Desenvolvimento de Aplicações com Arquitetura Baseada em Microservices

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[IF1007] - Tópicos Avançados em SI 4
https://github.com/vinicius3w/if1007-Microservices

AssertLab
Advanced Software and Systems Engineering Research Technologies
Centro de Informática
40 anos

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Resources

- There is no textbook required. However, the following are some books that may be recommended:
  - Building Microservices: Designing Fine-Grained Systems
  - Spring Microservices
  - Spring Boot: Acelere o desenvolvimento de microsserviços
  - Microservices for Java Developers A Hands-on Introduction to Frameworks and Containers
  - Migrating to Cloud-Native Application Architectures
  - Continuous Integration
  - Getting started guides from spring.io

Applying Microservices Concepts

Context

- Microservices are good, but can also be an evil if they are not properly conceived.
- Wrong microservice interpretations could lead to irrecoverable failures
- What are the technical challenges around practical implementations of microservices?
  - design decisions, solutions and patterns?

Patterns and common design decisions

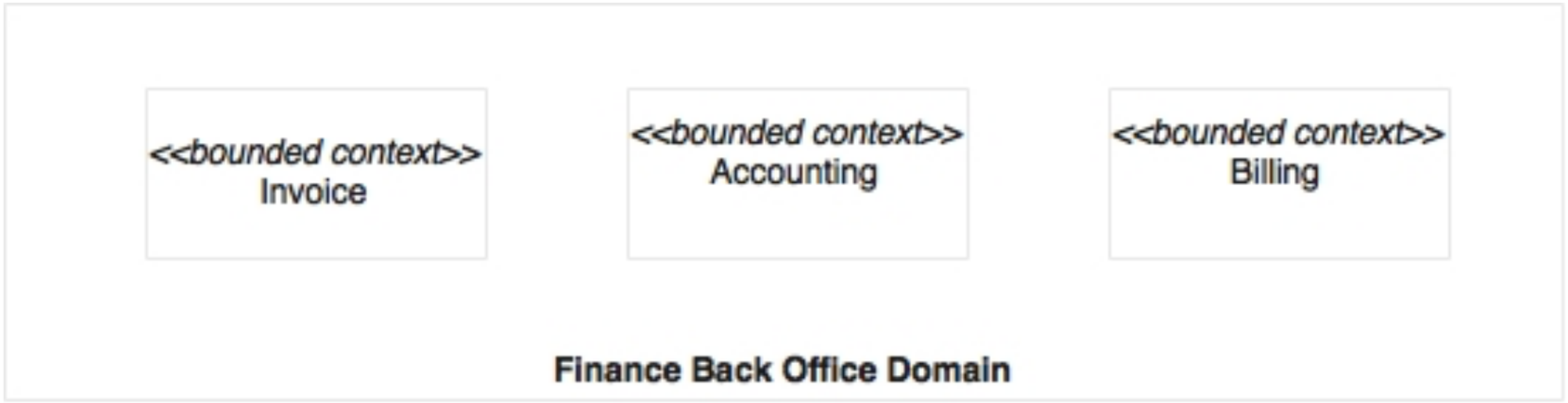
- Microservices are a vehicle for developing scalable cloud native systems, successful microservices need to be carefully designed to avoid catastrophes.
- Microservices are not the one-size-fits-all, universal solution for all architecture problems
- Generally speaking, microservices are a great choice for building a lightweight, modular, scalable, and distributed system of systems

Establishing appropriate microservice boundaries

- How big (mini-monolithic) or how small (nano service) can a microservice be, or is there anything like right-sized services?
  - Does size really matter?
- A quick answer could be
  - "one REST endpoint per microservice", or
  - "less than 300 lines of code", or
  - “a component that performs a single responsibility"

Establishing appropriate microservice boundaries

- Domain-driven design (DDD) defines the concept of a **bounded context**. A bounded context is a subdomain or a subsystem of a larger domain or system that is responsible for performing a particular function



Establishing appropriate microservice boundaries

- A bounded context is a good way to determine the boundaries of microservices
  - Each bounded context could be mapped to a single microservice.
  - In the real world, communication between bounded contexts are typically less coupled, and often, disconnected

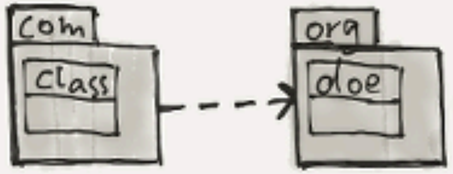
Establishing appropriate microservice boundaries

- There is no silver bullet to establish microservices boundaries
  - Establishing boundaries is much easier in the scenario of monolithic application to microservices migration, as the service boundaries and dependencies are known from the existing system.
  - On the other hand, in a green field microservices development, the dependencies are hard to establish upfront.
- The most pragmatic way to design microservices boundaries is to run a lot of scenarios

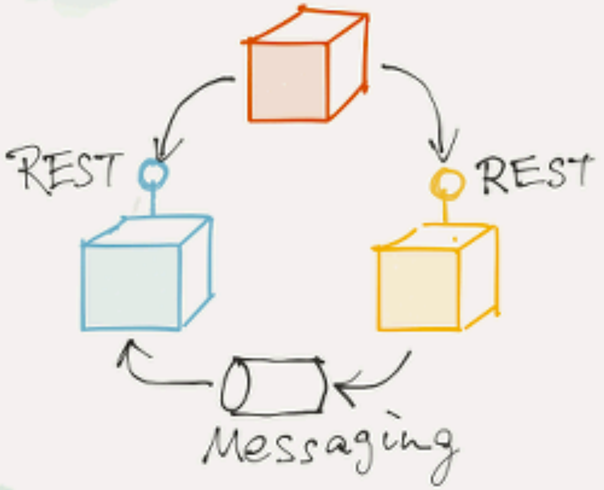
Scenarios could help in defining the microservice boundaries

- Autonomous functions
- Size of a deployable unit
- Most appropriate function or subdomain
- Polyglot architecture
- Selective scaling
- Small, agile teams
- Single responsibility (business capability or a technical capability)
- Replicability or changeability
- Coupling and cohesion
- Think microservice as a product

Architecture



Microservices

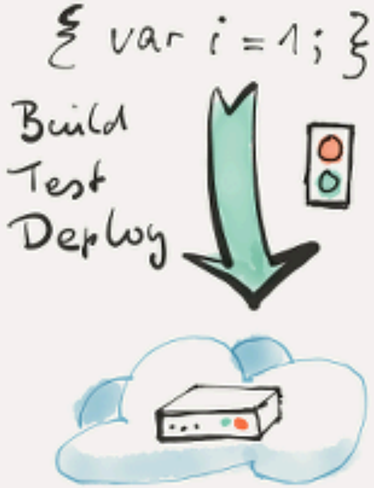


People & Teams

Communication
Collaboration

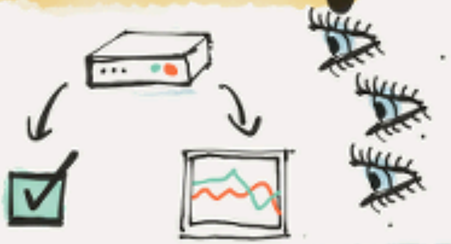
Deployment

Continous Delivery



Infrastructure

Monitoring



Features & Technology

Designing communication styles

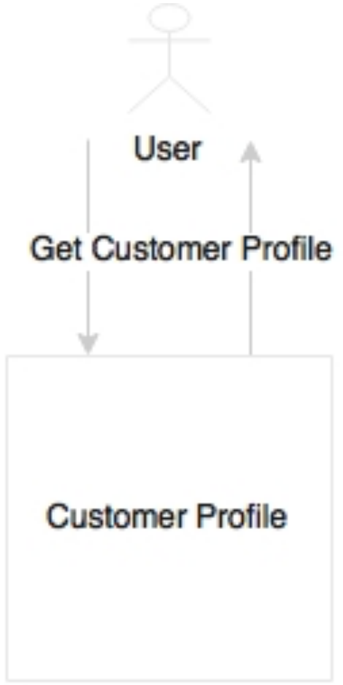
- Synchronous style communication
  - there is no shared state or object
  - When a caller requests a service, it passes the required information and waits for a response
  - Advantages and downsides?

Designing communication styles

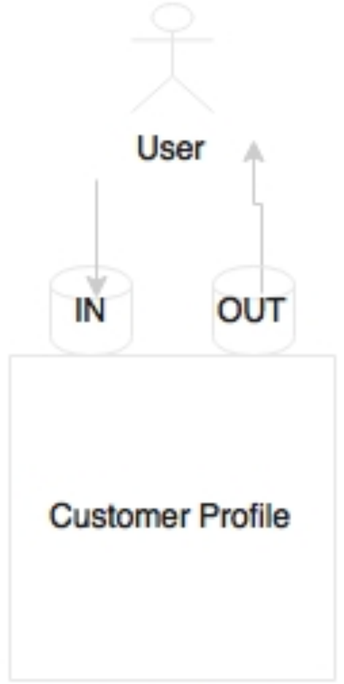
- Asynchronous style communication
  - The asynchronous style is based on reactive event loop semantics which decouple microservices.
  - This approach provides higher levels of scalability, because services are independent, and can internally spawn threads to handle an increase in load.
    - When overloaded, messages will be queued in a messaging server for later processing

How to decide which style to choose?

- Both approaches have their own merits and constraints
  - In principle, the asynchronous approach is great for building true, scalable microservice systems
  - However, attempting to model everything as asynchronous leads to complex system designs

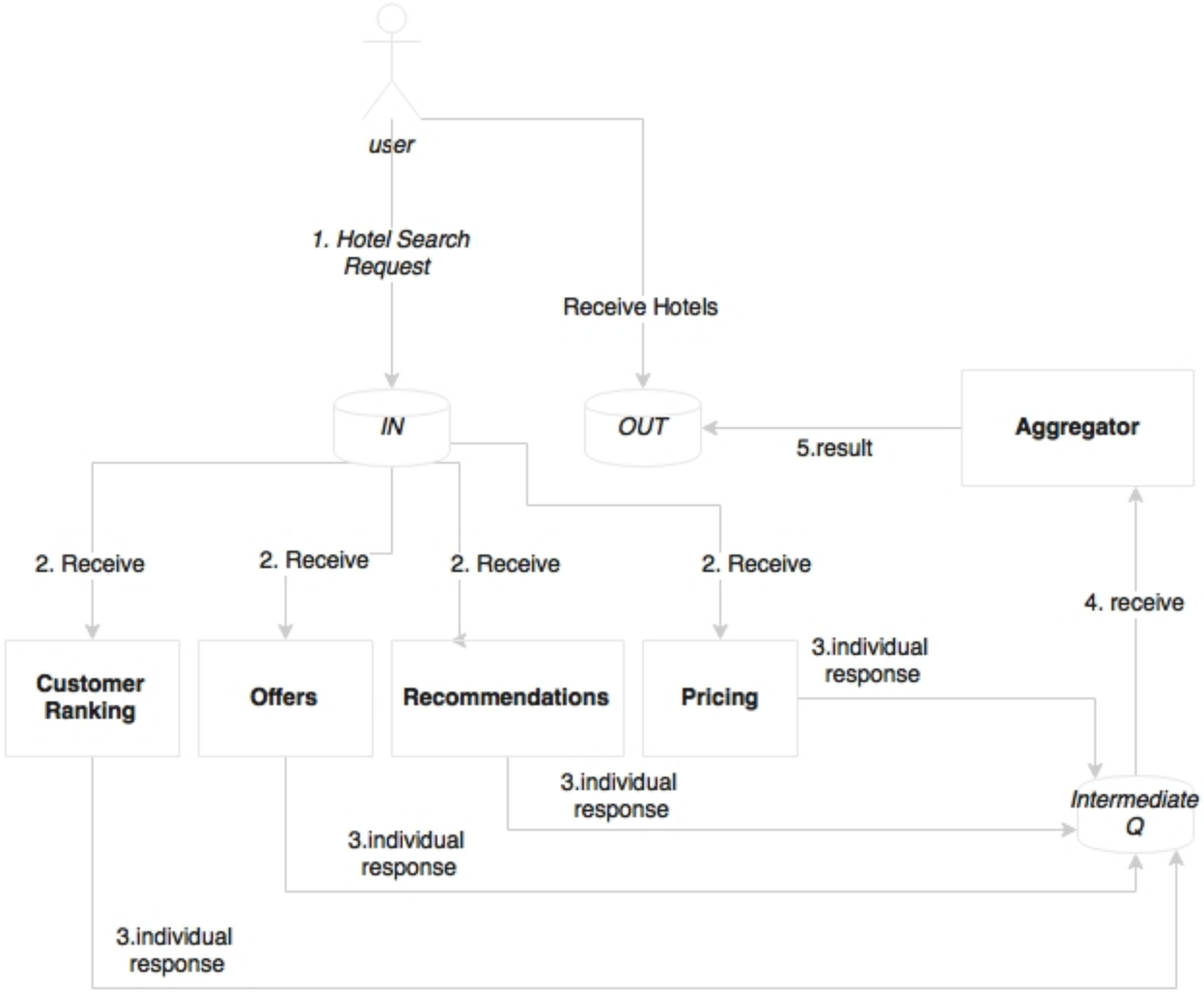


A) synchronous request - response



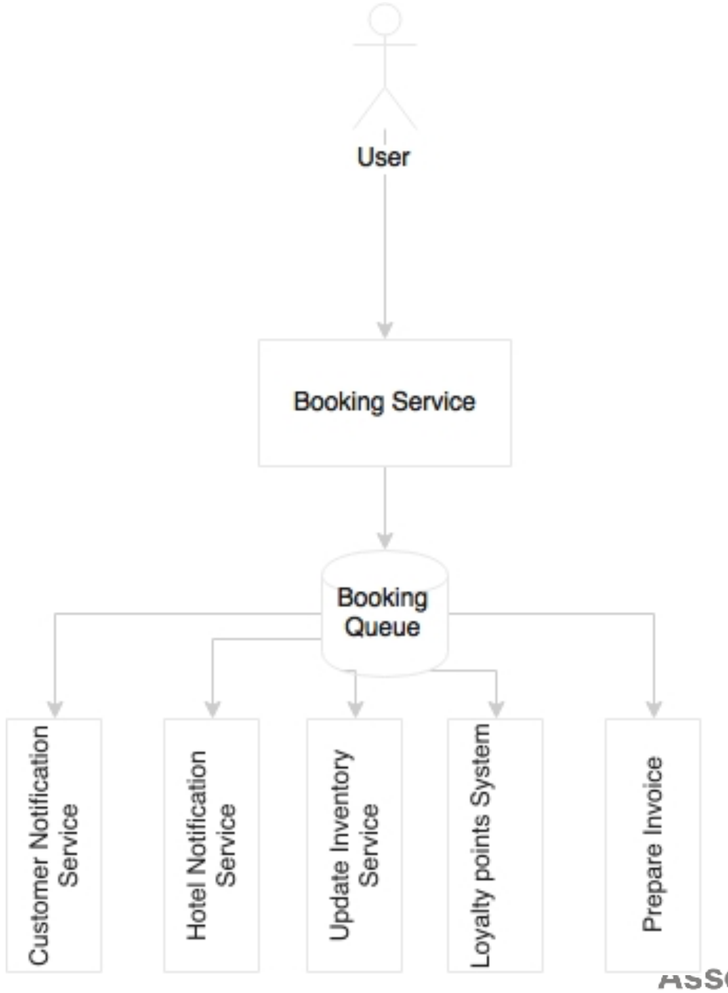
B) asynchronous request - response

How to decide which style to choose?



How to decide which style to choose?

- The service is triggered when the user clicks on the booking function.
- It is again, by nature, a synchronous style communication.
- When booking is successful, it sends a message to the customer's e-mail address, sends a message to the hotel's booking system, updates the cached inventory, updates the loyalty points system, prepares an invoice, and perhaps more

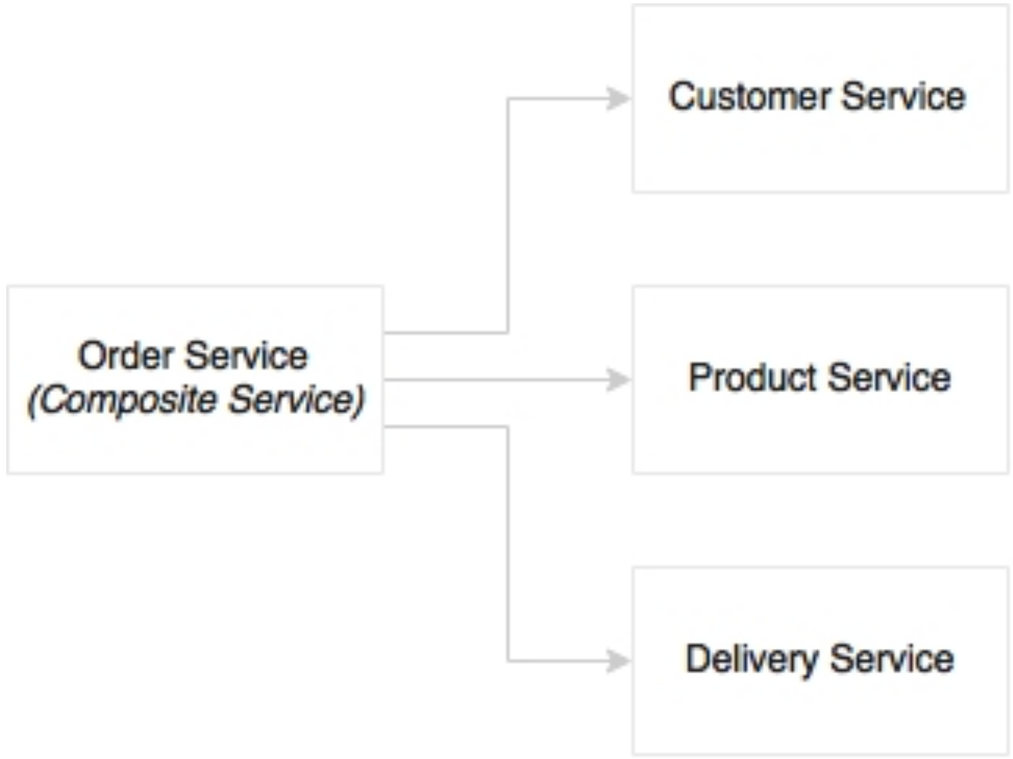


Orchestration of microservices

- Composability is one of the service design principles
  - Who is responsible for the composing services?
- SOA use ESBs (act as a proxy in some cases)
  - The first approach is orchestration

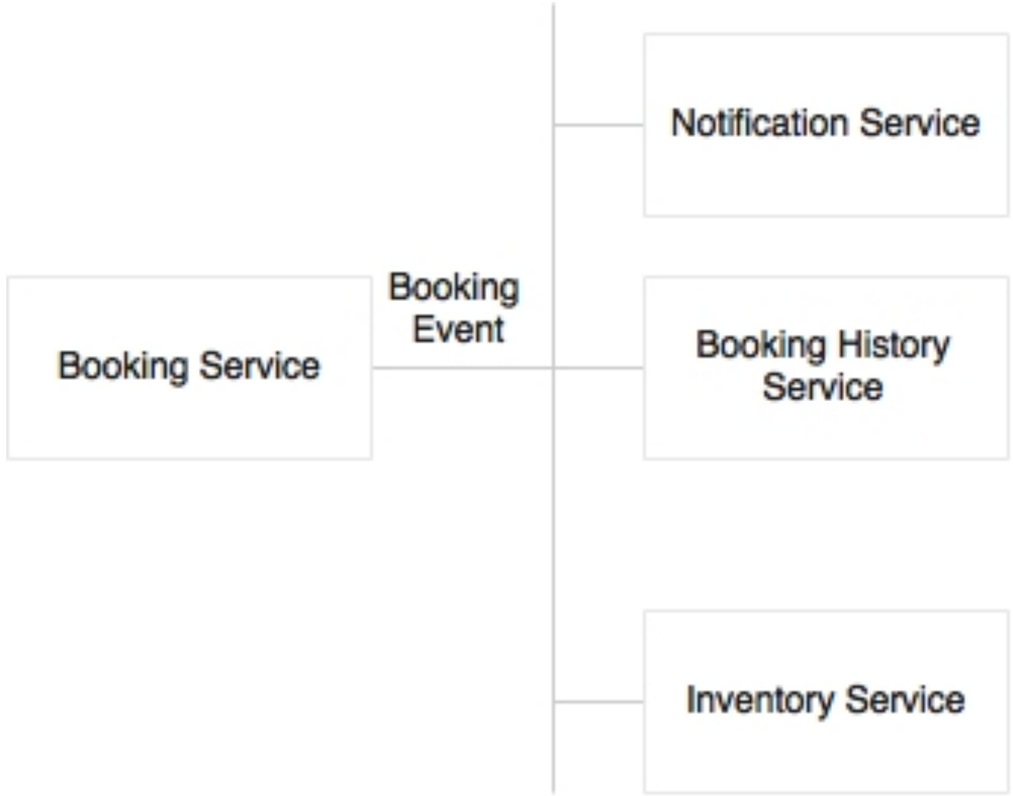
Orchestration of microservices

- Multiple services are stitched together to get a complete function. A central brain acts as the orchestrator
- In the SOA world, ESBs play the role of orchestration
- The orchestrated service will be exposed by ESBs as a composite service



Orchestration of microservices

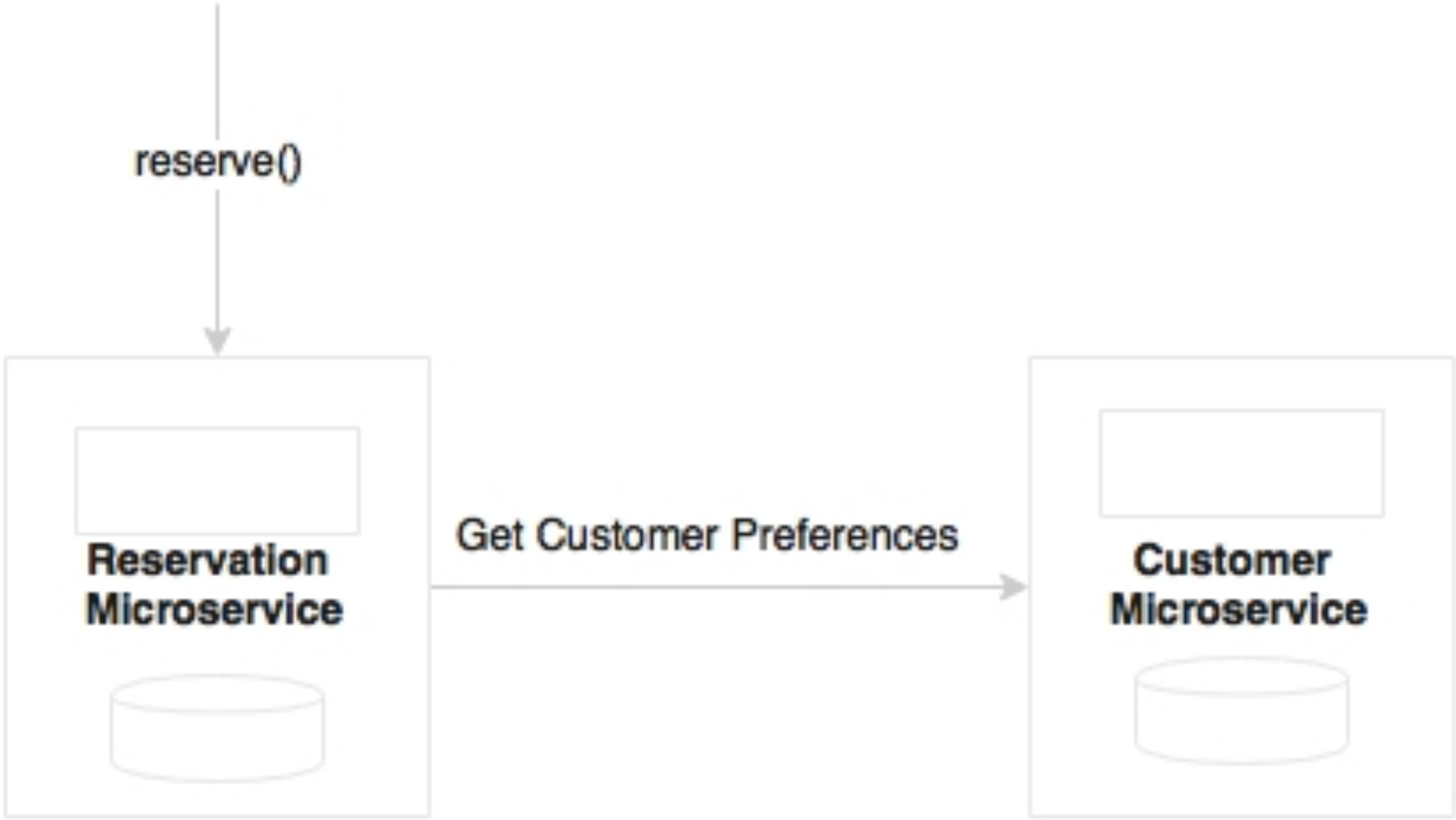
- The second approach is choreography, in where, there is no central brain
- In the SOA world, the caller pushes a message to the ESB, and the downstream flow will be automatically determined by the consuming services



Orchestration of microservices

- Microservices are autonomous
  - all required components to complete their function should be within the service
- The service endpoints provide coarse-grained APIs
  - there are no external touch points required
  - microservices may need to talk to other microservices to fulfil their function

We can model choreography in all cases?



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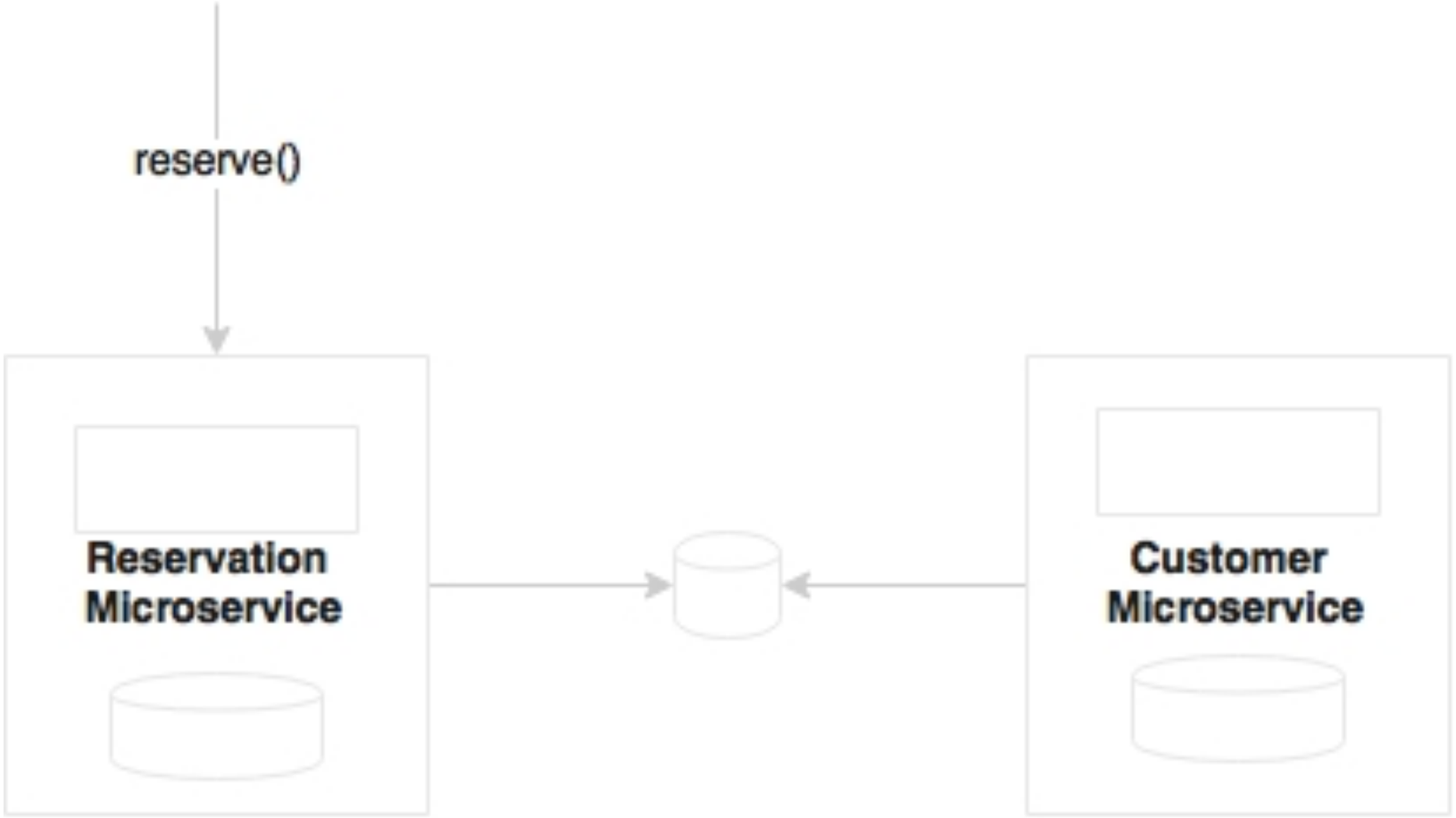

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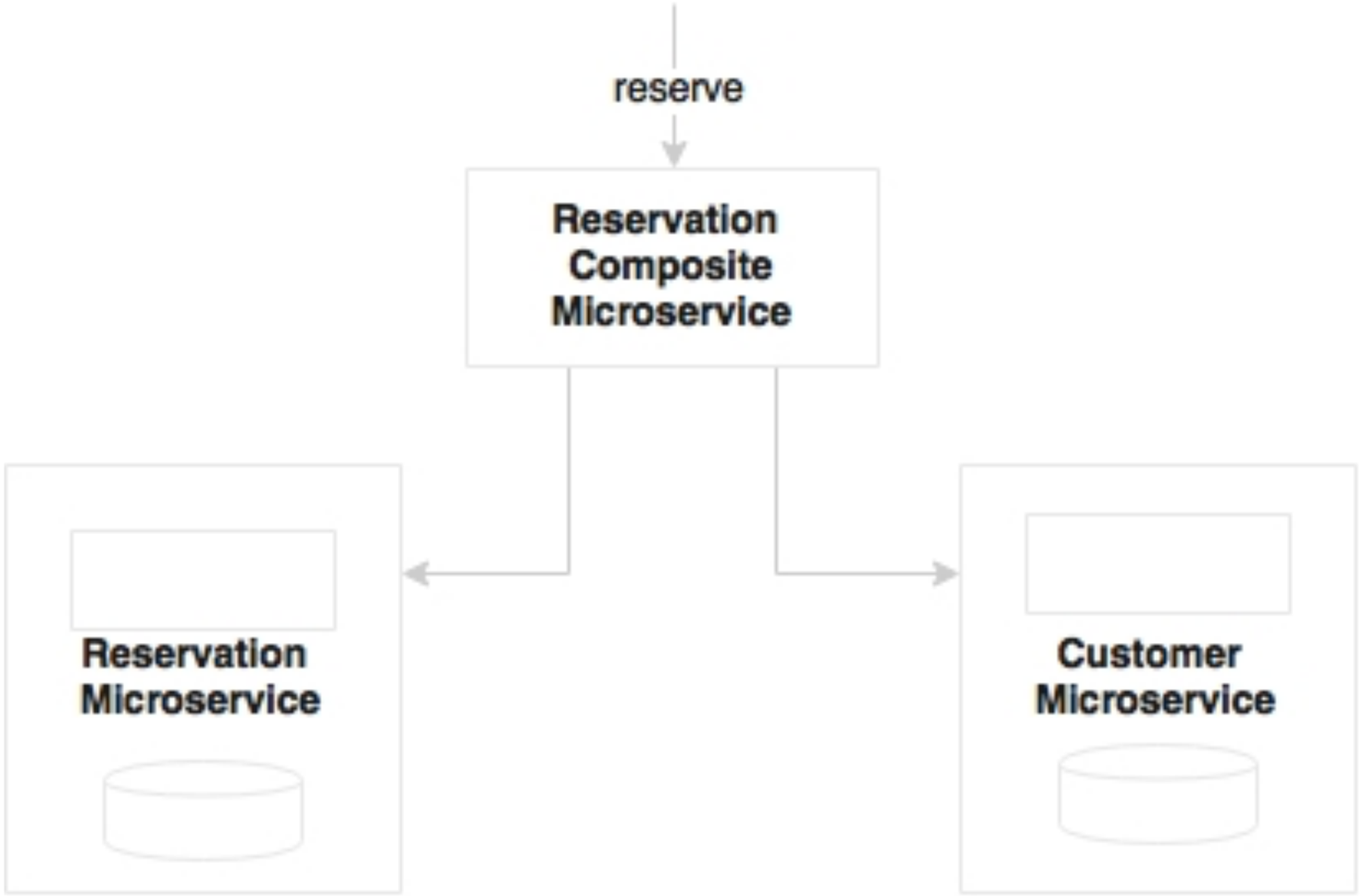

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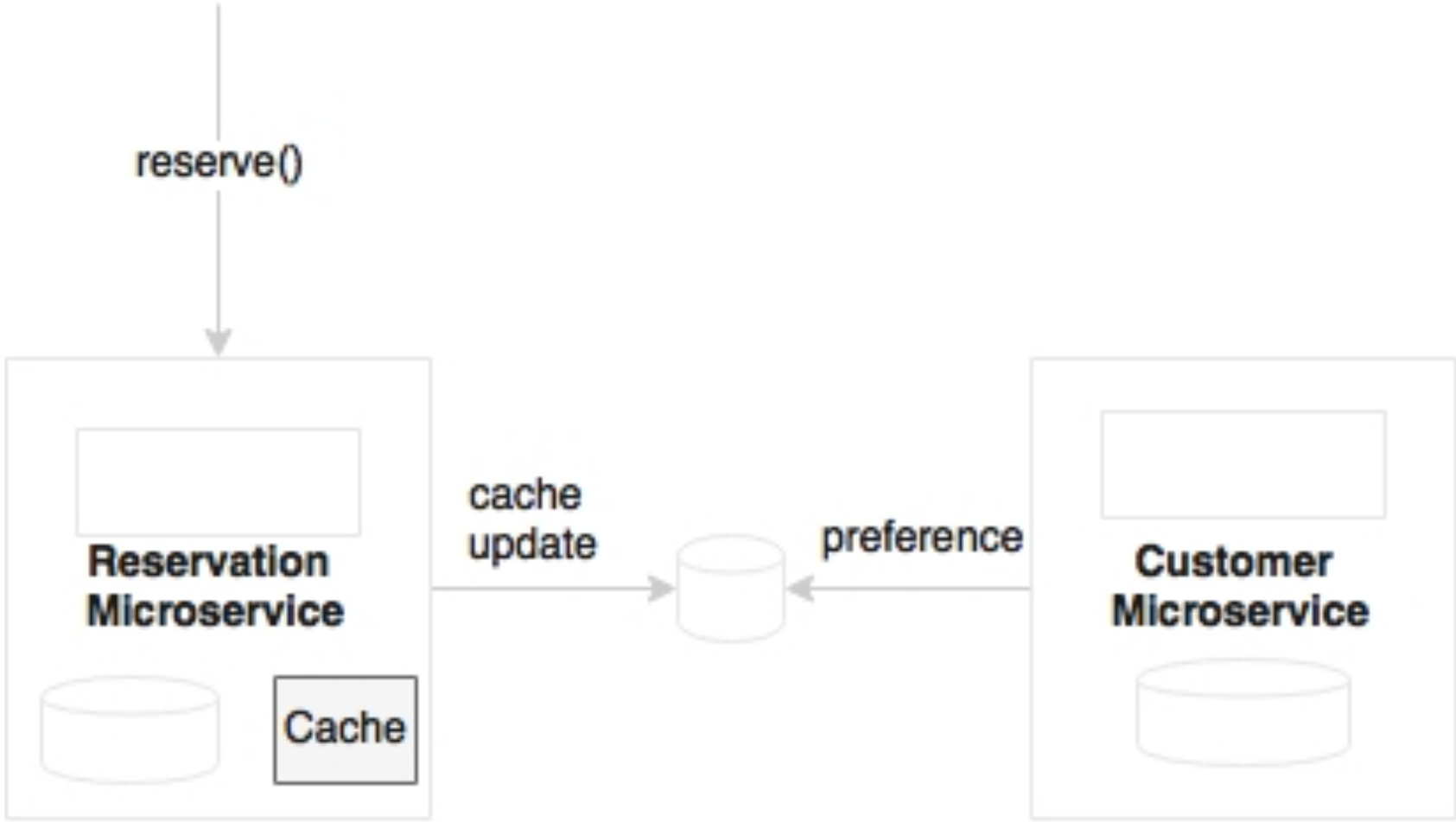
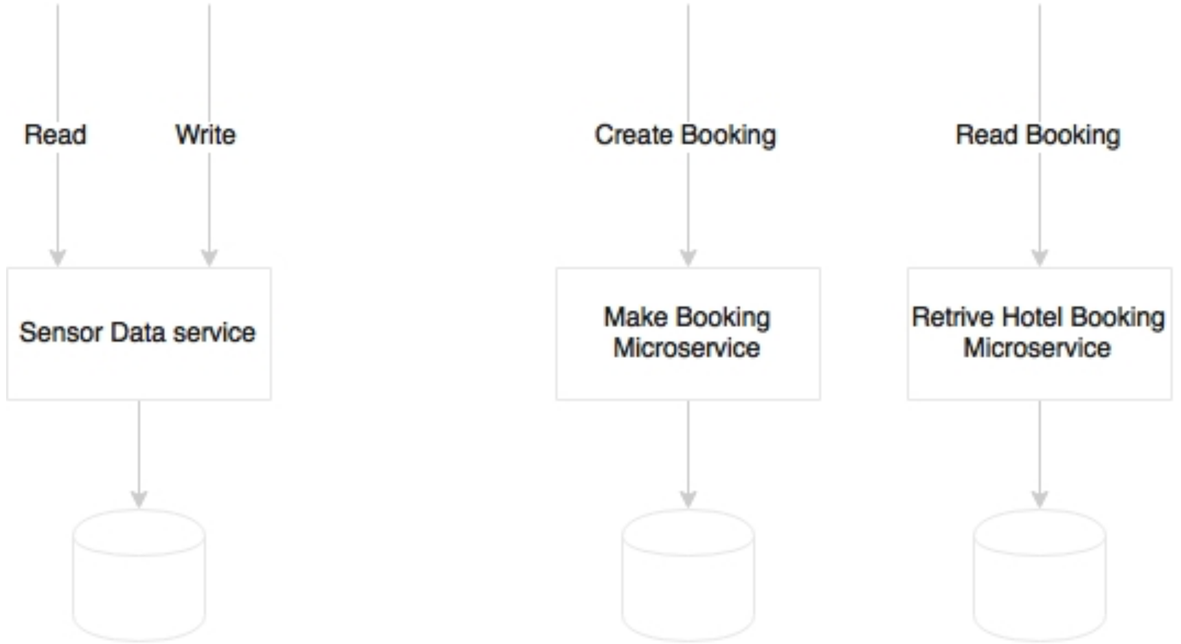


How many endpoints in a microservice?

- The question really is whether to limit each microservice with one endpoint or multiple endpoints
- Polyglot architecture could be another scenario where we may split endpoints into different microservices



One microservice per VM or multiple?

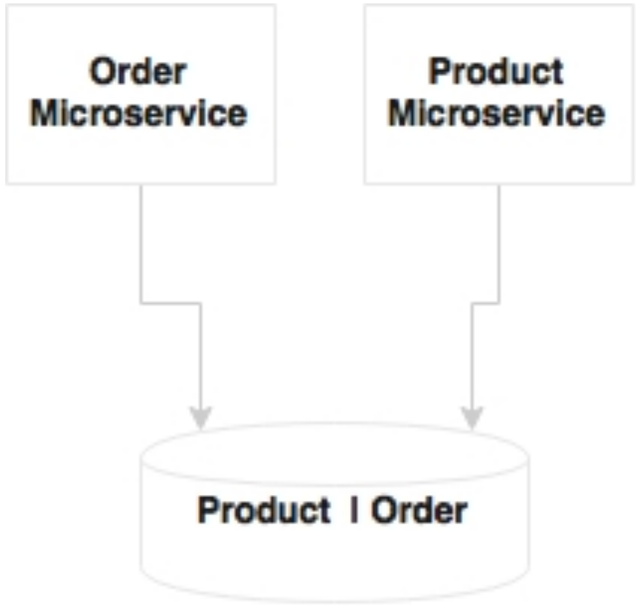
- Whether multiple microservices could be deployed in one virtual machine?
- The simplest way to approach this problem is to ask a few questions:
  - Does the VM have enough capacity to run both services under peak usage?
  - Do we want to treat these services differently to achieve SLAs (selective scaling)? For example, for scalability, if we have an all-in-one VM, we will have to replicate VMs which replicate all services.
  - Are there any conflicting resource requirements? For example, different OS versions, JDK versions, and others

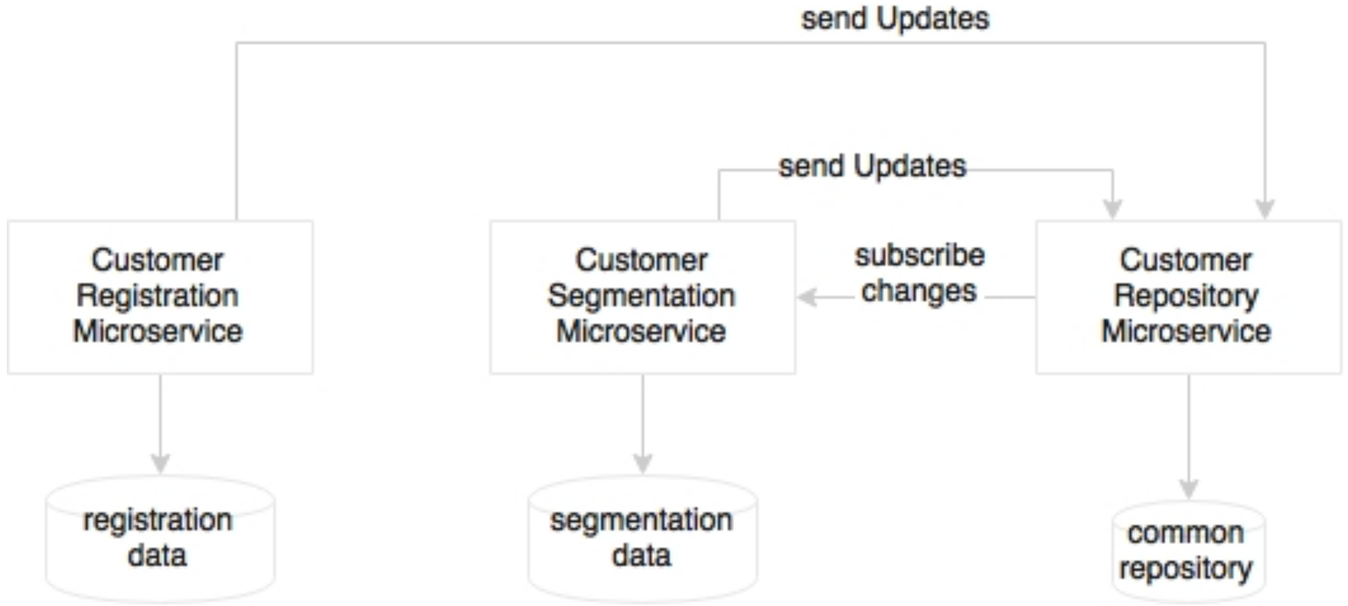
Rules engine – shared or embedded?

- Either we hand code rules, or we may use a rules engine. Many enterprises manage rules centrally in a rules repository as well as execute them centrally
  - **Drools** is one of the popular open source rules engines

Can microservices share data stores?

- In principle, microservices should abstract presentation, business logic, and data stores.
- If the services are broken as per the guidelines, each microservice logically could use an independent database





Setting up transaction boundaries

- Is there a place for transactions in microservices?
  - It is appropriate to define transaction boundaries within the microsystem using local transactions
  - However, distributed global transactions should be avoided in the microservices context

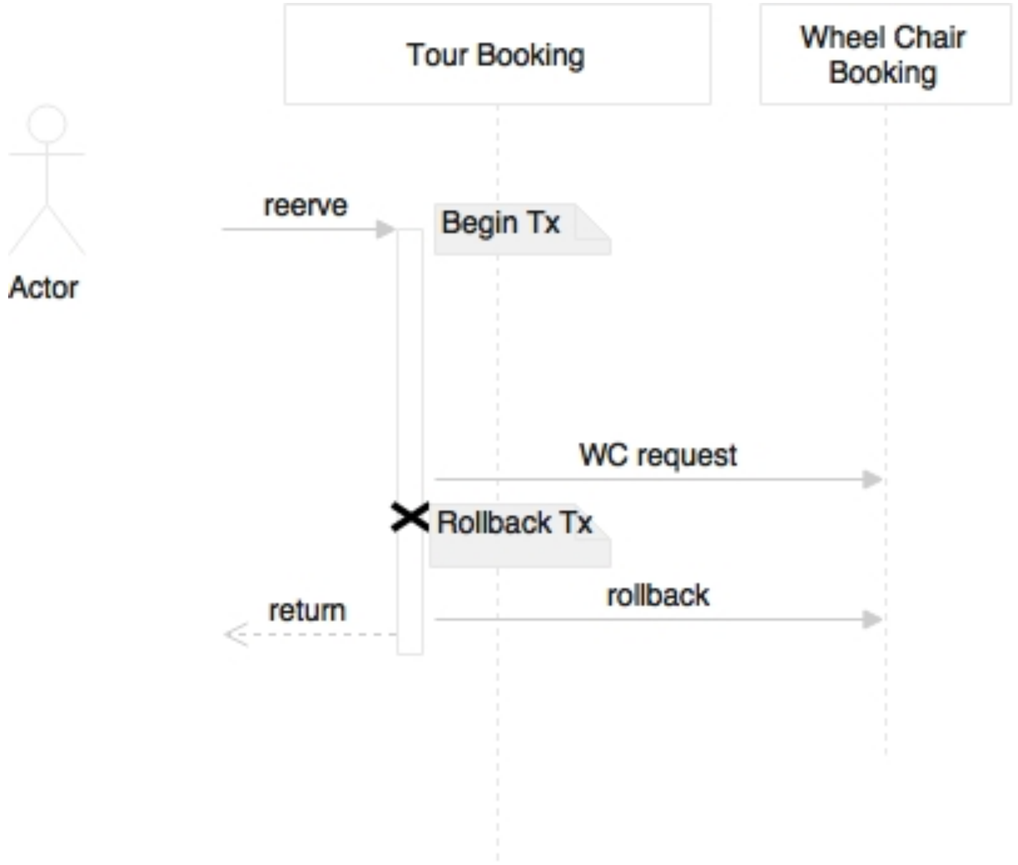
Altering use cases to simplify transactional requirements

- Eventual consistency is a better option than distributed transactions that span across multiple microservices
  - reduces a lot of overheads
  - but application developers may need to re-think the way they write application code

Distributed transaction scenarios

- The ideal scenario is to use local transactions within a microservice if required, and completely avoid distributed transactions

- There could be scenarios where at the end of the execution of one service, we may want to send a message to another microservice



Service endpoint design consideration

- Service design has two key elements: contract design and protocol selection
- Contract design
  - A complex service contract reduces the usability of the service
    - KISS (Keep It Simple Stupid)
    - YAGNI (You Ain't Gonna Need It)
  - Evolutionary design is a great concept
    - Consumer Driven Contracts (CDC) and Postel's law

Service endpoint design consideration

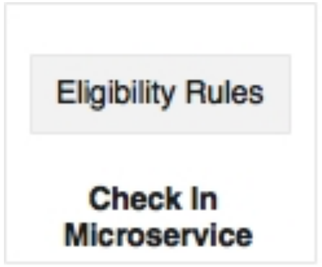
- Protocol selection
  - In the SOA world, HTTP/SOAP, and messaging were kinds of default service protocols for service interactions
  - increases the communication cost; susceptible to network failures; could result in poor performance of services
    - Message-oriented services (asynchronous style of communication)
    - HTTP and REST endpoints (interoperability, protocol handling, traffic routing, load balancing, security systems...)
    - Optimized communication protocols
    - API documentations

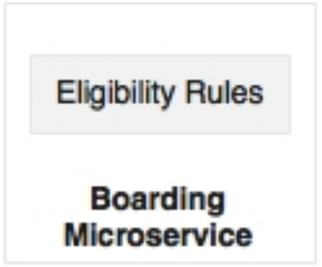
Homework 4.1

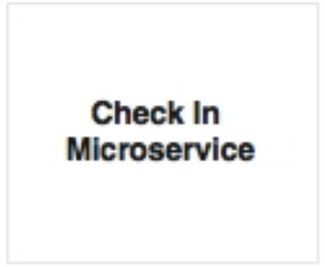
- What is the main concepts and principles of Consumer Driven Contracts (CDC)?
- How does it fit into the microservices approach?
- How Postel's law could be also relevant in this scenario?
- What are the main solutions (patterns, architectural styles, tools, etc.) to implement:
  - Message-oriented services;
  - HTTP and REST endpoints;
  - Optimized communication protocols;
  - API documentations

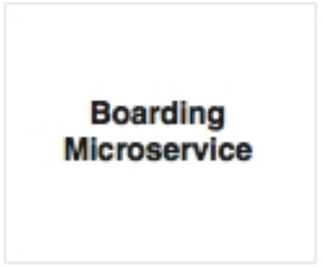
Handling shared libraries

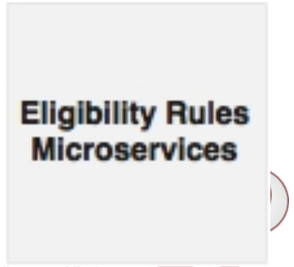
- Autonomous and self-contained
  - duplicate code and libraries





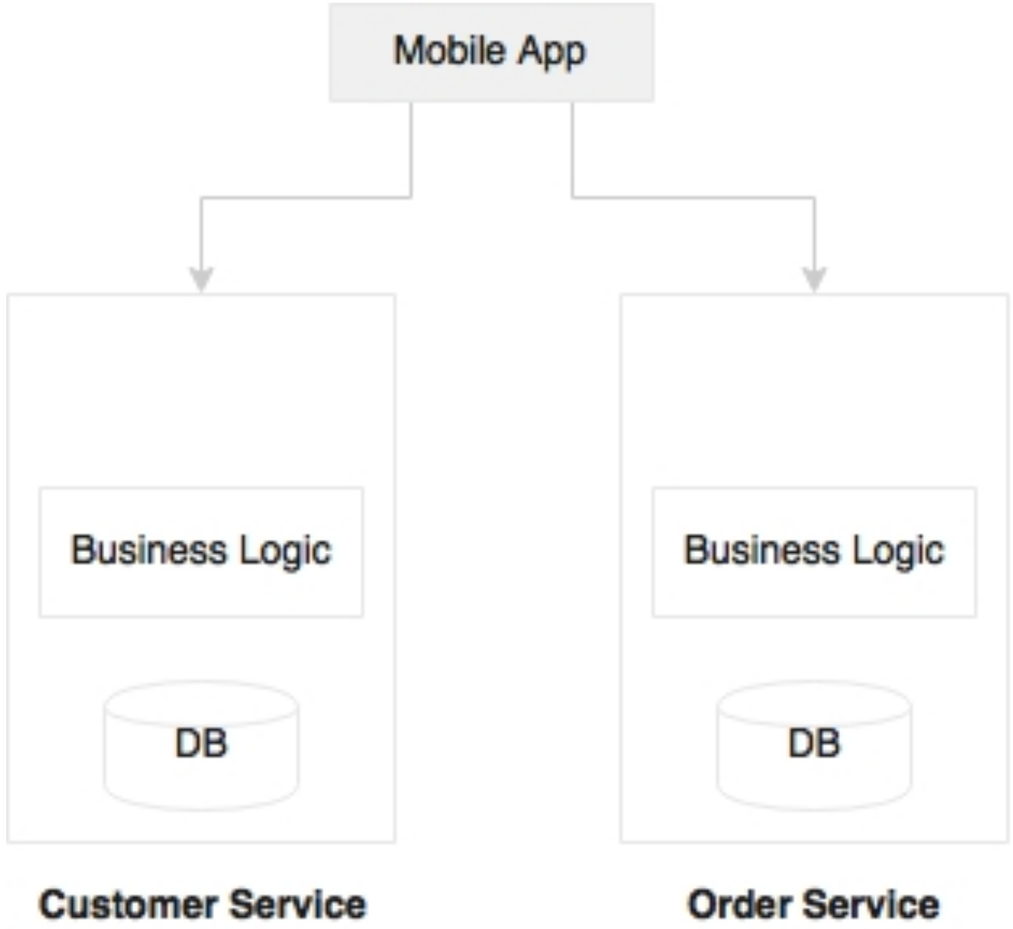






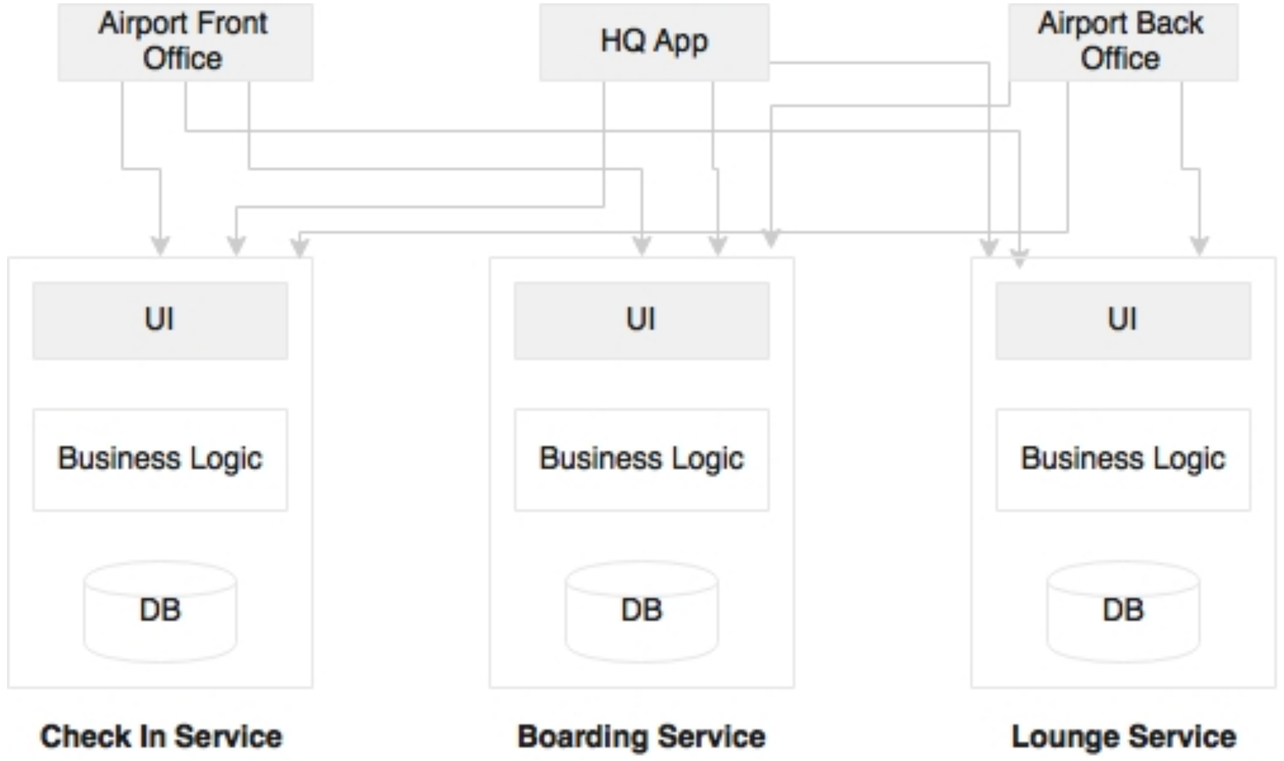
User interfaces in microservices

- The microservices principle advocates a microservice as a vertical slice from the database to presentation
  - build quick UI and mobile applications mashing up the existing APIs



User interfaces in microservices

- Build consolidated web applications targeted to communities
- One approach is to build a container web application or a placeholder web application, which links to multiple microservices at the backend
  - multiple placeholder web applications targeting different user communities

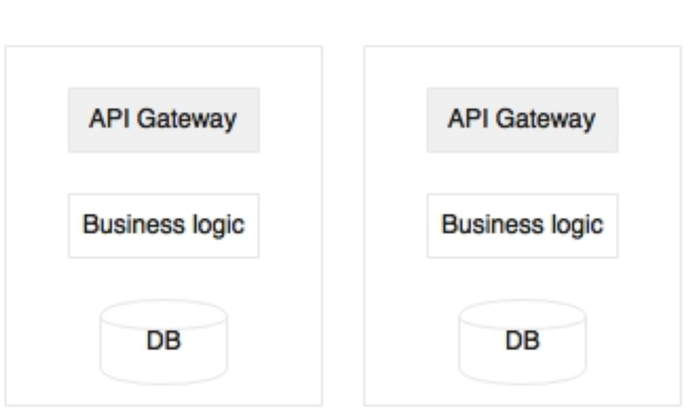


Use of API gateways in microservices

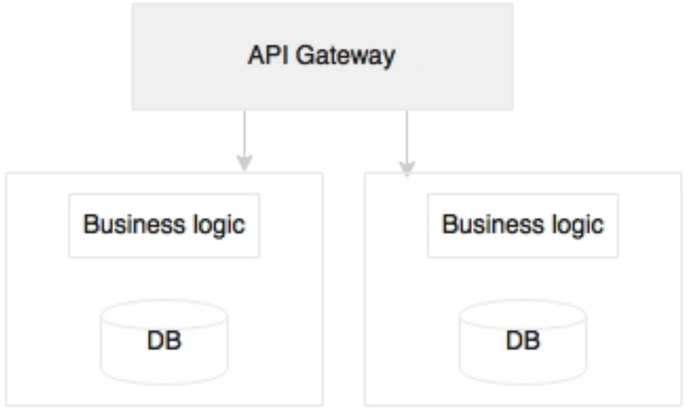
- With the advancement of client-side JavaScript frameworks, the server is expected to expose RESTful services
  - mismatch in contract expectations
    - minimal information is sent with links (HATEOAS)
  - multiple calls to the server to render a page
    - used when the client makes the REST call (also sends the required fields as part of the query string)

Use of API gateways in microservices

- Introduce a level of indirection
  - A gateway component sits between the client and the server, and transforms data as per the consumer's specification
    - do not compromise on the backend service contract
    - leads to UI services
  - In many cases, the API gateway acts as a proxy to the backend, exposing a set of consumer-specific APIs



A) API gateway is part of the micro service



B) Common API gateway

Use of ESB and iPaaS with microservices

- Theoretically, SOA is not all about ESBs, but the reality is that ESBs have always been at the center of many SOA implementations
- What would be the role of an ESB in the microservices world?
  - Microservices: fully cloud native systems, lightweight characteristics of microservices enable automation of deployments, scaling, and so on…
  - ESB: heavyweight in nature, not cloud friendly , protocol mediation, transformation, orchestration, and application adaptors ~> we may not need

Use of ESB and iPaaS with microservices

- Enterprises have legacy applications, vendor applications, and so on
  - Legacy services use ESBs to connect with microservices
- With the advancement of clouds, the capabilities of ESBs are not sufficient to manage integration between clouds, cloud to on-premise, and so on.
  - Integration Platform as a Service (iPaaS) is evolving as the next generation application integration platform, which further reduces the role of ESBs.
  - In typical deployments, iPaaS invokes API gateways to access microservices

Homework 4.2

- How can we have the same features present in EBS's with lightweight tools in the universe of microservices?

Service versioning considerations

- Versioning helps us to release new services without breaking the existing consumers
- There are three different ways in which we can version REST services:
  - URI versioning: version number is included in the URL itself

```
/api/v3/customer/1234
/api/customer/1234  - aliased to v3.

@RestController("CustomerControllerV3")
@RequestMapping("api/v3/customer")
public class CustomerController {

}
```

```
api/customer/100?v=1.5
```

  - Media type versioning: version is set by the client on the HTTP Accept header

```
Accept:  application/vnd.company.cus-
tomer-v3+json
```

Service versioning considerations

- A less effective approach for versioning is to set the version in the custom header

```
@RequestMapping(value = "/{id}", method
= RequestMethod.GET, headers = {"ver-
sion=3"})
public Customer getCustomer(@PathVari-
able("id") long id, {
    //other code goes here.
}
```

Service versioning considerations

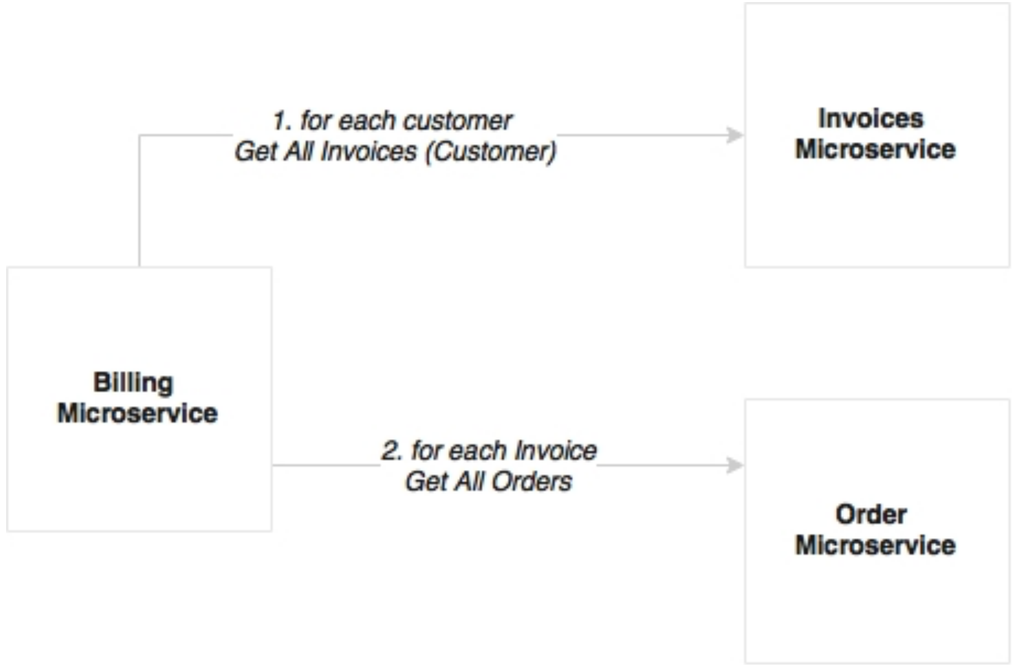
Design for cross origin

- Composite UI web applications may call multiple microservices for accomplishing a task, and these could come from different domains and hosts
- CORS allows browser clients to send requests to services hosted on different domains
  - One approach is to enable all microservices to allow cross origin requests from other trusted domains
  - The second approach is to use an API gateway as a single trusted domain for the clients

Microservices and bulk operations

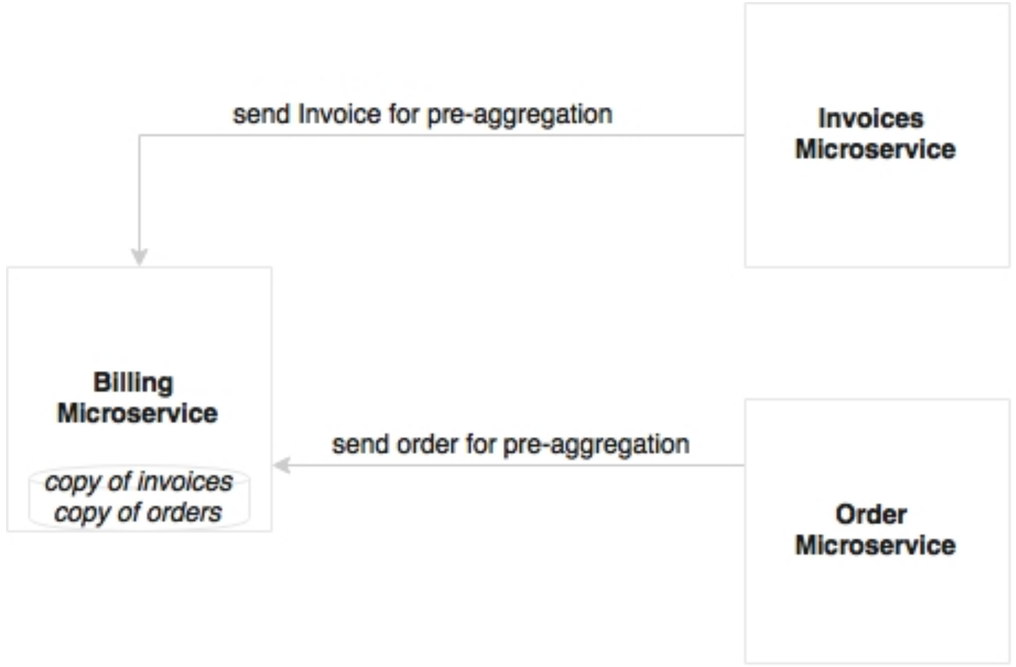
- Since we have broken monolithic applications into smaller, focused services, it is no longer possible to use join queries across microservice data stores

- The challenge that arises is that the **Billing** service has to query the **Invoices** service for each **customer** to get all the invoices, and then for each invoice, call the **Order** service for getting the orders



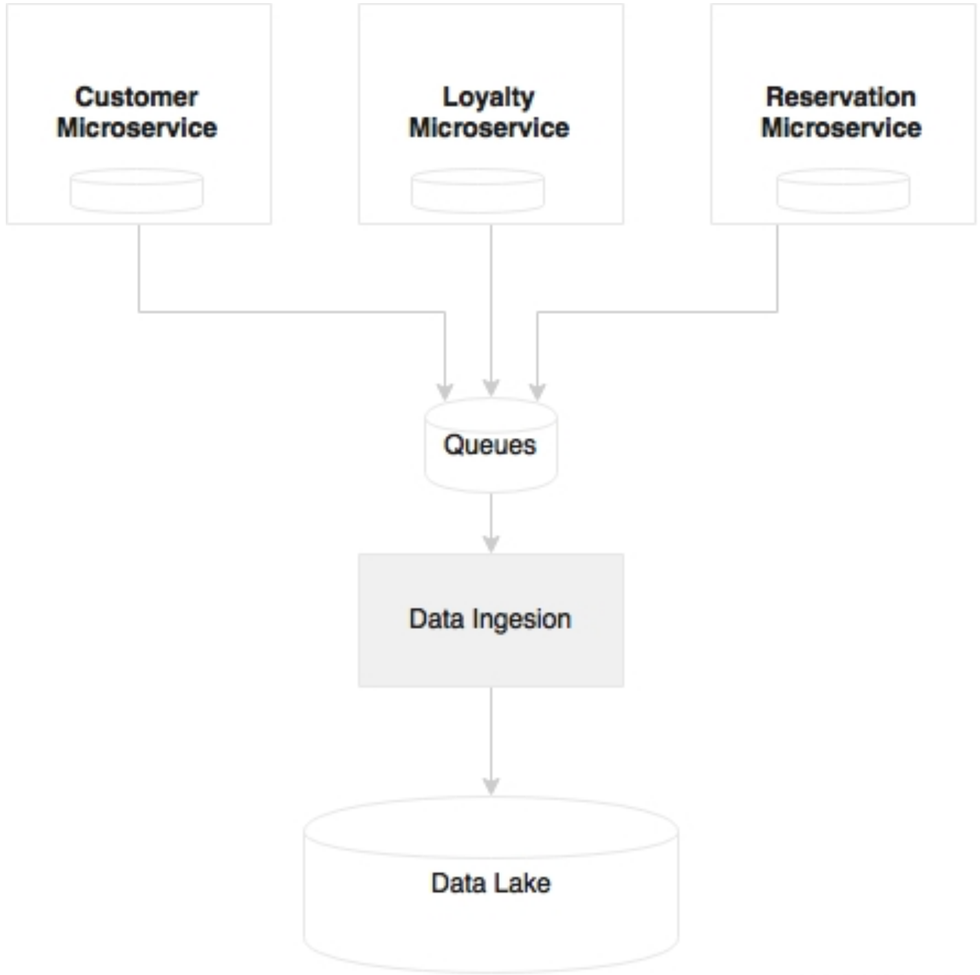
Microservices and bulk operations

- Pre-aggregate data as and when it is created
- Using of batch API
  - each batch further uses parallel threads



Microservices challenges

- Data islands
  - Fragmenting data into heterogeneous data islands
  - Traditional data warehouses like Oracle, Teradata, and others are used primarily for batch reporting
  - But with NoSQL databases (like Hadoop) and microbatching techniques, near real-time analytics is possible with the concept of data lakes

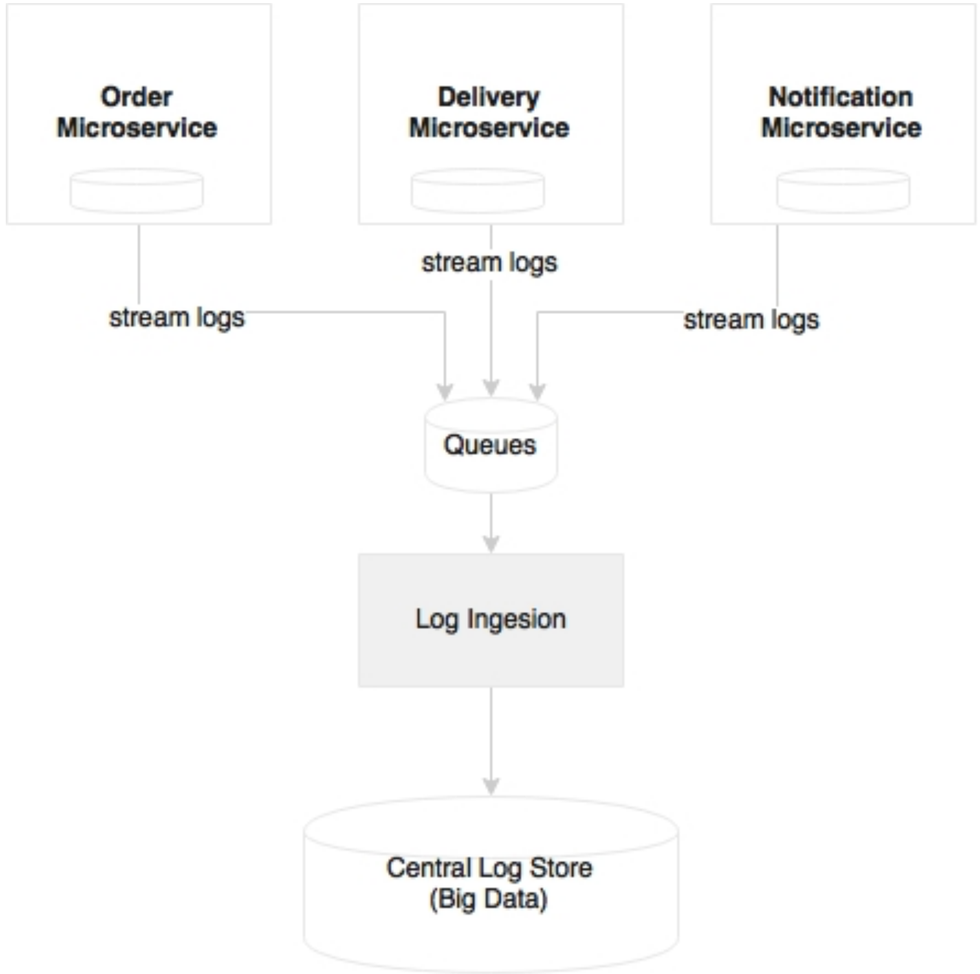


Homework 4.3

- How can be done data porting from microservices to a data lake or a data warehouse? Explain in details your answer.

Logging and monitoring

- Log files are a good piece of information for analysis and debugging
- When we scale services across multiple machines, each service instance could produce separate log files



Dependency management

- Too many dependencies could raise challenges in microservices. Four important design aspects are stated as follows:
  - Reducing dependencies by properly designing service boundaries.
  - Reducing impacts by designing dependencies as loosely coupled as possible. Also, designing service interactions through asynchronous communication styles.
  - Tackling dependency issues using patterns such as circuit breakers.
  - Monitoring dependencies using visual dependency graphs.

Organization culture

- Agile development processes, continuous integration, automated QA checks, automated delivery pipelines, automated deployments, and automatic infrastructure provisioning...

Governance challenges

- Microservices impose decentralized governance, and this is quite in contrast with the traditional SOA governance
- There are number of challenges that comes with a decentralized governance model
  - How do we understand who is consuming a service?
  - How do we ensure service reuse?
  - How do we define which services are available in the organization?
  - How do we ensure enforcement of enterprise polices?

Operation overheads

- Microservices deployment generally increases the number of deployable units and virtual machines (or containers)
  - the number of **configurable items** (CIs) becomes too high, and the number of servers in which these CIs are deployed might also be unpredictable

Testing microservices

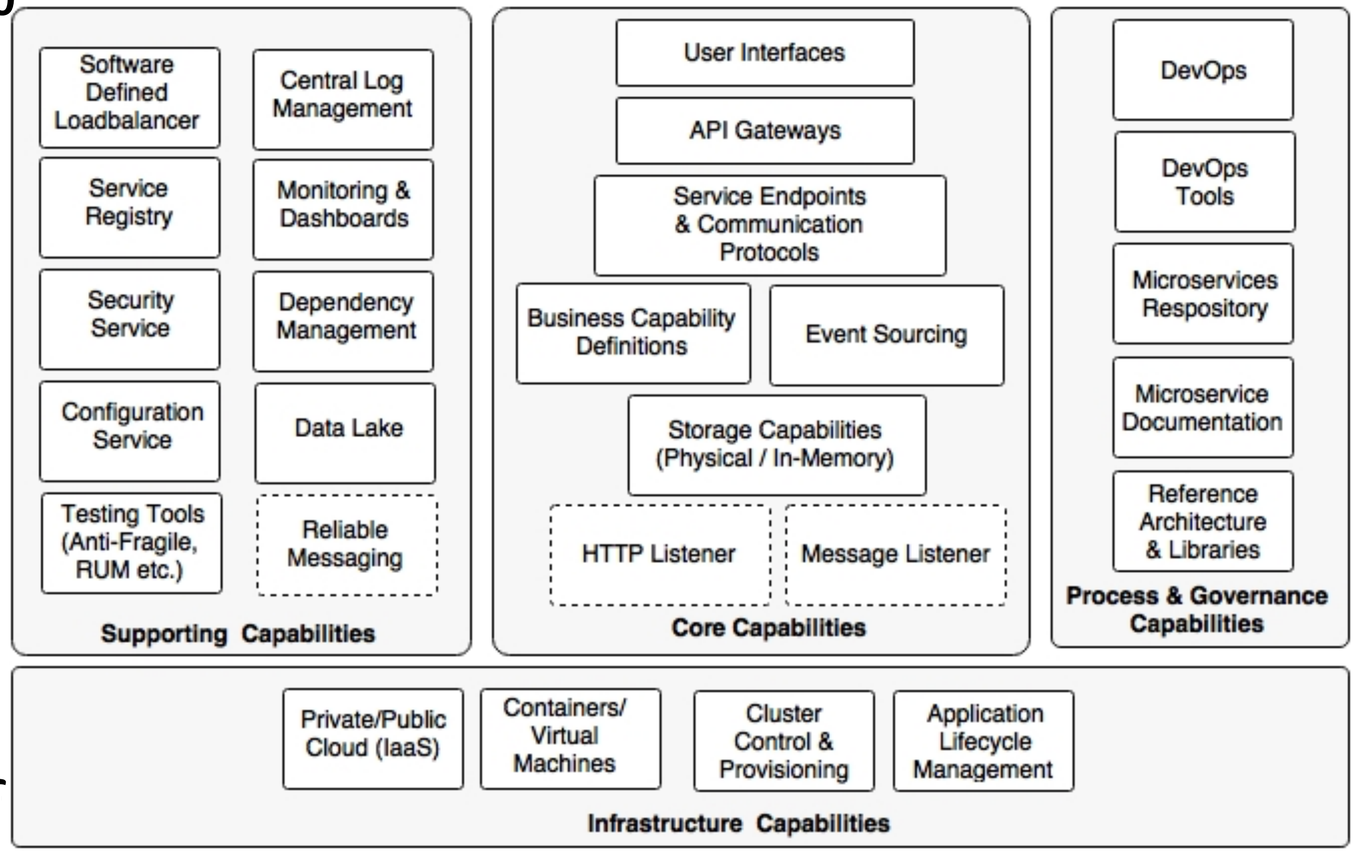
- The issue is how do we test an end-to-end service to evaluate its behavior?
  - Service virtualization or service mocking
  - Consumer driven contract
- Test automation, appropriate performance testing, and continuous delivery approaches such as A/B testing, future flags, canary testing, blue-green deployments, and red-black deployments, all reduce the risks of production releases

Infrastructure provisioning

- Manual deployment could severely challenge the microservices rollouts
- Microservices require a supporting elastic cloud-like infrastructure which can **automatically** provision VMs or containers, **automatically** deploy applications, adjust traffic flows, replicate new version to all instances, and gracefully phase out older versions

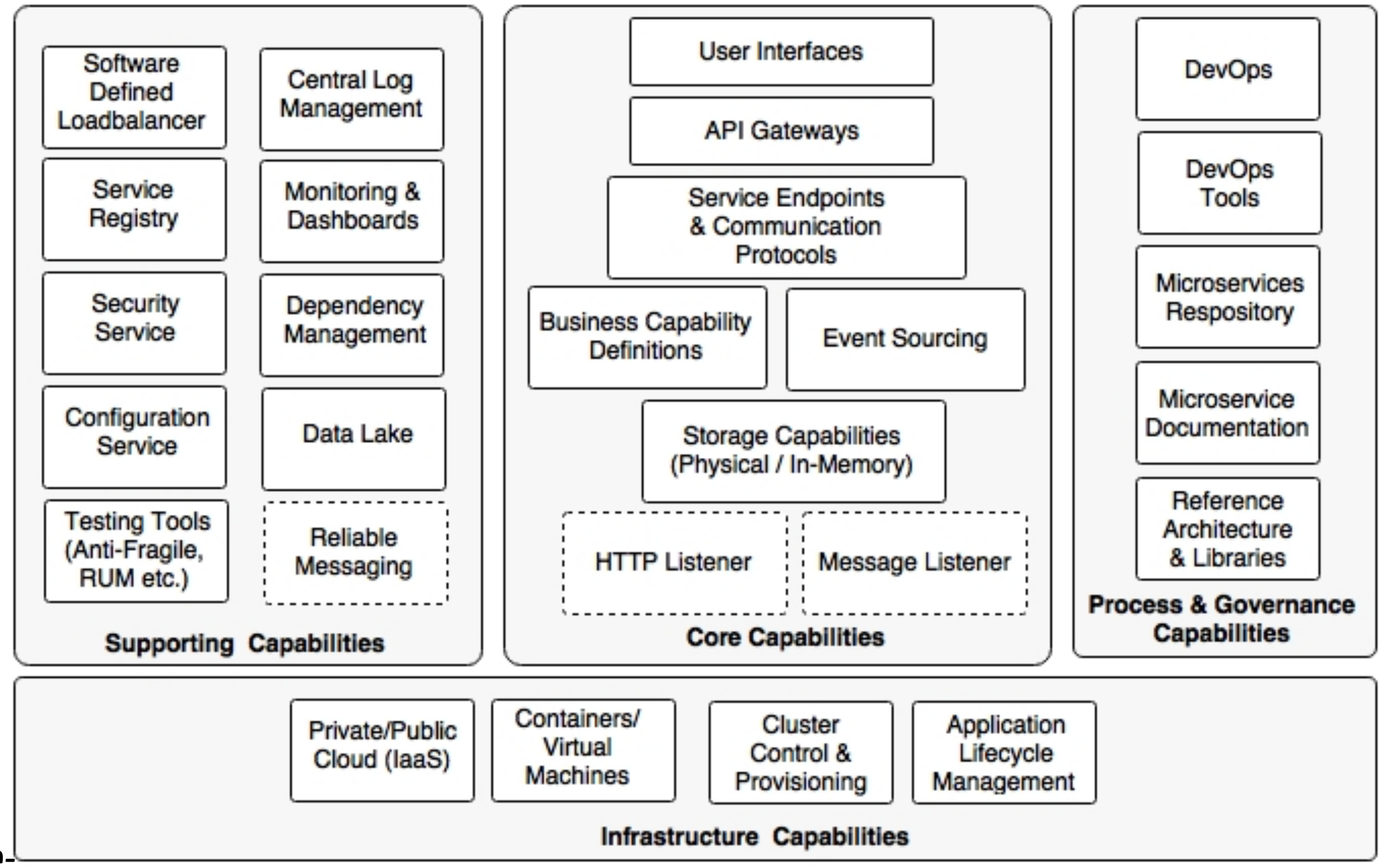
The microservices capability model

- The capability model is broadly classified in to four areas:
  - Core capabilities: These are part of the microservices themselves
  - Supporting capabilities: These are software solutions supporting core microservice implementations
  - Infrastructure capabilities: These are infrastructure level expectations for a successful microservices implementation
  - Governance capabilities: These are more of process, people, and reference information



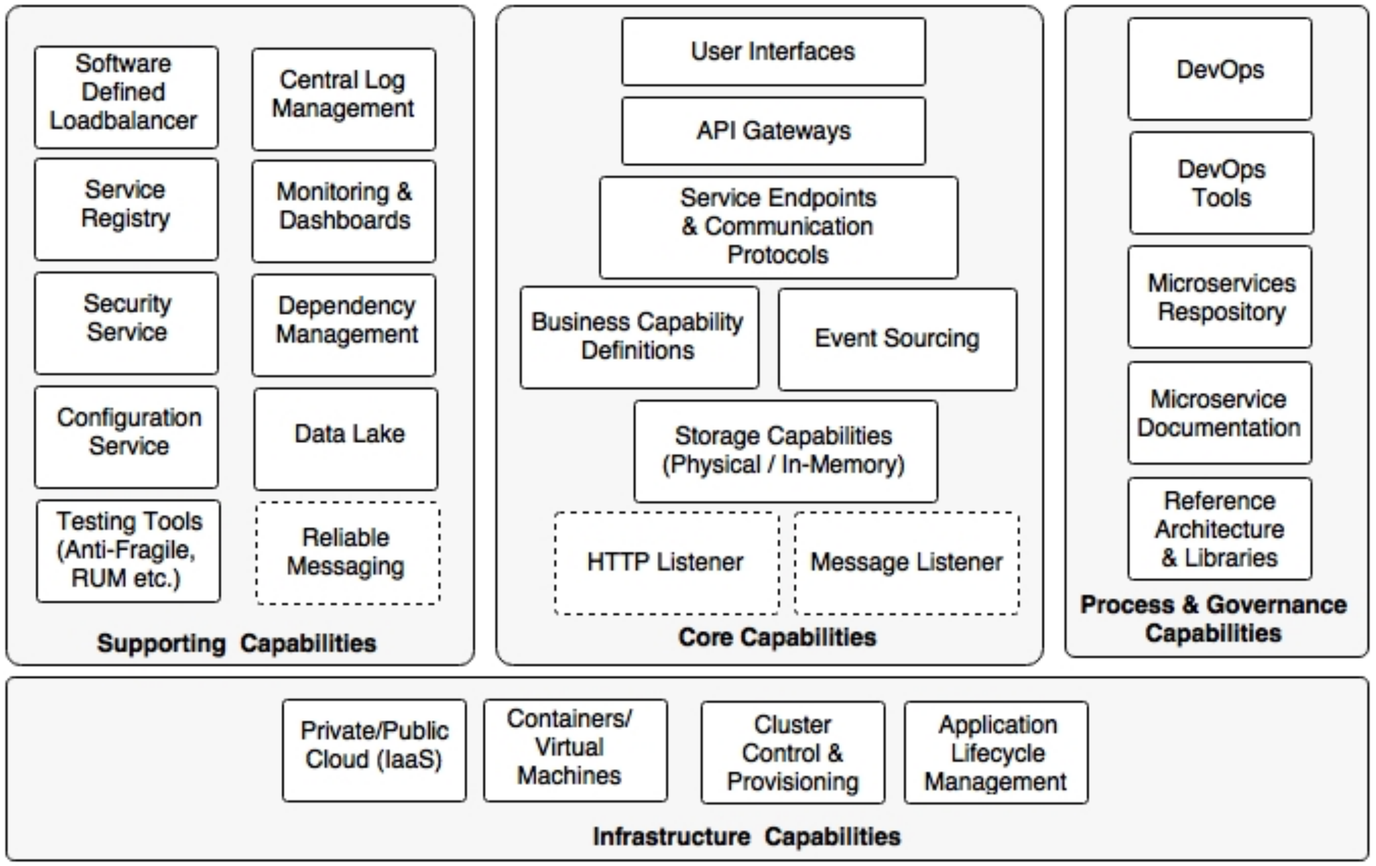
Core capabilities

- Service listeners (HTTP/messaging)
  - HTTP listener is embedded within the microservices, thereby eliminating the need to have any external application server requirement
- Storage capability
  - could be either a physical storage, or it could be an in-memory store
- Business capability definition
  - where the business logic is implemented
- Event sourcing
  - Microservices send out state changes
- Service endpoints and communication protocols
  - Define the APIs for external consumers to consume
- API gateway
  - useful for policy enforcements
- User interfaces
  - could be implemented in any technology, and are channel- and device-agnostic.



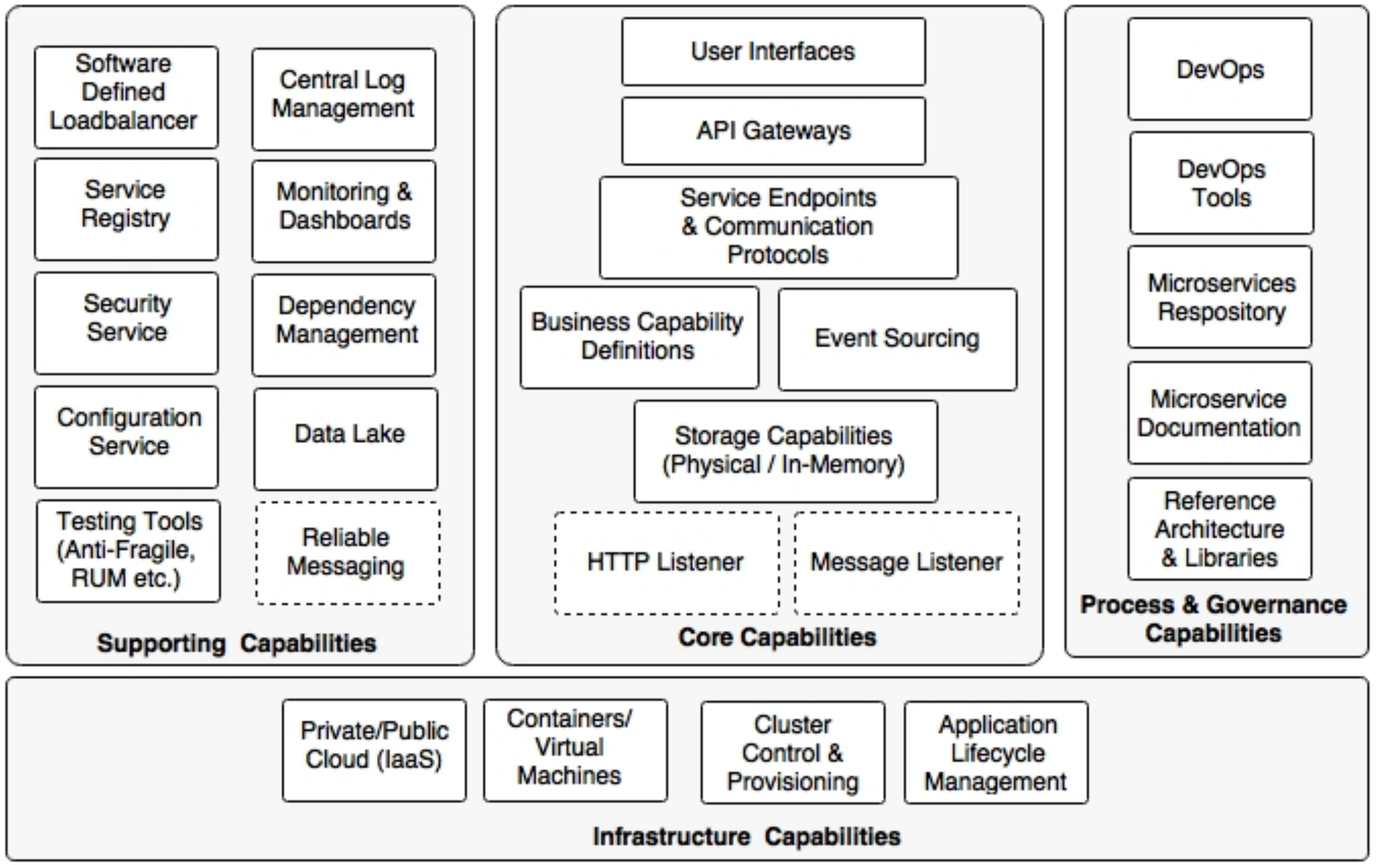
Infrastructure capabilities

- Cloud
  - traditional data center???
- Containers or virtual machines
  - Managing large physical machines is not cost effective
- Cluster control and provisioning
- Application lifecycle management



Supporting capabilities

- Software defined load balancer
- Central log management
- Service registry
- Security service
- Service configuration
- Testing tools (anti-fragile, RUM, and so on)
- Monitoring and dashboards
- Dependency and CI management
- Data lake
- Reliable messaging



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Process and governance capabilities

- DevOps
- DevOps tools
- Microservices repository
- Microservices documentation
- Reference Architecture & Libraries