TCSS 462/562: (SOFTWARE ENGINEERING FOR) CLOUD COMPUTING

Team 6, 7, 8 Presentations

Practice Talks:
Naman Bhaia, Xinghan Chen

Wes J. Lloyd
School of Engineering and Technology
University of Washington – Tacoma

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OFFICE HOURS – FALL 2023

- **THIS WEEK**

- **Tuesday:**
  - **2:30 to 3:30 pm - CP 229**
- **Friday:**
  - **11:00 am to 12:00 pm – ONLINE via Zoom**
- **Or email for appointment**

> *Office Hours set based on Student Demographics survey feedback*

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OBJECTIVES – 12/7

- **Questions from 12/5**
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  Cloud Technology or Research Paper Review
- A2: Term Project Report or Presentation
- Tutorial 8: AWS Step Functions, AWS SQS
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ONLINE DAILY FEEDBACK SURVEY

- Daily Feedback Quiz in Canvas – Take After Each Class
- Extra Credit for completing

Announcements
Assignments
Discussions
Zoom
Grades
People
Pages
Files
Quizzes
Collaborations
UW Libraries
UW Resources

▾ Upcoming Assignments

Class Activity 1 – Implicit vs. Explicit Parallelism
Available until Oct 11 at 11:59pm | Due Oct 7 at 7:50pm | -/10 pts

Tutorial 1 - Linux
Available until Oct 19 at 11:59pm | Due Oct 15 at 11:59pm | -/20 pts

▾ Past Assignments

TCSS 562 - Online Daily Feedback Survey - 10/5
Available until Dec 18 at 11:59pm | Due Oct 6 at 8:59pm | -/1 pts

TCSS 562 - Online Daily Feedback Survey - 9/30
Available until Dec 18 at 11:59pm | Due Oct 4 at 8:59pm | -/1 pts

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Slide 5

TCSS 562 - Online Daily Feedback Survey - 10/5

Started: Oct 7 at 1:13am

Quiz Instructions

Question 1   0.5 pts

On a scale of 1 to 10, please classify your perspective on material covered in today's class:

1	2	3	4	5	6	7	8	9	10
Mostly Review To Me				Equal New and Review					Mostly New to Me

Question 2   0.5 pts

Please rate the pace of today's class:

1	2	3	4	5	6	7	8	9	10
Slow				Just Right					Fast

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Slide 6

MATERIAL / PACE

- Please classify your perspective on material covered in today's class (**44** respondents):
- 1-mostly review, 5-equal new/review, 10-mostly new
- **Average – 5.95 (↓ - *previous 6.04*)**

- Please rate the pace of today's class:
- 1-slow, 5-just right, 10-fast
- **Average – 5.16 (↓ - *previous 5.32*)**

- **Response rates:**
- TCSS 462: 26/44 – 59.0%
- TCSS 562: 18/25 – 72.0%

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TCSS 462: Cloud Computing
TCSS 562: Software Engineering for Cloud Computing
School of Engineering and Technology, UW-Tacoma

[Fall 2023]

FEEDBACK FROM 12/5

- ..

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AWS CLOUD CREDITS UPDATE

- **AWS CLOUD CREDITS ARE NOW AVAILABLE FOR TCSS 462/562**
- Credits provided on request with expiry of Sept 30, 2024
- Credit codes must be securely exchanged
- Request codes by sending an email with the subject "**AWS CREDIT REQUEST**" to **wlloyd@uw.edu**
- Codes can also be obtained in person (or zoom), in the class, during the breaks, after class, during office hours, by appt
  - 63 credit requests fulfilled as of Dec 6 @ 11:59p
- Codes not provided using discord

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Don't Forget to Terminate (Shutdown) all EC2 instances for Tutorials 3 & 7

Spot instances:
c5d.large instance @ ~3c cents / hour

$0.72 / day
$5.04 / week
$21.88 / month
$262.80 / year

AWS CREDITS → → → → → → →

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QUIZ 2

- Opened **Thursday December 7 at 8:00 am**
- Closes **Monday December 11 at 11:59 pm**
- Individual work only
- Please answer every question
- Book, notes, slides, calculator, and internet are allowed

- **Grading:**
- The Canvas autograder produces a preliminary score, not the final score.
- The instructor will manually review all quizzes and add partial credit
- A curve adjustment may be applied as appropriate
- Updates may not occur until several days after the quiz closes
- Please report suspected grading problems to the instructor

- **Attempts:**
- 1 quiz attempt, 120 minute limit, 20 questions.
- Coverage is inclusive of Lectures ~1-16
- Once started, there will be 2 hours to complete, please plan accordingly.

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GROUP PRESENTATIONS

- TWO OPTIONS:
- *Cloud technology presentation*
- *Cloud research paper presentation*
  - Recent & suggested papers will be posted at:
    http://faculty.washington.edu/wlloyd/courses/tcss562/papers/
- Presentation dates:
  - Tuesday November 28, Tuesday November 30
  - Tuesday December 5, Thursday December 7
- Peer Reviews
  - Word DOCX form will be provided, fill out, submit PDF on Canvas
  - Feedback shared with groups
  - TCSS 462: 1 review/day required, additional are extra credit
  - TCSS 562: same as 462, but no peer review req'd on day of your talk

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PRESENTATION SCHEDULE

- **Tuesday December 5**
1. Kewei Liu, Sherry Liu (team 15)
Research paper: AWSomePy : A Dataset and Characterization of Serverless Applications
2. Sanjay Vuppugandla, Sai Prateek Atluri, Ankit Kadian (team 9*)
Cloud Technology: AWS CloudFormation

- **Thursday December 7**
1. Cynthia Pang, Lifan Cao (team 6)
Research paper: Evicting for the Greater Good: The Case for Reactive Check Pointing in Serverless Computing
2. Srishty, Angela C Farin, Tomoki Kusunoki (team 7)
Cloud Technology: Amazon Redshift
3. Xiaoqing Zhou, Mary Yang, Micaela Nomakchteinsky (team 8)
Research paper: Rendezvous - Where Serverless Functions Find Consistency

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TUTORIAL 8 – DEC 15

- Introduction to AWS Step Functions and Amazon Simple Queue Service (SQS)
- Not Required, available for extra credit
  - adds points to overall tutorials score
- https://faculty.washington.edu/wlloyd/courses/tcss562/tutorials/TCSS462_562_f2023_tutorial_8.pdf

- Tasks
  - Adapt Caesar Cipher Lambda functions for use with AWS Step Functions
  - Create AWS Step Functions State Machine
  - Create a BASH client to invoke the AWS Step Function
  - Create Simple Queue Service Queue for messages
  - Add message to SQS queue from AWS Lambda function
  - Modify AWS Step Function Bash client script to retrieve AWS Step Function result from SQS queue

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WE WILL RETURN AT
~4:50 PM

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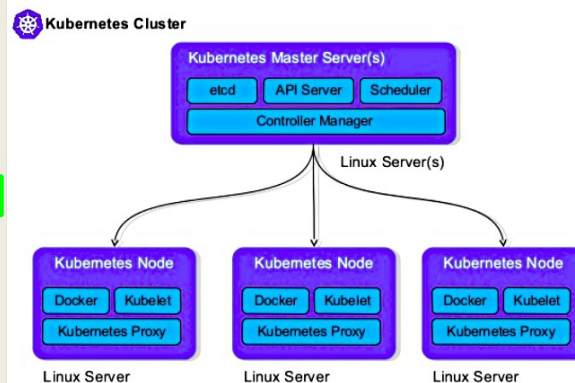- **Kubernetes**

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KUBERNETES
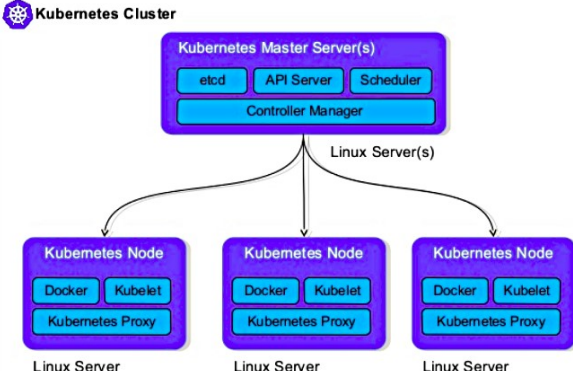
from: "The Kubernetes Book", Nigel Poulton and Pushkar Joglekar, Version 7.0, September 2020

L20.25

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MASTER SERVICES

- API Server
- Cluster store
- Controller Manager
- Scheduler
- Cloud controller

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CLOUD CONTROLLER MANAGER

- Abstracts and manages integration with specific cloud(s)

- Manages vendor specific cloud infrastructure to provide instances (VMs), load balancing, storage, etc.

- Support for AWS, Azure, GCP, Digital Ocean, IBM, etc.

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MASTER SERVICES

- API Server
- Cluster store
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WORKER NODES

- Nodes perform tasks (i.e. host containers & services)

- Three primary functions:
1. Wait for the scheduler to assign work
2. Execute work (host containers, etc.)
3. Report back state information, etc.

- Nodes are considerably simpler than masters

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WORKER NODES

- **Kubelet**
- Container runtime (*Docker, etc.*)
- Kubernetes Proxy

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KUBELET

- Main Kubernetes agent

- Runs on every node

- Adding a new node installs the kubelet onto the node

- Kubelet registers the node with the cluster

- Monitors API server for new work assignments

- Maintains reporting back to control plane

- When a node can't run a task, kubelet is NOT responsible for finding an alternate node
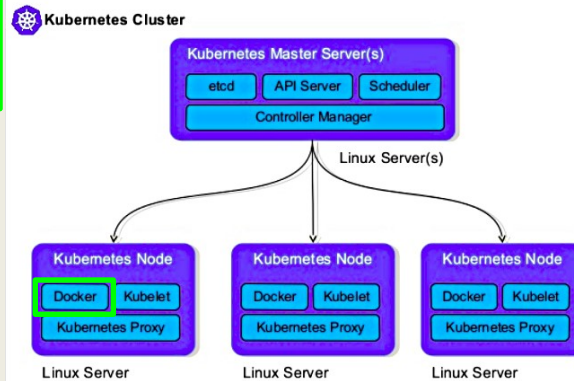
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WORKER NODES

- Kubelet
- Container runtime (*Docker, etc.*)
- Kubernetes Proxy
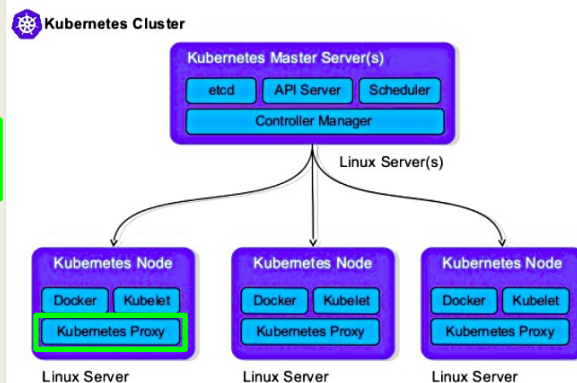
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CONTAINER RUNTIME(S)

- **Each node requires a container runtime to run containers**

- **Early versions had custom support for a limited number of container types, e.g. Docker**

- **Kubernetes now provides a standard Container Runtime Interface (CRI)**

- **CRI exposes a clean interface for 3rd party container runtimes to plug-in to**

- **Popular container runtimes: Docker, containerd, Kata**

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WORKER NODES

- **Kubelet**
- **Container runtime (*Docker, etc.*)**
- **Kubernetes Proxy**

Kubernetes Cluster

Kubernetes Master Server(s)
etcd API Server Scheduler
Controller Manager

Linux Server(s)

Kubernetes Node
Docker Kubelet
Kubernetes Proxy
Linux Server

Kubernetes Node
Docker Kubelet
Kubernetes Proxy
Linux Server

Kubernetes Node
Docker Kubelet
Kubernetes Proxy
Linux Server

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KUBE-PROXY

- Runs on every node in the cluster
- Responsible for managing the cluster's networking
- Ensures each node obtains a unique IP address
- Implemented local IPTABLES and IPVS rules to route and load-balance traffic

- IPTABLES (ipv4) – enables configuration of IP packet filtering rules of the Linux kernel firewall

- IPVS – IP Virtual Server: provides transport-layer (layer 4) load balancing as part of the Linux kernel; Configured using ipvsadm tool in Linux

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CORE KUBERNETES COMPONENTS

- **Kubernetes DNS**

- **Pods**

- **Services**

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KUBERNETES DNS

- **Every Kubernetes cluster has an internal DNS service**

- **Accessed with a static IP**

- **Hard-coded so that every container can find it**

- **Every service is registered with the DNS so that all components can find every Service on the cluster by NAME**

- **Is based on CoreDNS (https://coredns.io)**

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CORE KUBERNETES COMPONENTS

- **Kubernetes DNS**

- **Pods**

- **Services**

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PODS

- Pod – atomic unit of deployment & scheduling in Kubernetes
- A Kubernetes Pod is defined to run a containerized application
- Kubernetes manages Pods, not individual containers
- Cannot run a container directly on Kubernetes
- All containers run through Pods

- Pod comes from "pod of whales"
- Docker logo shows a whale with containers stacked on top
- Whale represents the Docker engine that runs on a single host
- Pods encapsulate the definition of a single microservice for hosting purposes
- Pods can have a single container, or multiple containers if the service requires more than one

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PODS - 2

- Examples of multi-container Pods:
  - Service meshes
  - Web containers with a helper container that pulls latest content
  - Containers with a tightly coupled log scraper or profiler
- YAML manifest files are used to provide a declarative description for how to run and manage a Pod

- To run a pod, POST a YAML to the API Server: "kubectl run <NAME>"   where NAME is the service
- A Pod runs on a single node (host)
- Pods share:
  - Interprocess communication (IPC) namespace
  - Memory, Volumes, Network stack

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PODS - 3

- Pods provide a "fenced" environment to run containers
- Provide a "sandbox"
- Only tightly coupled containers are deployed with a single pod
- Best practice: decouple individual containers to separate pods
  - *What is the best container composition into pods?* (1:1, 1:many)

- **Scaling**
  - Pods are the unit of scaling
  - Add and remove pods to scale up/down
  - Do not add containers to a pod, add pod instances
  - Pod instances can be scheduled on the same or different host

- **Atomic Operation**
  - Pods are either fully up and running their service (i.e. port open/exposed), or pods are down / offline

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PODS - 4

- **Pod Lifecycle**
  - An application should not be tightly bound or dependent on a specific Pod instance
  - Pods are designed to fail and be replaced
  - Use of **service objects** in Kubernetes help decouple pods to offer resiliency upon failure

- **Deployments**
  - Higher level controllers often used to deploy pods
  - Controllers implement a controller and watch loop:
  - "Deployments" – offer scalability & rolling updates
  - "DaemonSets" – run instance of service on every cluster node
  - "StatefulSets" – used for stateful components
  - "CronJobs" – for short lived tasks that need to run at specified times

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CORE KUBERNETES COMPONENTS

- **Kubernetes DNS**

- **Pods**

- **Services**

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KUBERNETES "SERVICES"

- **Pods managed with "Deployments" or "DameonSets" controllers are automatically replaced when they die**
  - **This provides resiliency for the application**
- **KEY IDEA: Pods are unreliable**

- **Services provide reliability by acting as a "GATEWAY" to pods that implement the services**
  - **They underlying pods can change over time**
  - **The services endpoints remain and are always available**

- **Service objects provide an abstraction layer w/ a reliable name and load balancing of requests to a set of pods**
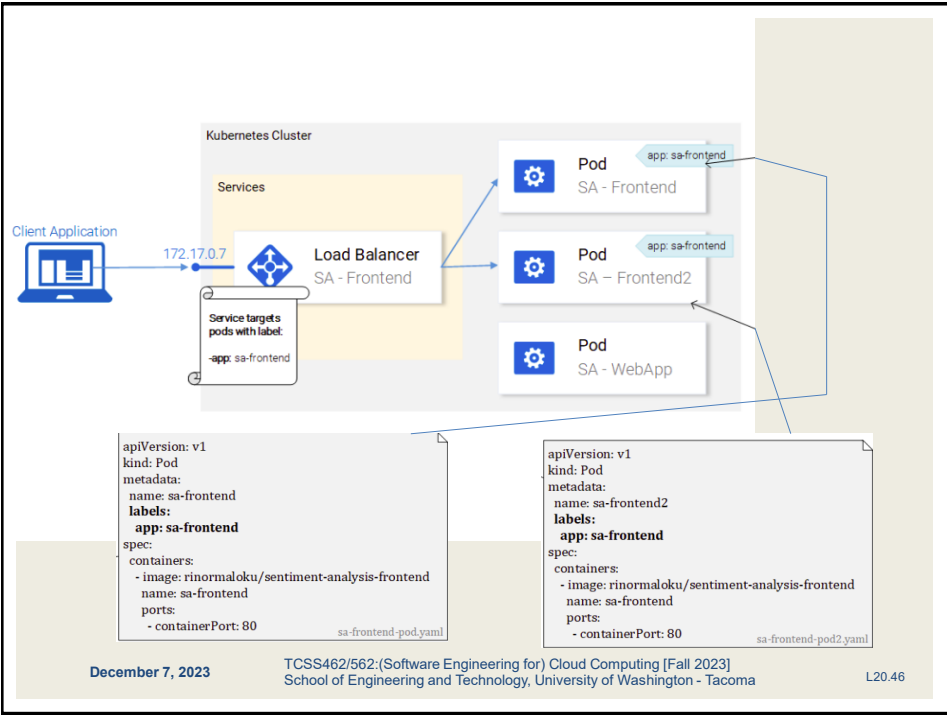
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SERVICES

- Provide reliable front-end with:
  - Stable DNS name
  - IP Address
  - Port
- Services do not posses application intelligence
- No support for application-layer host and path routing

- Services have a "label selector" which is a set of lables
- Requests/traffic is only sent to Pods with matching labels

- Services only send traffic to healthy Pods
- **KEY IDEA**: Services bring stable IP addresses and DNS names to unstable Pods

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QUESTIONS

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