Faculty Institute 2020 Continuous Integration and Delivery in Student Projects

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Google Cloud

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After working professionally as a software engineer, I went back to school and got my PhD. I've been at ECU since 2013, teaching courses related to software development and software engineering.

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Motivation

- Concepts related to DevOps are becoming increasingly prevalent in practice
- This includes continuous integration, containers, build automation, and cloud deployment

- How can we prepare our students for this?
- What backgrounds do they need to be able to learn these skills?
- Are there activities we can use to give them hands-on experience?
- If so, what are some examples of these activities?

A quick aside

- ITiCSE Working Group 7: Cloud Computing Curriculum: Developing Exemplar Modules for General Course Inclusion
- See https://iticse.acm.org/working-group-details/ for details

- I have been involved in this working group this year, but this is work from before joining
- I am not speaking for the working group, this is not a presentation of the work of WG-7

- Parts of this are also described in a CSEE&T 2020 short paper I authored

Introduction: What will we cover?

- A series of hands-on activities related to continuous integration, build automation, and continuous delivery
- Details of a student project that uses these techniques
- Some lessons learned

Introduction: Who is this for?

- The main audience for this presentation is faculty teaching undergraduate and graduate courses in computer science and software engineering (more about the course context coming up!)
- The secondary audience is interested faculty or professionals that would like to learn some of this material themselves and incorporate it into their own work

Overview: Computer Science at ECU

- Two undergraduate programs: BS in Computer Science, BS in Software Engineering (new!)
- Three graduate programs: MS in Computer Science, MS in Software Engineering, MS in Data Science

- Graduate programs attract a range of students
  - Fresh undergrads
  - Working professionals
  - Career switchers

- BS in CS has two SE courses (one regular course, one project/capstone course)

Zooming in: Undergrad context

- Software Engineering II: Undergrad project/capstone course

- Students work in teams of 5 or 6
- Projects based on student interest, some from outside, some proposed by students
- Some projects use web or mobile, use cloud credits to give students experience
- Note: students are encouraged, but not required, to use cloud

Zooming in: Grad context

- Software Construction: Grad software development course

- Students generally work individually
- Focus is on scaling up development skills for larger software systems
- Important concepts: abstraction, code comprehension/understanding, professional practice
- Lots of non-cloud skills: IDEs, version control (Git), build automation, unit testing, test mocks, code coverage, lightweight static analysis (SpotBugs/PMD)

- Originally, no focus on cloud

Activity origins: First attempt

- Goal: DevOps concepts are becoming widely used in practice, students should have some experience with them!

- First attempt: use existing “getting started” docs, online example, some online readings
- Goal was to get students to try things, not graded beyond participation
- This...didn’t go so well

Activity origins: First attempt problems

- Sometimes, technologies change faster than docs (minor issue)
- Many docs written for professionals with richer backgrounds (major issue)
- Students could not differentiate fundamentals from examples (major issue)
- Students would get lost, not know how to get back on track (major issue)

Activity origins: Second attempt

- Started over from scratch, created 4 activities

- Activity 1: Continuous Integration
- Activity 2: Docker
- Activity 3: Kubernetes
- Activity 4: Continuous Delivery

- Mixture of instructor-provided material, videos (LinkedIn Learning), vendor docs
- Ready-made “starters” for each step
- Participation credit, not formally graded (low stress)

The Hello-izer

- Activities use a simple Java Spring app, The Hello-izer!
- RESTful Web Service with one endpoint
- Only knows how to say “Hello”!

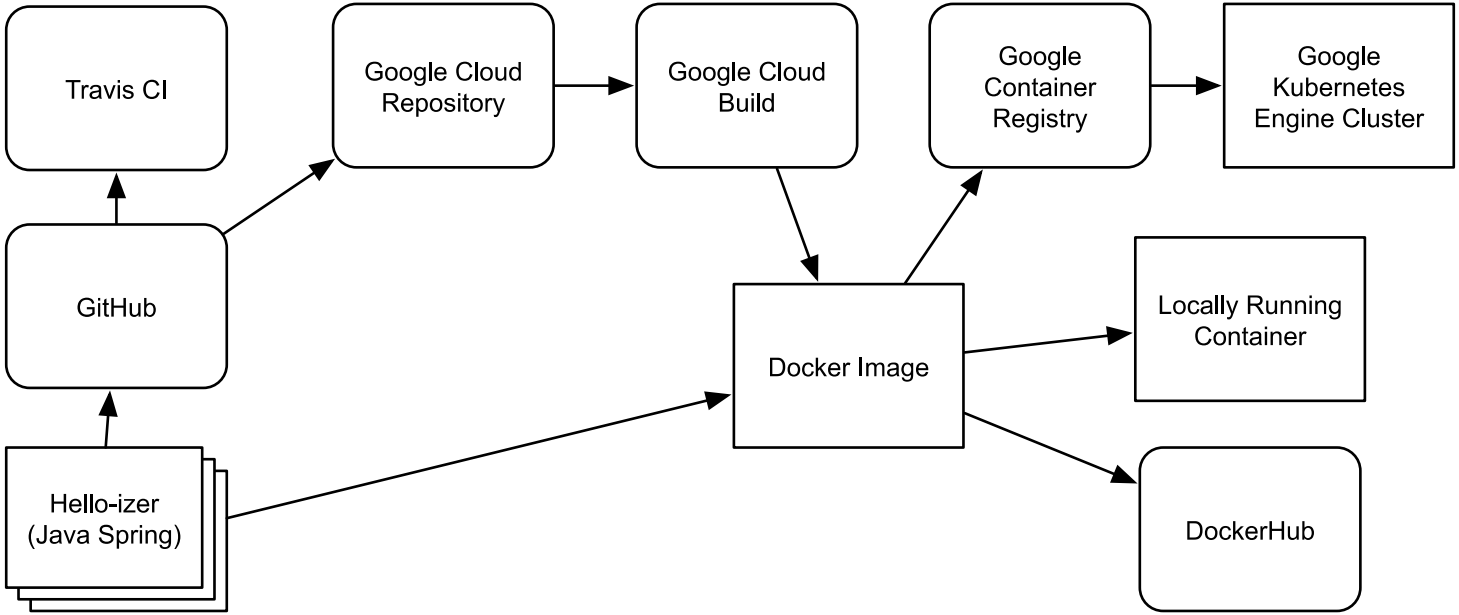
$ curl http://localhost:8080/hello

{"messageId":"3d071f7e-bd26-4b26-b77a-891ec1449da0","message":"Hello, anonymous person it is Fri Sep 04 16:06:52 EDT 2020","messageDate":"2020-09-04T20:06:52.749+0000"}

$ curl http://localhost:8080/hello\?name\=Mark

{"messageId":"284172ed-c4c1-4ced-bdce-c6f6e422b7f4","message":"Hello, Mark it is Fri Sep 04 16:06:58 EDT 2020","messageDate":"2020-09-04T20:06:58.199+0000"}

Activity overview: Moving parts



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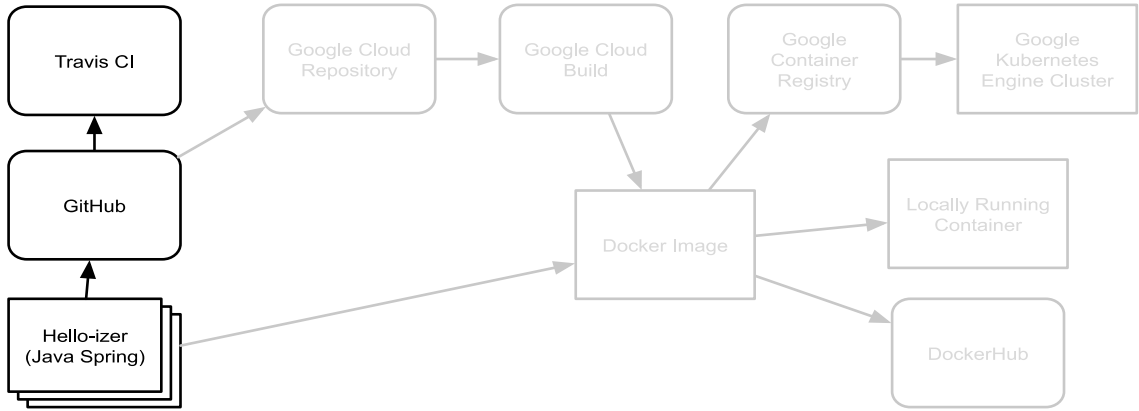
Activity 1: Continuous integration

- Overall goal: students enable CI, see it in action

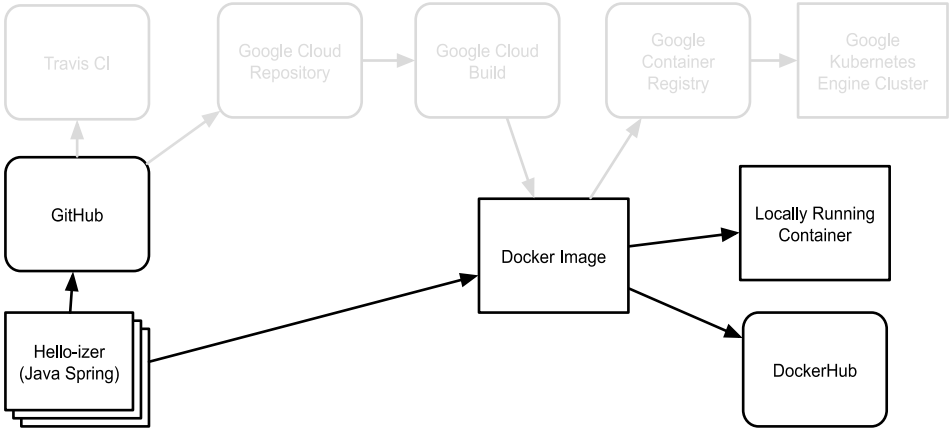
- Students fork Hello-izer repo
- Need to enable Travis-CI integration
- First push to GitHub will trigger Build with failing test
- Students fix code, push changes
- Now, all tests pass



Activity 2: Docker

- Overall goal: students learn how to build and share a Docker image, automate the build, run and test the container

- Students start with Activity 1 code
- Need to create Dockerfile to create the image
- Test the image to see if it can be used to make a working container
- Automate container build process
- Push results to DockerHub and GitHub



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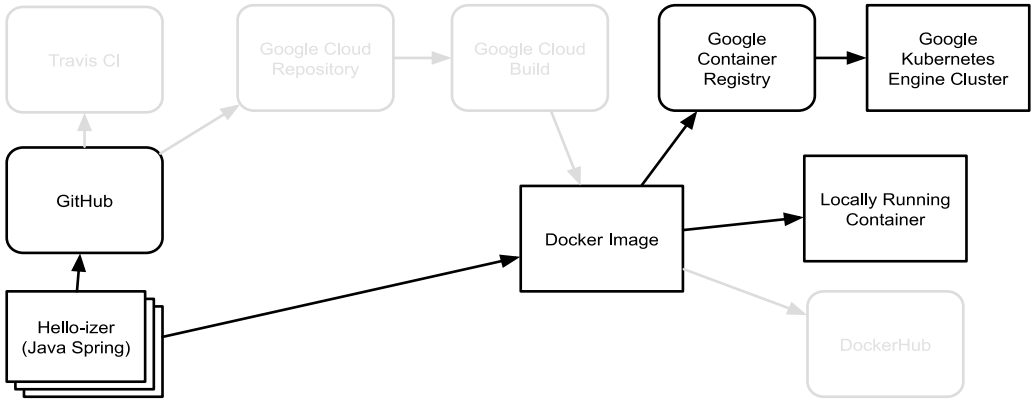
Activity 3: Kubernetes

- Overall goal: students learn how to deploy a Docker image to a Kubernetes cluster

- Students start with image from prior Activity or from instructor
- Set up project on Google Cloud
- Use SDK to push image to the Container Registry
- Create a Kubernetes cluster
- Deploy image to the cluster
- Make available using load balancer



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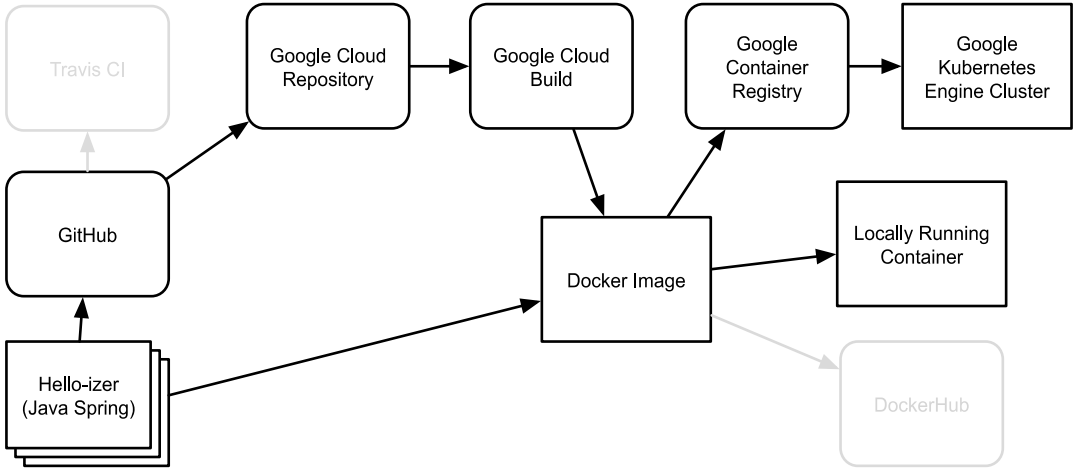
Activity 4: Continuous delivery

- Overall goal: students put this all together to deploy changes to their cluster

- Students create a Cloud Source Repository that syncs with GitHub
- Cloud Build enabled and configured
- Trigger added to trigger build when repository changes
- Check build by deploying to Kubernetes, then extend build to automate deployment



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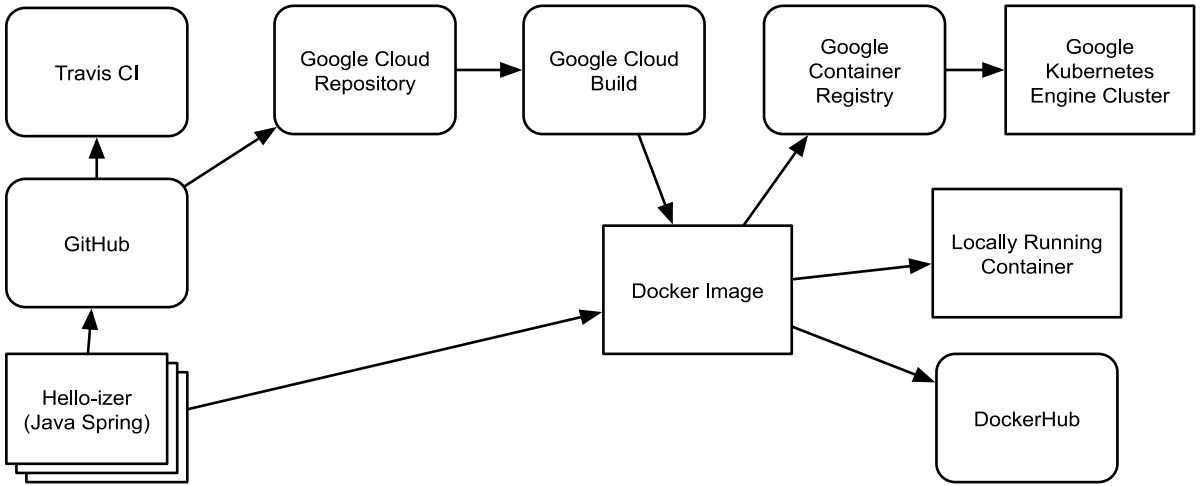
Activity summary

- By the end, changes to repository trigger test and creation of new Docker image
- Kubernetes automatically updated using newest changes committed to GitHub
- Students can change API output and quickly see deployed changes



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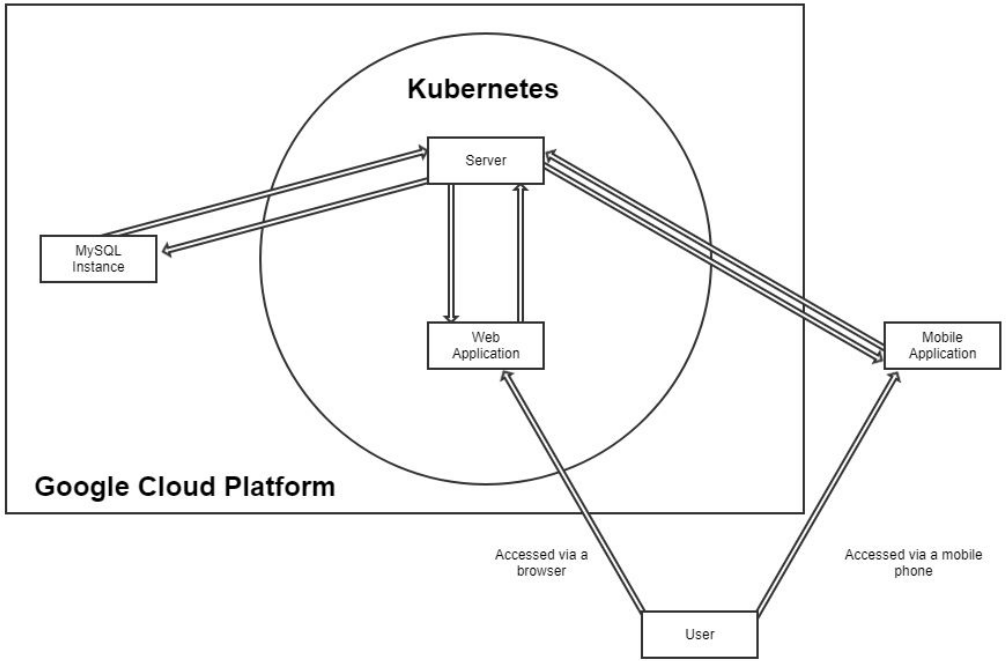
An example student project

- Note: image from their documentation
- Secure messaging app named Spark
- API and web server deployed to Google Cloud whenever GitLab is updated
- Uses Docker and Kubernetes



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Student project: deployment details

```
deploy:
  image: google/cloud-sdk:latest
  stage: deploy
  variables:
    DOCKER_IMAGE_TAG: theconartist/spark-web-application:latest
  script:
    # Authenticate with GKE
    - apt-get --assume-yes install gettext
    - echo "$SACK" > key.json
    - gcloud auth activate-service-account --key-file=key.json
    - gcloud config set project spark-266522
    - gcloud config set container/cluster spark-web-cluster
    - gcloud config set compute/zone us-east1-b
    - gcloud container clusters get-credentials spark-web-cluster --zone us-east1-b
    - sed -i "s/<VERSION>/${CI_COMMIT_SHORT_SHA}/g" deployment.yaml
    - cat deployment.yaml | envsubst | kubectl apply -f -
```

Student project: deployment details

```
spec:
  containers:
  - name: spark
    image: theconartist/spark-web-application:<VERSION>
    env:
      - name: "PORT"
        value: "19006"
```

Lessons learned

- Command line skills are important, but often missing
- Vendor documentation is important, but often missing context students need
- Kubernetes is tricky for students (and sometimes for faculty!)
- Don’t use latest with Kubernetes for Docker images, it doesn’t do what you think it does!
- Be ready to work with your students, it’s important they learn this material, but they will get stuck on parts of it
- Be patient with yourself, it’s hard to keep up with all this stuff!

Following up & next steps

- Working on converting activities to CodeLabs format
- Feel free to contact me if you want to discuss these! I'm at: hillsma@ecu.edu

Thank you.