微服务容错限流

Hystrix架构和实践

讲师：杨波

研发总监/资深架构师

第 1 部分

课程概述

课程大纲

01 课程概述

02 容错限流需求

03 容错限流原理

04 Netflix Hystrix背景介绍

05 Hystrix设计原理

06 Hystrix主要概念

07 信号量vs线程池隔离

08 Hystrix主要配置

09 Hystrix基础实验(Lab01)

课程大纲

10 Hystrix模拟案例分析(Code Review)

11 Hystrix+Dashboard实验(Lab02)

12 网关集成Hystrix(Code Review)

13 Spring Cloud Hystrix实验(Lab03)

14 Netflix Turbine简介

15 Hystrix生产最佳实践

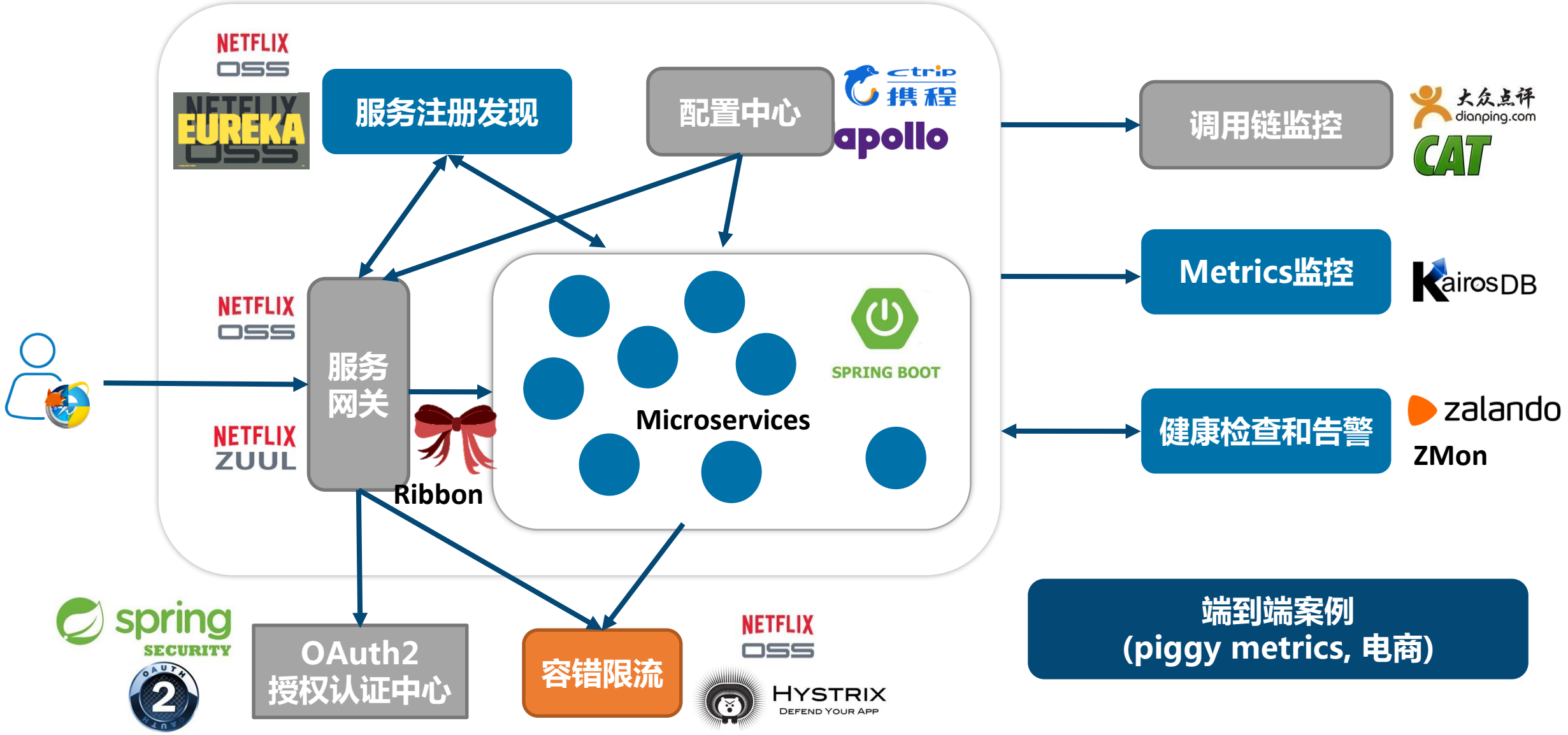
16 参考资料和后续课程预览

课程概述和亮点

1. 杨波的微服务基础架构体系的**第五个**模块
2. 容错限流**原理模式**剖析
3. Netflix开源容错限流组件**Hystrix深度剖析**
4. **Hystrix案例和实验**
5. **Zuul网关和Hystrix集成**
6. **Hystrix生产最佳实践**
7. **Spring Cloud Hystrix简介**

杨波的微服务基础架构体系2018预览(draft)

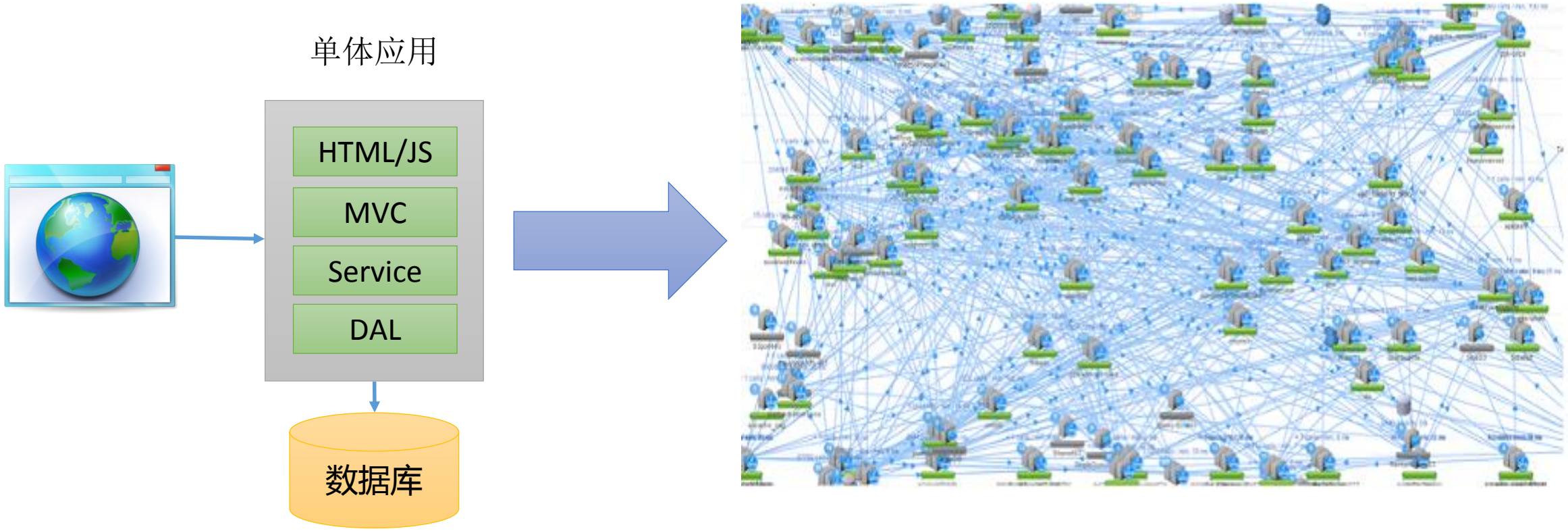
架构和技术栈预览


NETFLIX OSS
EUREKA
服务注册发现
配置中心
ctrip 携程
apollo
调用链监控
大众点评 dianping.com
CAT
NETFLIX OSS
服务网关
Metrics监控
KairosDB
NETFLIX ZUUL
Ribbon
Microservices
SPRING BOOT
健康检查和告警
zalando
ZMon
spring SECURITY
OAuth2 授权认证中心
容错限流
NETFLIX OSS
HYSTRIX
DEFEND YOUR APP
端到端案例
(piggy metrics, 电商)

第 2 部分

容错限流需求

从单块到微服务



微服务可用性

问题

假定一个**单块**服务的可用性是**99.99%**，如果我们有~**30个微服务**，每个的可用性都是99.99%，那么总体可用性是多少呢？

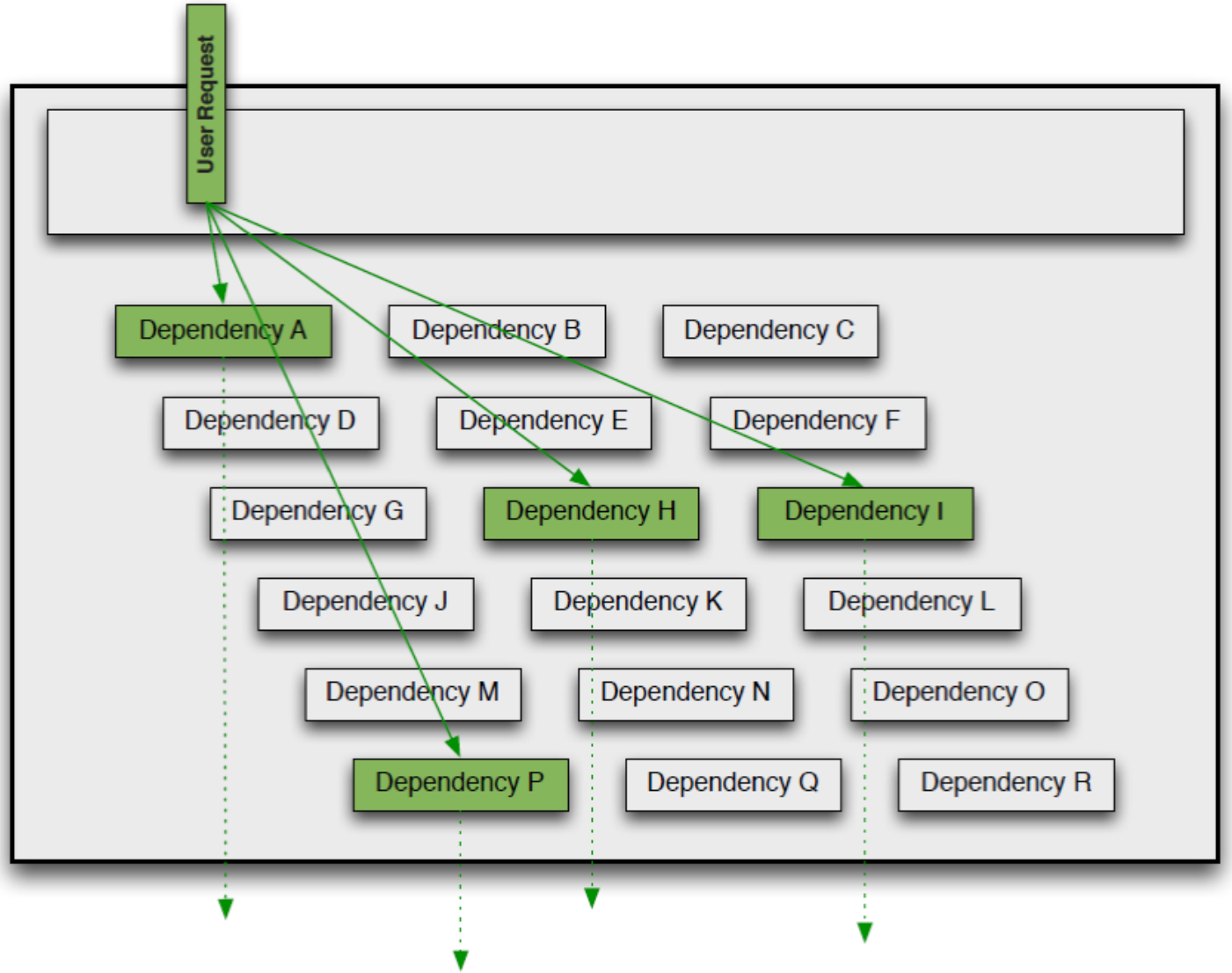
总体可用性

99.7% uptime!
每月**2小时**宕机时间
实际情况往往更糟糕

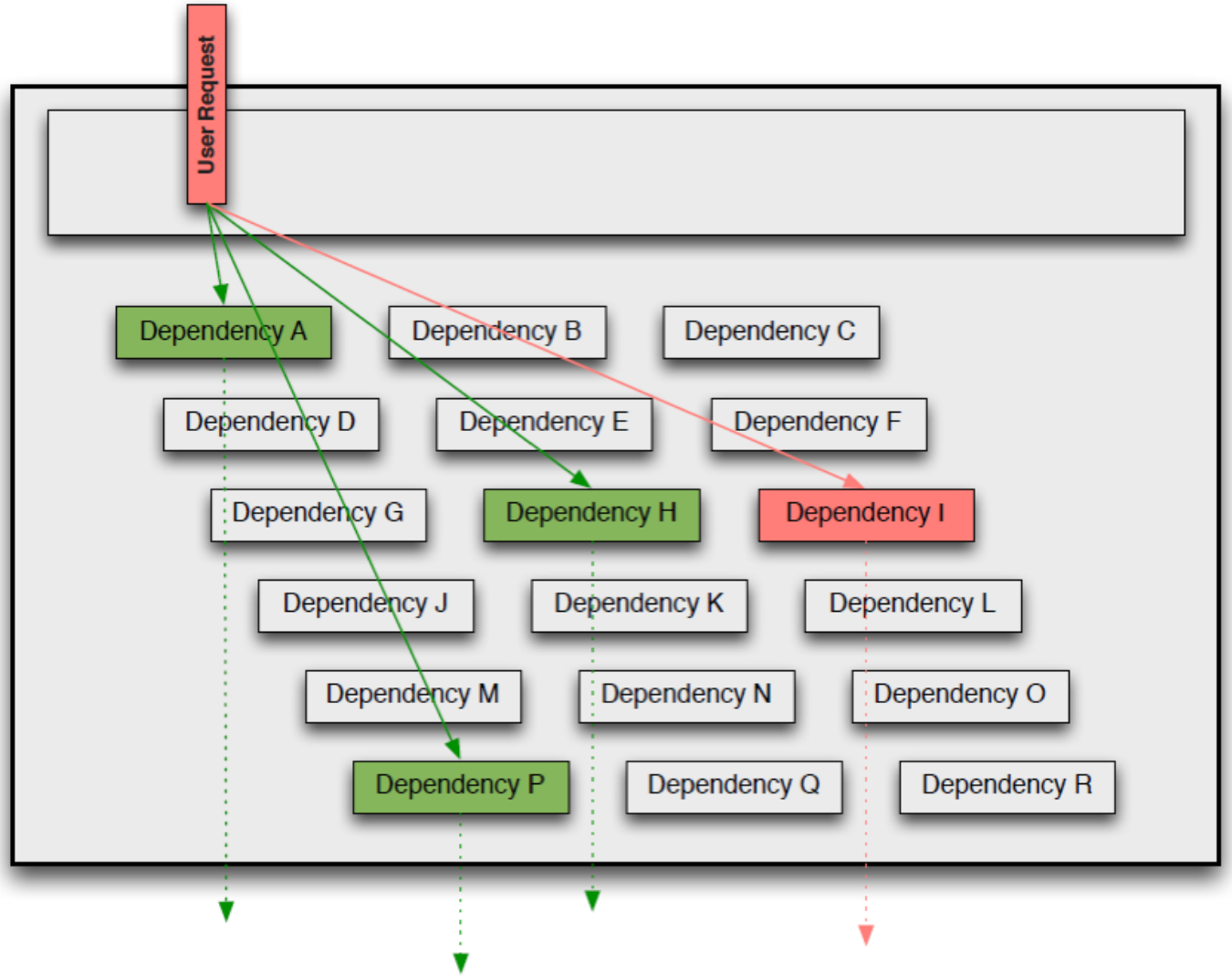
容错限流缺失的坑

- 复杂分布式系统通常有很多依赖，如果一个应用不能对来自依赖故障进行隔离，那么应用本身就处在被拖垮的风险中。在一个高流量的网站中，某个单一后端一旦发生延迟，将会在数秒内导致所有应用资源被耗尽
- 一个臭鸡蛋影响一篮筐
- 微服务需要容错限流！！！

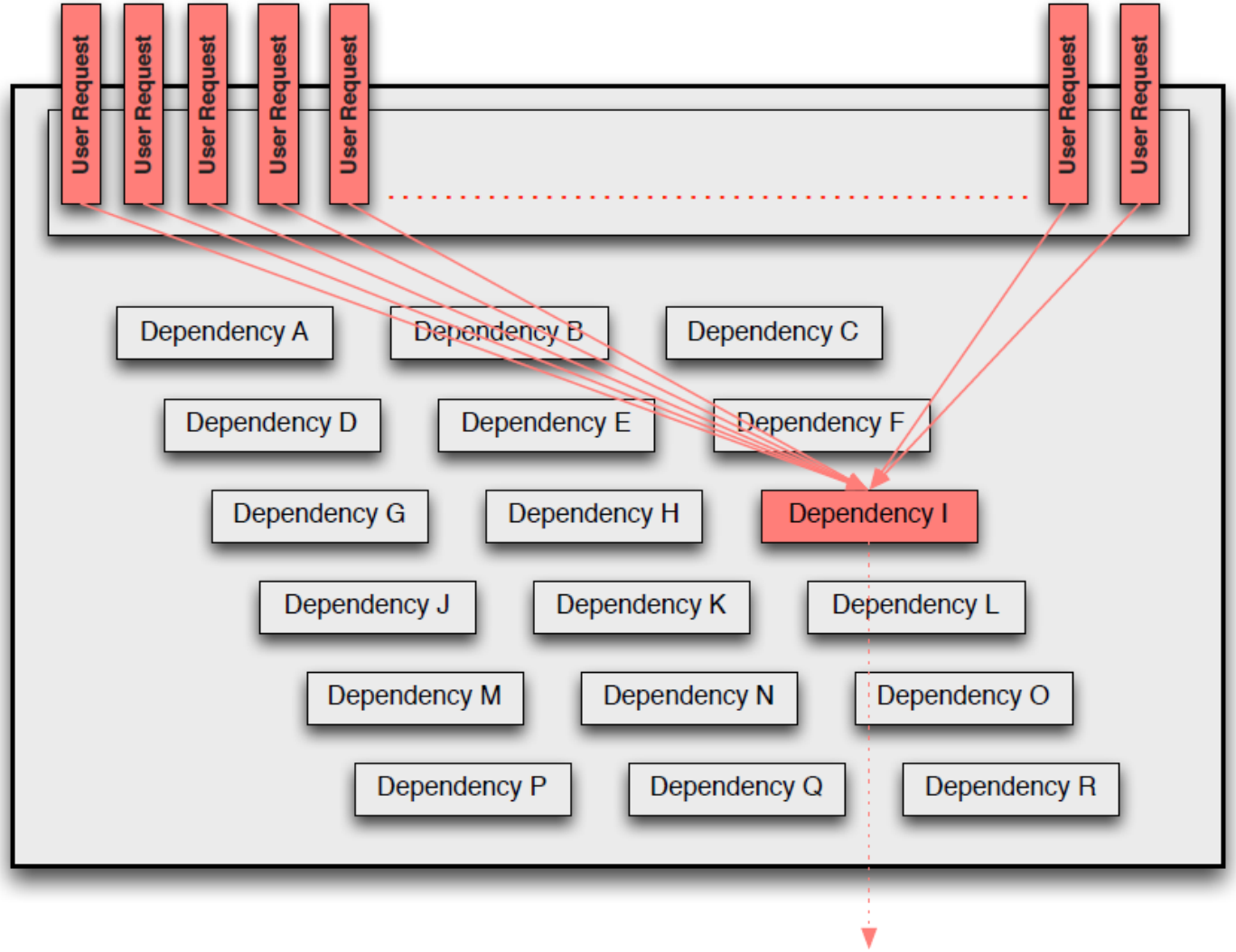
服务依赖


User Request
Dependency A
Dependency B
Dependency C
Dependency D
Dependency E
Dependency F
Dependency G
Dependency H
Dependency I
Dependency J
Dependency K
Dependency L
Dependency M
Dependency N
Dependency O
Dependency P
Dependency Q
Dependency R

单个服务延迟


User Request
Dependency A
Dependency B
Dependency C
Dependency D
Dependency E
Dependency F
Dependency G
Dependency H
Dependency I
Dependency J
Dependency K
Dependency L
Dependency M
Dependency N
Dependency O
Dependency P
Dependency Q
Dependency R

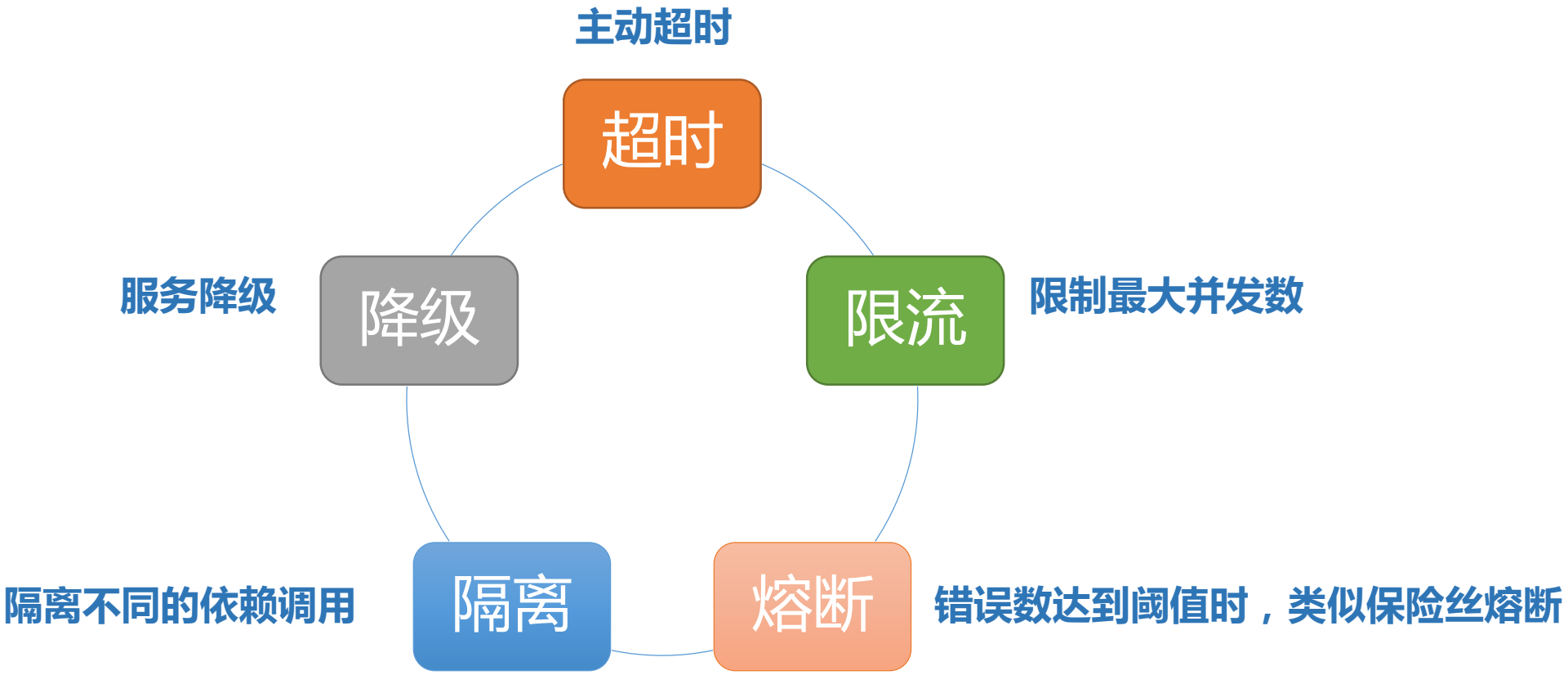
高峰期致雪崩效应


User Request
User Request
User Request
User Request
User Request
User Request
User Request
Dependency A
Dependency B
Dependency C
Dependency D
Dependency E
Dependency F
Dependency G
Dependency H
Dependency I
Dependency J
Dependency K
Dependency L
Dependency M
Dependency N
Dependency O
Dependency P
Dependency Q
Dependency R

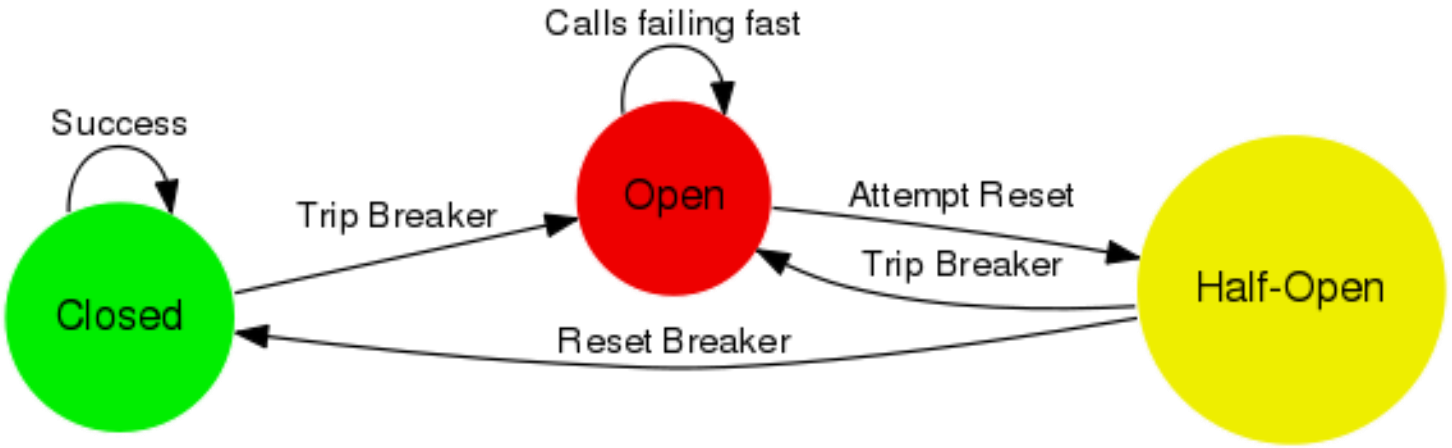
第 3 部分

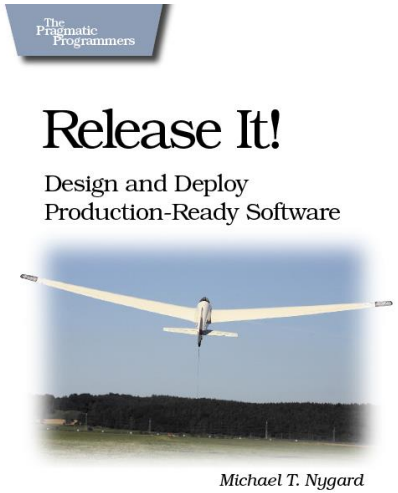
容错限流原理

基本的容错模式



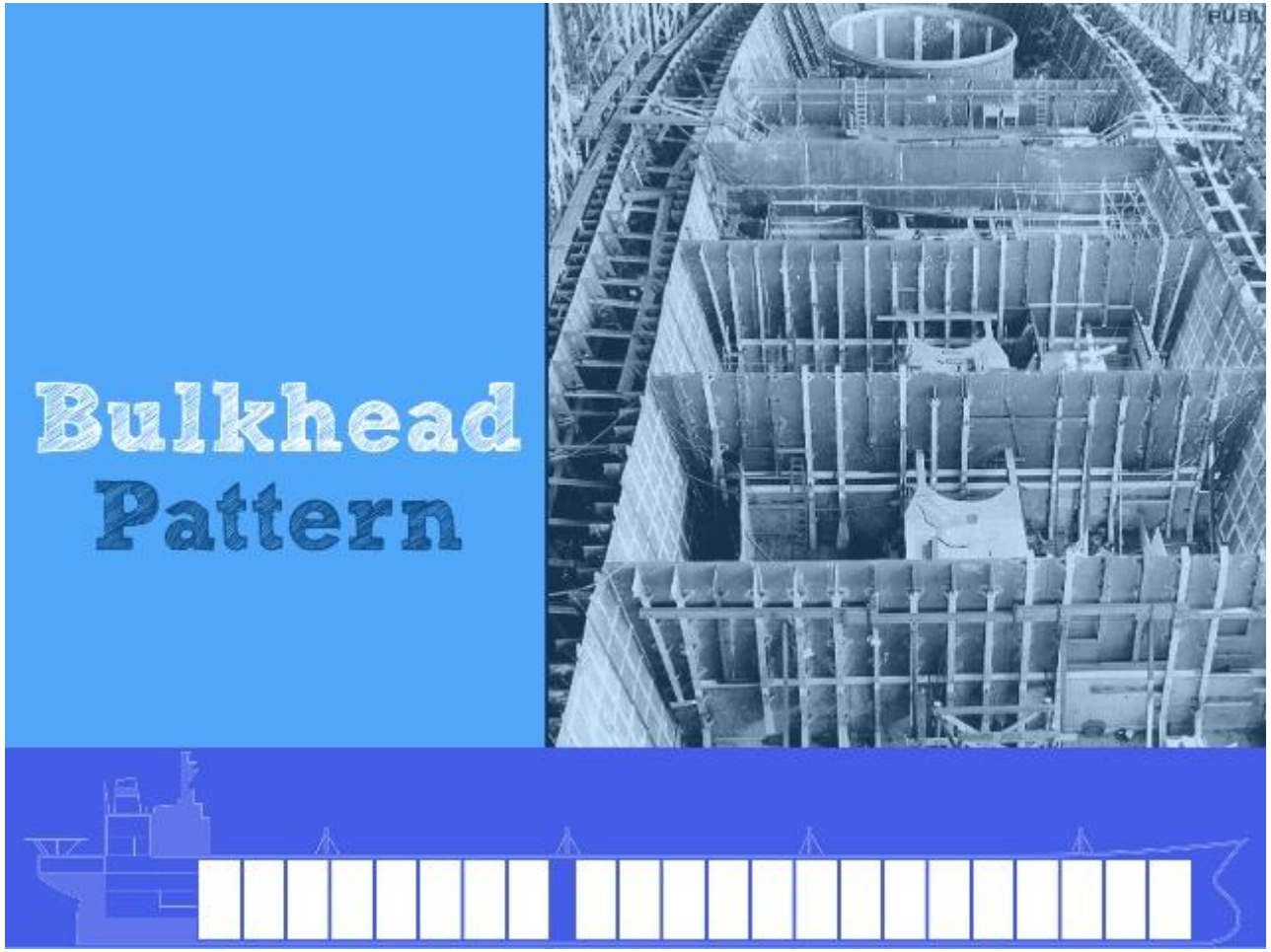
断路器模式


Calls failing fast
Success
Trip Breaker
Open
Attempt Reset
Trip Breaker
Half-Open
Closed
Reset Breaker


The Pragmatic Programmers
Release It!
Design and Deploy
Production-Ready Software
Michael T. Nygard


RU
RLM01-R1N

舱壁隔离模式



容错理念

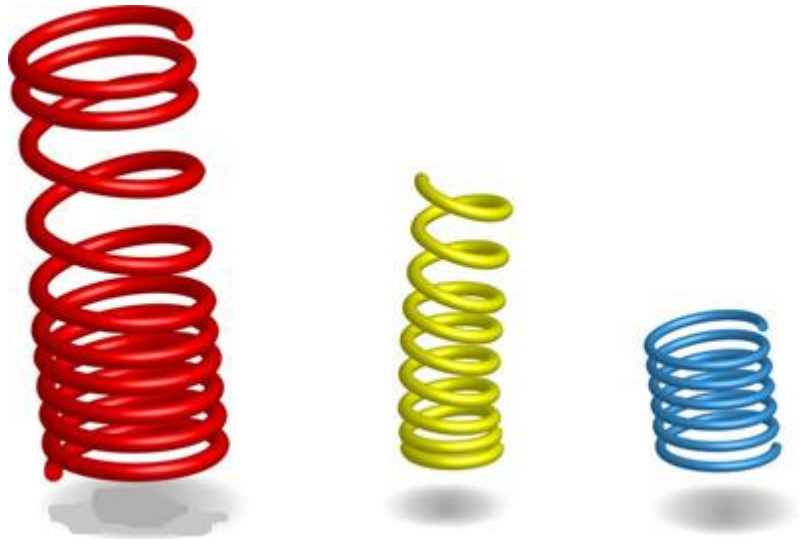
- 凡是依赖都可能会失败
- 凡是资源都有限制
  - CPU/Memory/Threads/Queue
- 网络并不可靠
- 延迟是应用稳定性杀手

弹性(Resilience)理念

在被弯曲，压缩或者拉伸之后，能够恢复原状的能力。

从疾病，抑郁和困境等类似情况中恢复出来的能力。

工程师需要弹性思维！！！

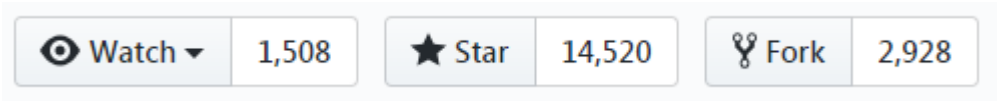


第 4 部分

Netflix Hystrix背景介绍

起源和现状(2013)

- Hystrix源于Netflix API团队在2011年启动的弹性工程项目，目前(2013)它在Netflix每天处理**数百亿**的线程隔离以及**数千亿**的信号量隔离调用
  - http://www.infoq.com/cn/news/2013/01/netflix-hystrix-fault-tolerance
- Hystrix是基于Apache License 2.0协议的开源库，目前托管在github上，当前超过**1.4万**颗星
  - https://github.com/Netflix/Hystrix
- Netflix云端开源工具Hystrix曾助奥巴马竞选
  - http://it.sohu.com/20121129/n358943361.shtml

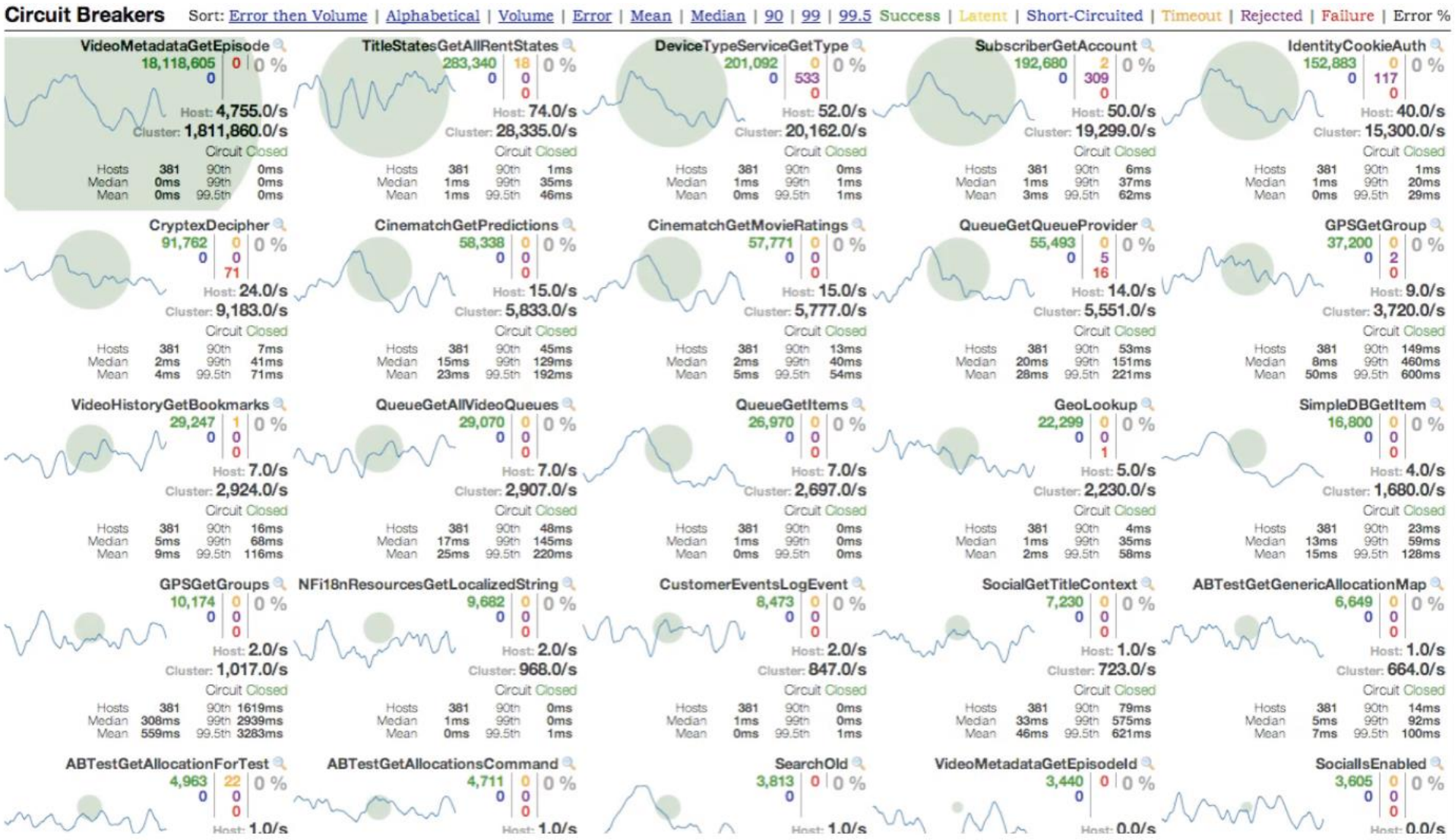


Hystrix主要作者

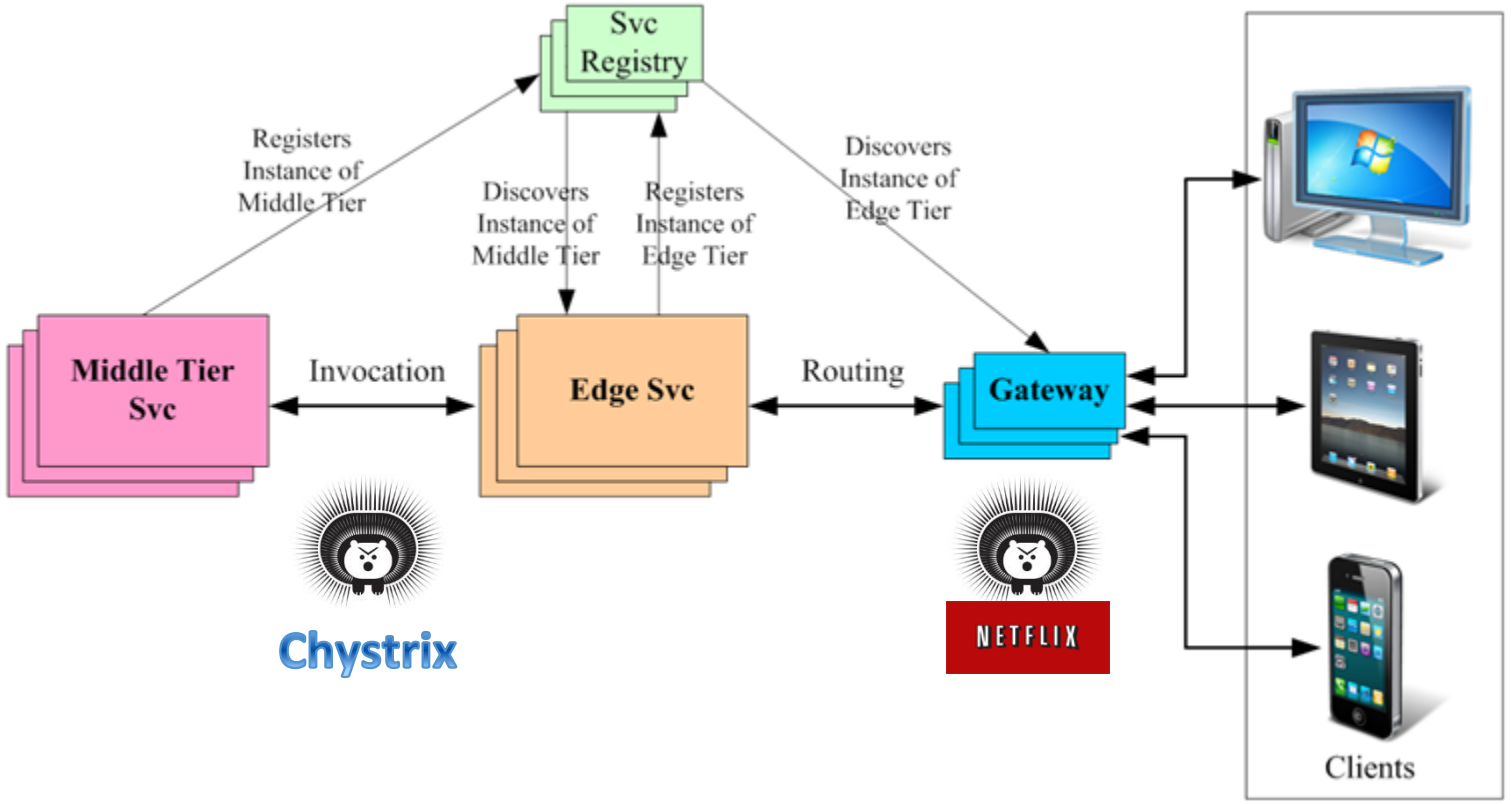
Ben Christensen

https://www.linkedin.com/in/benjchristensen

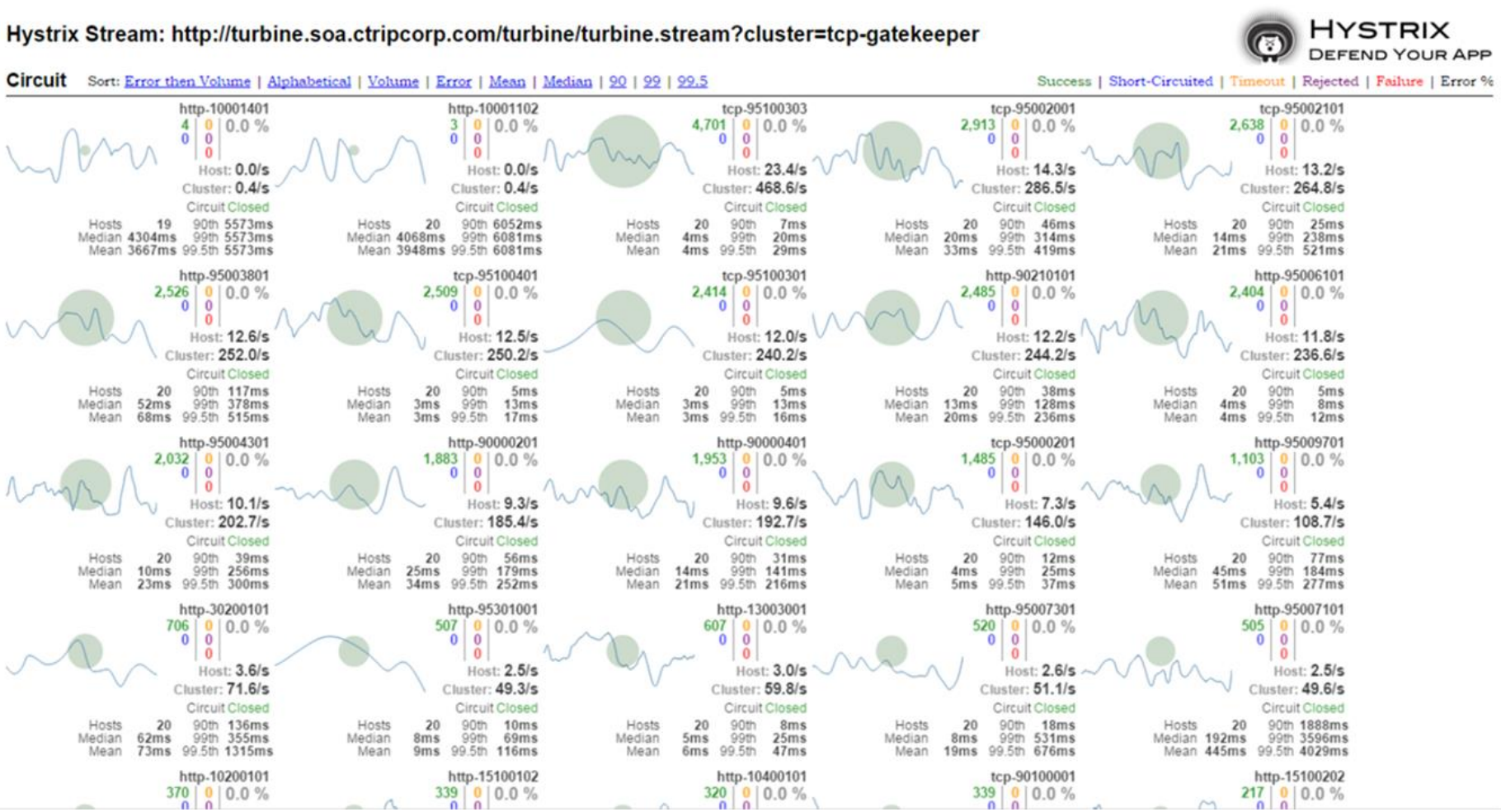
Netflix Hystrix Dashboard



携程案例(2015)


Svc
Registry
Registers
Instance of
Middle Tier
Discovers
Instance of
Middle Tier
Registers
Instance of
Edge Tier
Discovers
Instance of
Edge Tier
Middle Tier
Svc
Invocation
Edge Svc
Routing
Gateway
Chystrix
NETFLIX
Clients

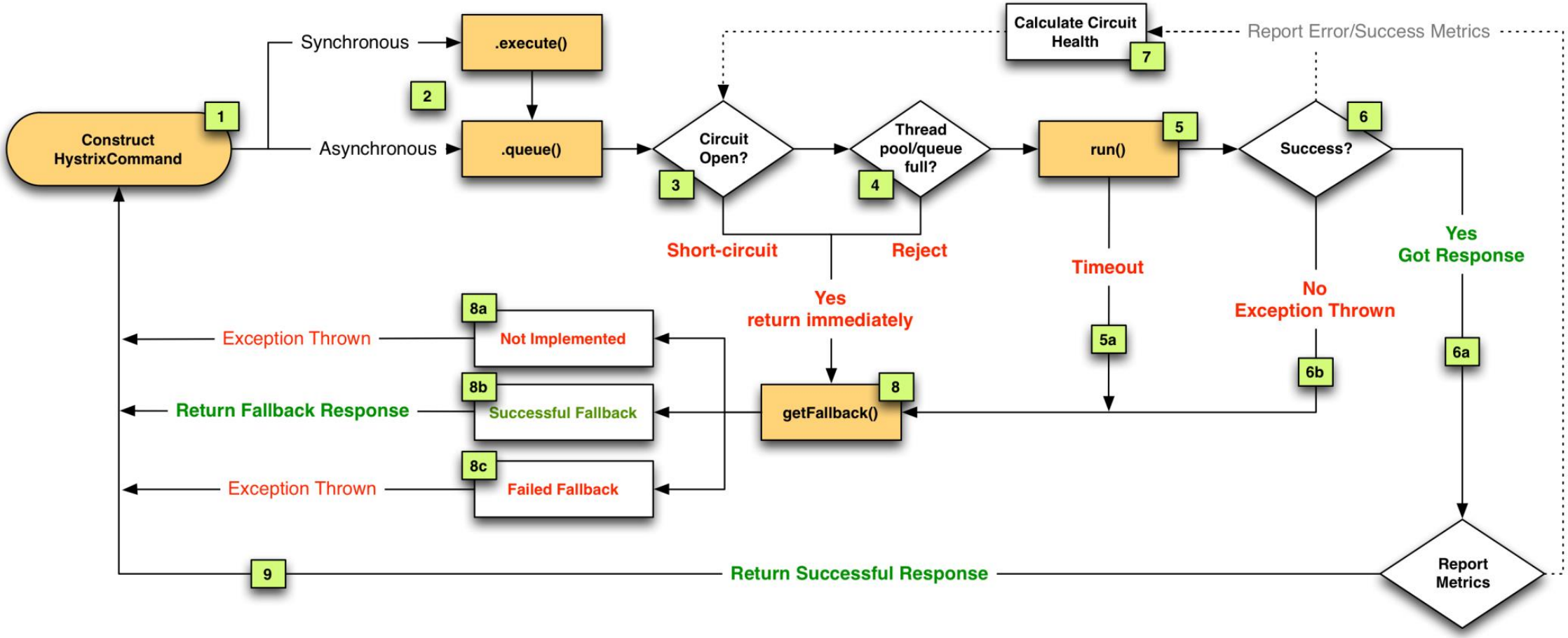
CTrip Hystrix Dashboard



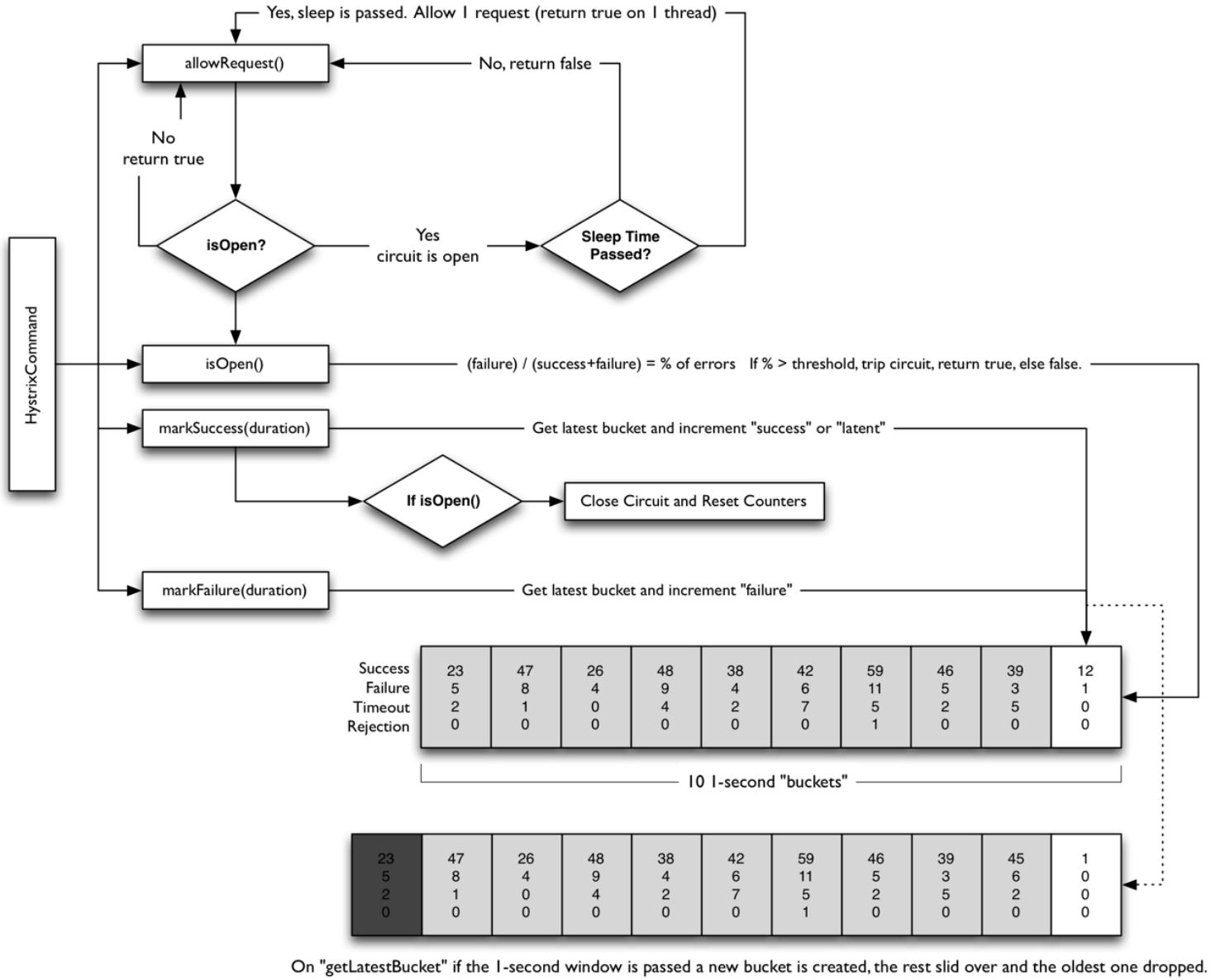
第5部分

Hystrix设计原理

Hystrix工作流程(自适应反馈机)



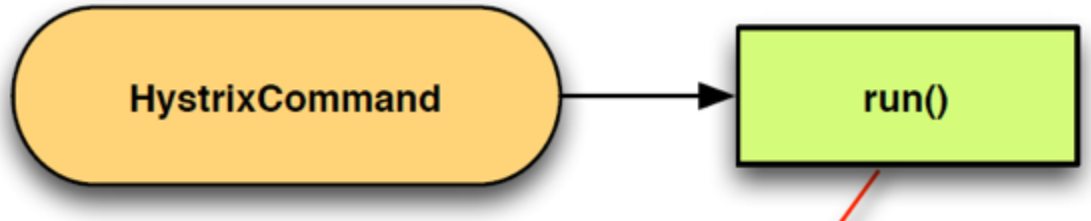
断路器内核


Yes, sleep is passed. Allow 1 request (return true on 1 thread)
allowRequest()
No, return false
No
return true
isOpen?
Yes
circuit is open
Sleep Time
Passed?
HystrixCommand
isOpen()
(failure) / (success+failure) = % of errors If % > threshold, trip circuit, return true, else false.
markSuccess(duration)
Get latest bucket and increment "success" or "latent"
If isOpen()
Close Circuit and Reset Counters
markFailure(duration)
Get latest bucket and increment "failure"
Success
Failure
Timeout
Rejection
23 5 2 0
47 8 1 0
26 4 0 0
48 9 4 0
38 4 2 0
42 6 7 0
59 11 5 1
46 5 2 0
39 3 5 0
12 1 0 0
10 1-second "buckets"
23 5 2 0
47 8 1 0
26 4 0 0
48 9 4 0
38 4 2 0
42 6 7 0
59 11 5 1
46 5 2 0
39 3 5 0
45 6 2 0
1 0 0 0
On "getLatestBucket" if the 1-second window is passed a new bucket is created, the rest slid over and the oldest one dropped.

第 6 部分

Hystrix主要概念

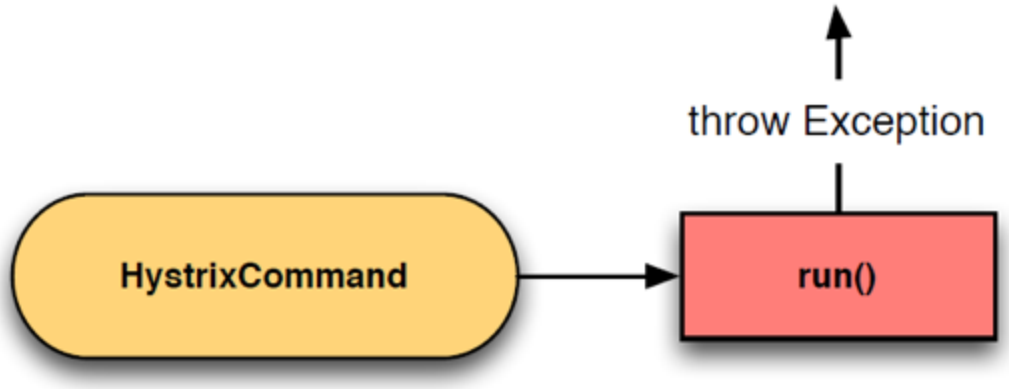
Hystrix Command



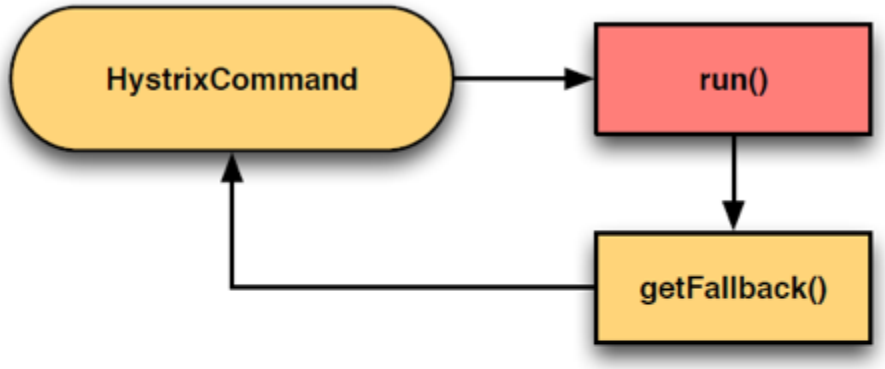

```
public class CommandHelloWorld extends HystrixCommand<String> {

    ...

    protected String run() {
        return "Hello " + name + "!";
    }
}
```

run() INVOKES "CLIENT" LOGIC

Fail Fast

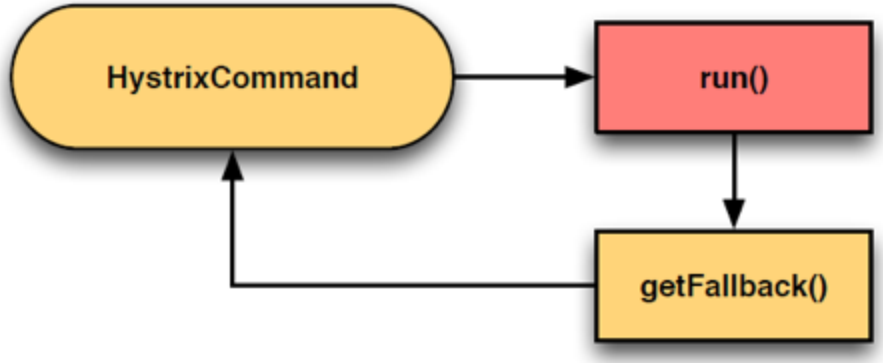


Fail Silent



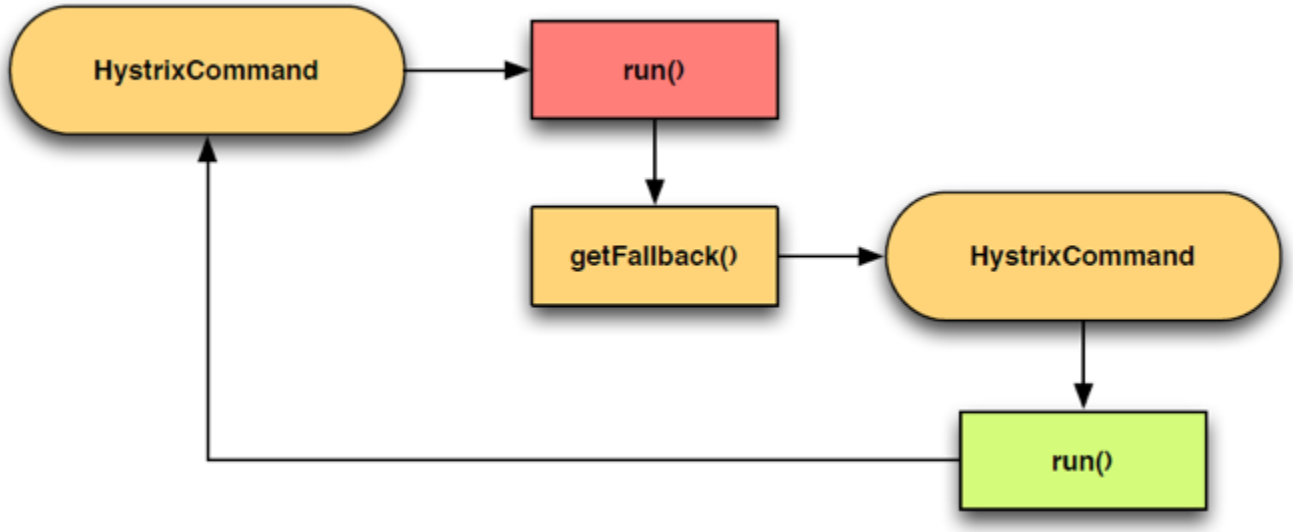

```
return null;
return new Option<T>();
return Collections.emptyList();
return Collections.emptyMap();
```

Static Fallback

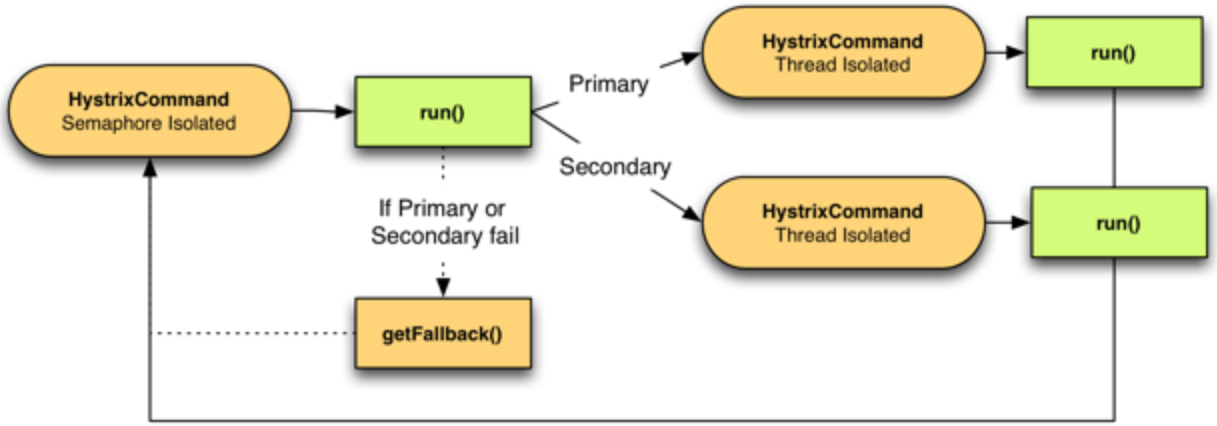



```
return true;
return DEFAULT_OBJECT;
```

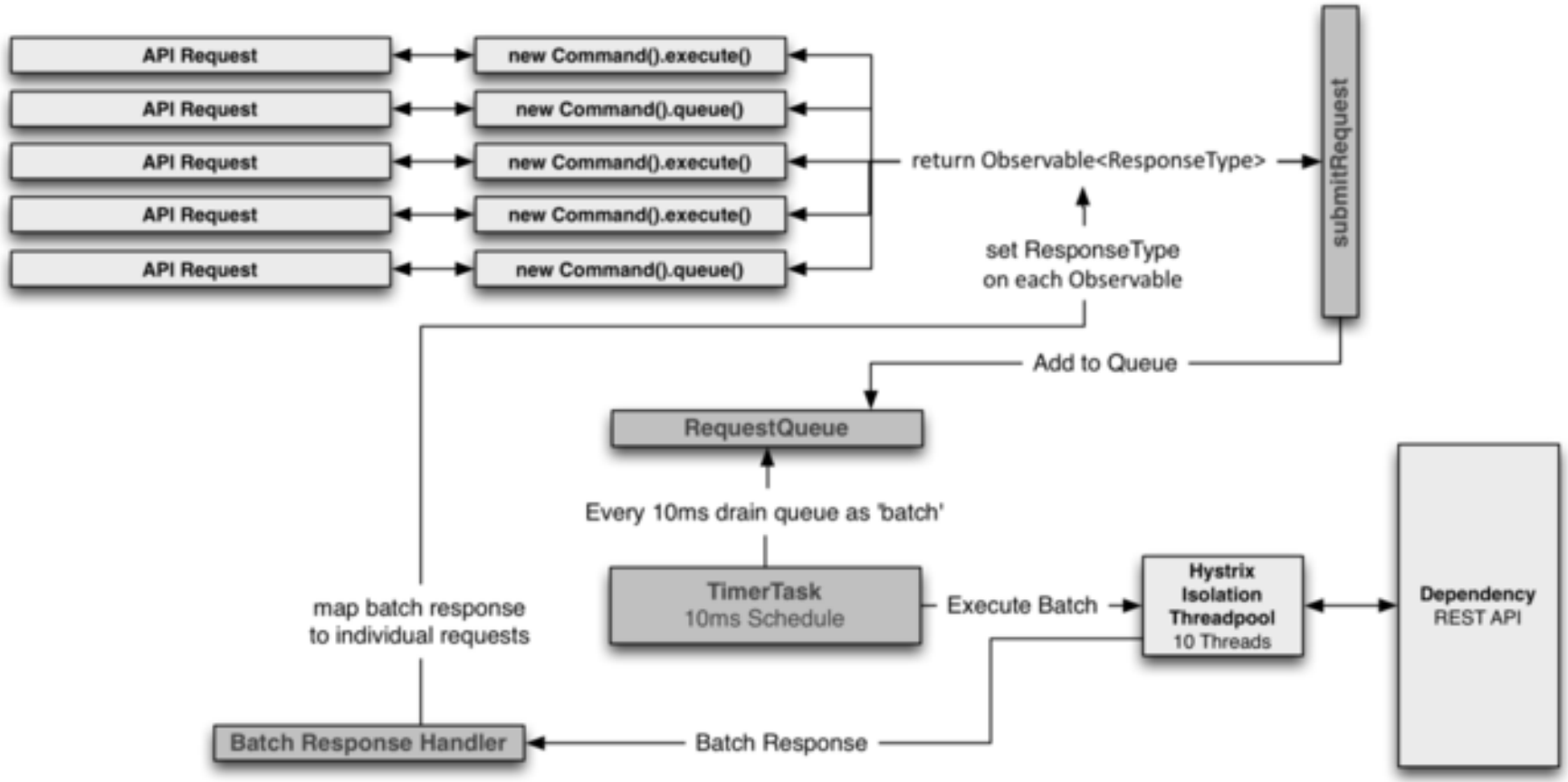
Fallback via Network



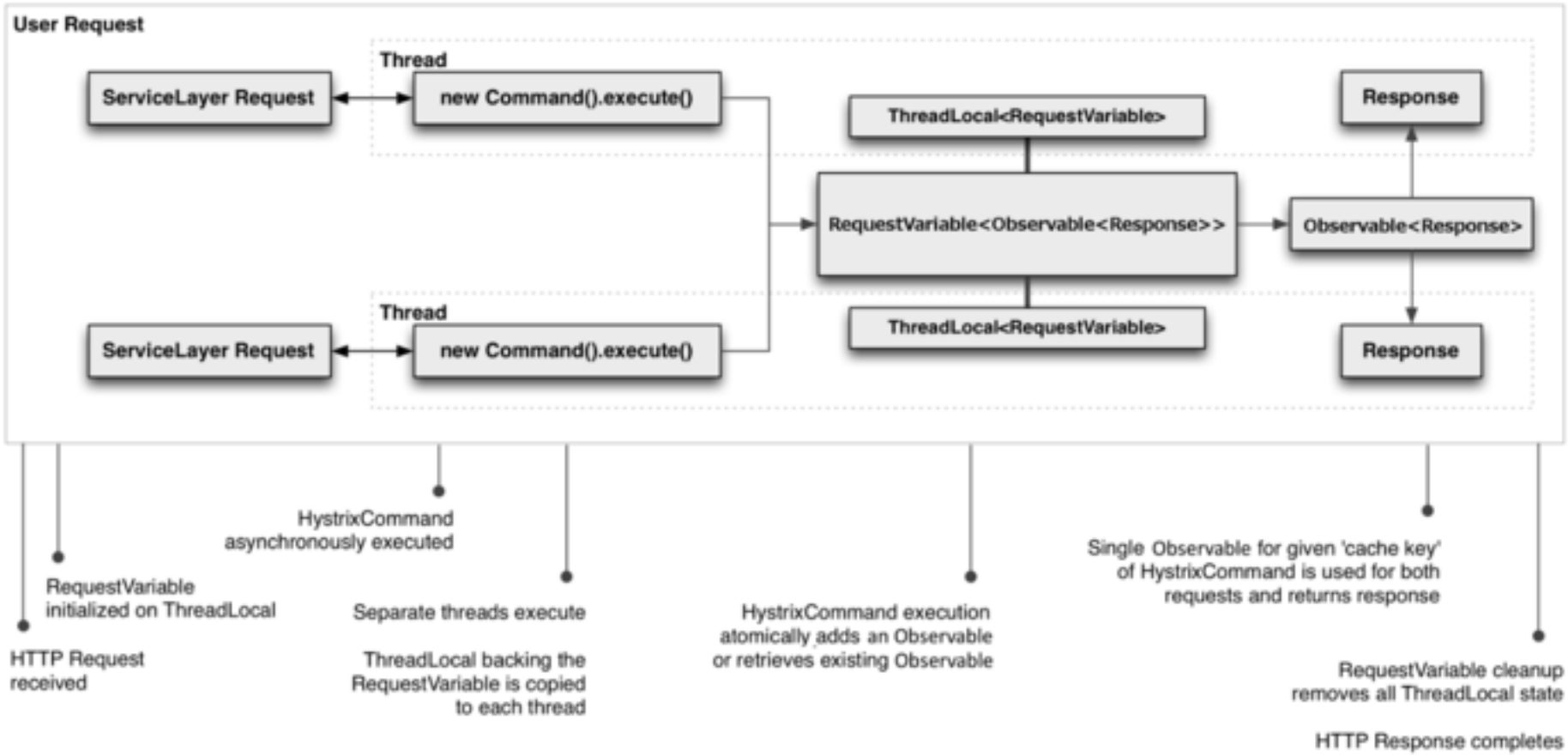
Primary + Secondary with Fallback



请求合并


API Request
API Request
API Request
API Request
API Request
new Command().execute()
new Command().queue()
new Command().execute()
new Command().execute()
new Command().queue()
return Observable<ResponseType>
submitRequest
set ResponseType
on each Observable
Add to Queue
RequestQueue
Every 10ms drain queue as 'batch'
TimerTask
10ms Schedule
Execute Batch
Hystrix
Isolation
Threadpool
10 Threads
Dependency
REST API
map batch response
to individual requests
Batch Response Handler
Batch Response

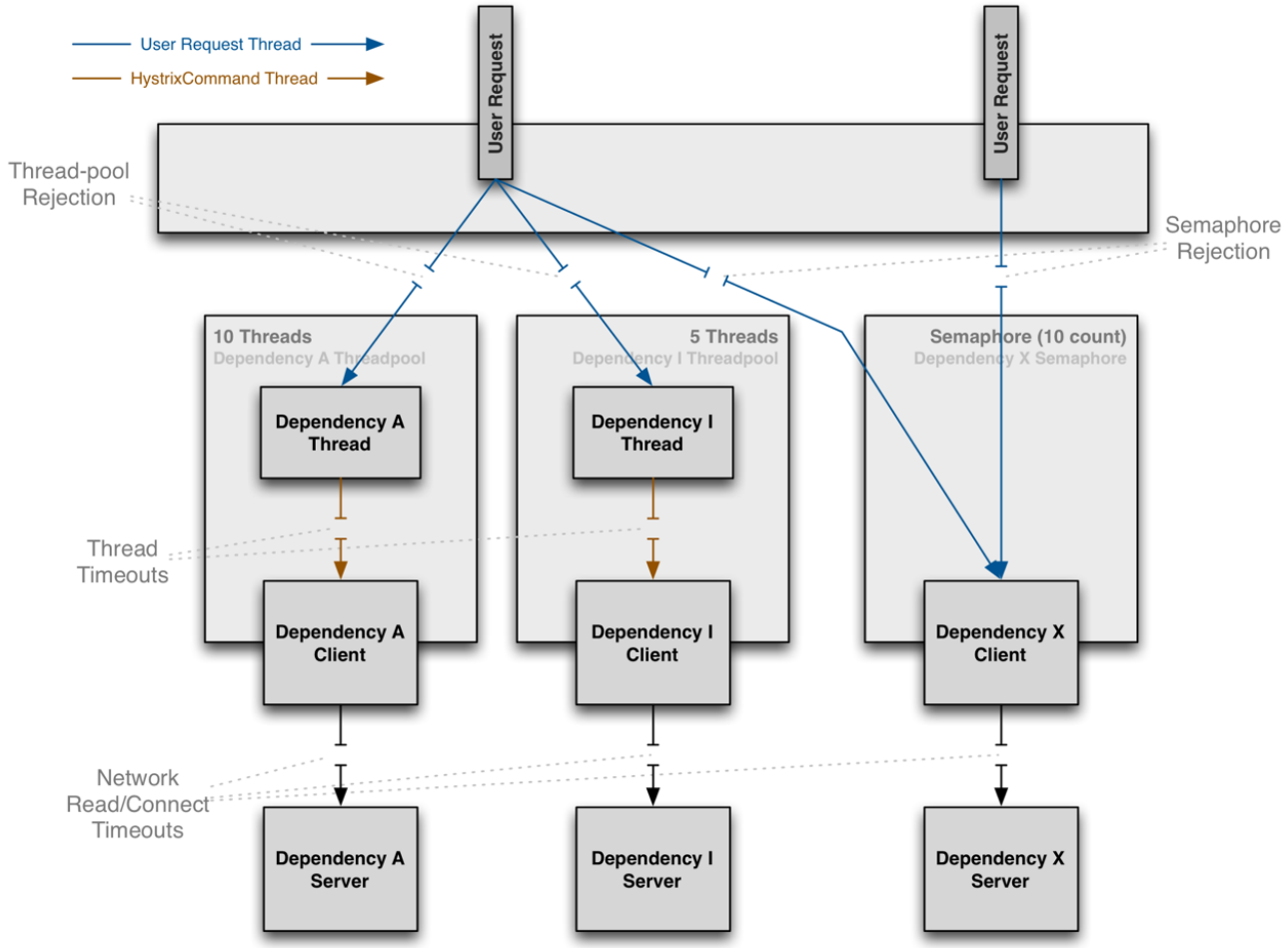
请求缓存


User Request
Thread
ServiceLayer Request
new Command().execute()
ThreadLocal<RequestVariable>
Response
RequestVariable<Observable<Response>>
Observable<Response>
Thread
ServiceLayer Request
new Command().execute()
ThreadLocal<RequestVariable>
Response
HystrixCommand asynchronously executed
RequestVariable initialized on ThreadLocal
Separate threads execute
HTTP Request received
ThreadLocal backing the RequestVariable is copied to each thread
HystrixCommand execution atomically adds an Observable or retrieves existing Observable
Single Observable for given 'cache key' of HystrixCommand is used for both requests and returns response
RequestVariable cleanup removes all ThreadLocal state
HTTP Response completes

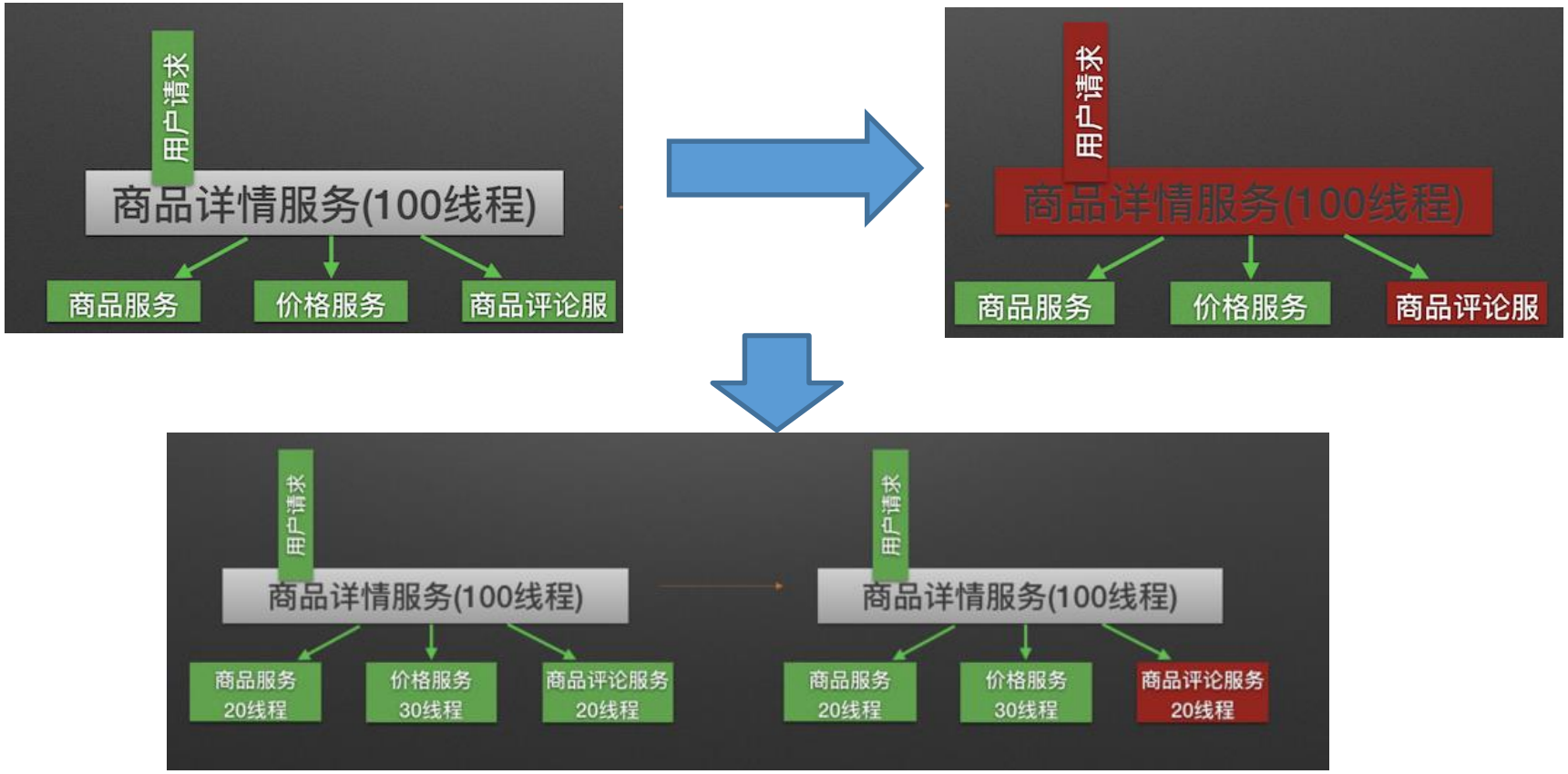
第 7 部分

信号量vs线程池隔离

线程和信号量隔离


User Request Thread
HystrixCommand Thread
User Request
User Request
Thread-pool Rejection
Semaphore Rejection
10 Threads
Dependency A Threadpool
5 Threads
Dependency I Threadpool
Semaphore (10 count)
Dependency X Semaphore
Dependency A Thread
Dependency I Thread
Thread Timeouts
Dependency A Client
Dependency I Client
Dependency X Client
Network Read/Connect Timeouts
Dependency A Server
Dependency I Server
Dependency X Server

线程隔离案例



防雪崩利器：熔断器Hystrix的原理与使用
https://segmentfault.com/a/1190000005988895

线程 vs 信号量隔离

- 信号量隔离
- 优点
  - 轻量，无额外开销
- 不足
  - 不支持任务排队和主动超时
  - 不支持异步调用
- 适用
  - 受信客户
  - 高扇出(网关)
  - 高频高速调用(cache)

- 线程池隔离
- 优点
  - 支持排队和超时
  - 支持异步调用
- 不足
  - 线程调用会产生额外的开销
- 适用
  - 不受信客户
  - 有限扇出

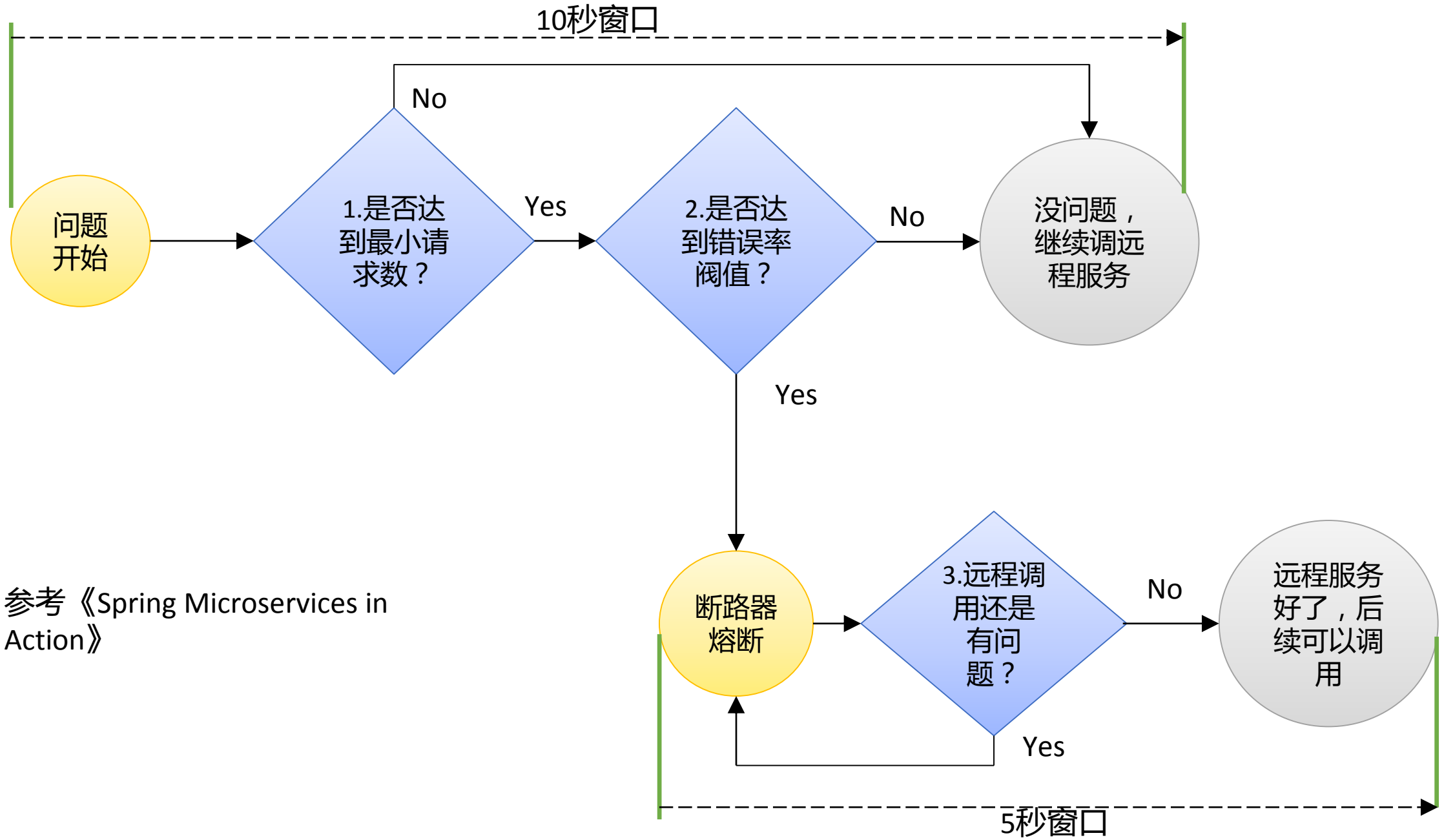
第 8 部分

Hystrix主要配置项

主要配置项

配置项(前缀hystrix.command.*.)	含义
execution.isolation.strategy	线程“THREAD”或信号量“SEMAPHORE”隔离(Default: THREAD)
execution.isolation.thread.timeoutInMilliseconds	run()方法执行超时时间(Default: 1000)
execution.isolation.semaphore.maxConcurrentRequests	信号量隔离最大并发数(Default:10)
circuitBreaker.errorThresholdPercentage	熔断的错误百分比阀值(Default:50)
circuitBreaker.requestVolumeThreshold	断路器生效必须满足的流量阀值(Default:20)
circuitBreaker.sleepWindowInMilliseconds	熔断后重置断路器的时间间隔(Default:5000)
circuitBreaker.forceOpen	设true表示强制熔断器进入打开状态(Default: false)
circuitBreaker.forceClosed	设true表示强制熔断器进入关闭状态(Default: false)

配置项(前缀hystrix.threadpool.*.)	含义
coreSize	使用线程池时的最大并发请求(Default: 10)
maxQueueSize	最大LinkedBlockingQueue大小，-1表示用SynchronousQueue(Default:-1)
default.queueSizeRejectionThreshold	队列大小阀值，超过则拒绝(Default:5)



参考《Spring Microservices in Action》

第 9 部分

Hystrix基础实验（Lab01）

第10部分

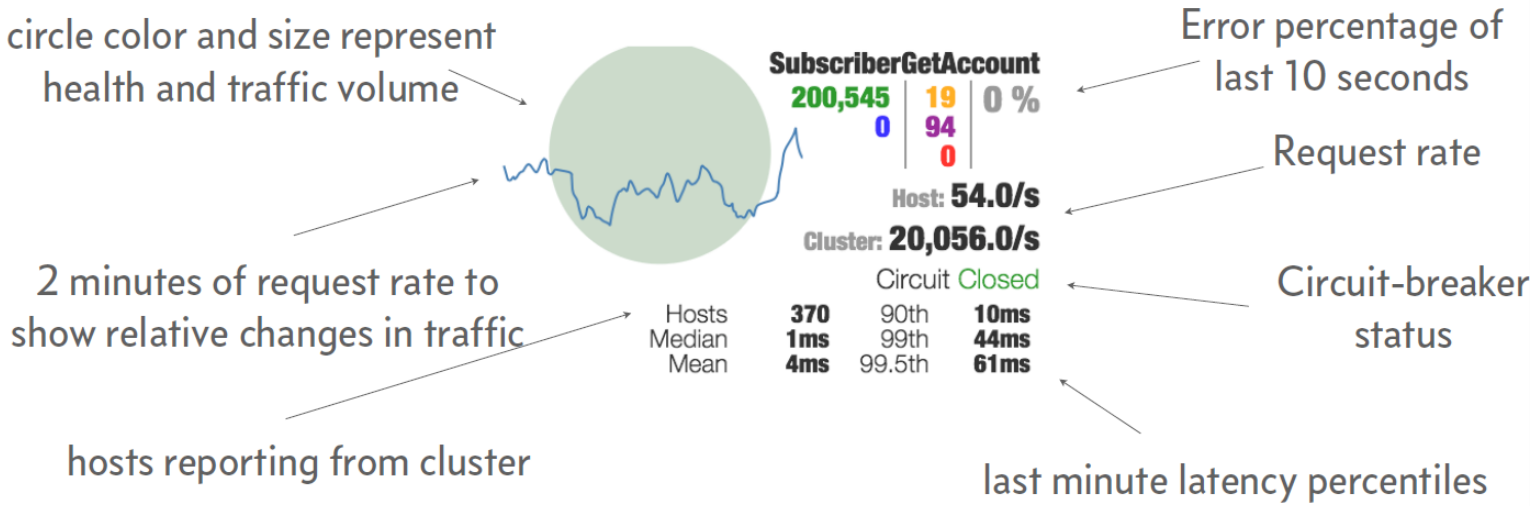
Hystrix模拟案例分析(Code Review)

模拟交易

第11部分

Hystrix + Dashboard实验（Lab02）

Hystrix Dashboard

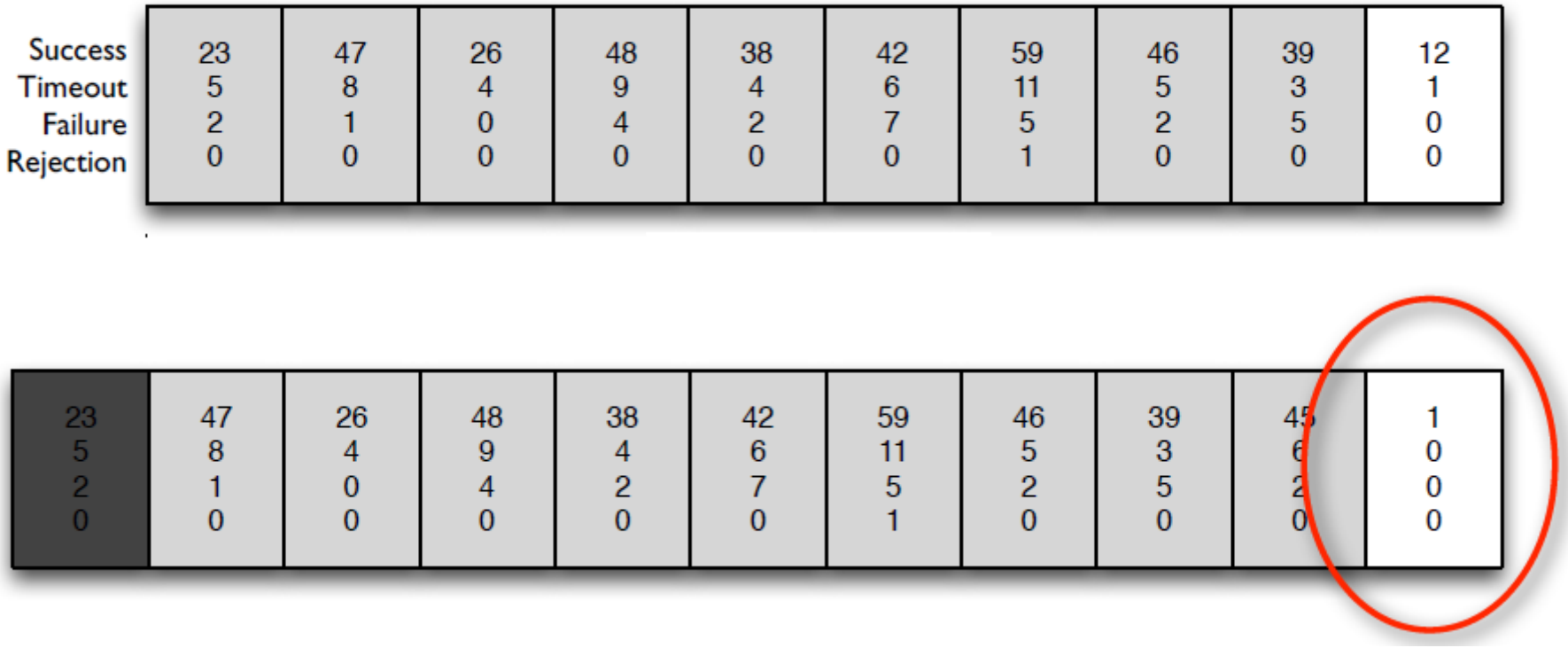


Rolling 10 second counters
with 1 second granularity

Successes	200,545	19	Thread timeouts
Short-circuited (rejected)	0	94	Thread-pool Rejections
		0	Failures/Exceptions

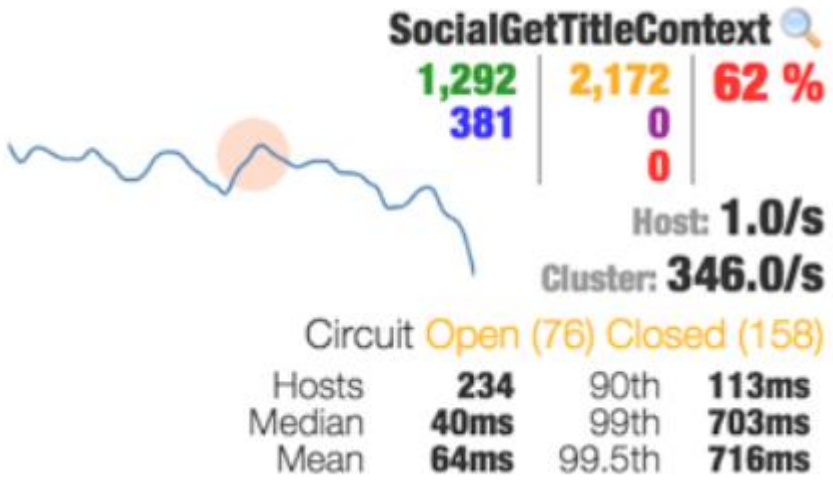
标识	含义
绿色计数	成功请求数
蓝色计数	短路请求数
黄色计数	超时请求数
紫色计数	线程池满拒绝请求数
红色计数	失败异常请求数
灰色百分比	10秒内错误百分比
Host	单机请求率
Cluster	集群请求率
Circuit	断路器状态
Hosts	主机实例数量
Median	请求耗时中位数
Mean	请求耗时平均值
90/99/99.5th	90/99/99.5百分位耗时
Rolling 10 sec counters	10秒钟滚动窗口统计
1 sec granularity	精度1秒一个桶

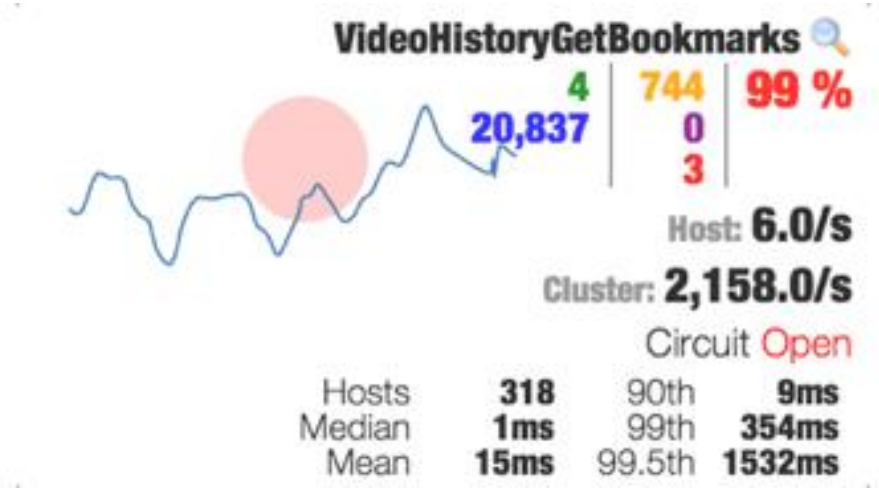
滚桶式统计



10秒钟滚动窗口，精度1秒钟一个桶

熔断

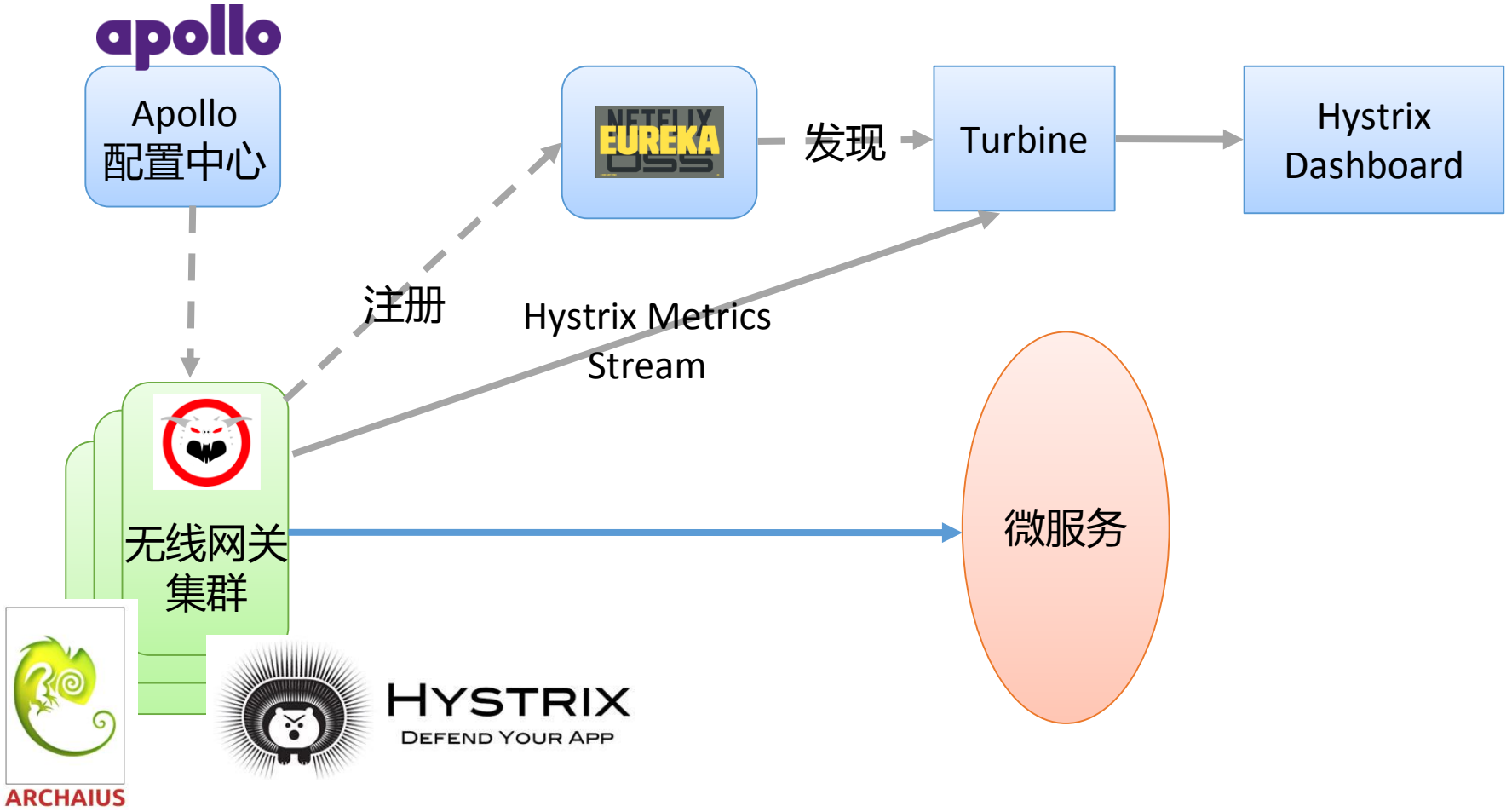

SocialGetTitleContext
1,292
381
2,172
0
0
62 %
Host: 1.0/s
Cluster: 346.0/s
Circuit Open (76) Closed (158)
Hosts 234
Median 40ms
Mean 64ms
90th 113ms
99th 703ms
99.5th 716ms


VideoHistoryGetBookmarks
4
20,837
744
0
3
99 %
Host: 6.0/s
Cluster: 2,158.0/s
Circuit Open
Hosts 318
Median 1ms
Mean 15ms
90th 9ms
99th 354ms
99.5th 1532ms

第12部分

网关集成Hystrix(Code Review)

网关和Hystrix参考部署



第13部分

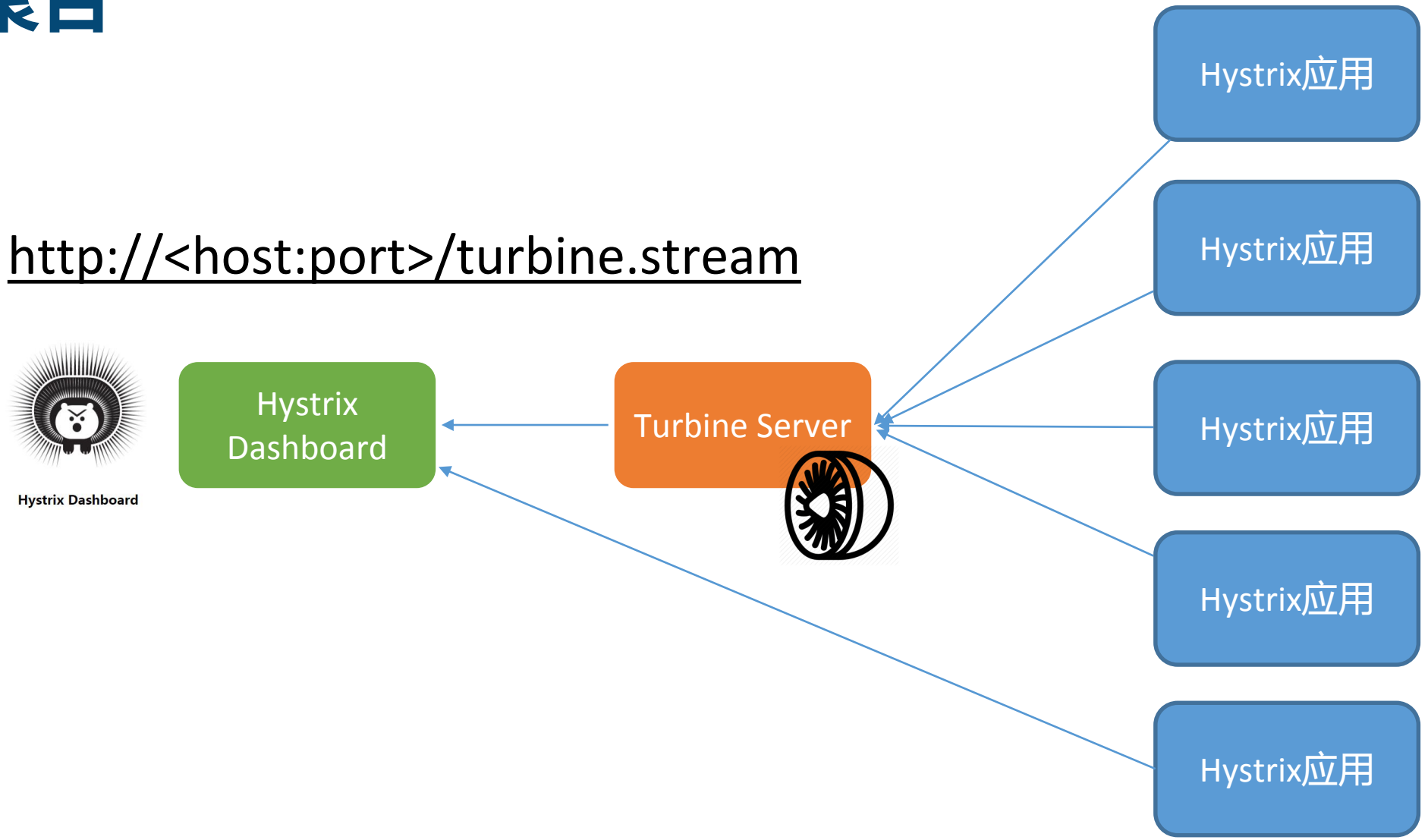
Spring Cloud Hystrix实验(Lab03)

第14部分

Netflix Turbine简介

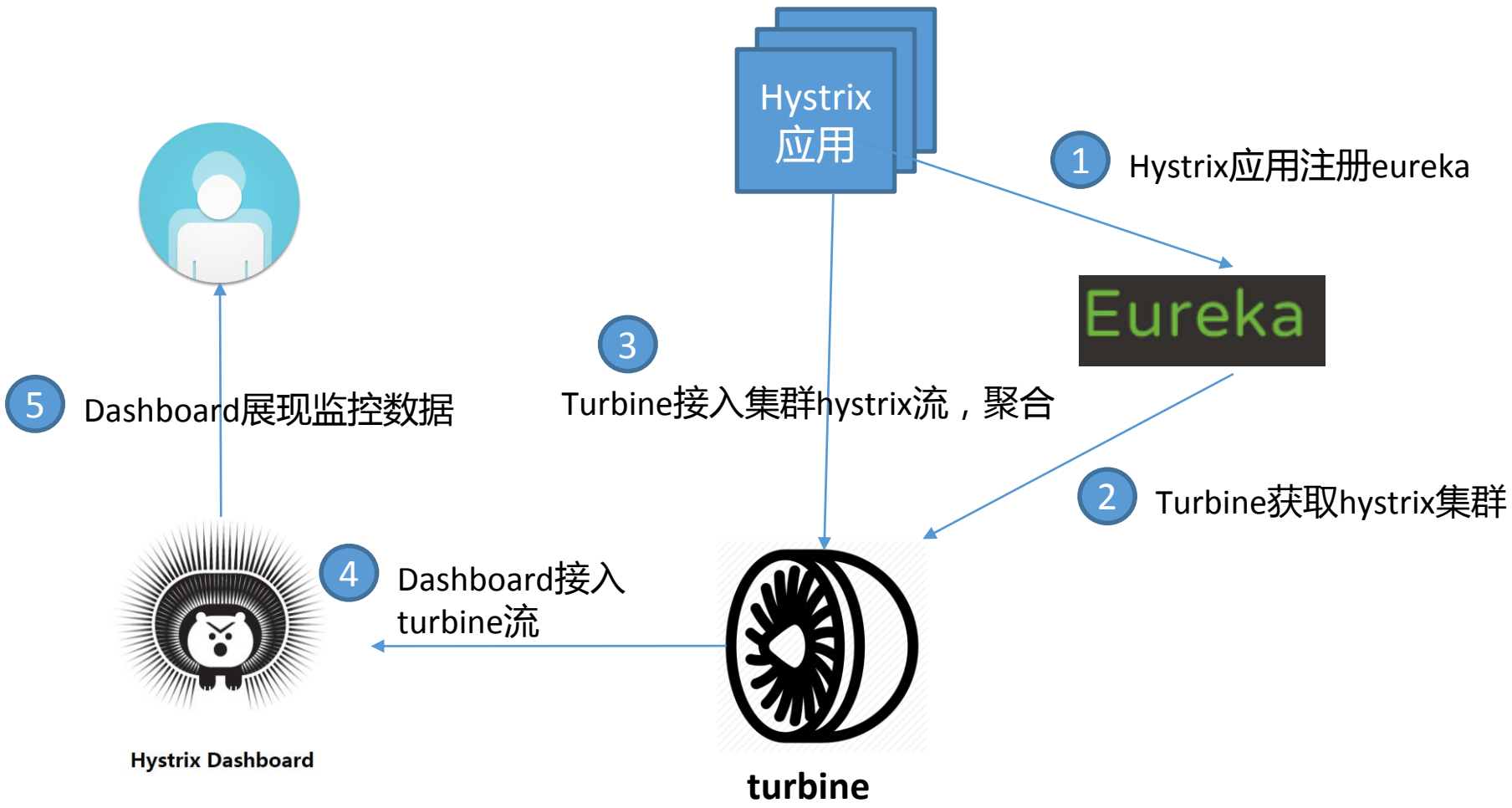
流聚合

http://<host:port>/turbine.stream



http://<host:port>/hystrix.stream

对接Eureka


Hystrix
应用
1
Hystrix应用注册eureka
Eureka
3
Turbine接入集群hystrix流，聚合
5
Dashboard展现监控数据
2
Turbine获取hystrix集群
4
Dashboard接入
turbine流
Hystrix Dashboard
turbine

第15部分

Hystrix生产最佳实践

最佳实践

- 网关集中埋点，覆盖大部分场景
- 尽量框架集中埋点，客户端为主
- 配置对接Apollo，根据实际使用调整阀值
- 信号量vs线程池场景
  - 信号量：网关，缓存
  - 线程池场景：服务间调用客户端，数据库访问，第三方访问
- 线程池大小经验值
  - 30 rps x 0.2 sec = 6 + breathing room = 10 threads
  - Thread-pool Queue size : 5 ~ 10
- 部署
  - Hystrix Dashboard大盘（无线/H5/第三方网关）
  - 共享Hystrix Dashboard/Turbine服务器
  - 熔断告警
- Spring Cloud Hystrix标注

第16部分

参考资源和后续课程预览

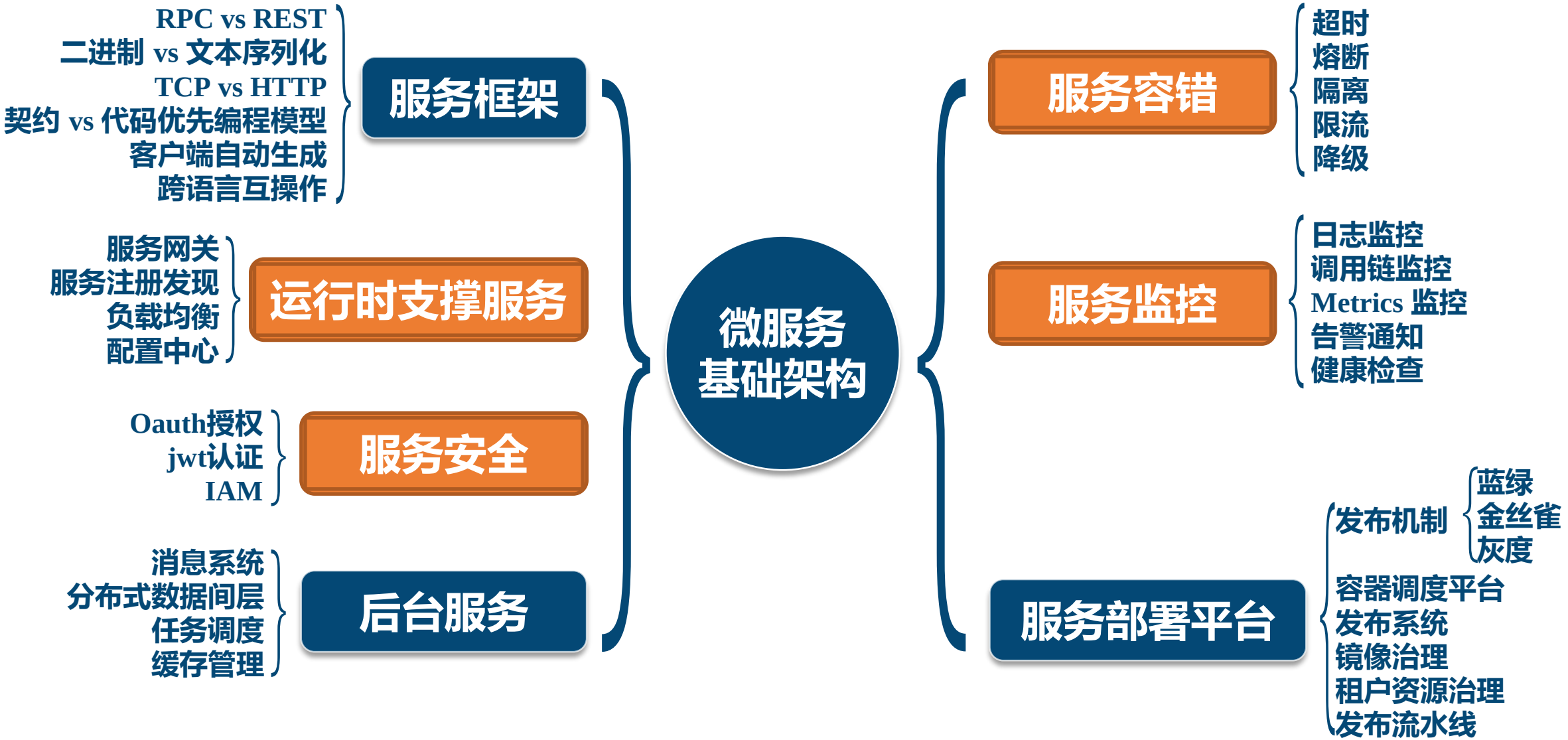
参考文章和ppt

- Netflix Hystrix
  - https://github.com/Netflix/Hystrix
- 防雪崩利器：熔断器Hystrix的原理与使用
  - https://segmentfault.com/a/1190000005988895
- Application Resilience Engineering and Operations at Netflix with Hystrix
  - https://speakerdeck.com/benjchristensen/application-resilience-engineering-and-operations-at-netflix-with-hystrix-javaone-2013

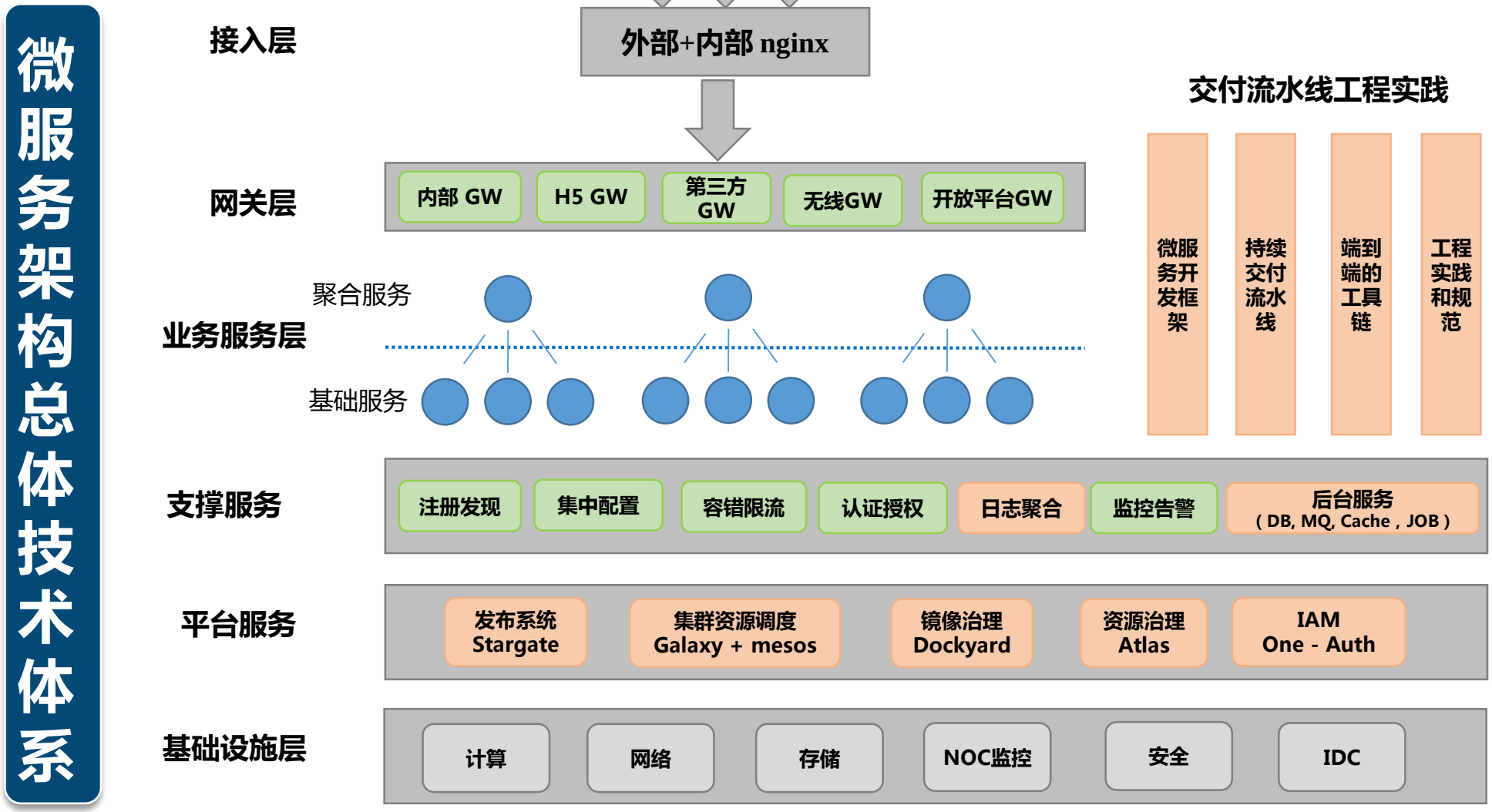
其它开源容错限流产品

- Alibaba Sentinel(Java，1.4k stars)
  - https://github.com/alibaba/Sentinel
- Polly(C#，4.6k stars)
  - https://github.com/App-vNext/Polly
- Hystrix-go(golang, 1.2k stars)
  - https://github.com/afex/hystrix-go
- Failsafe(Java，2.2k stars)
  - https://github.com/jhalterman/failsafe
- Resilience4j(Java，947k stars)
  - https://github.com/resilience4j/resilience4j

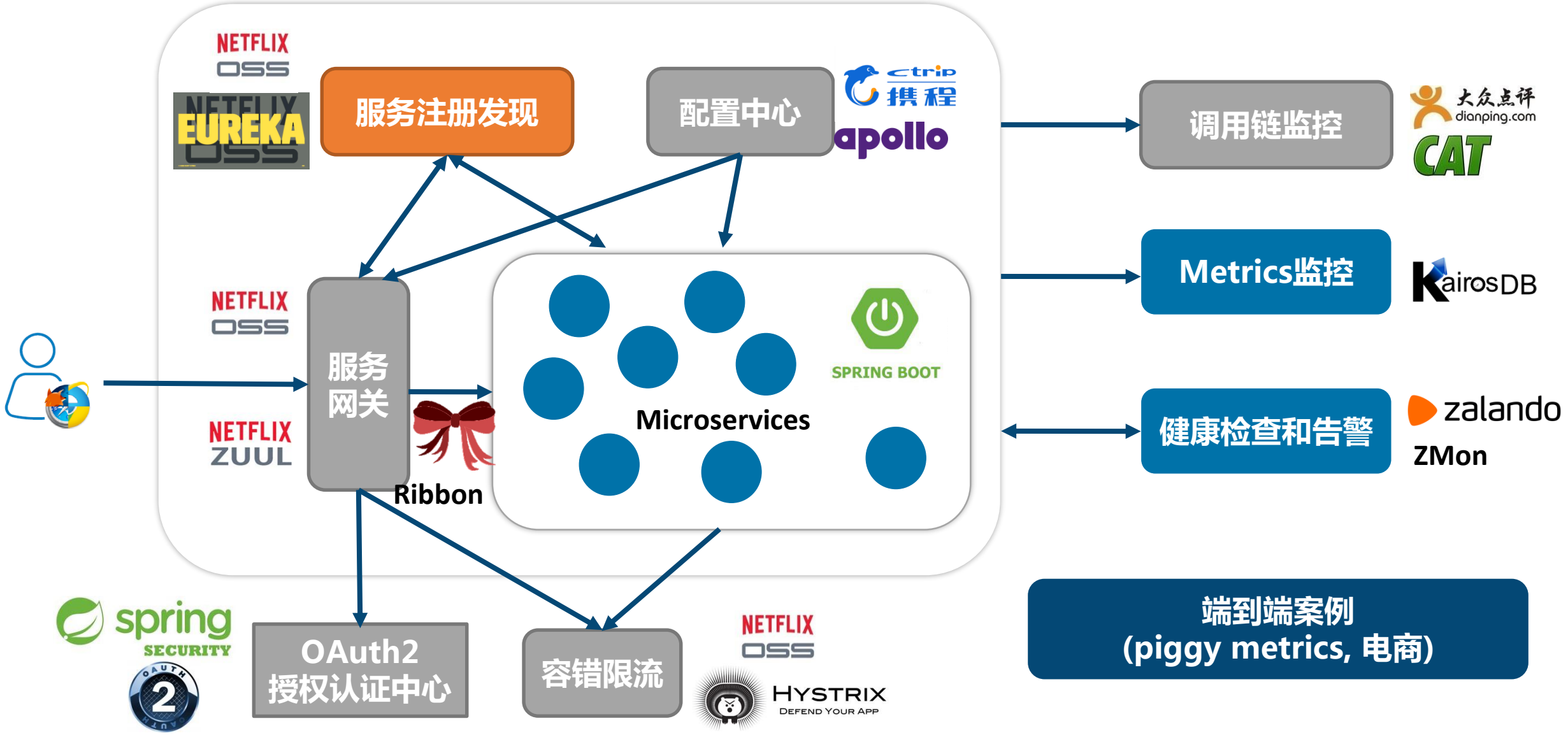
后续课程预览~2018课程模块



后续课程预览~技术体系


微服务架构总体技术体系
接入层
外部+内部 nginx
网关层
内部 GW
H5 GW
第三方 GW
无线GW
开放平台GW
聚合服务
业务服务层
基础服务
支撑服务
注册发现
集中配置
容错限流
认证授权
日志聚合
监控告警
后台服务
(DB, MQ, Cache , JOB)
平台服务
发布系统
Stargate
集群资源调度
Galaxy + mesos
镜像治理
Dockyard
资源治理
Atlas
IAM
One - Auth
基础设施层
计算
网络
存储
NOC监控
安全
IDC
交付流水线工程实践
微服务开发框架
持续交付流水线
端到端的工具链
工程实践和规范

架构和技术栈预览


NETFLIX OSS
EUREKA
服务注册发现
配置中心
ctrip 携程
apollo
调用链监控
大众点评 dianping.com
CAT
NETFLIX OSS
服务网关
Metrics监控
KairosDB
NETFLIX ZUUL
Ribbon
Microservices
SPRING BOOT
健康检查和告警
zalando
ZMon
spring SECURITY
OAuth2 授权认证中心
容错限流
NETFLIX OSS
HYSTRIX
DEFEND YOUR APP
端到端案例
(piggy metrics, 电商)