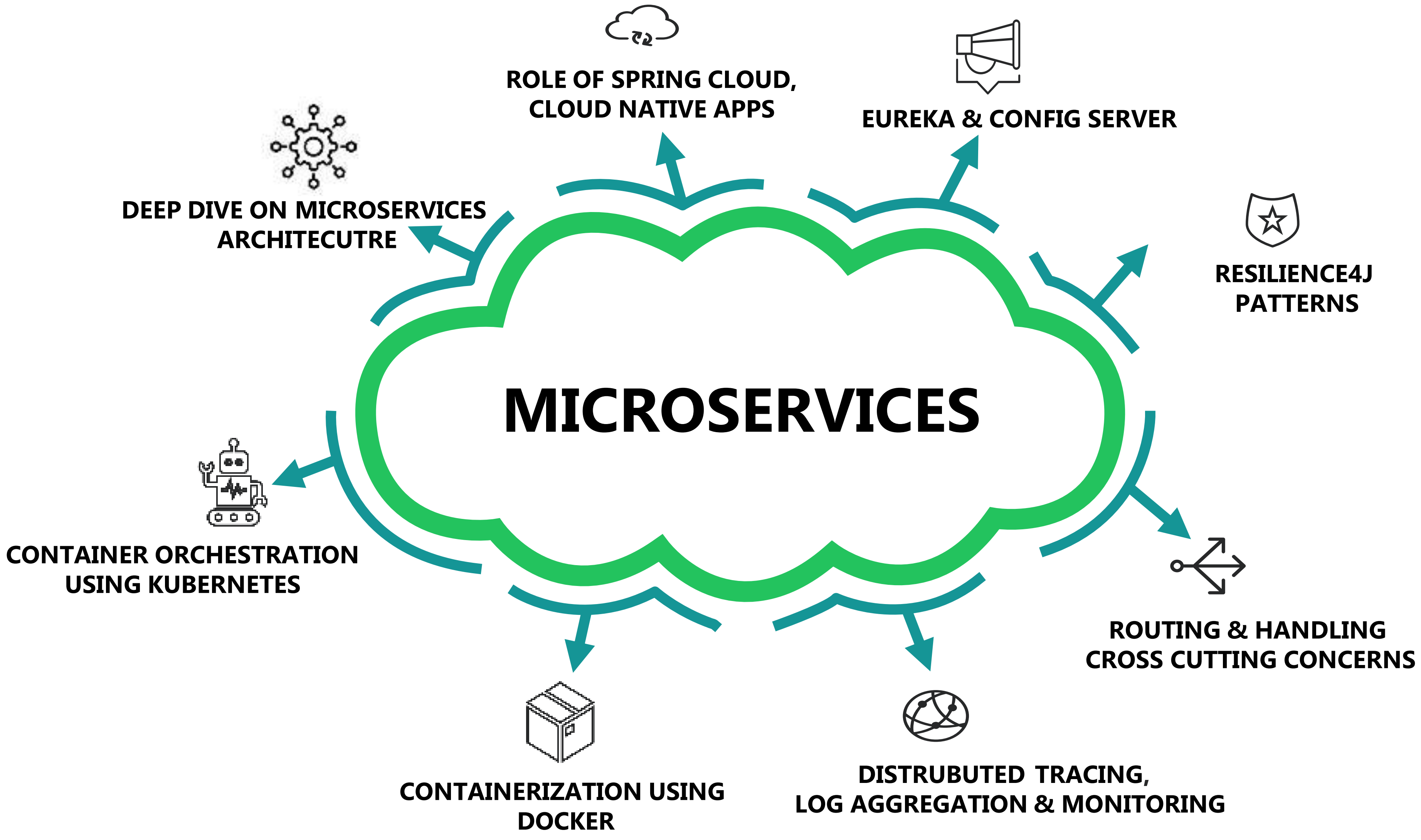
MICROSERVICES

USING SPRING, DOCKER, KUBERNETES

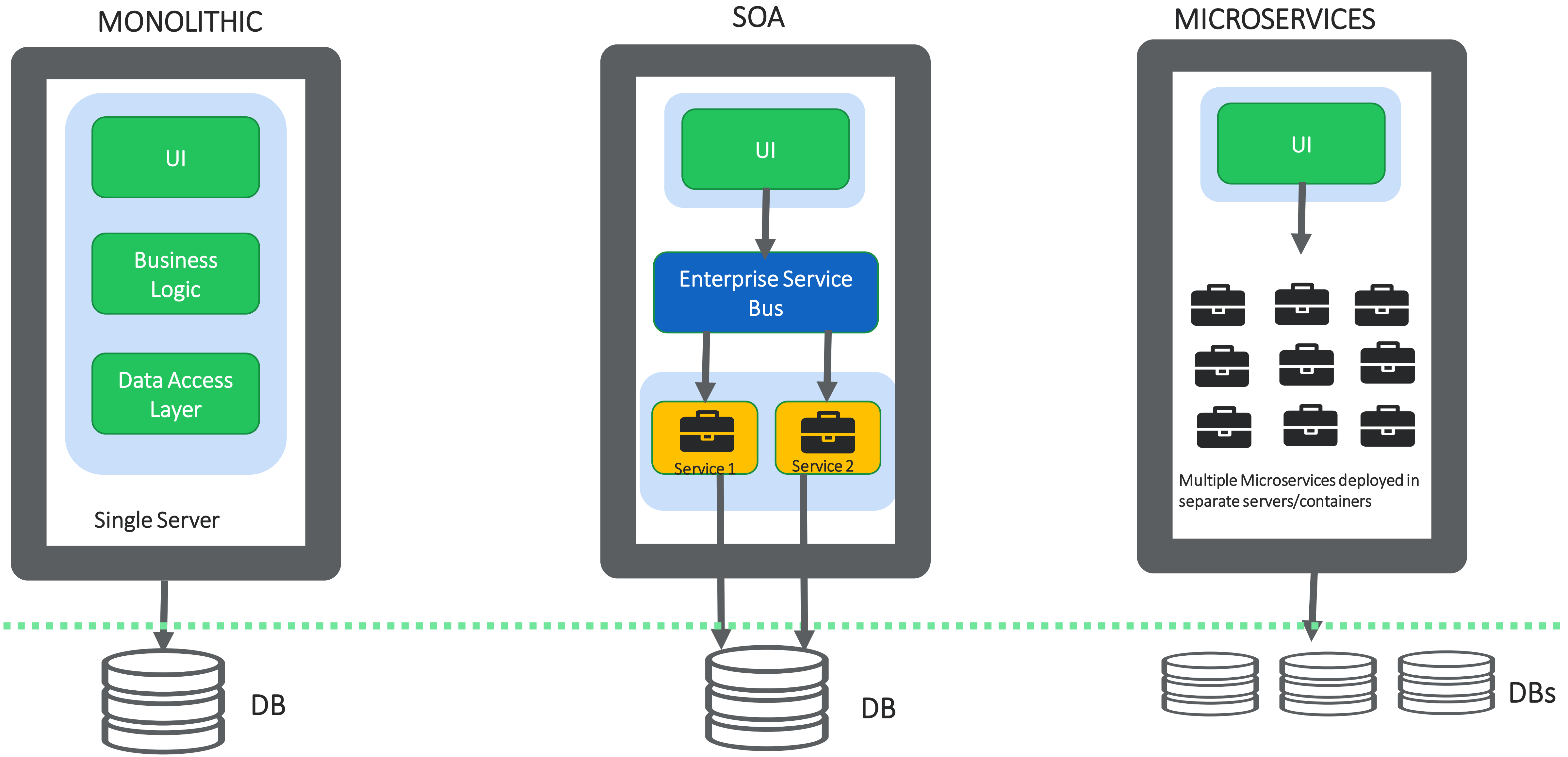
MICROSERVICES WITH SPRING, DOCKER, KUBERNETES

WHAT WE COVER IN THIS COURSE


MICROSERVICES
ROLE OF SPRING CLOUD, CLOUD NATIVE APPS
EUREKA & CONFIG SERVER
RESILIENCE4J PATTERNS
ROUTING & HANDLING CROSS CUTTING CONCERNS
DISTRUBUTED TRACING, LOG AGGREGATION & MONITORING
CONTAINERIZATION USING DOCKER
CONTAINER ORCHESTRATION USING KUBERNETES
DEEP DIVE ON MICROSERVICES ARCHITECUTRE

MONOLITHIC VS SOA VS MICROSERVICES

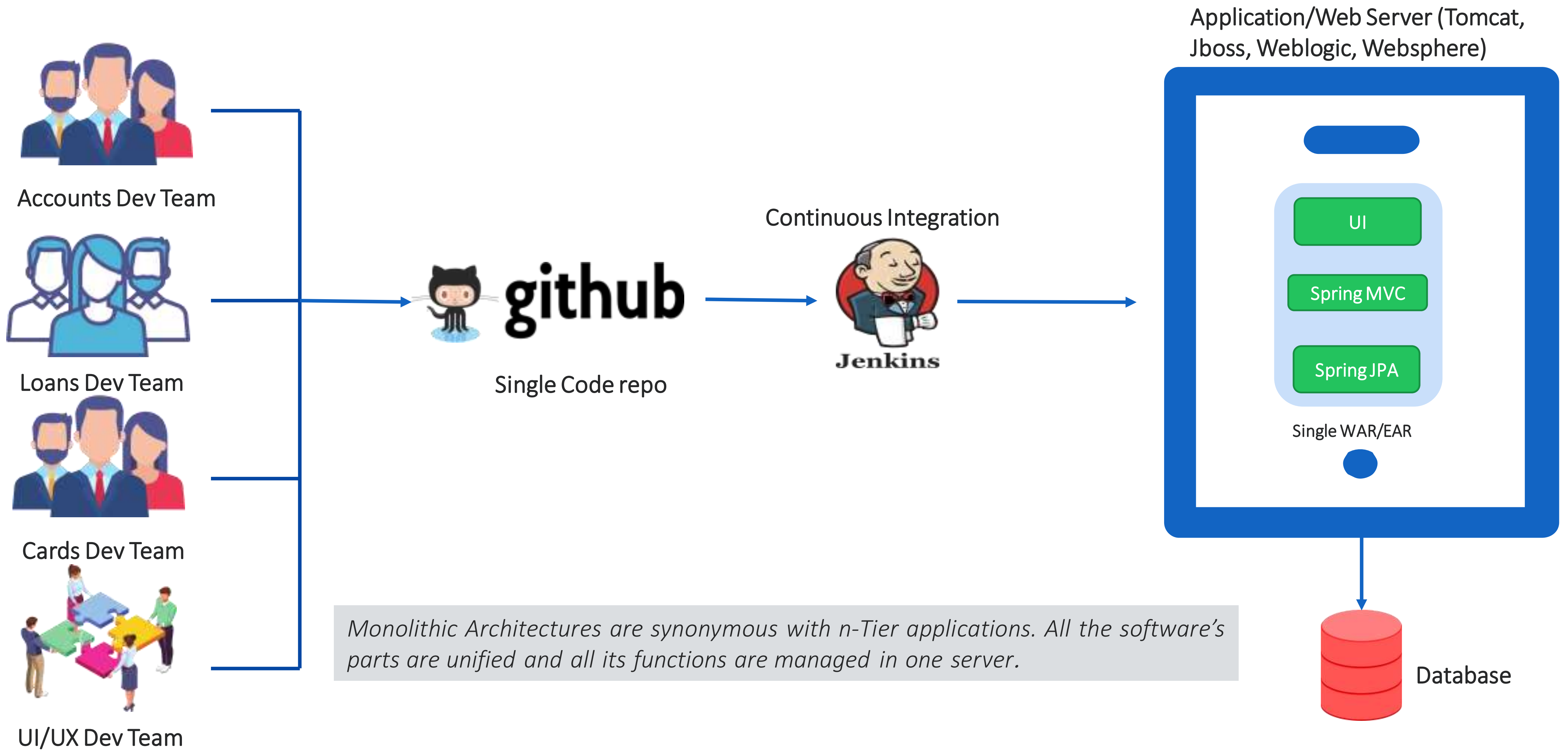
EVOLUTION OF MICROSERVICES



MONOLITHIC ARCHITECTURE

SAMPLE BANK APPLICATION

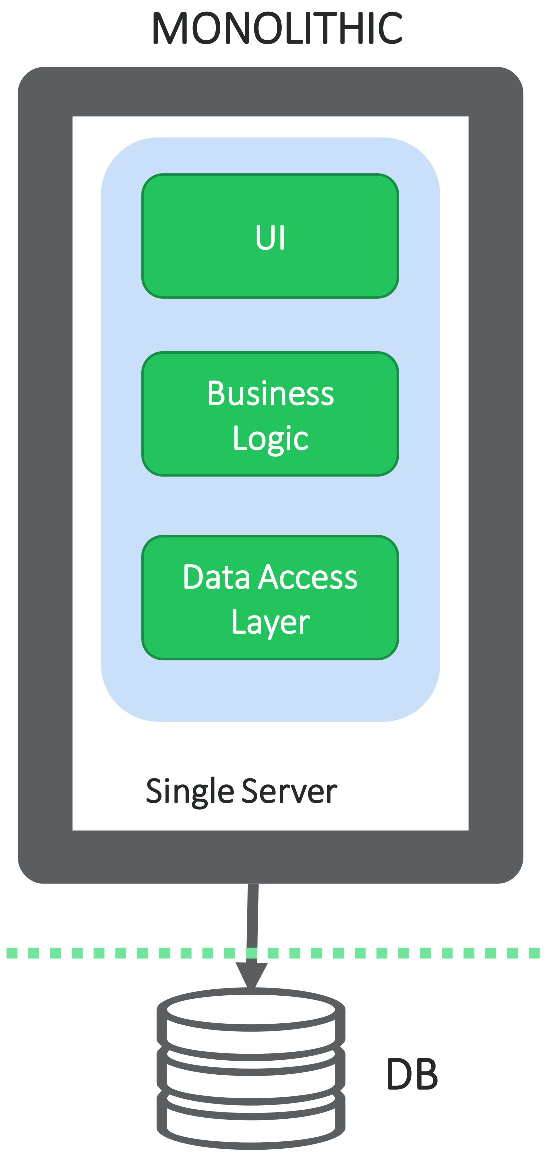
eazy bytes



Monolithic Architectures are synonymous with n-Tier applications. All the software's parts are unified and all its functions are managed in one server.

MONOLITHIC ARCHITECTURE

PROS & CONS



Pros

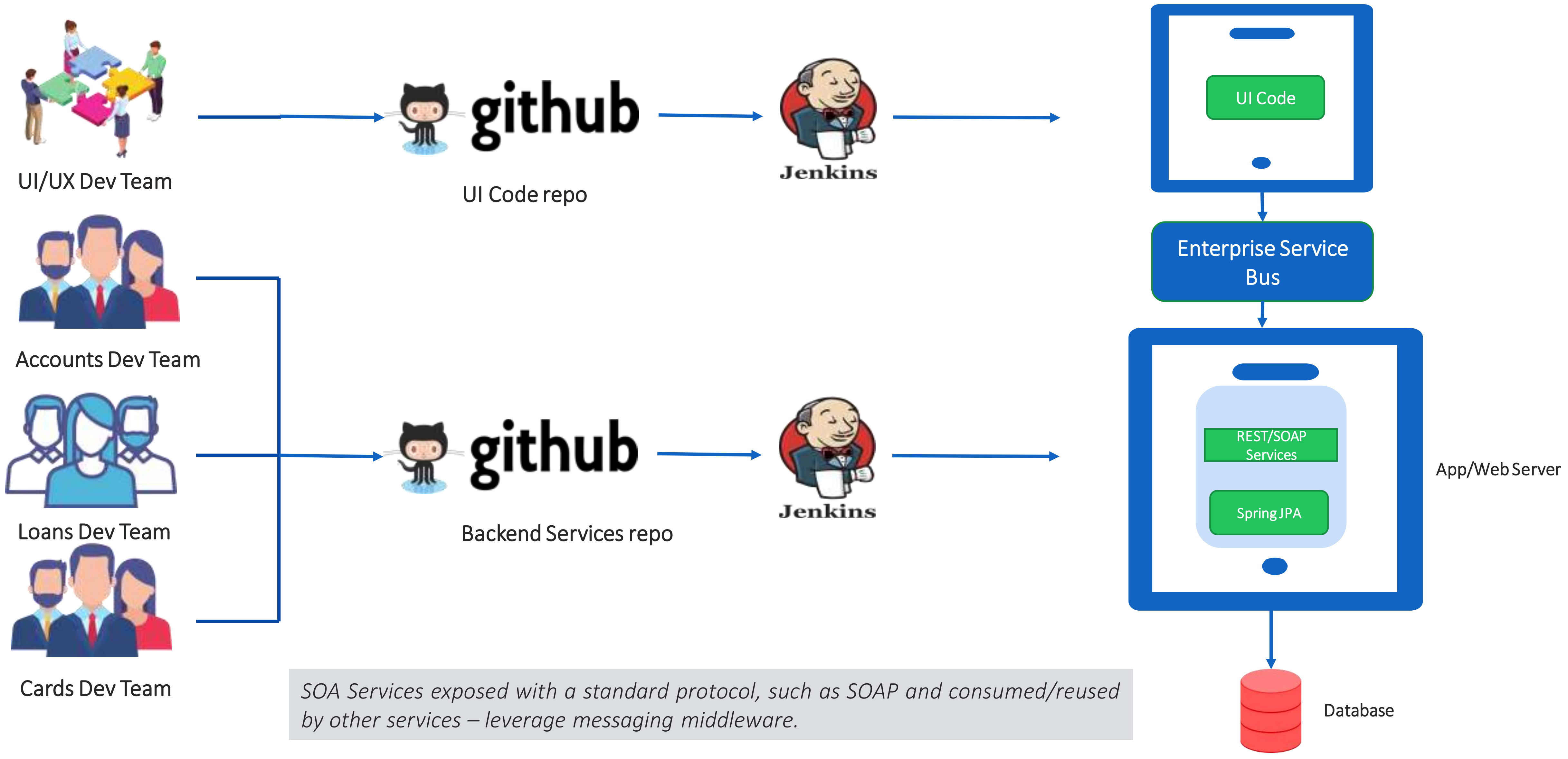
- Simpler development and deployment for smaller teams and applications
- Fewer cross-cutting concerns
- Better performance due to no network latency

Cons

- Difficult to adopt new technologies
- Limited agility
- Single code base and difficult to maintain
- Not Fault tolerance
- Tiny update and feature development always need a full deployment

SOA ARCHITECTURE

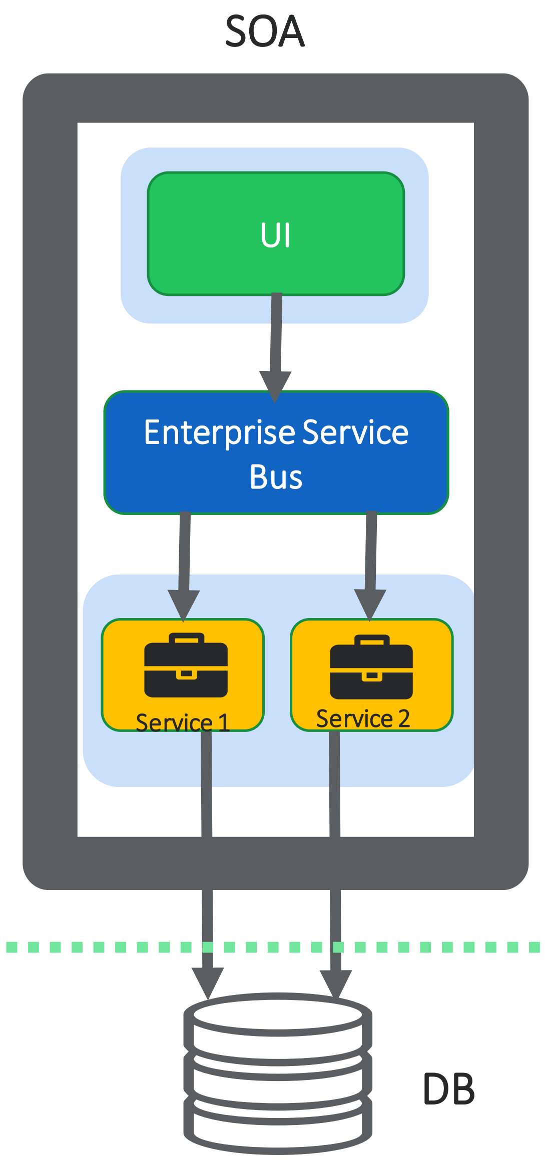
SAMPLE BANK APPLICATION



SOA Services exposed with a standard protocol, such as SOAP and consumed/reused by other services – leverage messaging middleware.

SOA ARCHITECTURE

PROS & CONS



<u>Pros</u>

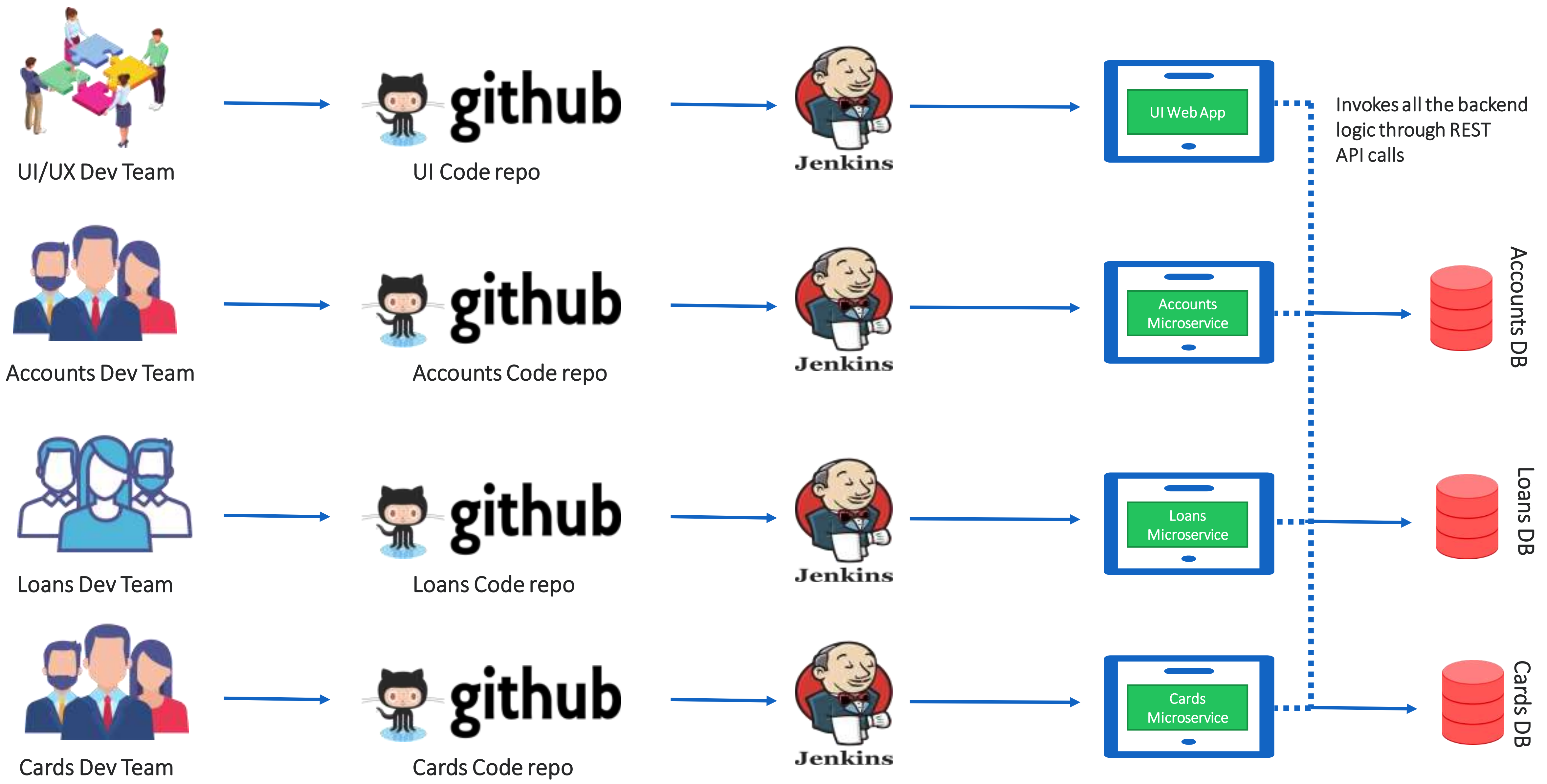
- Reusability of services
- Better maintainability
- Higher reliability
- Parallel development

<u>Cons</u>

- Complex management
- High investment costs
- Extra overload

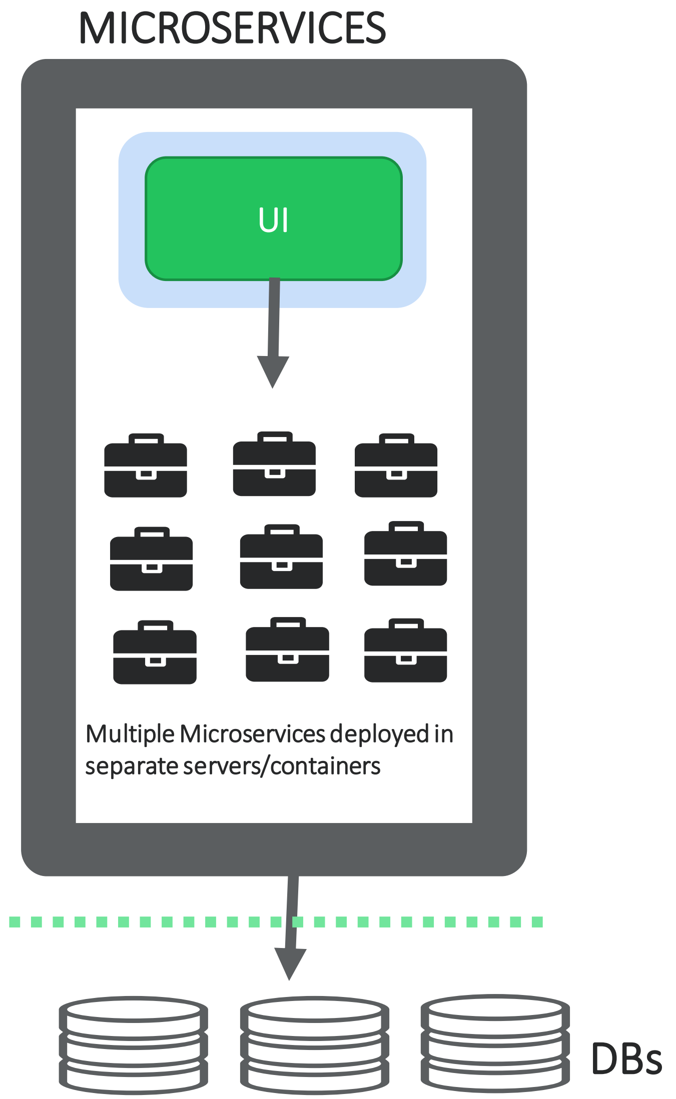
MICROSERVICES ARCHITECTURE

SAMPLE BANK APPLICATION



MICROSERVICES ARCHITECTURE

PROS & CONS


MICROSERVICES
UI
Multiple Microservices deployed in separate servers/containers
DBs

<u>Pros</u>

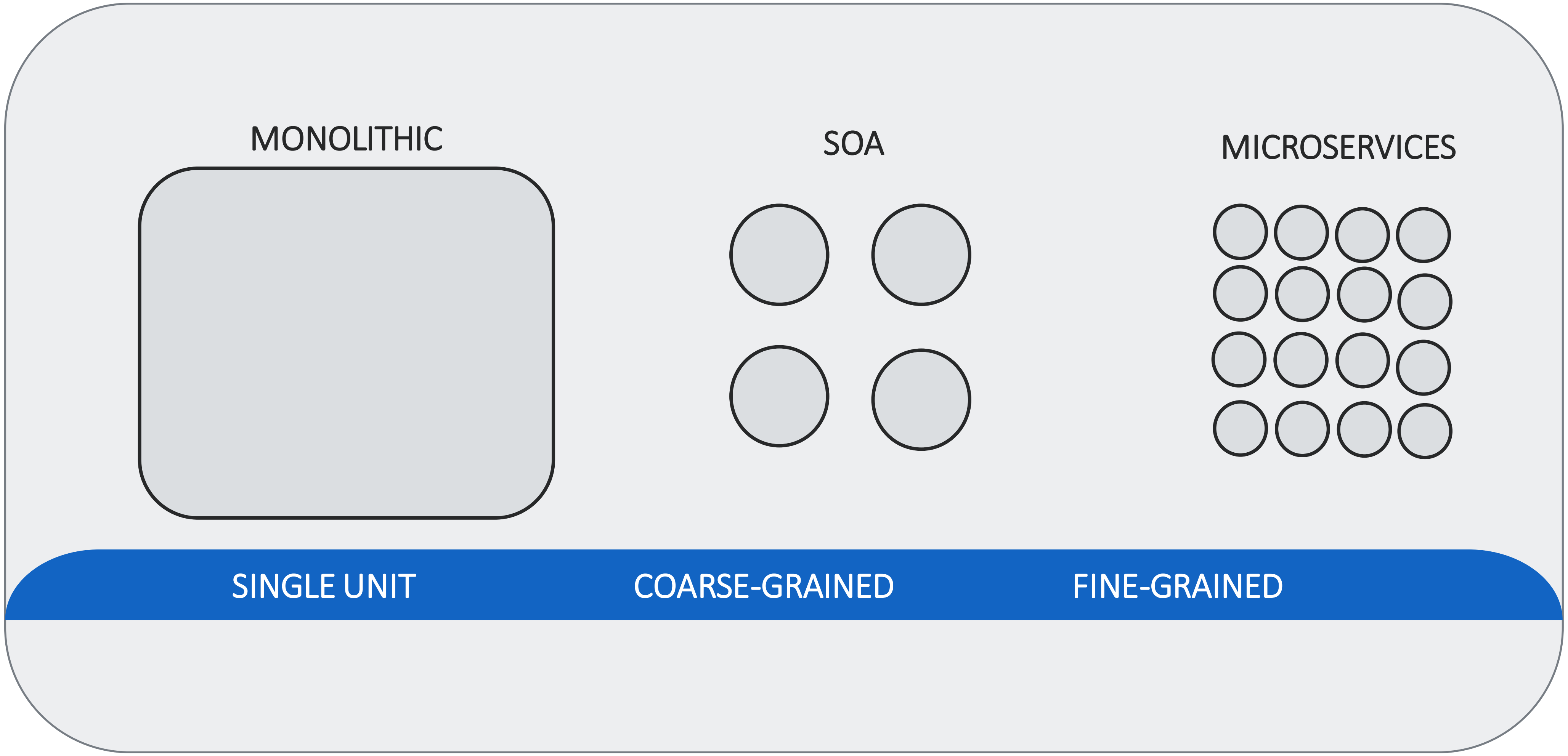
- Easy to develop, test, and deploy
- Increased agility
- Ability to scale horizontally
- Parallel development

<u>Cons</u>

- Complexity
- Infrastructure overhead
- Security concerns

MONOLITHIC VS SOA VS MICROSERVICES

COMPARISION



MONOLITHIC VS SOA VS MICROSERVICES

eazy bytes

COMPARISION

FEATURES	MONOLITHIC	SOA	MICROSERVICES
Parallel Development	😭	😕	😎
Agility	😭	😕	😎
Scalability	😭	😕	😎
Usability	😭	😕	😎
Complexity & Operational overhead	😎	😕	😭
Security Concerns & Performance	😎	😕	😭

WHAT ARE MICROSERVICES?

DEFINITION OF MICROSERVICES

"Microservices is an approach to developing a single application as a suite of small services, each running in its own process and communicating with lightweight mechanisms, built around business capabilities and independently deployable by fully automated deployment machinery."

- From Article by James Lewis and Martin Fowler's

WHY SPRING FOR MICROSERVICES?

WHY SPRING IS THE BEST FRAMEWORK TO BUILD MICROSERVICE

Spring is the most popular development framework for building java-based web applications & services. From the Day1, Spring is working on building our code based on principles like loose coupling by using dependency injection. Over the years, Spring framework is evolving by staying relevant in the market.

01

Building small services using SpringBoot is super easy & fast

02

Spring Cloud provides tools for dev to quickly build some of the common patterns in Microservices

03

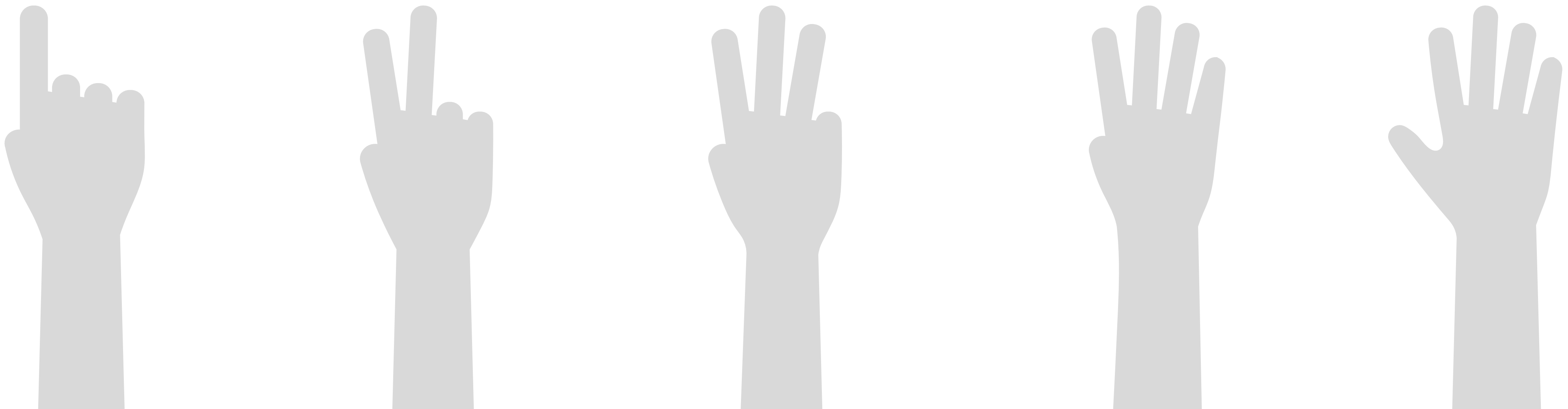
Provides production ready features like metrics, security, embedded servers

04

Spring Cloud makes deployment of microservices to cloud easy

05

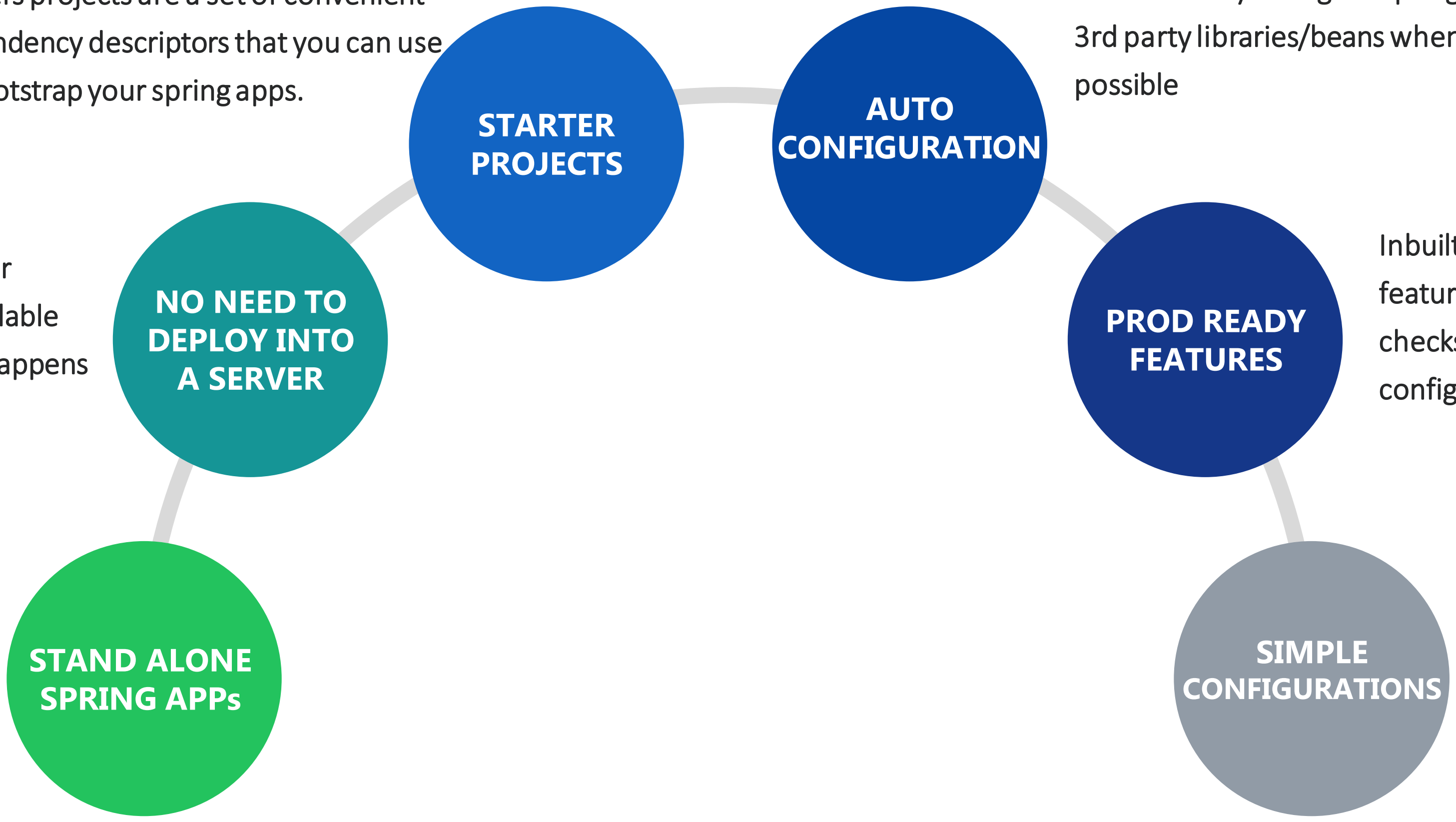
There is a large community of Spring developers who can help & adapt easily



WHAT IS SPRING BOOT?

USING SPRING BOOT FOR MICROSERVICES DEVELOPMENT

Spring Boot makes it easy to create stand-alone, production-grade Spring based Applications that you can "just run".



Creating Standalone Spring applications/REST services is super quick & easy

Embed Tomcat, Jetty or Undertow servers available and the deployment happens directly

Starters projects are a set of convenient dependency descriptors that you can use to bootstrap your spring apps.

Automatically configure Spring and 3rd party libraries/beans whenever possible

Inbuilt support of production-ready features such as metrics, health checks, and externalized configuration

Provides many annotations to do simple configurations and no requirement for XML configuration

WHAT IS SPRING CLOUD?

USING SPRING CLOUD FOR MICROSERVICES DEVELOPMENT

Spring Cloud provides tools for developers to quickly build some of the common patterns of Microservices

Makes sure that all calls to your microservices go through a single "front door" before the targeted service is invoked & the same will be traced.

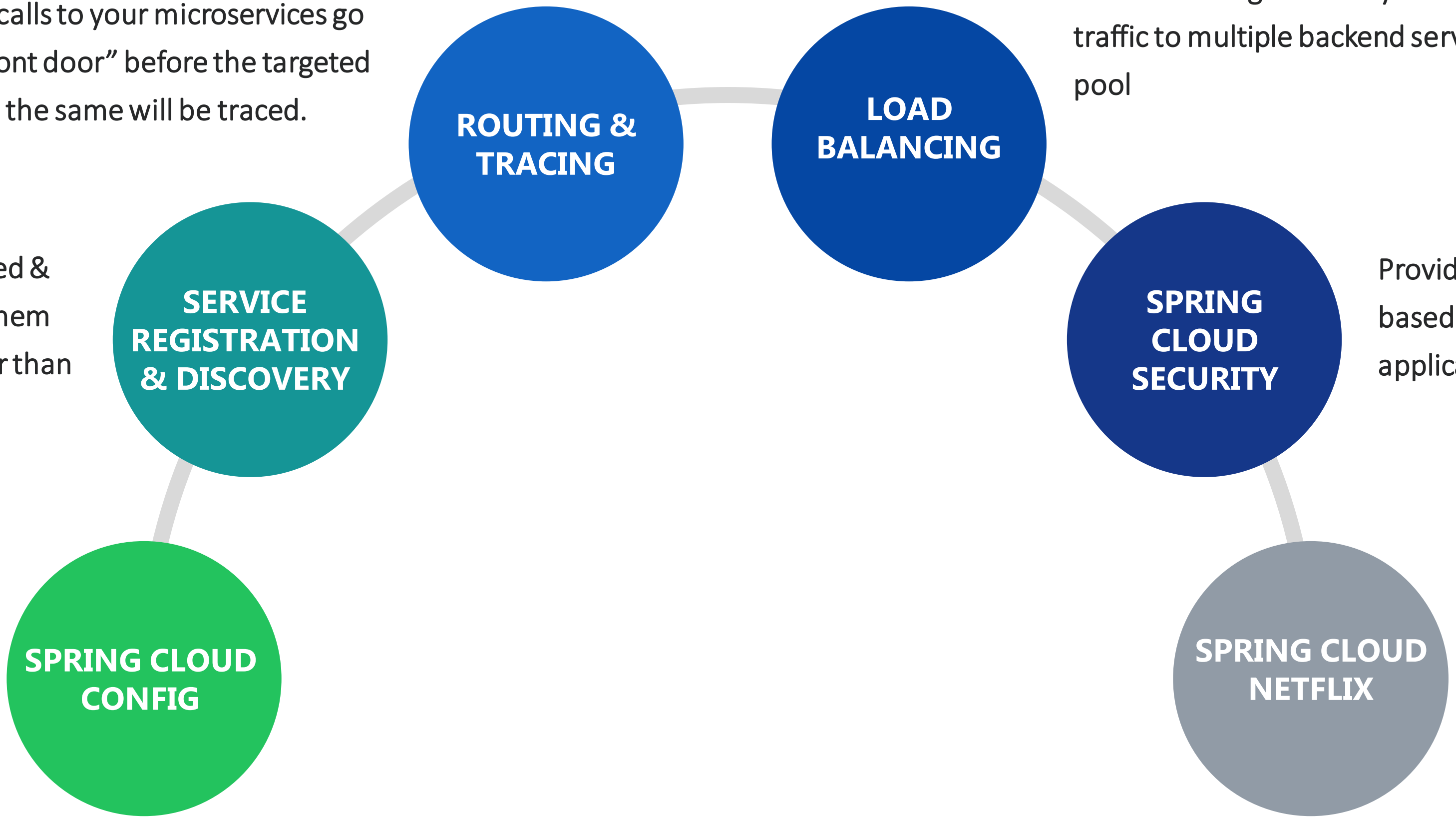
Load balancing efficiently distributes network traffic to multiple backend servers or server pool

New services will be registered & later consumers can invoke them through a logical name rather than physical location

Provides features related to token-based security in Spring Boot applications/Microservices

Ensures that no matter how many microservice instances you bring up; they'll always have the same configuration.

Incorporated battle-tested Netflix components include Service Discovery (Eureka), Circuit Breaker (Hystrix), Intelligent Routing (Zuul) and Client Side Load Balancing (Ribbon)..



CHALLENGE 1 WITH MICROSERVICES

RIGHT SIZING & IDENTIFYING SERVICE BOUNDARIES

- One of the most challenging aspects of building a successful microservices system is the identification of proper microservice boundaries and defining the size of each microservice

- Below are the most common followed approaches in the industry,

  ✓ Domain-Driven Sizing - Since many of our modifications or enhancements driven by the business needs, we can size/define boundaries of our microservices that are closely aligned with Domain-Driven design & Business capabilities. But this process takes lot of time and need good domain knowledge.

  ✓ Event Storming Sizing - Conducting an interactive fun session among various stake holder to identify the list of important events in the system like 'Completed Payment', 'Search for a Product' etc. Based on the events we can identify 'Commands', 'Reactions' and can try to group them to a domain-driven services.

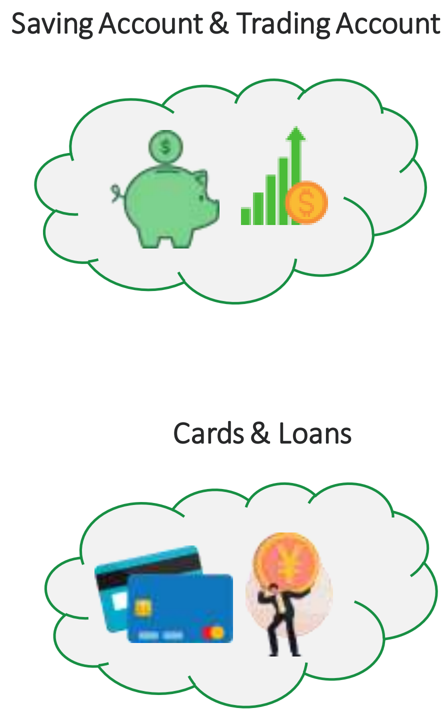
Reference for Event Storming Session : https://www.lucidchart.com/blog/ddd-event-storming

RIGHT SIZING MICROSERVICES

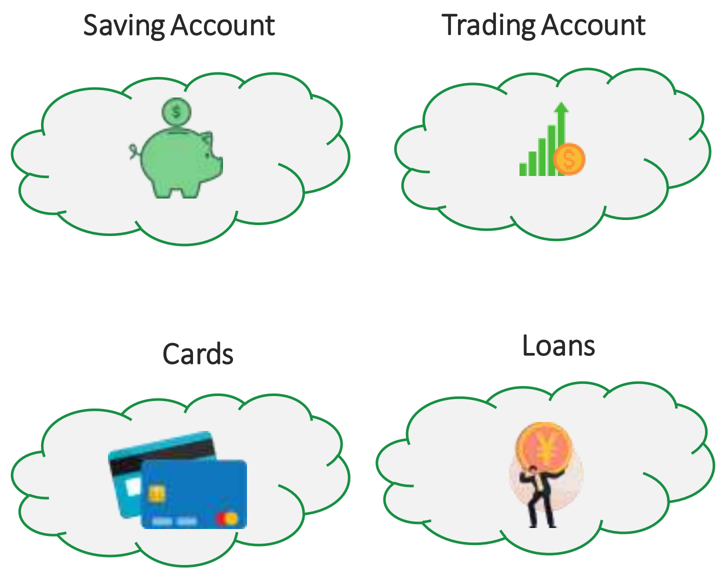
IDENTIFYING SERVICE BOUNDARIES

eazy bytes

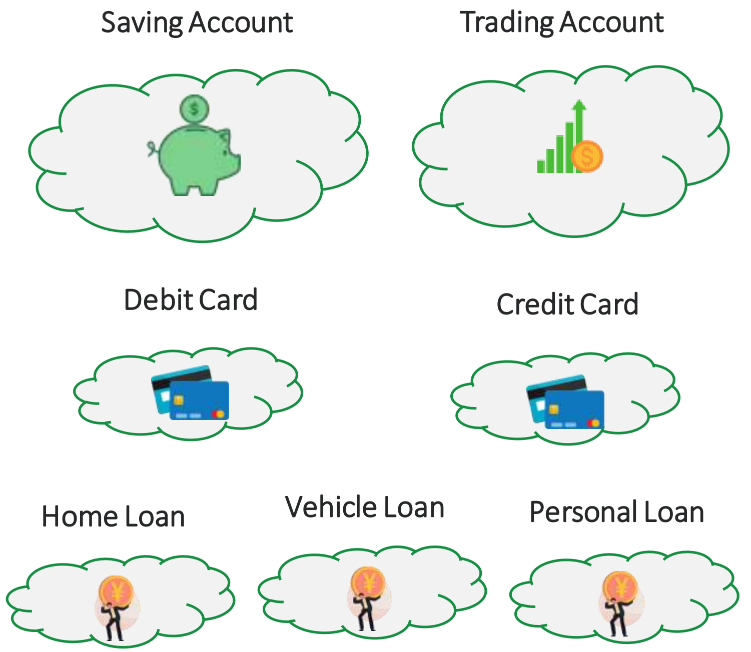
Now let’s take an example of a Bank application that needs to be migrated/build based on a microservices architecture and try to do sizing of the services.



NOT CORRECT SIZING AS WE CAN SEE INDEPENDENT MODULES LIKE CARDS & LOANS CLUBBED TOGETHER



THIS MIGHT BE THE MOST REASONABLE CORRECT SIZING AS WE CAN SEE ALL INDEPENDENT MODULES HAVE SEPARATE SERVICE MAINTAINING LOOSELY COUPLED & HIGHLY COHESIVE



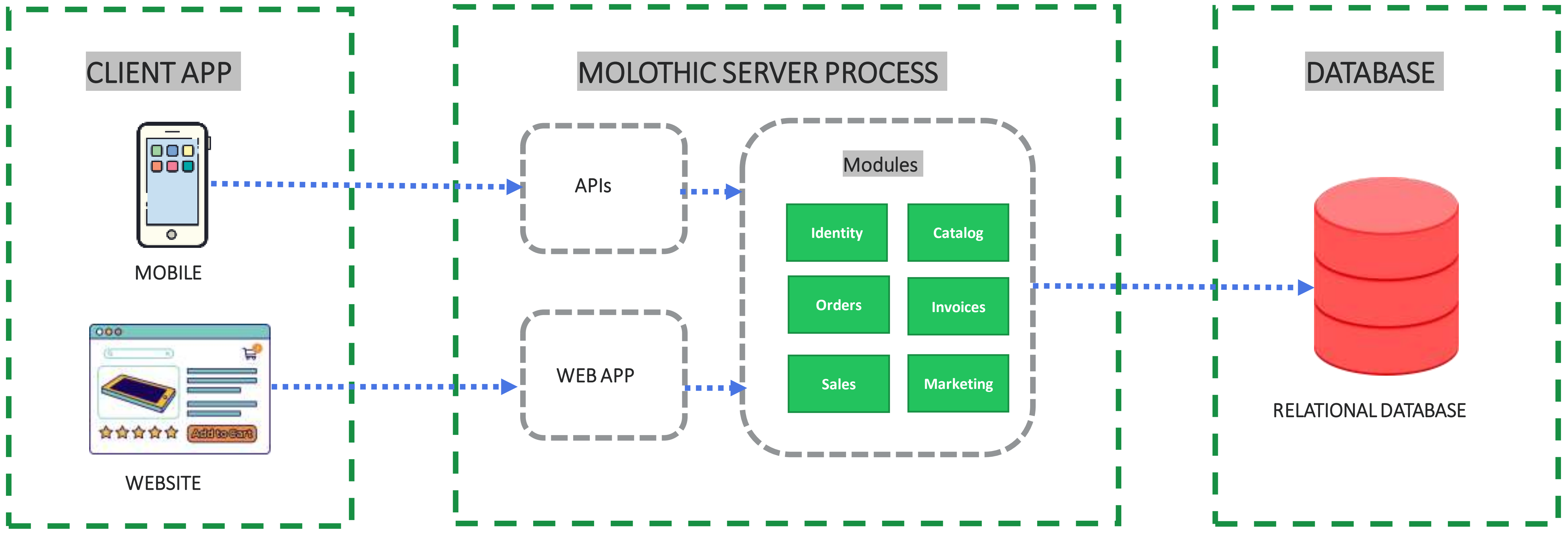
NOT CORRECT SIZING AS WE CAN SEE TOO MANY SERVICES UNDER LOANS & CARDS

MONOLOTHIC TO MICROSERVICES

MIGRATION USECASE

eazy bytes

Now let's take a scenario where an E-Commerce startup is following monolithic architecture and try to understand what's the challenges with it.



MONOLOTHIC TO MICROSERVICES

MIGRATION USECASE

eazy bytes

Problem that E-Commerce team is facing due to traditional monolithic design

Initial Days

- It is straightforward to build, test, deploy, troubleshoot and scale during the launch and when the team size is less

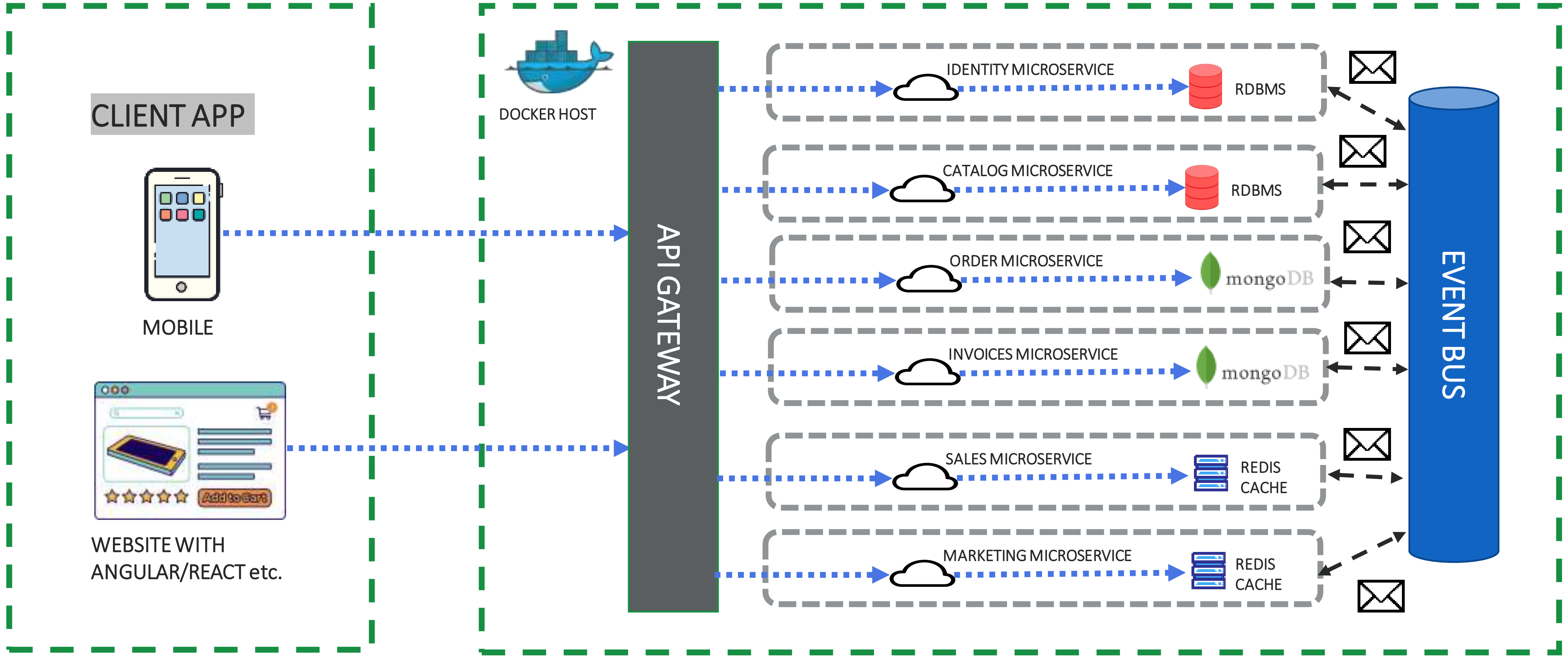
Later after few days the app/site is a super hit and started evolving a lot. Now team has below problems,

- The app has become so overwhelmingly complicated that no single person understands it.
- You fear making changes - each change has unintended and costly side effects.
- New features/fixes become tricky, time-consuming, and expensive to implement.
- Each release as small as possible and requires a full deployment of the entire application.
- One unstable component can crash the entire system.
- New technologies and frameworks aren't an option.
- It's difficult to maintain small isolated teams and implement agile delivery methodologies.

MONOLOTHIC TO MICROSERVICES

MIGRATION USECASE

So the Ecommerce company decided and adopted the below cloud-native design by leveraging Microservices architecture to make their life easy and less risk with the continuous changes.



CHALLENGE 2 WITH MICROSERVICES

DEPLOYMENT, PORTABILITY & SCALABILITY

DEPLOYMENT

How do we deploy all the tiny 100s of microservices with less effort & cost?

PORTABILITY

How do we move our 100s of microservices across environments with less effort, configurations & cost?

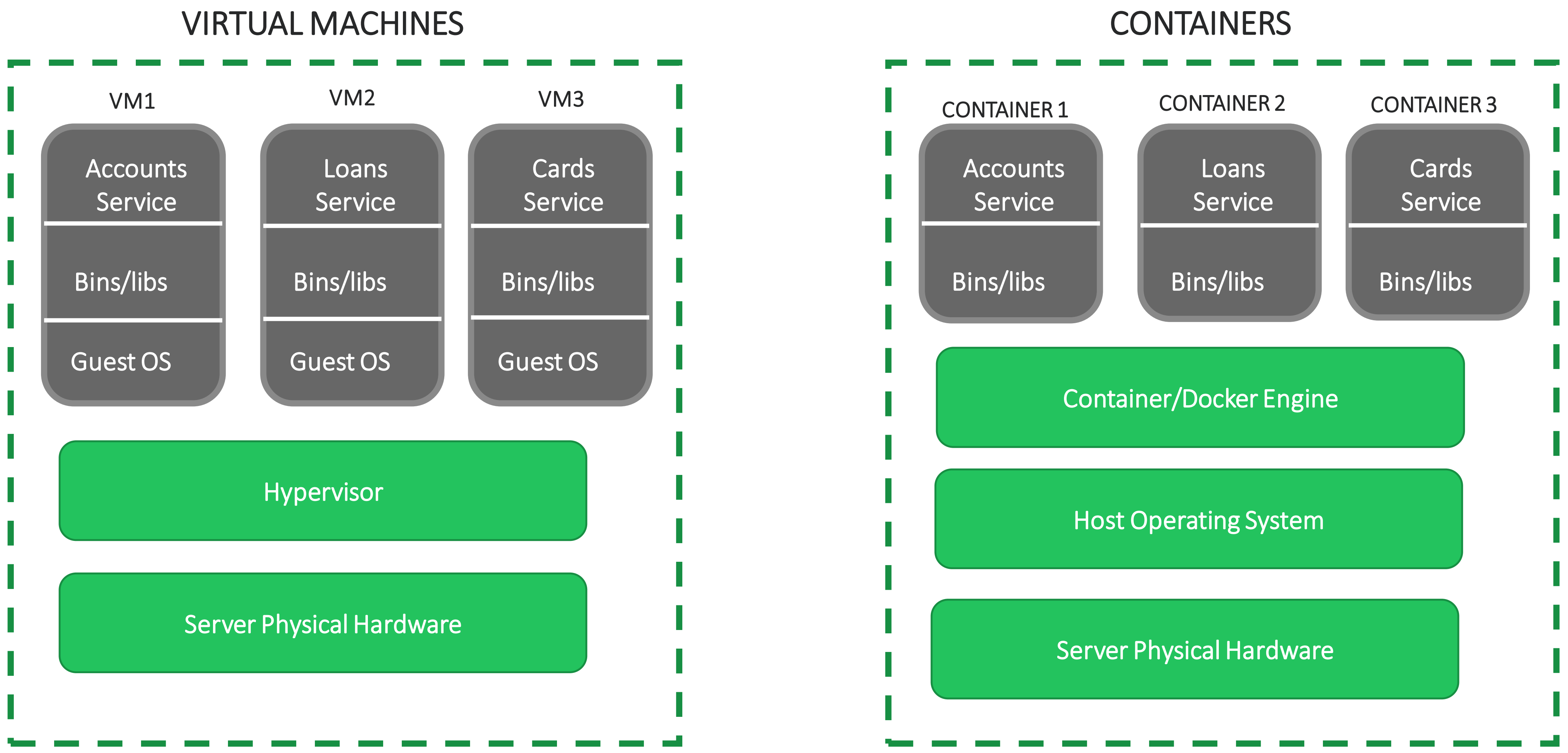
SCALABILITY

How do we scale our applications based on the demand on the fly with minimum effort & cost?

CONTAINERIZATION TECHNOLOGY

USING DOCKER

eazy bytes



Main differences between virtual machines and containers. Containers don't need the Guest Os nor the hypervisor to assign resources; instead, they use the container engine.

INTRO TO DOCKER

WHAT ARE CONTAINERS & DOCKER?

What is a container ?

A container is a loosely isolated environment that allows us to build and run software packages. These software packages include the code and all dependencies to run applications quickly and reliably on any computing environment. We call these packages container images.

What is software containerization?

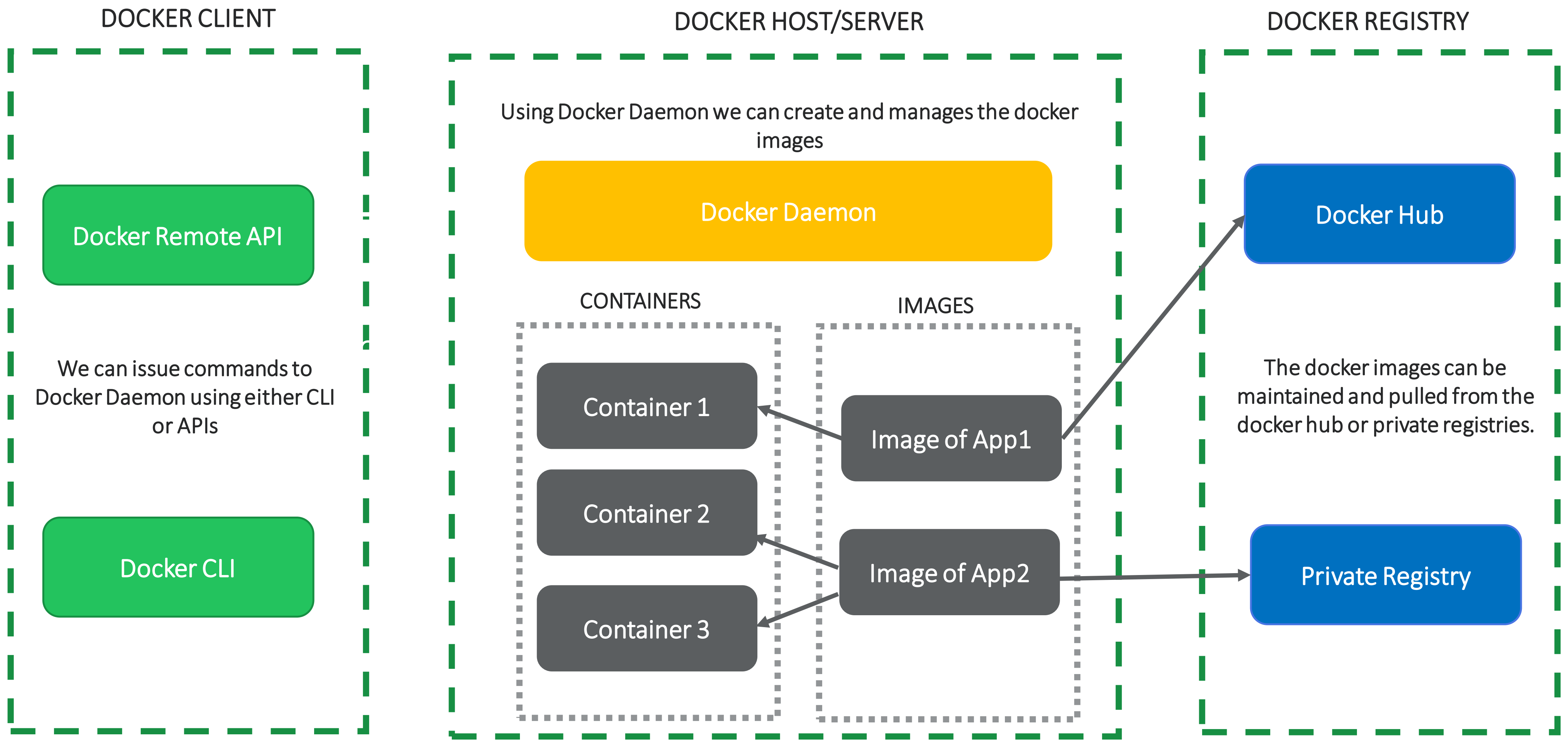
Software containerization is an OS virtualization method that is used to deploy and run containers without using a virtual machine (VM). Containers can run on physical hardware, in the cloud, VMs, and across multiple OSs.

What is Docker?

Docker is one of the tools that used the idea of the isolated resources to create a set of tools that allows applications to be packaged with all the dependencies installed and ran wherever wanted.

INTRO TO DOCKER

DOCKER ARCHITECTURE


DOCKER CLIENT
Docker Remote API
We can issue commands to Docker Daemon using either CLI or APIs
Docker CLI
DOCKER HOST/SERVER
Using Docker Daemon we can create and manages the docker images
Docker Daemon
CONTAINERS
Container 1
Container 2
Container 3
IMAGES
Image of App1
Image of App2
DOCKER REGISTRY
Docker Hub
The docker images can be maintained and pulled from the docker hub or private registries.
Private Registry

CLOUD-NATIVE APPLICATIONS

INTRODUCTION

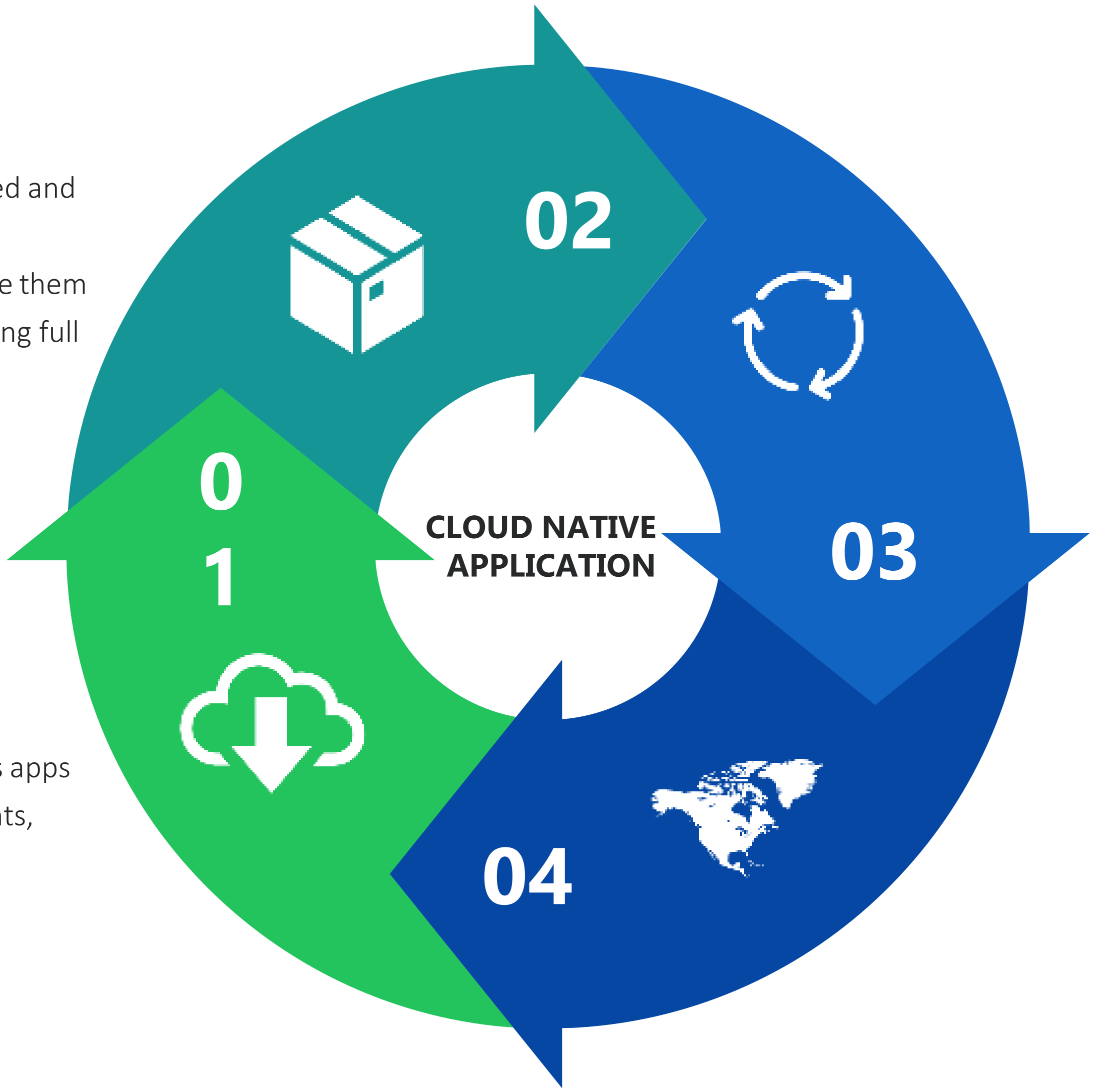
- Cloud-native applications are a collection of small, independent, and loosely coupled services. They are designed to deliver well-recognized business value, like the ability to rapidly incorporate user feedback for continuous improvement. Its goal is to deliver apps users want at the pace a business needs.

- If an app is "cloud-native," it’s specifically designed to provide a consistent development and automated management experience across private, public, and hybrid clouds. So it’s about how applications are created and deployed, not where.

- When creating cloud-native applications, the developers divide the functions into microservices, with scalable components such as containers in order to be able to run on several servers. These services are managed by virtual infrastructures through DevOps processes with continuous delivery workflows. It's important to understand that these types of applications do not require any change or conversion to work in the cloud and are designed to deal with the unavailability of downstream components.

CLOUD-NATIVE APPLICATIONS

PRINCIPLES OF CLOUD-NATIVE APPLICATIONS



CONTAINERS

Containers allow apps to be packaged and isolated with their entire runtime environment, making it easy to move them between environments while retaining full functionality.

DEVOPS

DevOps is an approach to culture, automation, and platform design intended to deliver increased business value and responsiveness.

MICROSERVICE

A microservices architecture breaks apps down into their smallest components, independent from each other.

CONTINOUS DELIVERY

It's a software development practice in which the process of delivering software is automated to allow short-term deliveries into a production environment.

To build and develop cloud native applications (microservices), we need to follow the best practises mentioned in the twelve factor app methodology (https://12factor.net/)

eazy bytes

CLOUD-NATIVE APPLICATIONS

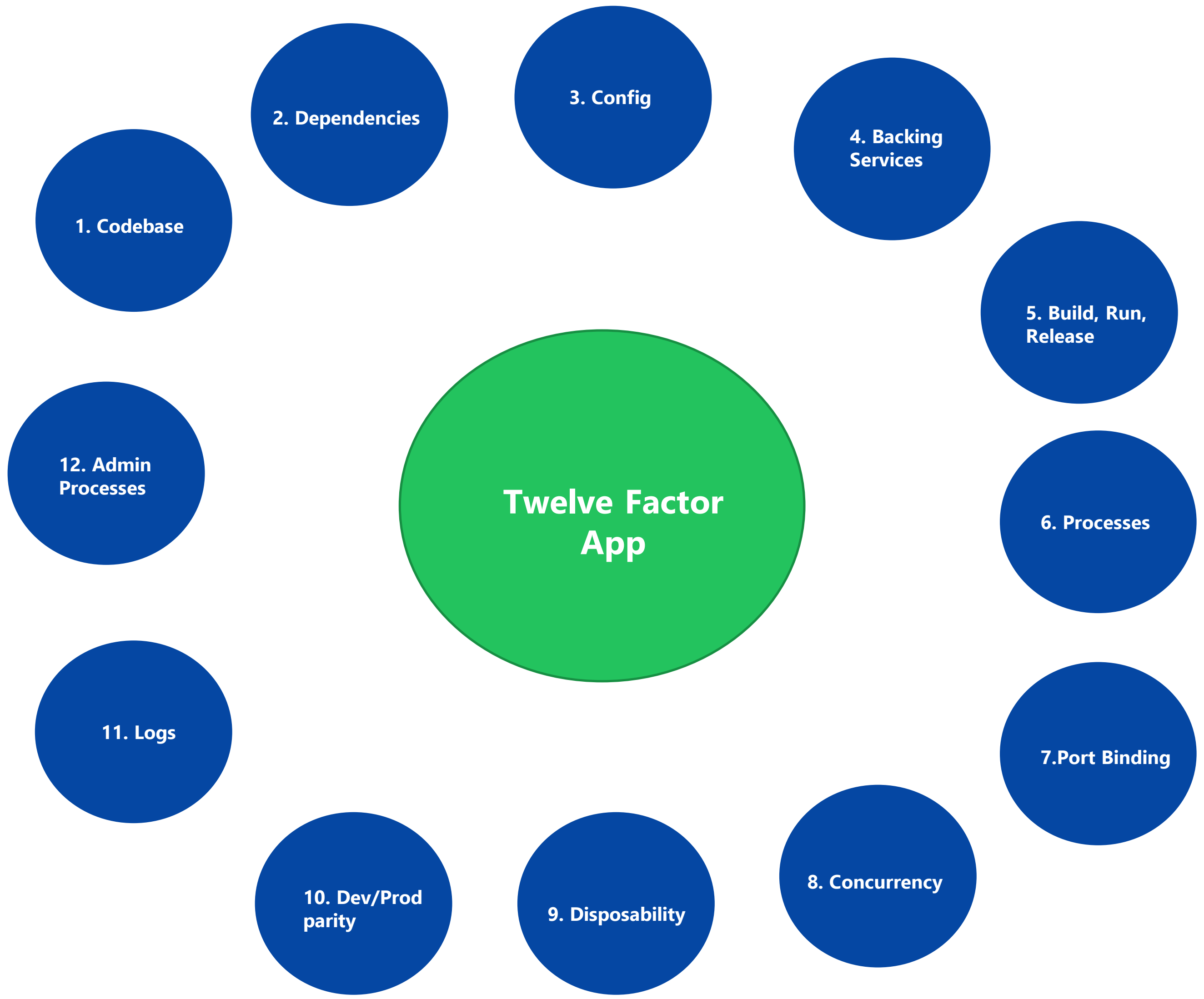
DIFFERENCE B/W CLOUD-NATIVE & TRADITIONAL APPS

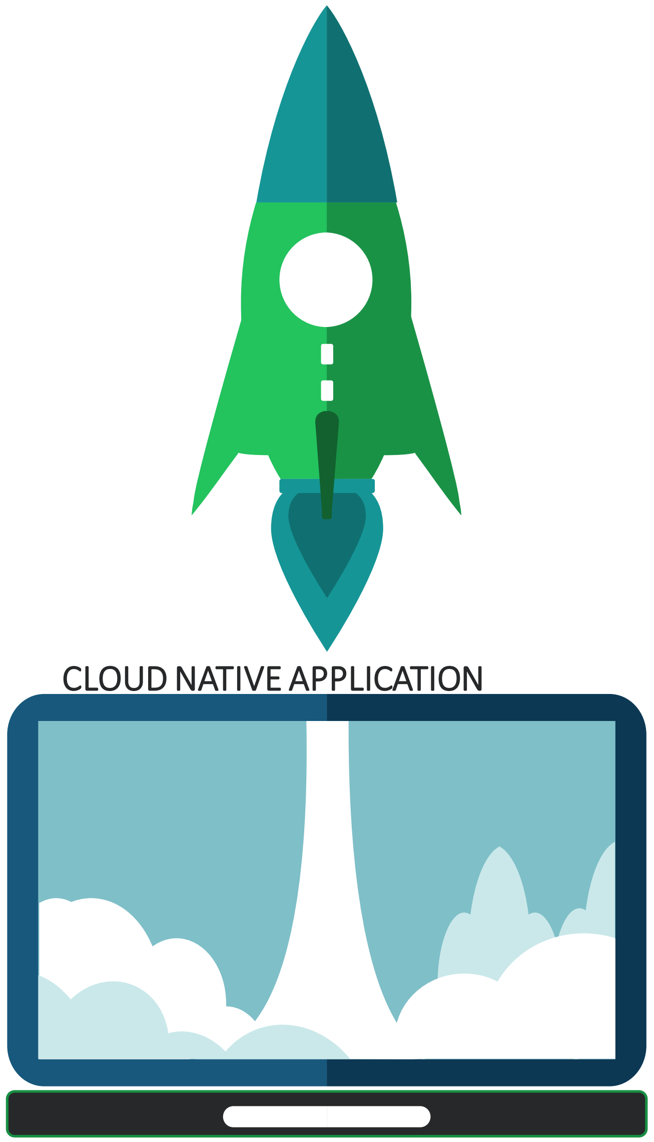
CLOUD NATIVE APPLICATIONS	TRADITIONAL ENTERPRISE APPLICATIONS
Predictable Behavior	Unpredictable Behavior
OS abstraction	OS dependent
Right-sized capacity & Independent	Oversized capacity & Dependent
Continuous delivery	Waterfall development
Rapid recovery & Automated scalability	Slow recovery

TWELVE FACTOR APP

BEST PRACTICES

eazy bytes

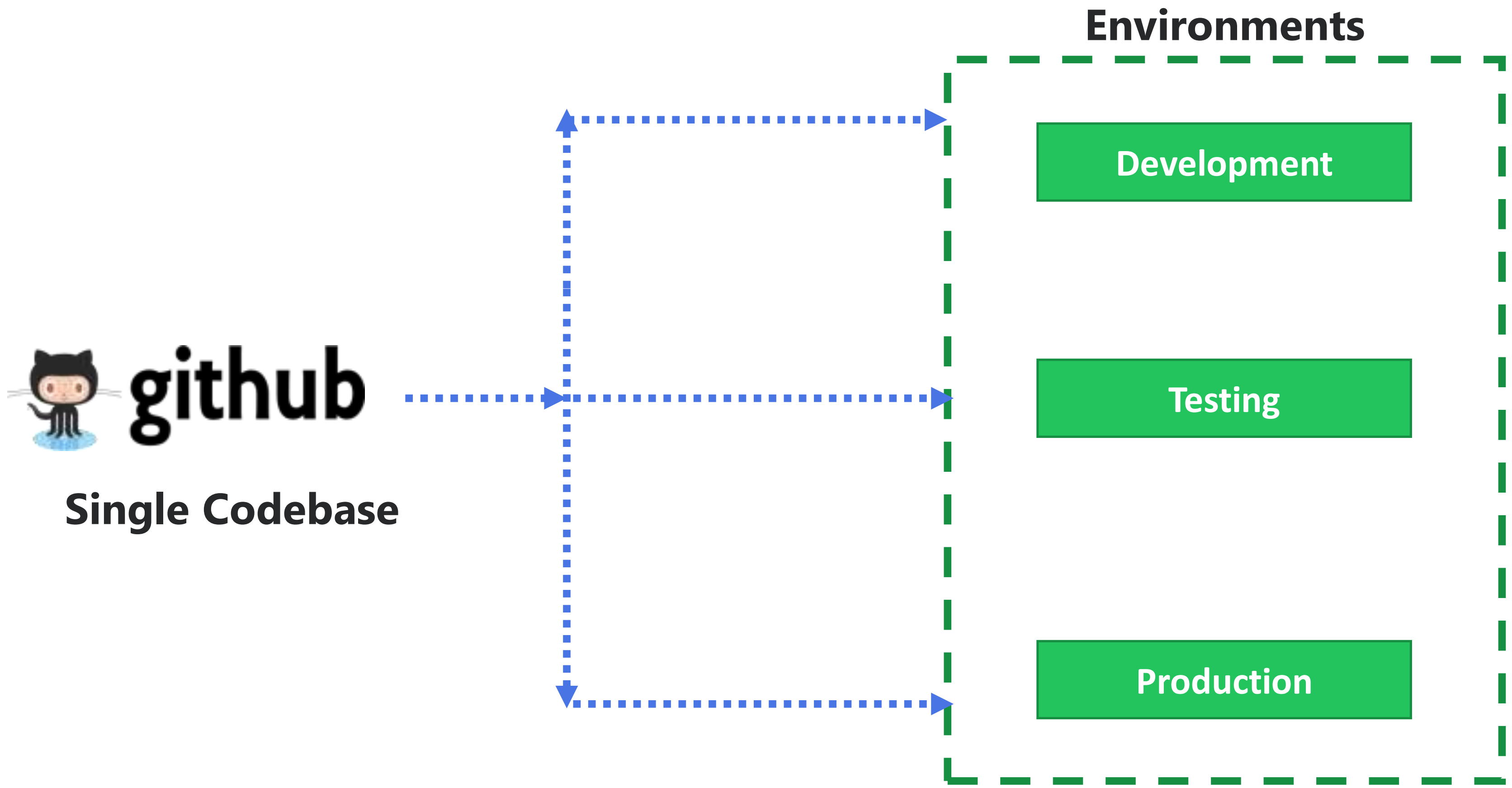




TWELVE FACTOR APP

1. CODEBASE

- Each microservice should have a single codebase, managed in source control. The code base can have multiple instances of deployment environments such as development, testing, staging, production, and more but is not shared with any other microservice.

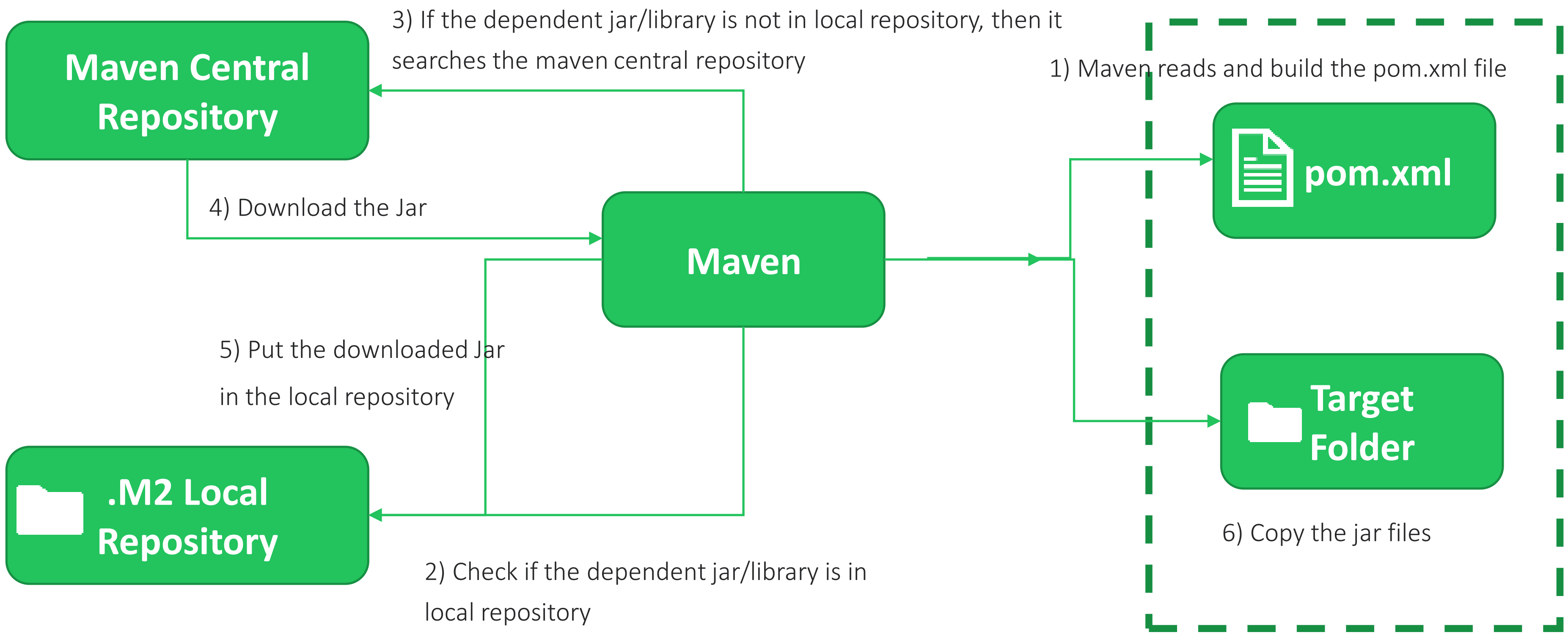


TWELVE FACTOR APP

2. DEPENDENCIES

- Explicitly declare the dependencies your application uses through build tools such as Maven, Gradle (Java). Third-party JAR dependence should be declared using their specific versions number. This allows your microservice to always be built using the same version of libraries.

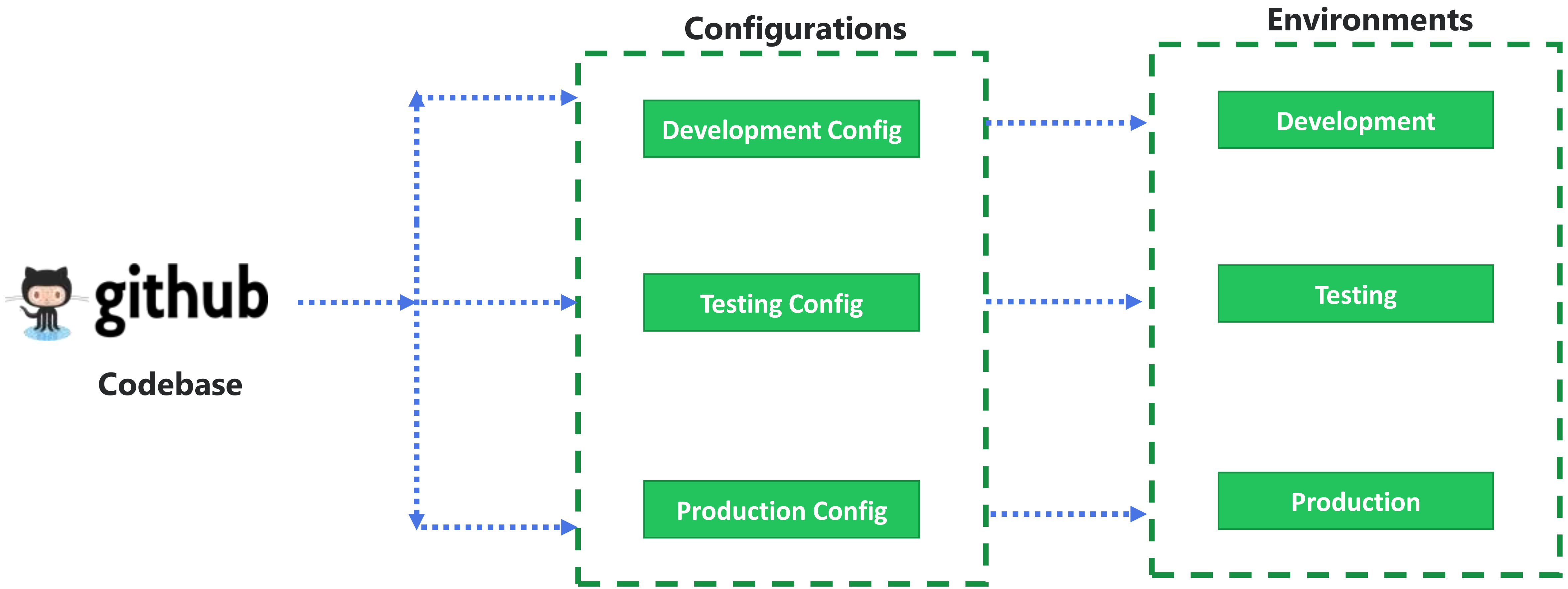
- A twelve-factor app never relies on implicit existence of system-wide packages.


3) If the dependent jar/library is not in local repository, then it searches the maven central repository
Maven Central Repository
1) Maven reads and build the pom.xml file
pom.xml
4) Download the Jar
Maven
5) Put the downloaded Jar in the local repository
Target Folder
.M2 Local Repository
6) Copy the jar files
2) Check if the dependent jar/library is in local repository

TWELVE FACTOR APP

3. CONFIG

- Store environment-specific configuration independently from your code. Never add embedded configurations to your source code; instead, maintain your configuration completely separated from your deployable microservice. If we keep the configuration packaged within the microservice, we'll need to redeploy each of the hundred instances to make the change.

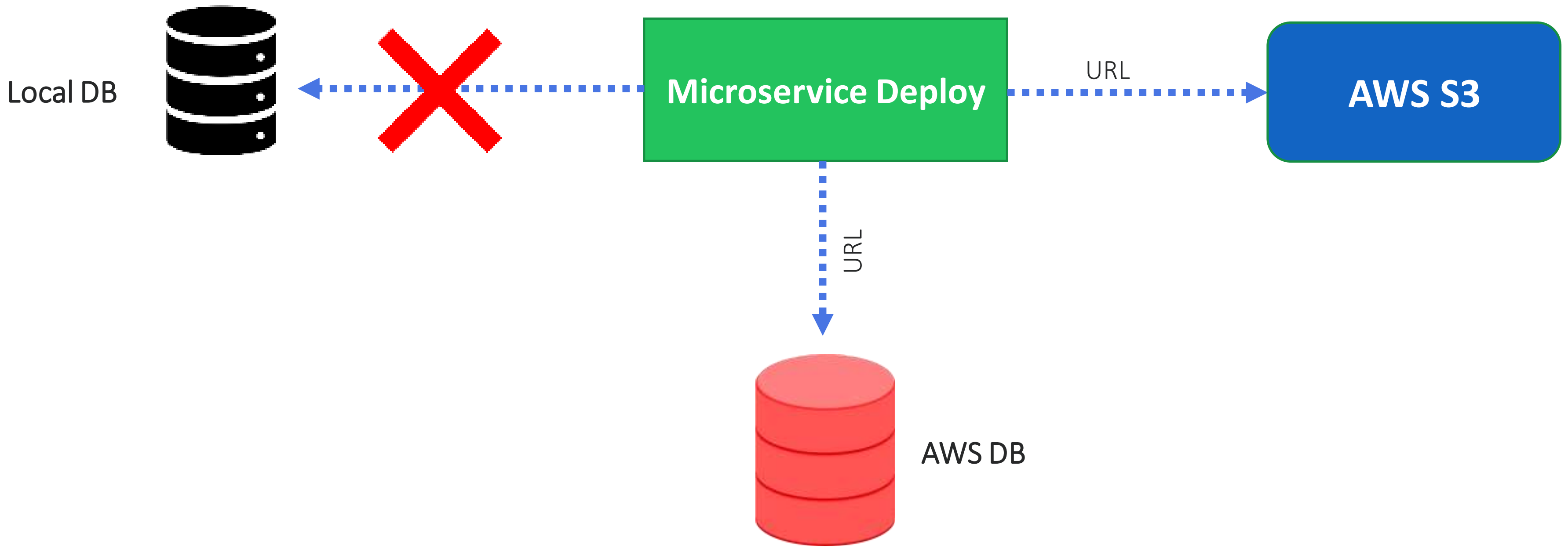


TWELVE FACTOR APP

4. BACKING SERVICES

- Backing Services best practice indicates that a microservices deploy should be able to swap between local connections to third party without any changes to the application code.

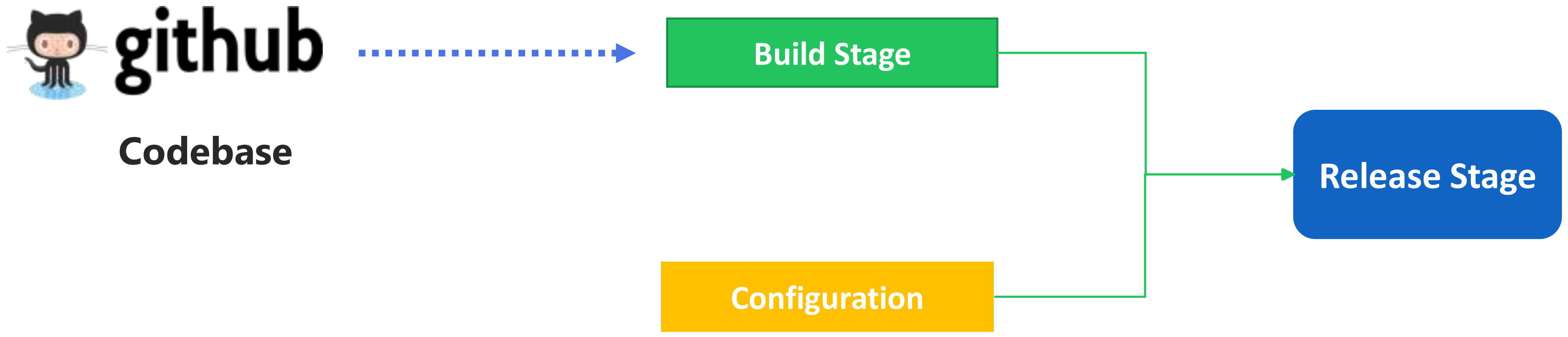
- In the below example, we can see that a local DB can be swapped easily to a third-party DB which is AWS DB here with out any code changes.



TWELVE FACTOR APP

5. BUILD, RELEASE, RUN

- Keep your build, release, and run stages of deploying your application completely separated. We should be able to build microservices that are independent of the environment which they are running.

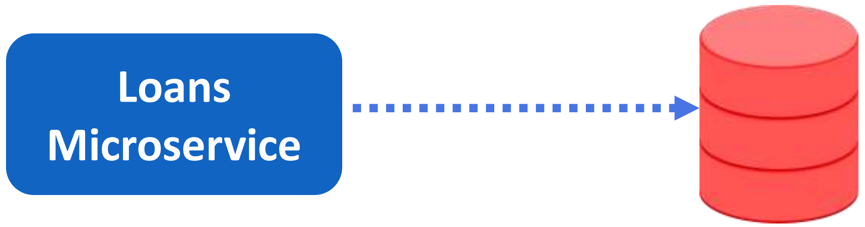


TWELVE FACTOR APP

6. PROCESSES

- Execute the app as one or more stateless processes. Twelve-factor processes are stateless and share-nothing. Any data that needs to persist must be stored in a stateful backing service, typically a database.

- Microservices can be killed and replaced at any time without the fear that a loss of a service-instance will result in data loss.



We can store the data of the loans microservice inside a SQL or NoSQL DB

TWELVE FACTOR APP

7. PORT BINDING

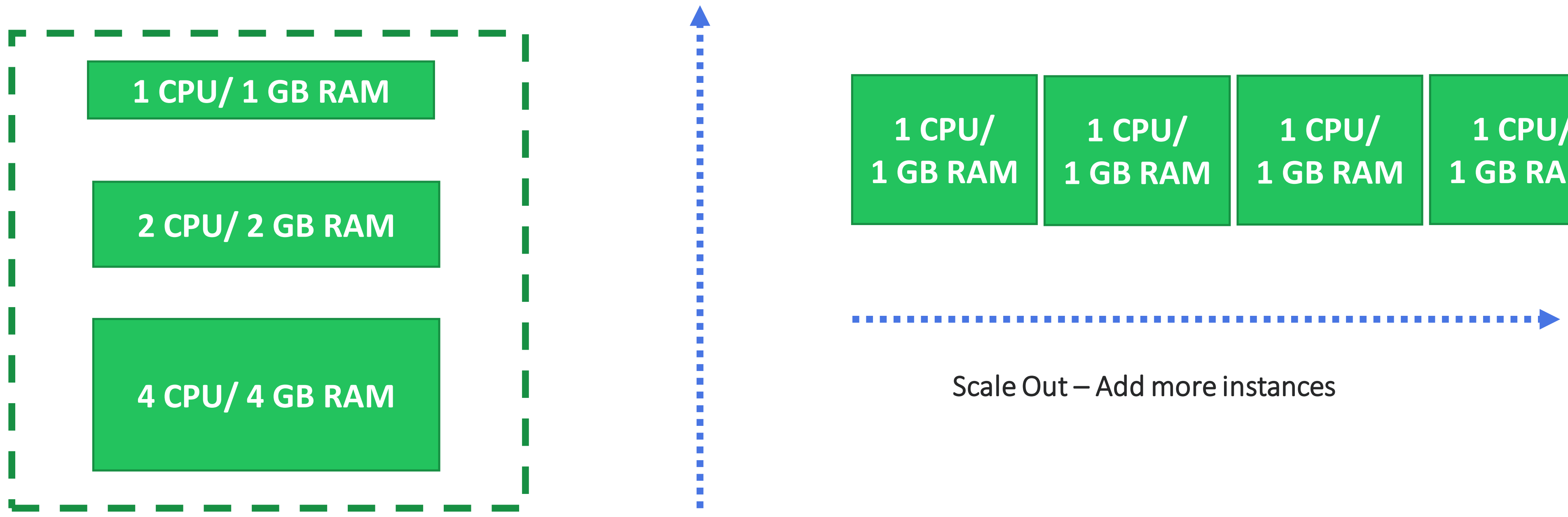
- Web apps are sometimes executed inside a webserver container. For example, PHP apps might run as a module inside Apache HTTPD, or Java apps might run inside Tomcat. But each microservice should be self-contained with its interfaces and functionality exposed on its own port. Doing so provides isolation from other microservices.

- We will develop an application using Spring Boot. Spring Boot, apart from many other benefits, provides us with a default embedded application server. Hence, the JAR we generated earlier using Maven is fully capable of executing in any environment just by having a compatible Java runtime.

TWELVE FACTOR APP

8. CONCURRENCY

- Services scale out across a large number of small identical processes (copies) as opposed to scaling-up a single large instance on the most powerful machine available.
- Vertical scaling (Scale up) refers to increase the hardware infrastructure (CPU, RAM). Horizontal scaling (Scale out) refers to adding more instances of the application. When you need to scale, launch more microservice instances and scale out and not up.



Scale Up – Increase size of RAM, CPU

TWELVE FACTOR APP

9. DISPOSABILITY

- Service instances should be disposable, favoring fast startups to increase scalability opportunities and graceful shutdowns to leave the system in a correct state. Docker containers along with an orchestrator inherently satisfy this requirement.

- For example, if one of the instances of the microservice is failing because of a failure in the underlying hardware, we can shut down that instance without affecting other microservices and start another one somewhere else if needed.

TWELVE FACTOR APP

10. Dev/Prod parity

- Keep environments across the application lifecycle as similar as possible, avoiding costly shortcuts. Here, the adoption of containers can greatly contribute by promoting the same execution environment.

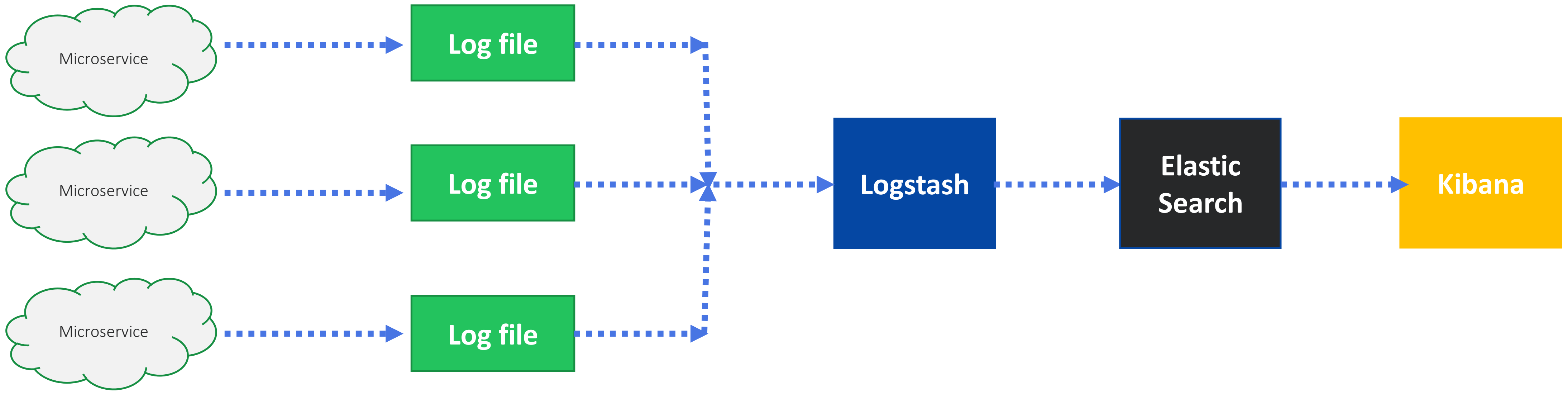
- As soon as a code is committed, it should be tested and then promoted as quickly as possible from development all the way to production. This guideline is essential if we want to avoid deployment errors. Having similar development and production environments allows us to control all the possible scenarios we might have while deploying and executing our application.

TWELVE FACTOR APP

11. Logs

- Treat logs generated by microservices as event streams. As logs are written out, they should be managed by tools, such as Logstash(https://www.elastic.co/products/logstash) that will collect the logs and write them to a central location.

- The microservice should never be concerned about the mechanisms of how this happens, they only need to focus on writing the log entries into the stdout. We will discuss on how to provide an autoconfiguration for sending these logs to the ELK stack (Elasticsearch, Logstash and Kibana) in the coming sections.



TWELVE FACTOR APP

12. Admin processes

- Run administrative/management tasks as one-off processes. Tasks can include data cleanup and pulling analytics for a report. Tools executing these tasks should be invoked from the production environment, but separately from the application.

- Developers will often have to do administrative tasks related to their microservices like Data migration, clean up activities. These tasks should never be ad hoc and instead should be done via scripts that are managed and maintained through source code repository. These scripts should be repeatable and non-changing across each environment they're run against. It's important to have defined the types of tasks we need to take into consideration while running our microservice, in case we have multiple microservices with these scripts we are able to execute all of the administrative tasks without having to do it manually.

CHALLENGE 3 WITH MICROSERVICES

CONFIGURATION MANAGEMENT

SEPARATION OF CONFIGs/PROPERTIES

How do we separate the configurations/properties from the microservices so that same Docker image can be deployed in multiple envs.

INJECT CONFIGs/PROPERTIES

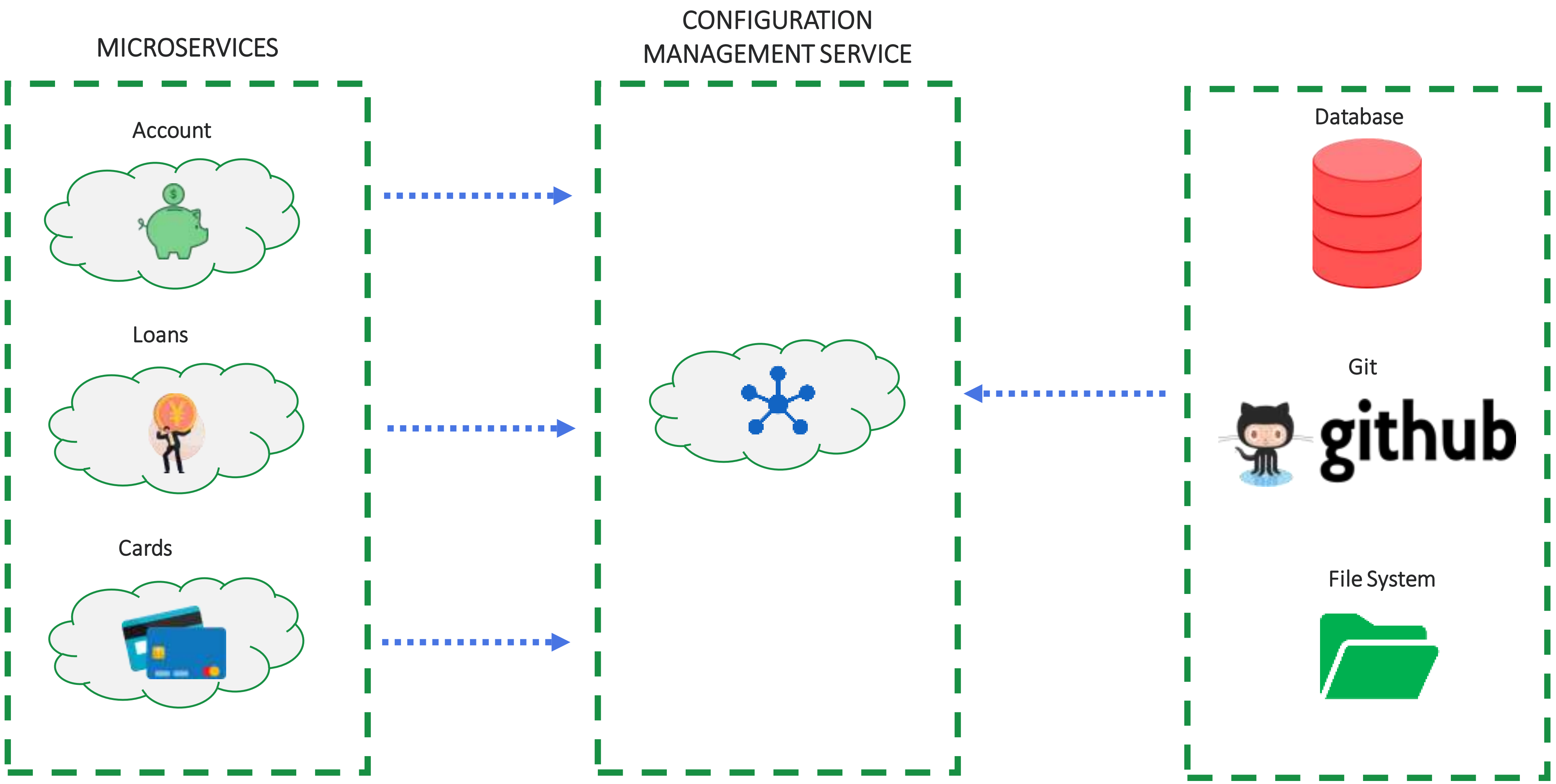
How do we inject configurations/properties that microservice needed during start up of the service

MAINTAIN CONFIGs/PROPERTIES

How do we maintain configurations/properties in a centralized repository along with versioning of them

CONFIGURATION MANAGEMENT

ARCHITECTURE INSIDE MICROSERVICES



Loan configurations during startup by connecting to Configuration service

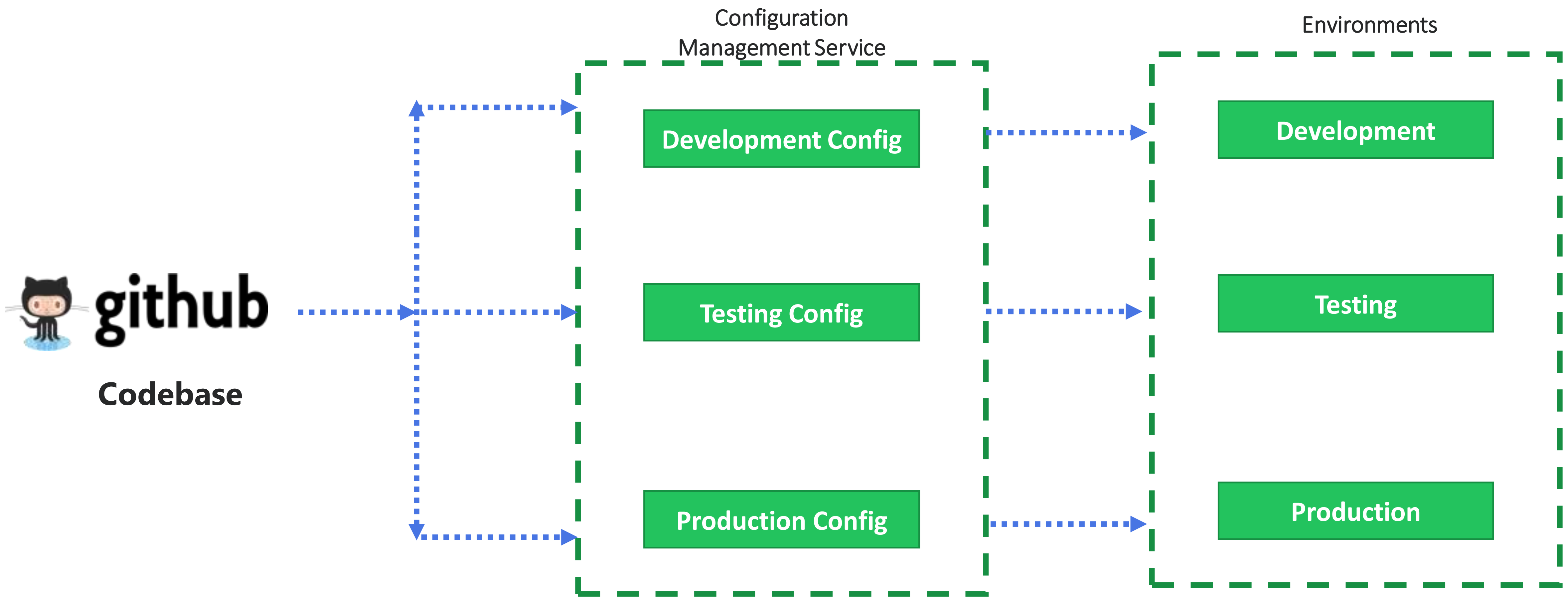
Configuration service load all the configurations by connecting to central repository

Most commonly used central repositories

SPRING CLOUD CONFIG

FOR CONFIGURATION MANAGEMENT IN MICROSERVICES

- Spring Cloud Config provides server and client-side support for externalized configuration in a distributed system. With the Config Server you have a central place to manage external properties for applications across all environments.



SPRING CLOUD CONFIG

FOR CONFIGURATION MANAGEMENT IN MICROSERVICES

Spring Cloud Config Server features:

- *HTTP, resource-based API for external configuration (name-value pairs, or equivalent YAML content)*
- *Encrypt and decrypt property values*
- *Embeddable easily in a Spring Boot application using @EnableConfigServer*

Config Client features (for Microservices):

- *Bind to the Config Server and initialize Spring Environment with remote property sources*
- *Encrypt and decrypt property values*

CHALLENGE 4 WITH MICROSERVICES

SERVICE DISCOVERY & REGISTRATION

HOW DO SERVICES LOCATE EACH OTHER INSIDE A NETWORK?

Each instance of a microservice exposes a remote API with it's own host and port. how do other microservices & clients know about these dynamic endpoint URLs to invoke them. So where is my service?

HOW DO NEW SERVICE INSTANCES ENTER INTO THE NETWORK?

If an microservice instance fails, new instances will be brought online to ensure constant availability. This means that the IP addresses of the instances can be constantly changing. So how does these new instances can start serving to the clients?

LOAD BALANCE, INFO SHARING B/W MICROSERVICE INSTANCES

How do we make sure to properly load balance b/w the multiple microservice instances especially a microservice is invoking another microservice? How do a specific service information shared across the network?

SERVICE DISCOVERY & REGISTRATION

INSIDE MICROSERVICES NETWORK

- Service discovery & registrations deals with the problems about how microservices talk to each other, i.e. perform API calls.

- In a traditional network topology, applications have static network locations. Hence IP addresses of relevant external locations can be read from a configuration file, as these addresses rarely change.

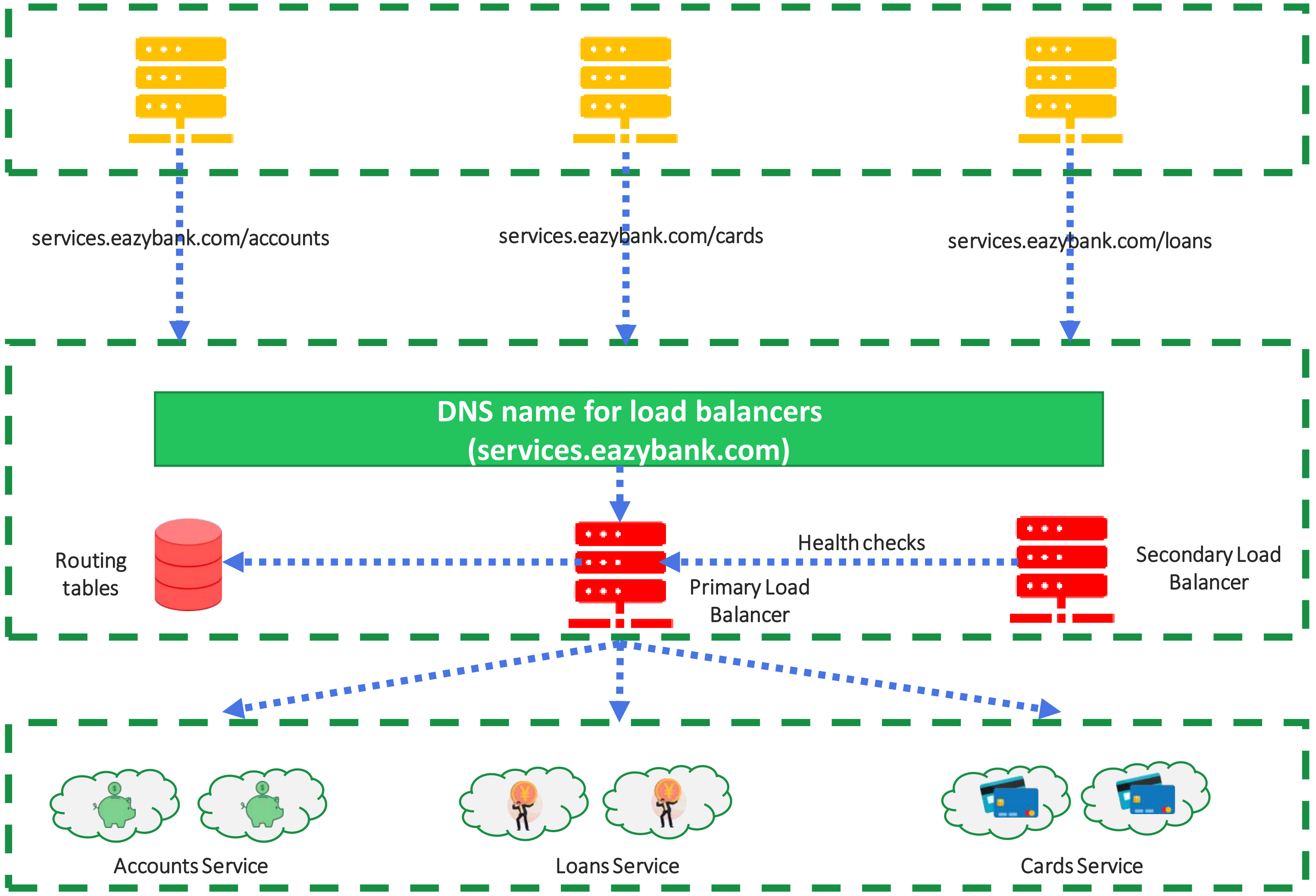
- In a modern microservice architecture, knowing the right network location of an application is a much more complex problem for the clients as service instances might have dynamically assigned IP addresses. Moreover the number instances may vary due to autoscaling and failures.

- Microservices service discovery & registration is a way for applications and microservices to locate each other on a network. This includes,
  - ✓ *A central server (or servers) that maintain a global view of addresses.*
  - ✓ *Microservices/clients that connect to the central server to register their address when they start & ready*
  - ✓ *Microservices/clients need to send their heartbeats at regular intervals to central server about their health*

WHY NOT TRADITIONAL LOAD BALANCERS

FOR SERVICE DISCOVERY & REGISTRATION

Applications like UI or other services uses generic DNS along with the service specific path to invoke a specific service



services.eazybank.com/accounts
services.eazybank.com/cards
services.eazybank.com/loans
DNS name for load balancers (services.eazybank.com)
Routing tables
Health checks
Primary Load Balancer
Secondary Load Balancer
Accounts Service
Loans Service
Cards Service

Traditional Service location resolution architecture using DNS & a load balancer

WHY NOT TRADITIONAL LOAD BALANCERS

FOR SERVICE DISCOVERY & REGISTRATION

- With traditional approach each instance of a service used to be deployed in one or more application servers. The number of these application servers was often static and even in the case of restoration it would be restored to the same state with the same IP and other configurations.

- While this type of model works well with monolithic and SOA based applications with a relatively small number of services running on a group of static servers, it doesn’t work well for cloud-based microservice applications for the following reasons,

    - Limited horizontal scalability & licenses costs
    - Single point of failure & Centralized chokepoints
    - Manually managed to update any IPs, configurations
    - Not containers friendly
    - Complex in nature

ARCHITECTURE OF SERVICE DISCOVERY

IN MICROSERVICES

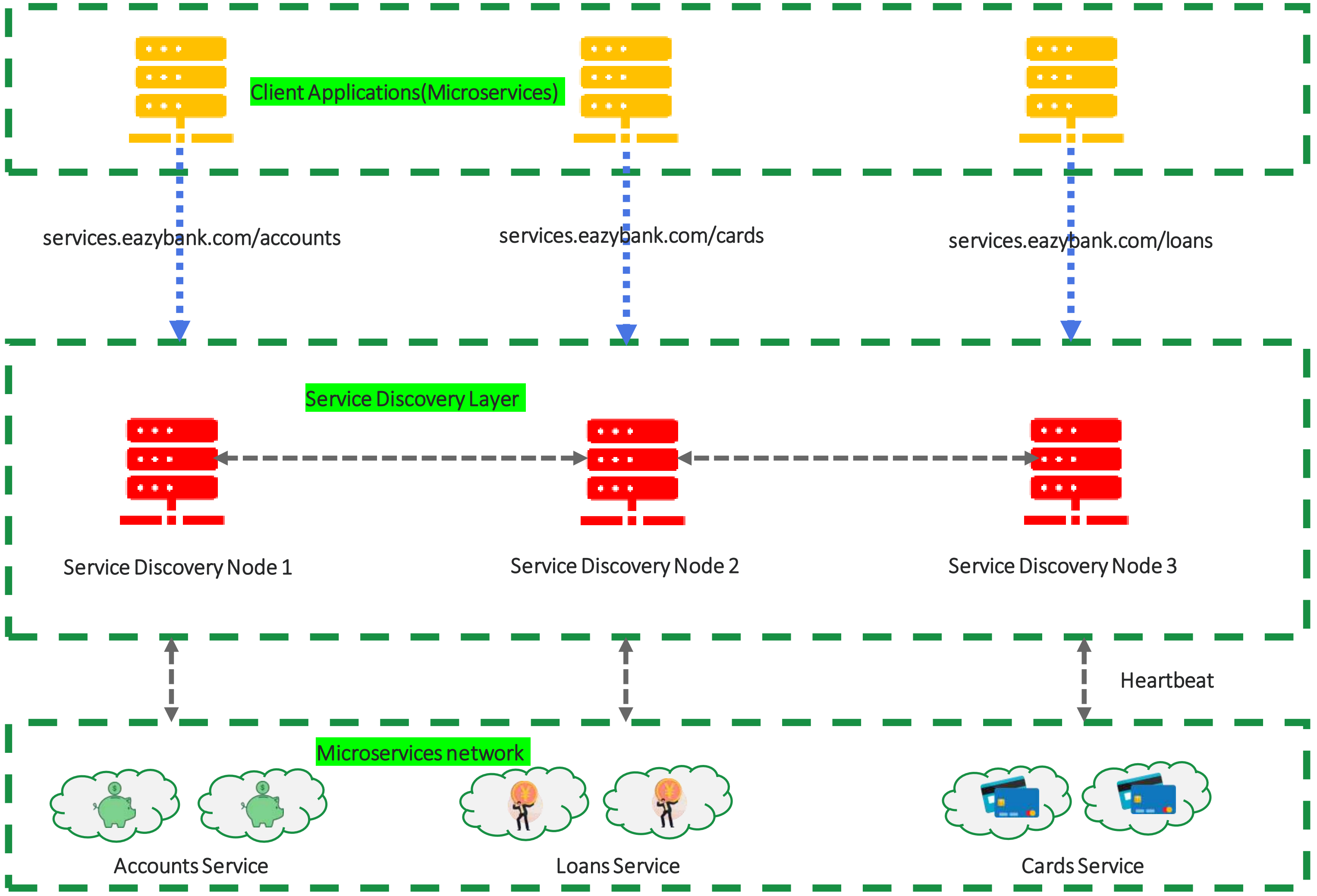
Client Applications never worry about the direct IP details of the microservice. They will just invoke service discovery layer with a logical service name

1. A service actual location can be looked up based on the given logical name

2. When a service comes online it register its IP address with a service discovery agent and let it know that it is ready to take requests

3. Service discovery nodes communicate with each other about new services, health of the services etc.

4. Service instances send a heartbeat to the service discovery agent. If a service didn't send a heartbeat, service discovery will remove the IP of the dead instance from the list



Server-Side discovery pattern/load Balancing

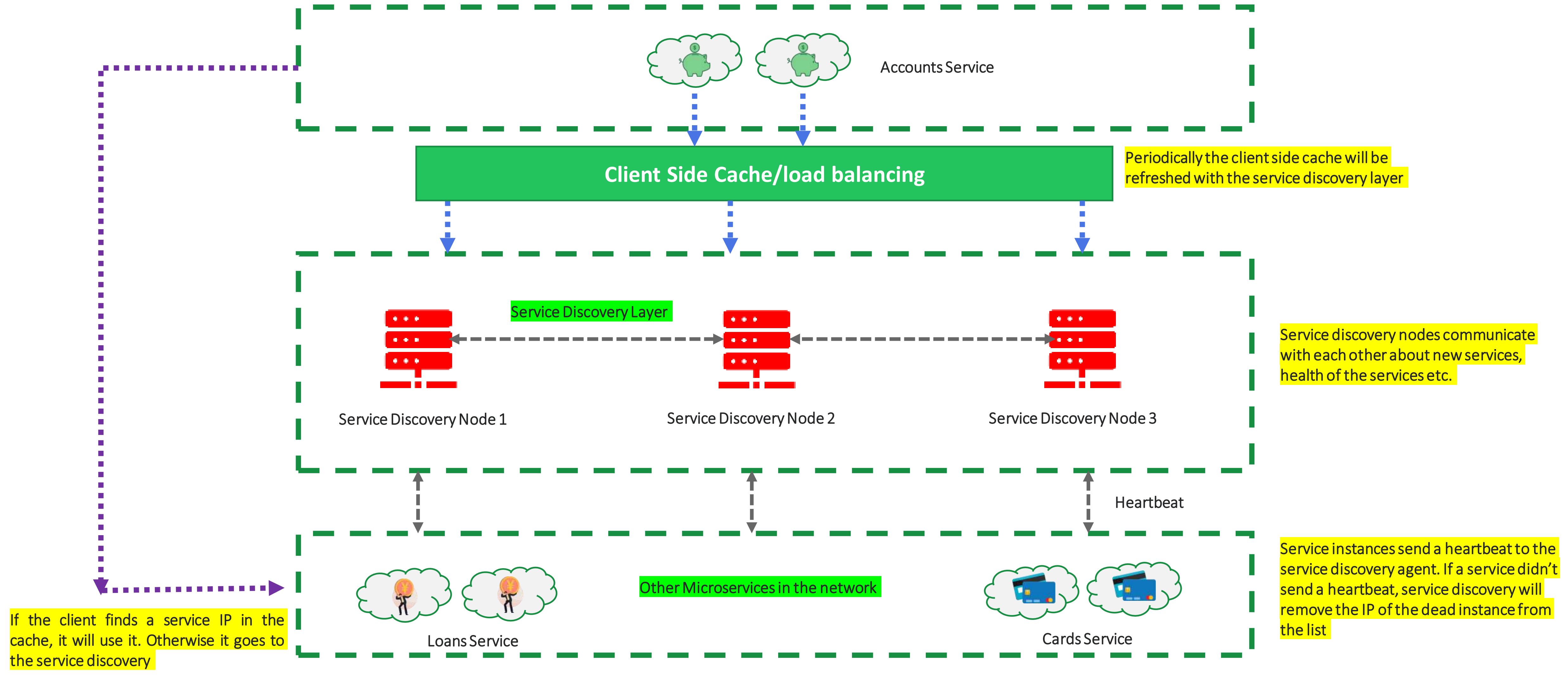
ARCHITECTURE OF SERVICE DISCOVERY
IN MICROSERVICES

- Service discovery tools and patterns are developed to overcome the challenges with traditional load balancers.
- Mainly service discovery consists of a key-value store (Service Registry) and an API to read from and write to this store. New instances of applications are saved to this service registry and deleted when the service is down or not healthy.
- Clients, that want to communicate with a certain service are supposed to interact with the service registry to know the exact network location(s).
- Advantages of Service Discovery approach,
  - No limitations on availability
  - Peer to peer communication b/w Service Discovery agents
  - Dynamically managed IPs, configurations & Load balanced
  - Fault-tolerant & Resilient in nature

CLIENT-SIDE LOAD BALANCING

IN MICROSERVICES

When a microservice want to connect with other microservice, it will check the local cache for the service instances IPs. Load balancing also happens at the service level itself w/o depending on the Service Discovery



Accounts Service
Client Side Cache/load balancing
Periodically the client side cache will be refreshed with the service discovery layer
Service Discovery Layer
Service Discovery Node 1
Service Discovery Node 2
Service Discovery Node 3
Service discovery nodes communicate with each other about new services, health of the services etc.
Heartbeat
Service instances send a heartbeat to the service discovery agent. If a service didn't send a heartbeat, service discovery will remove the IP of the dead instance from the list
Other Microservices in the network
Loans Service
Cards Service
If the client finds a service IP in the cache, it will use it. Otherwise it goes to the service discovery

SPRING CLOUD SUPPORT
FOR SERVICE DISCOVERY & REGISTRATION

- Spring Cloud project makes Service Discovery & Registration setup trivial to undertake with the help of the below components,
    - Spring Cloud Netflix's Eureka service which will act as a service discovery agent*
    - Spring Cloud Load Balancer library for client-side load balancing**
    - Netflix Feign client to look up for a service b/w microservices

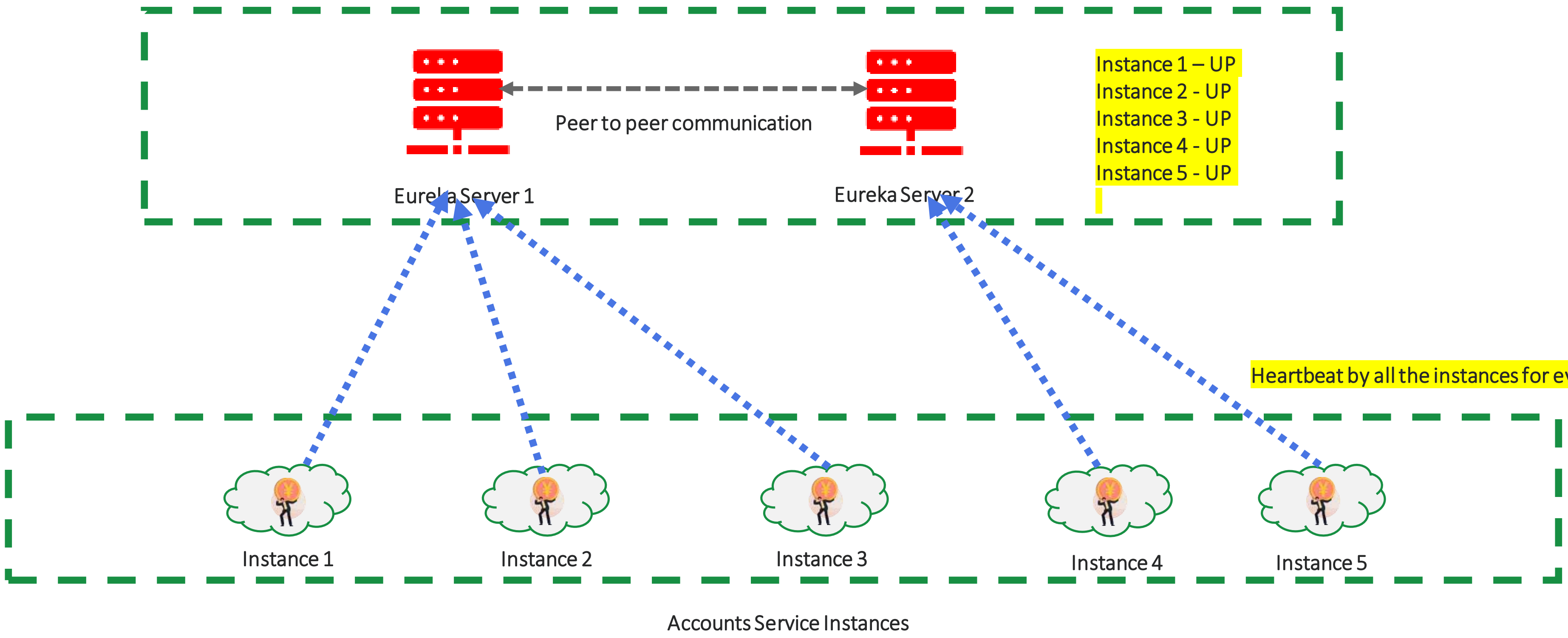
** Though in this course we use Eureka since it is mostly used but they are other service registries such as etcd,Consul, and Apache Zookeeper which are also good.*

*** Though Netflix Ribbon client-side is also good and stable product, we are going to use Spring Cloud Load Balancer for client-side load balancing. This is because Ribbon has entered a maintenance mode and unfortunately, it will not be developed anymore*

EUREKA SELF-PRESERVATION

TO AVOID TRAPS IN NETWORK

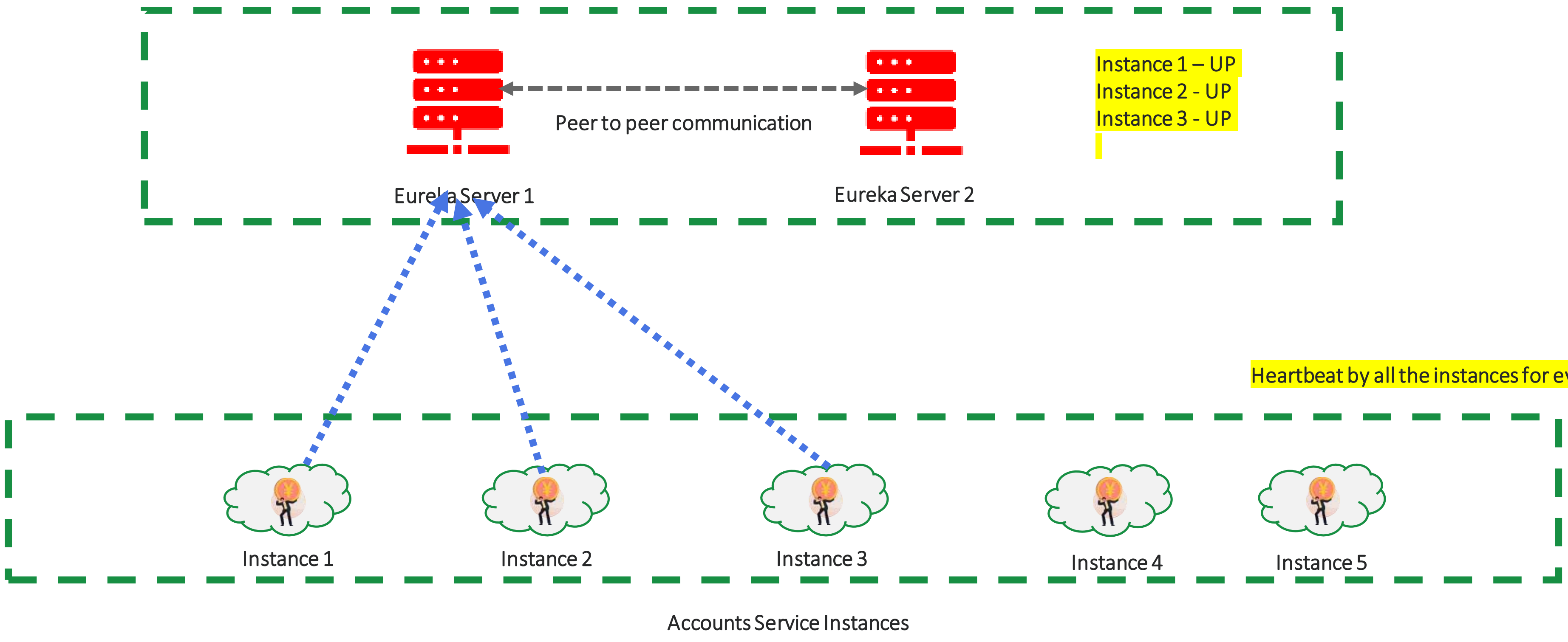
eazy bytes



Healthy Microservices System with all 5 instances up before encountering network problems

EUREKA SELF-PRESERVATION

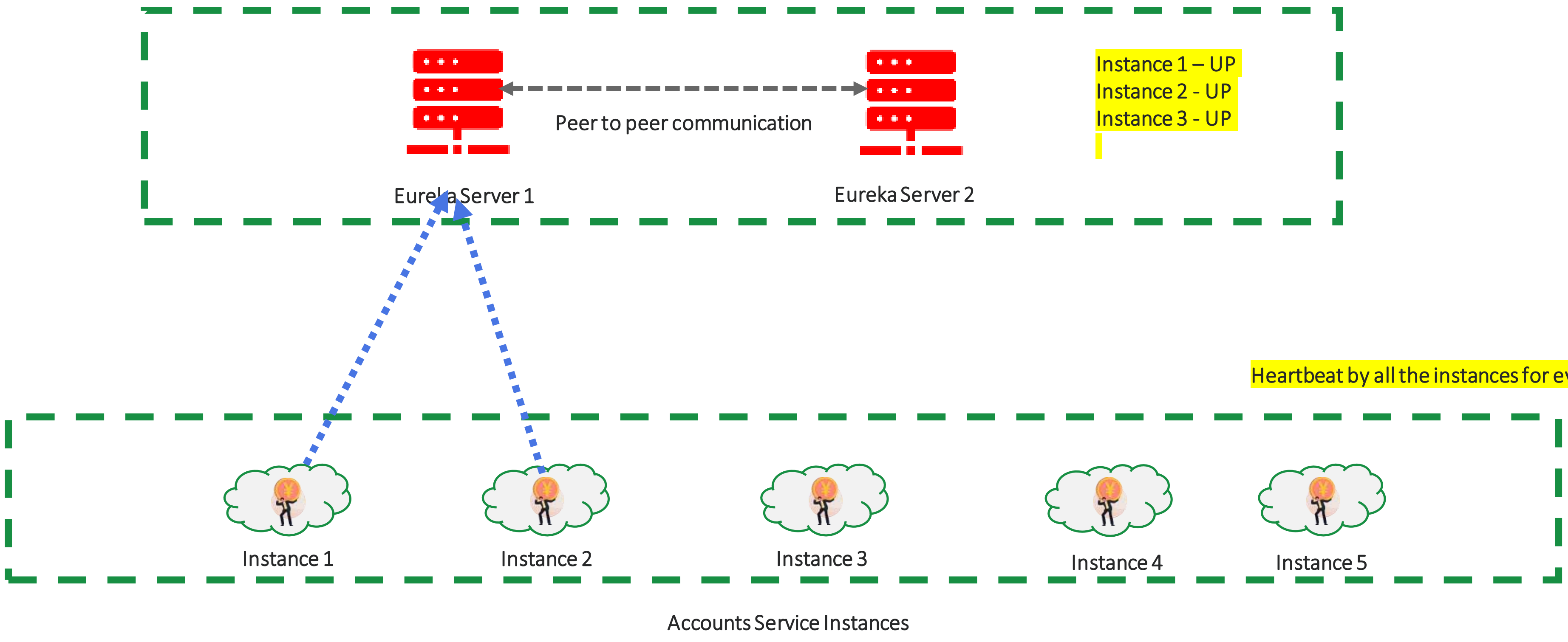
TO AVOID TRAPS IN NETWORK



2 of the instances not sending heartbeat. Eureka enters self-preservation mode since it met threshold percentage

EUREKA SELF-PRESERVATION

TO AVOID TRAPS IN NETWORK



During Self-preservation, eureka will stop expiring the instances though it is not receiving heartbeat from instance 3

EUREKA SELF-PRESERVATION

TO AVOID TRAPS IN NETWORK

- The reason behind self-preservation mode in eureka

    ✓ Servers not receiving heartbeats could be due to a poor network issue but does not necessarily mean the clients are down which may be resolved sooner. So with out self-preservation we will end up have zero instances up with Eureka though the instances might be up and running.

    ✓ Even though the connectivity is lost between servers and some clients, clients might have connectivity with each other. With their local cache registration details they can keep communicating with each other

- Self-preservation mode never expires, until and unless the down microservices are brought back or the network glitch is resolved. This is because eureka will not expire the instances till it is above the threshold limit.

- Self-preservation will be a savior where the networks glitches are common and help us to handle false-positive alarms.

EUREKA SELF-PRESERVATION

TO AVOID TRAPS IN NETWORK

eazy bytes

- Configurations which will directly or indirectly impact self-preservation behavior of eureka

  - ✓ eureka.instance.lease-renewal-interval-in-seconds = 30
    Indicates the frequency the client sends heartbeats to server to indicate that it is still alive.
  - ✓ eureka.instance.lease-expiration-duration-in-seconds = 90
    Indicates the duration the server waits since it received the last heartbeat before it can evict an instance
  - ✓ eureka.server.eviction-interval-timer-in-ms = 60 * 1000
    A scheduler(EvictionTask) is run at this frequency which will evict instances from the registry if the lease of the instances are expired as configured by lease-expiration-duration-in-seconds. It will also check whether the system has reached self-preservation mode (by comparing actual and expected heartbeats) before evicting.
  - ✓ eureka.server.renewal-percent-threshold = 0.85
    This value is used to calculate the expected % of heartbeats per minute eureka is expecting.
  - ✓ eureka.server.renewal-threshold-update-interval-ms = 15 * 60 * 1000
    A scheduler is run at this frequency which calculates the expected heartbeats per minute
  - ✓ eureka.server.enable-self-preservation = true
    By default self-preservation mode is enabled but if you need to disable it you can change it to 'false'

CHALLENGE 5 WITH MICROSERVICES

eazy bytes

RESILIENCY

HOW DO WE AVOID CASCADING FAILURES?

One failed or slow service should not have a ripple effect on the other microservices. Like in the scenarios of multiple microservices are communicating, we need to make sure that the entire chain of microservices does not fail with the failure of a single microservice

HOW DO WE HANDLE FAILURES GRACEFULLY WITH FALLBACKS?

In a chain of multiple microservices, how do we build a fallback mechanism if one of the microservice is not working. Like returning a default value or return values from cache or call another service/DB to fetch the results etc.

HOW TO MAKE OUR SERVICES SELF-HEALING CAPABLE

In the cases of slow performing services, how do we configure timeouts, retries and give time for a failed services to recover itself.

SPRING SUPPORT

FOR RESILIENCY USING RESILIENCE4J

- Resilience4j is a lightweight, easy-to-use fault tolerance library inspired by Netflix Hystrix, but designed for Java 8 and functional programming. Lightweight, because the library only uses Vavr, which does not have any other external library dependencies. Netflix Hystrix, in contrast, has a compile dependency to Archaius which has many more external library dependencies such as Guava and Apache Commons Configuration.

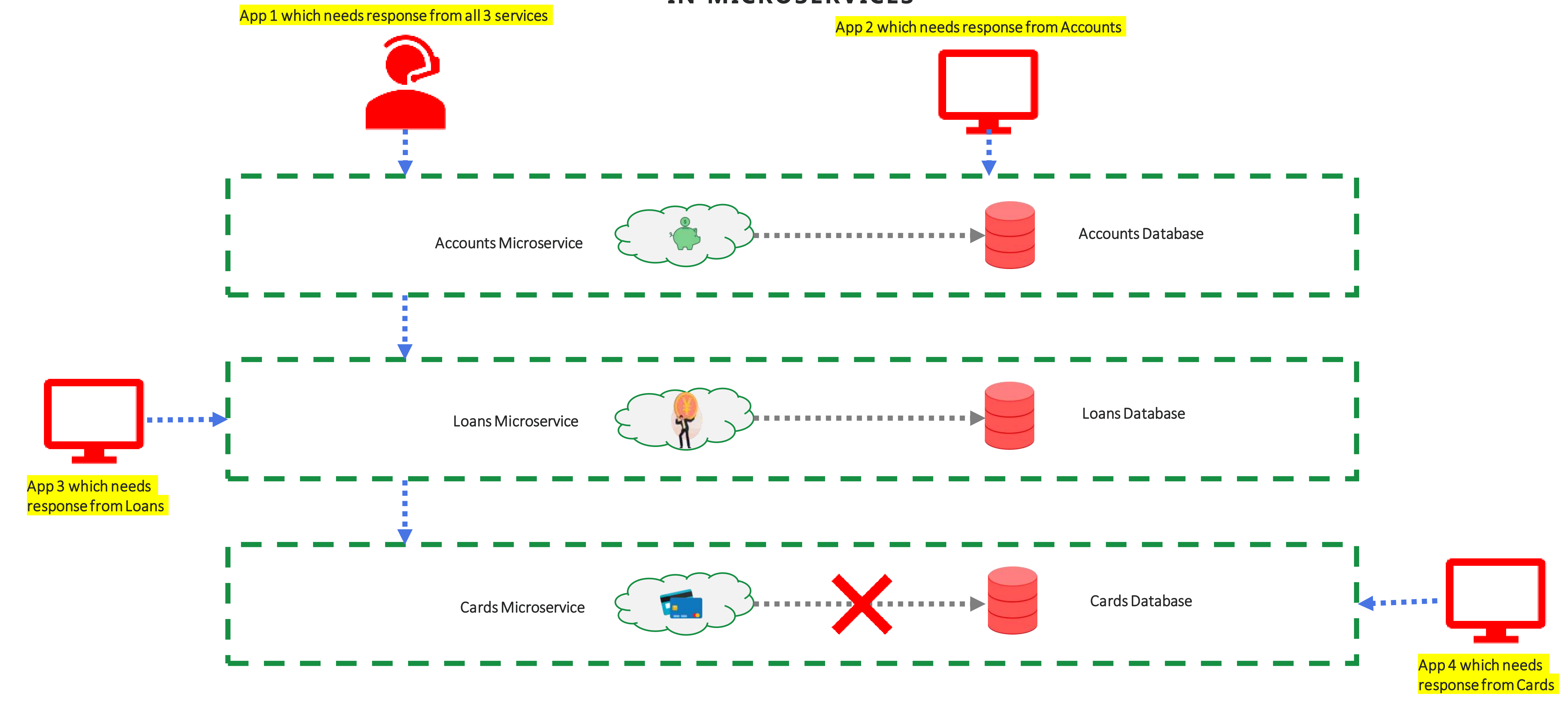
- Resilience4j offers the following patterns for increasing fault tolerance due to network problems or failure of any of the multiple services:

  - ✓ Circuit breaker - Used to stop making requests when a service invoked is failing.
  - ✓ Fallback - Alternative paths to failing requests.
  - ✓ Retry - Used to make retries when a service has temporarily failed.
  - ✓ Rate limit - Limits the number of calls that a service receives in a time.
  - ✓ Bulkhead - Limits the number of outgoing concurrent requests to a service to avoid overloading.

- Before using Resilience4j, Developers used to use Hystrix, one of the most common java libraries to implement the resiliency patterns in microservices. But now Hystrix is in maintenance mode and no new features are developed. Due to this reason now everyone uses Resilience4j which has more features than Hystrix.

TYPICAL SCENARIO

IN MICROSERVICES


App 1 which needs response from all 3 services
App 2 which needs response from Accounts
Accounts Microservice
Accounts Database
Loans Microservice
Loans Database
App 3 which needs response from Loans
Cards Microservice
Cards Database
App 4 which needs response from Cards

In my microservices network both Accounts, Loans are working fine but Cards is not responding properly due to DB connectivity issues

CIRCUIT BREAKER PATTERN

FOR RESILIENCY IN MICROSERVICES

- In a distributed environment, calls to remote resources and services can fail due to transient faults, such as slow network connections, timeouts, or the resources being overcommitted or temporarily unavailable. These faults typically correct themselves after a short period of time, and a robust cloud application should be prepared to handle them.

- The Circuit Breaker pattern which inspired from electrical circuit breaker will monitor the remote calls. If the calls take too long, the circuit breaker will intercede and kill the call. Also, the circuit breaker will monitor all calls to a remote resource, and if enough calls fail, the circuit break implementation will pop, failing fast and preventing future calls to the failing remote resource.

- The Circuit Breaker pattern also enables an application to detect whether the fault has been resolved. If the problem appears to have been fixed, the application can try to invoke the operation.

- The advantages with circuit breaker pattern are,

  ✓ Fail fast
  ✓ Fail gracefully
  ✓ Recover seamlessly

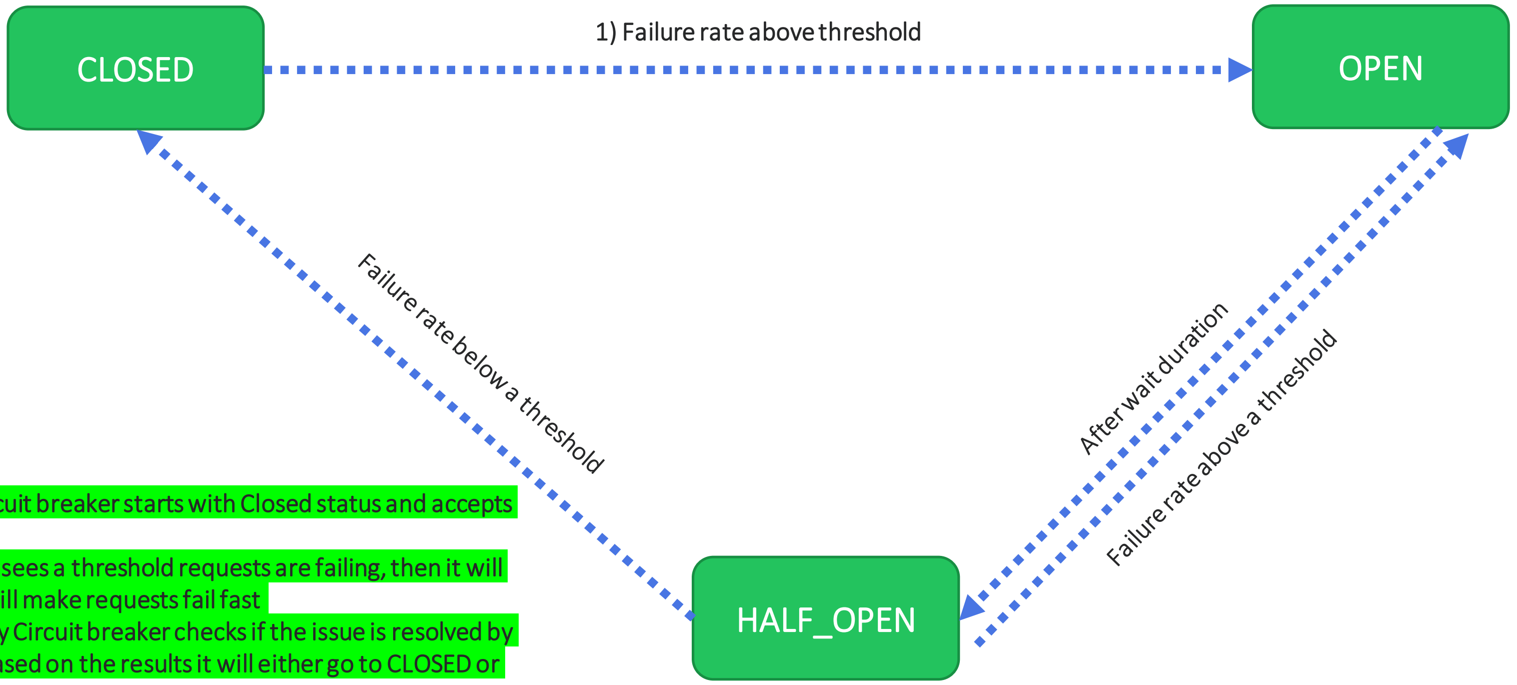
```
@CircuitBreaker(name="detailsForCustomerSupportApp",
fallbackMethod= "myCustomerDetailsFallBack")
```

CIRCUIT BREAKER PATTERN

FOR RESILIENCY IN MICROSERVICES

eazy bytes

In Resilience4j the circuit breaker is implemented via a finite state machine with the following states

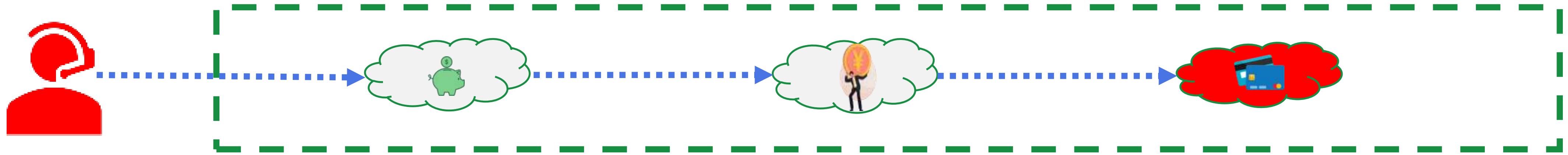

CLOSED
1) Failure rate above threshold
OPEN
Failure rate below a threshold
After wait duration
Failure rate above a threshold
HALF_OPEN

1) CLOSED – Initially the circuit breaker starts with Closed status and accepts client requests
2) OPEN – If Circuit breaker sees a threshold requests are failing, then it will OPEN the circuit which will make requests fail fast
3) HALF_OPEN – Periodically Circuit breaker checks if the issue is resolved by allowing few requests. Based on the results it will either go to CLOSED or OPEN.

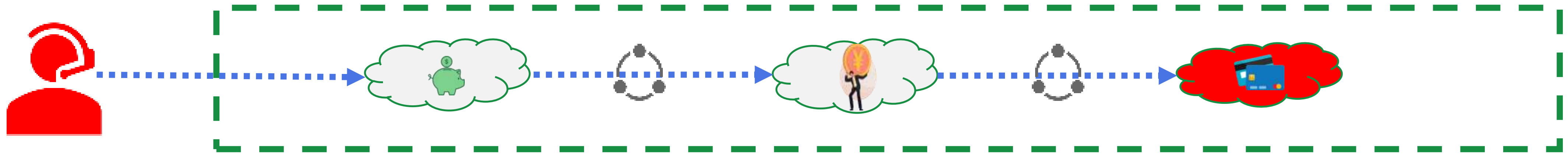
CIRCUIT BREAKER PATTERN

FOR RESILIENCY IN MICROSERVICES

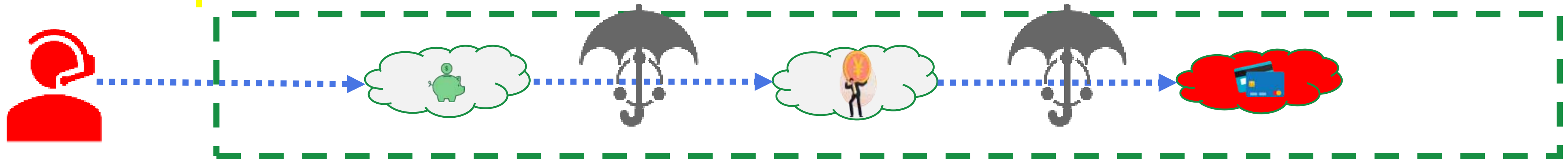
eazy bytes



Scenario 1 – If Cards microservice is responding slowly, then with out circuit breaker it will start eating up all the resources threads on the Loans and Accounts microservices which will make them also slow/down eventually



Scenario 2 – If Cards microservice is responding slowly, then with circuit breakers in between it will start acting and failing the services fast with the states OPEN, HALF_OPEN, CLOSED. This way at least Accounts and Loans services will not have any issues for other Apps.



Scenario 3 – If Cards microservice is responding slowly then with circuit breakers and fallback mechanism, we can make sure that at least we are failing gracefully with some default response is being returned and at the same time other microservices will not get impacted

RETRY PATTERN

FOR RESILIENCY IN MICROSERVICES

eazy bytes

- The retry pattern will make configured multiple retry attempts when a service has temporarily failed. This pattern is very helpful in the scenarios like network disruption where the client request may successful after a retry attempt.

- For retry pattern we can configure the following values,

  - ✓ maxAttempts - The maximum number of attempts
  - ✓ waitDuration - A fixed wait duration between retry attempts
  - ✓ retryExceptions - Configures a list of Throwable classes that are recorded as a failure and thus are retried.
  - ✓ ignoreExceptions - Configures a list of Throwable classes that are ignored and thus are not retried.

- We can also define a fallback mechanism if the service call fails even after multiple retry attempts. Below is a sample configuration,

```
@Retry(name="detailsForCustomerSupportApp",fallbackMethod=
"myCustomerDetailsFallBack")
```

RATE LIMITTER PATTERN

FOR RESILIENCY IN MICROSERVICES

- The rate limiter pattern will help to stop overloading the service with more calls more than it can consume in a given time. This is an imperative technique to prepare our API for high availability and reliability.

- This pattern protect APIs and service endpoints from harmful effects, such as denial of service, cascading failure.

- For rate limiter pattern we can configure the following values,

  ✓ timeoutDuration - The default wait time a thread waits for a permission
  ✓ limitForPeriod - The number of permissions available during one limit refresh period
  ✓ limitRefreshPeriod - The period of a limit refresh. After each period the rate limiter sets its permissions count back to the limitForPeriod value

- We can also define a fallback mechanism if the service call fails due to rate limiter configurations. Below is a sample configuration,

```
@RateLimiter(name="detailsForCustomerSupportApp",fallbackMethod=
"myCustomerDetailsFallBack")
```

BULKHEAD PATTERN

FOR RESILIENCY IN MICROSERVICES

- A ship is split into small multiple compartments using Bulkheads. Bulkheads are used to seal parts of the ship to prevent entire ship from sinking in case of flood.

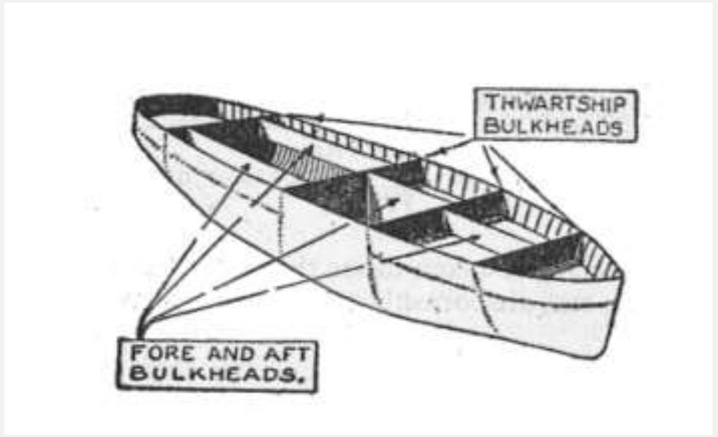
- Similarly microservices resources should be isolated in such a way that failure of one component is not affecting the entire microservice.

- Bulkhead Pattern helps us to allocate limit the resources which can be used for specific services. So that resource exhaustion can be reduced.

- For Bulkhead pattern we can configure the following values,

  ✓ maxConcurrentCalls - Max amount of parallel executions allowed by the bulkhead

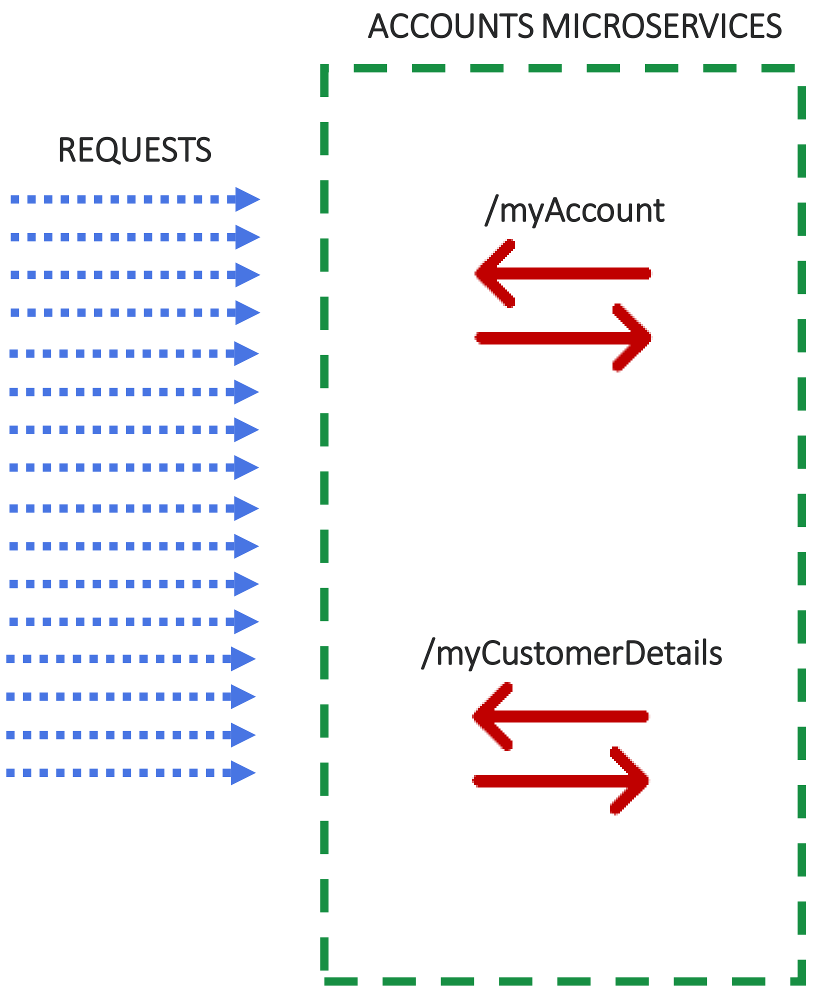
  ✓ maxWaitDuration - Max amount of time a thread should be blocked for when attempting to enter a saturated bulkhead.



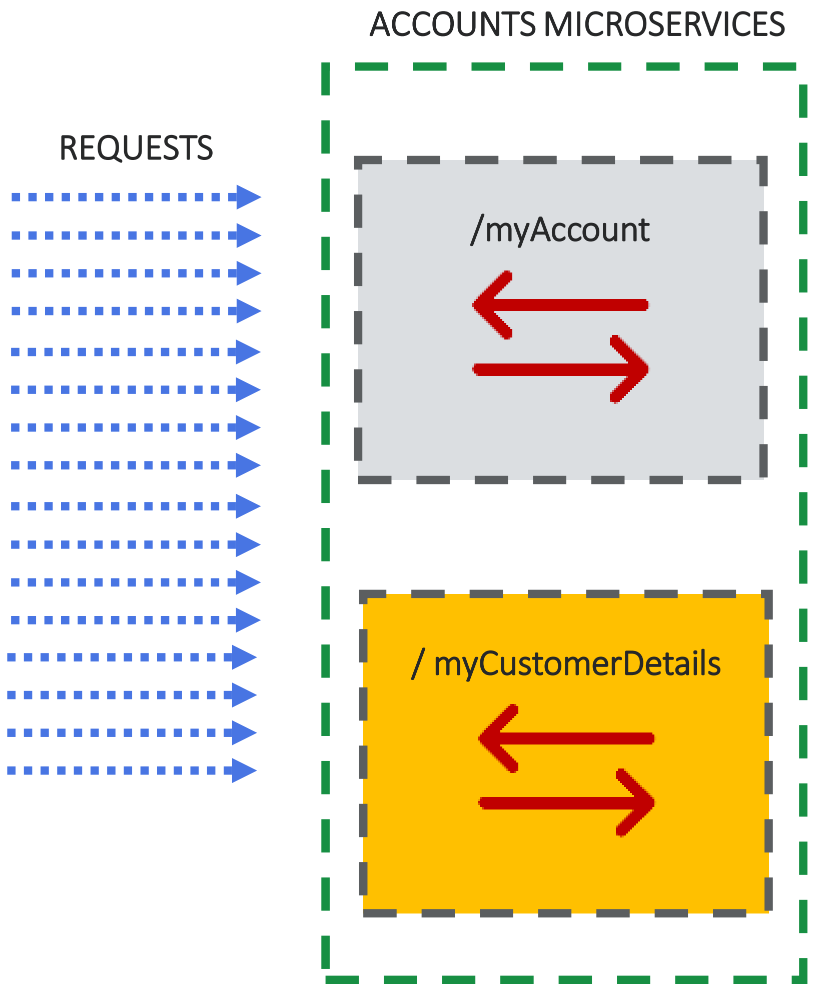
```
@Bulkhead(name="bulkheadAccounts",fallbackMethod=
"bulkheadAccountsFallBack")
```

BULKHEAD PATTERN

ARCHITECTURE INSIDE MICROSERVICES



Without Bulkhead, /myCustomerDetails will start eating all the threads, resources available which will effect the performance of /myAccount



With Bulkhead, /myCustomerDetails and /myAccount will have their own resources, threads pool defined

CHALLENGE 6 WITH MICROSERVICES

ROUTING, CROSS CUTTING CONCERNS

HOW DO WE ROUTE BASED ON CUSTOM REQUIREMENTS

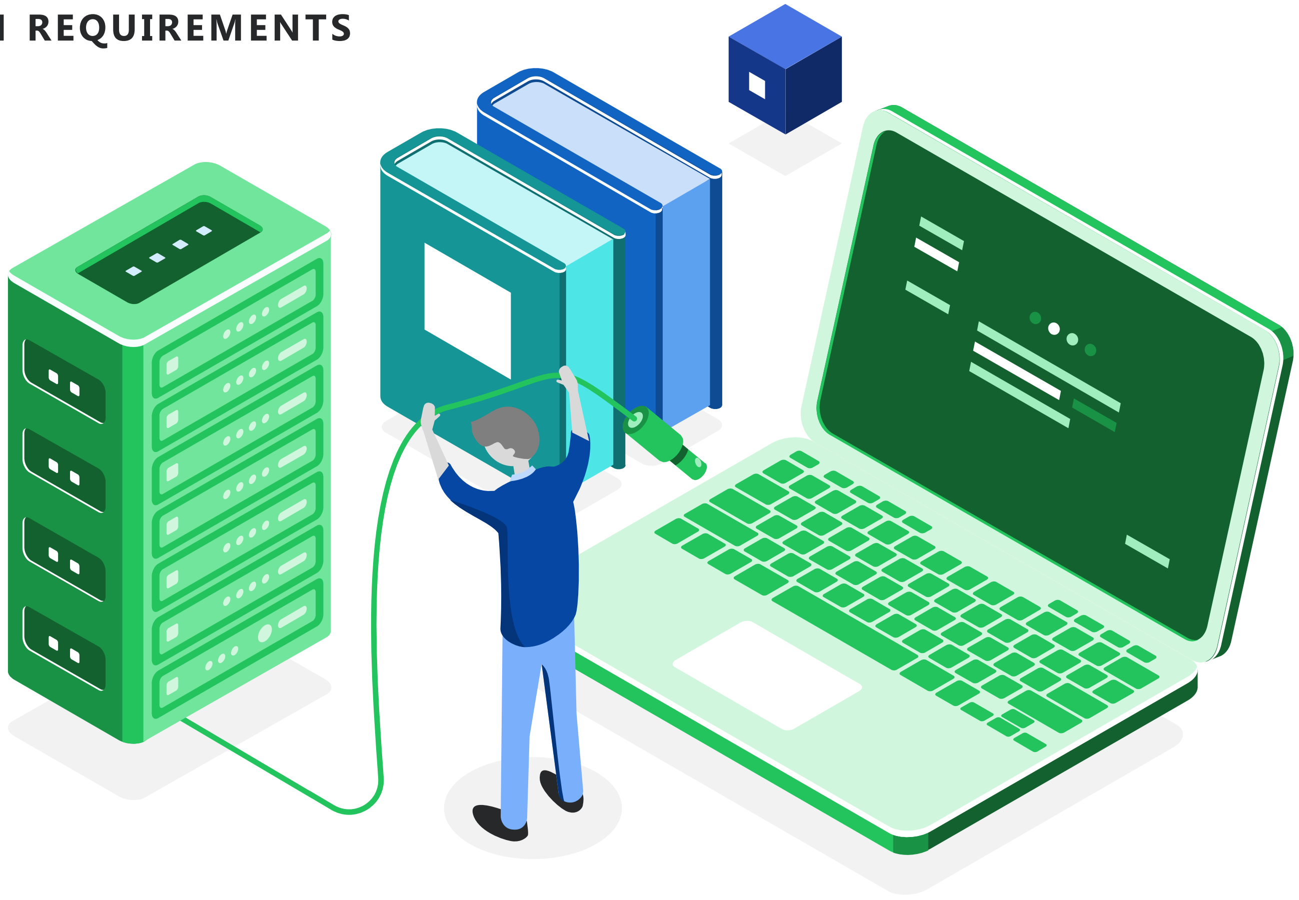
If we have a custom requirements to route the incoming requests to the appropriate destination both in static and dynamic way, how do we do that?

HOW DO WE HANDLE CROSS CUTTING CONCERNS?

In a distributed microservices architecture, how do we make sure to have a consistently enforced cross cutting concerns like logging, auditing, tracing, security and metrics collection across multiple microservices

HOW DO WE BUILD A SINGLE GATEKEEPER?

How do we build a single gatekeeper for all the inbound traffic to our microservices which will act as a central Policy Enforcement Point (PEP) for all service calls?



SPRING CLOUD SUPPORT
FOR ROUTING, CROSS CUTTING CONCERNS

- Spring Cloud Gateway is API Gateway implementation by Spring Cloud team on top of Spring reactive ecosystem. It provides a simple and effective way to route incoming requests to the appropriate destination using Gateway Handler Mapping.

- The service gateway sits as the gatekeeper for all inbound traffic to microservice calls within our application. With a service gateway in place, our service clients never directly call the URL of an individual service, but instead place all calls to the service gateway.

- The service gateway sits between all calls from the client to the individual services, it also acts as a central Policy Enforcement Point (PEP) like below for service calls.

  ✓ Routing (Both Static & Dynamic)
  ✓ Security (Authentication & Authorization)
  ✓ Logging, Auditing and Metrics collection

SPRING CLOUD SUPPORT

FOR ROUTING, CROSS CUTTING CONCERNS

- Spring Cloud Gateway is a library for building an API gateway, so it looks like any another Spring Boot application. If you're a Spring developer, you'll find it's very easy to get started with Spring Cloud Gateway with just a few lines of code.

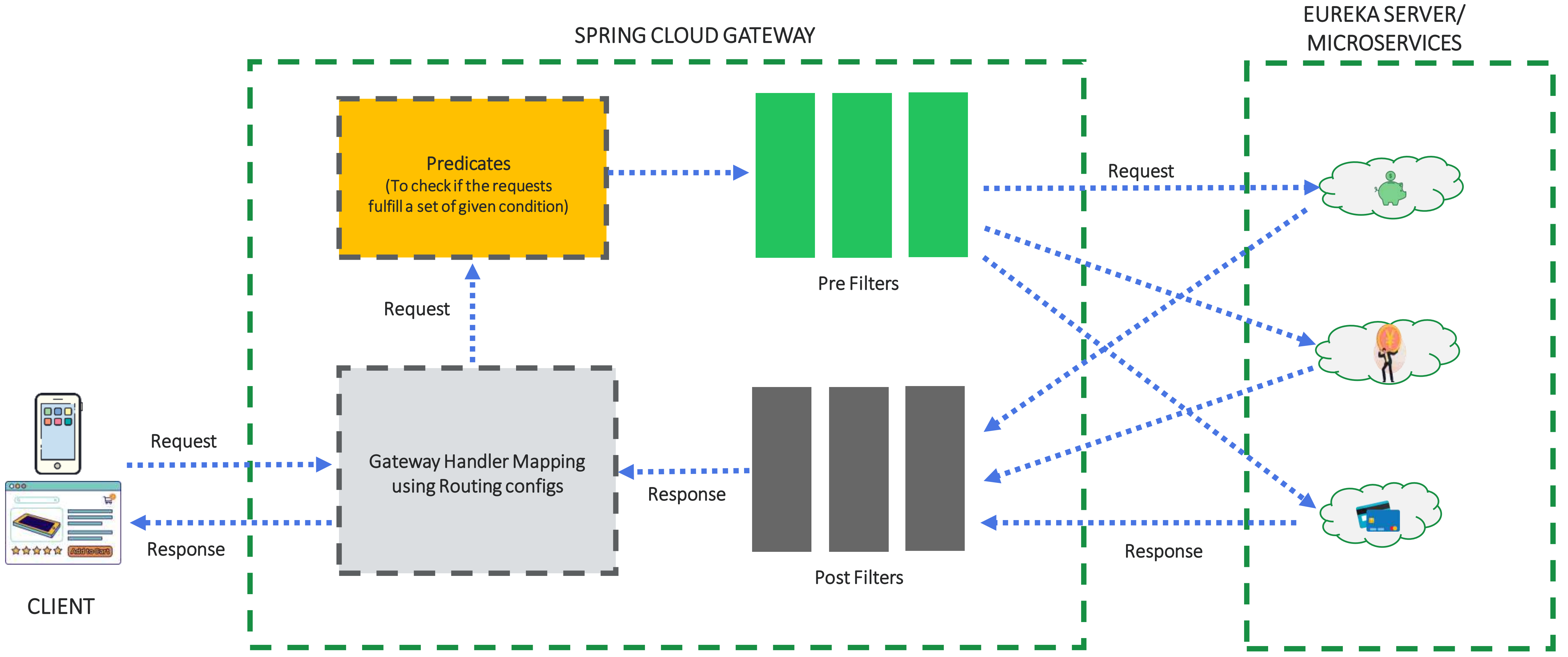
- Spring Cloud Gateway is intended to sit between a requester and a resource that's being requested, where it intercepts, analyzes, and modifies every request. That means you can route requests based on their context. Did a request include a header indicating an API version? We can route that request to the appropriately versioned backend. Does the request require sticky sessions? The gateway can keep track of each user's session.

- Spring Cloud Gateway is replacement of Zuul for the following reasons and advantages,

  - Spring Cloud Gateway is the preferred API gateway implementation from the Spring Cloud Team. It's built on Spring 5, Reactor, and Spring WebFlux. Not only that, it also includes circuit breaker integration, service discovery with Eureka
  - ✓ Spring Cloud Gateway is non-blocking in nature. Though later Zuul 2 also supports it, but still Spring Cloud Gateway has an edge here
  - ✓ Spring Cloud Gateway has a superior performance compared to that of Zuul.

SPRING CLOUD GATEWAY

INTERNAL ARCHITECTURE


SPRING CLOUD GATEWAY
EUREKA SERVER/ MICROSERVICES
Predicates
(To check if the requests fulfill a set of given condition)
Pre Filters
Request
Request
Gateway Handler Mapping using Routing configs
Request
Response
Response
Post Filters
Response
CLIENT

When the client makes a request to the Spring Cloud Gateway, the Gateway Handler Mapping first checks if the request matches a route. This matching is done using the predicates. If it matches the predicate then the request is sent to the filters. Post filter it will send to the actual microservices or Eureka Server

CHALLENGE 7 WITH MICROSERVICES

DISTRIBUTED TRACING & LOG AGGREGATION

HOW DO WE DEBUG WHERE A PROBLEM IN MICROSERVICES?

How do we trace one or more transactions across multiple services, physical machines, and different data stores, and try to find where exactly the problem or bug is?

HOW DO WE AGGREGATE ALL APPLICATION LOGS?

How do we combine all the logs from multiple services into a central location where they can be indexed, searched, filtered, and grouped to find bugs that are contributing to a problem?

HOW DO WE MONITOR OUR CHAIN OF SERVICE CALLS?

How do we understand for a specific chain service call the path it travelled inside our microservices network, time it took at each microservice etc. ?

SPRING CLOUD SUPPORT

FOR DISTRIBUTED TRACING & LOG AGGREGATION

Spring Cloud Sleuth *(https://spring.io/projects/spring-cloud-sleuth)*

- Spring Cloud Sleuth provides Spring Boot auto-configuration for distributed tracing.
- It adds trace and span ids to all the logs, so you can just extract from a given trace or span in a log aggregator.
- It does this by adding the filters and interacting with other Spring components to let the correlation IDs being generated pass through to all the system calls.

Zipkin *(https://zipkin.io/)*

- Zipkin is a is an open-source data-visualization tool that can helps aggregating all the logs and gather timing data needed to troubleshoot latency problems in microservices architectures.
- It allows us to break a transaction down into its component pieces and visually identify where there might be performance hotspots. Thus reducing time in triaging by contextualizing errors and delays.

SPRING CLOUD SLEUTH

TRACE FORMAT

eazy bytes

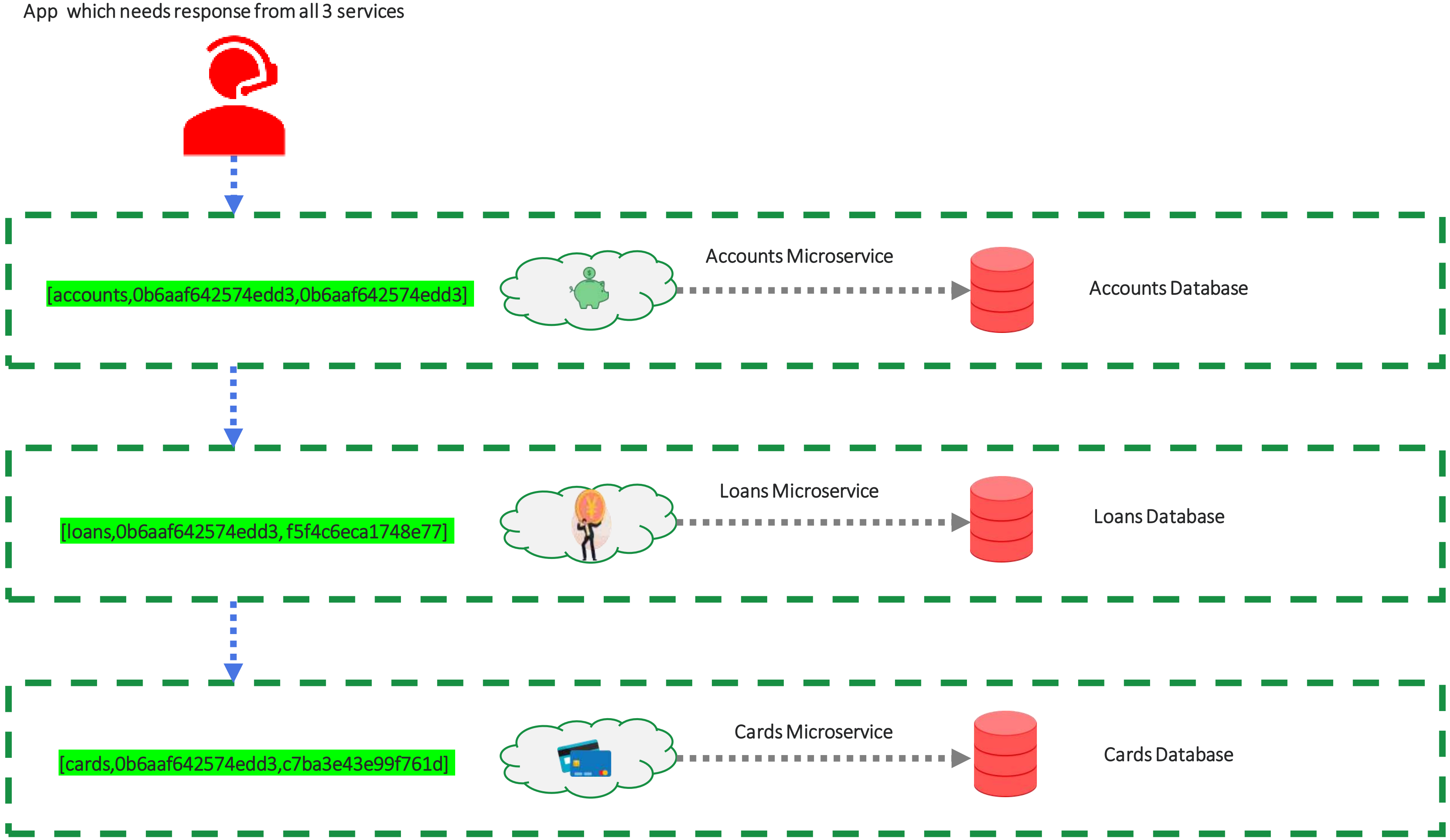
- Spring Cloud Sleuth will add three pieces of information to all the logs written by a microservice.

[<App Name>,<Trace ID>, <Span ID>]

- Application name of the service: This is going to be the application name where the log entry is being made. Spring Cloud Sleuth get this name from the 'spring.application.name' property.
- Trace ID: Trace ID is the equivalent term for correlation ID. It's a unique number that represents an entire transaction.
- Span ID: A span ID is a unique ID that represents part of the overall transaction. Each service participating within the transaction will have its own span ID. Span IDs are particularly relevant when you integrate with Zipkin to visualize your transactions.

SPRING CLOUD SLEUTH

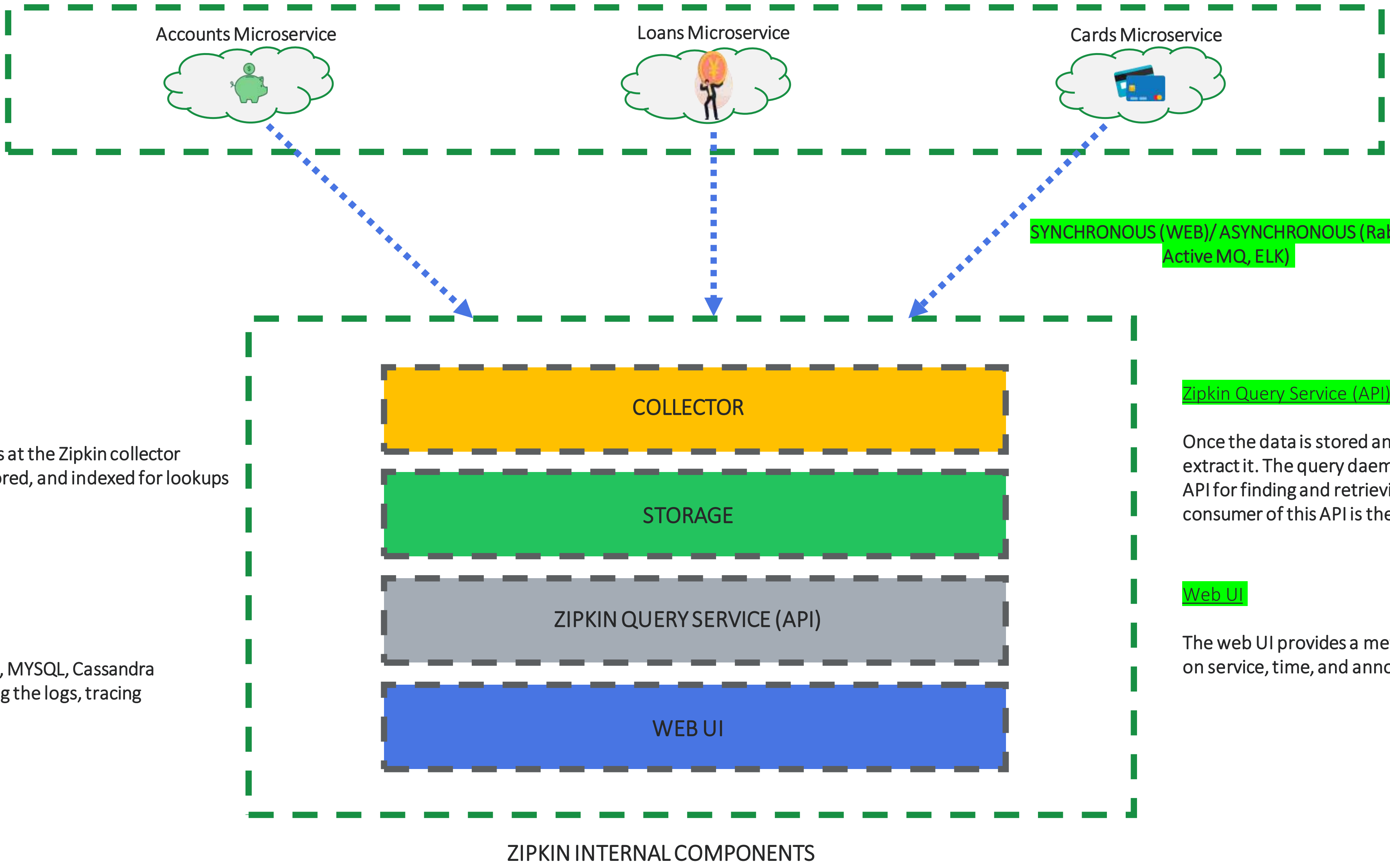
TRACE FORMAT



App which needs response from all 3 services
[accounts,0b6aaf642574edd3,0b6aaf642574edd3]
Accounts Microservice
Accounts Database
[loans,0b6aaf642574edd3, f5f4c6eca1748e77]
Loans Microservice
Loans Database
[cards,0b6aaf642574edd3,c7ba3e43e99f761d]
Cards Microservice
Cards Database

ZIPKIN

ARCHITECTURE OVERVIEW


Accounts Microservice
Loans Microservice
Cards Microservice
SYNCHRONOUS (WEB)/ ASYNCHRONOUS (Rabbit, Active MQ, ELK)
COLLECTOR
STORAGE
ZIPKIN QUERY SERVICE (API)
WEB UI
ZIPKIN INTERNAL COMPONENTS

Zipkin Collector

Once the trace data arrives at the Zipkin collector daemon, it is validated, stored, and indexed for lookups by the Zipkin collector.

Storage

Zipkin supports in-memory, MYSQL, Cassandra and Elasticsearch for storing the logs, tracing information.

Zipkin Query Service (API)

Once the data is stored and indexed, we need a way to extract it. The query daemon provides a simple JSON API for finding and retrieving traces. The primary consumer of this API is the Web UI.

Web UI

The web UI provides a method for viewing traces based on service, time, and annotations.

CHALLENGE 8 WITH MICROSERVICES

MONITORING MICROSERVICES HEALTH & METRICS

HOW DO WE MONITOR SERVICES METRICS?

How do we monitor the metrics like CPU usage, JVM metrics etc. for all the microservices applications we have inside our network easily and efficiently?

HOW DO WE MONITOR SERVICES HEALTH?

How do we monitor the status/health for all the microservices applications we have inside our network in a single place?

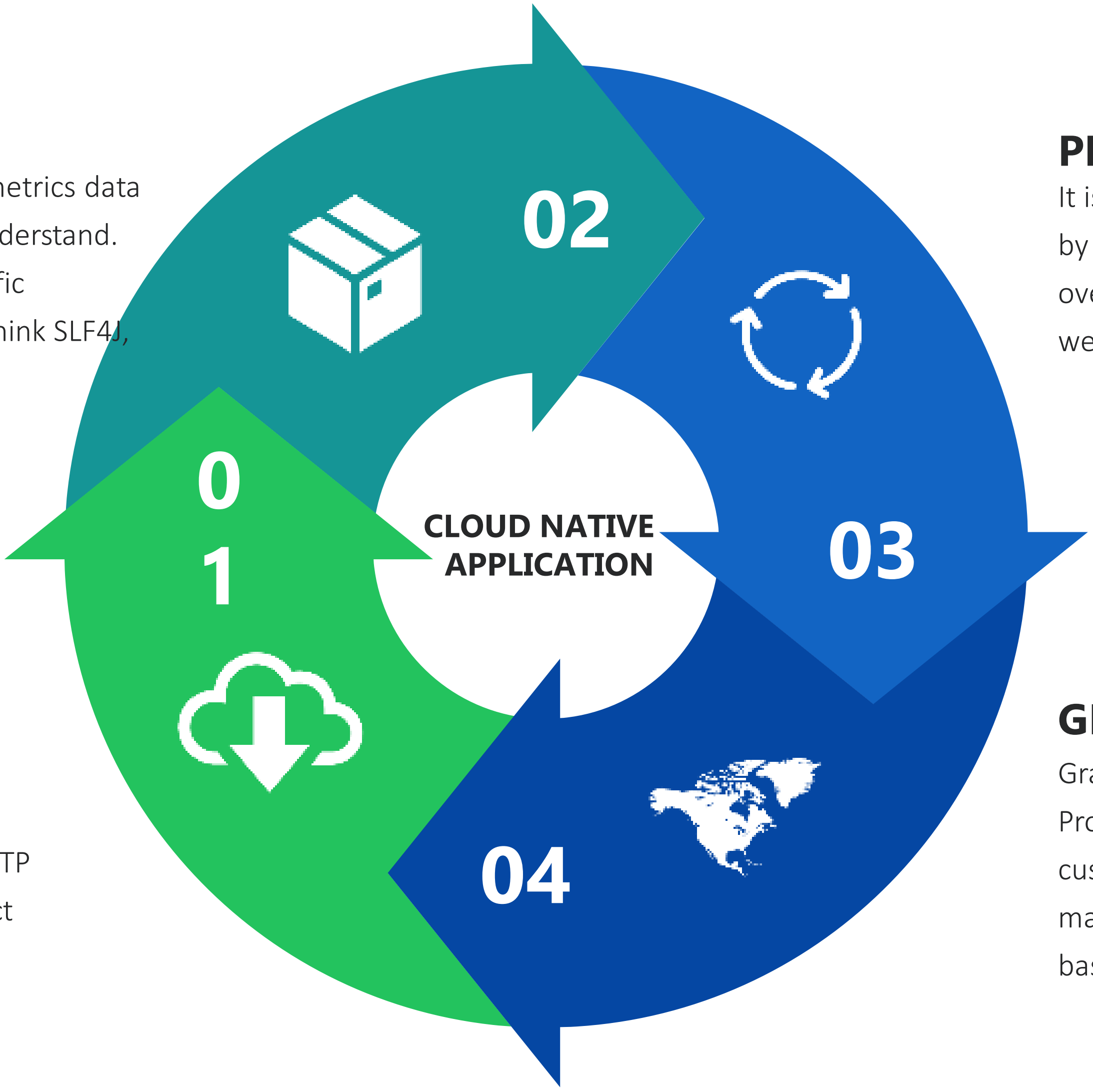
HOW DO WE CREATE ALERTS BASED ON MONITORING ?

How do we create alerts/notifications for any abnormal behavior of the services?

DIFF APPROACHES TO MONITOR

MICROSERVICES HEALTH & METRICS

eazy bytes



MICROMETER

Micrometer automatically exposes /actuator/metrics data into something your monitoring system can understand. All you need to do is include that vendor-specific micrometer dependency in your application. Think SLF4J, but for metrics.

ACTUATOR

Actuator is mainly used to expose operational information about the running application — health, metrics, info, dump, env, etc. It uses HTTP endpoints or JMX beans to enable us to interact with it.

PROMETHEUS

It is a time-series database that stores our metric data by pulling it (using a built-in data scraper) periodically over HTTP. It also has a simple user interface where we can visualize/query on all of the collected metrics.

GRAFANA

Grafana can pull data from various data sources like Prometheus and offers a rich UI where you can build up custom graphs quickly and create a dashboard out of many graphs in no time. It also allows you to set rule-based alerts, for notifications.

CHALLENGE 9 WITH MICROSERVICES

CONTAINER ORCHESTRATION

HOW DO WE AUTOMATE THE DEPLOYMENTS, ROLLOUTS & ROLLBACKS?

How do we automate deployment of the containers into a complex cluster env and perform rollout of new versions of the containers with out down time along with an option of automatic rollback in case of any issues?

HOW DO WE MAKE SURE OUR SERVICES ARE SELF-HEALING?

How do we automatically restarts containers that fail, replaces containers, kills containers that don't respond to your user-defined health check, and doesn't advertise them to clients until they are ready to serve.

HOW DO WE AUTO SCALE OUR SERVICES ?

How do we monitor our services and scale them automatically based on metrics like CPU Utilization etc. ?

KUBERNETES (K8S)

FOR CONTAINER ORCHESTRATION

- Kubernetes, is an open-source system for automating deployment, scaling, and managing containerized applications. It is the most famous orchestration platform and it is cloud neutral.

- The name Kubernetes originates from Greek, meaning helmsman or pilot. K8s as an abbreviation results from counting the eight letters between the "K" and the "s".

- Google open-sourced the Kubernetes project in 2014. Kubernetes combines over 15 years of Google's experience running production workloads at scale with best-of-breed ideas and practices from the community.

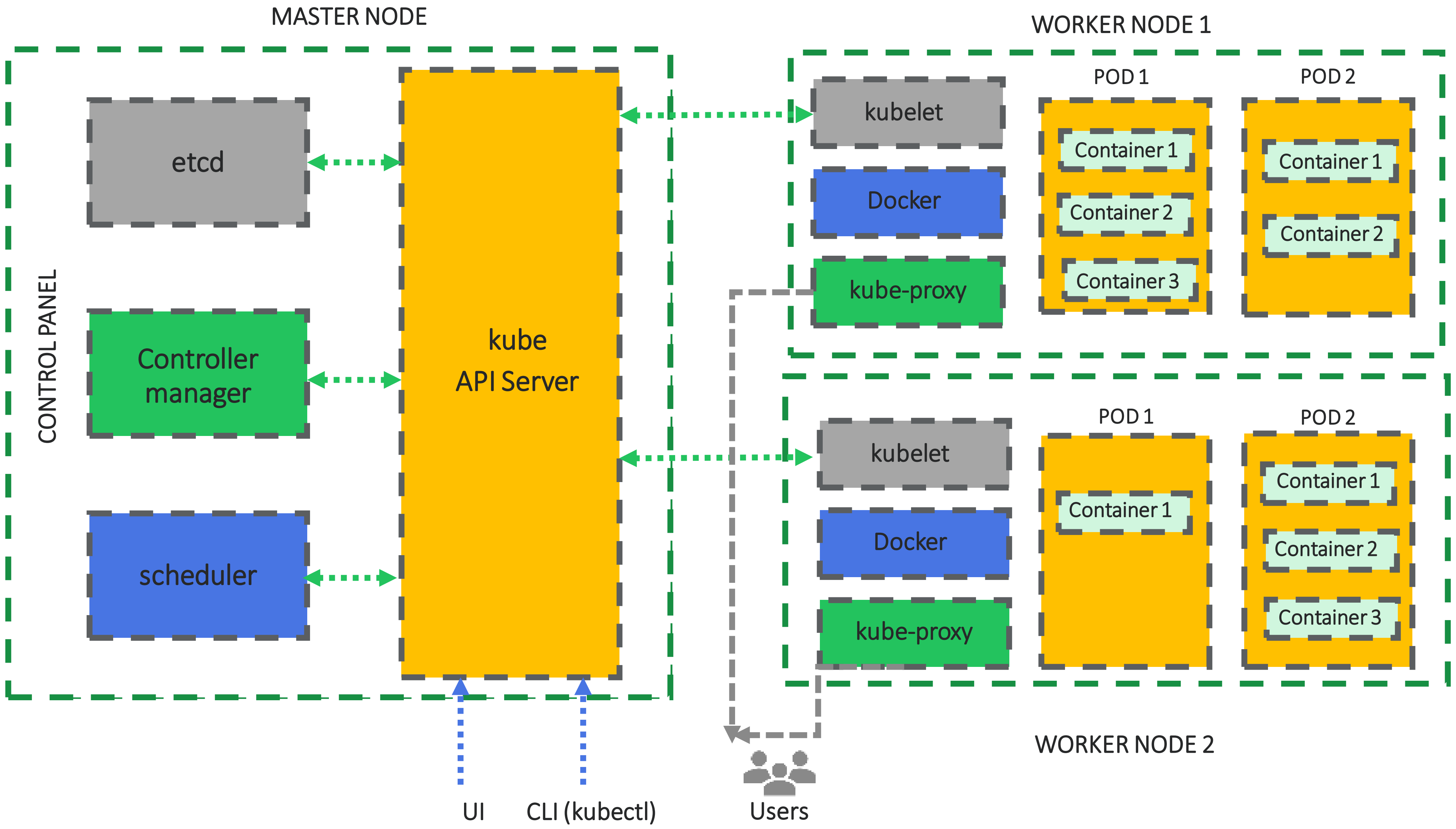
- Kubernetes provides you with a framework to run distributed systems resiliently. It takes care of scaling and failover for your application, provides deployment patterns, and more. It provides you with:

  - *Service discovery and load balancing*
  - *Storage orchestration*
  - *Automated rollouts and rollbacks*
  - *Automatic bin packing*
  - *Self-healing*
  - *Secret and configuration management*

KUBERNETES (K8S)

INTERNAL ARCHITECTURE

eazy bytes



KUBERNETES (K8S)

INTERNAL ARCHITECTURE

eazy bytes

Master Node (Control Plane)

- The master node is responsible for managing an entire cluster. It monitors the health check of all the nodes in the cluster, stores members' information regarding different nodes, plans the containers that are scheduled to certain worker nodes, monitors containers and nodes, etc. So, when a worker node fails, the master moves the workload from the failed node to another healthy worker node.

- The Kubernetes master is responsible for scheduling, provisioning, configuring, and exposing APIs to the client. So, all these are done by a master node using control plane components. Kubernetes takes care of service discovery, scaling, load balancing, self-healing, leader election, etc. Therefore, developers no longer have to build these services inside their applications.

KUBERNETES (K8S)
INTERNAL ARCHITECTURE

eazy bytes

Master Node (Control Plane)

- Four basic components of the master node (control plane):

  ✓ *API server - The API Server is the front-end of the control plane and the only component in the control plane that we interact with directly. Internal system components, as well as external user components, all communicate via the same API.*

  ✓ *Scheduler - Control plane component that watches for newly created Pods with no assigned node, and selects a node for them to run on. Factors taken into account for scheduling decisions include: individual and collective resource requirements, hardware/software/policy constraints, affinity and anti-affinity specifications, data locality, inter-workload interference, and deadlines.*

  ✓ *Controller manager - The controller manager maintains the cluster. It handles node failures, replicates components, maintains the correct number of pods, etc. It constantly tries to keep the system in the desired state by comparing it with the current state of the system.*

  ✓ *Etcd - Etcd is a data store that stores the cluster configuration. It is a distributed reliable, key-value store; all the configurations are stored in documents, and it's schema-less.*

KUBERNETES (K8S)

INTERNAL ARCHITECTURE

Worker Node (Data plane)

- The worker node is nothing but a virtual machine (VM) running in the cloud or on-prem (a physical server running inside your data center). So, any hardware capable of running container runtime can become a worker node. These nodes expose underlying compute, storage, and networking to the applications.

- Worker nodes do the heavy-lifting for the application running inside the Kubernetes cluster. Together, these nodes form a cluster – a workload assign is run to them by the master node component, similar to how a manager would assign a task to a team member. This way, we will be able to achieve fault-tolerance and replication.

- Pods are the smallest unit of deployment in Kubernetes just as a container is the smallest unit of deployment in Docker. To understand in an easy way, we can say that pods are nothing but lightweight VMs in the virtual world. Each pod consists of one or more containers. Pods are ephemeral in nature as they come and go, while containers are stateless in nature. Usually, we run a single container inside a pod. There are some scenarios where we will run multiple containers that are dependent on each other inside a single pod. Each time a pod spins up, it gets a new IP address with a virtual IP range assigned by the pod networking solution.

KUBERNETES (K8S)
INTERNAL ARCHITECTURE

eazy bytes

Worker Node (Data plane)

- There are three basic components of the worker node (data plane):
  - ✓ *Kubelet - An agent that runs on each node in the cluster. It makes sure that containers are running in a Pod. The kubelet takes a set of PodSpecs that are provided through various mechanisms and ensures that the containers described in those PodSpecs are running and healthy.*
  - ✓ *Kube-proxy - kube-proxy is a network proxy that runs on each node in your cluster, implementing part of the Kubernetes Service concept. kube-proxy maintains network rules on nodes. These network rules allow network communication to your Pods from network sessions inside or outside of your cluster.*
  - ✓ *Container runtime - Container runtime runs containers like Docker, or containerd. Once you have the specification that describes the image for your application, the container runtime will pull the images and run the containers.*

KUBERNETES (K8S)
SUPPORT BY CLOUD PROVIDERS

- Kubernetes is so modular, flexible, and extensible that it can be deployed on-prem, in a third-party data center, in any of the popular cloud providers and even across multiple cloud providers.

- Creating and maintaining a K8S cluster can be very challenge in on-prem. Due that many enterprises look for the cloud providers which will make their job easy to maintain their microservice architecture using Kubernetes.

- Below is the different famous cloud providers and their support to Kubernetes with the different names,

    - GCP - GKE (Google Kubernetes Engine)
    - AWS - EKS (Elastic Kubernetes Service)
    - Azure - AKS (Azure Kubernetes Service)

THANK YOU & CONGRATULATIONS

YOU ARE NOW A MASTER OF MICROSERVICES USING SPRING, DOCKER AND KUBERNETES

eazy bytes