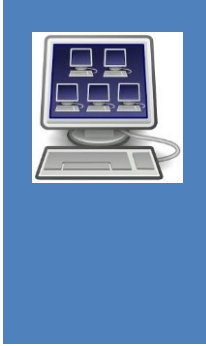


TCSS 562: SOFTWARE ENGINEERING FOR CLOUD COMPUTING

Tutorial Demos

Wes J. Lloyd
School of Engineering and Technology
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1

OFFICE HOURS – FALL 2023

- **THIS WEEK**
- Campus is closed Friday November 10, due to the Veteran’s Day holiday
- **Tuesdays:**
 - 2:30 to 3:30 pm - CP 229
- **Friday*:**
 - 1:00 pm to 2:00 pm – CP 229 and via Zoom*
- Or email for appointment

> Office Hours set based on Student Demographics survey feedback
* - tentative – waiting on confirmation of Friday faculty meeting schedule

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THIS WEEK

- **Tuesday November 14th**
- **The class will meet and begin with the usual review, but instead of new lecture, we will focus on tutorial demonstrations and questions to provide a catch-up day**

- **Thursday November 16th**
- **Quiz 1 to be posted to Canvas**
- **Lecture 15 on containerization**

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OBJECTIVES - 11/14

- **Questions from 11/9**
- **Tutorials Questions**
- **Class Presentations:**
 - **Cloud Technology or Research Paper Review**
- **Quiz 1**
- **GraphQL**
- **Tutorial 5 Demo**
- **Tutorial 6 Demo**

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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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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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MATERIAL / PACE

- Please classify your perspective on material covered in today's class (**55** respondents):
 - 1-mostly review, 5-equal new/review, 10-mostly new
 - **Average - 6.02** (↓ - *previous 6.20*)

- Please rate the pace of today's class:
 - 1-slow, 5-just right, 10-fast
 - **Average - 5.44** (↓ - *previous 5.82*)

- **Response rates:**
 - TCSS 462: 33/44 - 75.00%
 - TCSS 562: 22/25 - 88.00%

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FEEDBACK FROM 11/9

- **What is the difference between a VM and an OS container?**

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FEEDBACK FROM 11/7

- ***OS containers still remain unclear to me.***
How do they differ from a VM ?
- Linux containers differ than VMs in that all instances share the same Linux operating system kernel
- All processes and threads across all running OS containers on the host must be scheduled through the same Linux kernel
- If all containers on a host share the same Linux kernel, how is isolation different than sharing the host using virtual machines?
- When you run Windows and Virtual Box Linux on the same computer, do the operating systems share the same kernel?
- Containers partition the Linux host into distinct sand boxes so that each container has a private view of only its resources

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FEEDBACK - 2

- ***Can OS containers perform the same operations as a VM ?***
- OS containers run a full set of OS processes to mimic a Virtual Machine
- With many OS container instances, common OS processes are duplicated in every container increasing memory consumption and overhead
 - How many processes does your Linux Virtual Box VM run when booted? Check with 'top'
 - Each OS container runs a few hundred processes like a VM
- With more processes on the host, there is more context switching between processes on the CPU, and more performance overhead
 - More processes may also lead to more memory page faults

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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 wllloyd@uw.edu
- Codes can also be obtained in person (or zoom), in the class, during the breaks, after class, during office hours, by appt
 - 61 credit requests fulfilled as of Nov 13 @ 11:59p
- Codes not provided using discord

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OBJECTIVES - 11/14

- Questions from 11/9
- **Tutorials Questions**
- Class Presentations:
Cloud Technology or Research Paper Review
- Quiz 1
- GraphQL
- Tutorial 5 Demo
- Tutorial 6 Demo

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TUTORIAL 0

- Getting Started with AWS
- http://faculty.washington.edu/wlloyd/courses/tcss562/tutorials/TCSS462_562_f2023_tutorial_0.pdf
- Create an AWS account
- Create account credentials for working with the CLI
- Install awsconfig package
- Setup awsconfig for working with the AWS CLI


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

Spot instances:
c5d.large instance @ ~2 cents / hour

\$0.48 / day
\$3.36 / week
\$14.60 / month
\$175.20 / year

AWS CREDITS → → → → → → → → 

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TUTORIAL 5 – DUE ~~NOV 14~~ NOV 15

- Introduction to Lambda II: Working with Files in S3 and CloudWatch Events
- https://faculty.washington.edu/wlloyd/courses/tcss562/tutorials/TCSS462_562_f2023_tutorial_5.pdf
- Customize the Request object (add getters/setters)
 - Why do this instead of HashMap ?
- Import dependencies (jar files) into project for AWS S3
- Create an S3 Bucket
- Give your Lambda function(s) permission to work with S3
- Write to the CloudWatch logs
- Use of CloudTrail to generate S3 events
- Creating CloudWatch rule to capture events from CloudTrail
- Have the CloudWatch rule trigger a target Lambda function with a static JSON input object (hard-coded filename)
- **Optional:** for the S3 PutObject event, dynamically extract the name of the file put to the S3 bucket for processing

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TUTORIAL 6 – NOV 21

- Introduction to Lambda III: Serverless Databases
- https://faculty.washington.edu/wlloyd/courses/tcss562/tutorials/TCSS462_562_f2023_tutorial_6.pdf
- Create and use Sqlite databases using sqlite3 tool
- Deploy Lambda function with Sqlite3 database under /tmp
- Compare in-memory vs. file-based Sqlite DBs on Lambda
- Create an Amazon Aurora “Serverless” v2 MySQL database
- Using an ec2 instance in the same VPC (Region + availability zone) connect and interact with the database using the mysql CLI app
- Deploy an AWS Lambda function that uses the MySQL “serverless” database

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TUTORIAL 7 – TO BE POSTED

- Introduction to Docker
- (to be posted)
https://faculty.washington.edu/wlloyd/courses/tcss562/tutorials/TCSS462_562_f2023_tutorial_7.pdf
- Must complete using Ubuntu 22.04 (for cgroups v2)
- Use DOCX file for copying and pasting Docker install commands
- Topics:
 - Installing Docker
 - Creating a container using a Dockerfile
 - Using cgroups virtual filesystem to monitor CPU utilization of a container
 - Persisting container images to Docker Hub image repository
 - Container vertical scaling of CPU/memory resources
 - Testing container CPU and memory isolation

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TUTORIAL COVERAGE

- Docker CLI → Docker Engine (dockerd) → containerd → runc
- Working with the docker CLI:
 - docker run create a container
 - docker ps -a list containers, find CONTAINER ID
 - docker exec --it run a process in an existing container
 - docker stop stop a container
 - docker kill kill a container
 - docker help list available commands
 - man docker Docker Linux manual pages

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```
Commands:
attach      Attach local standard input, output, and error streams to a running container
build       Build an image from a Dockerfile
commit     Create a new image from a container's changes
cp          Copy files/folders between a container and the local filesystem
create     Create a new container
deploy     Deploy a new stack or update an existing stack
diff        Inspect changes to files or directories on a container's filesystem
events     Get real time events from the server
exec       Run a command in a running container
export     Export a container's filesystem as a tar archive
history    Show the history of an image
images     List images
import     Import the contents from a tarball to create a filesystem image
info       Display system-wide information
inspect    Return low-level information on Docker objects
kill       Kill one or more running containers
load       Load an image from a tar archive or STDIN
login      Log in to a Docker registry
logout     Log out from a Docker registry
logs       Fetch the logs of a container
pause     Pause all processes within one or more containers
port       List port mappings or a specific mapping for the container
ps         List containers
pull       Pull an image or a repository from a registry
push       Push an image or a repository to a registry
rename     Rename a container
restart    Restart one or more containers
rm         Remove one or more containers
rmi        Remove one or more images
run        Run a command in a new container
save       Save one or more images to a tar archive (streamed to STDOUT by default)
search     Search the Docker Hub for images
start     Start one or more stopped containers
stats     Display a live stream of container(s) resource usage statistics
stop      Stop one or more running containers
tag        Create a tag TARGET_IMAGE that refers to SOURCE_IMAGE
top        Display the running processes of a container
unpause   Unpause all processes within one or more containers
update    Update configuration of one or more containers
version   Show the Docker version information
wait      Block until one or more containers stop, then print their exit codes
```

Docker CLI

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TUTORIAL 7

- Tutorial introduces use of two common Linux performance benchmark applications
 - stress-ng
 - 100s of CPU, memory, disk, network stress tests
- Sysbench
 - Used in tutorial for memory stress test

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OBJECTIVES - 11/14

- Questions from 11/9
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GROUP PRESENTATION

- **TWO OPTIONS:**
- *Cloud technology presentation*
- *Cloud research paper presentation*
 - Recent & suggested papers will be posted at:
<http://faculty.washington.edu/wlloyd/courses/tcss562/papers/>
- **Submit presentation type and topics (paper or technology) with desired dates of presentation via Canvas by:
*Friday November 17th @ 11:59pm***
- **Presentation dates:**
 - Tuesday November 28, Thursday November 30
 - Tuesday December 5, Thursday December 7

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OBJECTIVES - 11/14

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- **Quiz 1**
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QUIZ 1

- Opens **Thursday November 16 at 8:00 am**
- Closes **Monday November 20 at 11:59 am**
- 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, ~25 questions.
 - Coverage is inclusive of Lectures ~1-10
 - Please plan accordingly. Once started, there will be 2 hours to complete

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OBJECTIVES - 11/14

- Questions from 11/9
- Tutorials Questions
- Class Presentations:
Cloud Technology or Research Paper Review
- Quiz 1
- **GraphQL**
- Tutorial 5 Demo
- Tutorial 6 Demo

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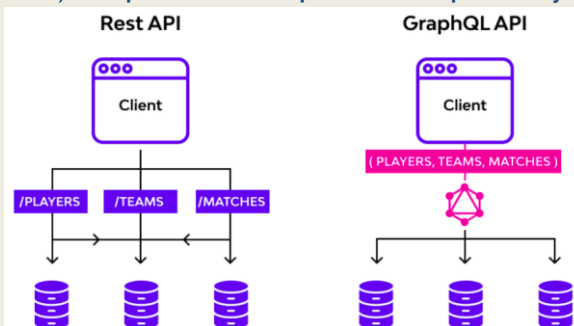
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GRAPHQL

- **GraphQL** provides an alternative to RESTful APIs
- Instead of requiring a remote client to call multiple endpoints to obtain separate data, a GraphQL server provides a single aggregated (combined) endpoint and responds with precisely the data a client asks for.



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GRAPHQL - 2

- GraphQL is responsible for fetching data that a client requests from multiple databases, storage engines, or services (including FaaS AWS Lambda functions)
- For remote mobile clients, reduces the # of client service calls (round-trips) by aggregating them together
 - Only pay for the cost of network latency between the client and server one time
- Initially created by Facebook in 2012, and released as open source in 2015
- Supports reading and writing data, and also subscribing to updates

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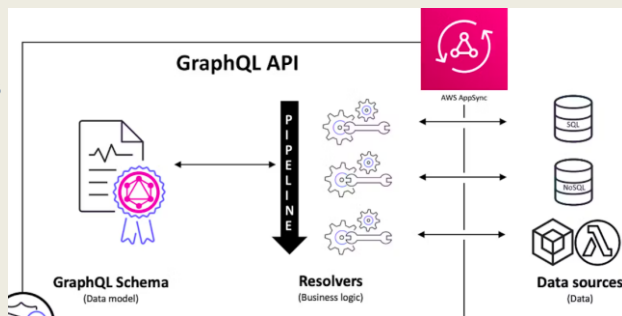
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GRAPHQL - 3

- GraphQL service consists of **types** with **fields** then provides functions to resolve data for each field
- The collection of types and fields is the **schema** definition
- Functions that retrieve and map data are called **resolvers**
- Data sources:
SQL, NoSQL,
services, Lambdas



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GRAPHQL - 4

- GraphQL requires a server to implement schemas using resolvers
- The server is typically hosted in the cloud near the databases and services
- Open source:
 - Apollo Server – build and run GraphQL APIs w/ Node.js
 - Express GraphQL – also Node.js based
 - Hot Chocolate – create GraphQL APIs for .NET
- Managed solutions:
 - AWS AppSync
 - Google Apigee
 - Azure API Management
 - IBM API Connect

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GRAPHQL - 5

- Managed GraphQL services or Open Source GraphQL servers would be good topics for the Cloud Technology Presentation
- For the standard TLQ term project, a GraphQL could be developed against the database
- Using 5 separate 'Q'ery Lambda functions different data could be fetched from the sales or medical records datasets
- A schema could be defined to fetch all 5 elements as a single query
- Client performance could be compared for fetching the data using separate REST/Lambda calls vs. an aggregated GraphQL API

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OBJECTIVES - 11/14

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WE WILL RETURN AT ~4:50 PM



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OBJECTIVES - 11/14

- Questions from 11/9
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QUESTIONS



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