

# Multi-Level Tracing of Containerized Application Orchestrator

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Cloud Computing

- aggregation and distribution of computing resources in a homogeneous way to clients
- **2** Allows customers to scale up operations instantly
- 3 Also facilitate the restitution of resources as needed
- **4** Flexible billing based on usage

#### Containers

- Containers have emerged as a more efficient method for resource allocation and isolation
- Share the same Kernel
- 8 Containers simplify packaging and distribution services
- Provide a consistent runtime environment in both development and production



- Orchestrators are an easy way to deploy containers to the cloud
- 2 They enable the deployment of services using descriptive configurations
- Orchestrators facilitate achieving and maintaining the desired state
- Also offers utilities for automatic scaling, implementing rollout strategies, and managing configurations and secrets

- 1 Performance is an important factor
- 2 Reduced latency enhances the quality of service provided
- **3** Quicker boot times improves elastic scaling
- One efficient resource utilization directly leads to reduced hosting costs

**Research Objective** 

To observe and analyze the behaviour of a distributed system of orchestrated containers, with the aim of facilitating the diagnosis of performance issues



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Performance Aspects

- 1 Quicker boot times enhance elasticity in scaling
- Better utilization of resources improves Quality of Service (QoS) and reduces costs



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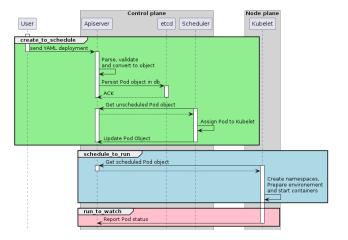
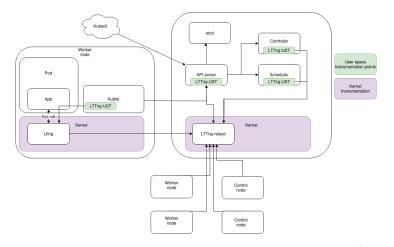


Figure: Components and phases of a pod start up

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#### Figure: Tracing Architecture

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Common Issue During Execution : Managing CPU Limits Limits are specified in cores, but enforced as quotas

2 A container can use more cores than allocated

*Quota* = Cores Limit × *Period* 

Throttled Time =  $Period \times (Cores Used - Cores Limit)$ 



#### Expectation

Running	Running
Running	Running
Iddle	Iddle

#### Reality

Running	PREEMPTED	Running	PREEMPTED
Running	PREEMPTED	Running	PREEMPTED
Running	PREEMPTED	Running	PREEMPTED
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The app needed 100ms The app was throttled 120ms

### Figure: Example of Latency Introduced by CPU Limit



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### Algorithm to characterize CPU usage per pod

Algorithm 1 CPU usage calculation per Cgroup

```
1: Define the function normalize(prevTime, time, cpuTime) as \frac{\text{cpuTime}}{\text{time-prevTime}} \times 100
 2: procedure ANALYZECPUUSAGE(fetchParameters, stateSystem)
       Initialize totalCpu \leftarrow 0
 3.
       Initialize prevTime \leftarrow Get the start time from fetchParameters
 4:
       Initialize xAxis \leftarrow Initialize xAxis based on the time range and resolution
 5:
       Initialize map thread Usage \leftarrow Initialize the cpu usage of each thread based on stateSystem
 6:
       Initialize map CaroupUsage \leftarrow Initialize the cpu usage of each caroup based on stateSystem
 7:
       for i \leftarrow 0 to xAxis.length - 1 do
 8:
           time \leftarrow xAxis[i]
9:
           for all (threadName, cpuTime) \in fetchThreadsCpuUsage(time) do
10.
11:
              totalCpu \leftarrow totalCpu + cpuTime
12:
              normalizedThreadCpuUsage \leftarrow normalize(prevTime, time, cpuTime)
13.
              threadUsage[threadName][i] \leftarrow normalizedThreadCpuUsage
14 \cdot
              if TidToCgroup.contains(threadName) then
15:
                  key \leftarrow TidToCgroup.get(threadName)
                  CaroupUsage[key][i]
                                                                    CaroupUsage[key][i]
16
                                                                                                +
    normalizedThreadCpuUsage
17:
              end if
           end for
18:
           prevTime \leftarrow time
19-
       end for
20:
       return CgroupUsage, threadUsage
21:
```

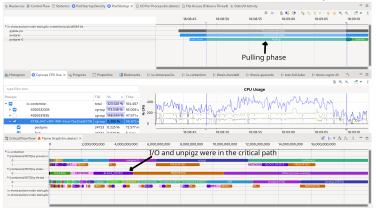
22: end procedure

#### Pod Lifecycle

	10:26:40	10:27:00	10:27:20	10:27:40	10:28:00	10:28:20	10:28:40	10:29:00	10:29:20	10:29:40	10:30:00	10:30:20	10:30:40	
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#### Diagnosing Slow Pod Startup Issues Attributable to I/O Contention

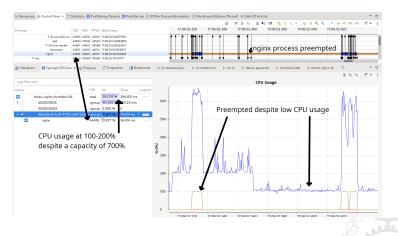


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#### CPU usage per cgroup and pod

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#### Diagnose latency due to limits



## Conclusion

- Demonstrates how tracing aids in observing the internal states of the orchestrator
- 2 Diagnosing issues at both the orchestrator and kernel levels
- **8** Highlights the utility of multi-level tracing for diagnostic purposes



## Conclusion

Future work

- Reuse methodology for other resources: Network, memory, disk, etc.
- 2 Use the trace data to characterize workload and improve scheduling

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## Conclusion

Thank you! Questions?



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