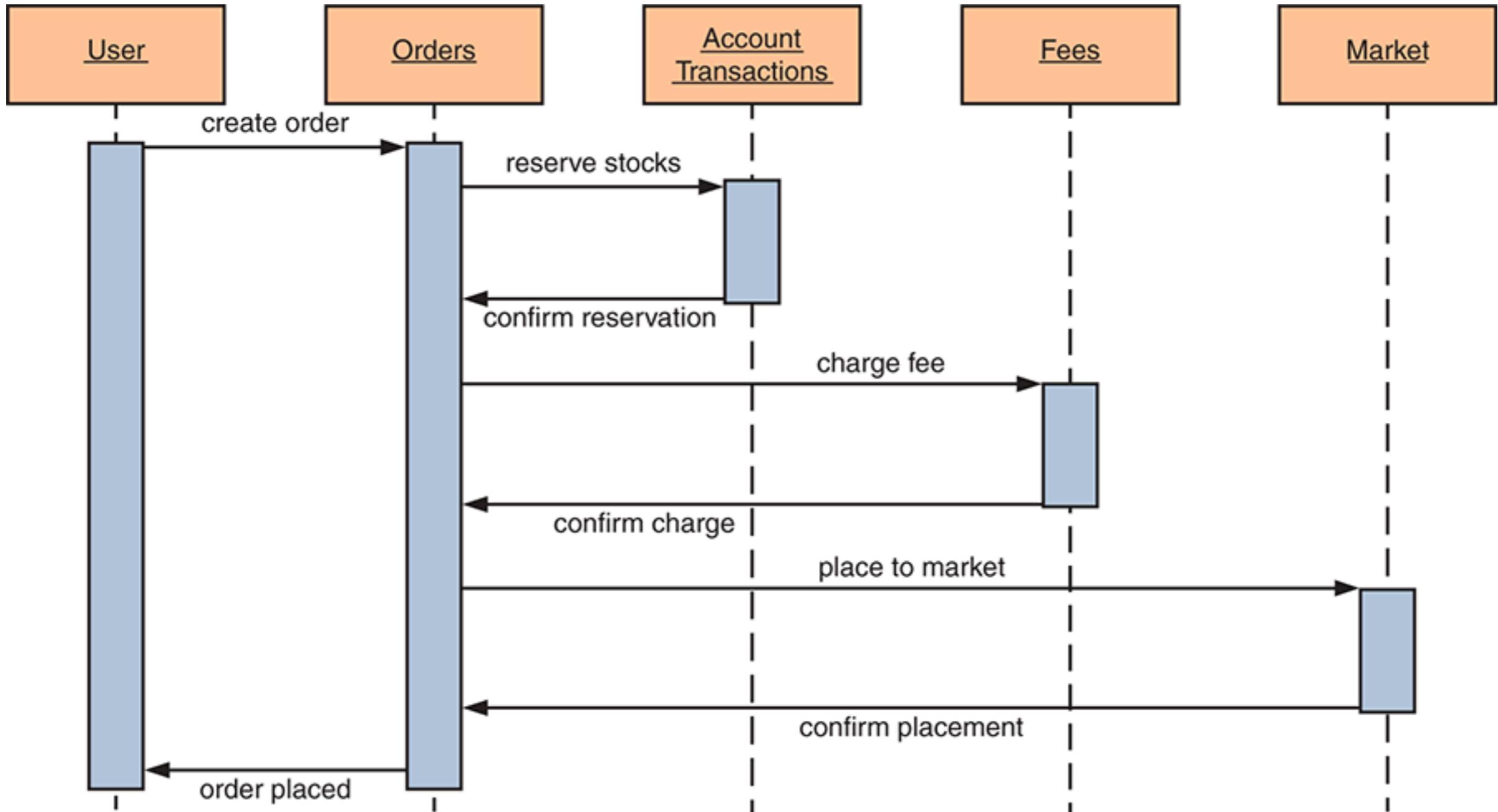


We need ...

Don't need distributed transaction
Reduce complexity of code
Reliable



Synchronous process

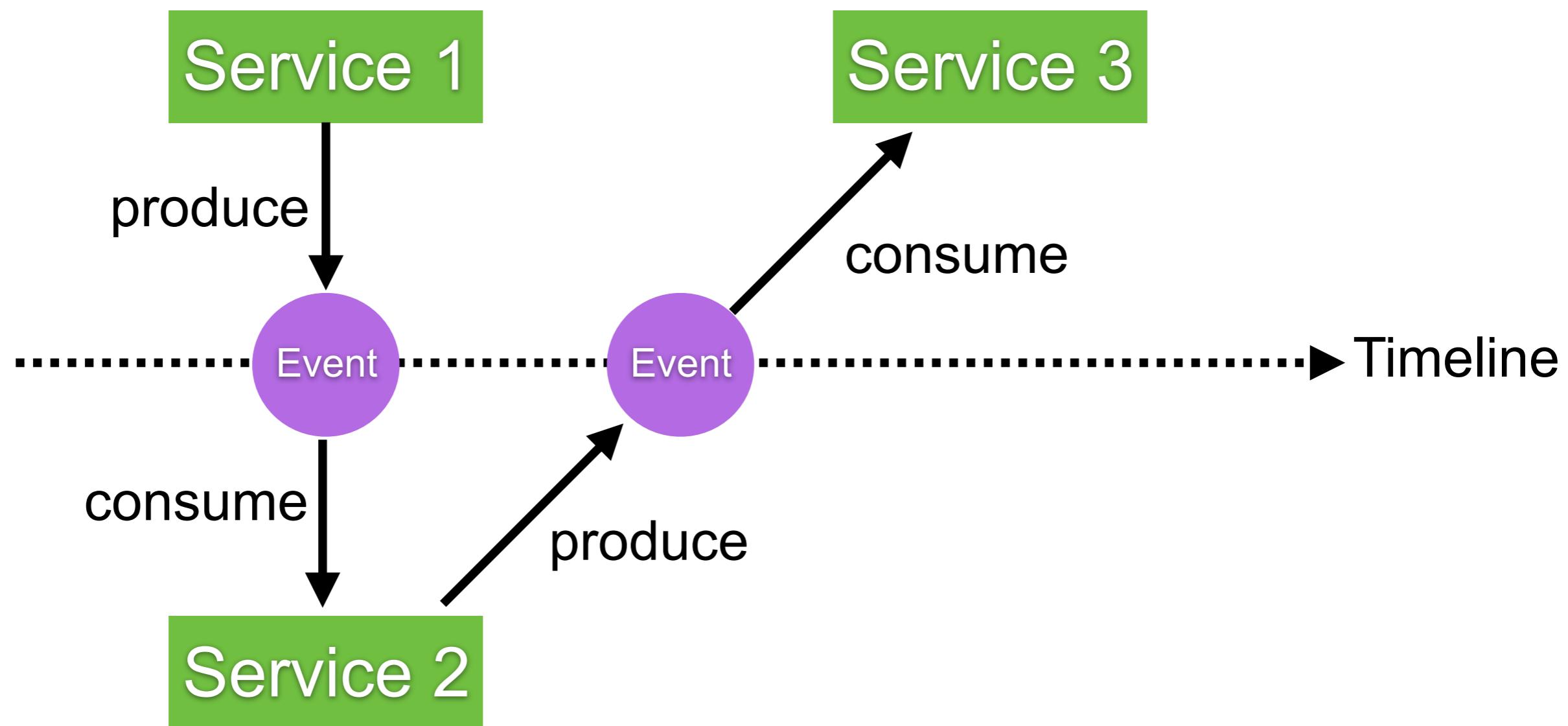


Event-based communication



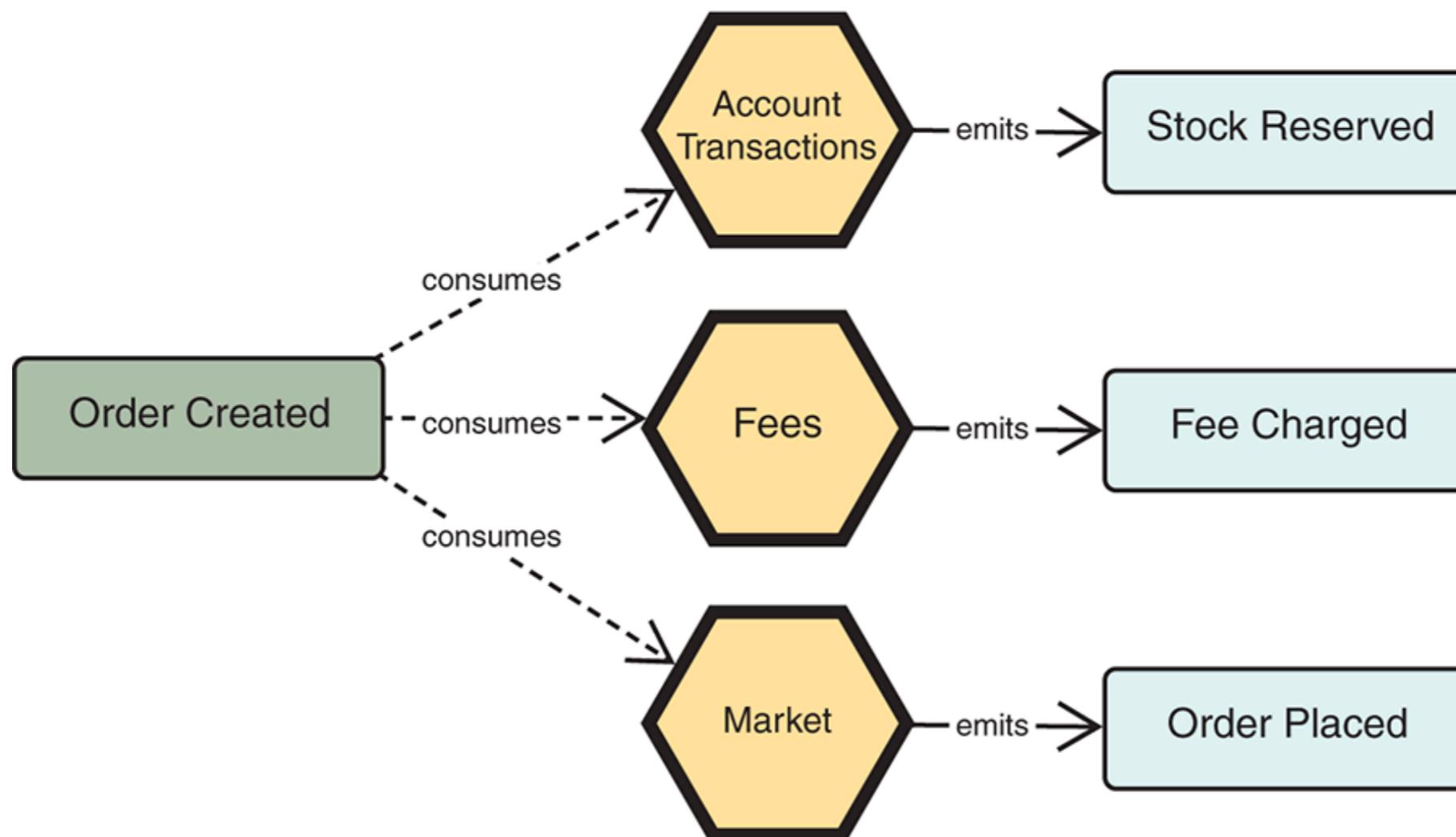
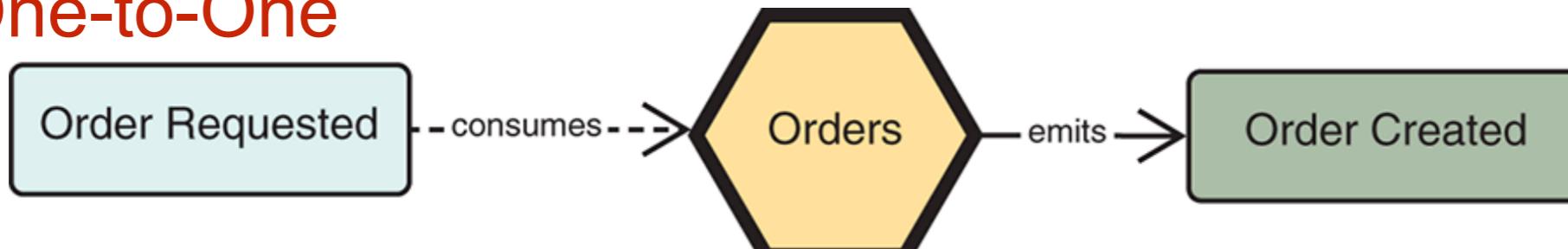
Choreography pattern

Sequence of Tx and emit **event** or **message** that trigger the next process in Tx

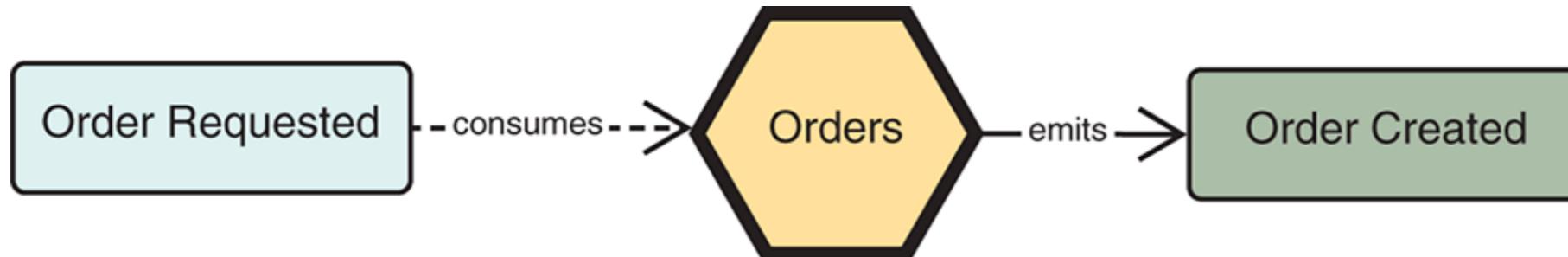


Service consume and emit event

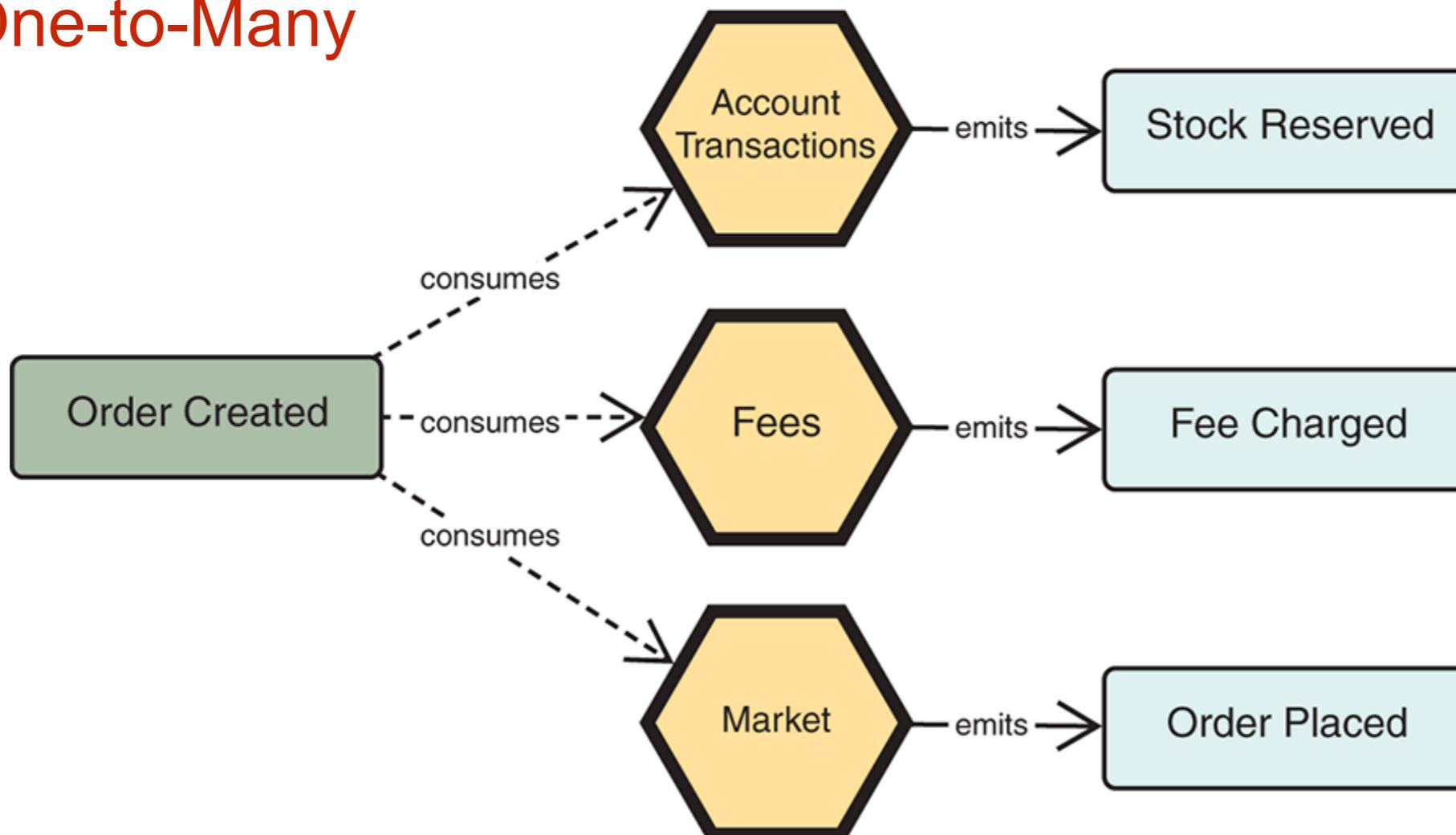
One-to-One



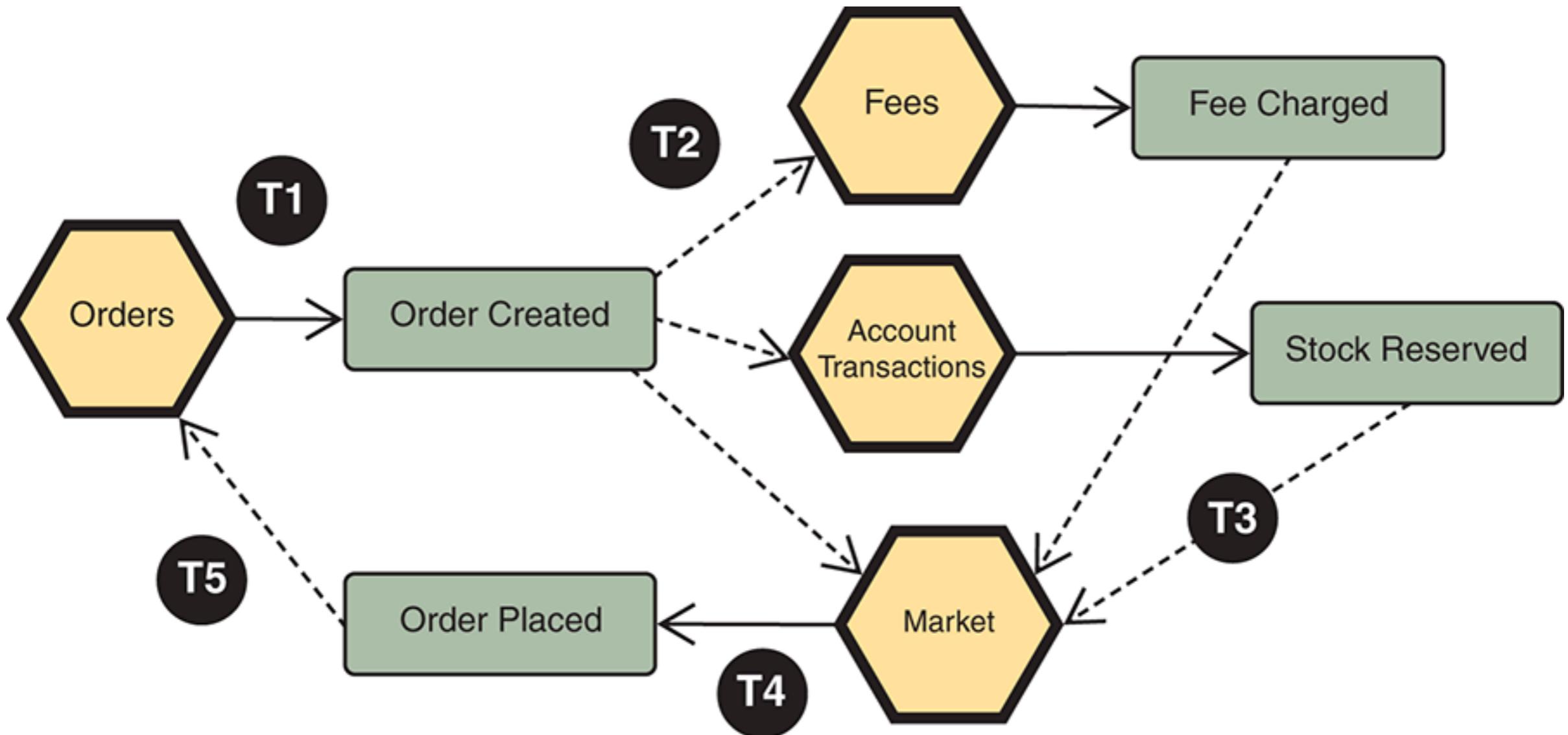
Service consume and emit event



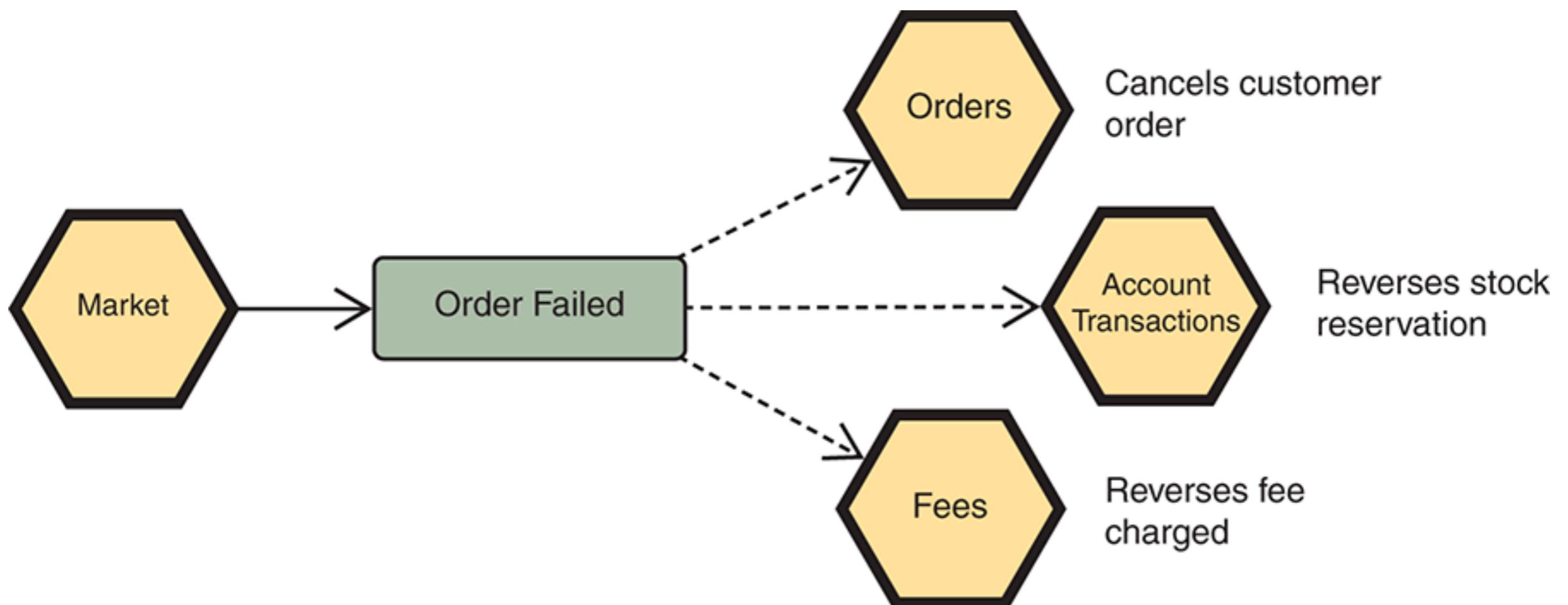
One-to-Many



Example (Success)

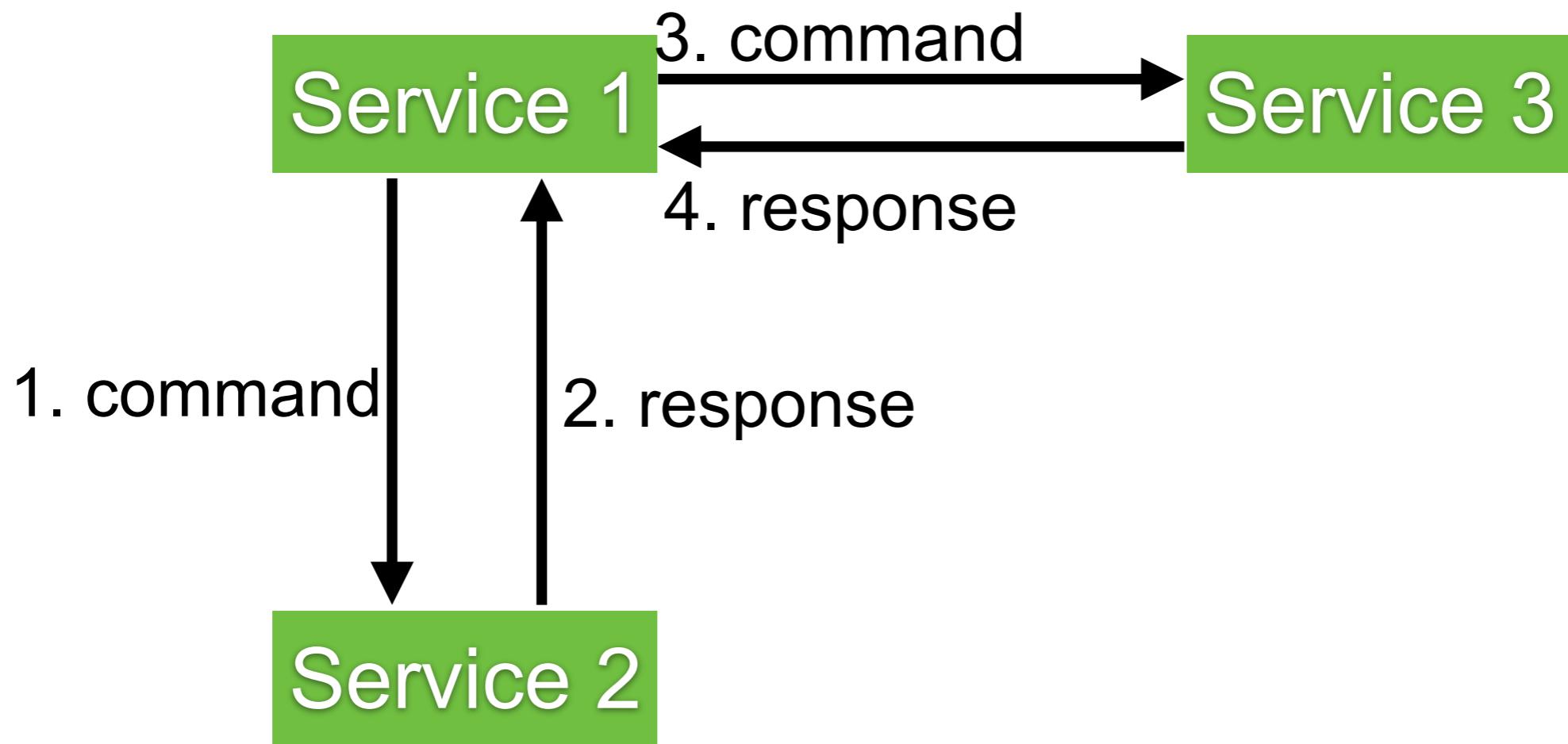


Example (Fail)

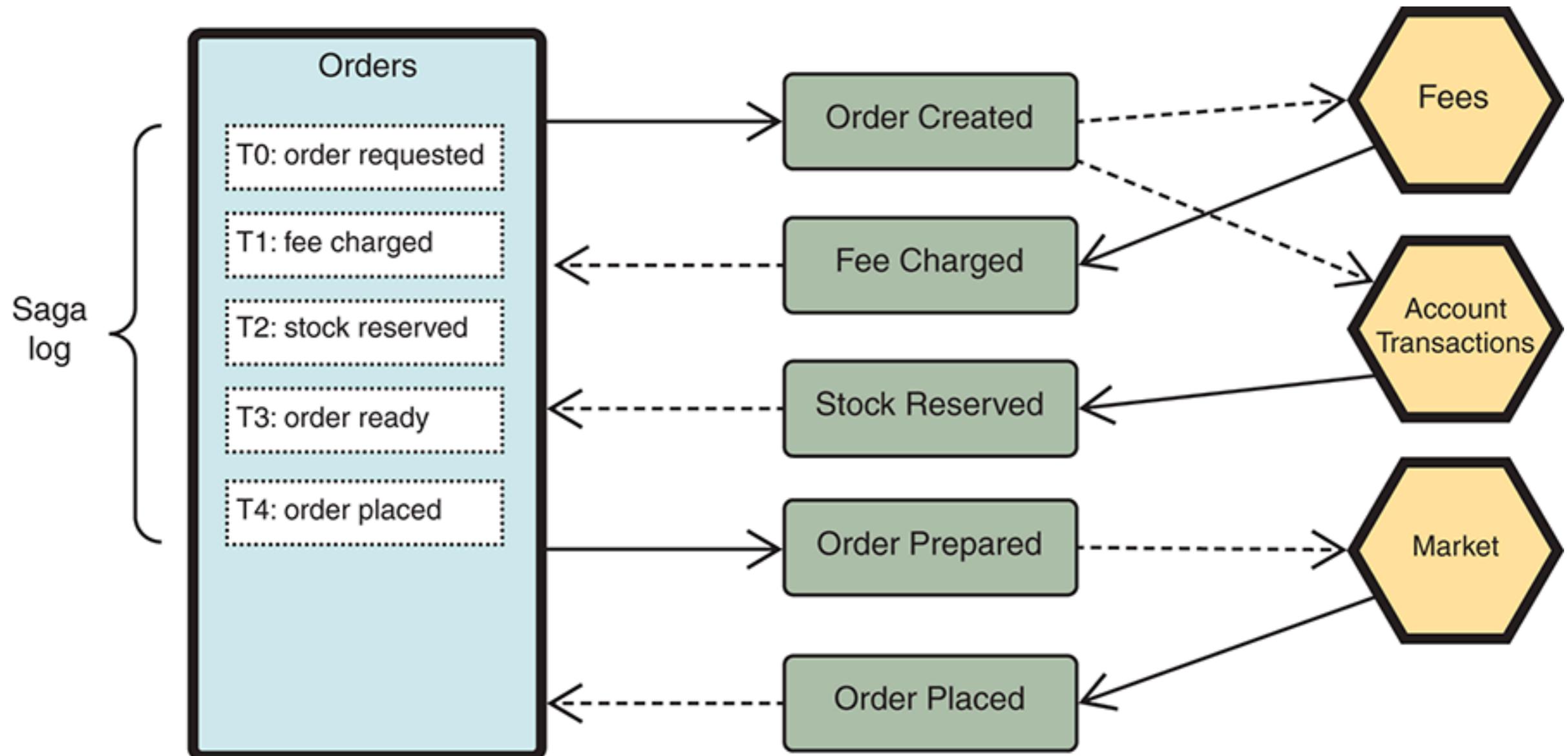


Orchestrate pattern

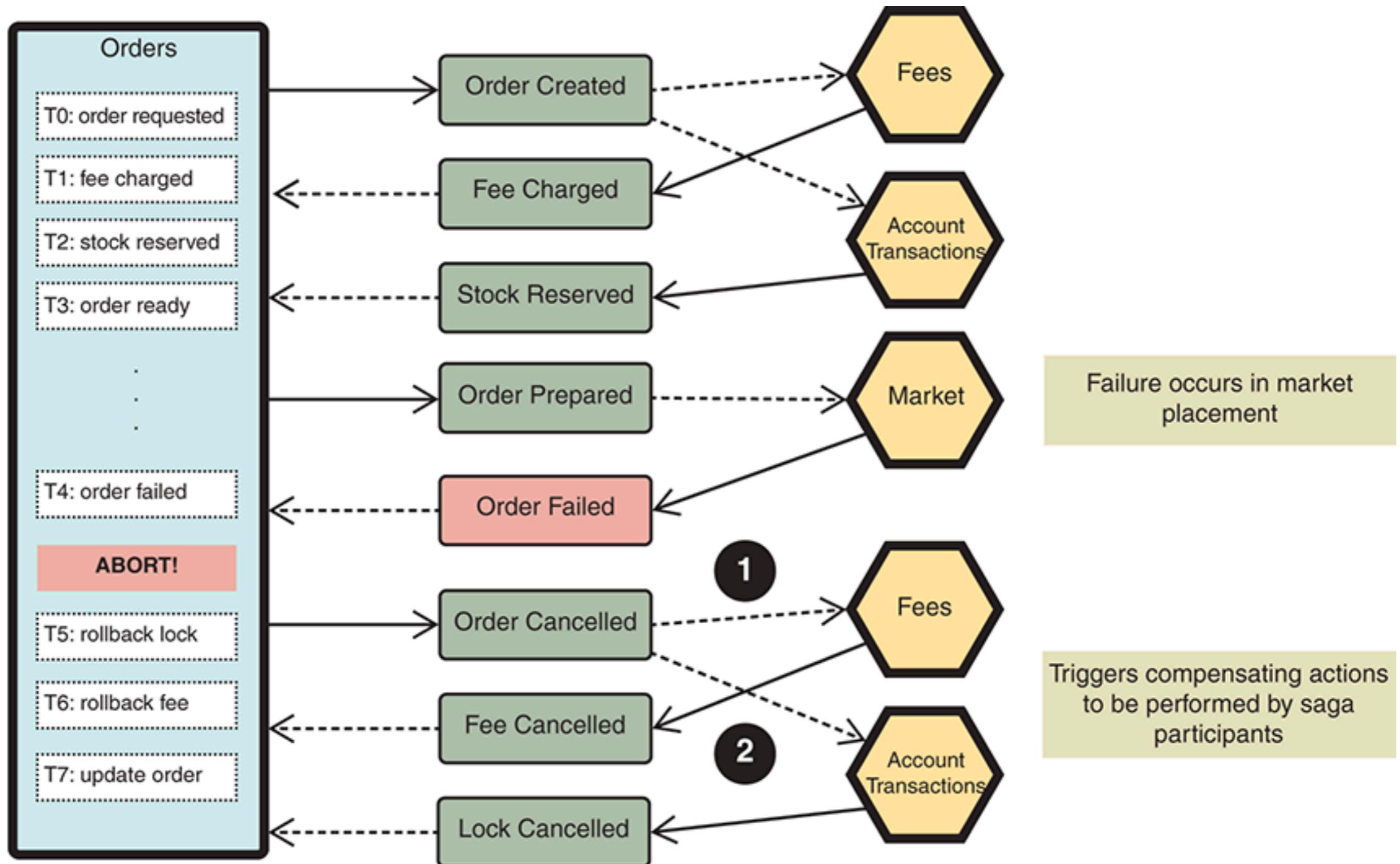
Sequence of Tx and emit **event or message** that trigger the next process in Tx



Example (Success)



Example (Fail)



Consistency patterns

Name	Strategy
Compensating action	Perform action that undo prior action(s)
Retry	Retry until success or timeout
Ignore	Do nothing in the event of errors
Restart	Reset to the original state and start again
Tentative operation	Perform a tentative operation and confirm (or cancel) later



“Saga”



Message vs Event

Message is addressed to someone

Event is something that happen and someone can react to that



Event sourcing

Maintain source of truth of business
Immutable sequence of events

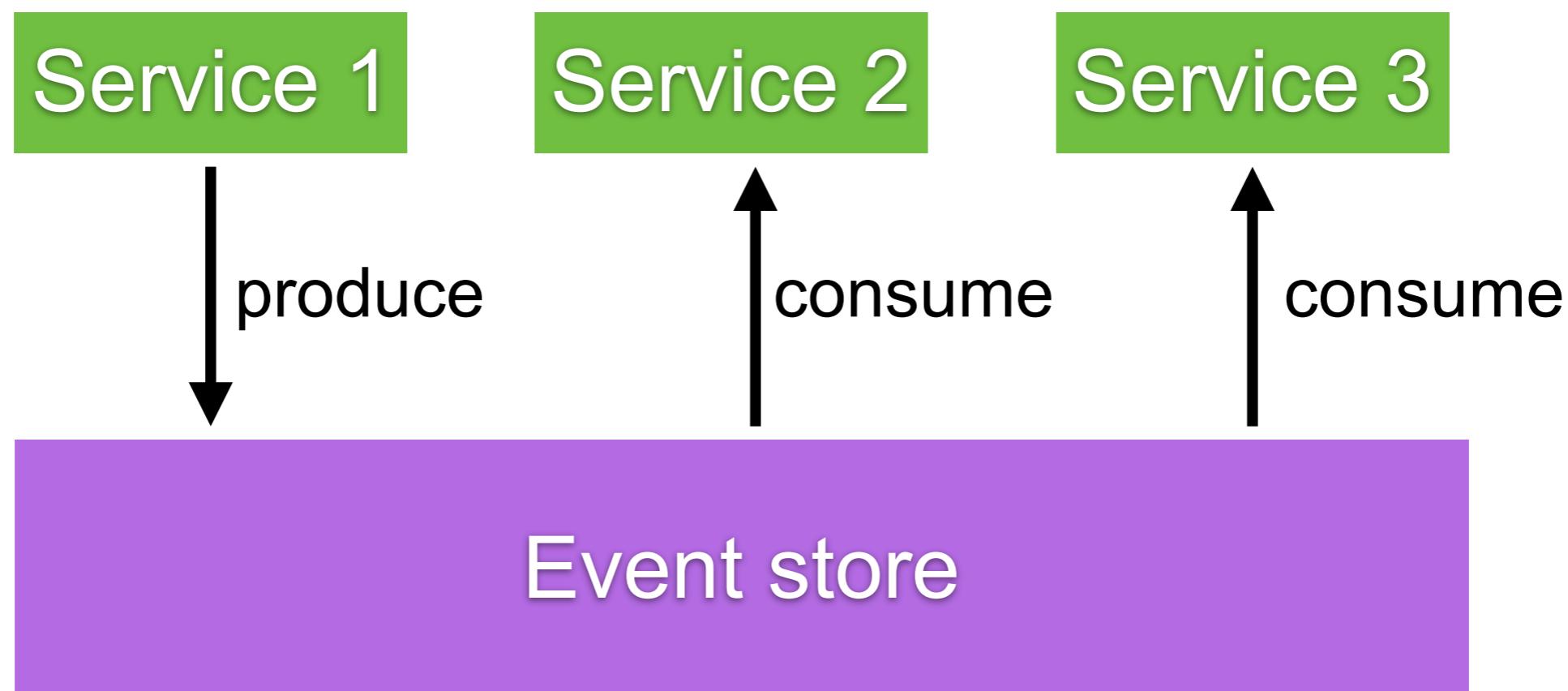


Sequence of event is keep in **Event store**



Event store

Keep events in order
Broadcast new event

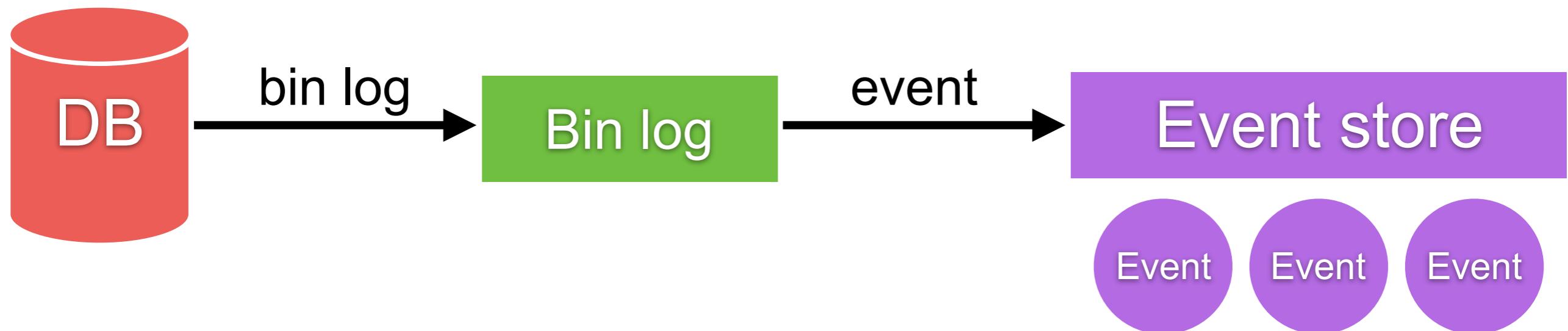


**With Event sourcing, we can
decouple services (query and
command)**



Event sourcing with database

Working with database



Binlog or Binary log event is information about data modification made to database



Event sourcing

Duplication data (denormalize database)
Complexity (separate query and command)
Difficult to maintain



Event sourcing can't solve all problems



Start with understand your purpose



Start with understand your
problem to resolve



How to implement queries ?



Query data from multiple services

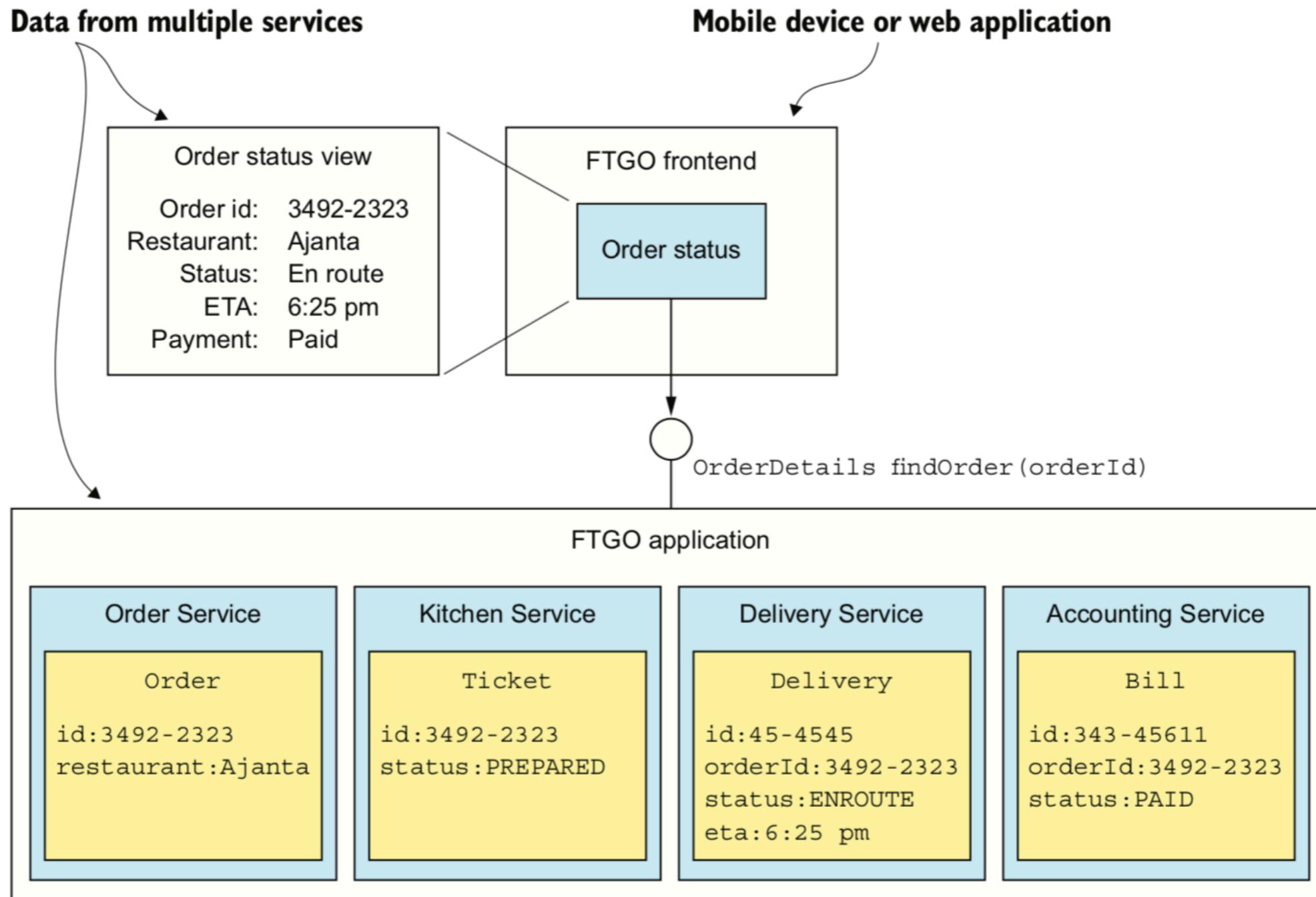
API composition

Cold data from services

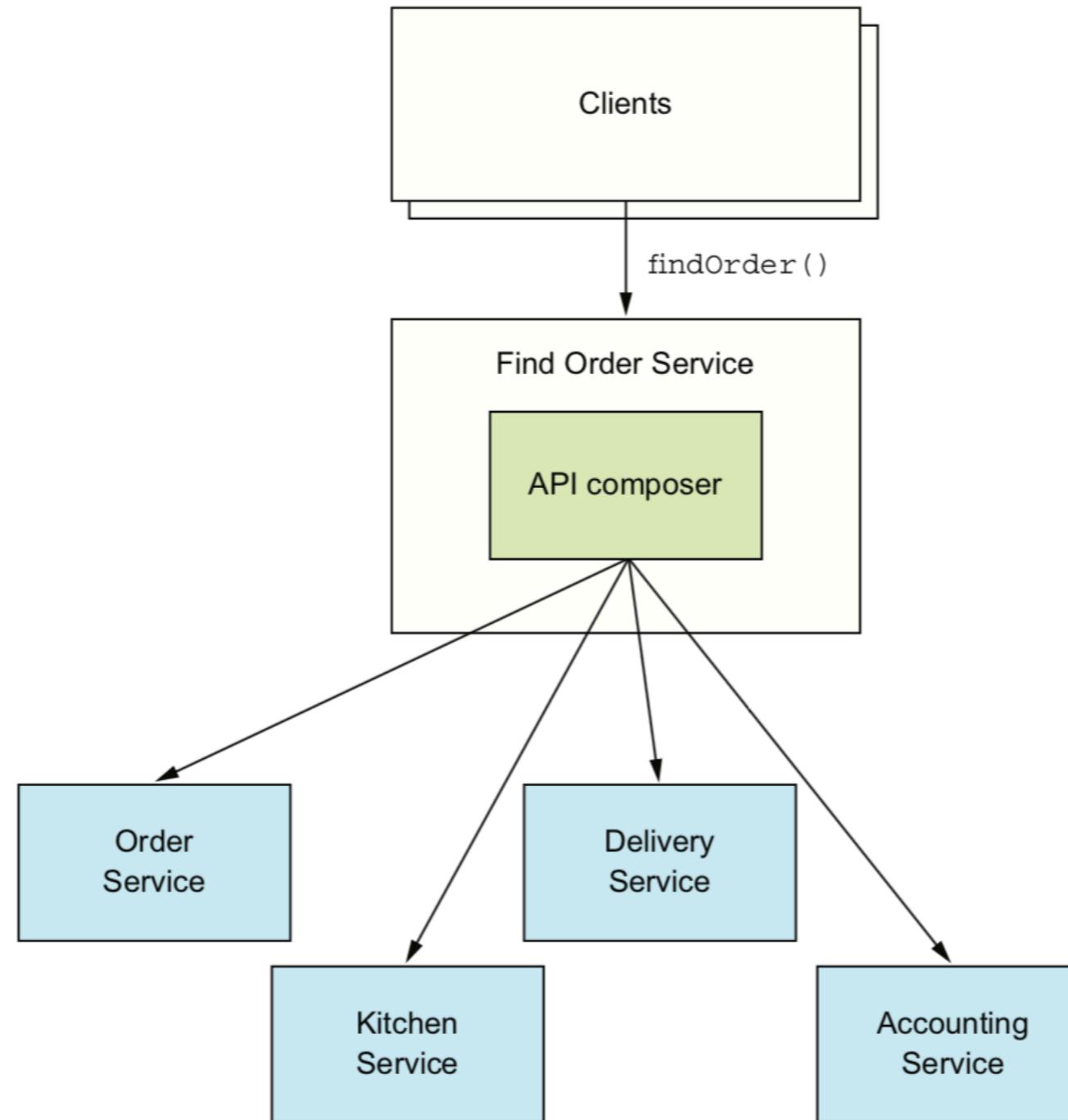
CQRS (Command Query Responsibility Segregation)



Problem ?



API composition pattern



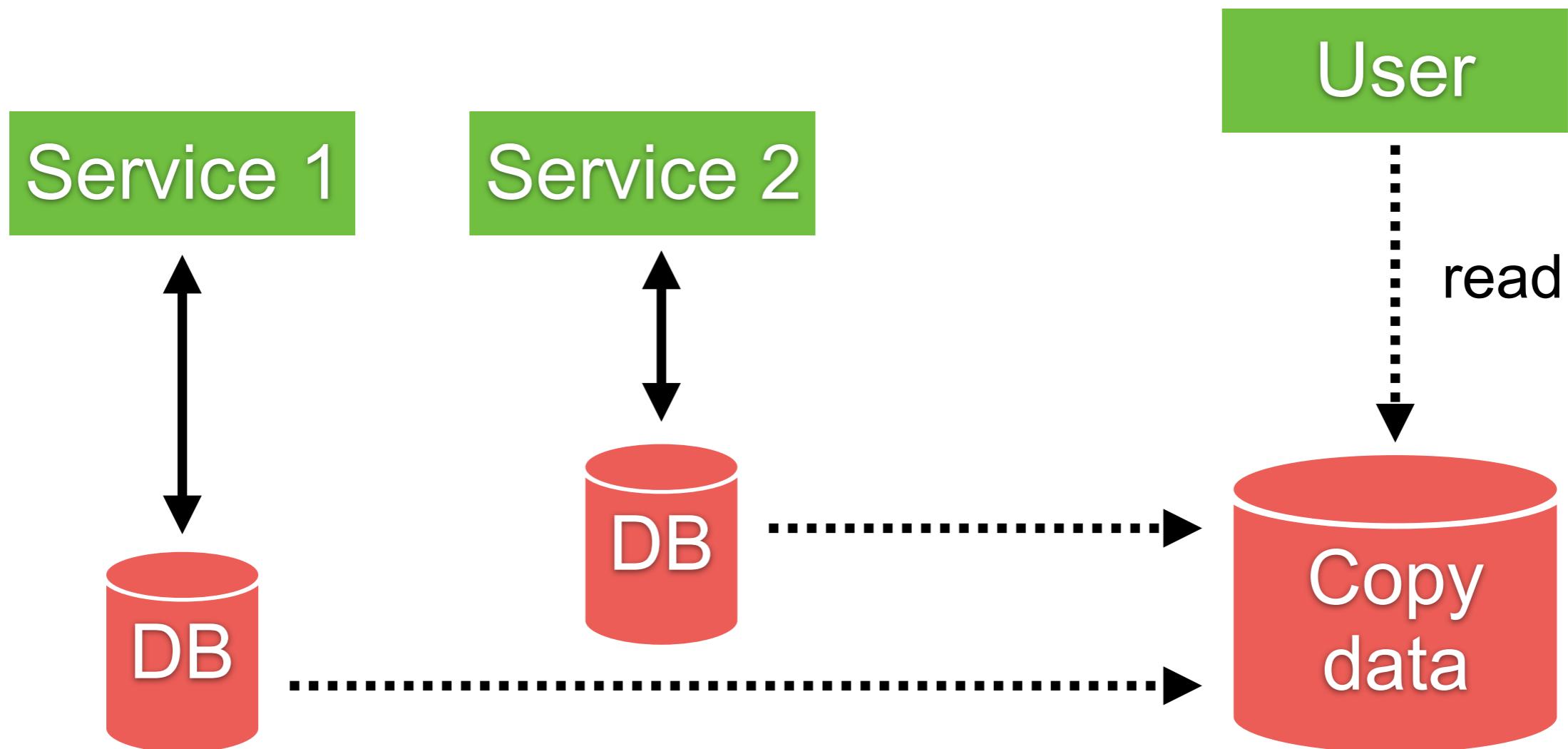
Drawbacks

Increase overhead
Lack of transactional data consistency
Reduce availability



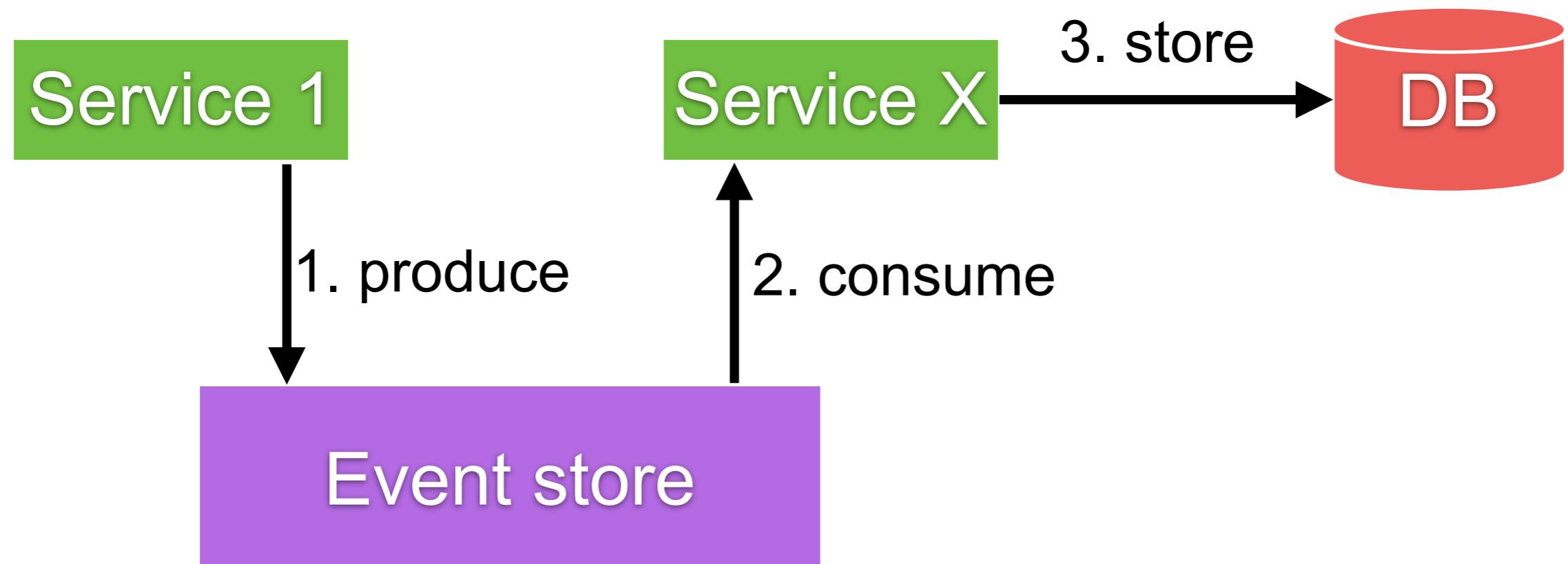
Storing copy data

Copy or caching data to other database



Working with Event-based

Publish event to store copy data

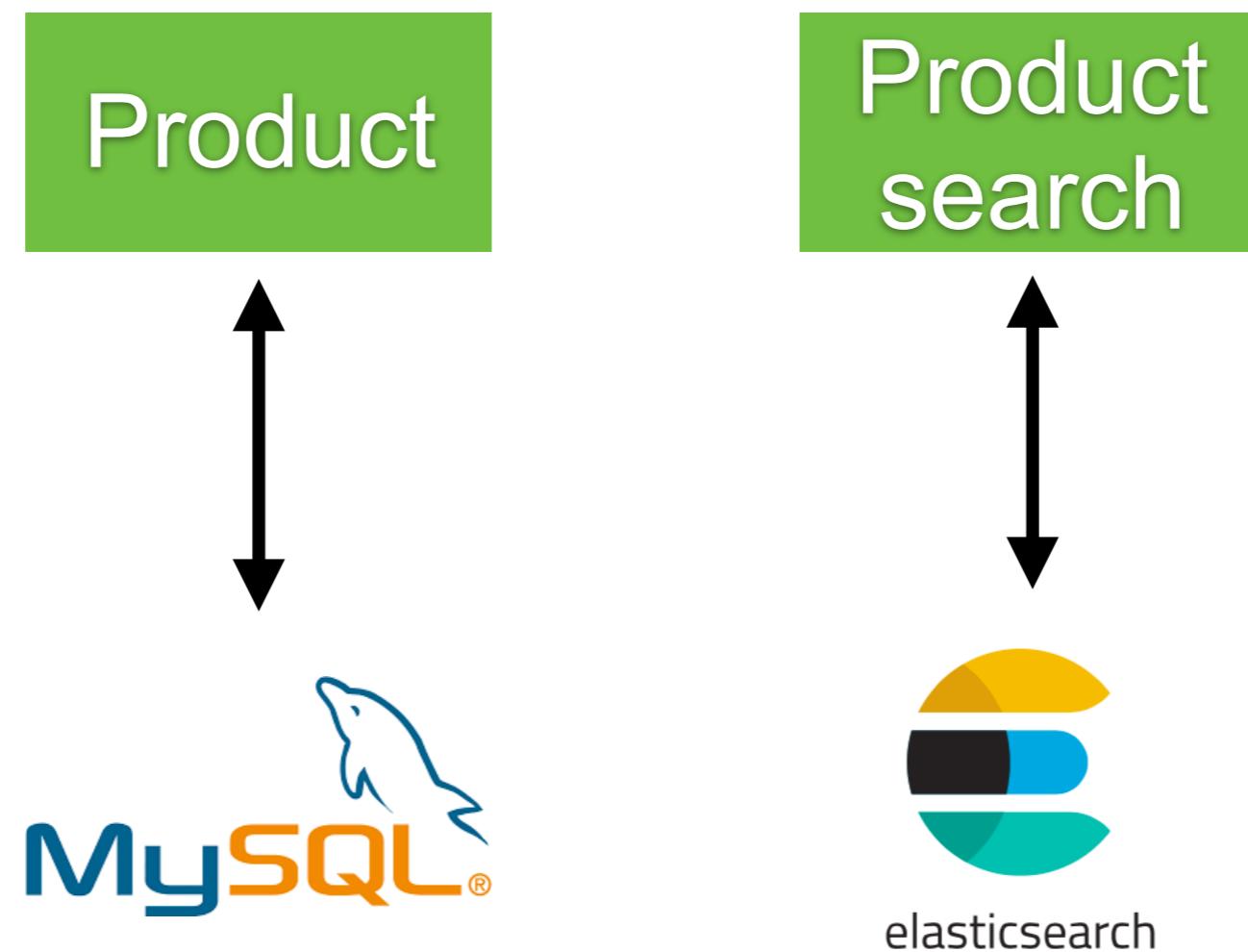


Separate query and command



Separate data for read and write

For example MySQL to write, Elasticsearch to search

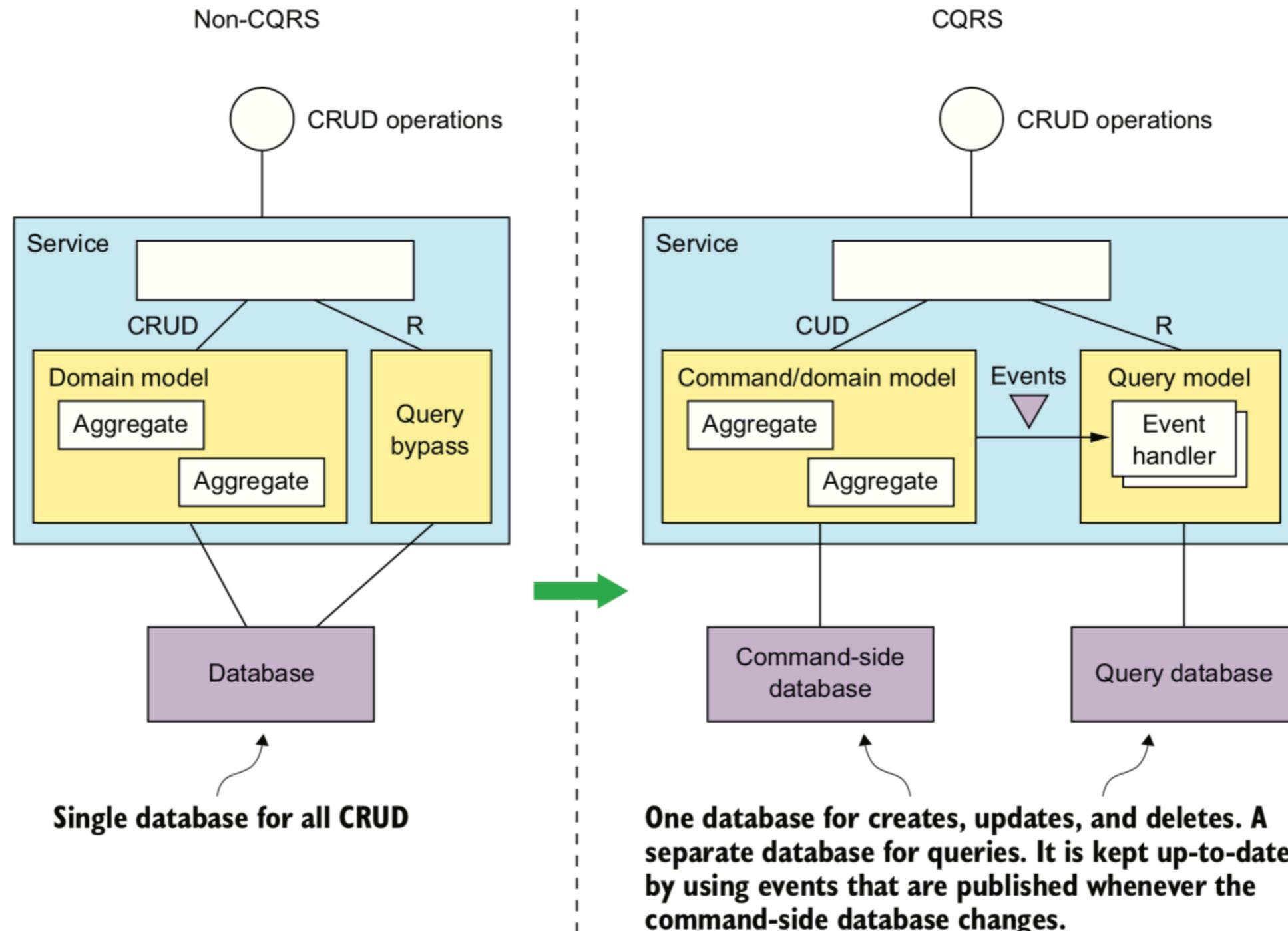


CQRS

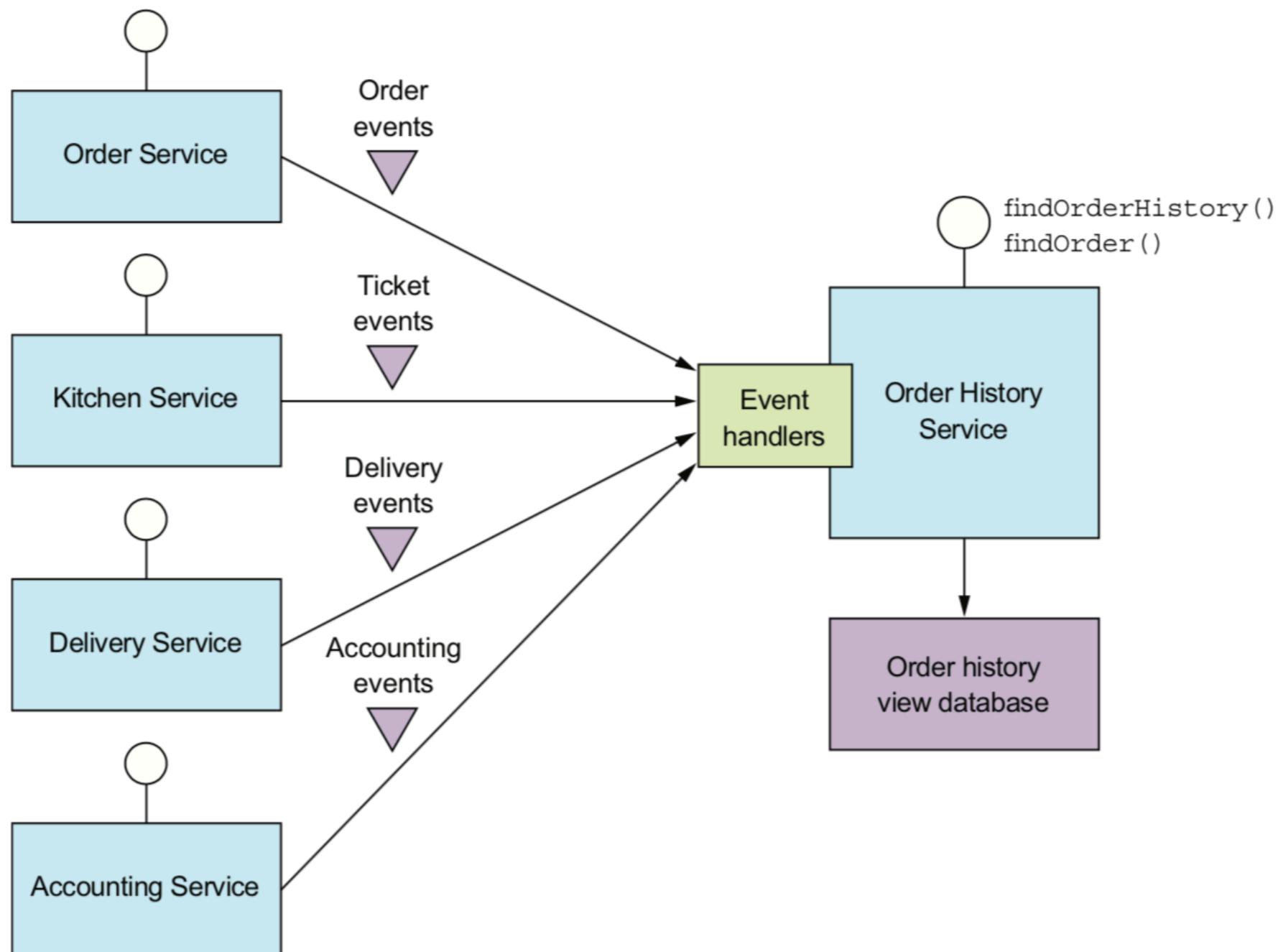
Command Query Responsibility Segregation



CQRS = Separate command from query



CQRS = Query-side service



Benefits

Improve separation of concern
Efficiency query



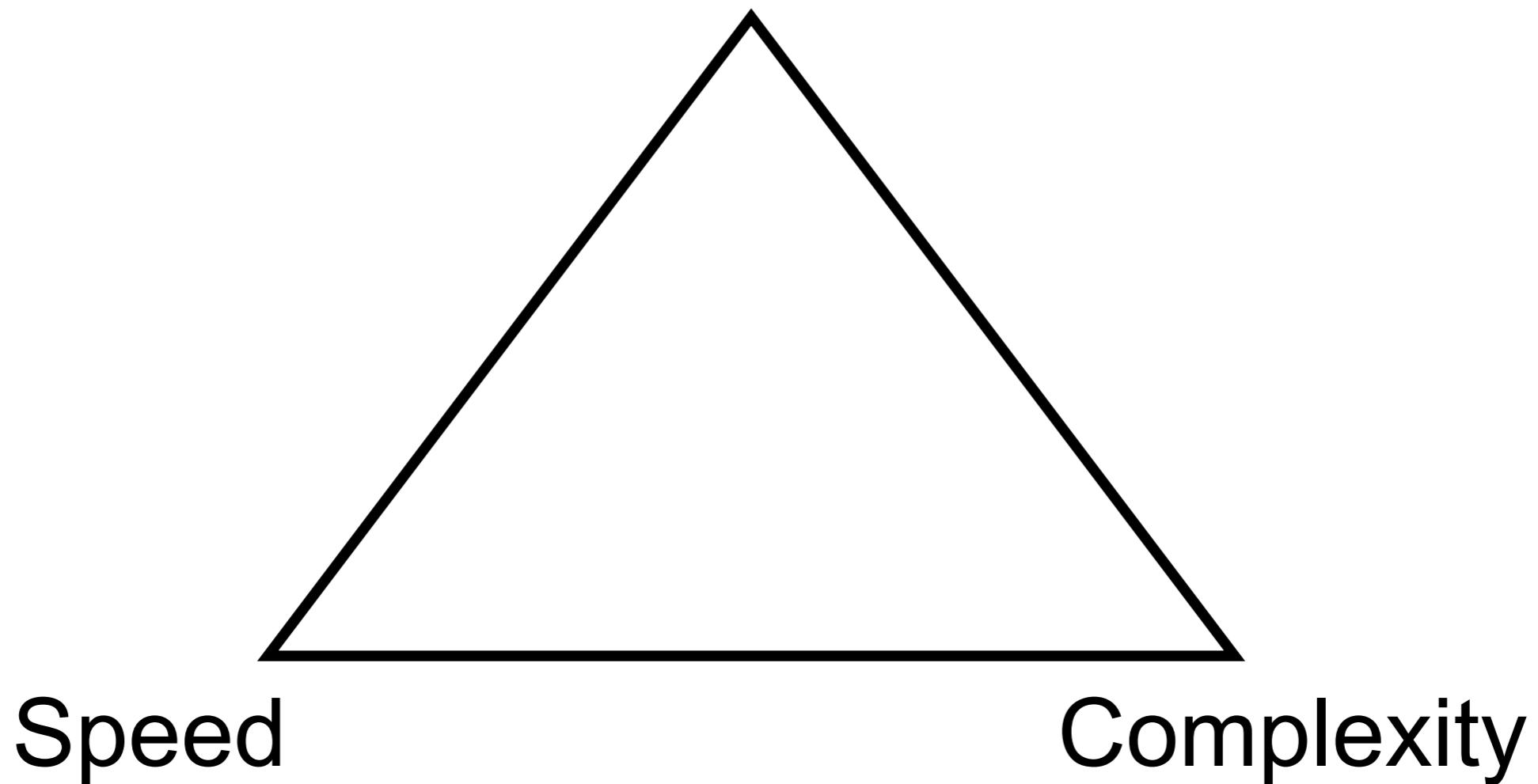
Drawbacks

More complex

Lag between command and query side



Customer value

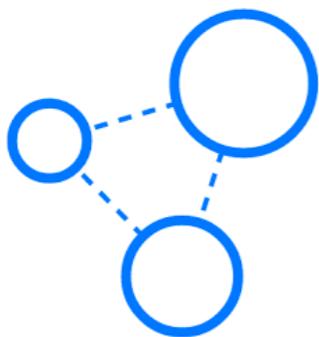


More ...



Beyond Microservice

Process and Organization



Flexible organizational structure

With clear roles and accountabilities



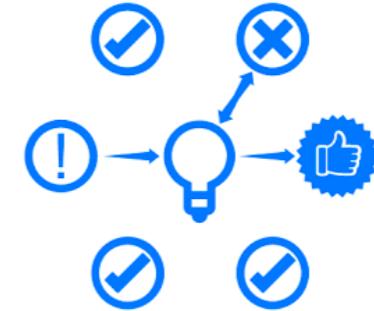
Efficient meeting formats

Geared toward action and eliminating over-analysis



More autonomy to teams and individuals

Individuals solve issues directly without bureaucracy



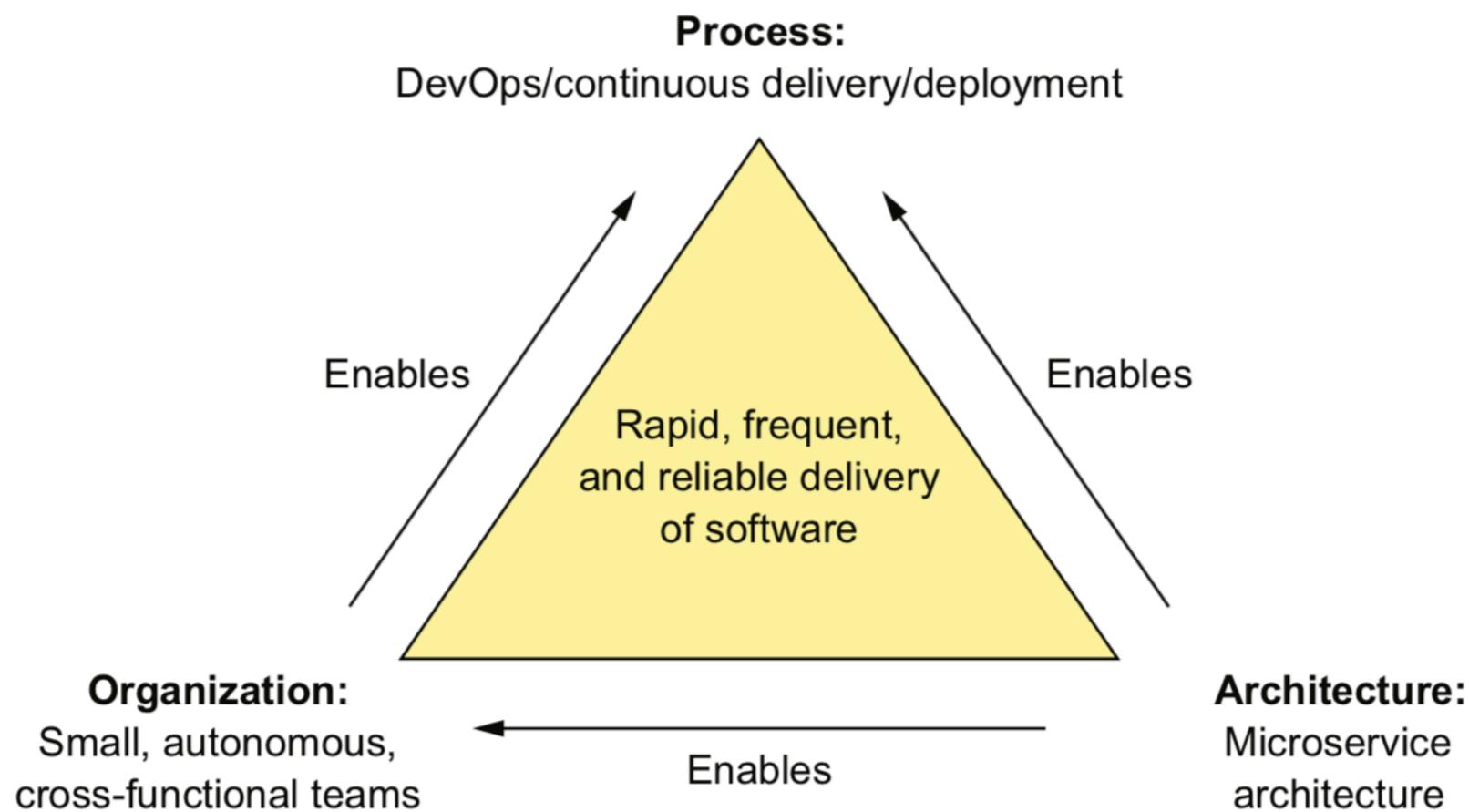
Unique decision-making process

To continuously evolve the organization's structure.



Success project needs ...

Organization process
Development process
Delivery process



Don't forget about the human side when adopt Microservice



"organizations which design systems ... are constrained to produce designs which are copies of the communication structures of these organizations"

- *Melvin Conwey, 1968* -



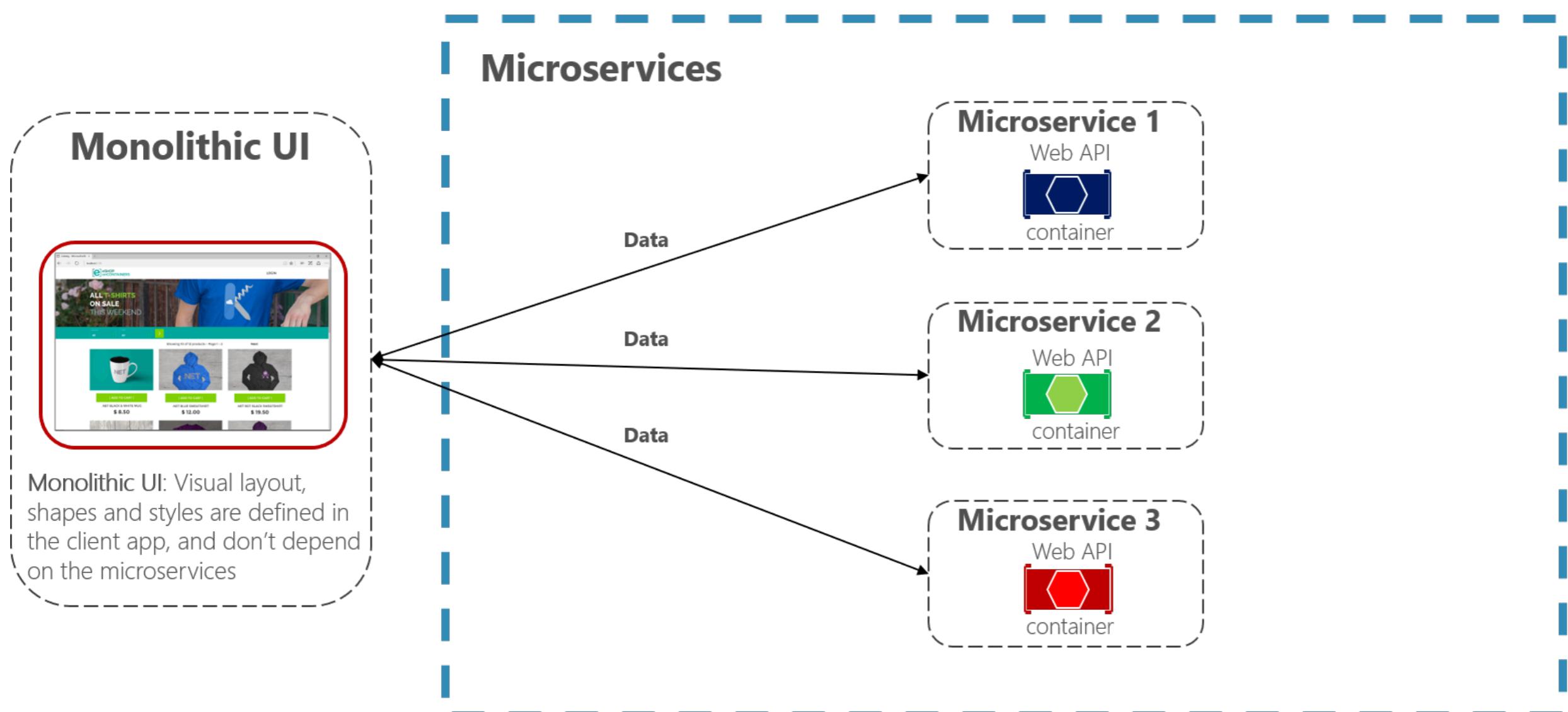
More ...



Integrate services with User Interface



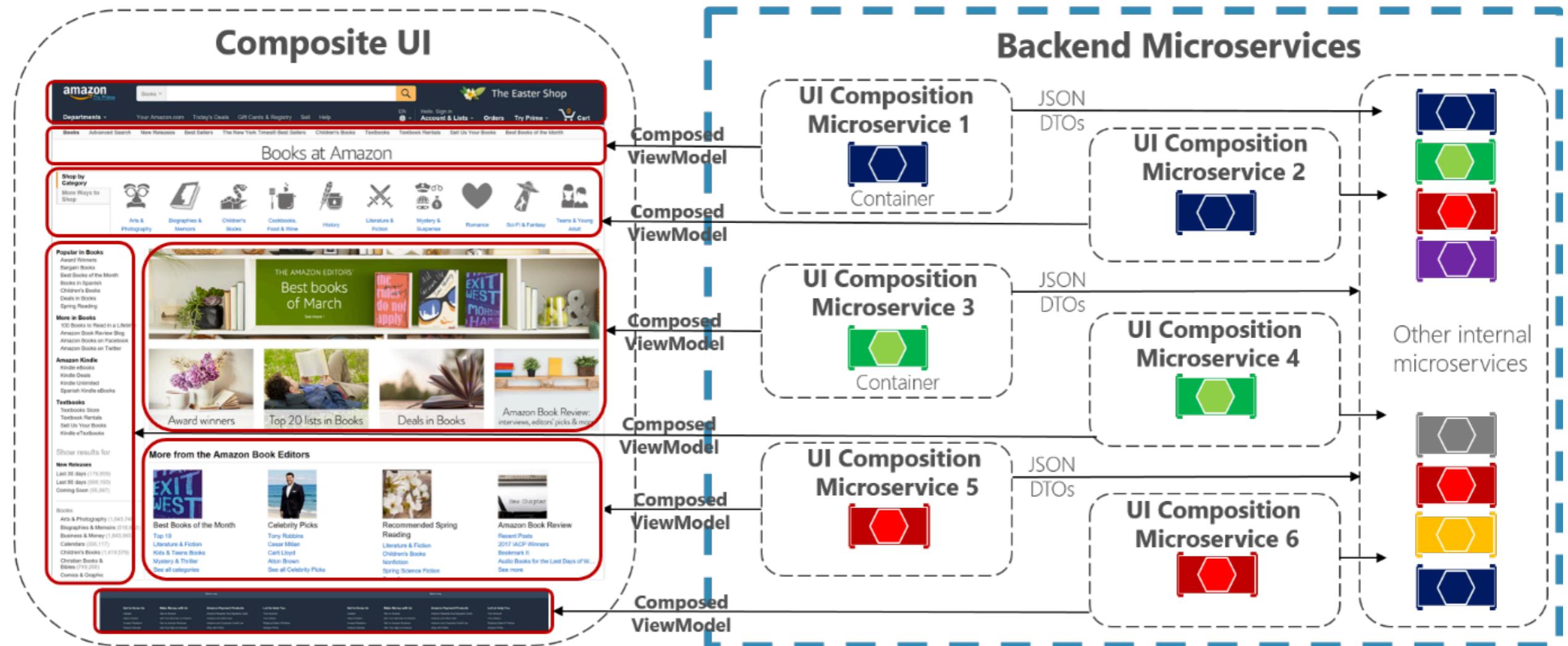
Monolithic UI consuming microservices



<https://docs.microsoft.com>



Composite UI generated by microservices



<https://docs.microsoft.com>

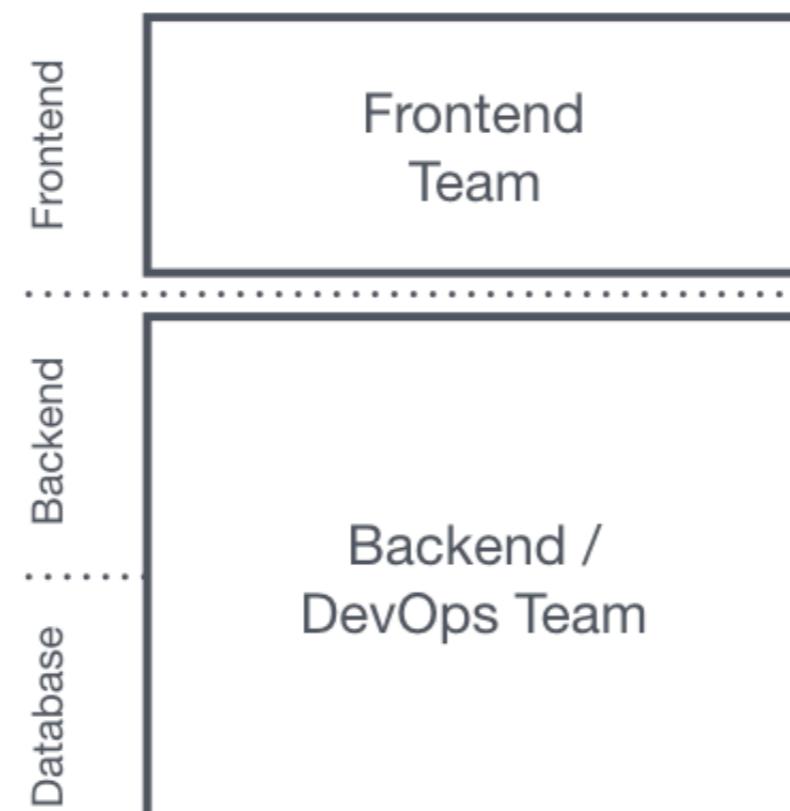


Monolith frontend

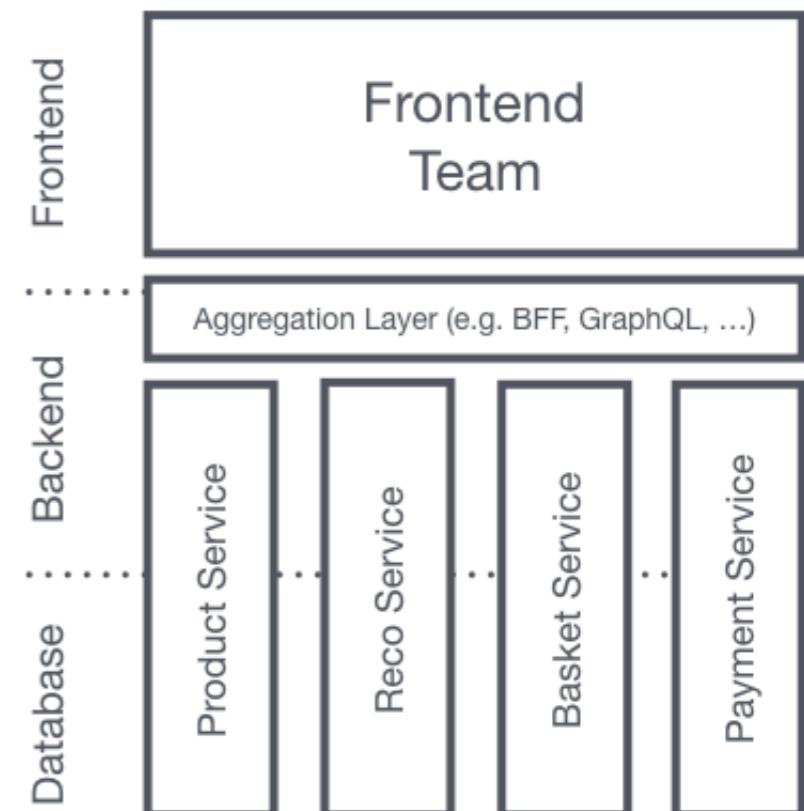
The Monolith



Front & Back



Microservices

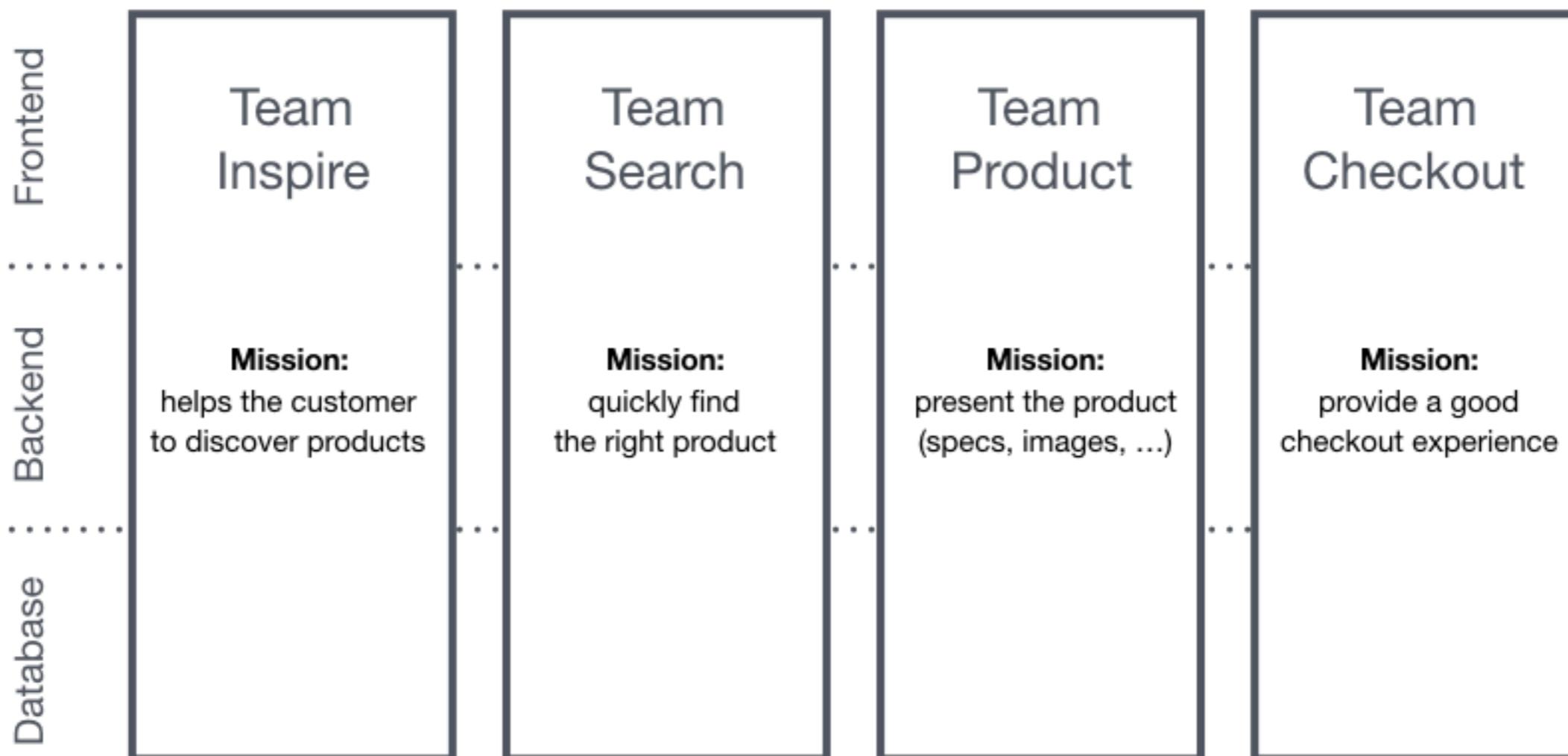


<https://micro-frontends.org/>



Micro frontend

End-to-End Teams with Micro Frontends



<https://micro-frontends.org/>



Summary



Let's start with good monolith



Module 1

Module 2

Module 3

Module 4

Module 5

Module 6



Find your problem



Module 1

Module 2

Module 3

Module 4

Module 5

Module 6



Module 1

Module 2

Module 3

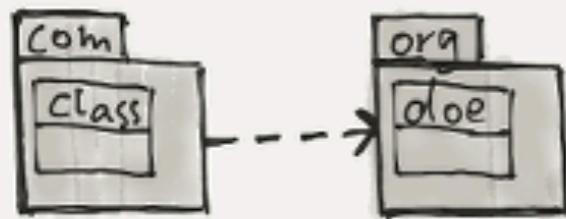
Module 5

Module 6

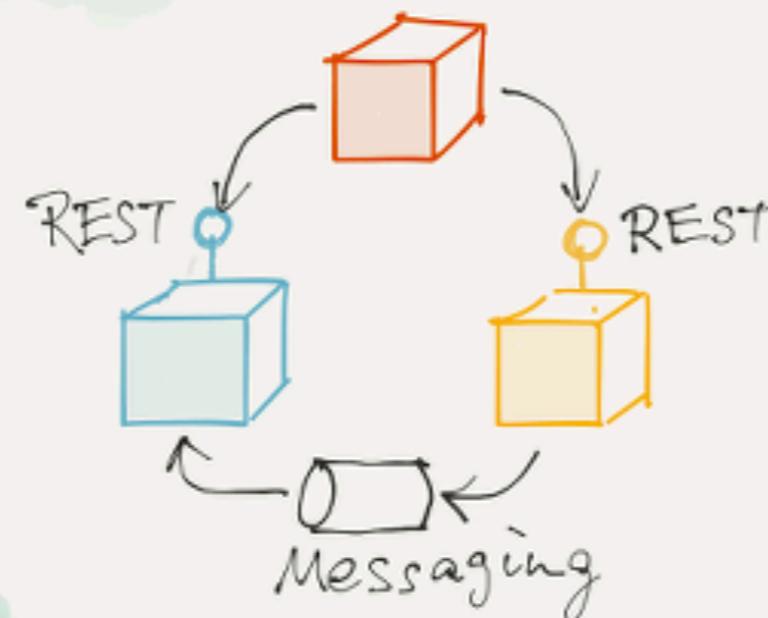
Module 4



Architecture



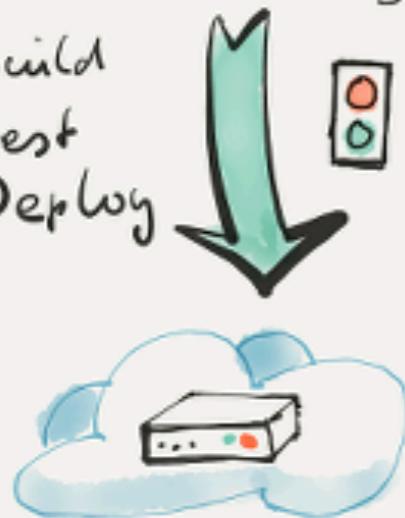
Microservices



Deployment

Continuous Delivery

`{ var i=1; }`
Build
Test
Deploy



Infrastructure

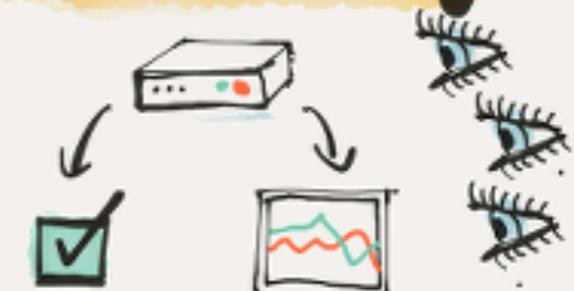


People & Teams



Communication
Collaboration

Monitoring

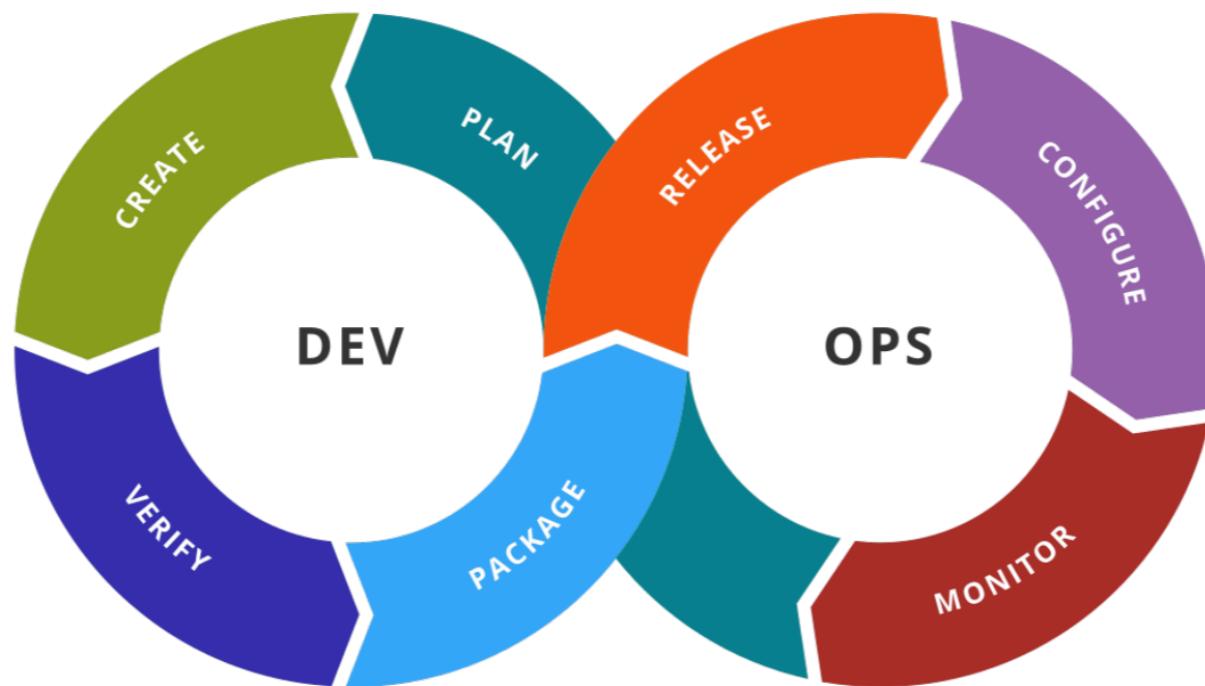


Features & Technology



Microservice prerequisites

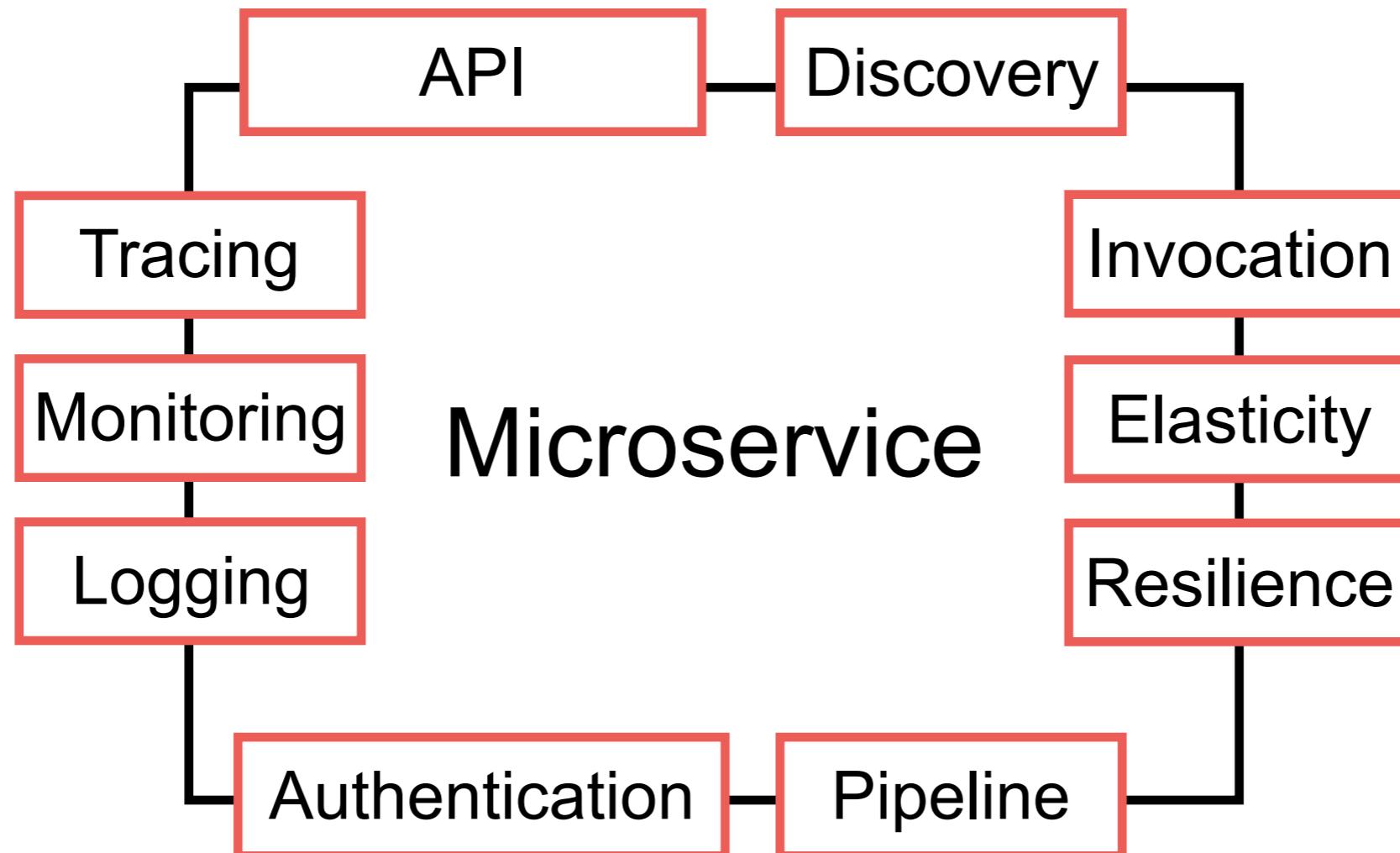
Rapid provisioning
Basic monitoring
Rapid Application Deployment
DevOps culture



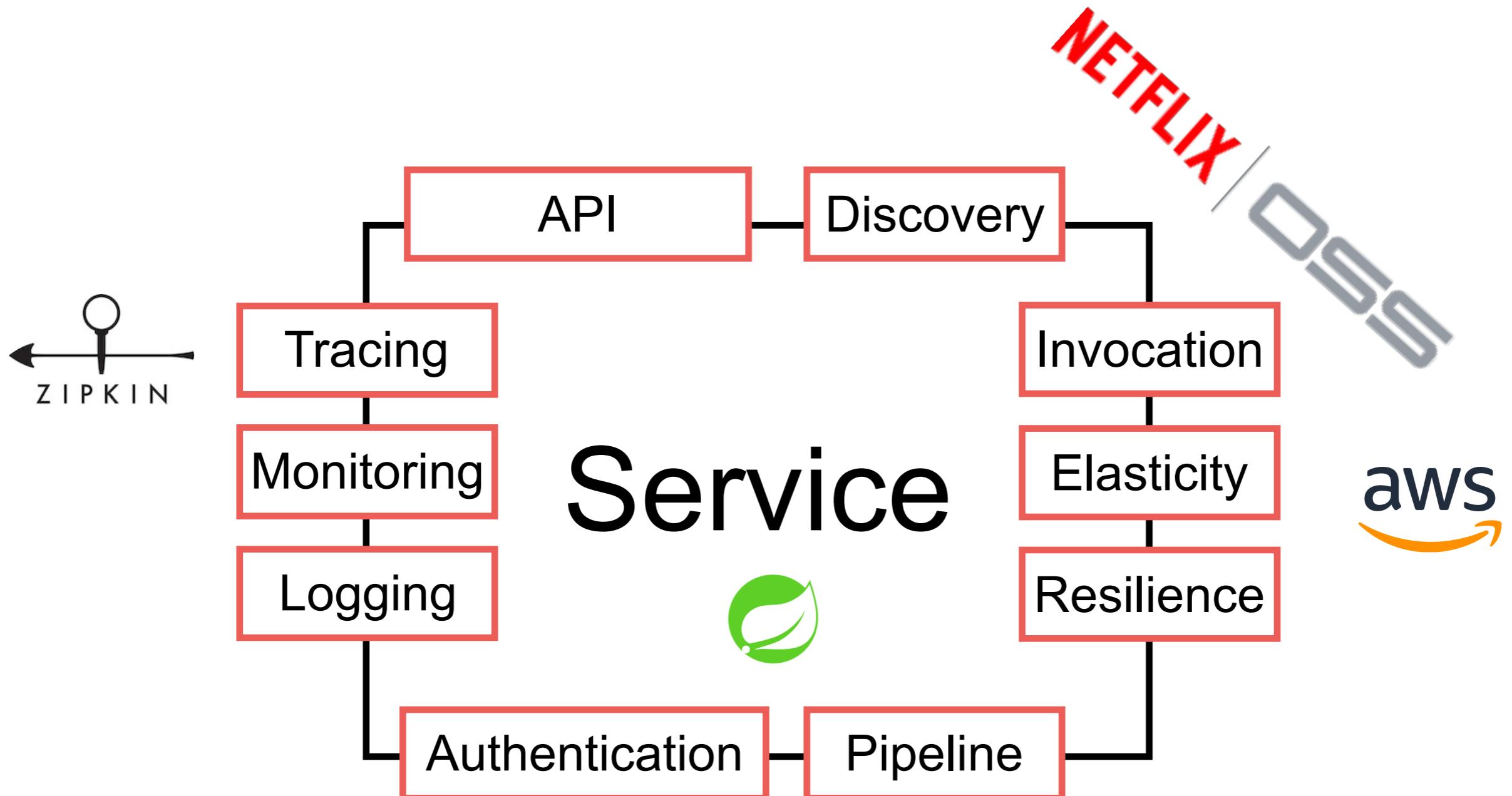
Module 2 : Develop and Testing



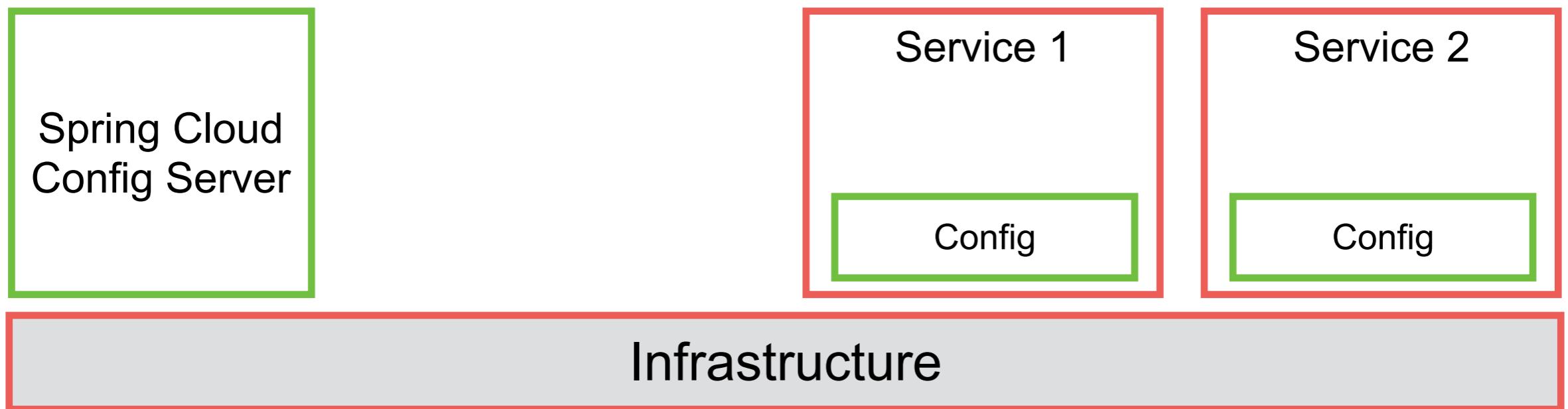
Properties of Microservice



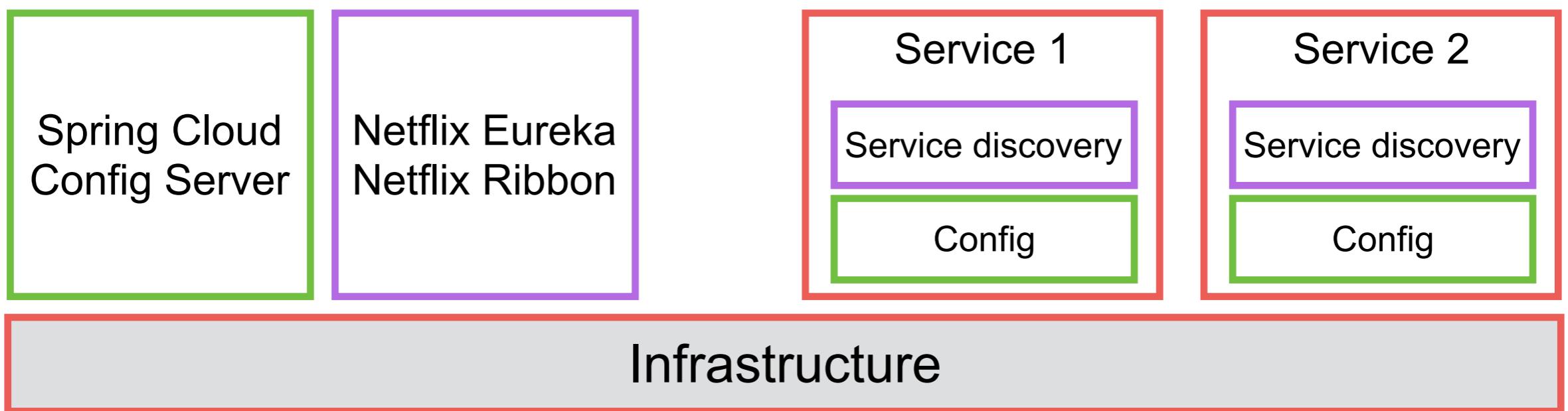
Microservice 1.0



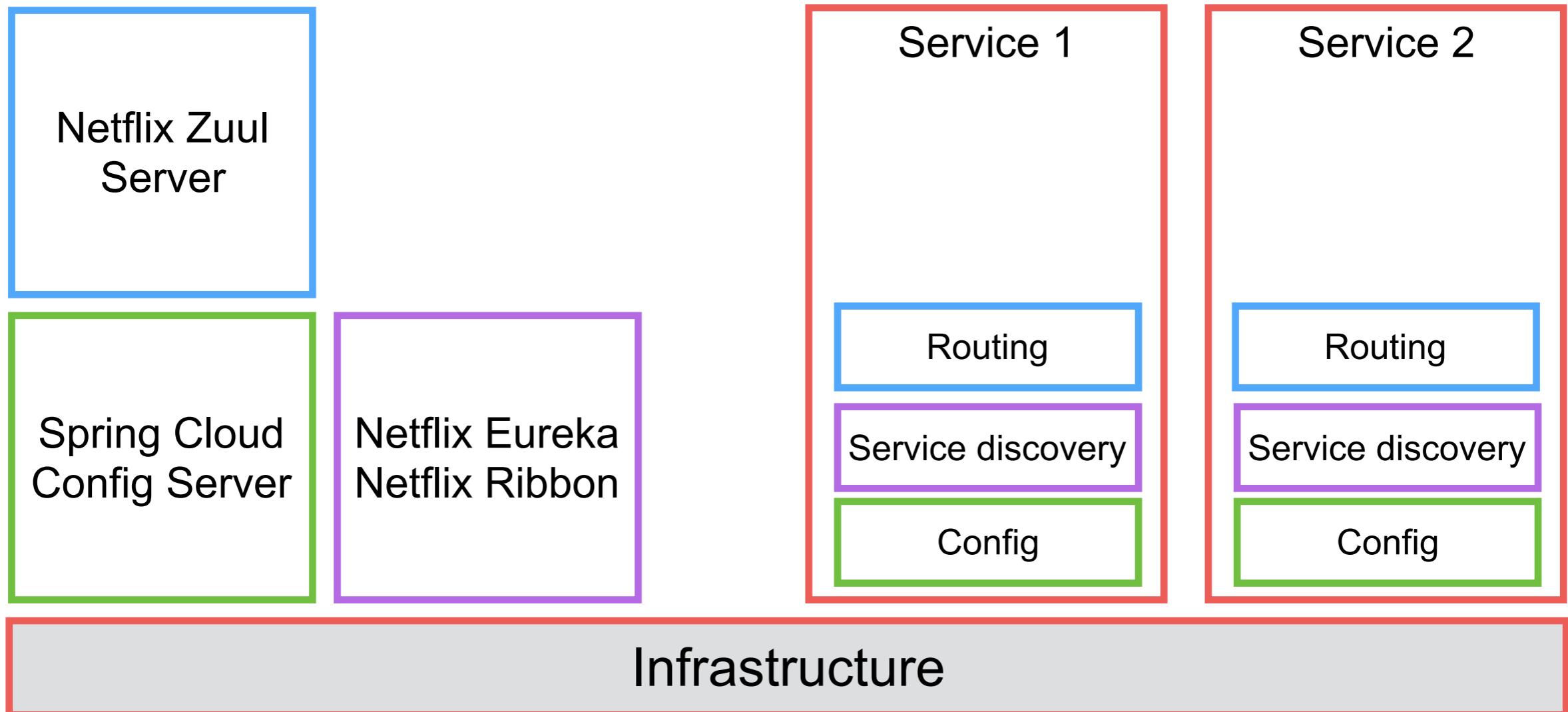
Configuration



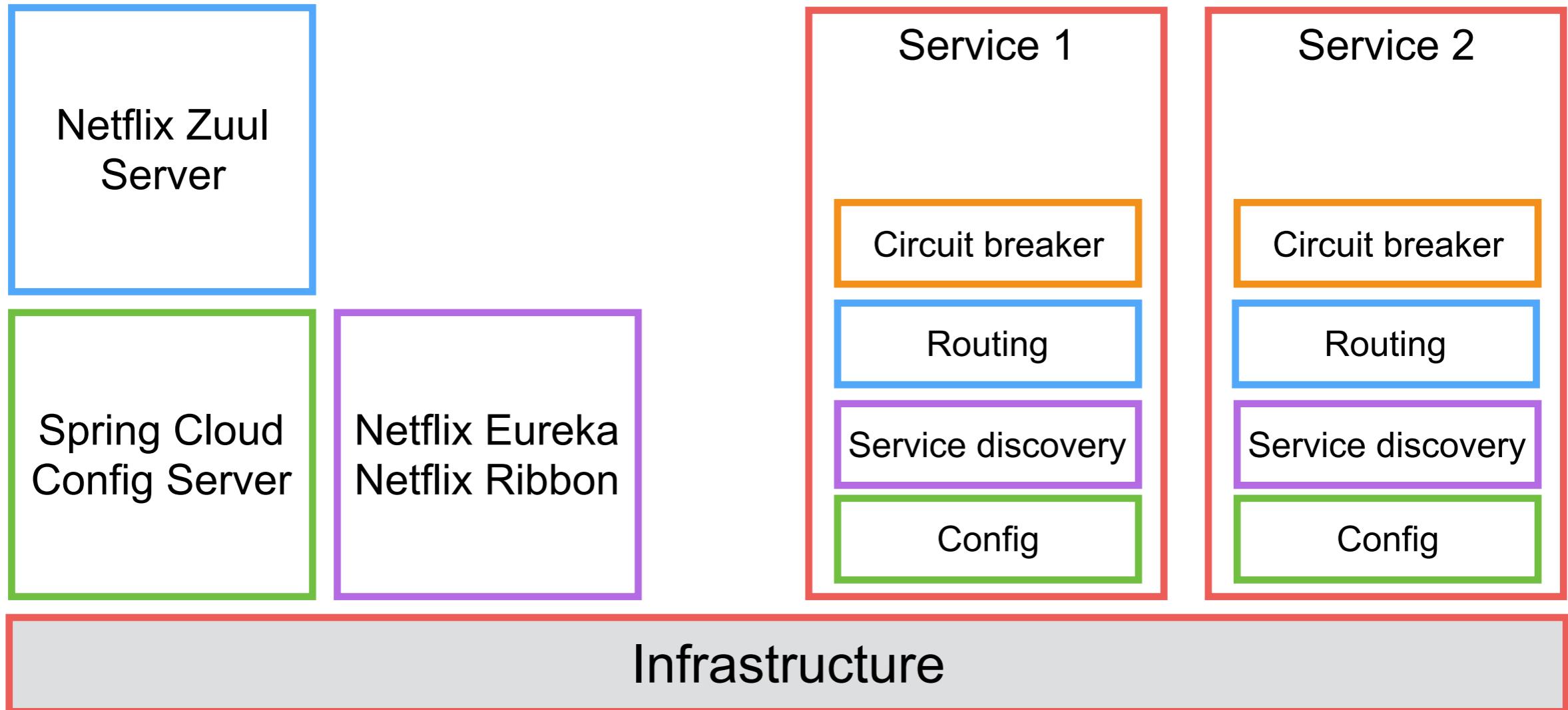
Service Discovery



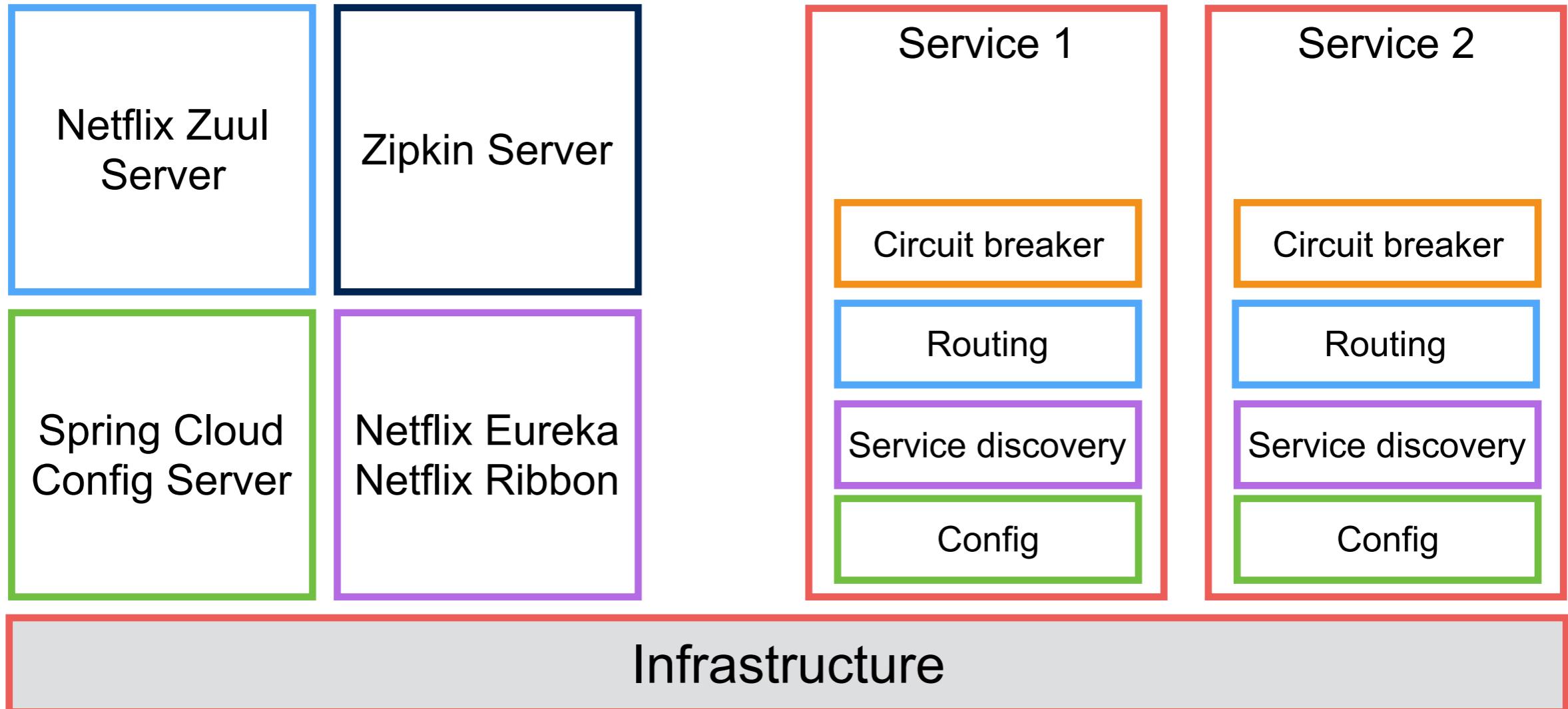
Dynamic Routing



Fault Tolerance



Tracing and Visibility



Microservice 1.0

JVM only
Add libraries to your code/service

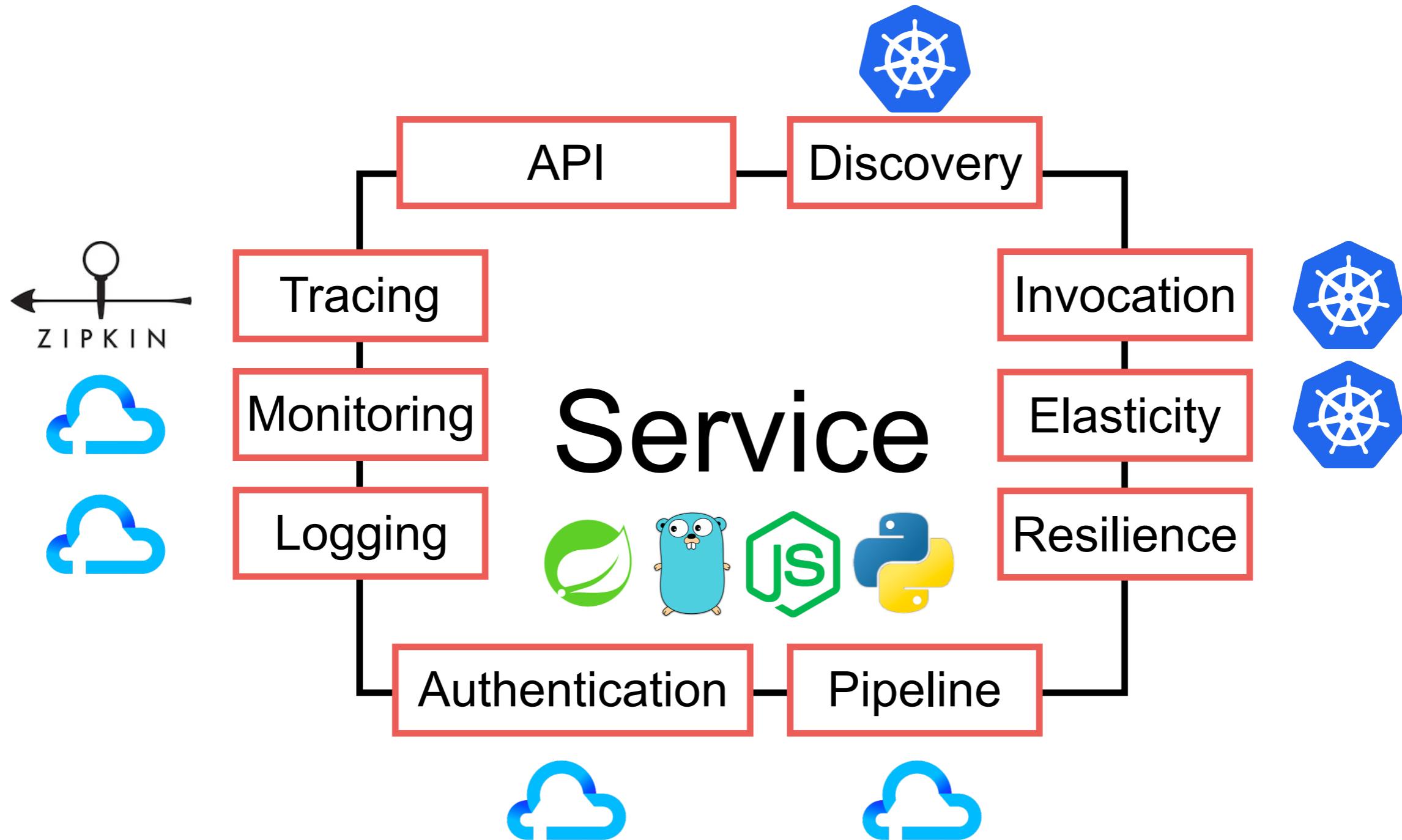


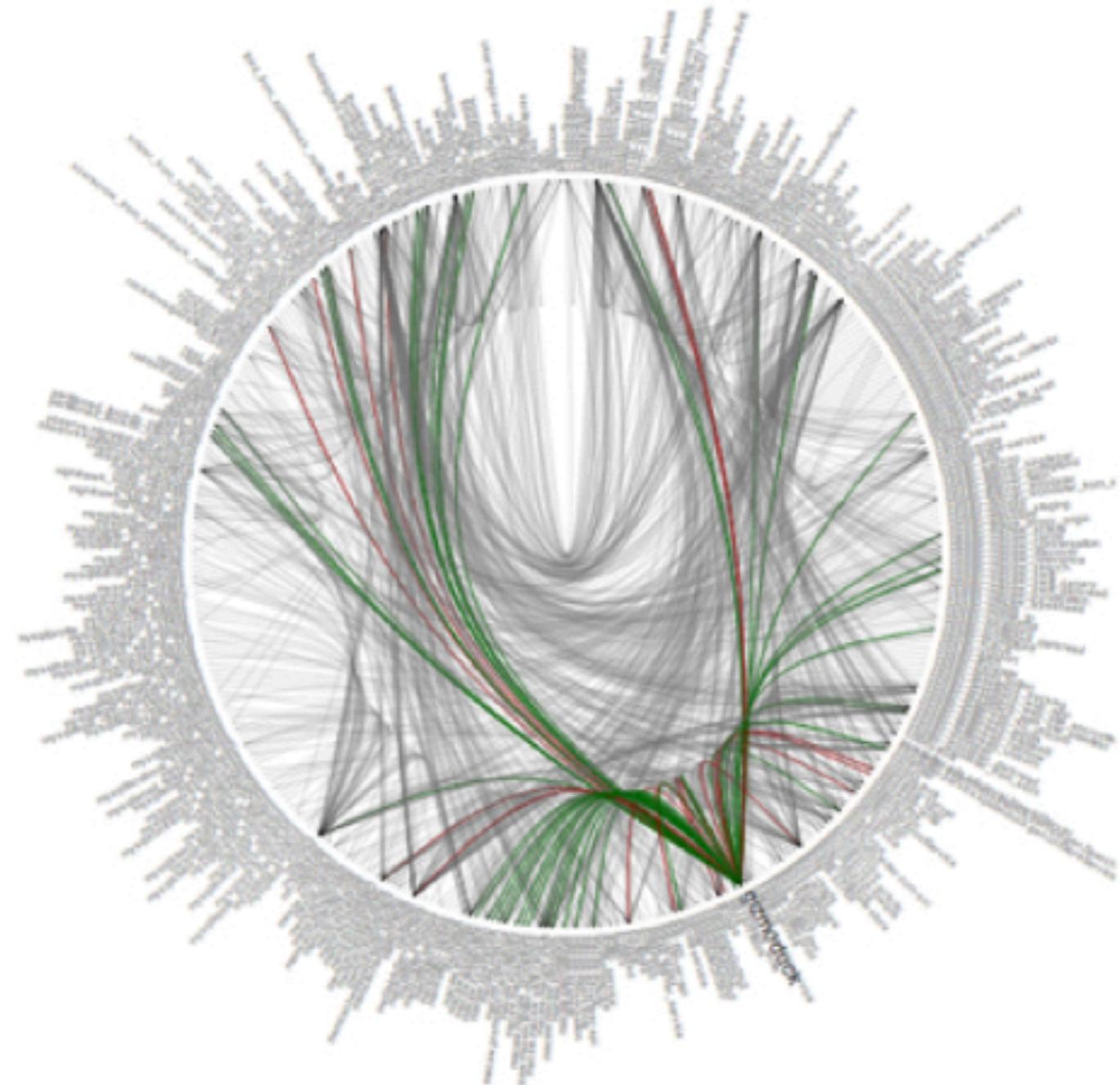


kubernetes



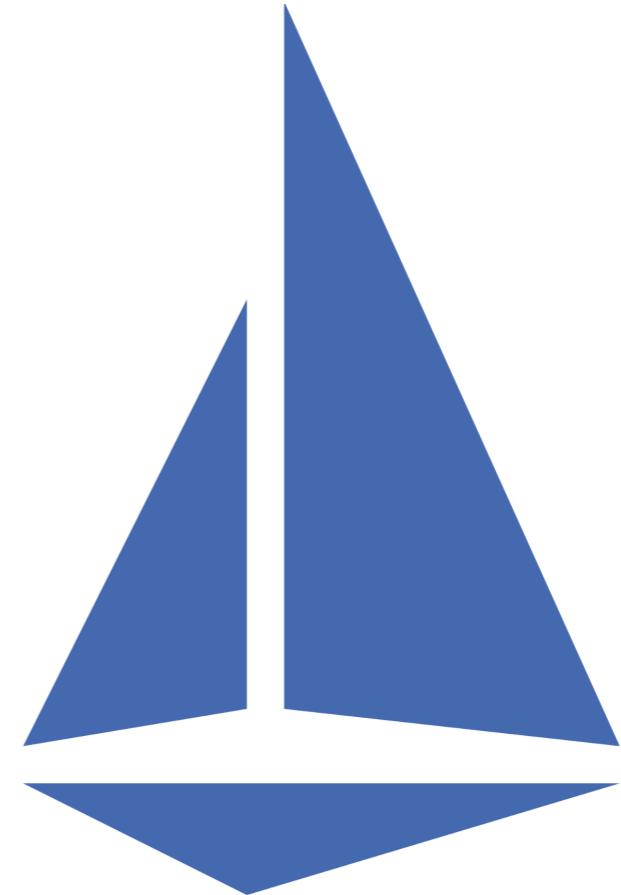
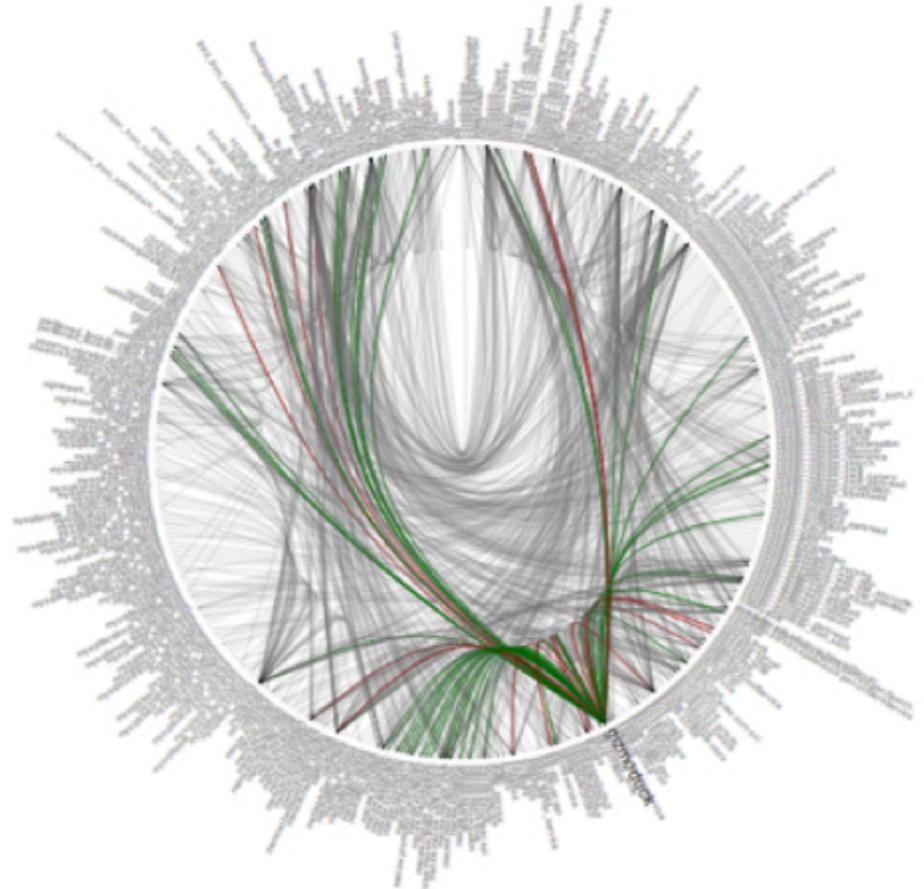
Microservice 2.0





Service Mesh

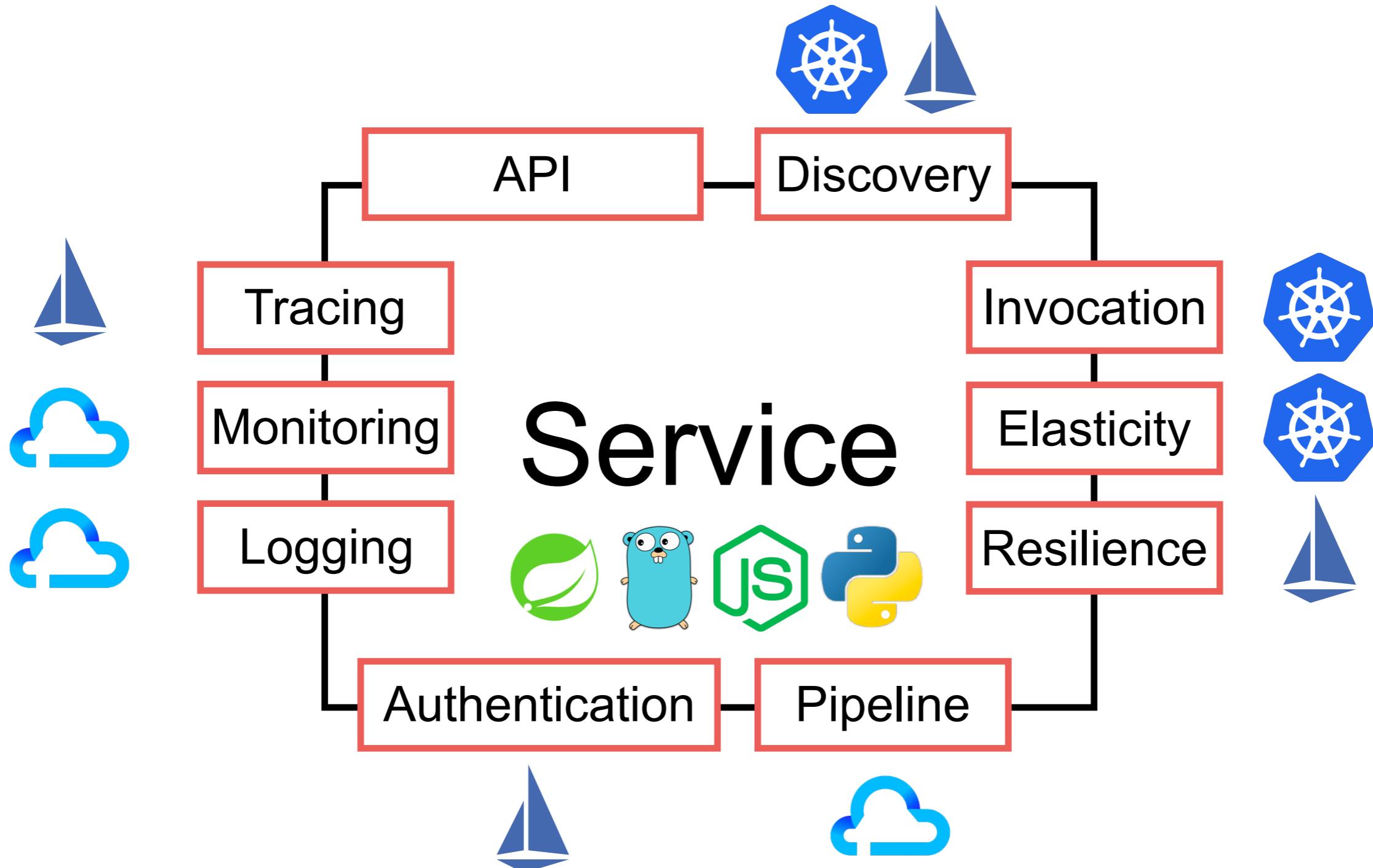




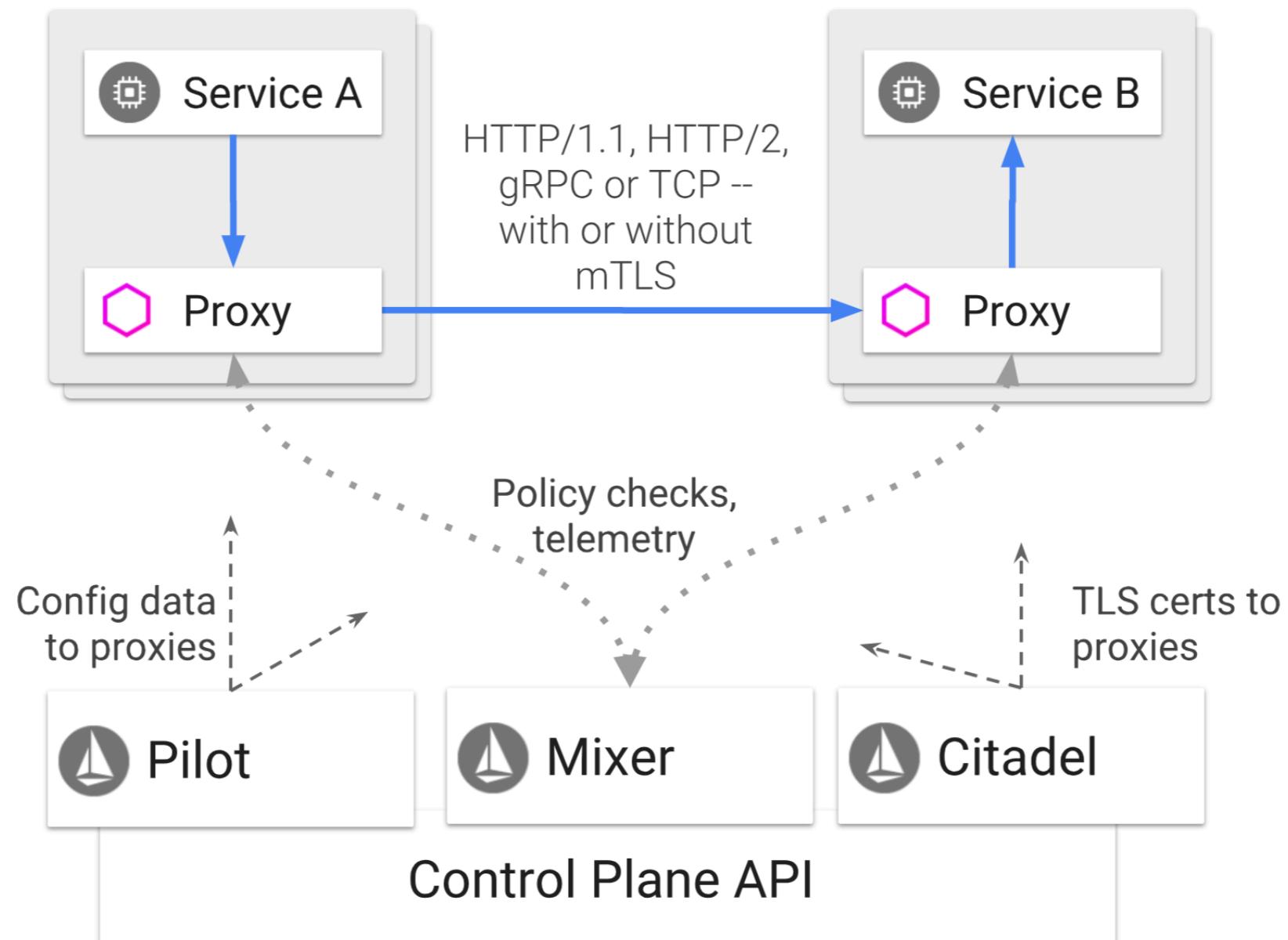
Service Mesh with Istio



Microservice 3.0



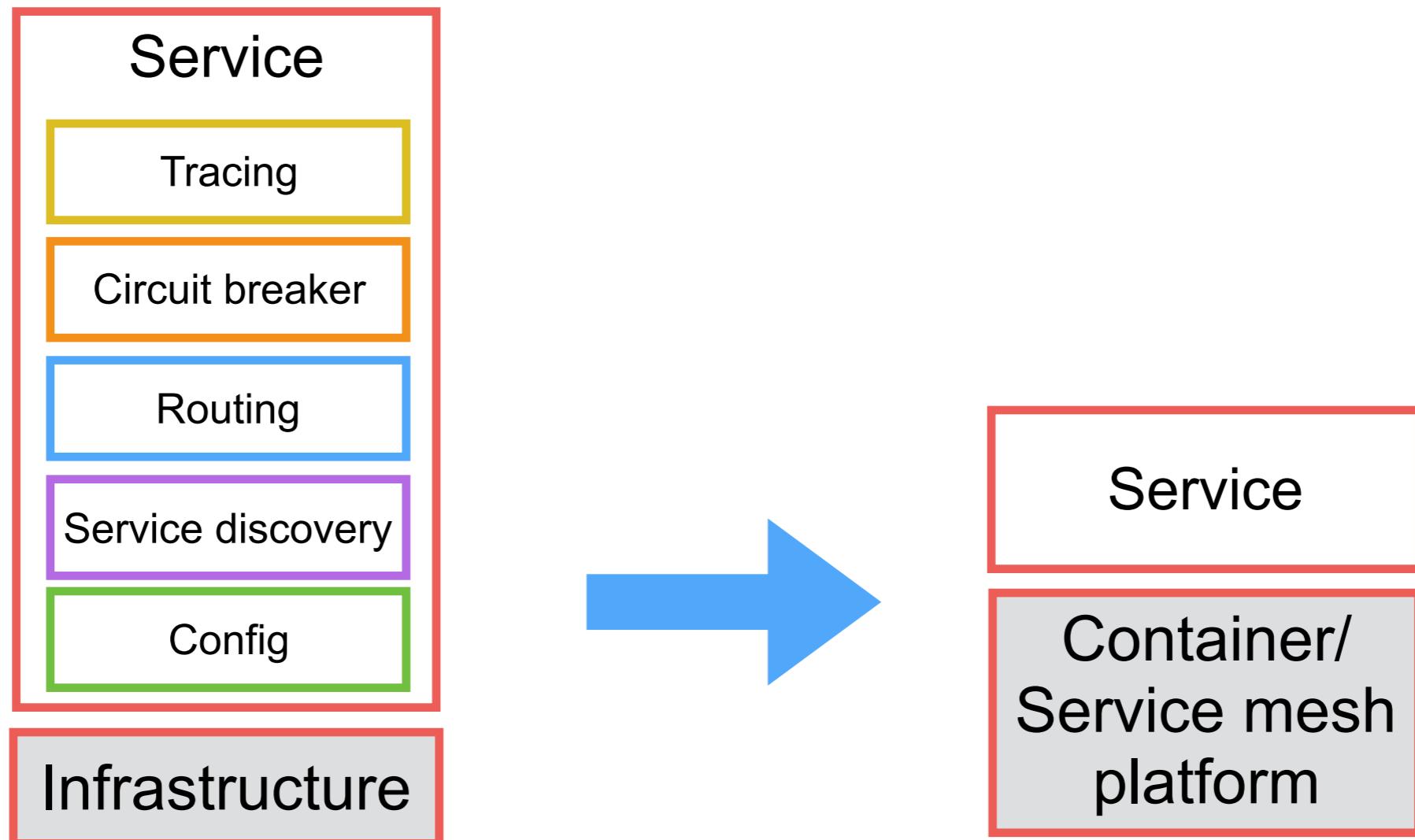
Istio



<https://istio.io/docs/concepts/what-is-istio/>



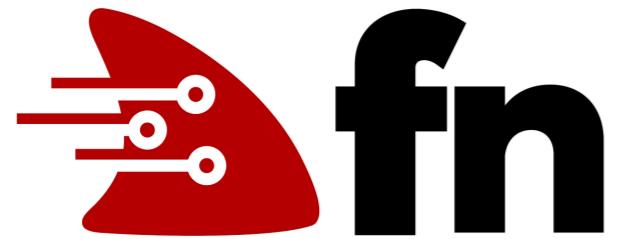
Microservice Evolution



Function-as-a-Service (FaaS)



Microservice 4.0 == FaaS



OPENFAAS



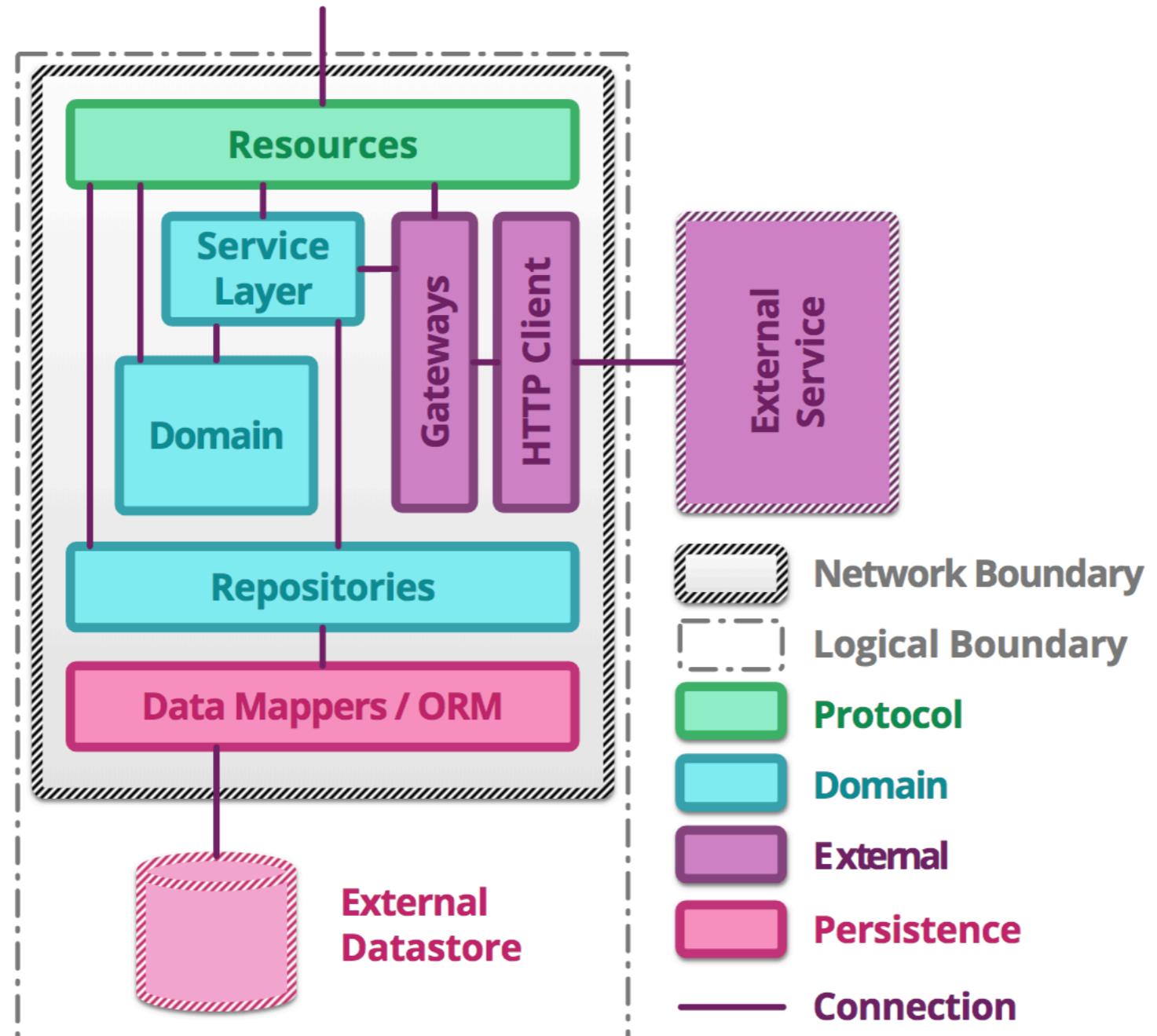
APACHE
OpenWhisk™



Microservice Testing



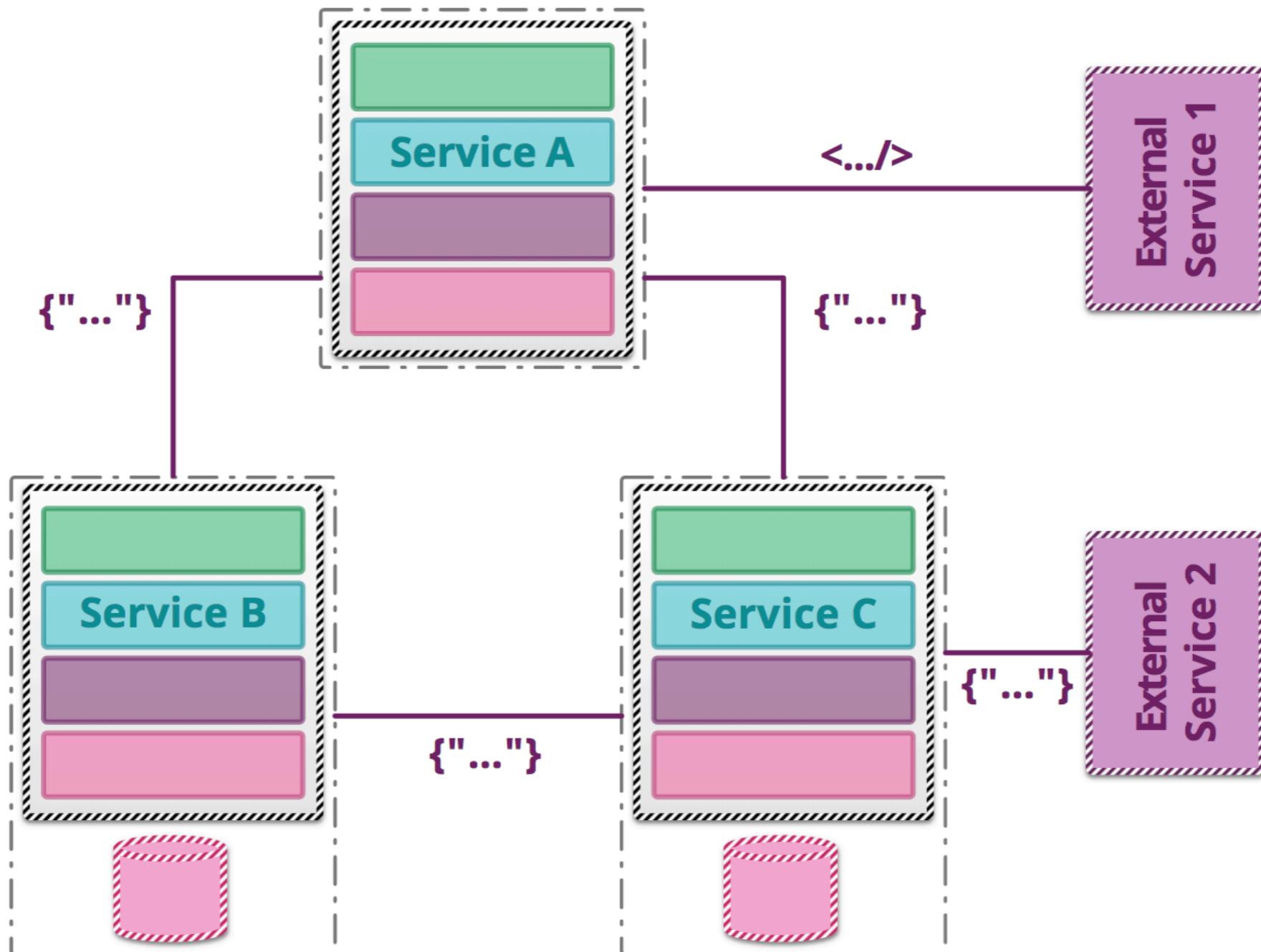
Service structure



<https://martinfowler.com/articles/microservice-testing>



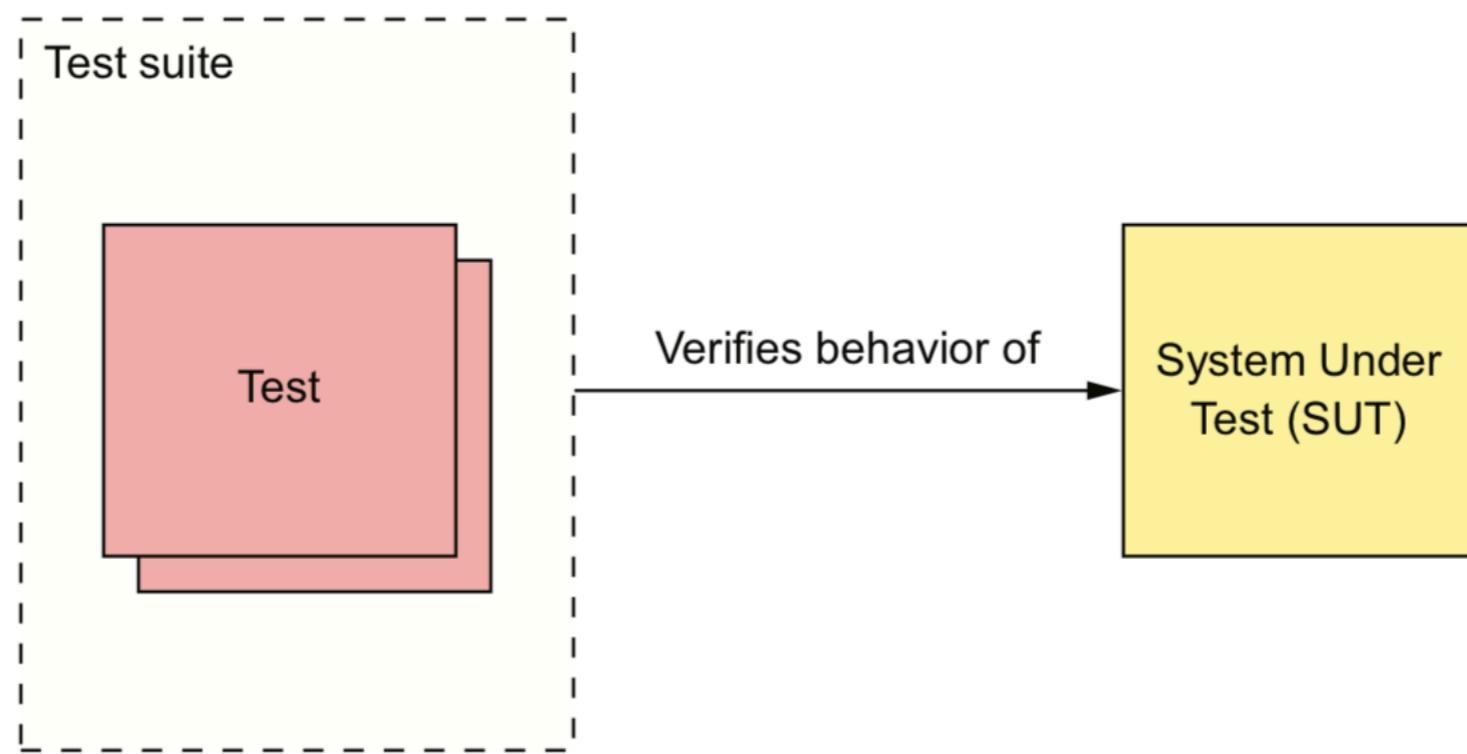
Multiple services



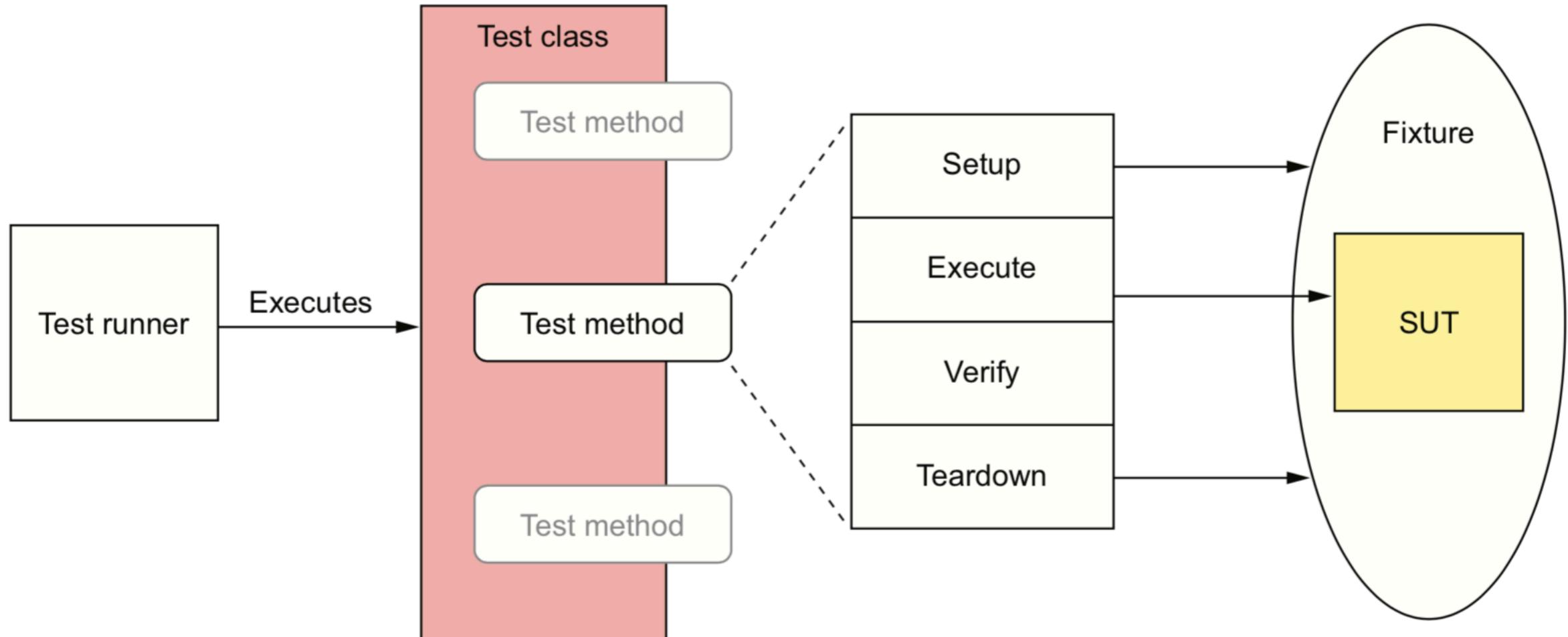
<https://martinfowler.com/articles/microservice-testing>



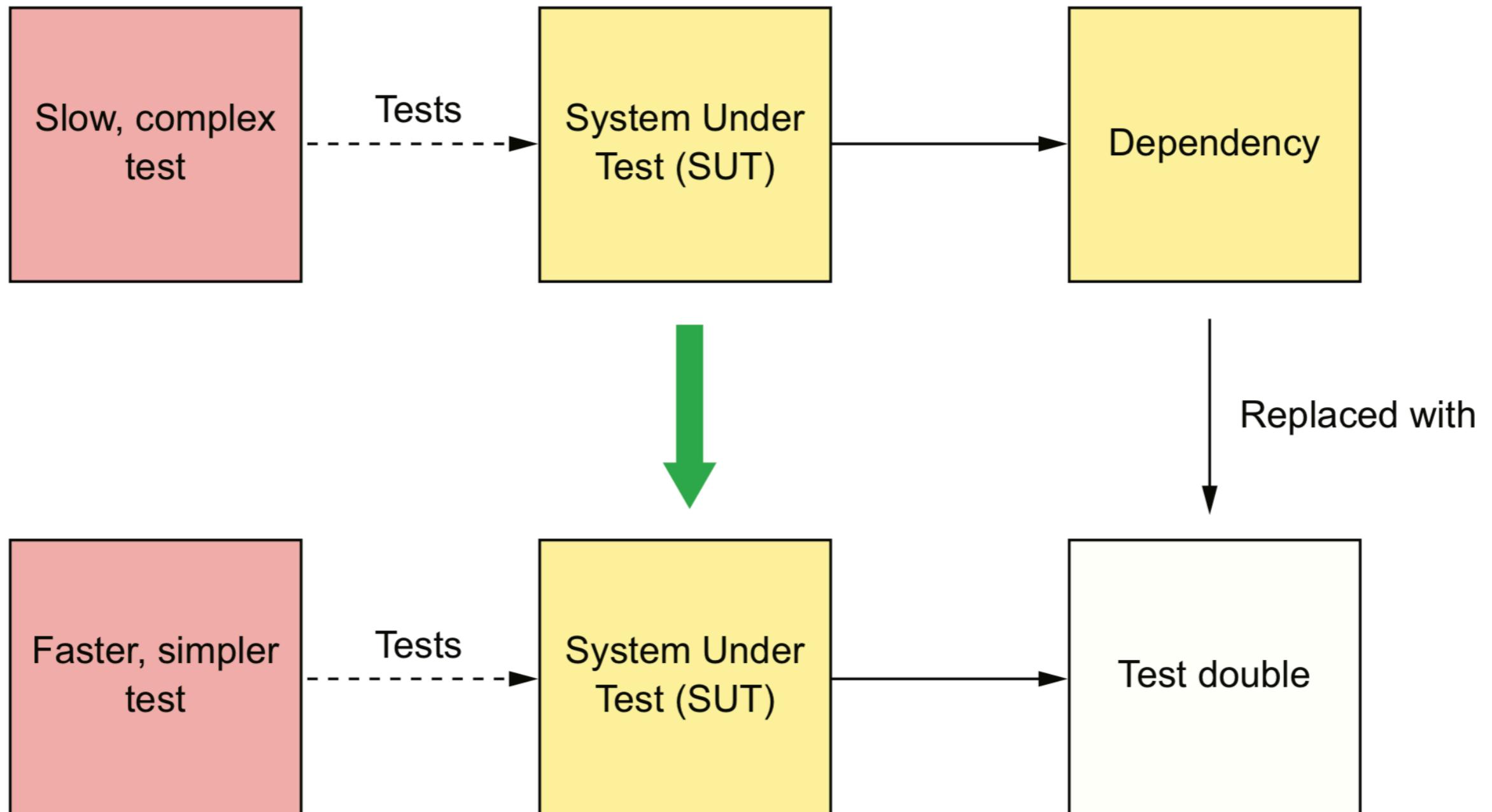
Testing



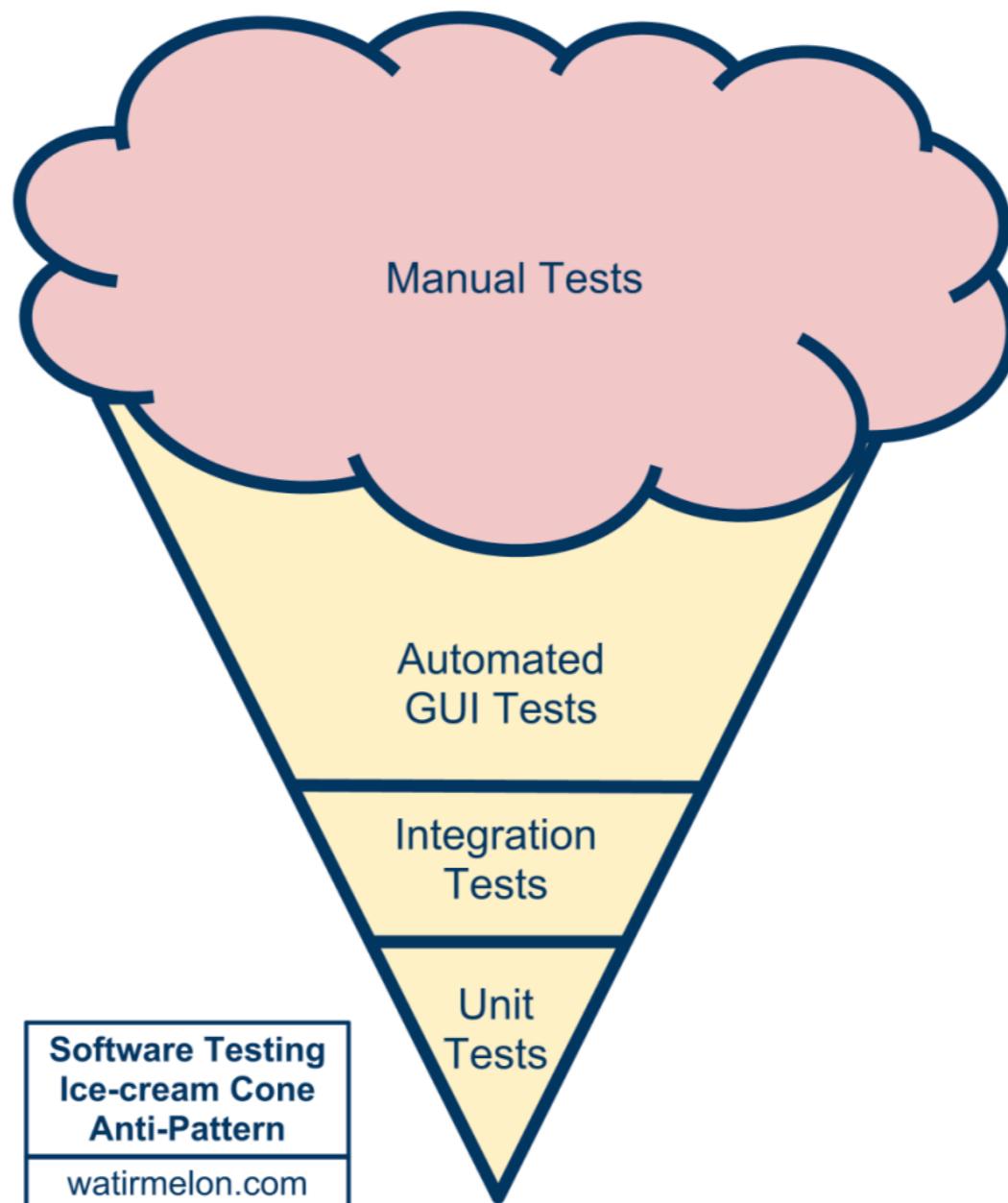
Structure of Automated tests



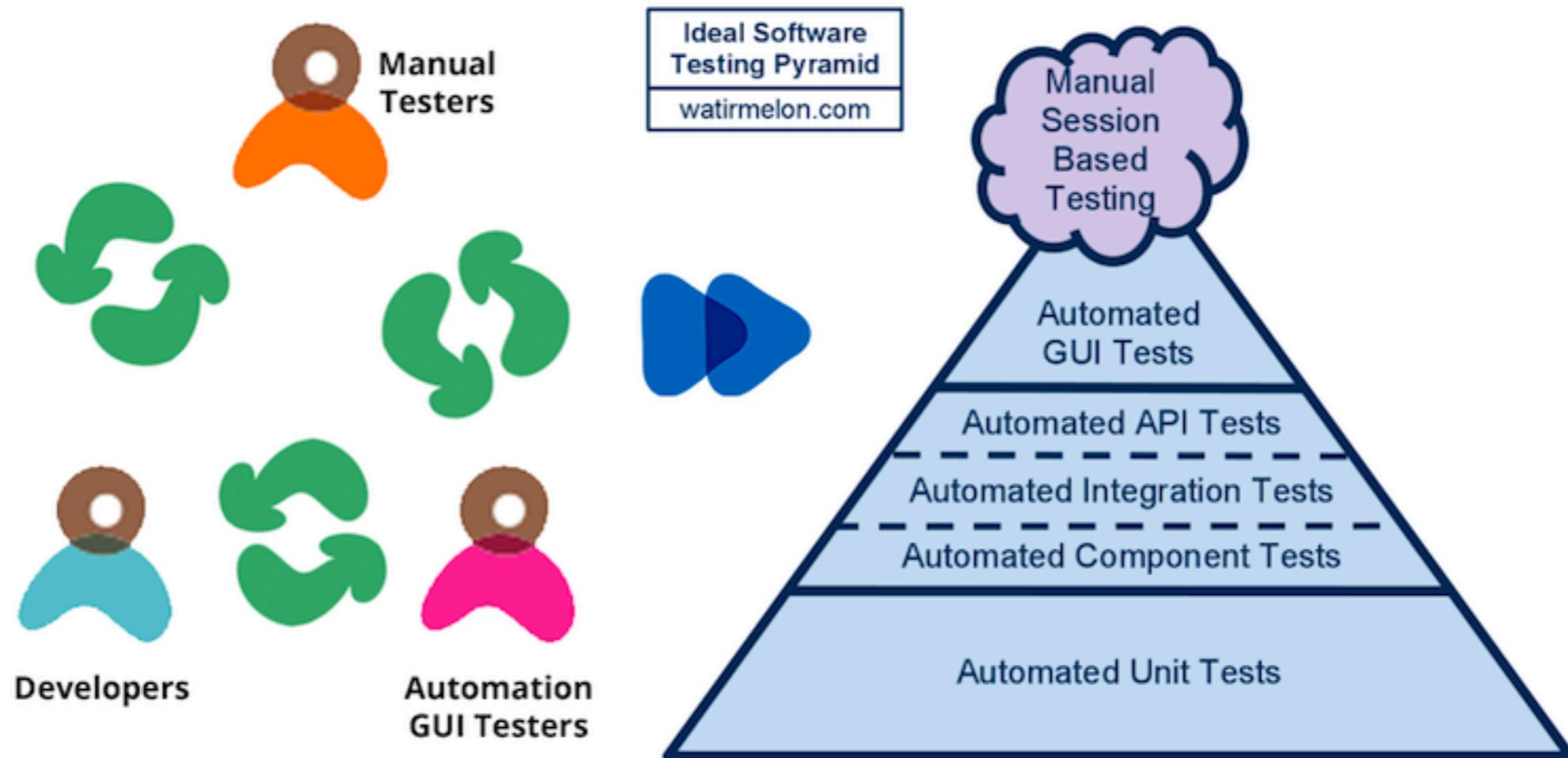
Working with Test double

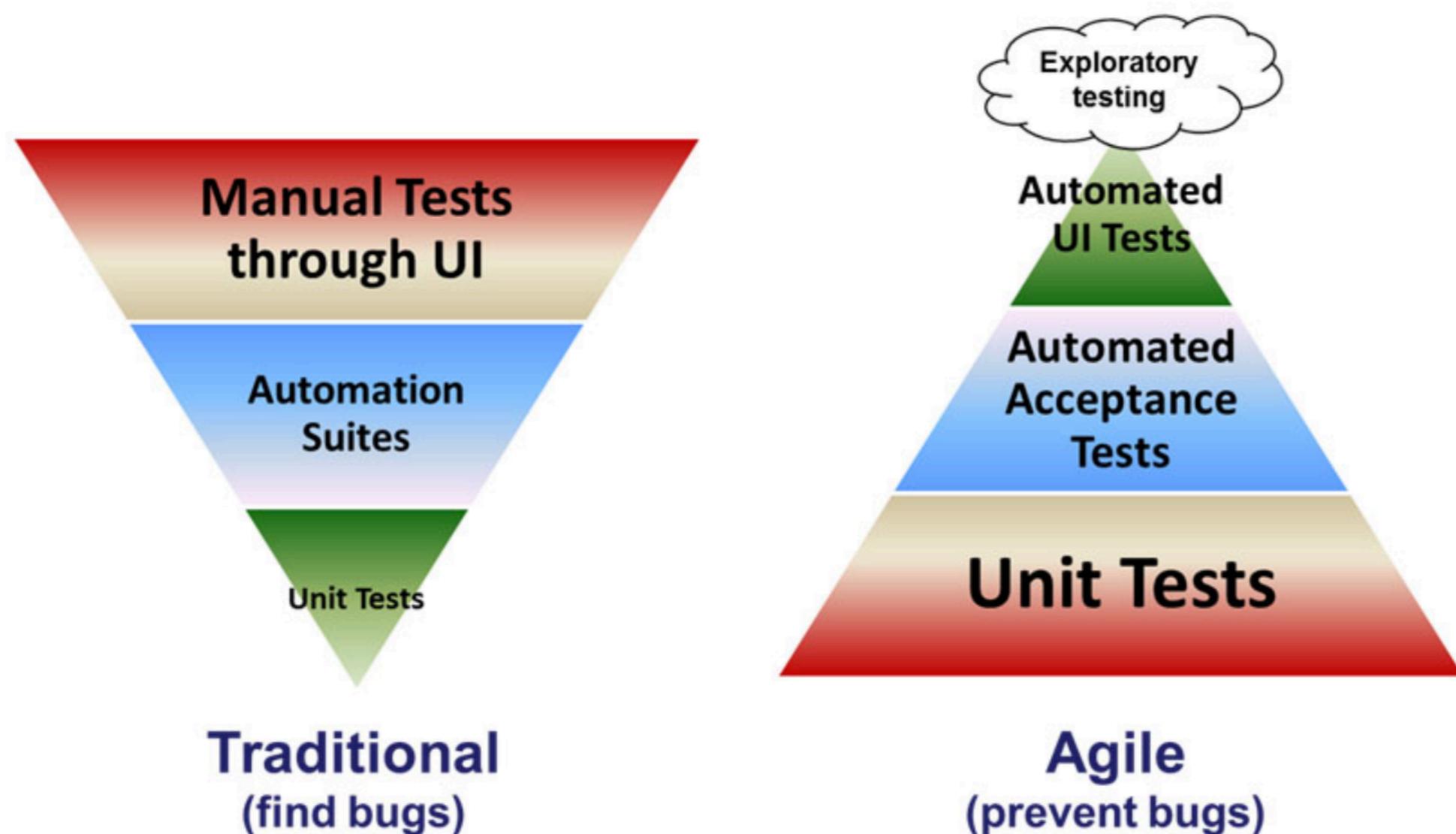


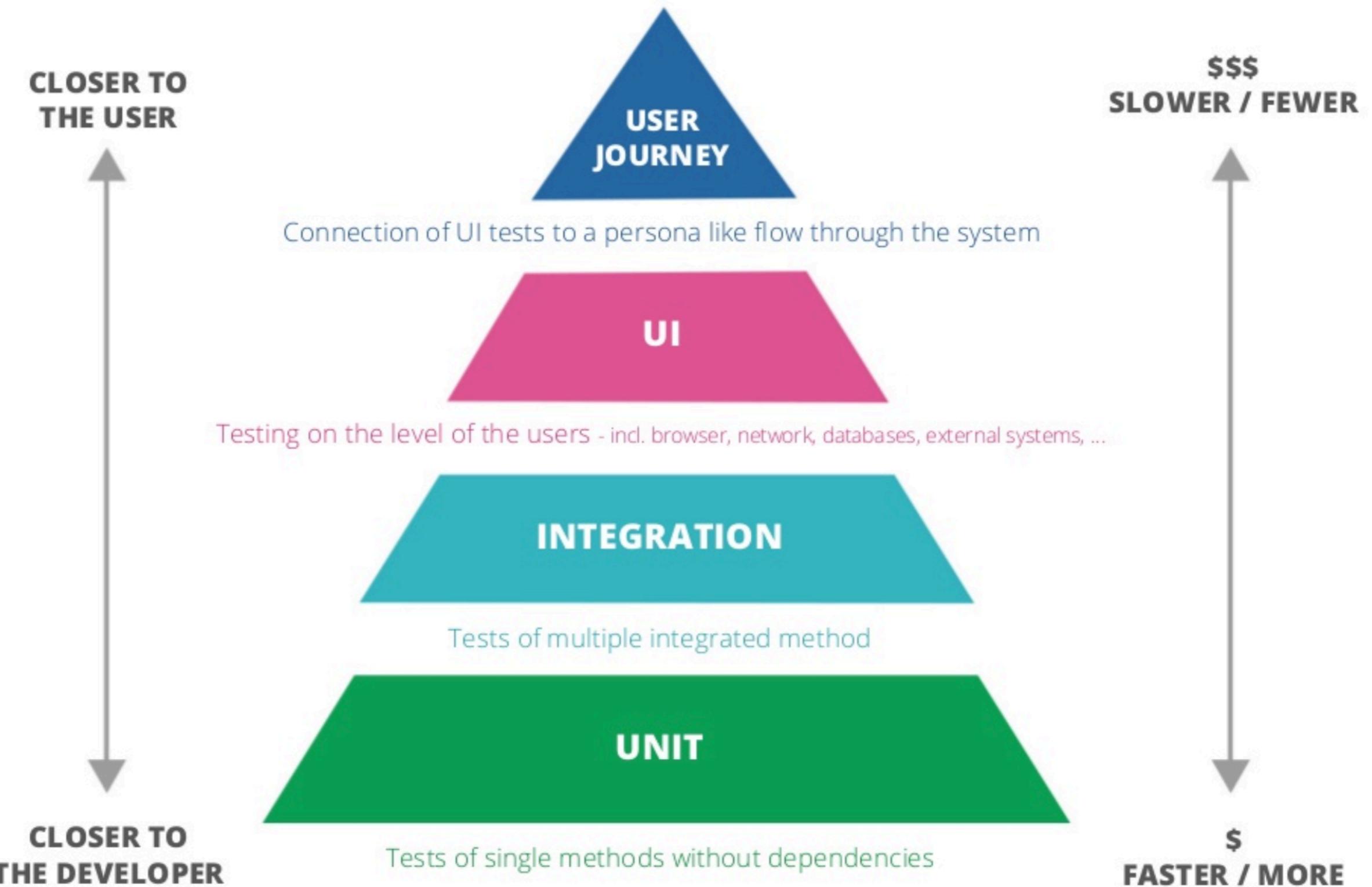
Ice-cream testing



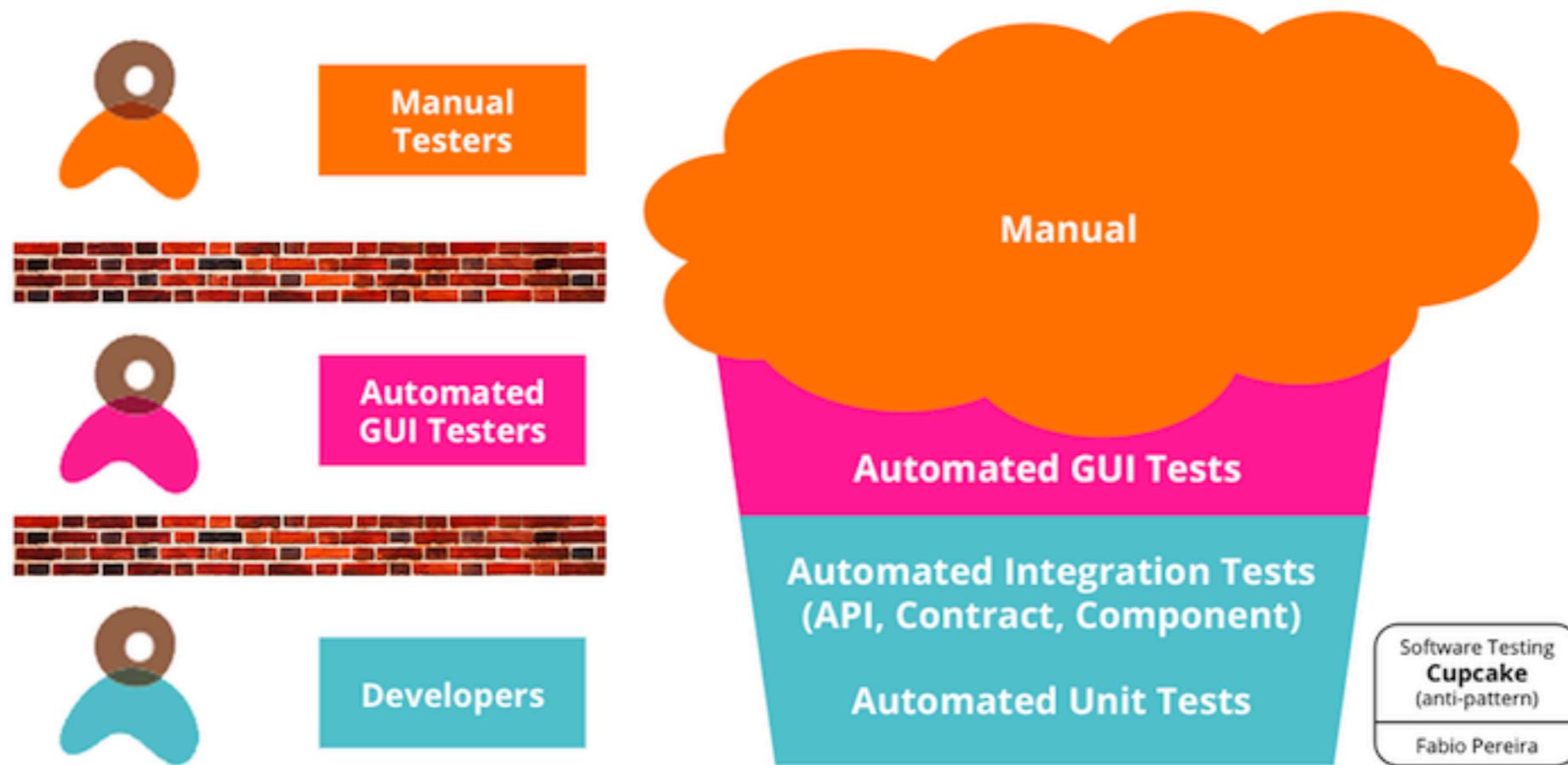
Pyramid testing



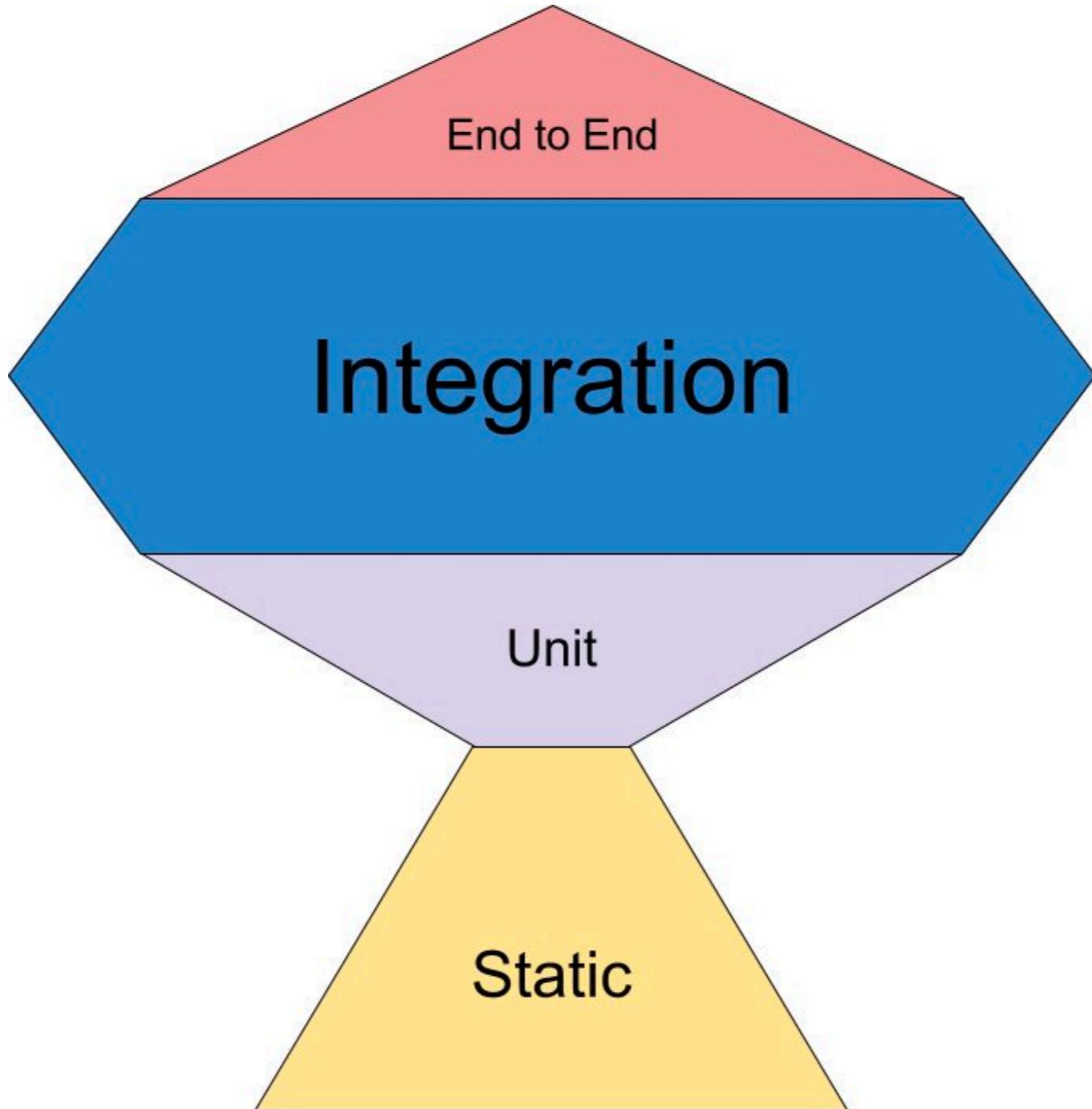




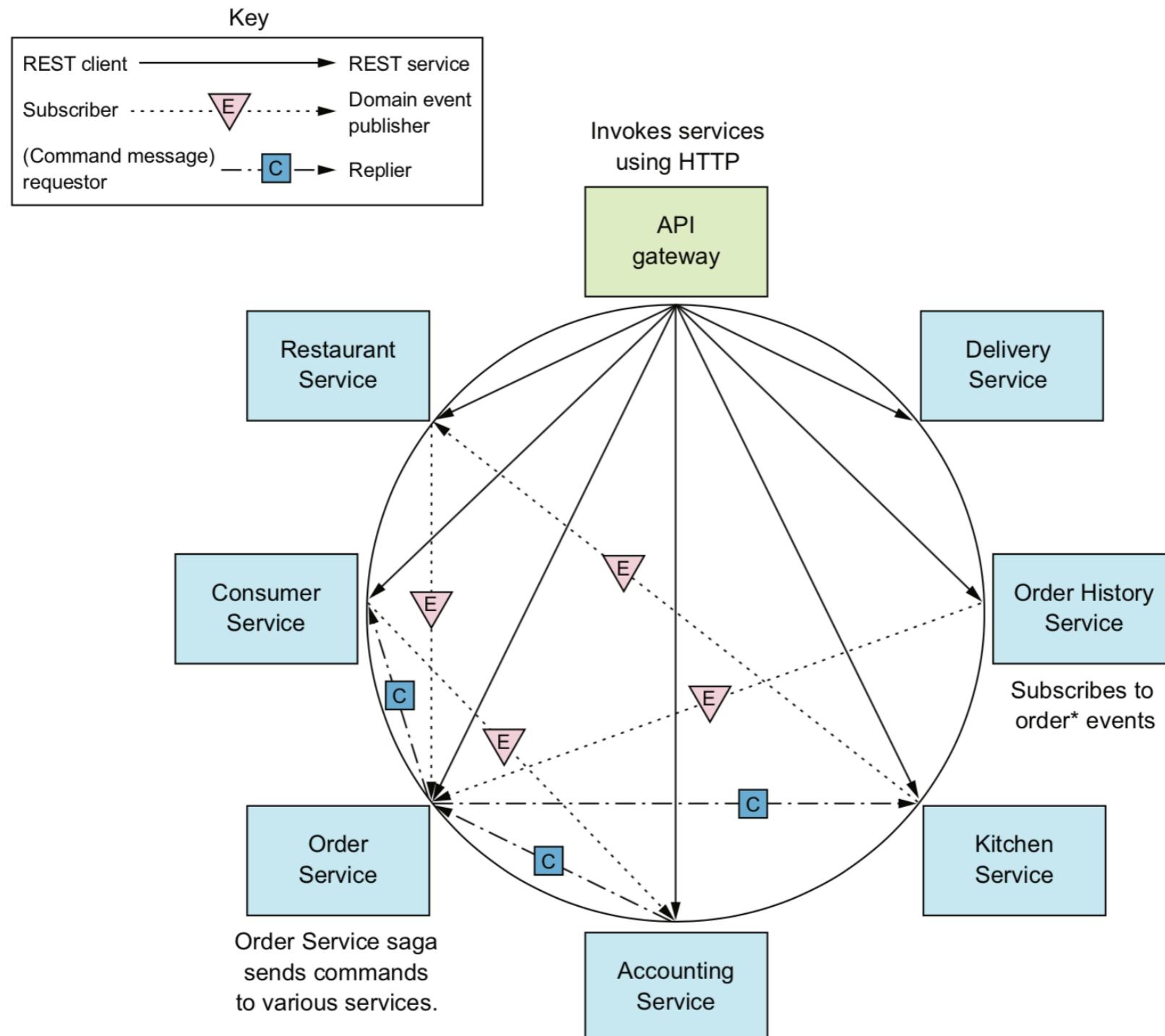
Cupcake testing



Trophy testing

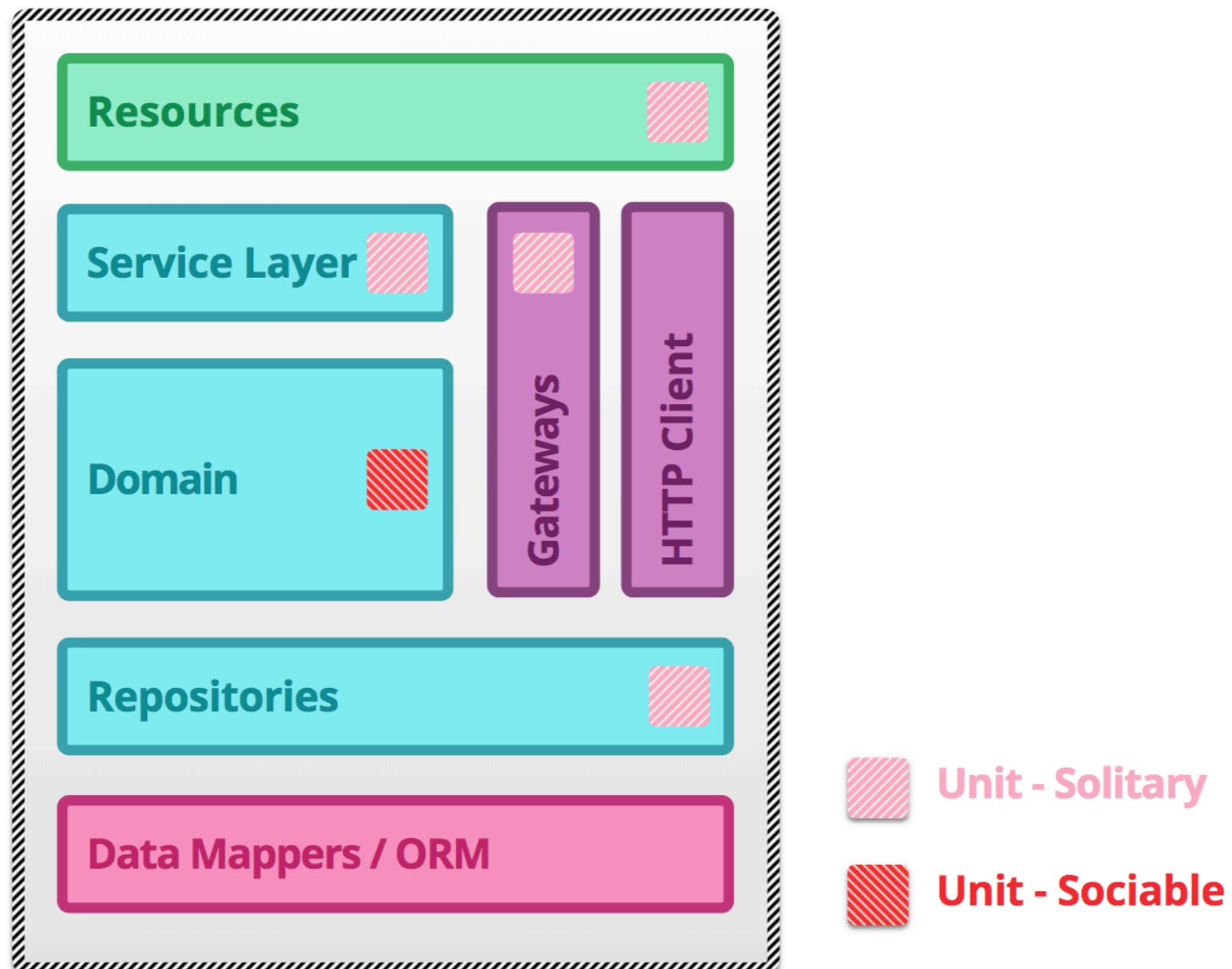


Testing Microservices ?

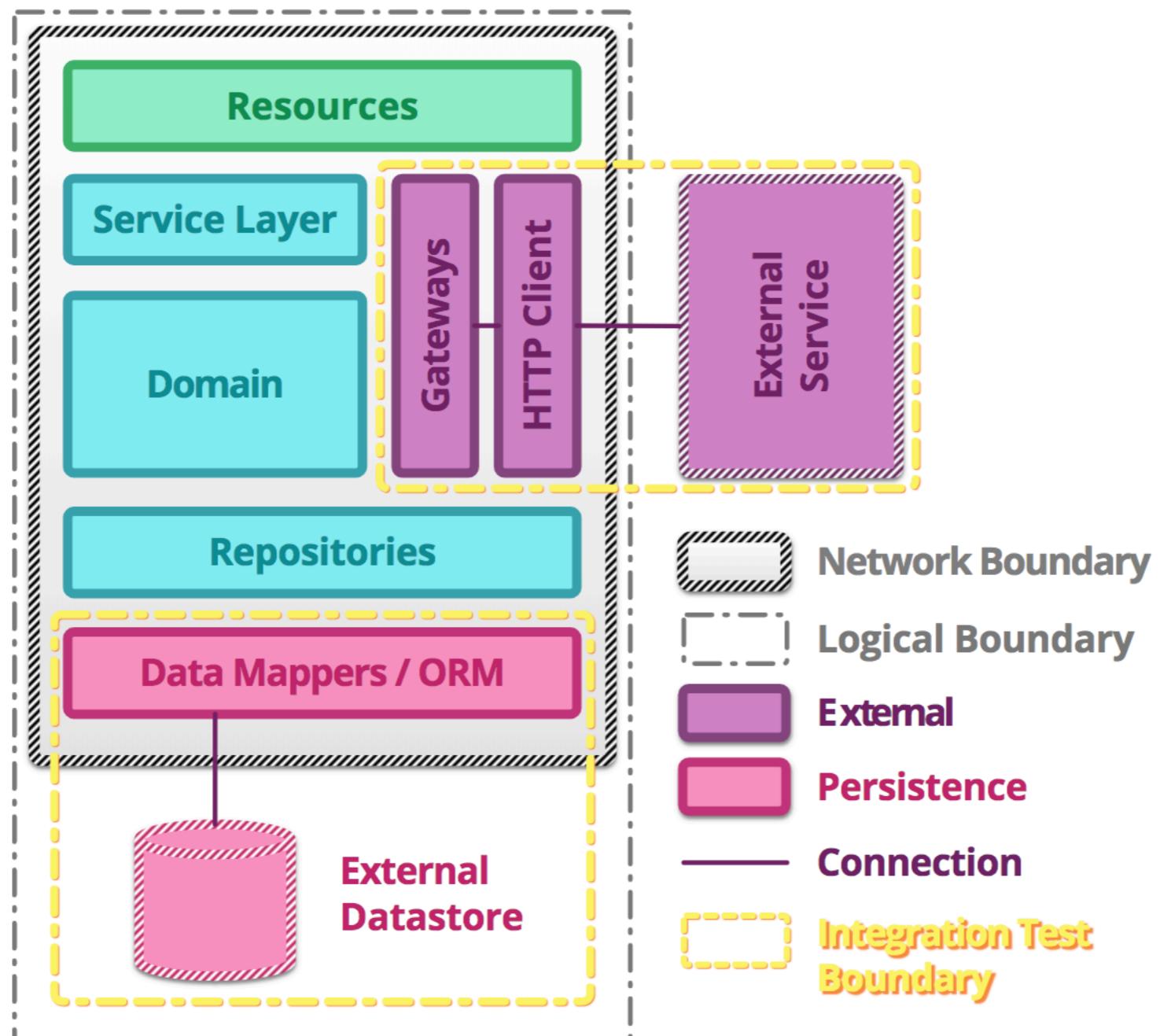




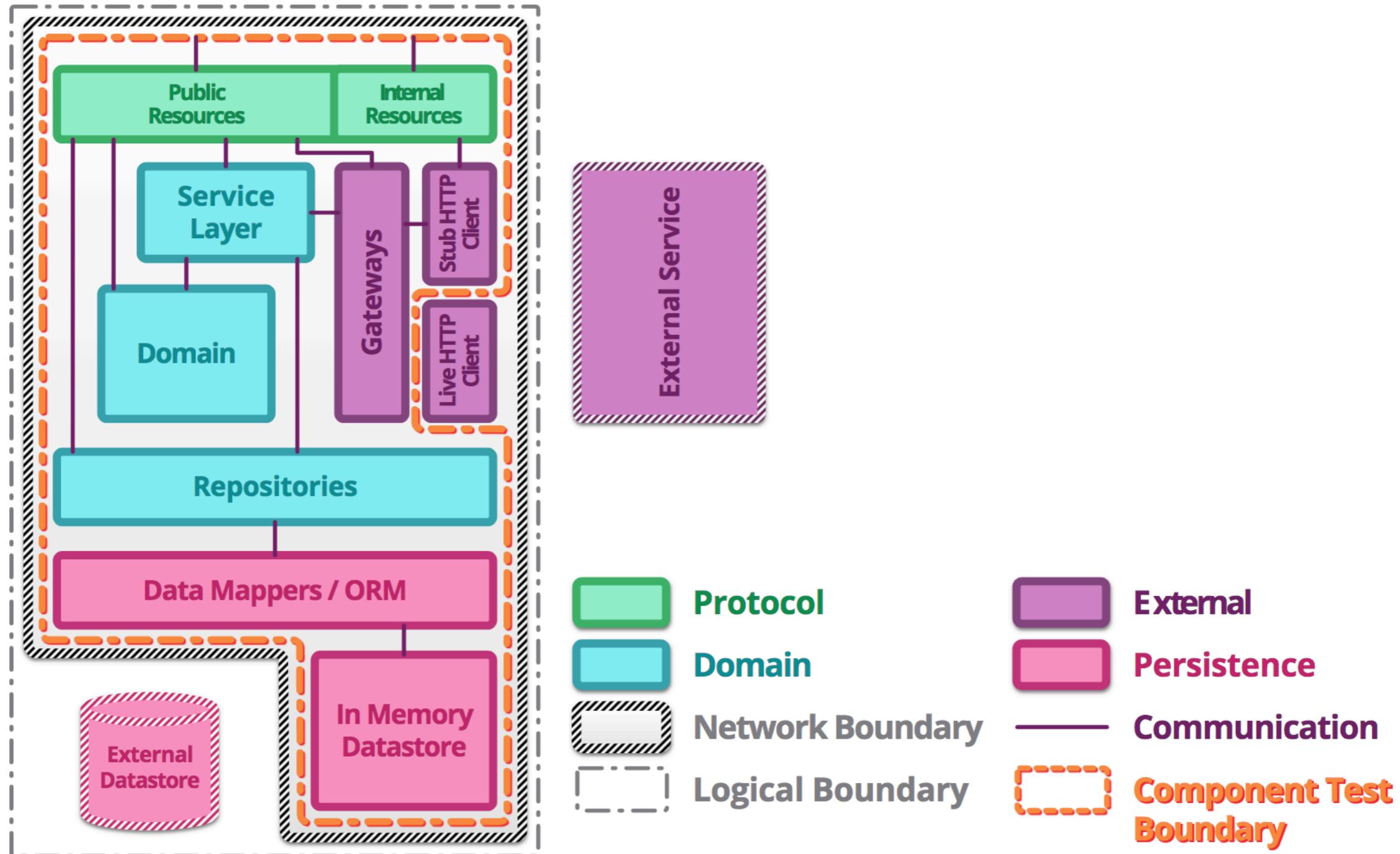
Unit testing



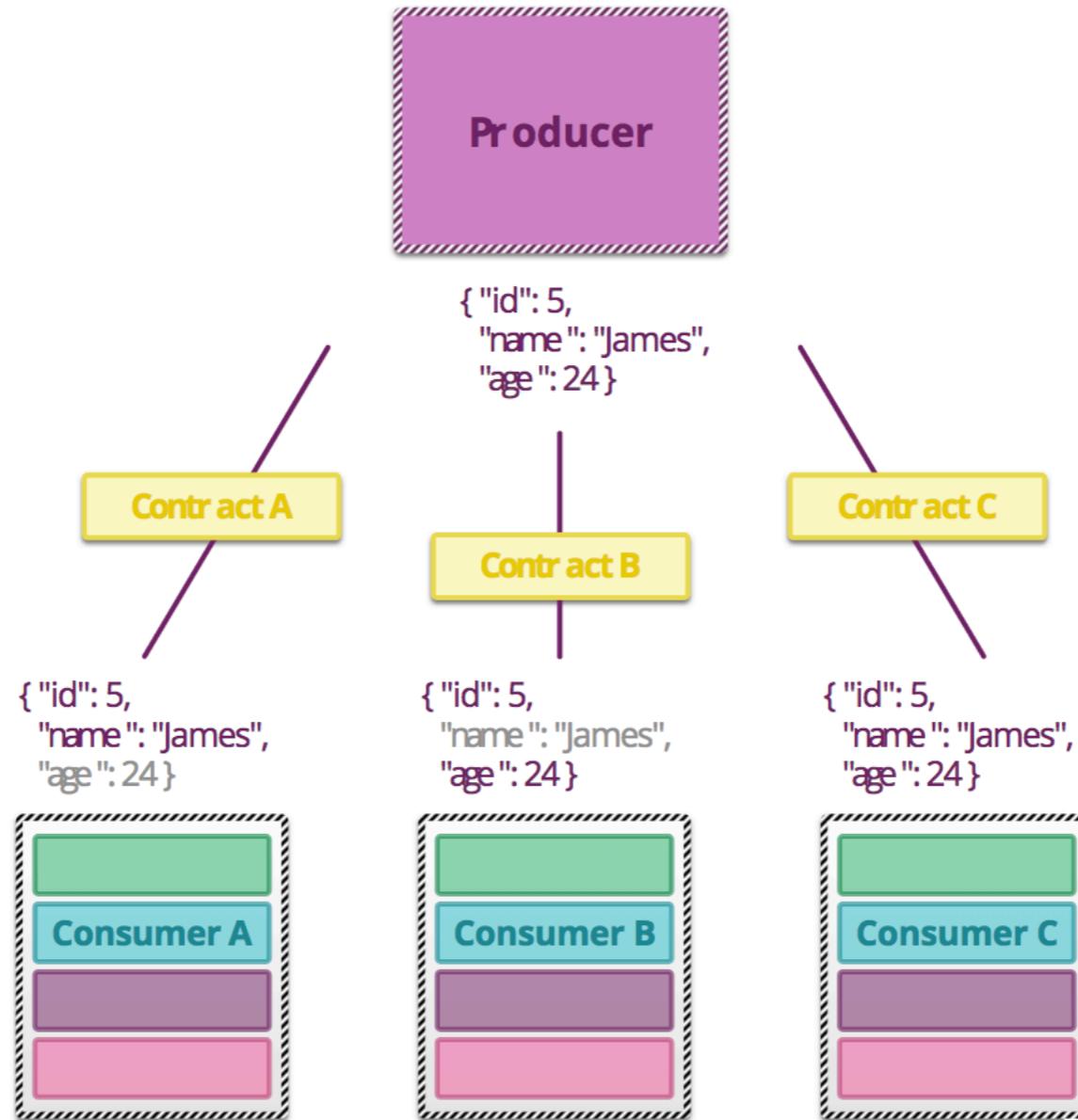
Integration testing



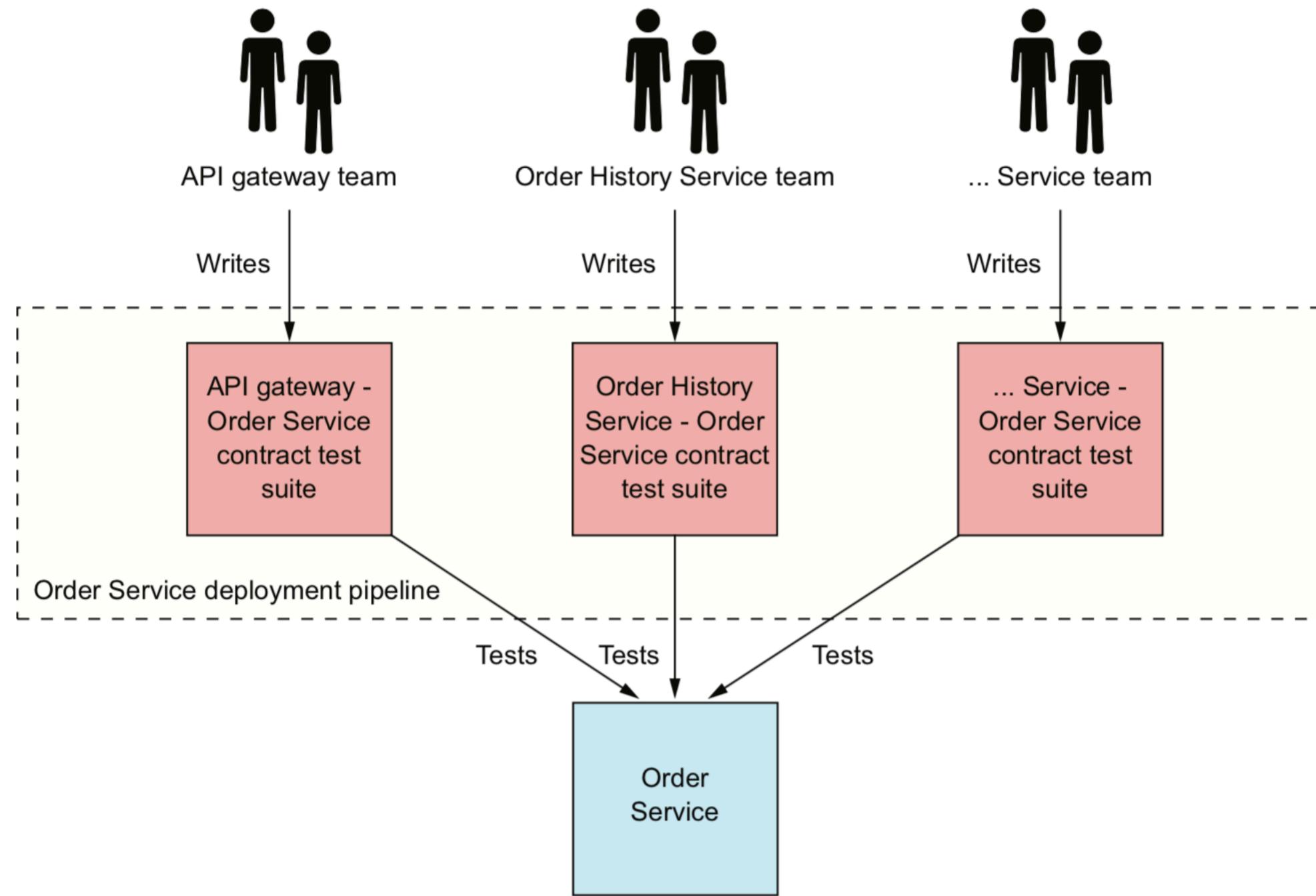
Component testing



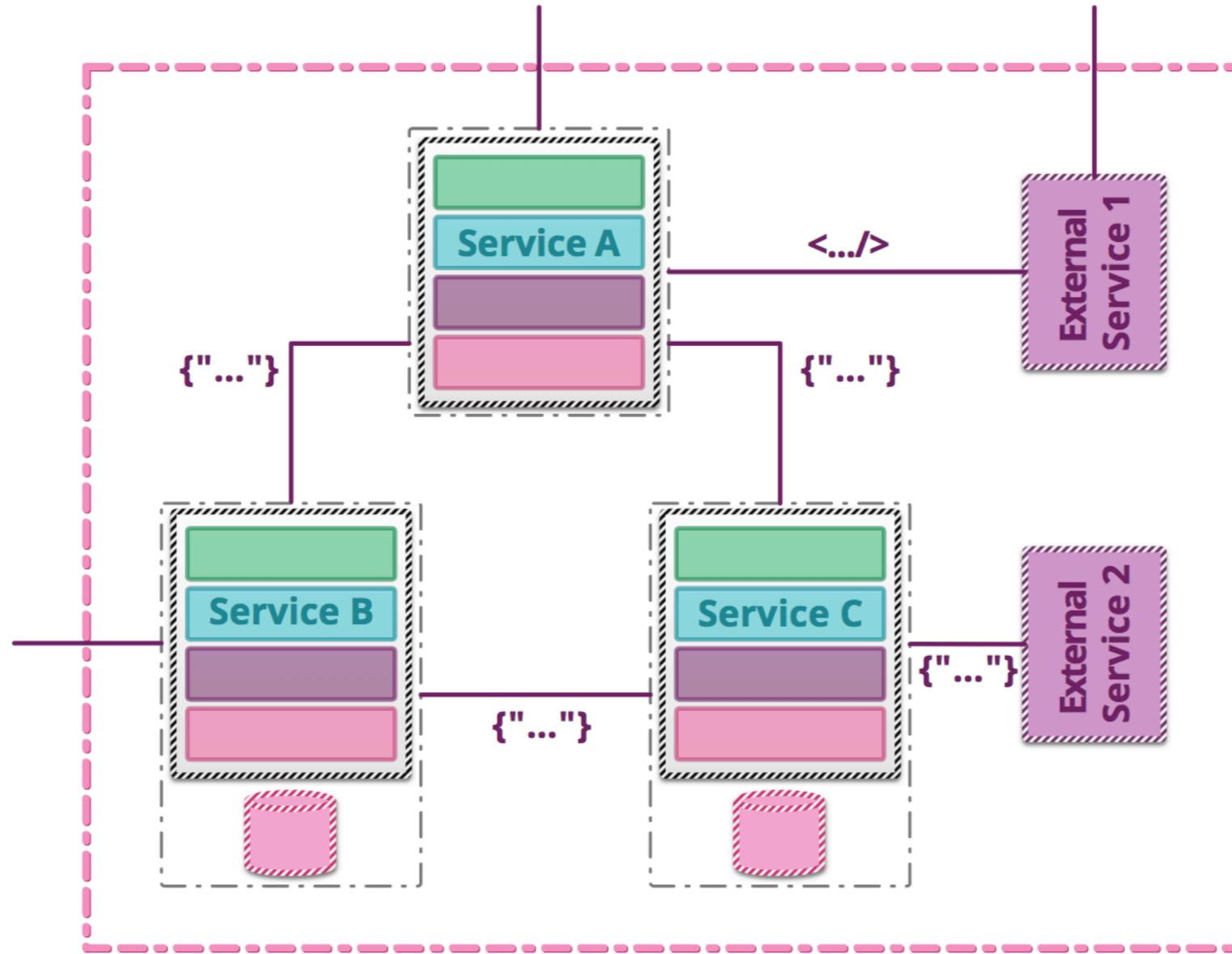
Contract testing



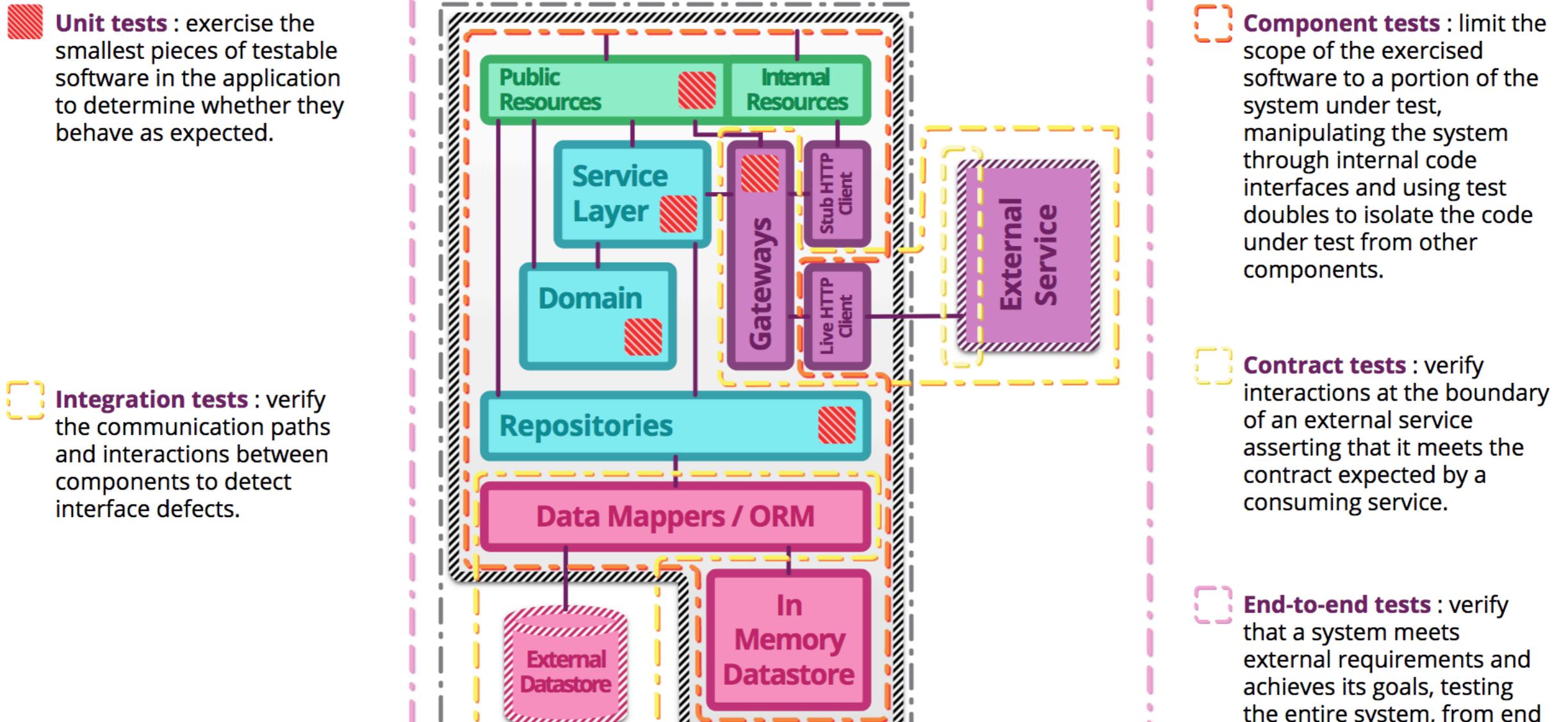
Consumer Contract testing



End-to-End testing



Summary



What is your testing strategy ?



Performance testing ?

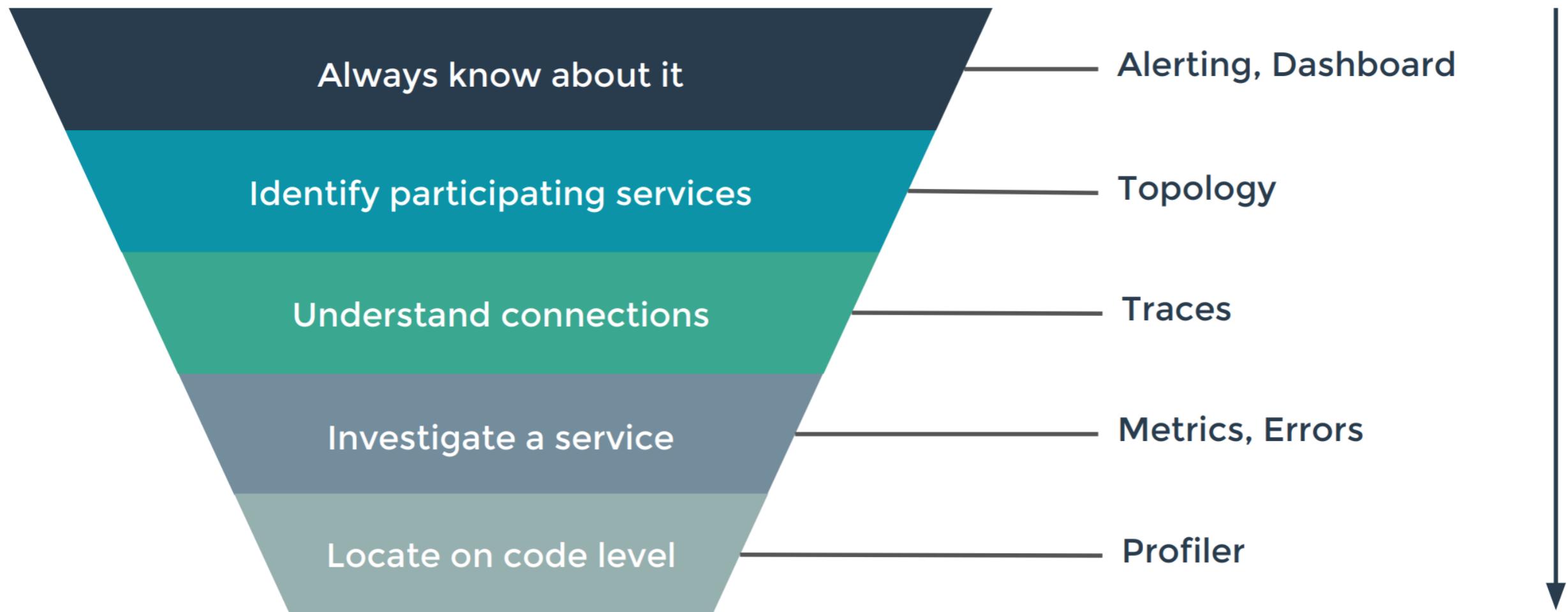
Security testing ?



How to find an issue ?



How to find an issue ?



Develop production-ready services



Important quality attributes

Security
Configurability
Observability



Secure services



Develop secure services

Authentication

Authorization

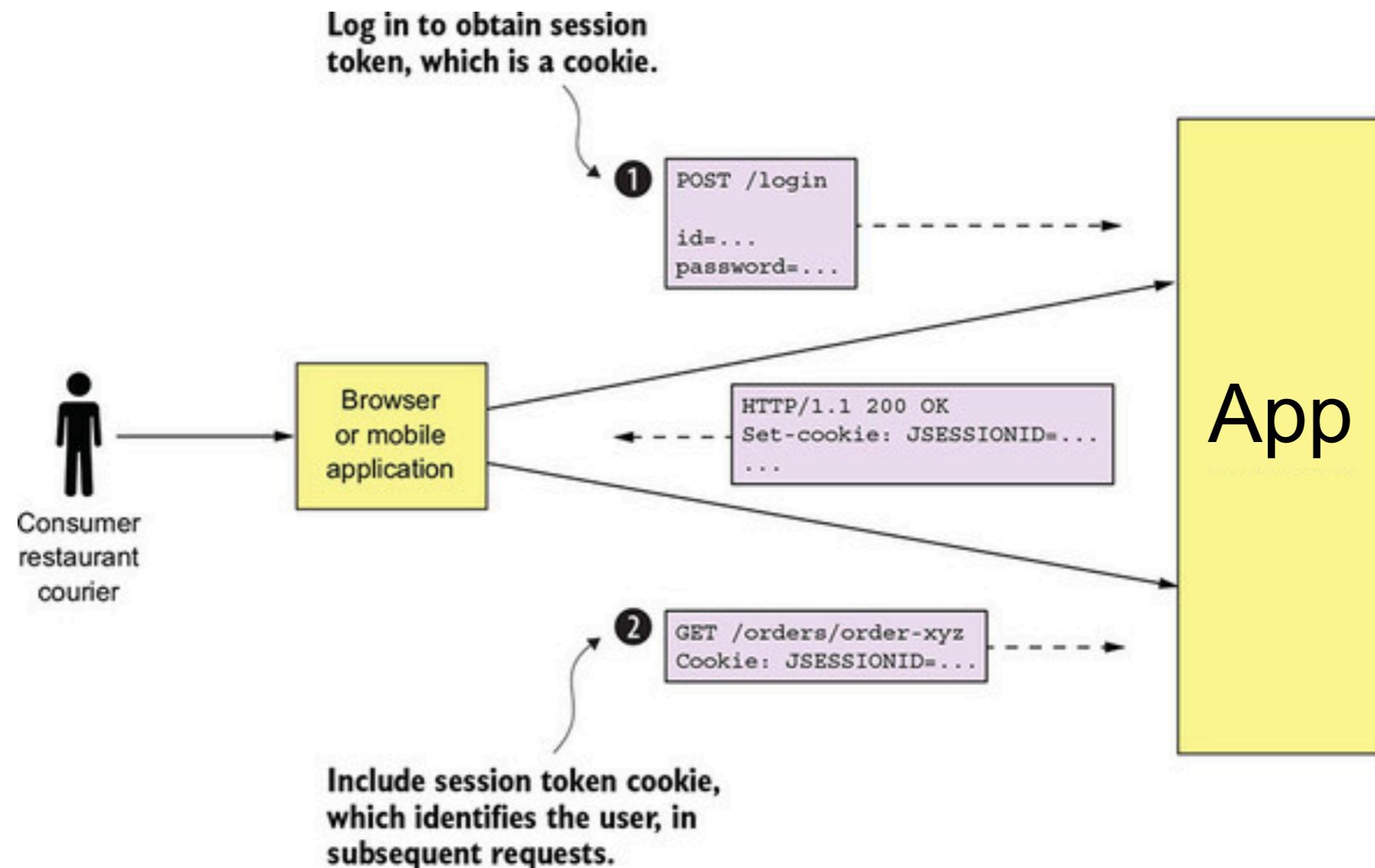
Auditing

Secure interprocess communication



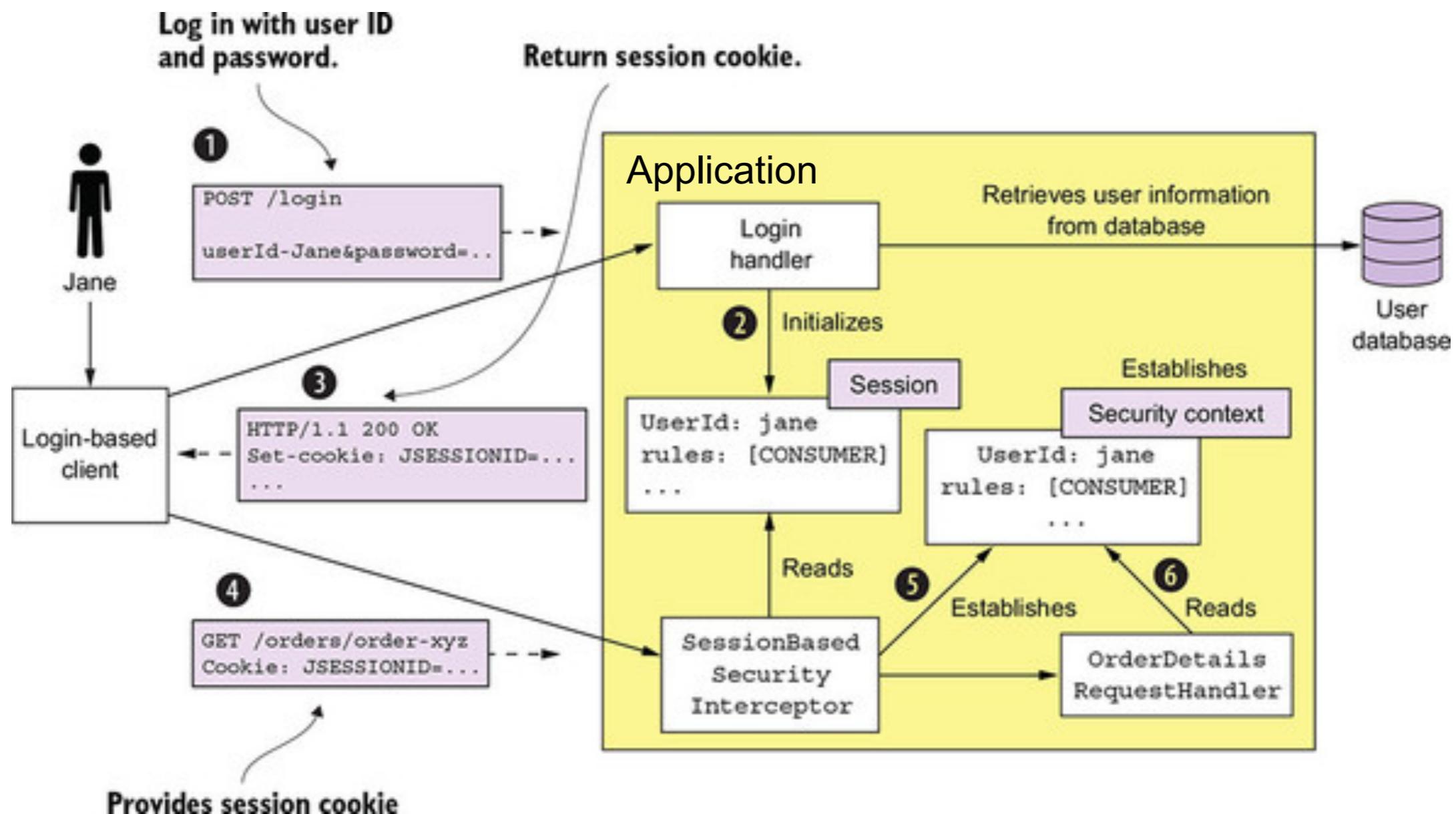
Security in traditional application

Keep security information in browser's cookie



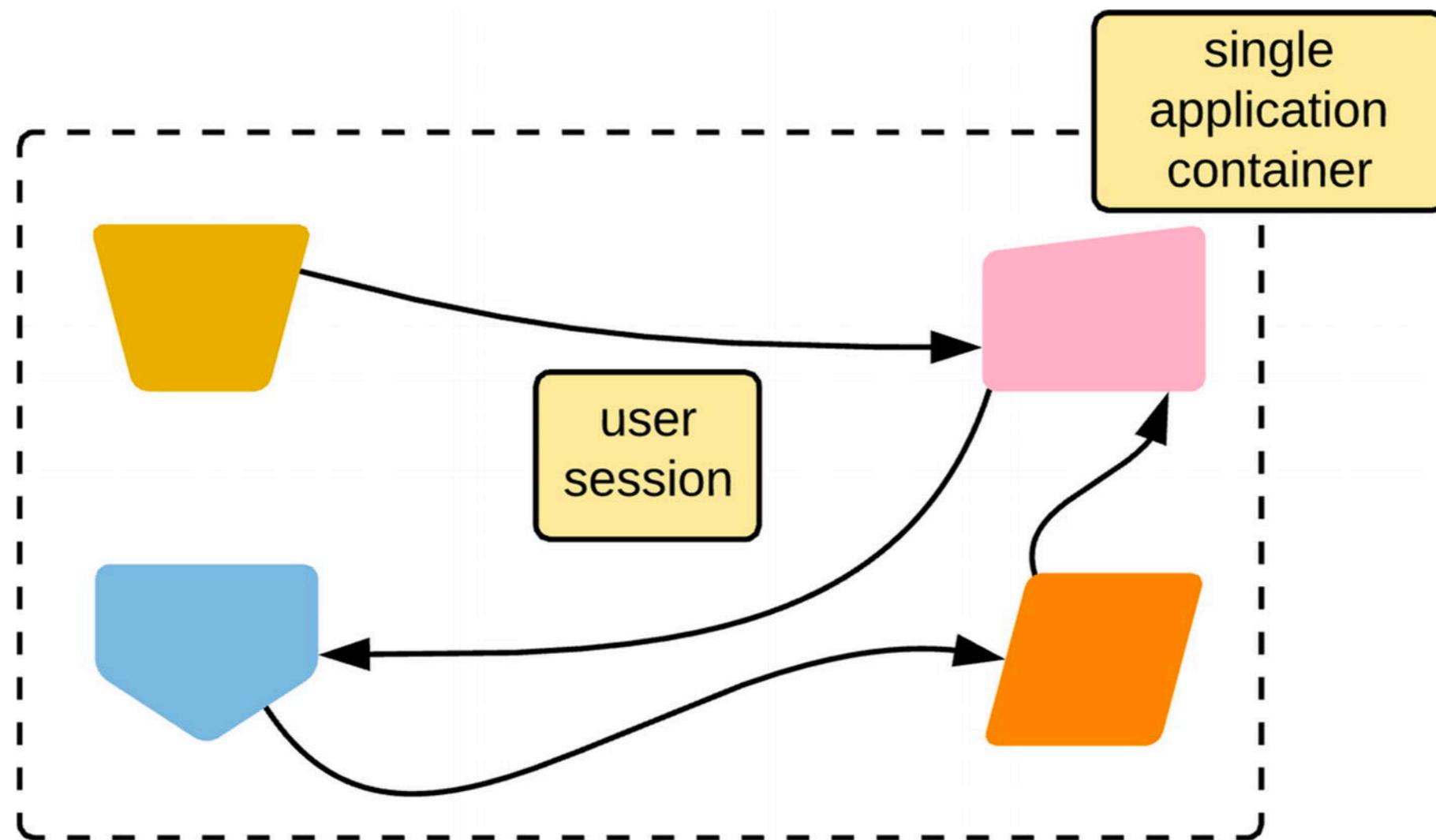
Security in traditional application

Implement security process in application



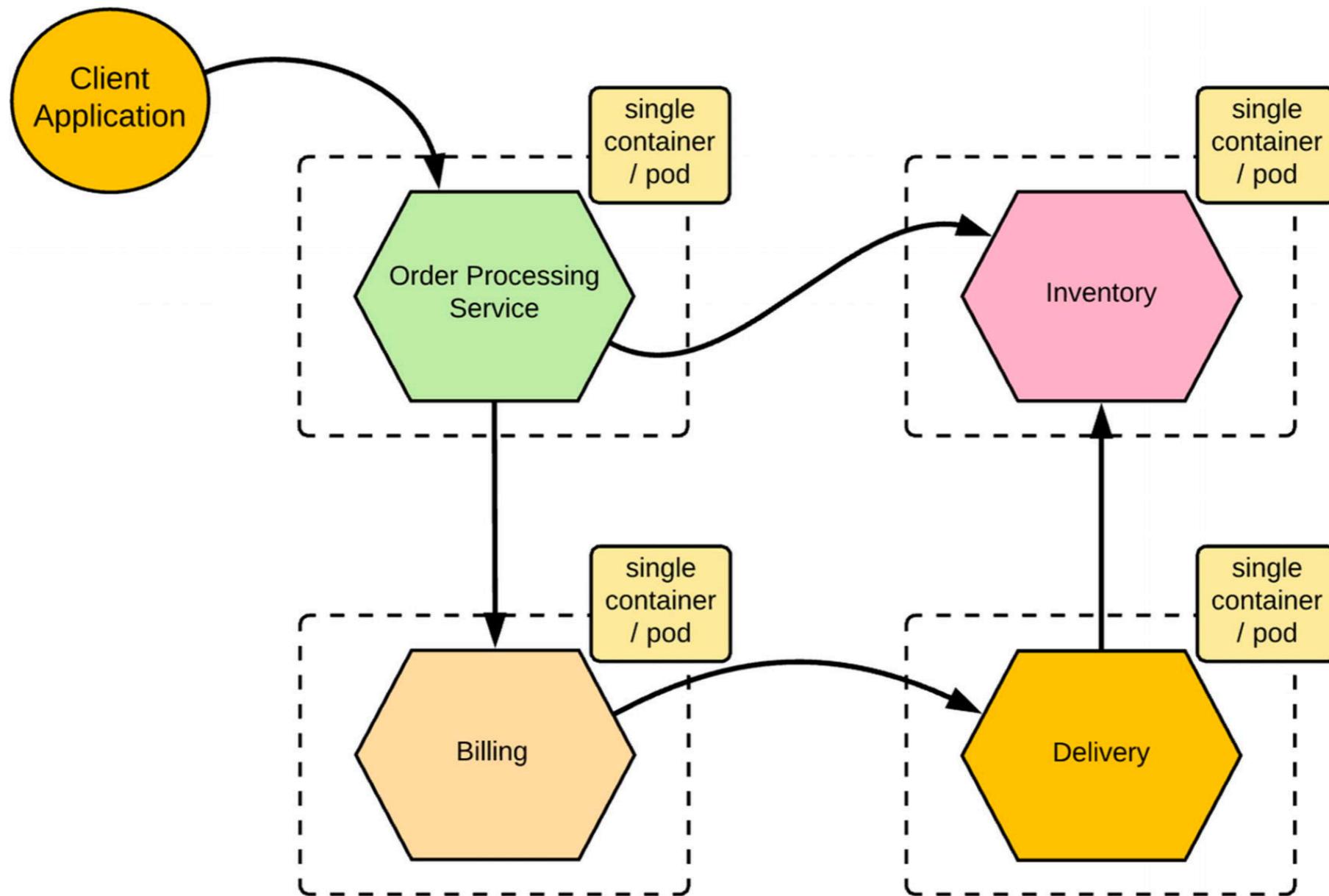
Security in traditional application

Sharing a user session in application



Security in multiple services ?

Interaction between multiple services



Secure service-to-service communication

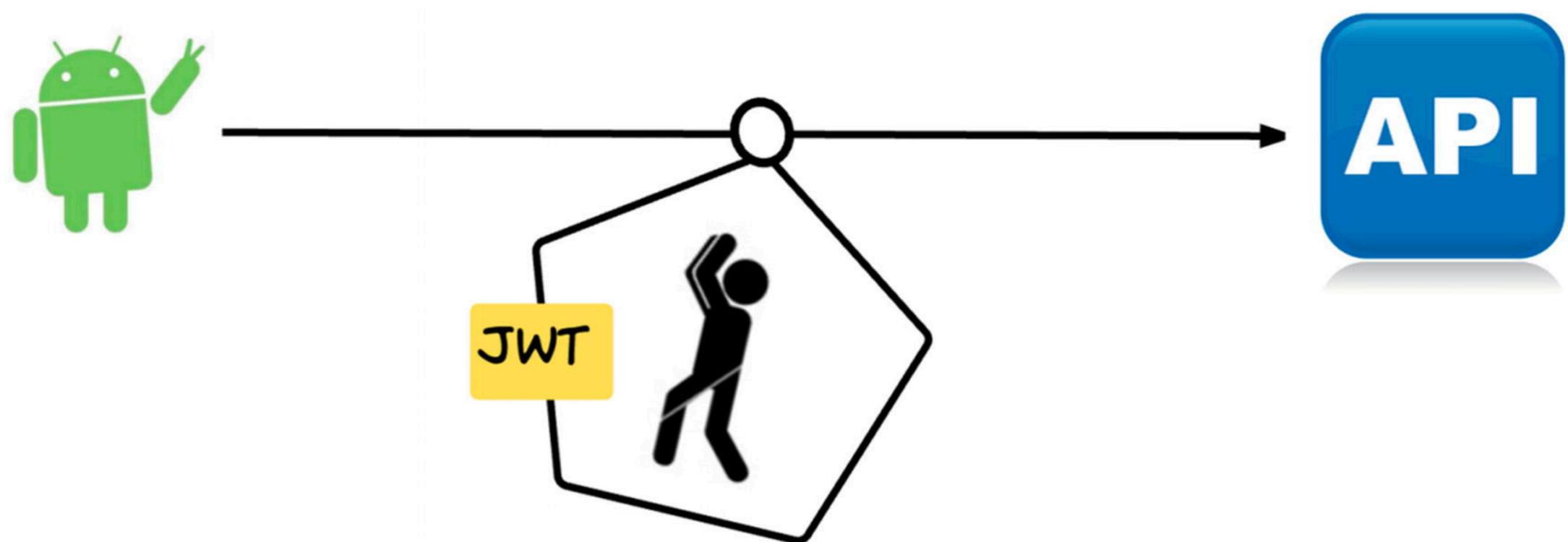
JSON Web Token (JWT)

Transport Layer Security (TLS) mutual authentication

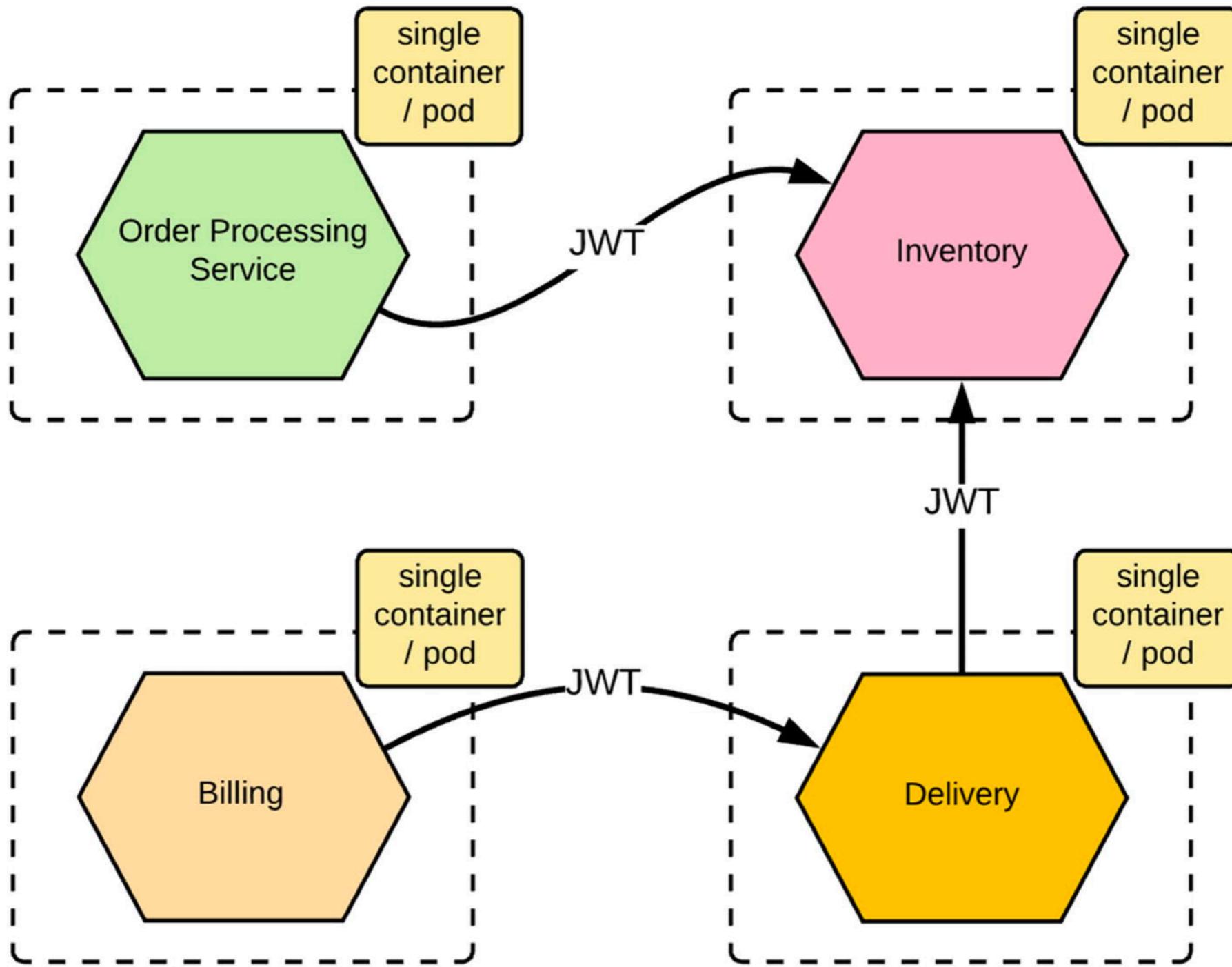


JSON Web Token (JWT)

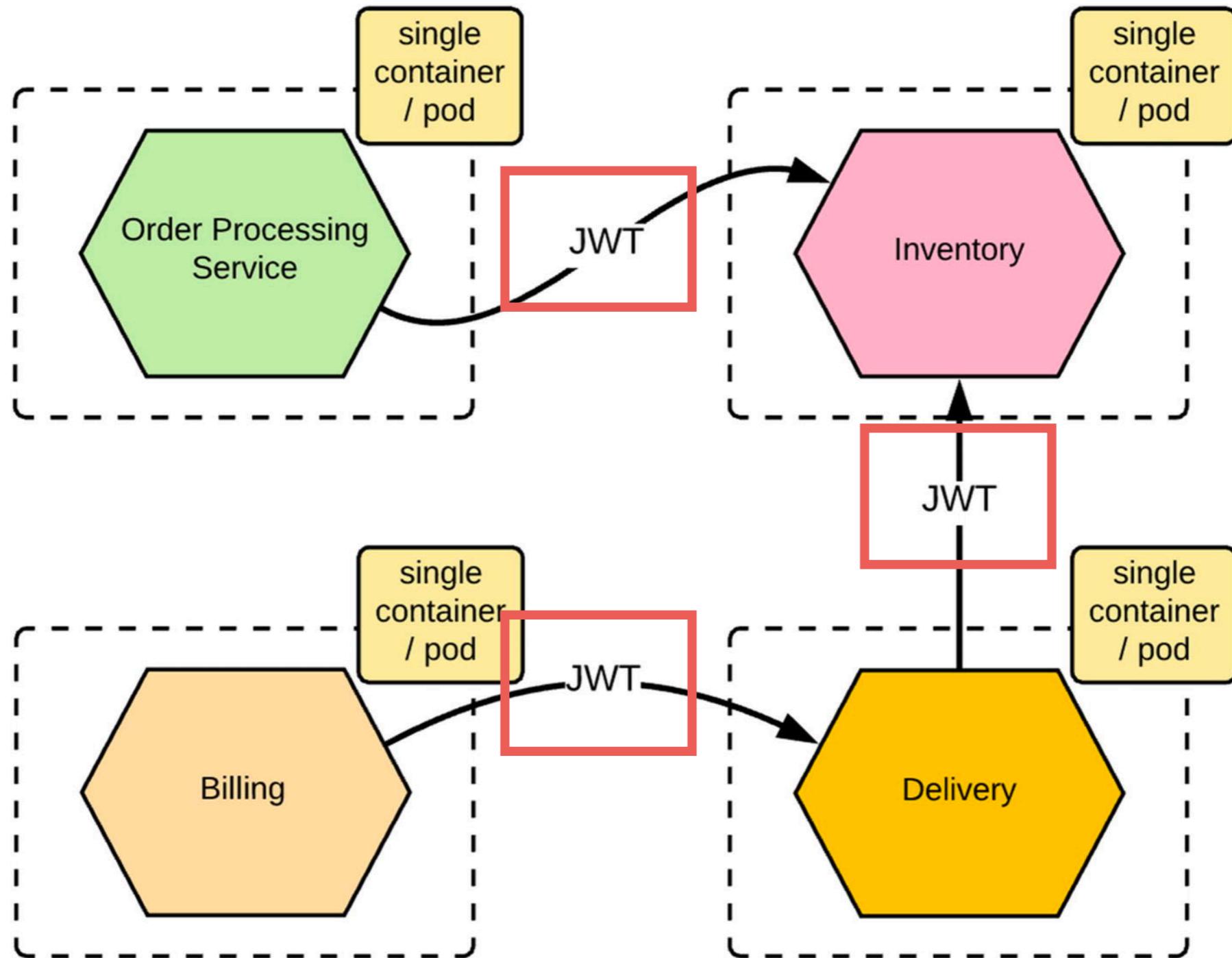
Define a container to transport data between interested parties



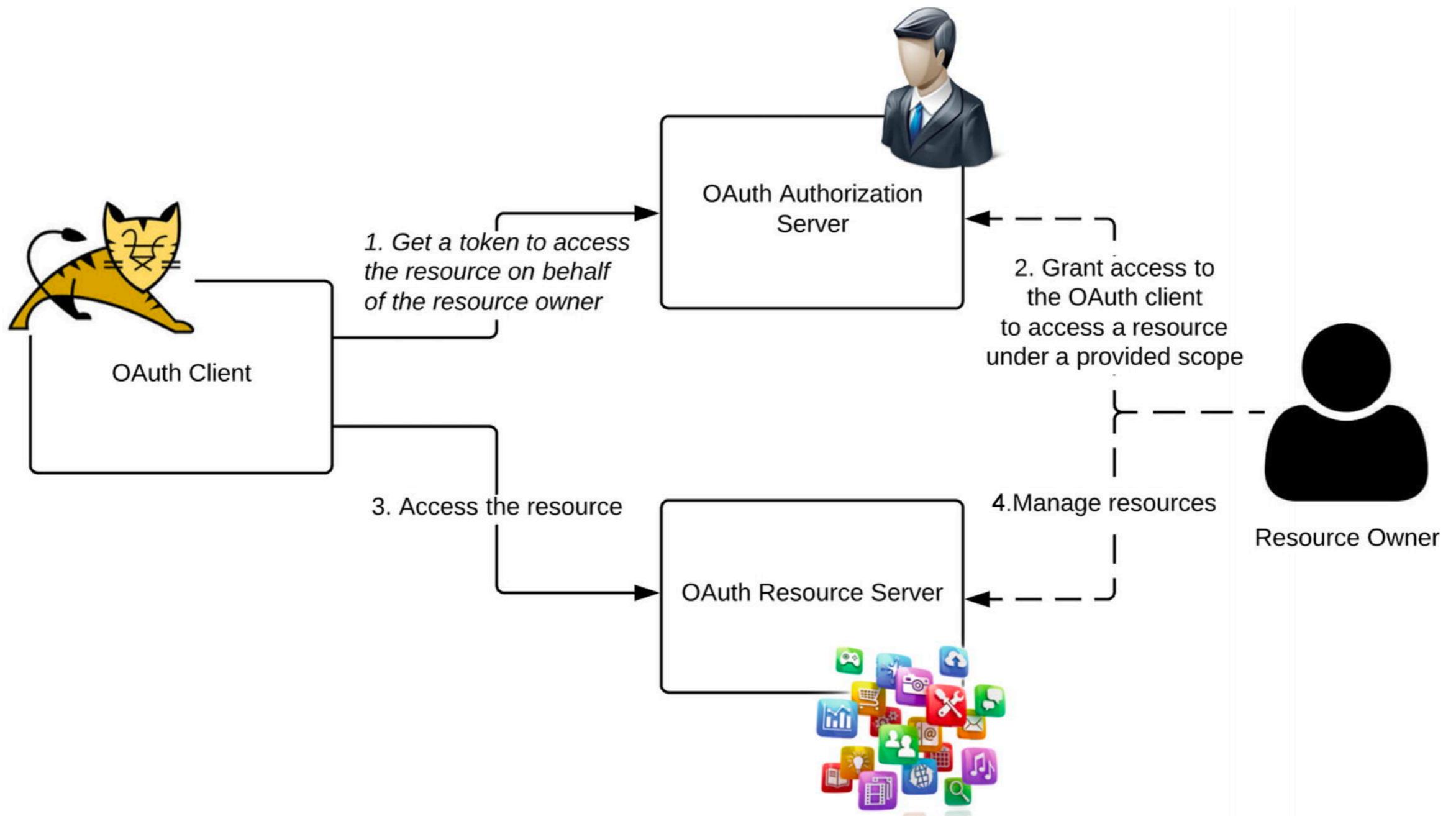
Passing user context as JWT



Problem ?

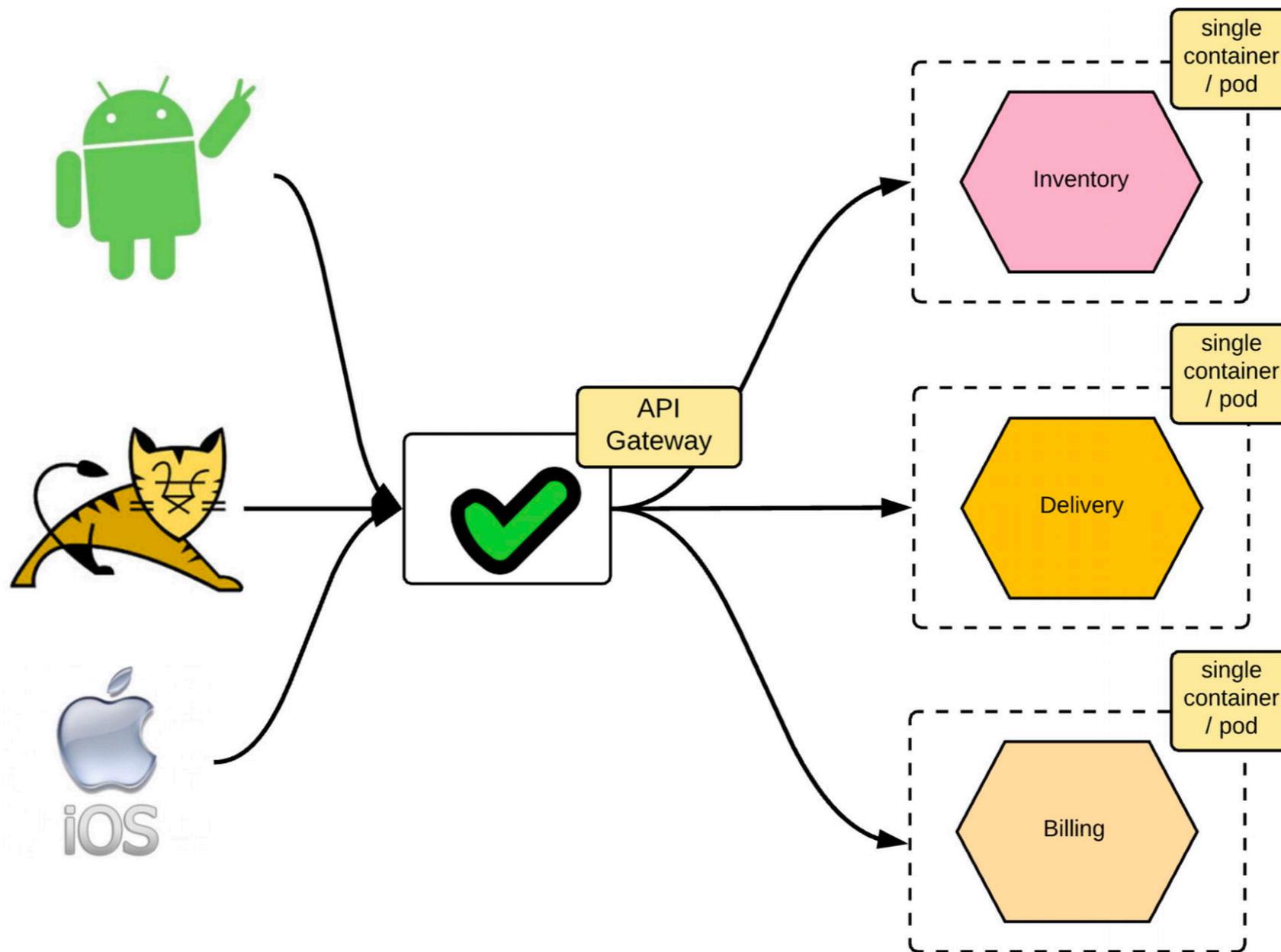


OAuth 2.0



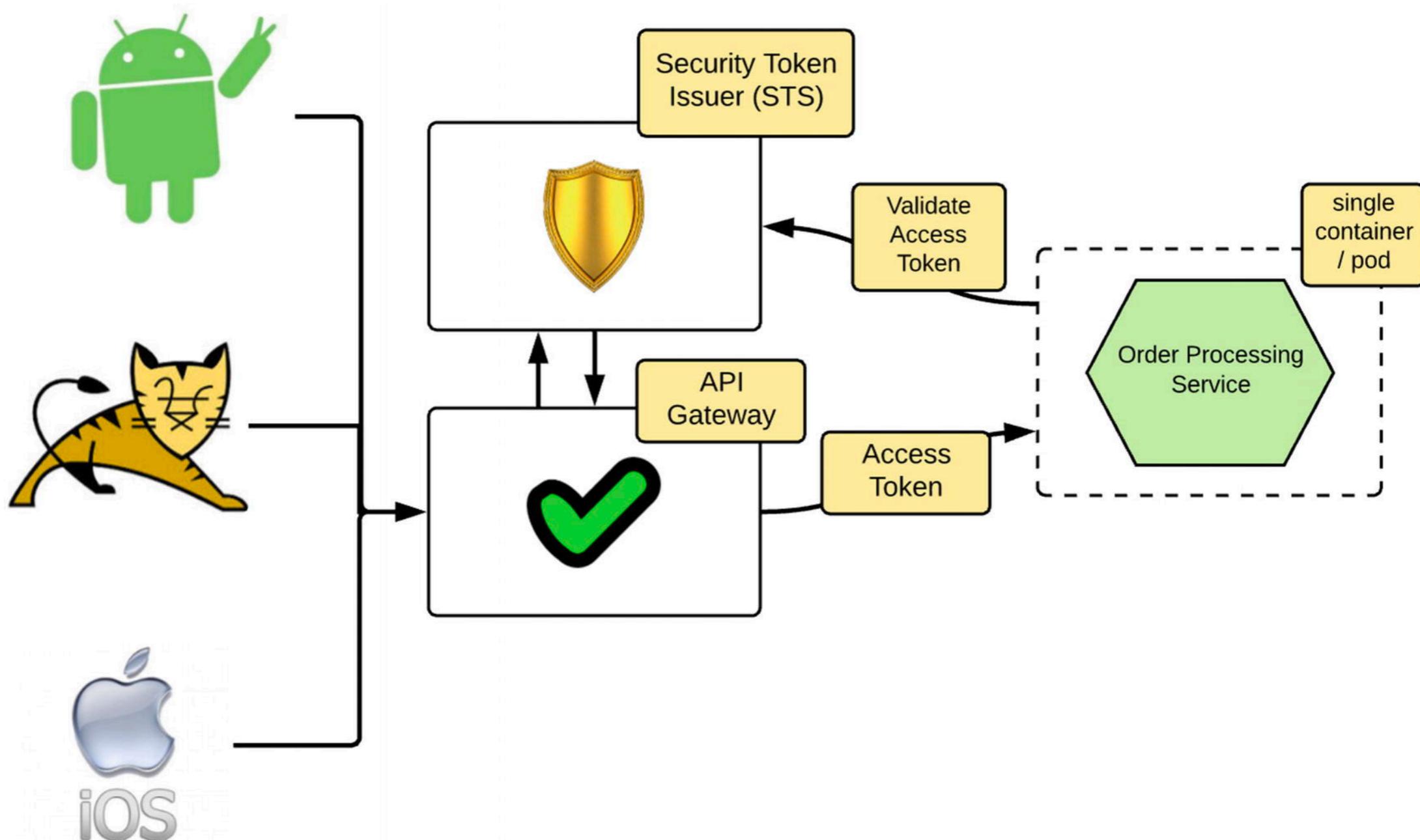
Centralize pattern

Using API gateway pattern

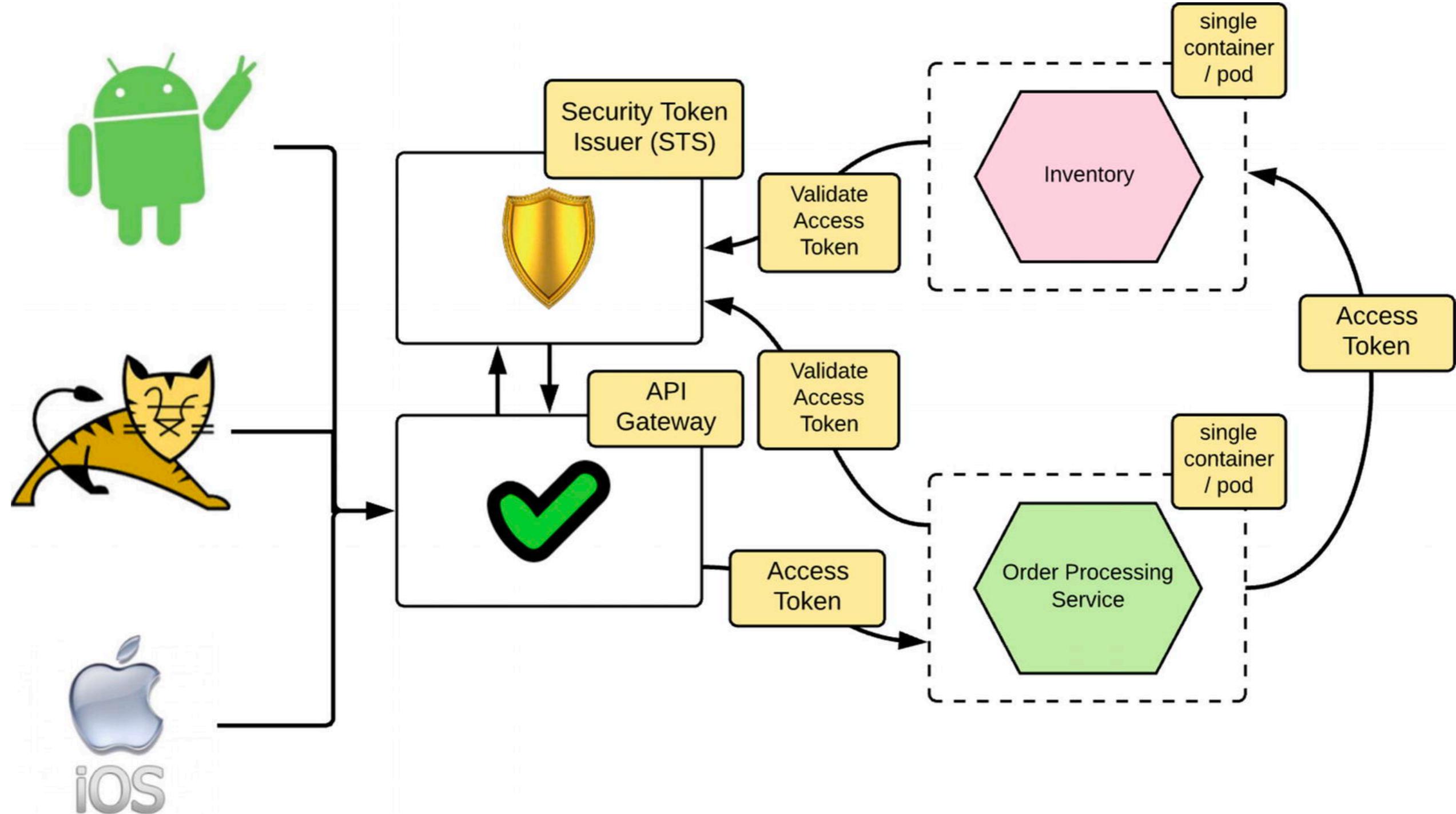


Centralize pattern

Using API gateway pattern

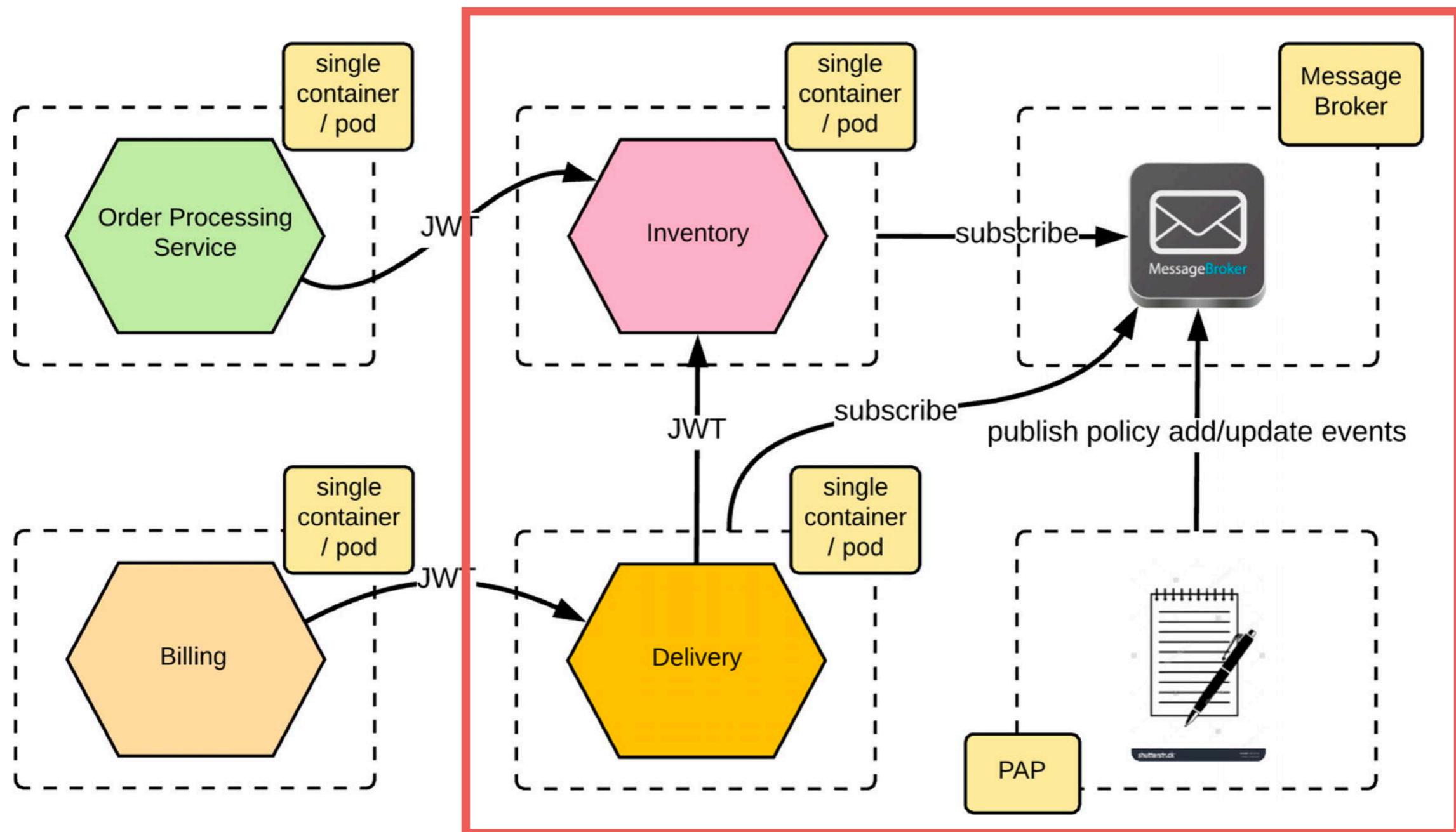


API gateway with OAuth 2.0



Access control of services

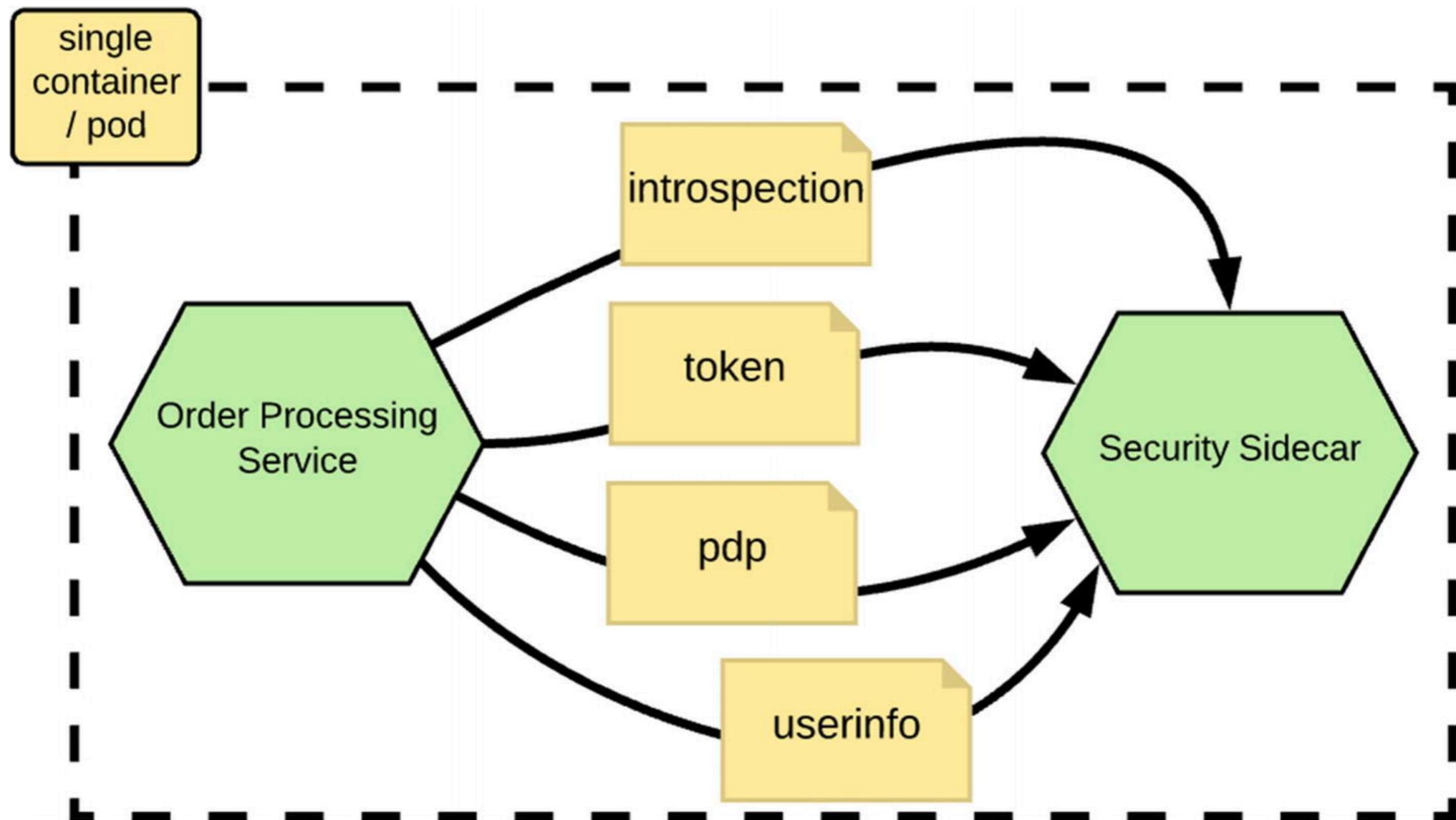
Policy Administration Point



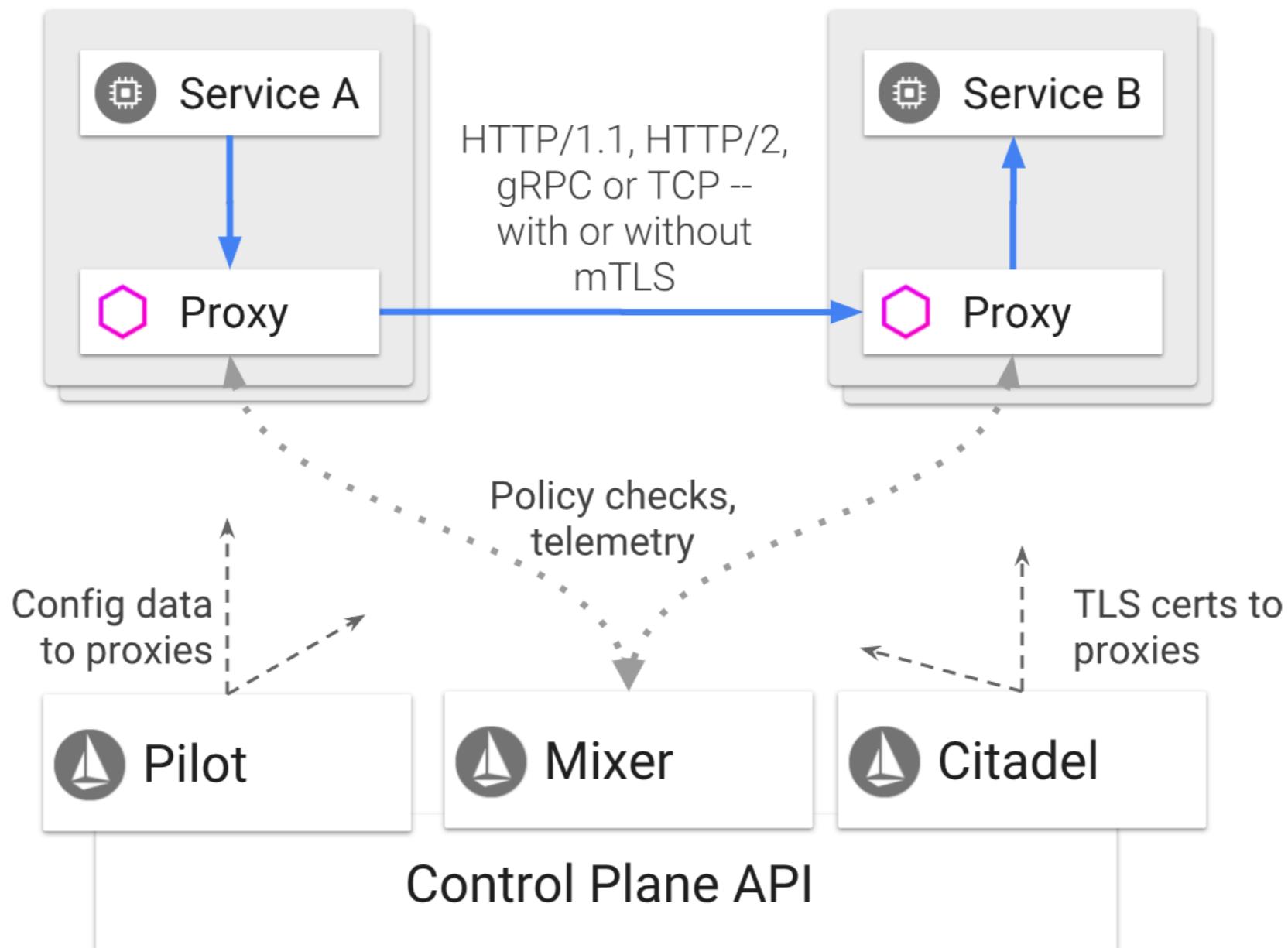
Working sidecar



Security sidecar



Security sidecar



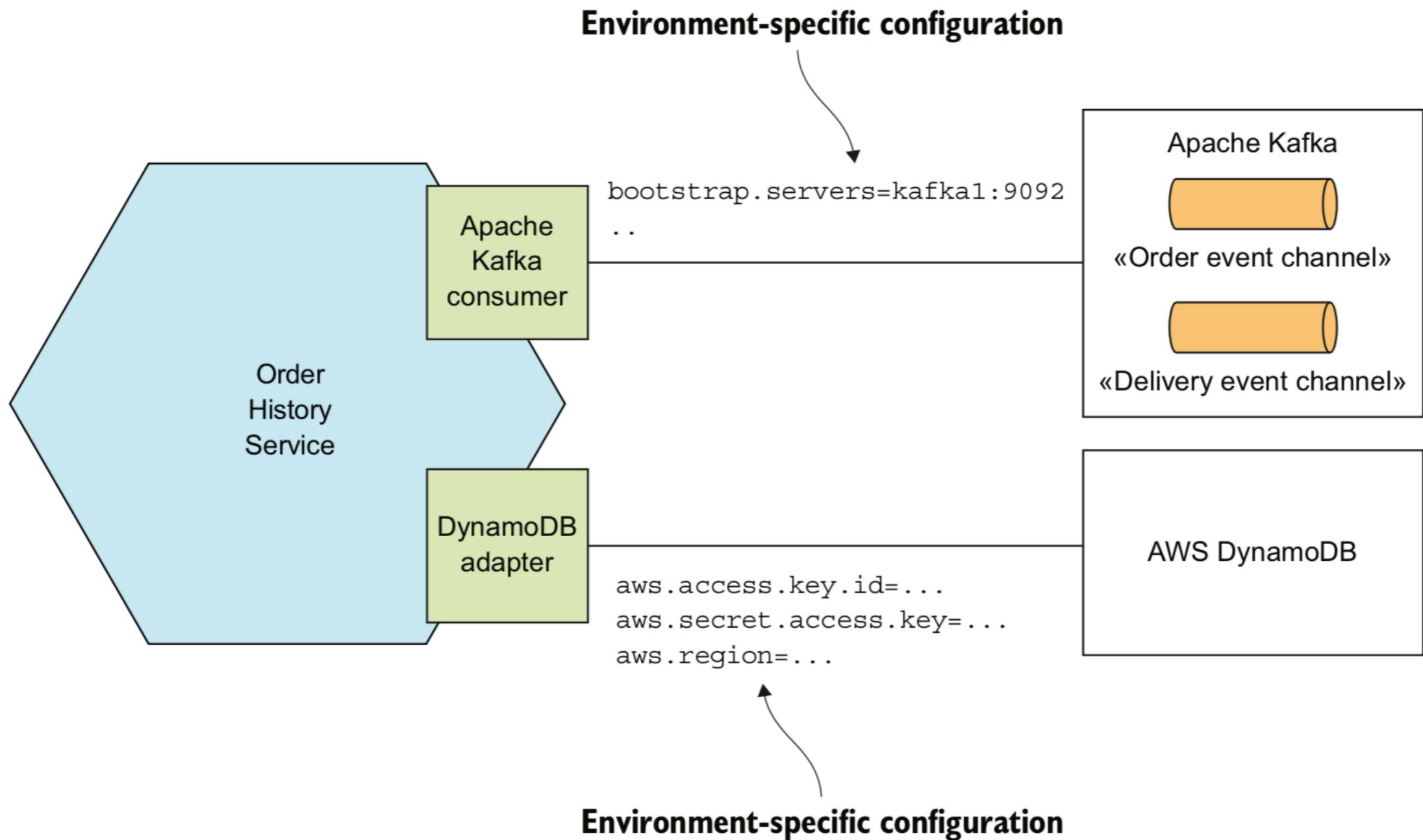
<https://istio.io/docs/concepts/what-is-istio/>



Configurable services



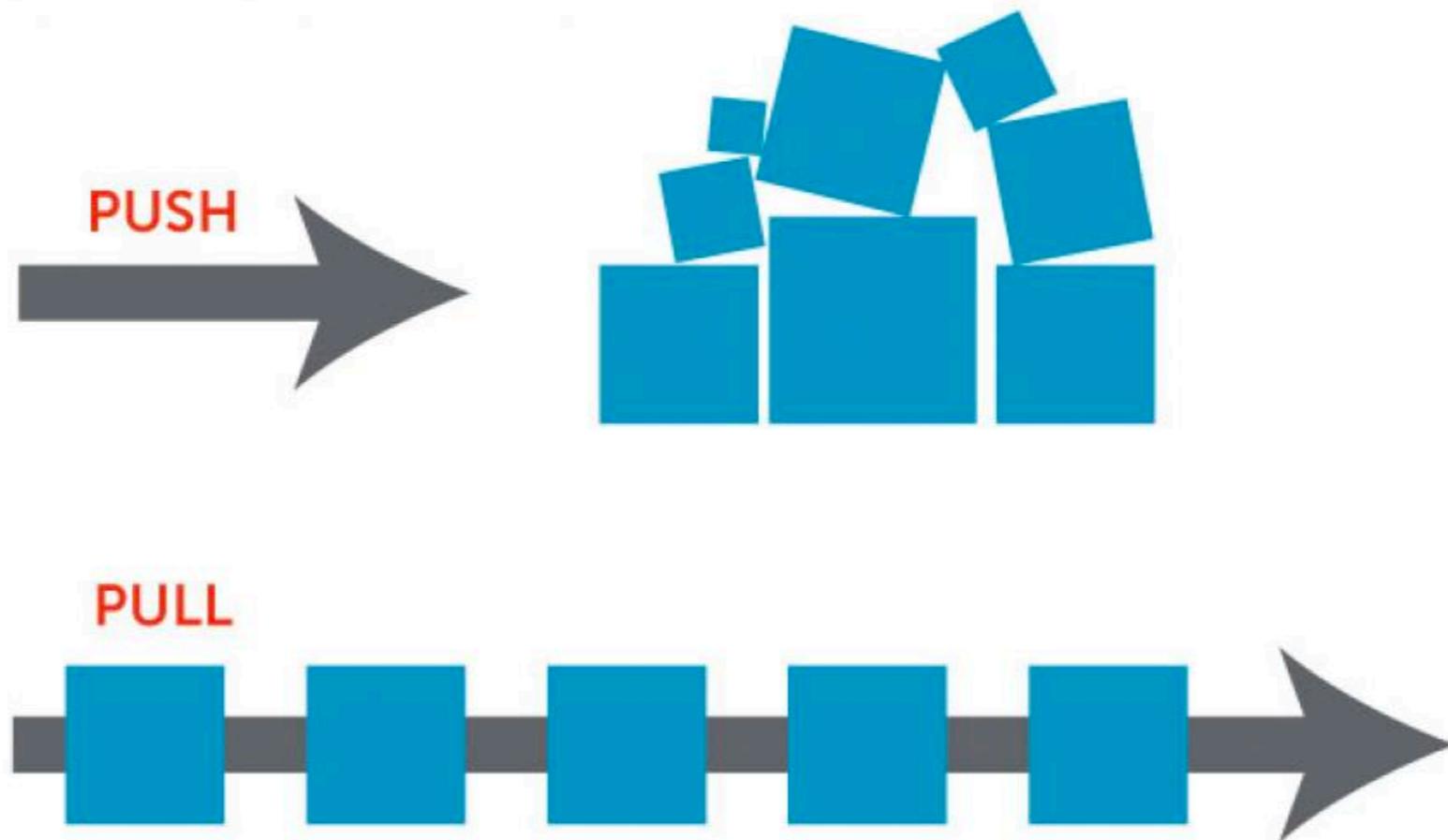
Design configurable services



External configuration models

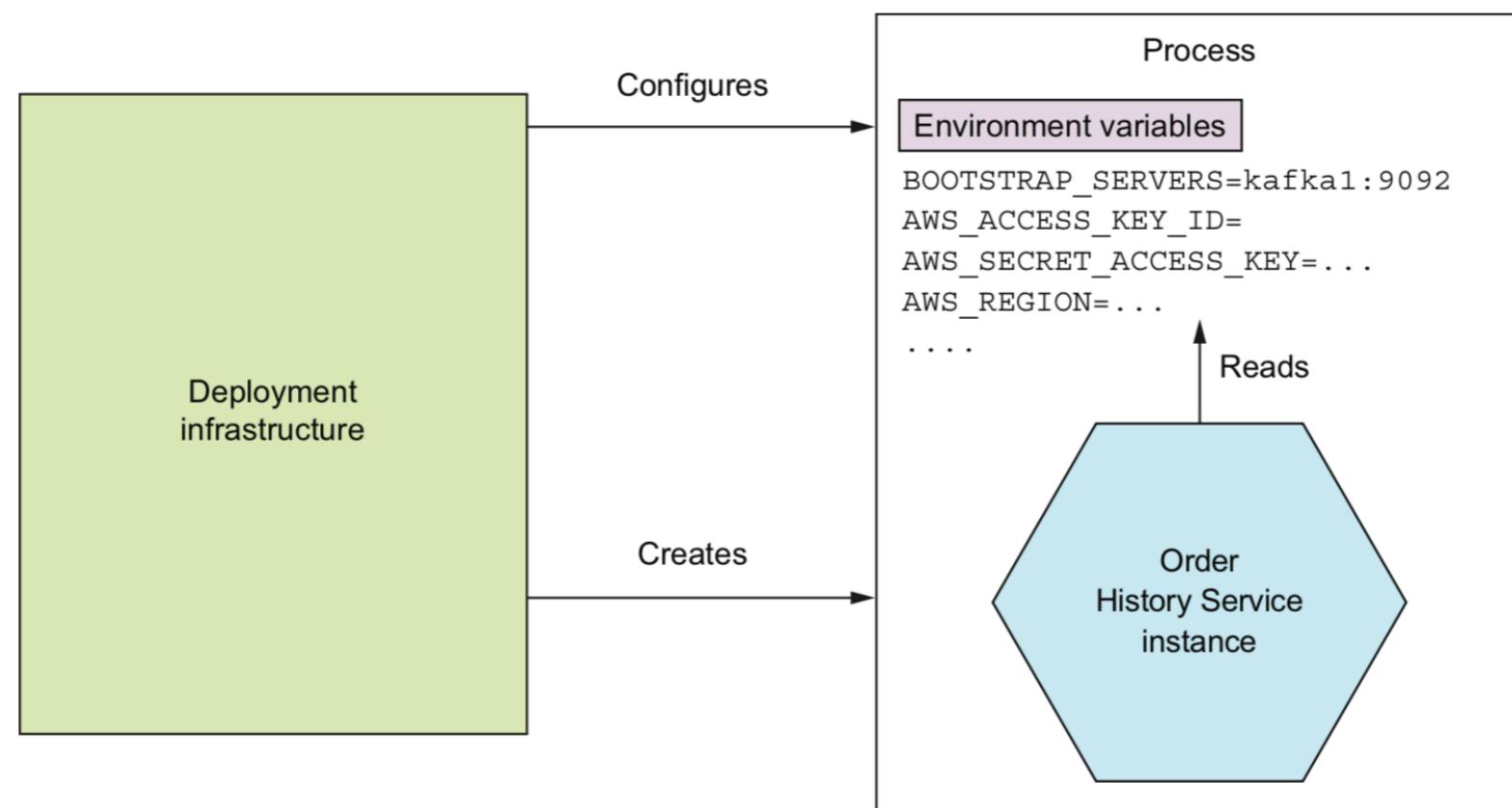
Push model

Pull model



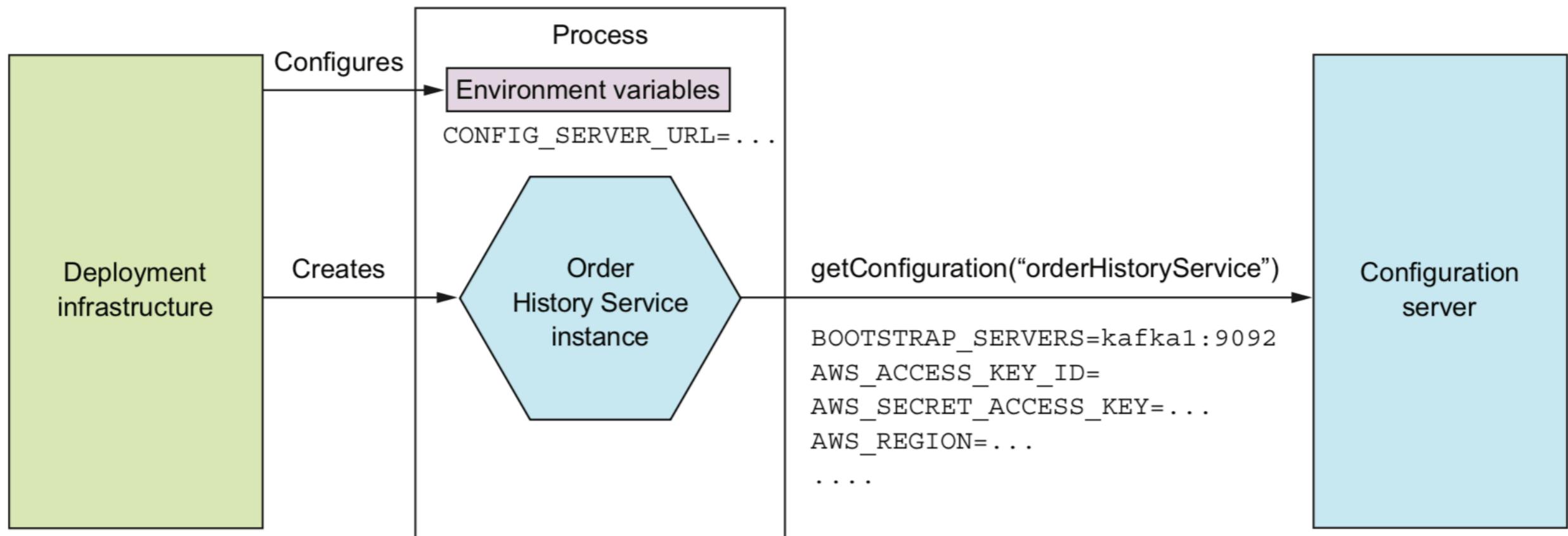
Push model

Pass the configuration to service
OS environment variables
Configuration files



Pull model

Service read configuration from configuration server



Benefits of configuration server

Centralized configuration

Transparent decryption of sensitive data

Dynamic reconfiguration



Drawbacks of configuration server

Need setup and maintain !!

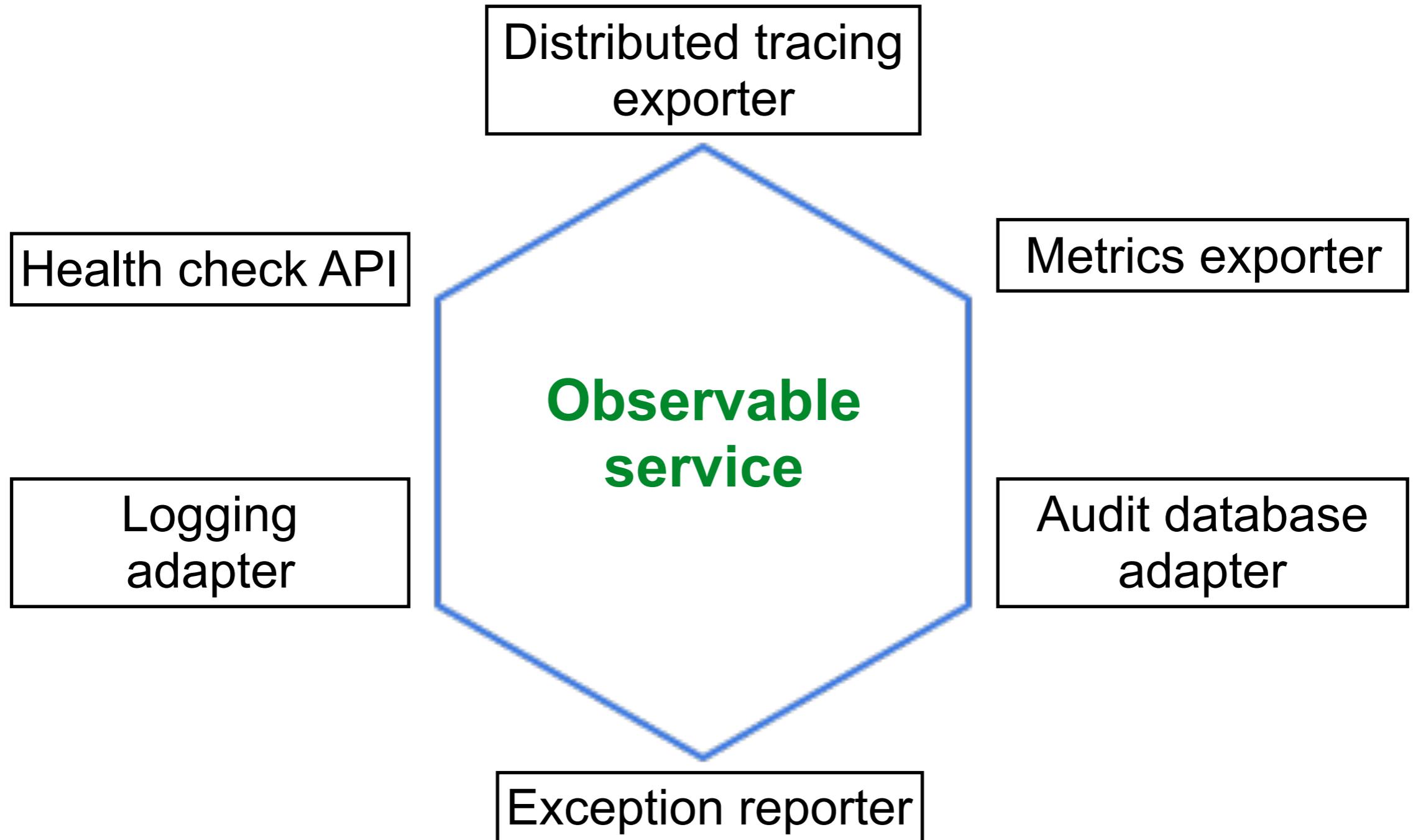


Design observable services

- Health check API
- Log aggregation
- Distributed tracing
- Exception tracking
- Application metrics
- Audit logging

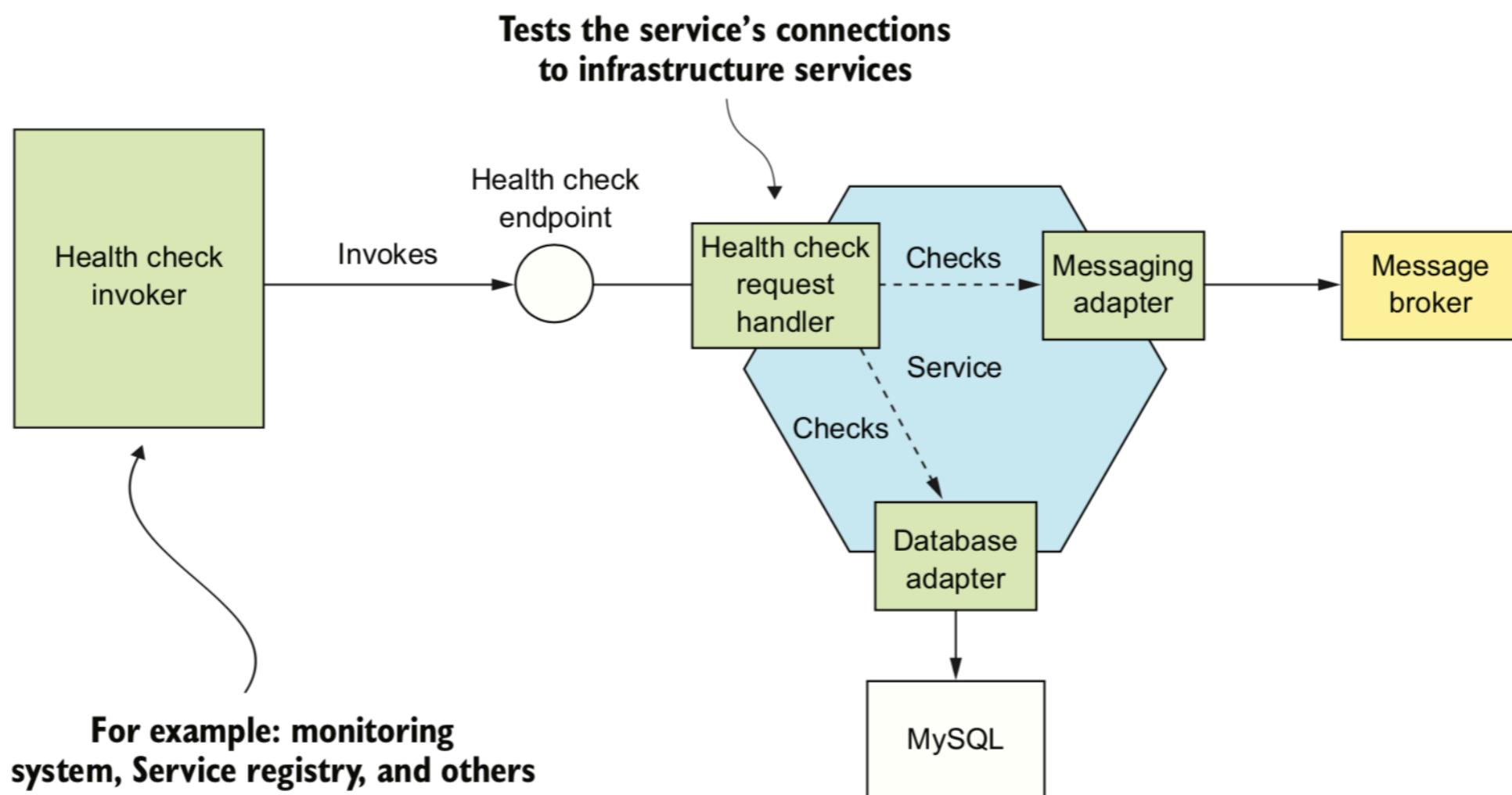


Observable services



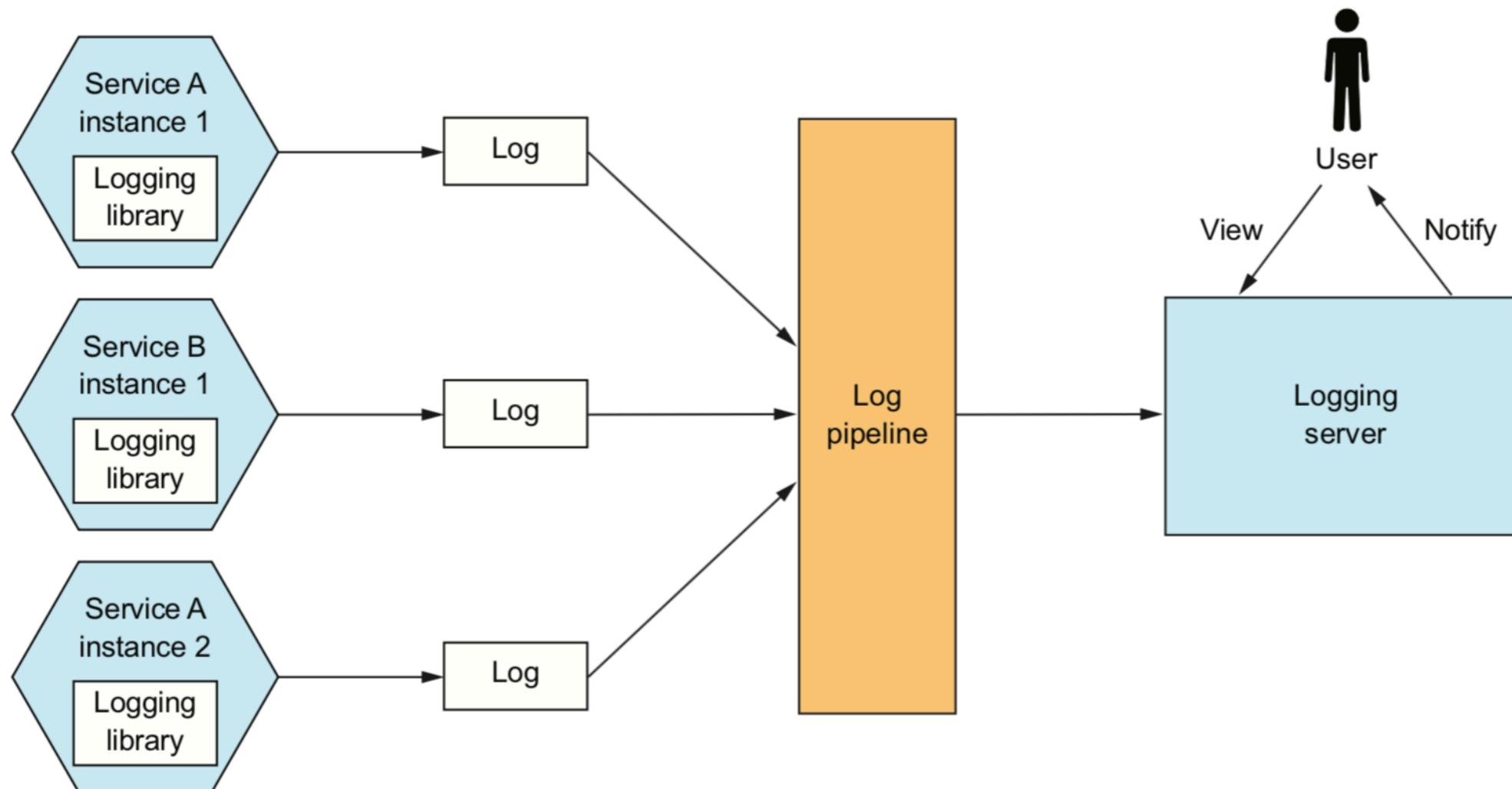
Health check API

Expose an endpoint that return the health of service



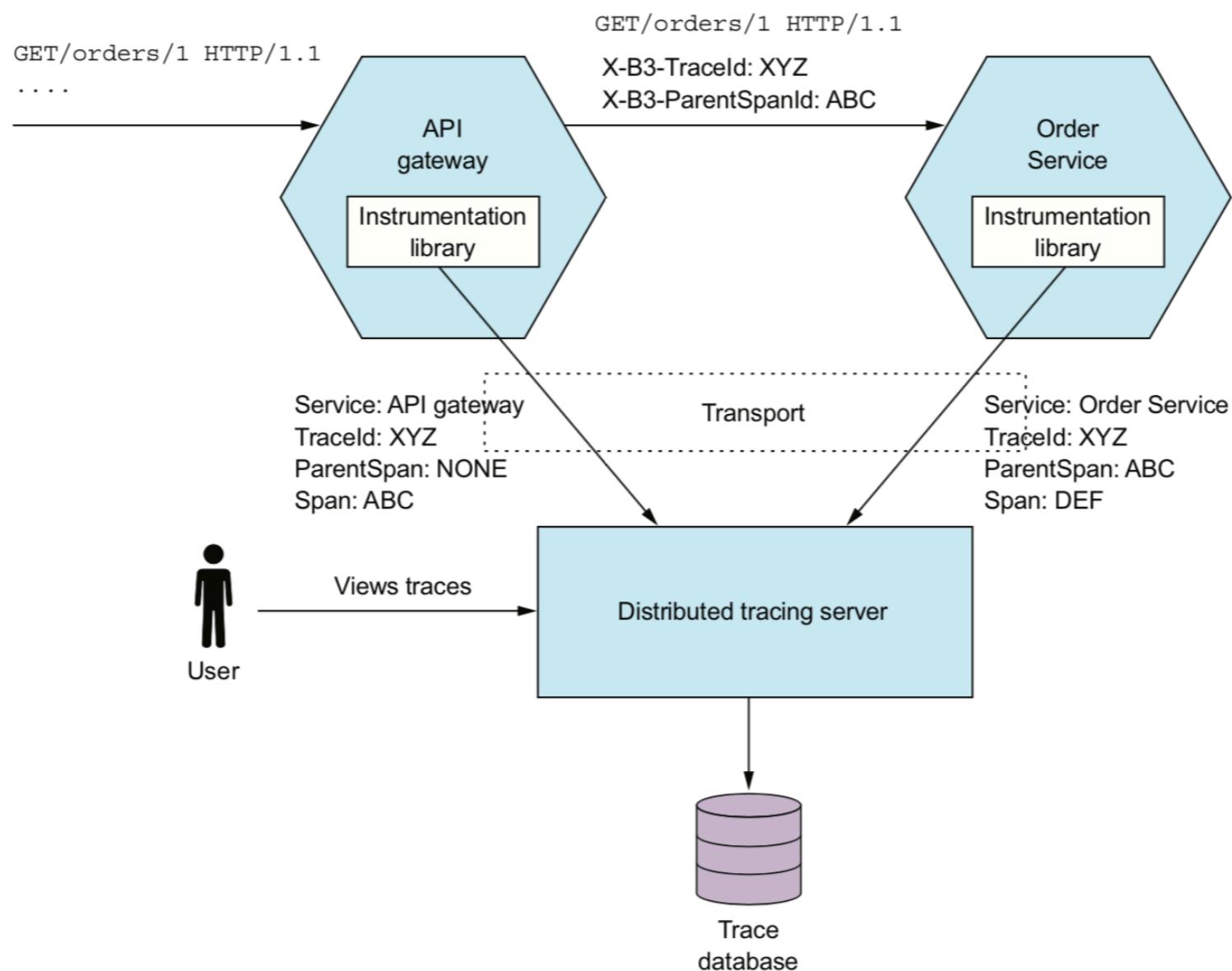
Log aggregation

Log service activity and write logs into a centralized logging server. (searching, alerting)

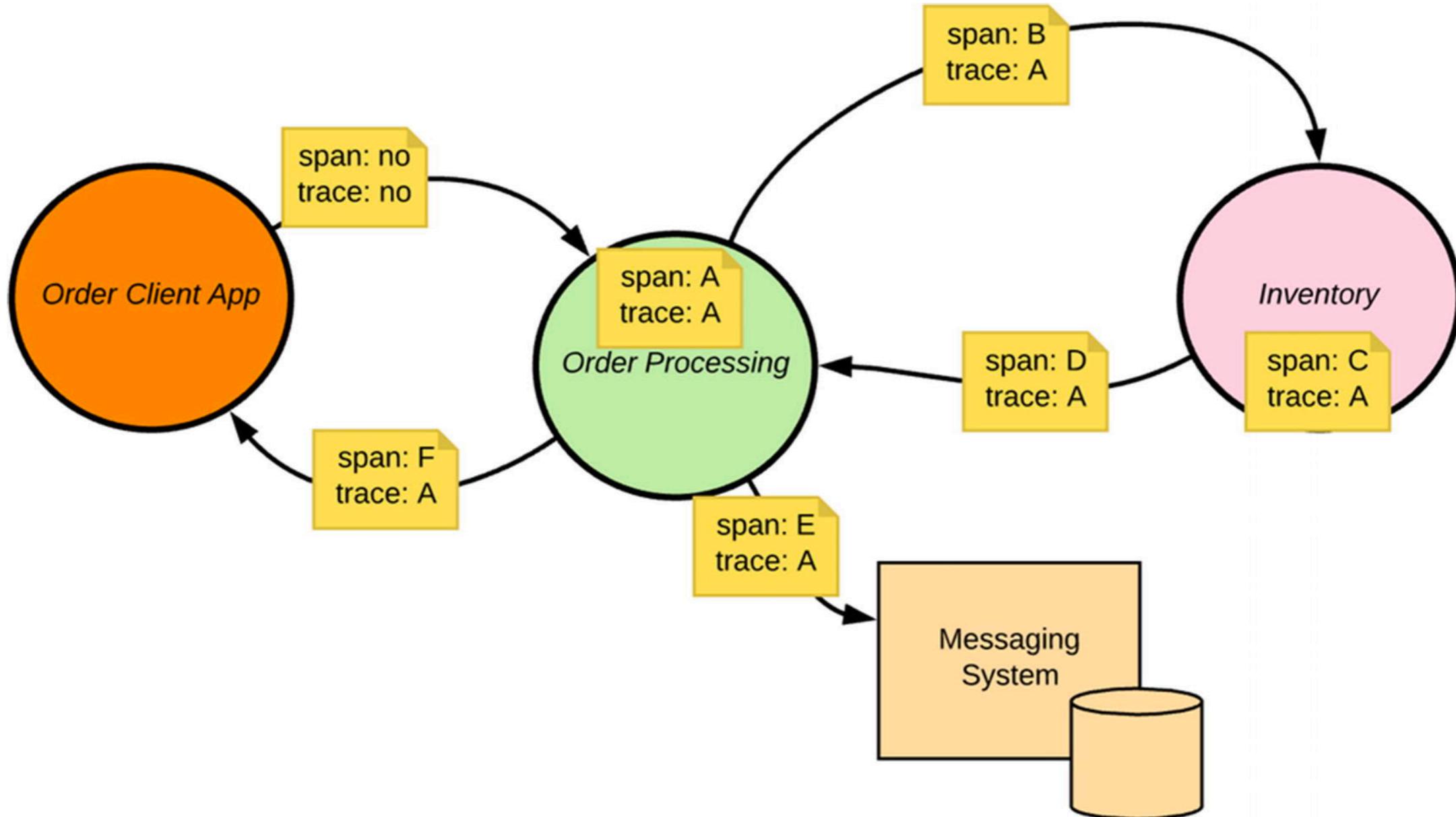


Distributed tracing

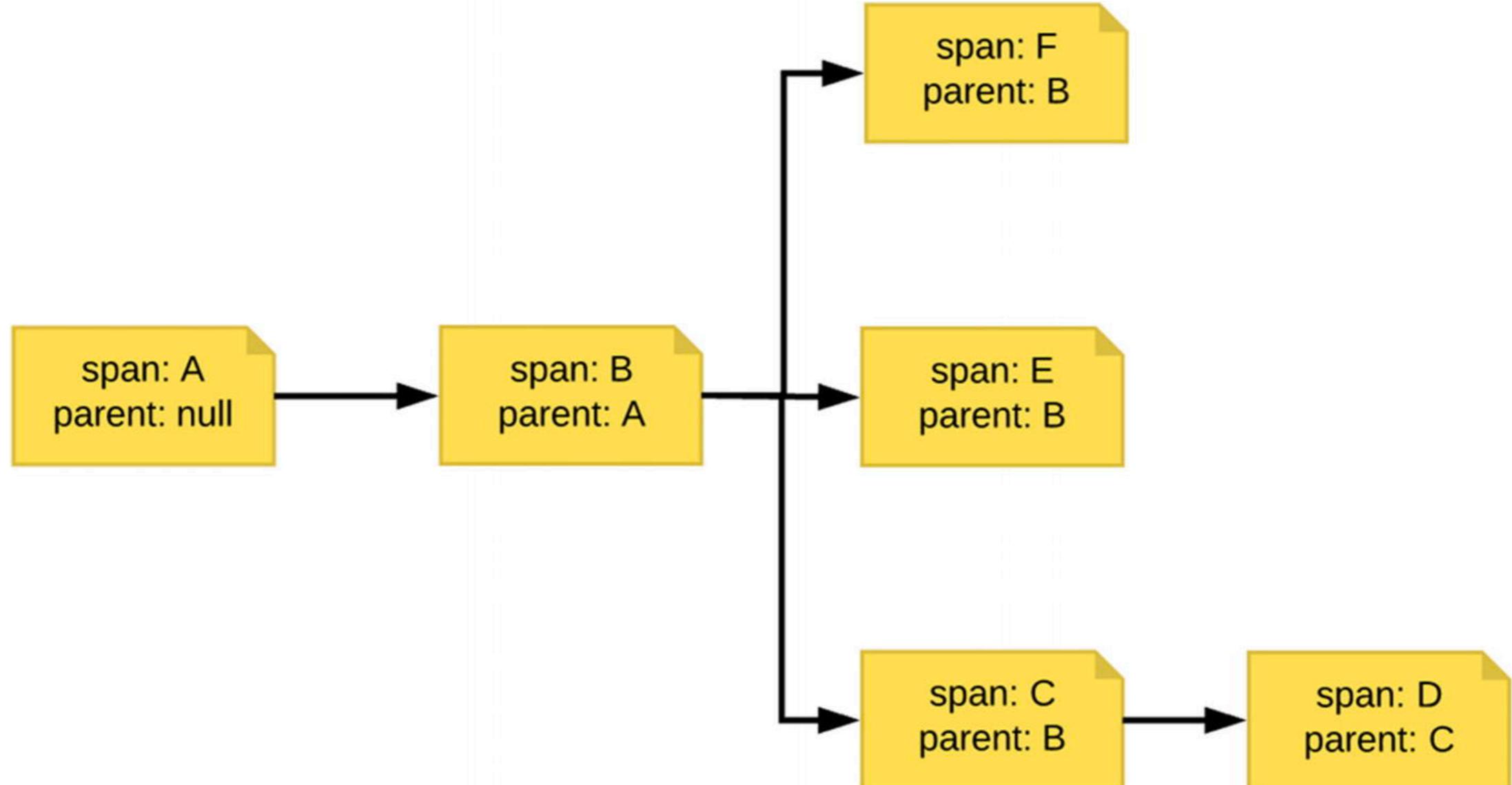
Assign each external request a unique ID and trace requests as flow between services



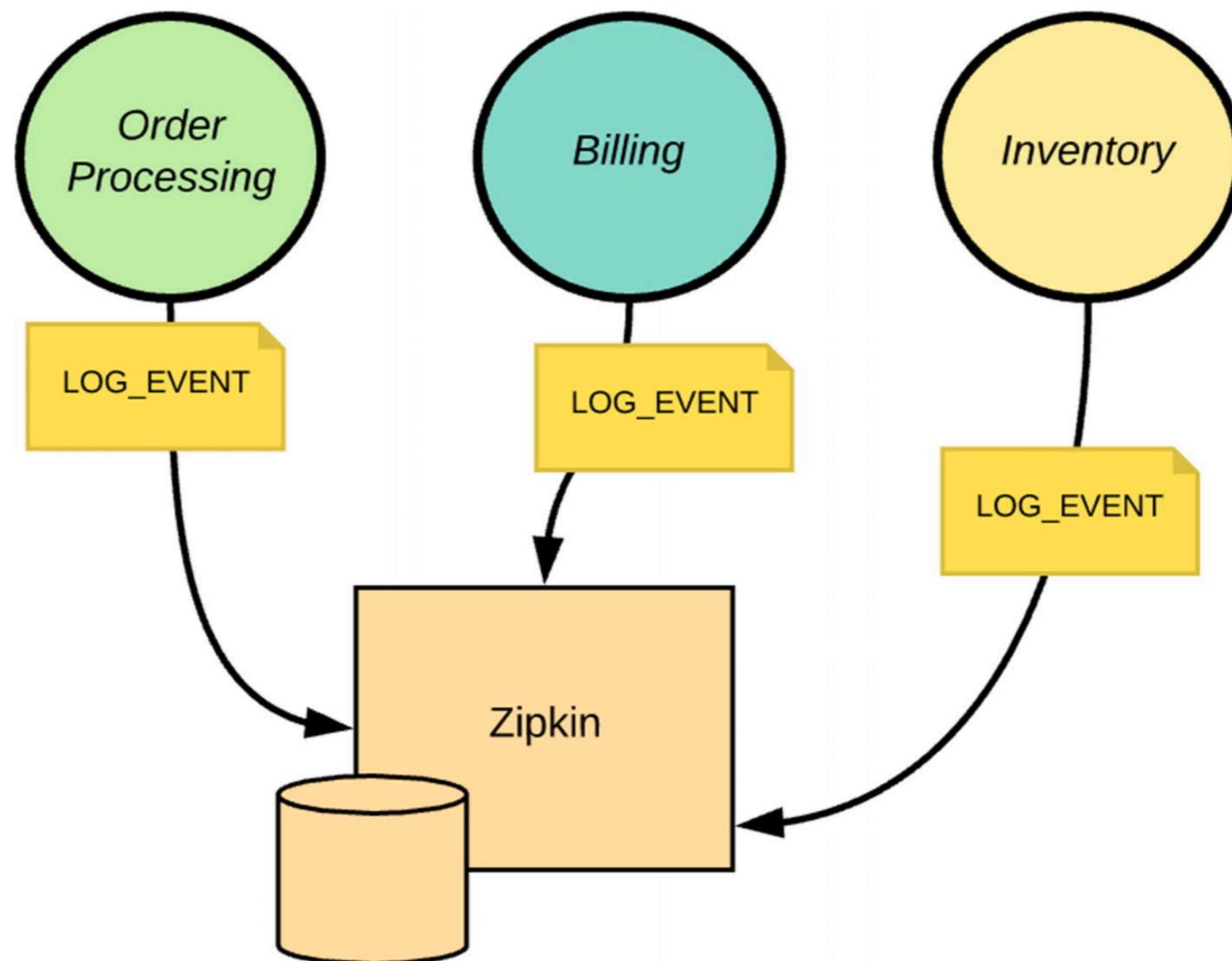
Distributed tracing



Distributed tracing



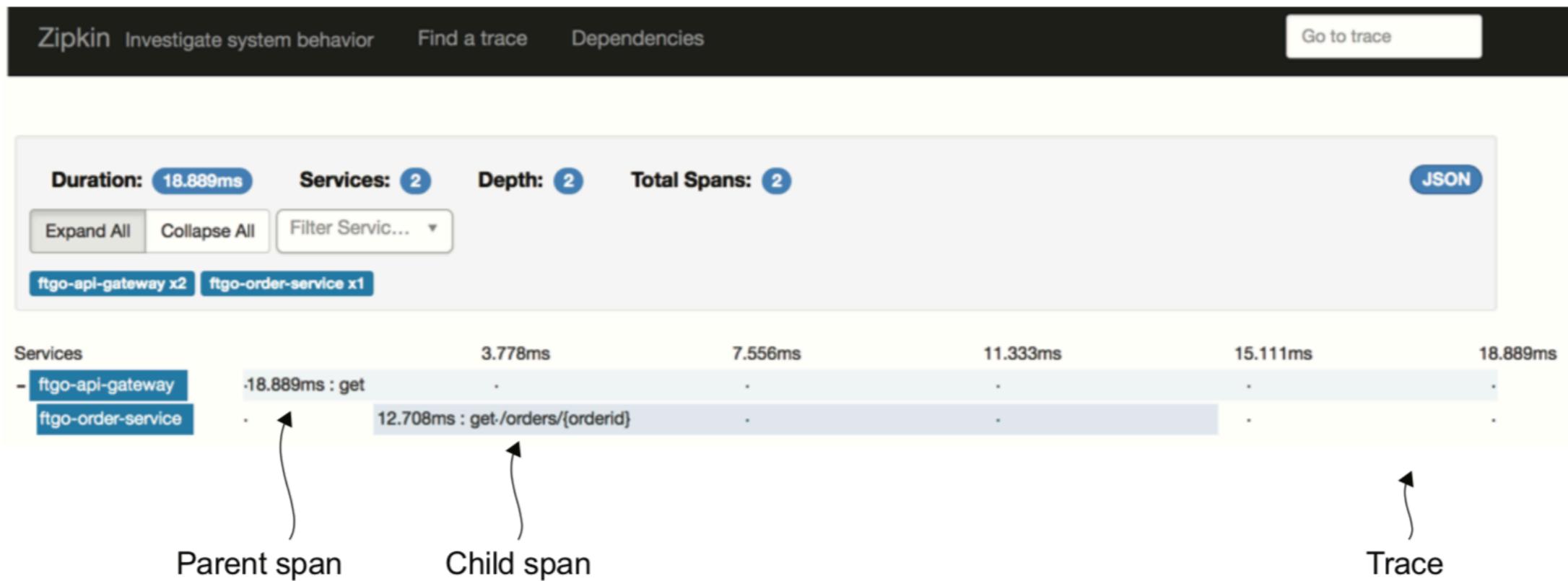
Distributed tracing with Zipkin



<https://zipkin.io/>



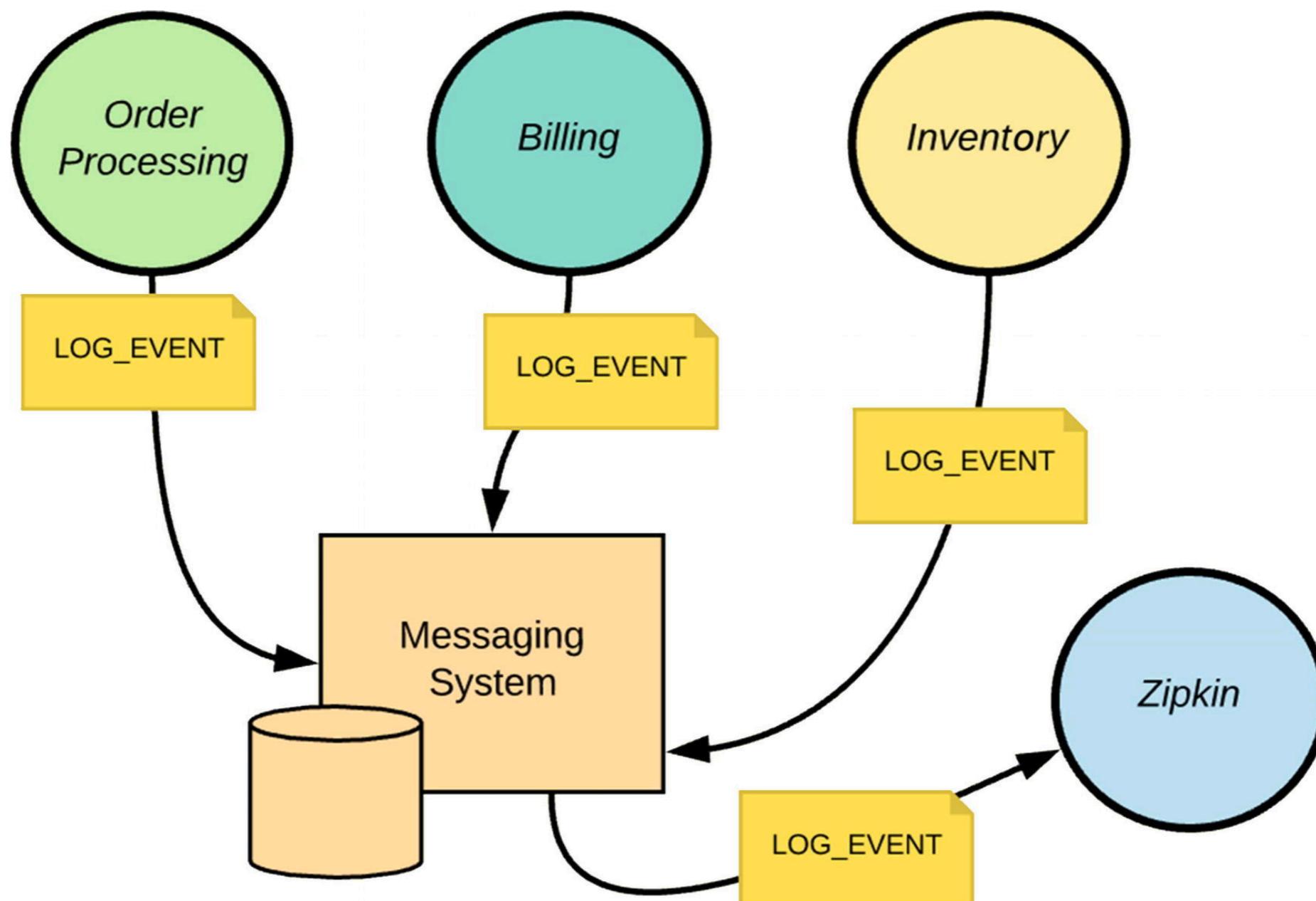
Distributed tracing with Zipkin



<https://zipkin.io/>

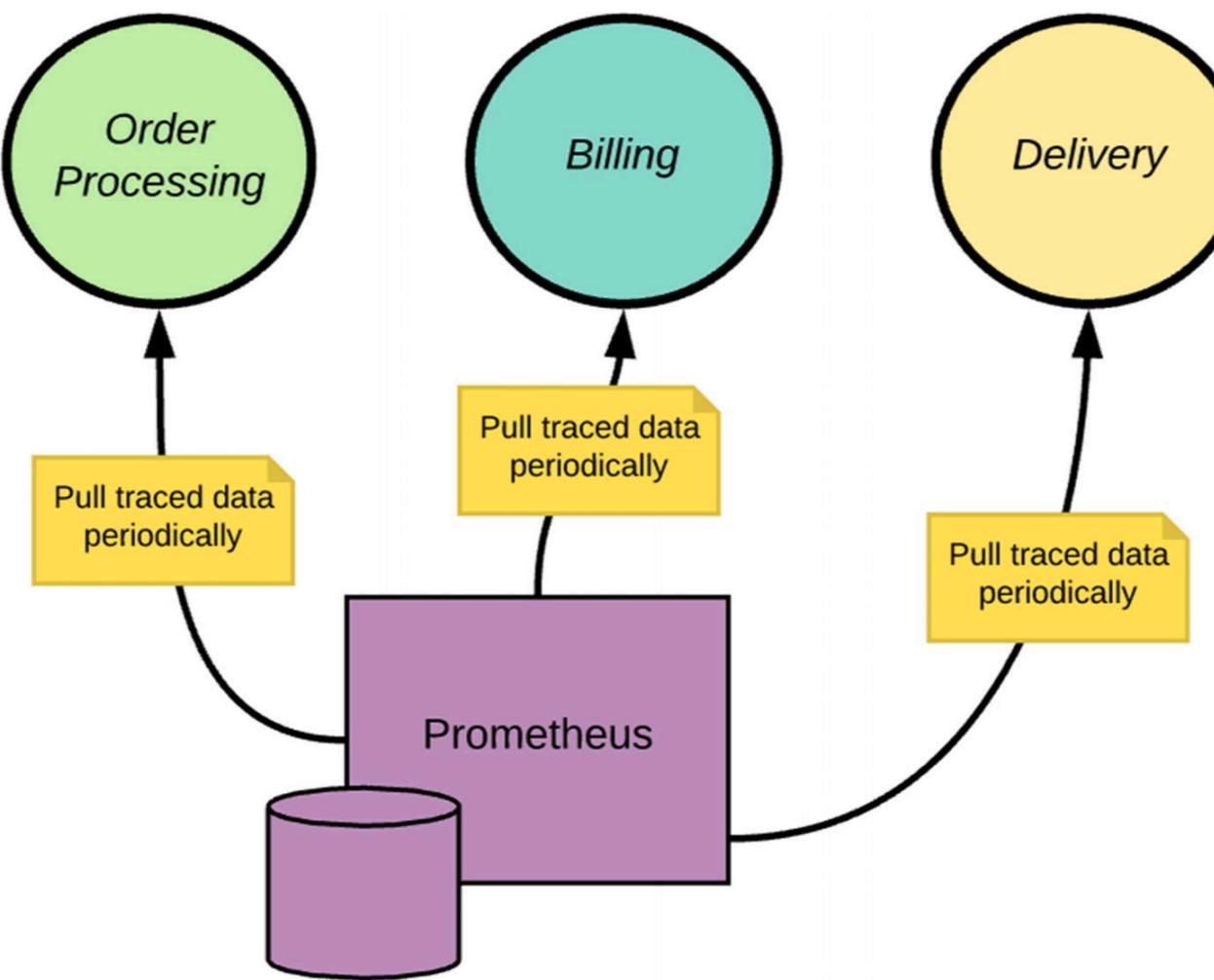


Distributed tracing with Zipkin



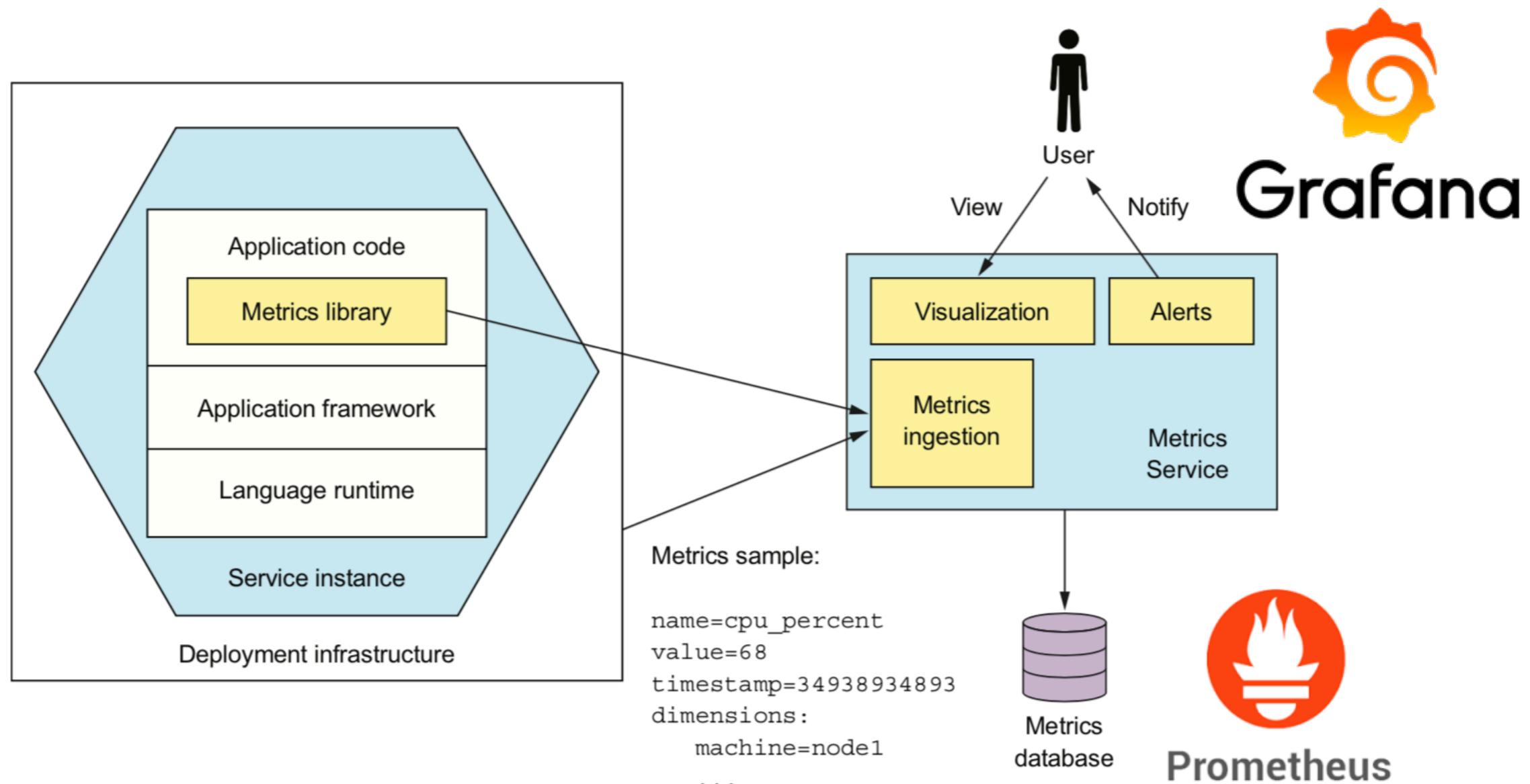
Application metrics

Services maintain metrics and expose to metric server (counters, gauges)



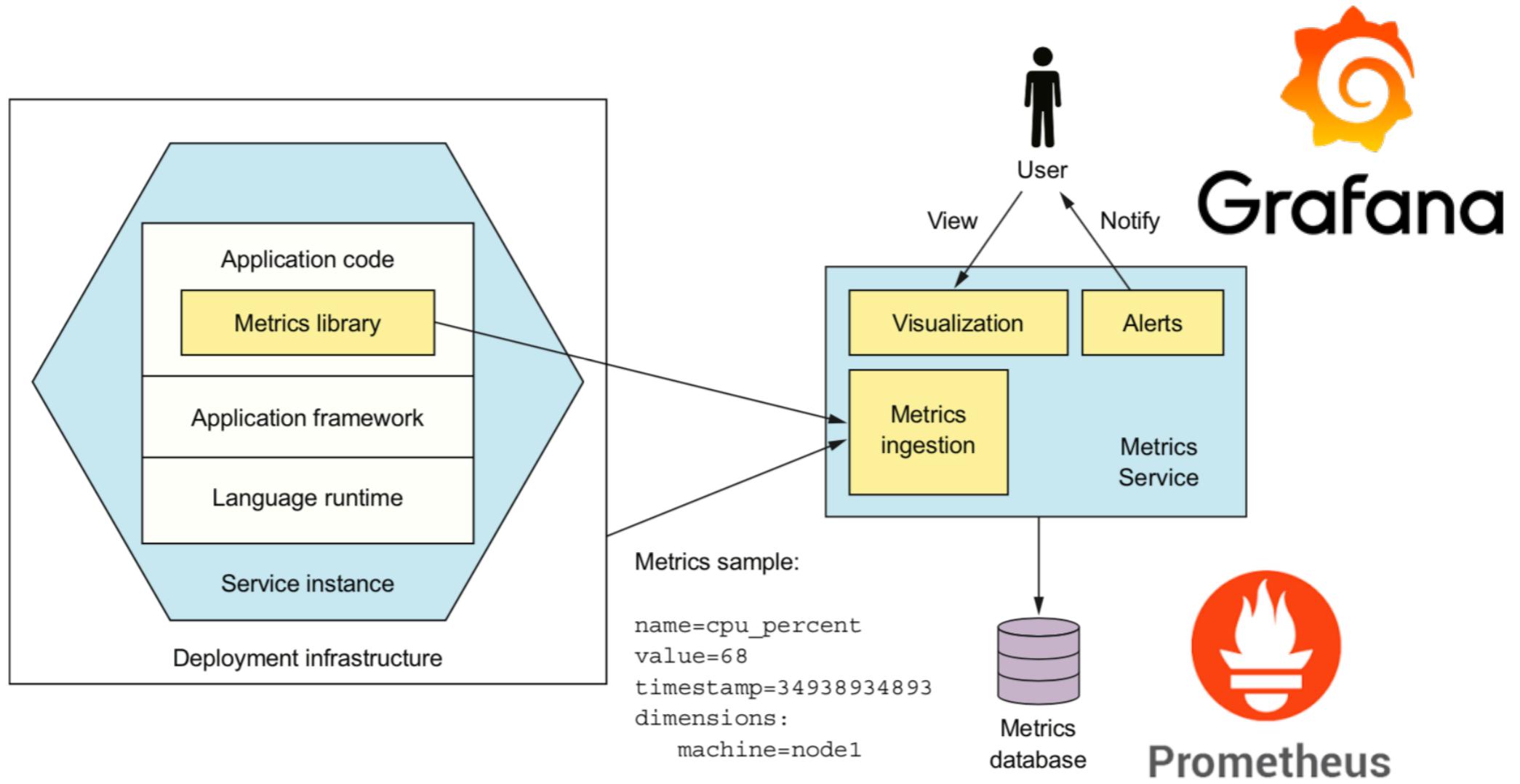
Application metrics

Services maintain metrics and expose to metric server (counters, gauges)



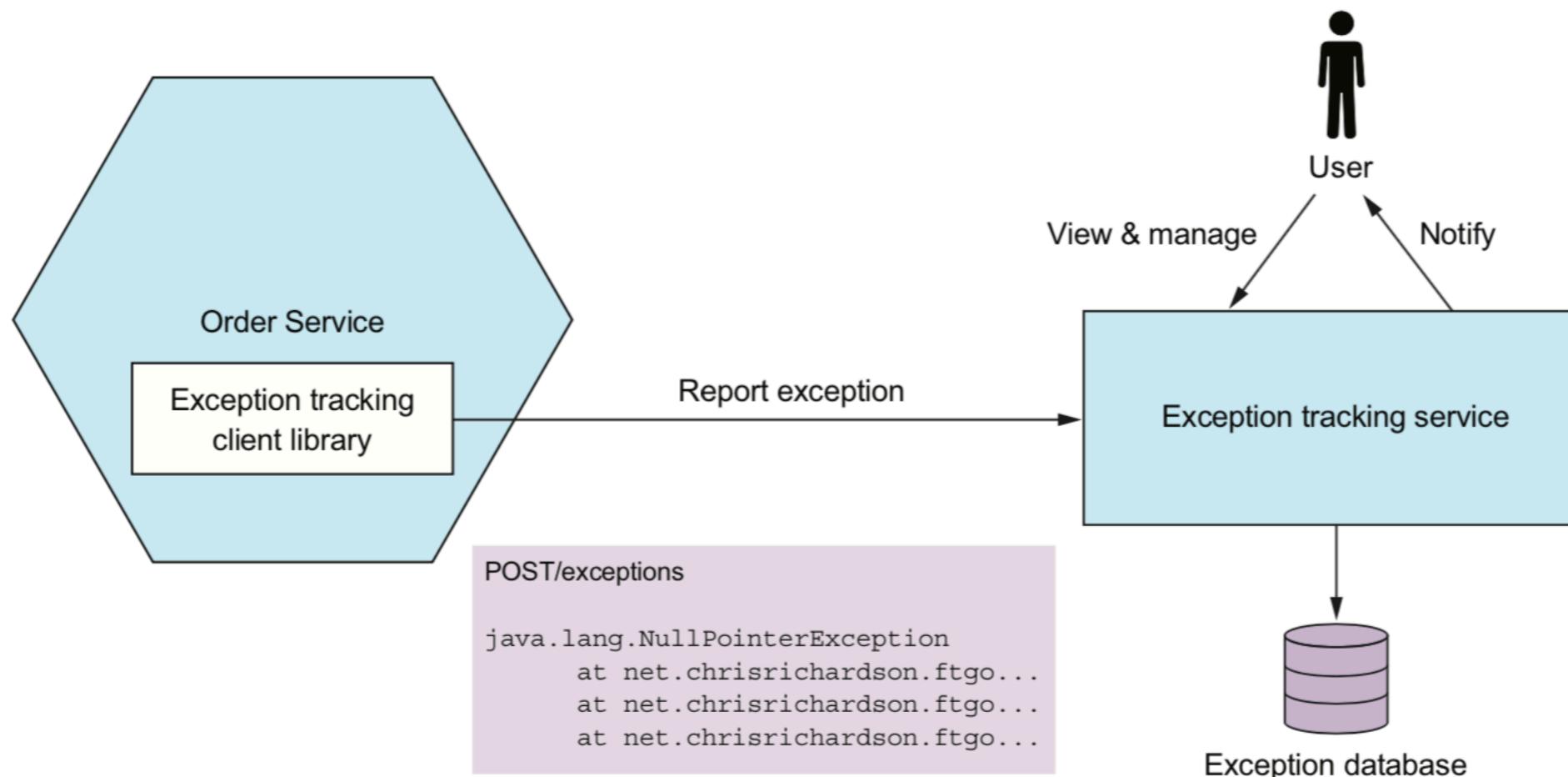
Application metrics

Metrics database => Prometheus
Visualization, Alert => Grafana



Exception tracking

Report exceptions to exception tracking service
Help to identify the root cause



Exception tracking services



Audit logging

Log of user actions

Help customer support

Ensure compliance

Detect suspicious behaviour



How to implement the audit logging ?

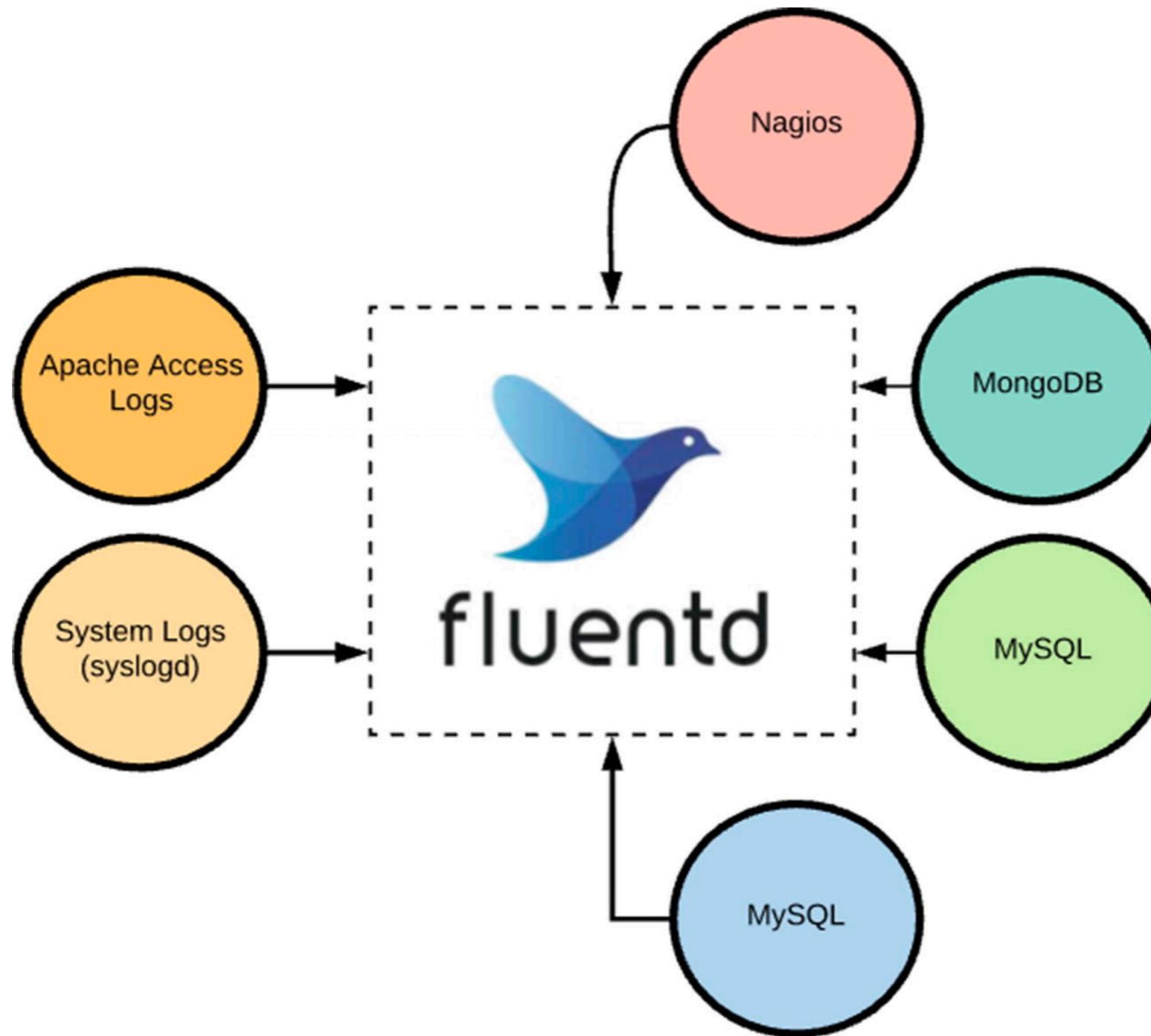
Add logging code in business logic

Use AOP (Aspect-Oriented Programming)

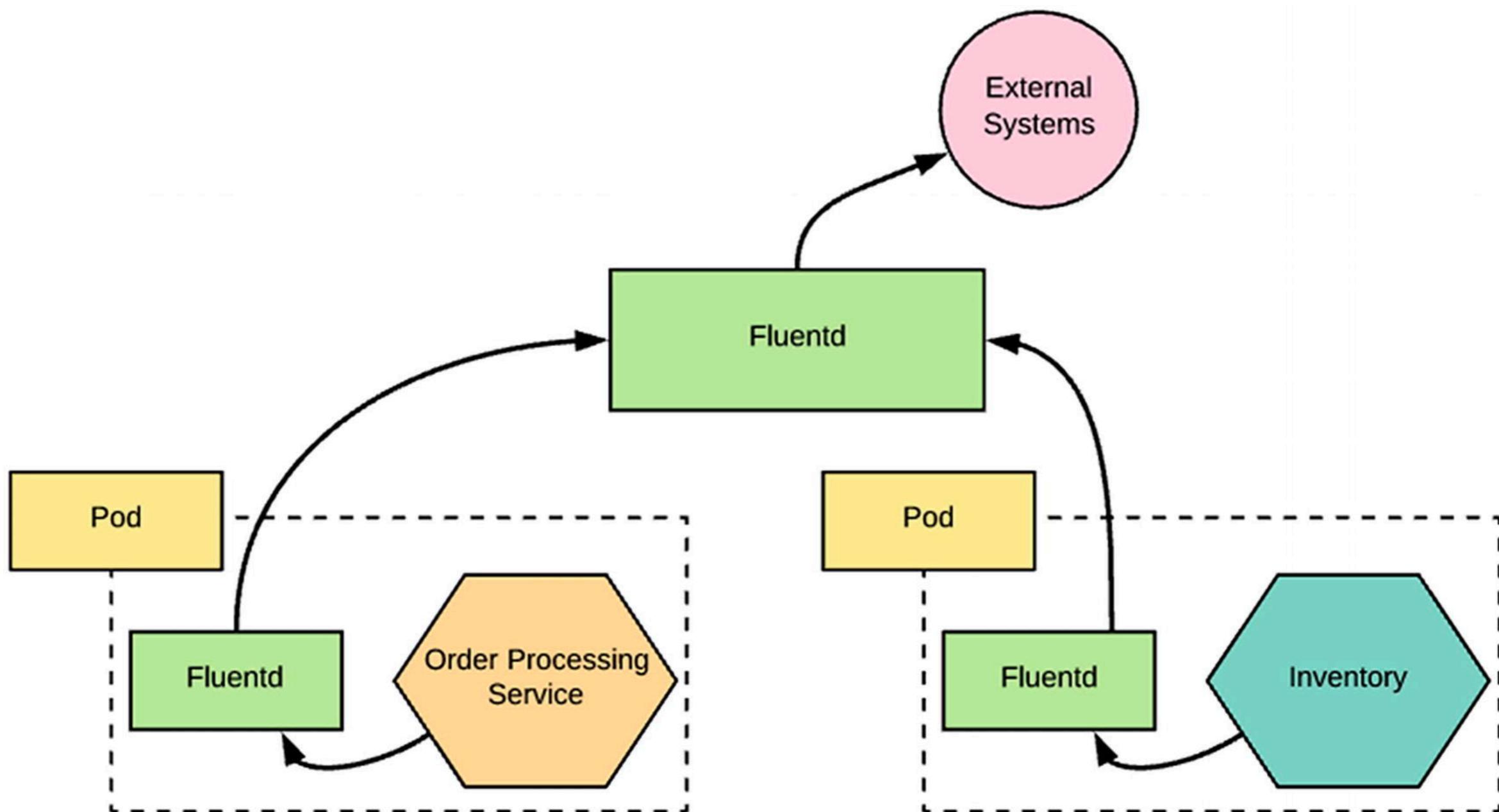
Use event sourcing



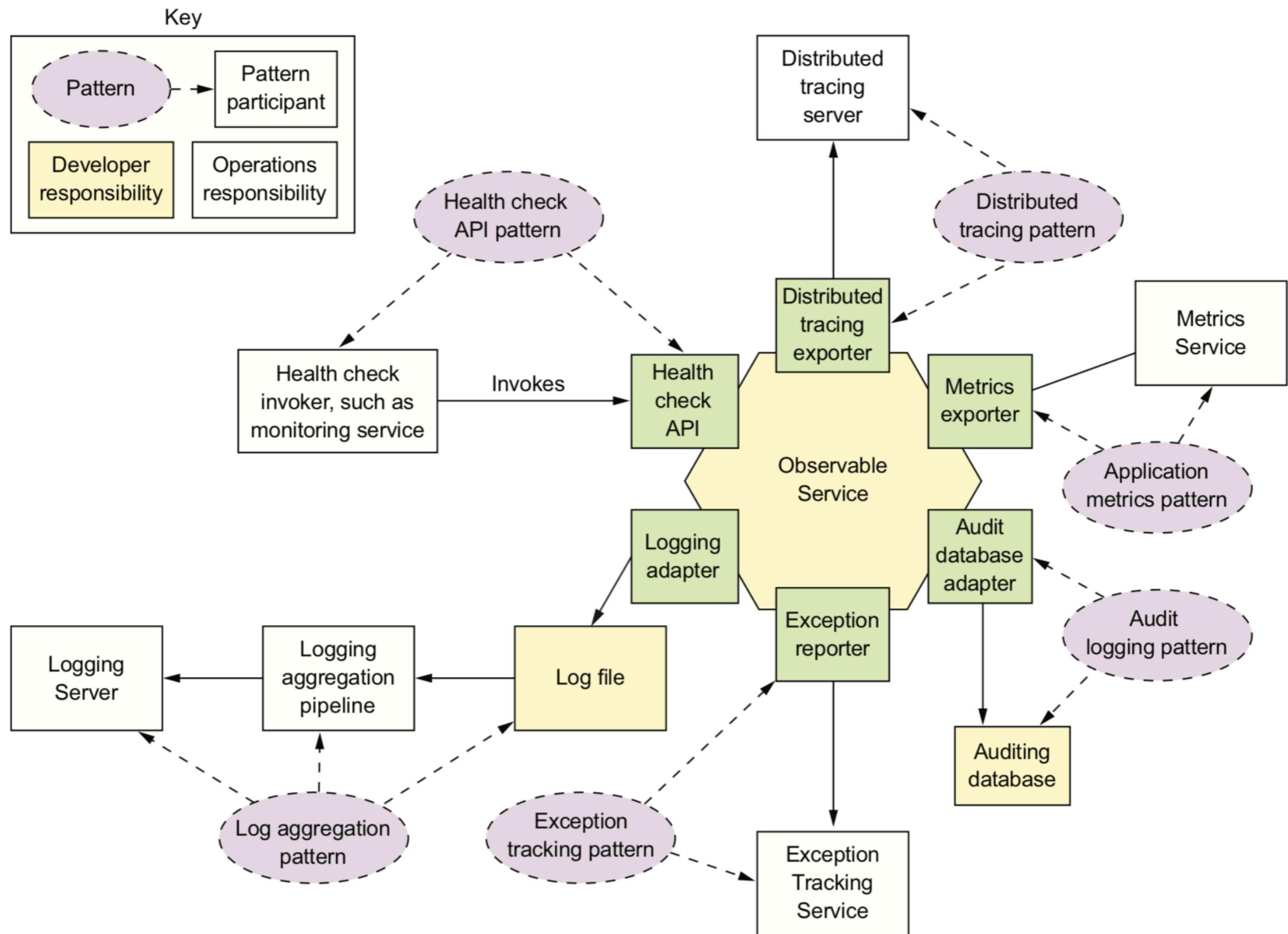
Centralize logging



Centralize logging



Observable services



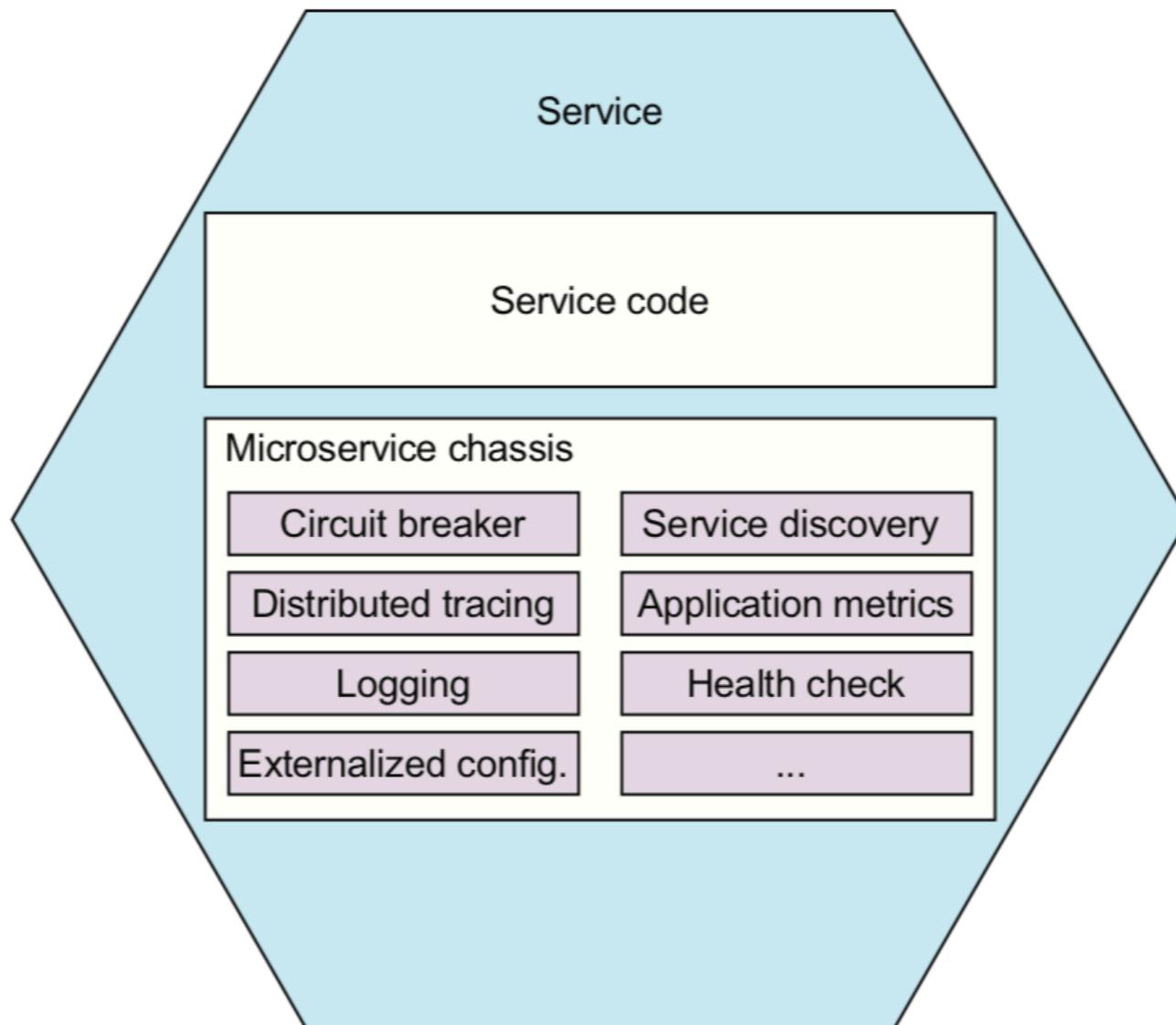
Workshop



Microservice framework



Microservice framework

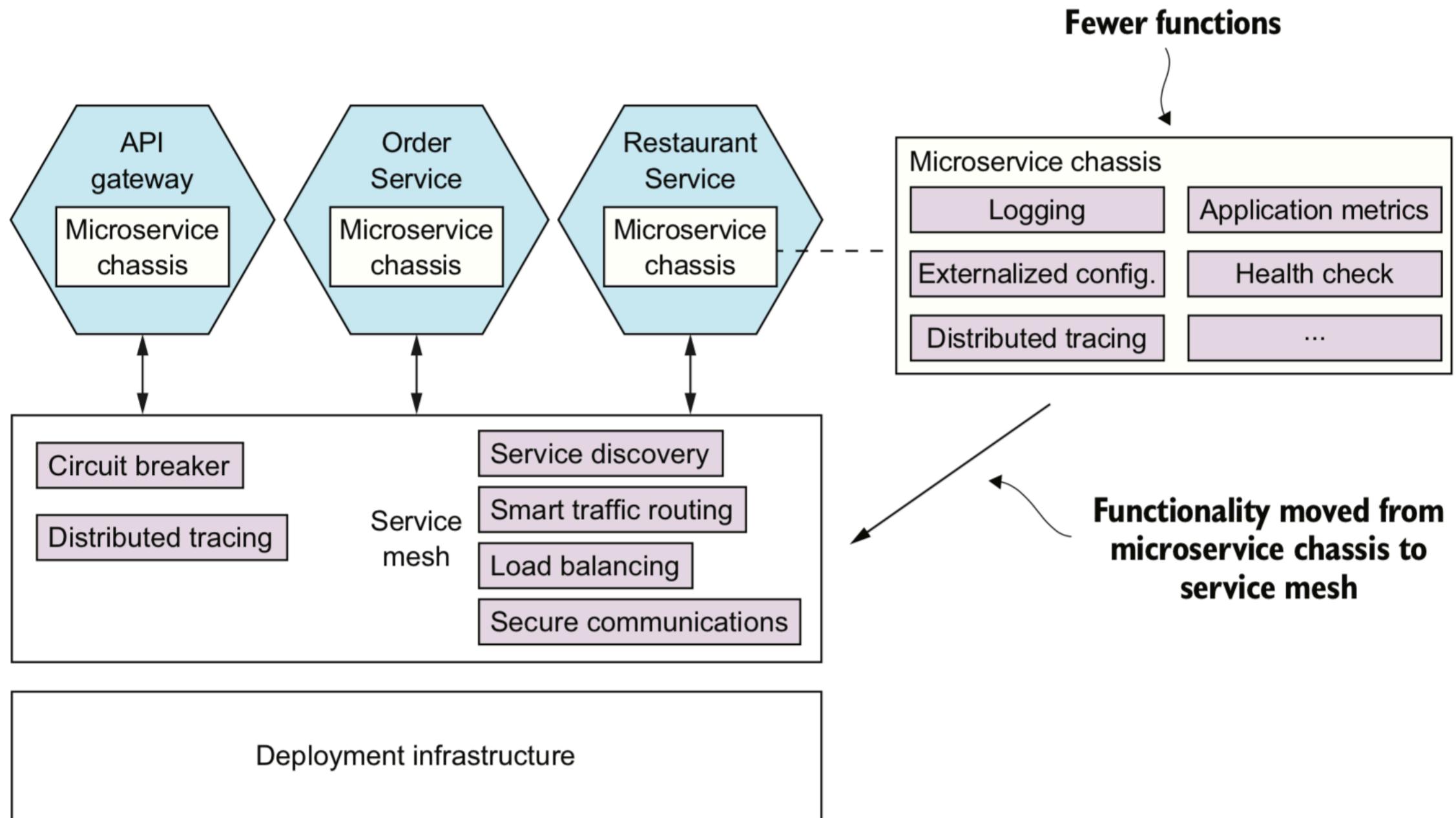


Microservice framework

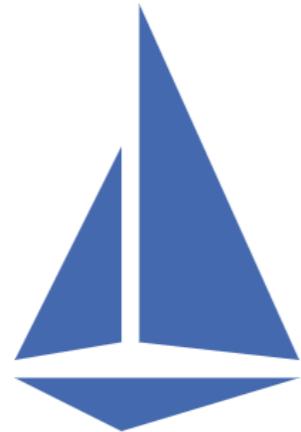
Programming language	Framework
Java	Spring boot Spring cloud
Golang	Go-kit Micro



Service Mesh



Service Mesh



Istio

Connect, secure, control, and observe services.



CONDUIT



linkerd

