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Dynamic Pod Resource Boundary Adjustment in Web Scale Clusters

Cheng Wang & Xiaoyu Zhang, Alibaba Group

About us

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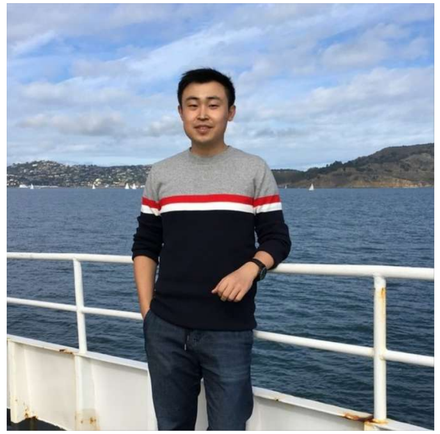

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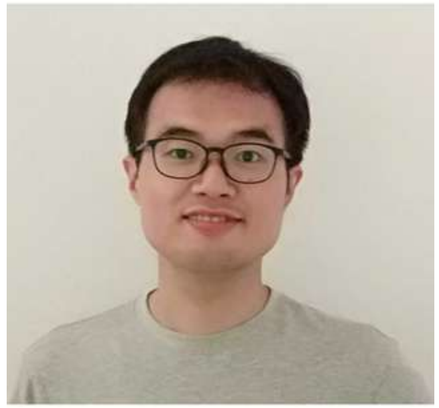

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我们的挑战

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阿里巴巴这样规模庞大的全球电商巨头，其所拥有的应用数量和应用种类的都是超大规模的。规模本身就是我们最大的挑战。

- 容器调度
- 容器编排
- 负载均衡
- 集群扩缩容
- 集群升级
- 应用发布
- 应用升级
- ...

Kubernetes的帮助

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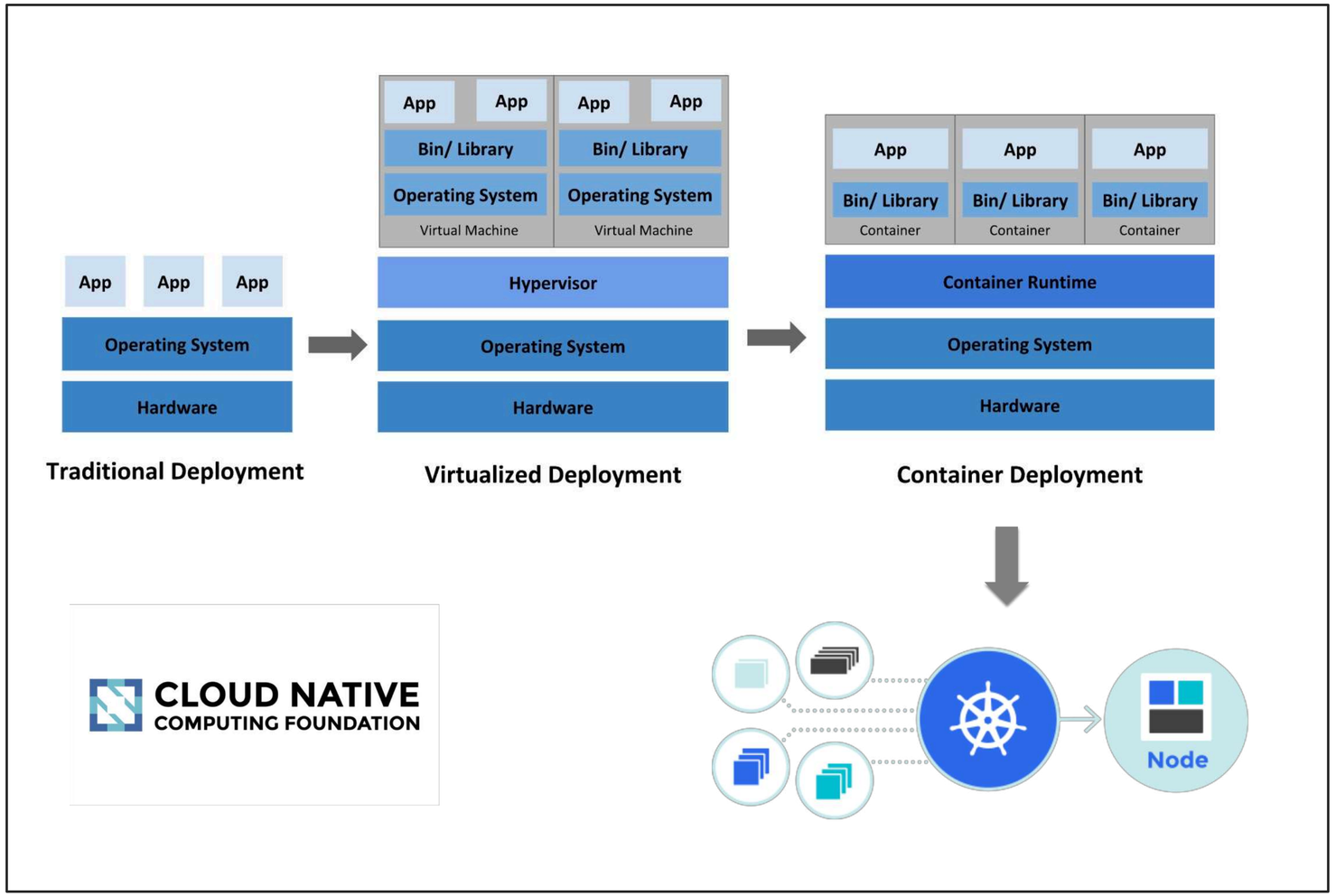


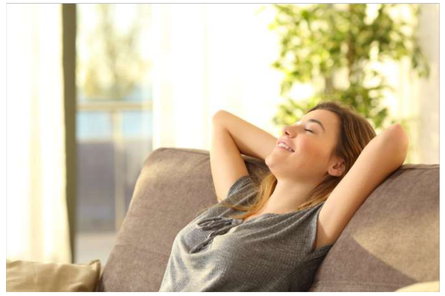
绕开阻碍

难度降低

目标达成

灵活度

我们蓝图中的容器编排效果



从容

优雅

有序

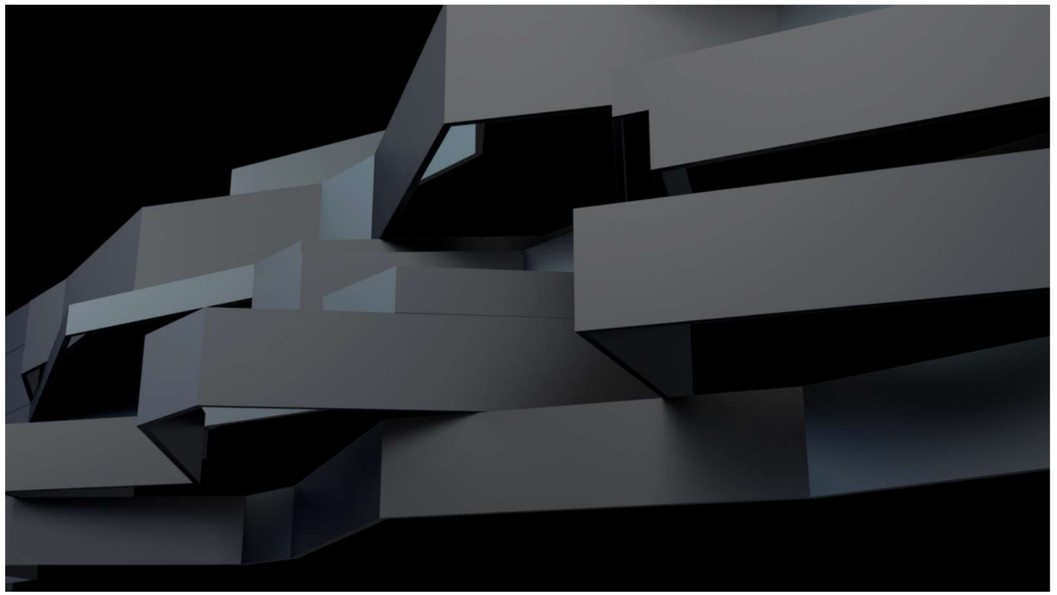
SLA 99.999%

稳定

高效

但，现实却没设计的那么完美

杂乱



形态各异

有时候，应用crash无处不在...

内存OOM?

CPU throttle ?

关键应用交易量

断崖式下跌...

根源分析

如果觉得哪里不太对，那么肯定有些地方出问题了。

If you feel something wrong, there must be something wrong.

- 没人知道如何配置合适的值

稳定性Stability

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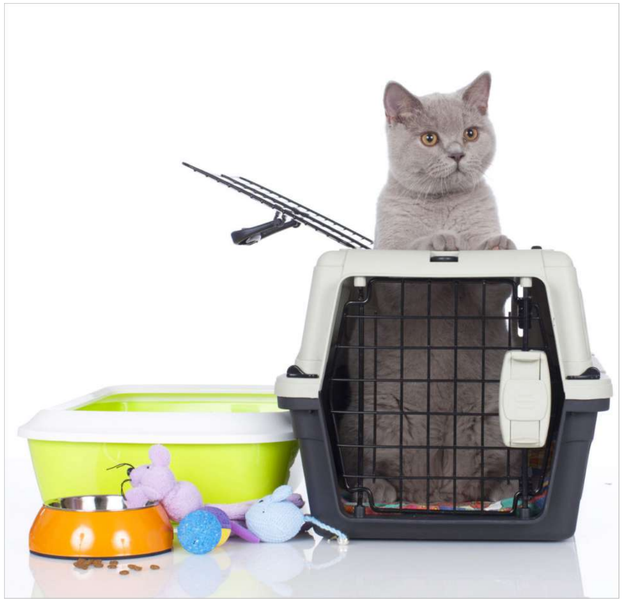
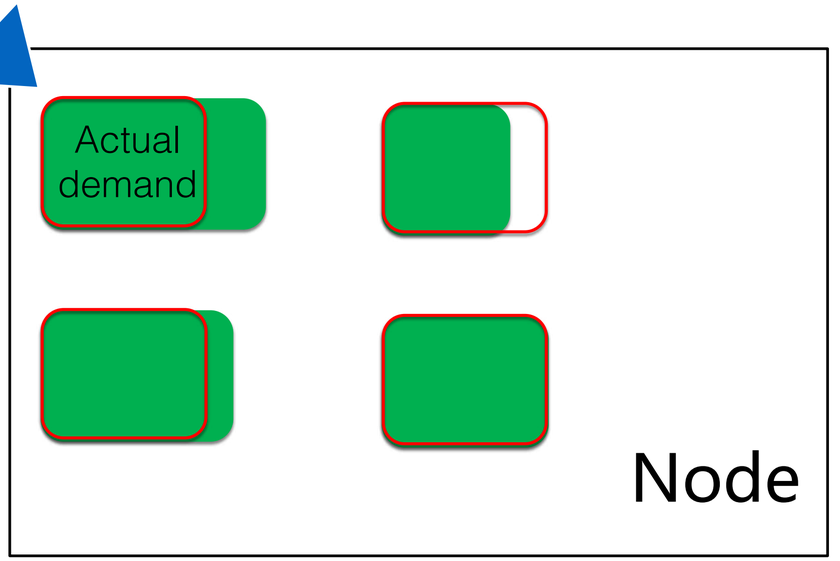
不合理的资源初始分配

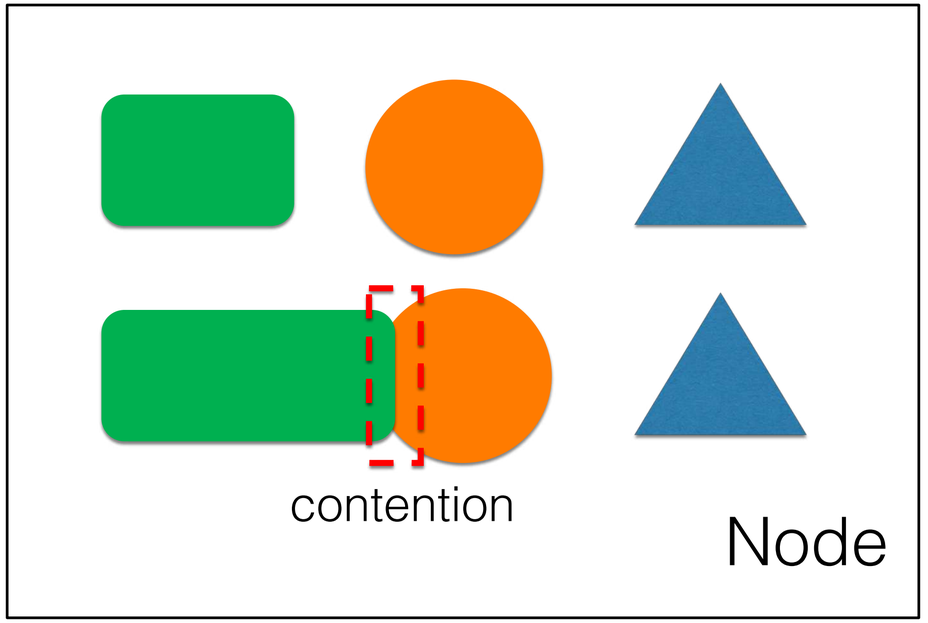


```
apiVersion: v1
kind: Pod
metadata:
    name: example
spec:
    containers:
    - name: example
      image: example-image
      resources:
          limits:
            cpu: ”1"
            memory: "200Mi"
```



稳定性Stability

应用容器资源竞争



安全生产很重要

为了避免灾难的发生，我们可以做很多方案。例如：

预防

- 提前大规模压测
- 分配过量的资源

兜底

- 服务降级
- 水平扩容
- ...

然而为了几分钟的交易峰值，以上开销都显得过于庞大

根源分析

如果觉得哪里不太对，那么肯定有些地方出问题了。

If you feel something wrong, there must be something wrong.

- 没人知道如何配置合适的值
- 错峰的同级别应用该如何科学使用资源

资源利用率

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潮汐应用：分时复用

容器的资源需求并非一成不变，

恰好满足才最“节能，环保”，

但是怎么做到

资源利用率

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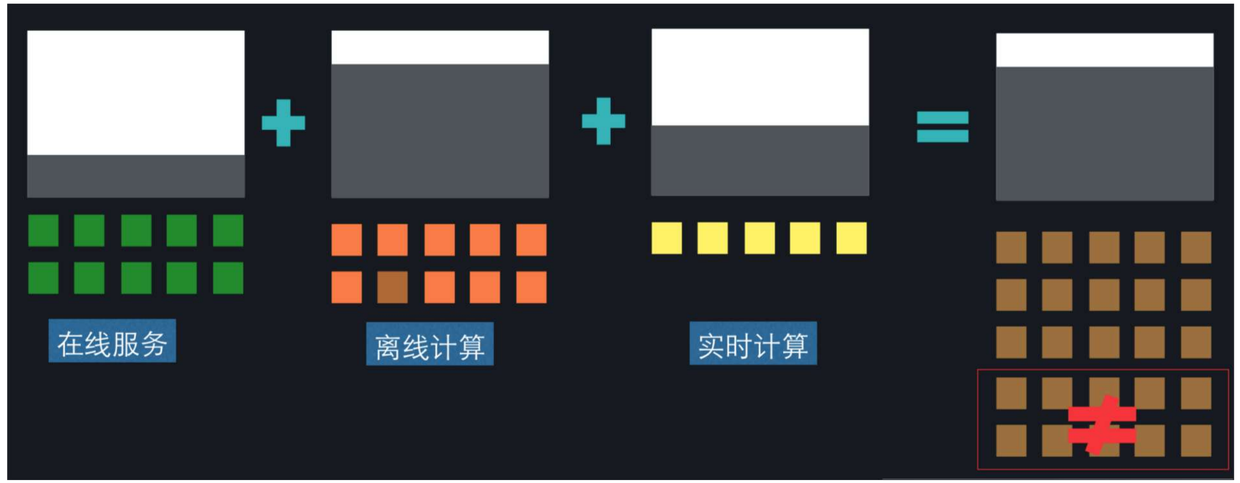
Resource packing: 减少资源碎片



在线 v.s. 离线

- 在线优先级高，延时敏感
- 离线优先级低，延时不敏感
- 低优先级牺牲
- 优先级互补性

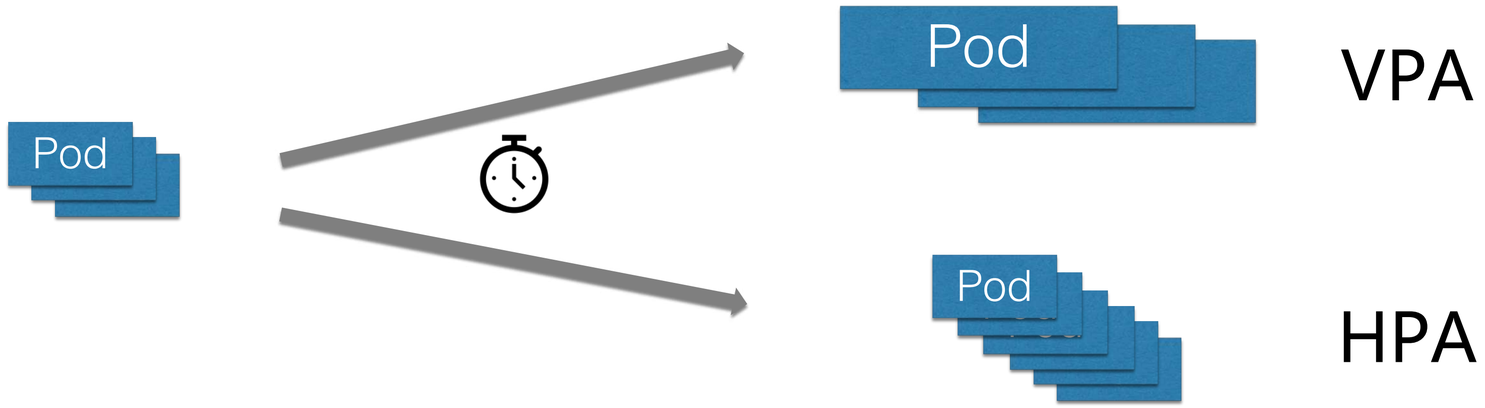
在离线资源竞争

VPA or HPA

如果觉得哪里不太对，那么肯定有些地方出问题了。

If you feel something wrong, there must be something wrong.

- 没人知道如何配置合适的值
- 错峰的同级别应用该如何科学使用资源
- 关键应用突遇流量高峰期时重建Pod不现实



既要(稳定性)也要(利用率)还要(自动化智能化)

老板 v.s. 我

设想如阿里巴巴集团，数十万节点，总体百万容器，上万个应用，如何做到既要...也要...还要...

图片来源：https://www.freepik.com/free-vector/boss-yelling-employee_1106864.htm

我们该怎么做？

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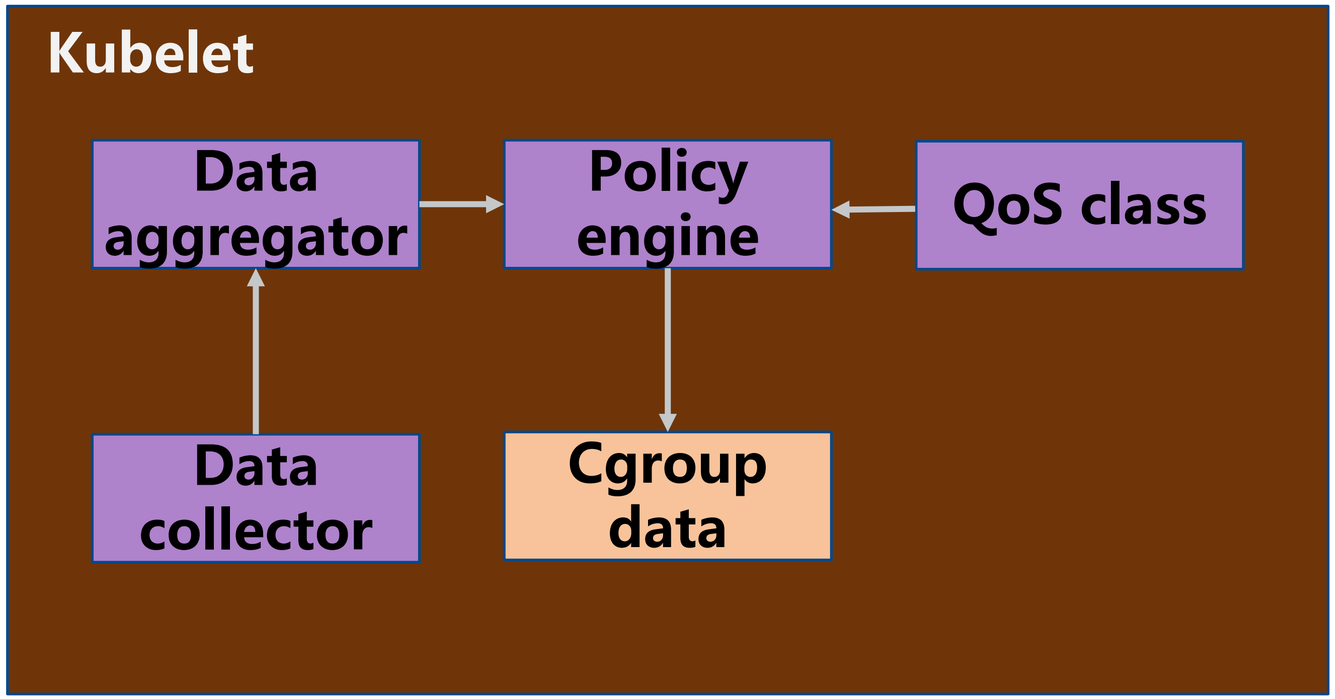
一个轻量级的可以正确帮助业务容器分配资源的手段或者方法。具备以下特点：

- 安全稳定
- 业务容器按需分配资源
- 工具本身资源开销小
- 操作方便，扩展性强
- 快速发现 & 及时响应

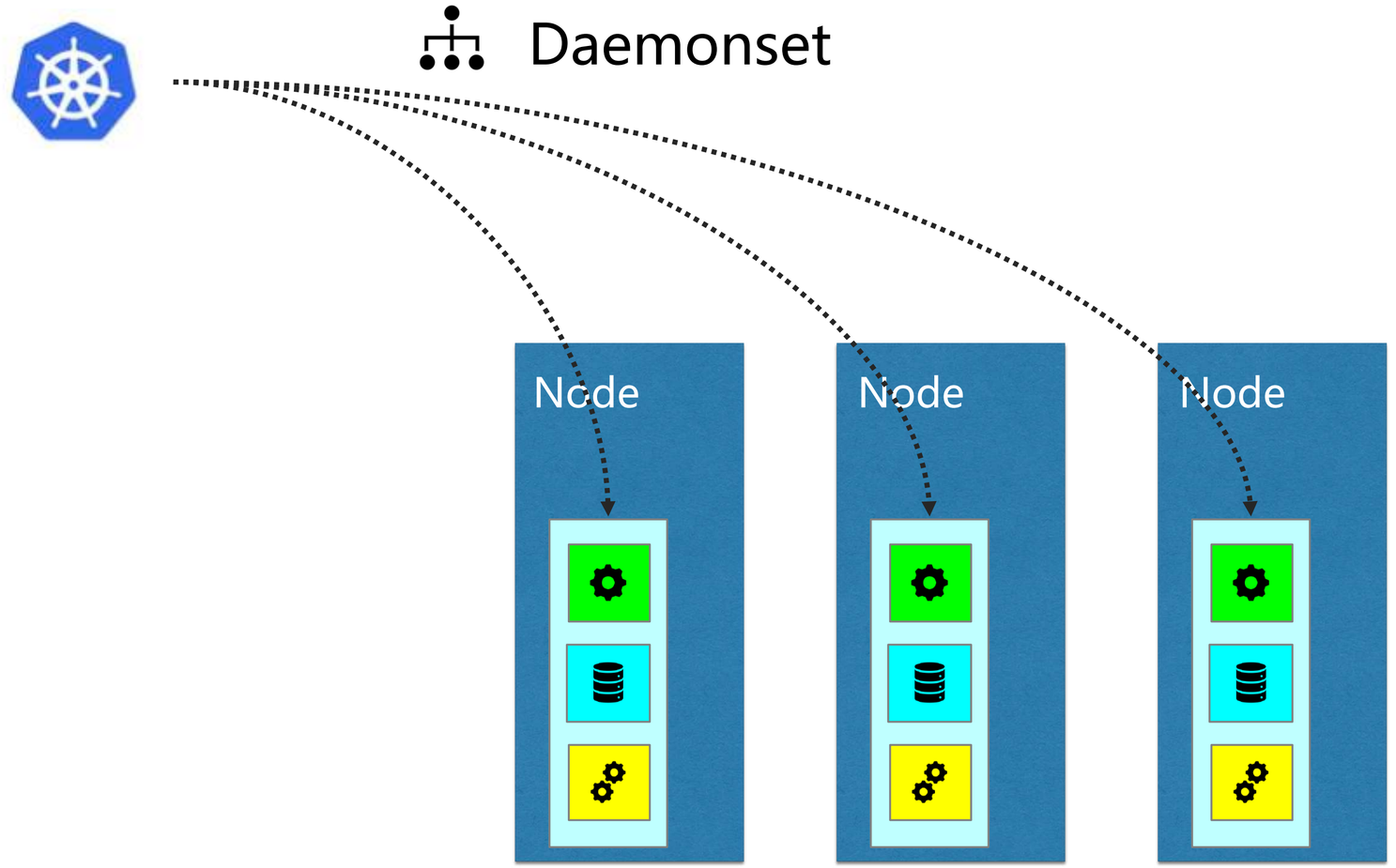
最初的设计

得益于Kubernetes本身提供的技术灵活性，我们可以在关键应用稳定性和资源利用率提升方面做一些事情。



- Data collector – 数据采集
- Data aggregator – 容器画像
- Policy engine – 资源调整

演进 & 现状：如何快速迭代和交付？



- 不侵入修改K8s核心组件
- 方便迭代&发布
- 资源开销可控
- 具备自愈能力
- …

规划中：多组件联动

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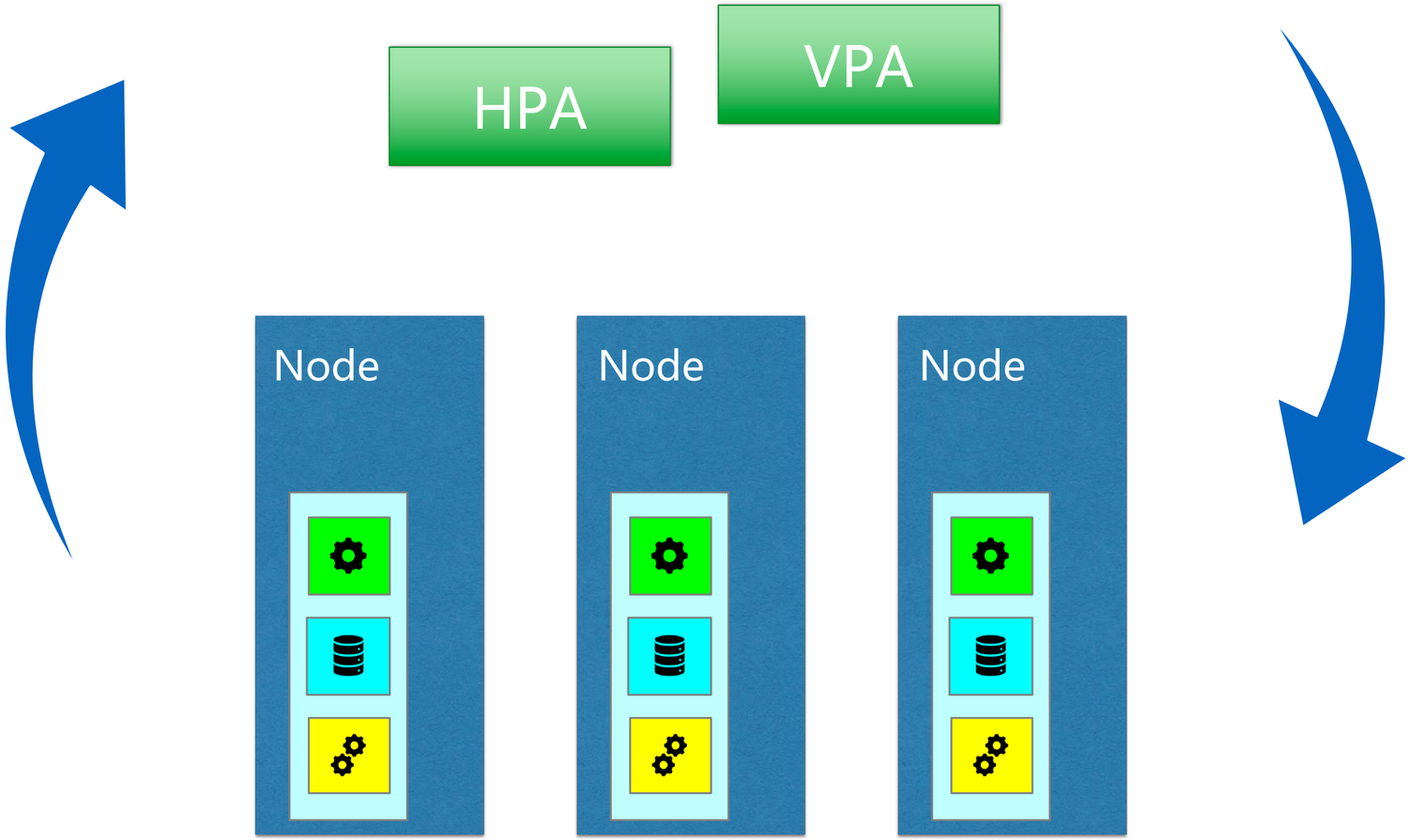
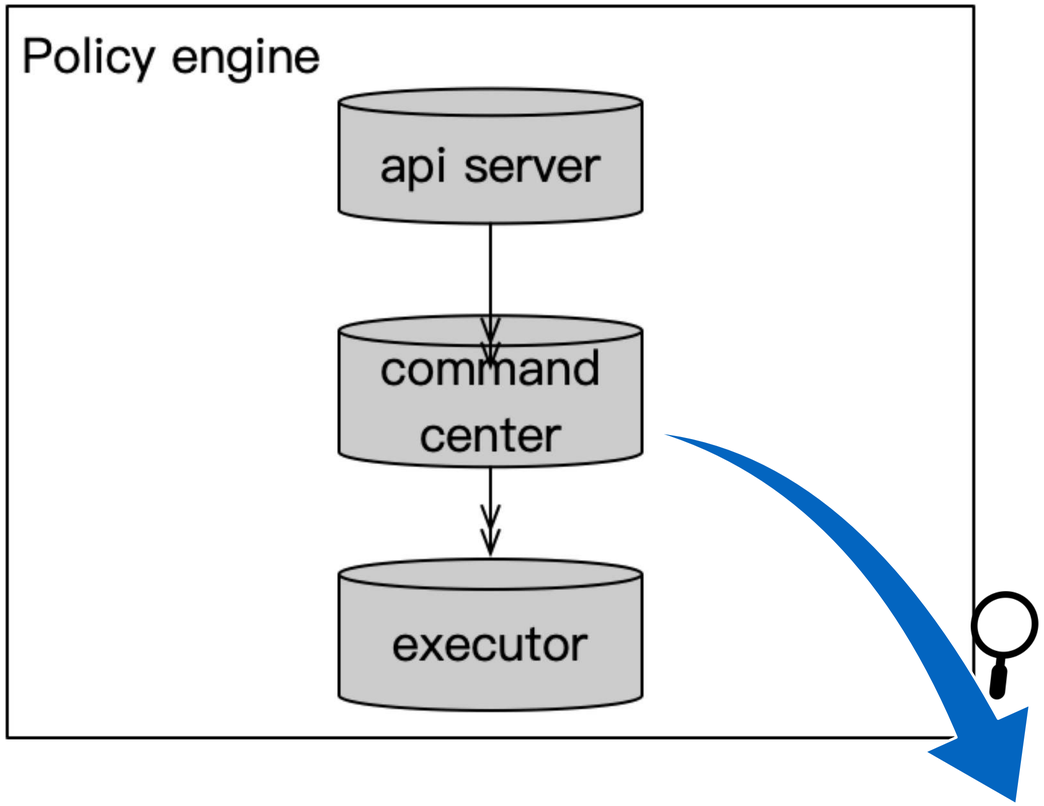
Policy engine，VPA， HPA and All

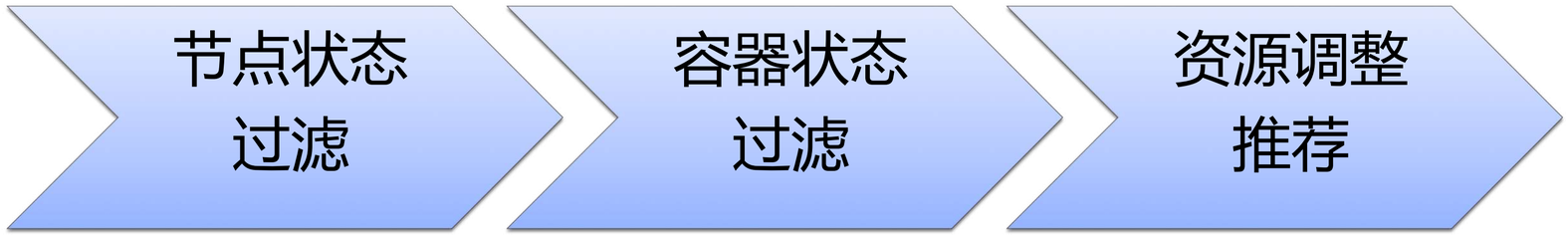


策略层框架设计



设计原则

- 插件化
- 稳定： 控制器、触发规则、不主动驱逐
- 自愈
- 不依赖先验知识



资源调整

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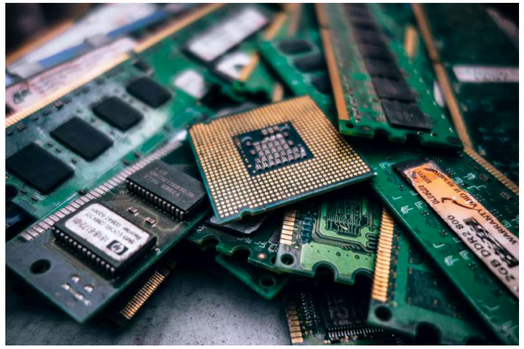
- CPU: CPU share, CPU quota, cpuset
- Memory: memory limit, swap
- 网络带宽
- 磁盘IO



调整效果

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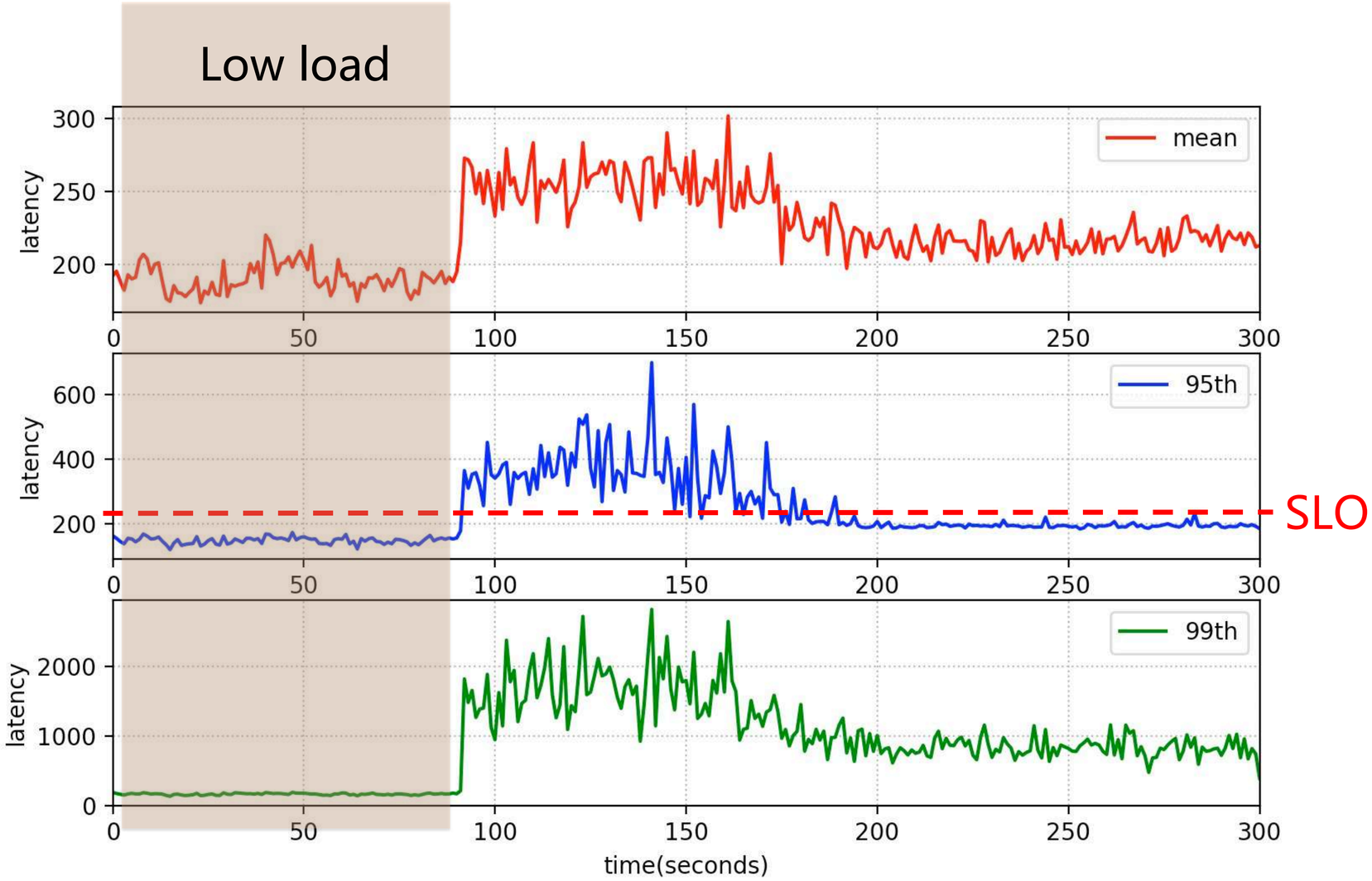
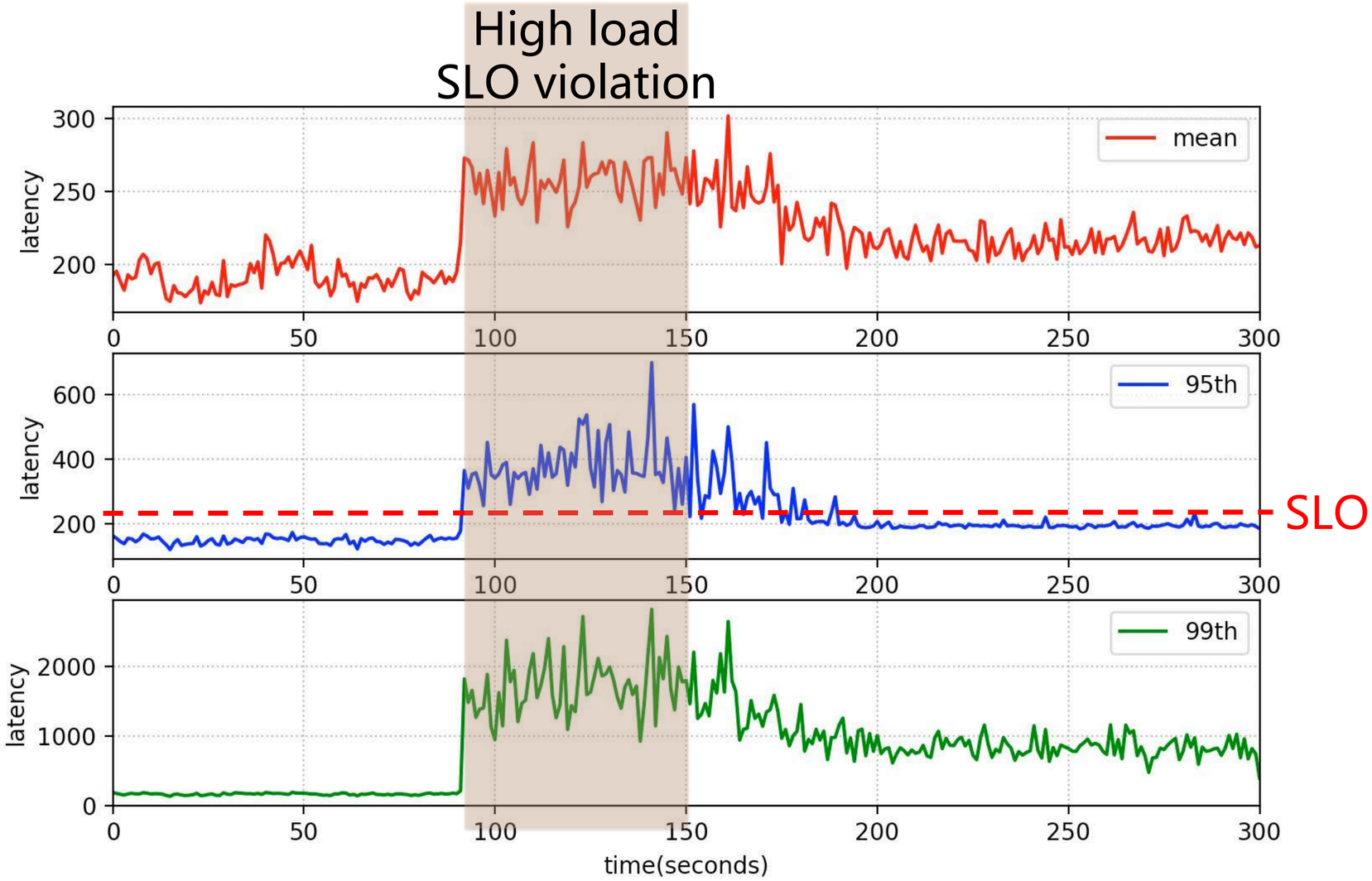
SLA： Latency 95th (95百分位) ≤ 250ms



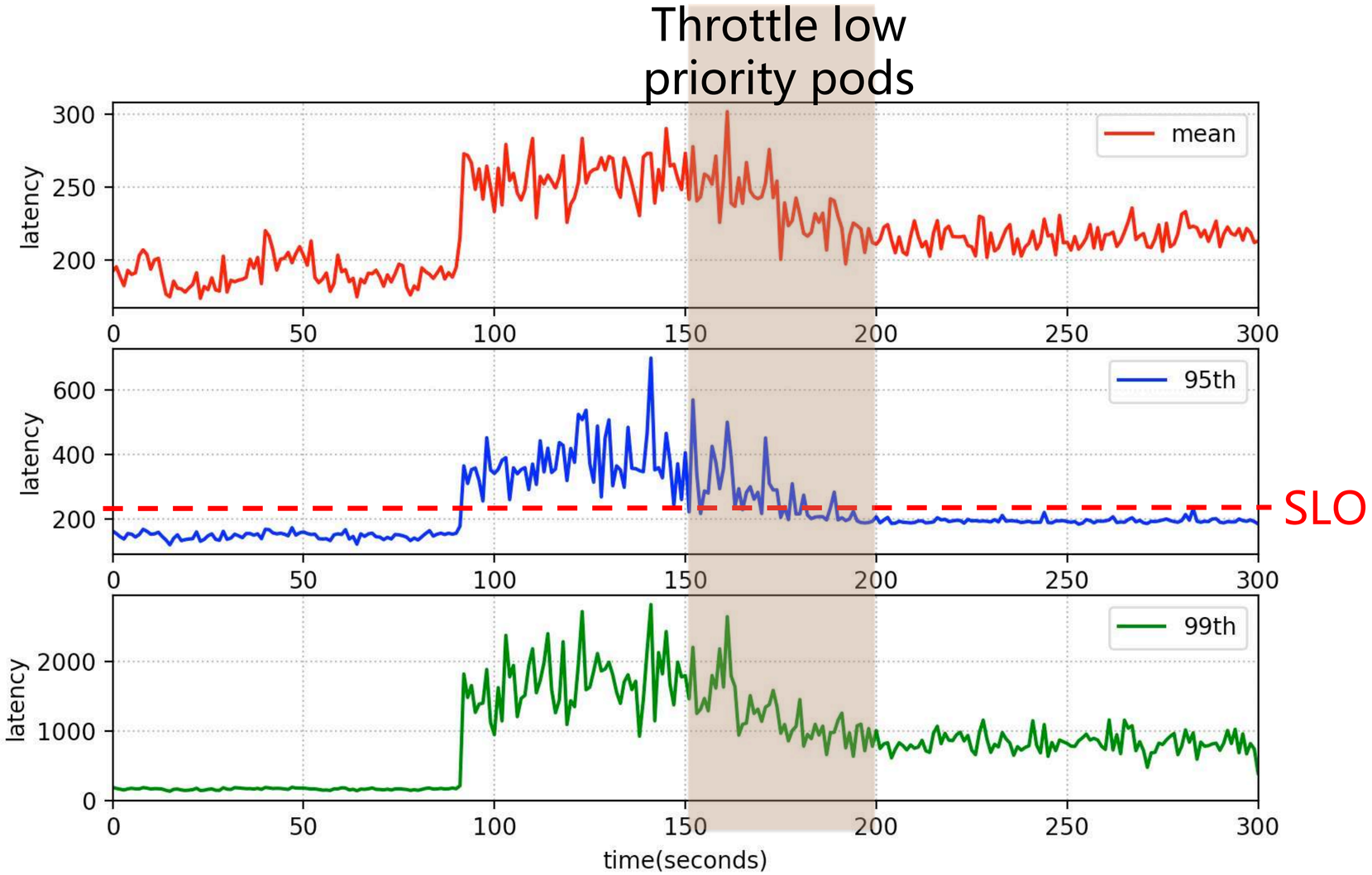
调整效果

SLA： Latency 95th (95百分位) ≤ 250ms



调整效果

SLA： Latency 95th (95百分位) ≤ 250ms



调整效果

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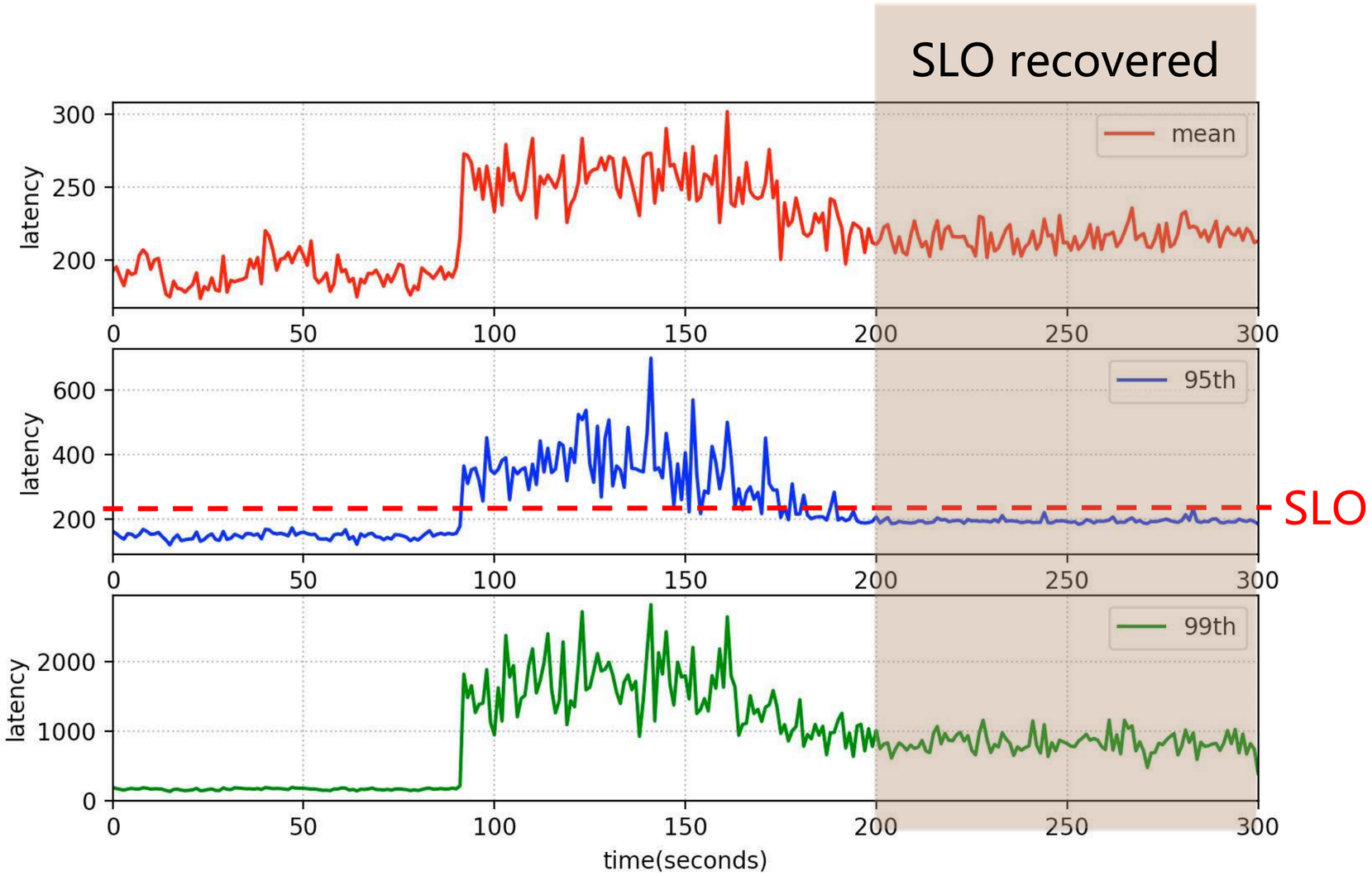

我们的一些思考（经验、教训）

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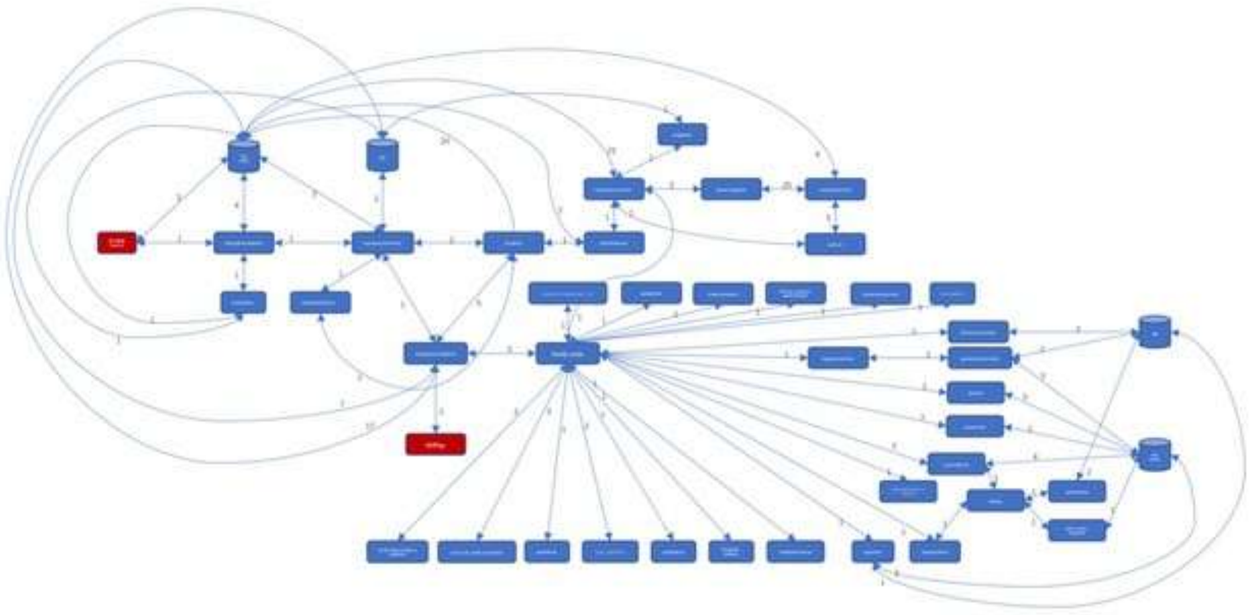
- 基于云原生的演进和实现工作快速交付
- CRI接口不稳定
- 基于QoS的资源动态调整: 应用全局调用链路复杂，单机只能尽力而为(best effort)



rpcId	状态	时间轴
0	OK	8s79ms
0.1	UNKNOWN	0ms
0.1.1	UNKNOWN	0ms
0.1.1.1	OK	0ms
0.1.1.2	TIMEOUT	, 8s33ms
0.1.1.2.1	DATANOTEXSITS	0ms
0.1.1.2.2	OK	0ms
0.1.1.2.3	OK	0ms
0.1.1.2.4	OK	0ms
0.1.1.2.5	OK	0ms
0.1.1.2.6	OK	0ms
0.1.1.2.7	OK	0ms
0.1.1.2.8	OK	1ms
0.1.1.2.9	OK	0ms
0.1.1.2.10	OK	1ms
0.1.1.2.11	OK	0ms
0.1.1.2.12	OK	0ms
0.1.1.2.13	OK	1ms
0.1.1.2.14	OK	0ms
0.1.1.2.15	OK	0ms
0.1.1.2.16	OK	0ms
0.1.1.2.17	OK	6ms
0.1.1.2.18	OK	1ms
0.1.1.2.19	OK	13ms
0.1.1.2.20	OK	1ms
0.1.1.2.21	OK	839ms
0.1.1.2.22	OK	10ms
0.1.1.2.23	OK	1ms
0.1.1.2.24	OK	3ms
0.1.1.2.25	OK	1s30ms
0.1.1.2.26	OK	0ms
0.1.1.2.27	OK	3s733ms
0.1.1.2.28	OK	1ms
0.1.1.2.29	OK	25ms
0.1.1.2.30	OK	35ms
0.1.1.2.31	DATANOTEXSITS	0ms
0.1.1.2.32	OK	3s701ms
0.1.1.2.32.1	OK	3s626ms
0.1.1.2.32.2	OK	1ms
0.1.1.2.32.3	OK	0ms
0.1.1.2.32.4	OK	1ms
0.1.1.2.32.5	OK	0ms
0.1.1.2.32.6	OK	0ms
0.1.1.2.32.7	OK	55ms
0.1.1.2.32.8	OK	0ms
0.1.1.2.32.9	OK	1ms
0.1.1.2.32.10	OK	1ms
0.1.1.2.32.11	OK	1ms
0.1.1.2.33	OK	3ms
0.1.1.2.34	OK	28ms

我们的一些思考（经验、教训）

- 资源 v.s. 性能模型：论文中常见

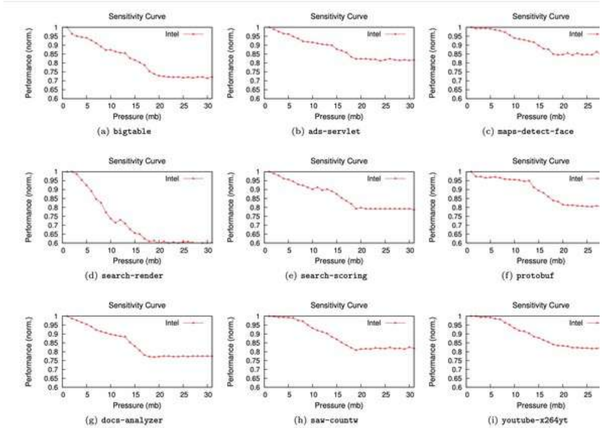


Figure 9: Bubble-Up Sensitivity Curves for 9 Highly Sensitive Google Workloads.

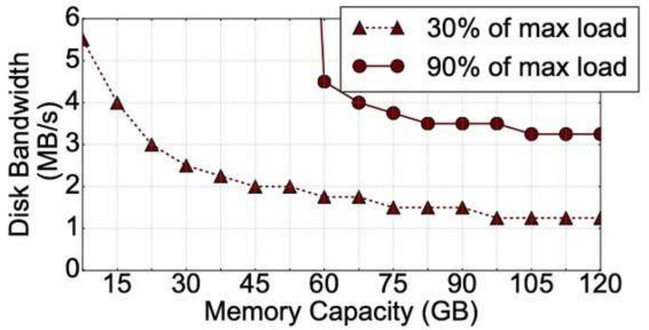


Figure 3. Sensitivity of MongoDB to memory capacity and disk band-

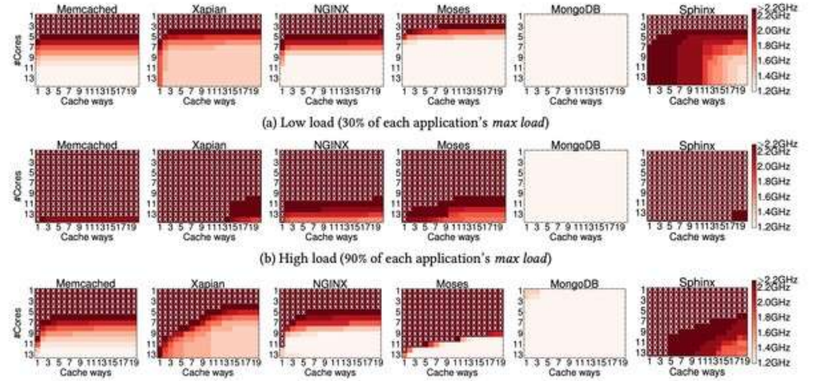


Figure 2. Sensitivity to resource allocation under different loads and interference sources. Each column/row represents a fixed number of cache ways/cores assigned to an application using the core and LLC isolation mechanisms. Each cell represents the minimum frequency needed to meet QoS under a given number of cores and cache ways. The darker the color, the higher the required frequency. Cells with cross marks mean that QoS cannot be satisfied even at the highest possible frequency.

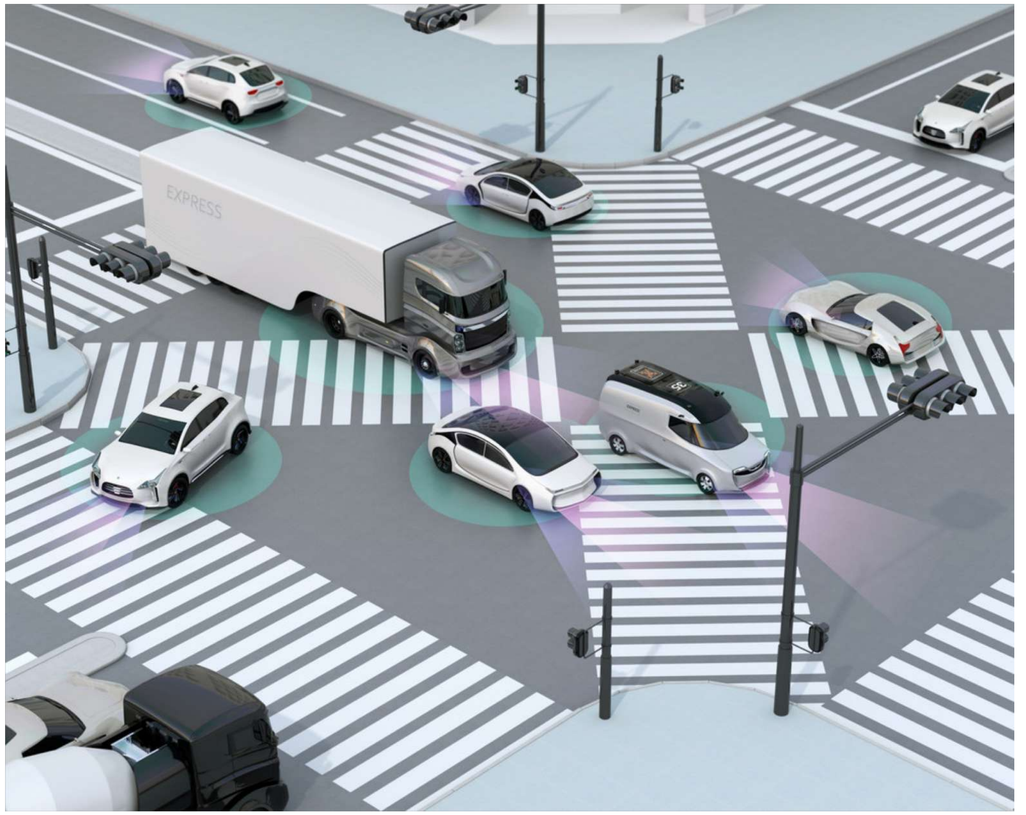
应用数目多
版本发布频繁
异构集群

不进行离线压测
实时动态容器画像
小步快跑，边走边看，尽力而为

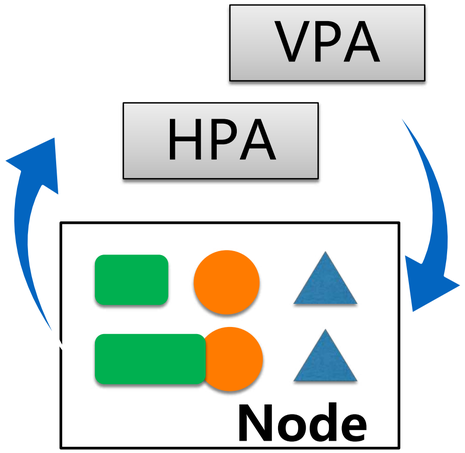
Figure ref:
Left: J. Mars, et al. Bubble-Up: Increasing Utilization in Modern Warehouse Scale Computers via Sensible Co-locations. MICRO'11
Middle & right: S. Chen, et al. PARTIES: QoS-Aware Resource Partitioning for Multiple Interactive Services. ASPLOS'19

总结

- 资源优化 – 提高利用率
- 智能调度 – 降低应用干扰
- 自动化/智能化运维 – 节约成本



展望



与HPA形成闭环控制链路

策略智能化

容器画像精细化

集群容器重新编排

查找干扰源

开源计划

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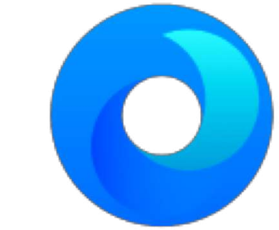

OpenKruise

预计2019/09，我们的项目也将出现在OpenKruise中

https://github.com/openkruise

敬请期待

Thanks !

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