Serverless Application Architecture

Charles Engelke

Welcome to the Workshop

We will explore the ways that designing serverless applications differs from traditional server-side apps.

- Serverless
    - Of course there are still servers
    - But they aren't your problem

- The cloud provider handles scaling, deployment, monitoring, availability, backup

- Think of this as **managed** application platforms

I'm Charlie Engelke

Google Cloud Developer Relations Engineer

Specializing in serverless products

My career prior to Google was with a medium-sized application company

Pretty much every tech job over time

Led application development projects on lots of platforms

Cloud computing was a great equalizer, allowing us to compete against enormous competitors

My job now is to help developers take advantage of Google's offerings to solve their own problems

And what about Python?

- This isn't a workshop ***about*** Python, it's a workshop that ***uses*** Python

- Python is a core technology at Google
    - Google's first serverless offering, App Engine, was built with Python, for Python
    - (Guido van Rossum was involved)

- All our cloud offerings support Python

- I learned Python so I could use App Engine
    - Python and PyCon made me a Googler

Agenda

1. Serverless application characteristics

2. High-level design concepts for a very minimal serverless application

3. Description of a larger, distributed, serverless application and design
   - Slides, GitHub repo, codelabs, running demo, and videos at serverlessworkshop.dev

4. Q&A during the scheduled time in chat

Some Serverless differences

Serverless code runs **on-demand**

- When there's no work to do, it goes away

Serverless code is **stateless**

- When the code goes away, so does its memory and file system

Serverless code **scales** on demand

- Demand increases, more instances are provided
- Or it can scale down to zero

Details

- Most applications need state
  - So must use external data storage
  - Preferably serverless itself

- Events (like web requests) are handled by the platform
  - Which then invokes your code
  - Once the event is handled, code stops

- The application is no longer **a** program
  - It's a cooperating collection of pieces

Serverless Options

Important note:

- I am showing Google Cloud serverless offerings
  - I know them best, and after all, this is a sponsored workshop

- But every major cloud provider has similar offerings
  - Everything here can apply to most of them
  - Specifics will change, but concepts remain
  - I was a frequent, successful user of one of those cloud providers at my prior job

Google Cloud Serverless Compute

App Engine

Google's first serverless offering

- Launched in 2008, just became a teenager
- Python only at first, Java next, now 6 languages
- Useful as a web app backend

First generation included bundled APIs

- Current generation uses APIs available to all platforms instead

Google Cloud Serverless Compute

App Engine

Cloud Functions

- Good fit for small, focused event handlers
  - E.g., a web app user uploads an image that needs post processing
  - Instead of waiting for main app, have the upload trigger an event
  - A Cloud function handles the event

Google Cloud Serverless Compute

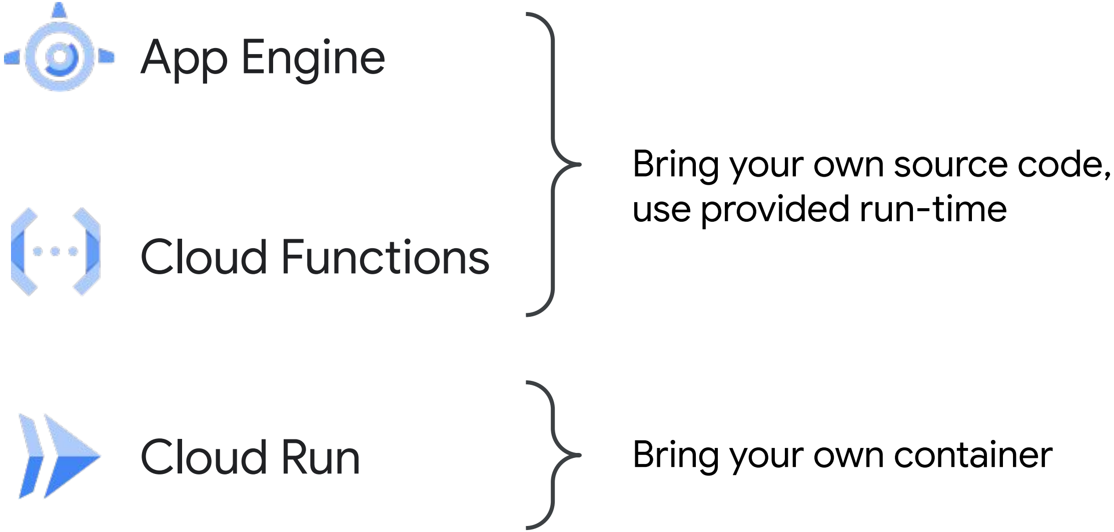
App Engine

Cloud Functions

Cloud Run

- Container based
  - Similar to App Engine and Cloud Functions, but takes a container
- No longer limited to supported languages

Key differences



App Engine

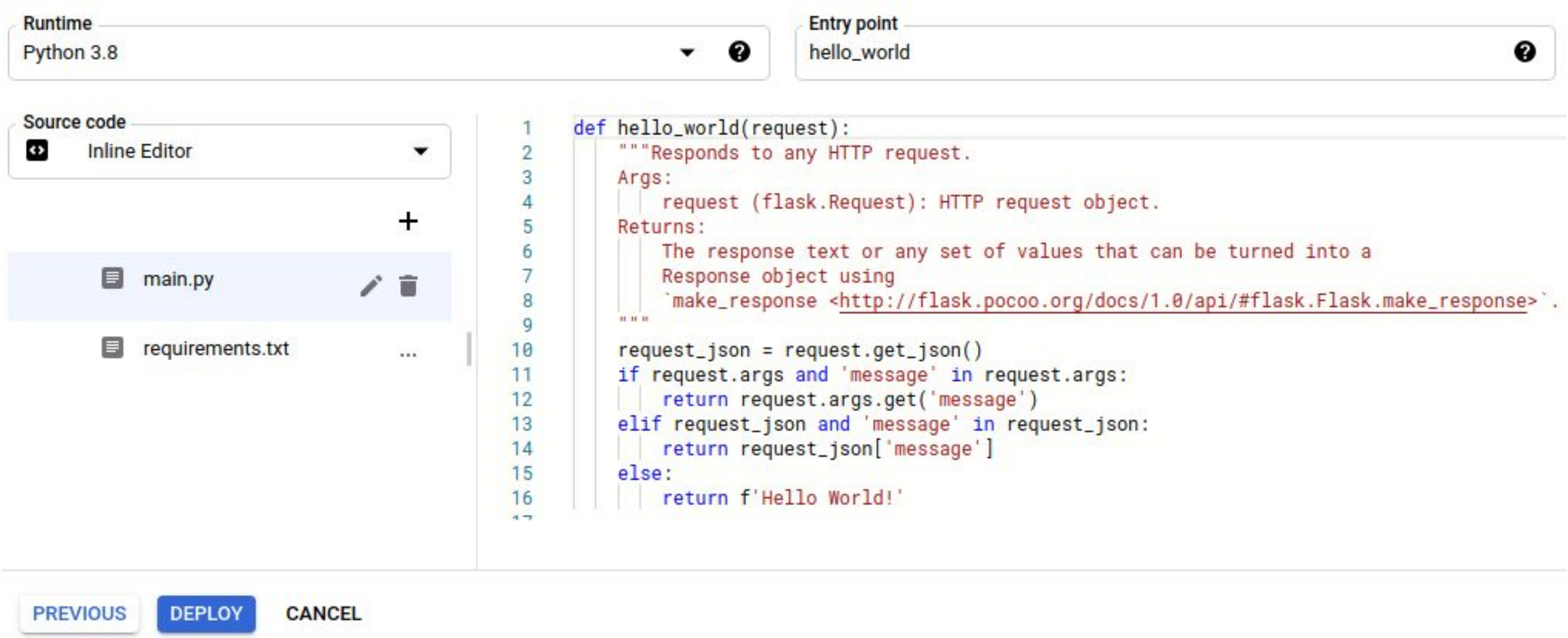
Cloud Functions

Bring your own source code, use provided run-time

Cloud Run

Bring your own container

Cloud Functions: short path to live code online



Runtime: Python 3.8

Entry point: hello_world

Source code: Inline Editor

```
def hello_world(request):
    """Responds to any HTTP request.
    Args:
        request (flask.Request): HTTP request object.
    Returns:
        The response text or any set of values that can be turned into a
        Response object using
        `make_response <http://flask.pocoo.org/docs/1.0/api/#flask.Flask.make_response>`.
    """
    request_json = request.get_json()
    if request.args and 'message' in request.args:
        return request.args.get('message')
    elif request_json and 'message' in request_json:
        return request_json['message']
    else:
        return f'Hello World!'
```

Google Cloud Serverless state (data)

Cloud Firestore

Firestore in Datastore Mode

Document oriented NoSql

Cloud Storage

Blob store

Some Cloud Event Sources

Web requests

Updated data

Tasks, Scheduler, Pub/Sub

Basic Serverless App Example

Consider a basic Todo app

- Keep it super simple
- One user (or a group sharing todo items)
- One list of items
- Any user can list, view, update, add, or delete items

One possible approach

- Get a Linux virtual machine
- Install a web server (e.g., NGINX)
- Install a programming language
  - Python, of course
- Install libraries
- Install a database server (MySQL? SQLite? Postgres?)
- Put in your source code
- Configure and start everything up
- Figure out backup, redundancy, disaster recovery, monitoring...

Or a serverless approach

- State (persistent data)
  - A list of items "to do"
- Events
  - Request to display the list
  - Request to add an item
  - Request to remove an item
- Compute
  - Respond to these requests by fetching from the list or modifying the list, as needed

Select tool(s) for State

- State
  - Cloud Firestore
  - ✓ Cloud Datastore
  - Cloud Storage

Cloud Firestore would be a good fit, too.

Cloud Storage would not be as good for this use case.

Events

- Make each event a web request
    - GET / displays the list
    - POST / adds an item
    - DELETE /item_id deletes an item
        - or POST to /?
    - PUT /item_id updates an item

Serverless tools for compute

- Respond to web requests, update datastore
- Three strong serverless options
  - ✓ App Engine, the original
  - Cloud Functions, functions as a service
  - Cloud Run, serverless containers

Any of them can handle this well

App Engine has a little better fit, and can use Identity-Aware Proxy to handle user authentication

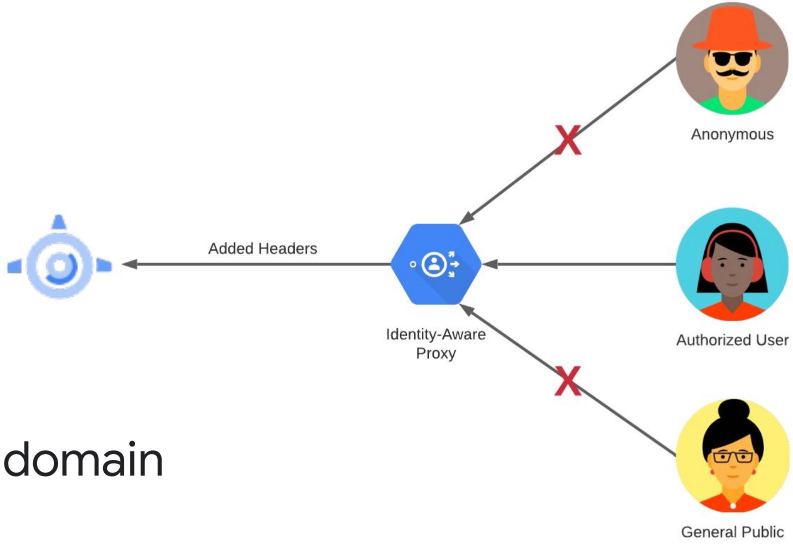
Identity-Aware Proxy

- Intercepts requests to your app

- Allows only authorized users through
  - List of email addresses
  - Google Groups
  - All email addresses in a Workspace domain
  - allUsers and allAuthenticatedUsers

- Adds headers to every request with user ID

- Easy to set up for App Engine, possible for other compute platforms via load balancers



Larger Serverless App

Student Programming Contest

serverlessworkshop.dev

- Faculty judges create problems to code
  - "read an input file, produce an output file"
- Students are given the problem descriptions and code solutions
- Solutions are turned in
  - Judges compile and run solutions with multiple data sets
- Students are told whether they passed, failed, timed out, or crashed

People involved

- Judges
  - Write up problems to solve with code
  - Check student solutions
- Students
  - Write a program for each problem
  - ~~Create and use test data~~
  - Submit solutions for scoring
- Managers
  - Distribute problems to students
  - Accept solutions, assign judges
  - Track results

Solve with a distributed application

Each of the three parties has their own platform

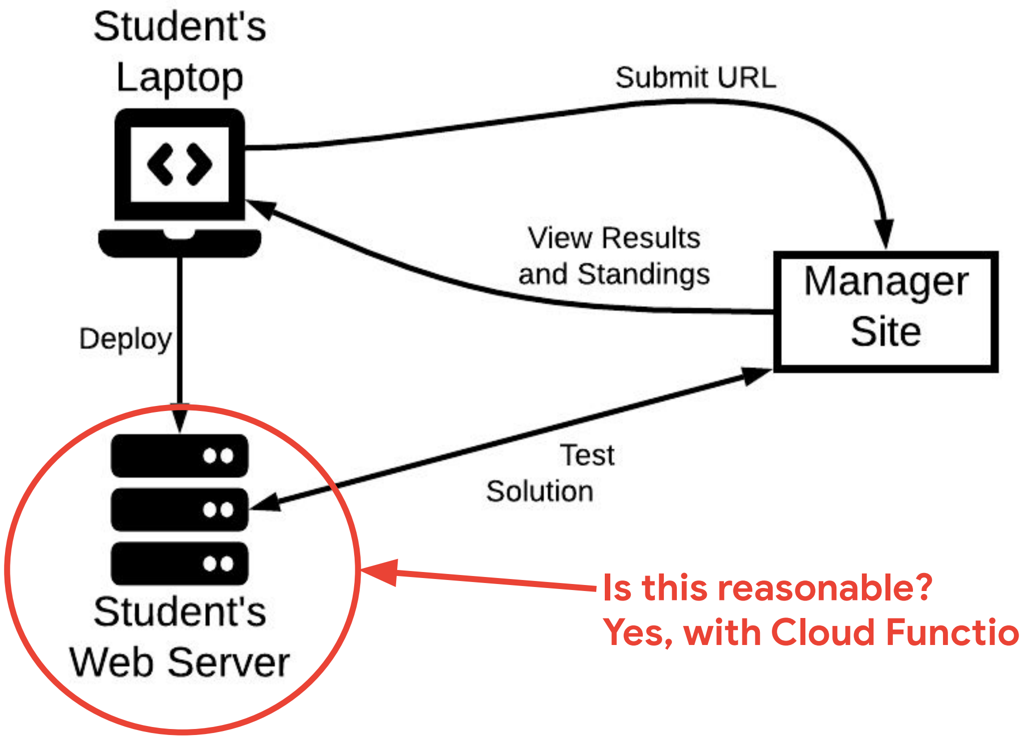
- **Students** deploy solutions to their own server
- **Judges** run their tests against solutions
- **Managers** provide a web site
  - Form for accepting submitted solution URL
  - Create event triggering judging
  - Handle results from judges
  - Track and display standings

Projects

- All Google Cloud resources live in **projects**
  - Resources in the same project can usually interact with each other
  - You can enable resources in different projects to interact with each other

- Students, judges, and the manager each own their own separate projects
  - So they may need to allow the other projects to interact with them
  - The codelabs all use the same project to avoid this complexity **to keep them simple**

Student's view of the system



Is this reasonable?
Yes, with Cloud Functions

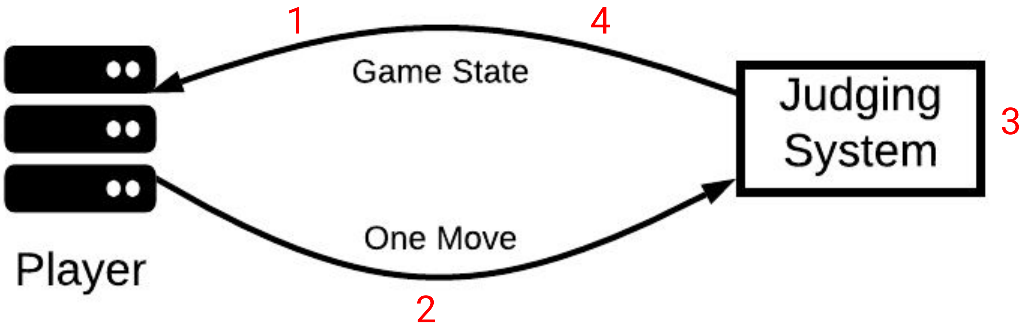
Example: play a game

- Student writes a solution
  - Accepts request representing game state
  - Responds with game move

- Deploys program to the internet
  - Submits the URL for judging

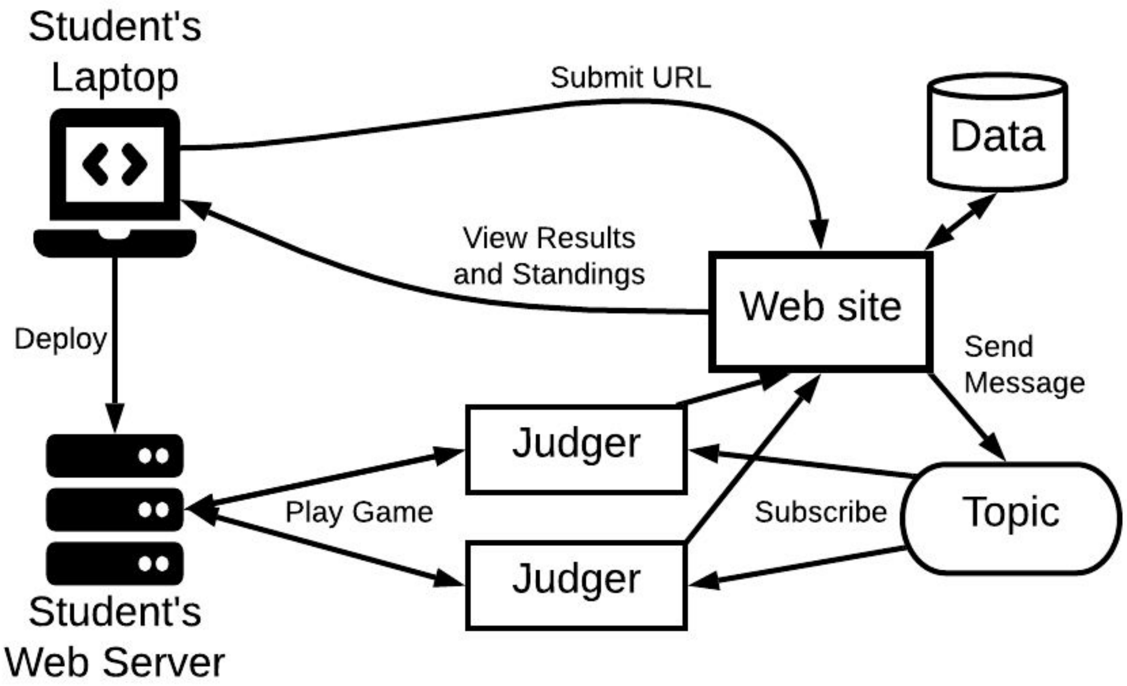
- Judging system makes web request with data in the body, solution returns output in response

Multiple steps the judges' responsibility

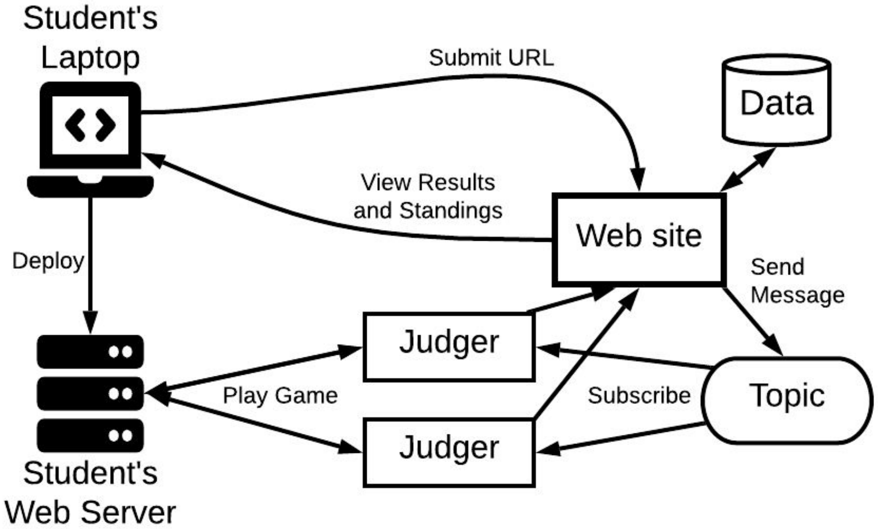


1. Judge sends initial game state to player
2. Game player returns a move
3. Judge updates the game state, adding player's move and judge's next move in response
4. Repeat with updated game state

Overall system



- Student
  - Create solution, deploy to web
  - Submit URL via web form for judging
- Judge
  - Create judging program(s)
    - Trigger on new message to a topic
    - Exercise solution via web
  - Report result to manager
- Manager
  - Accept submissions
  - Publish message
  - Accept results from judges
  - Display web page



Solution platform

- Compute is Cloud Functions
  - Fewest steps to deploy
  - Creates a public URL
  - Function should allow requests from anyone

- Events
  - One web request provides the input, and the response has the output

- There is no state
  - If judging system wants a multi-step process, it includes the prior step results in the request

Judger platform

- Compute: Cloud Functions or Cloud Run
  - Interact with student submissions via sequence of web request/responses

- Events
  - Trigger on Pub/Sub message from manager
  - Report results to URL in message

- There is no state
  - Judger handles one message, may make series of requests to player, sends results, and it's done

Question: Cloud Function or Cloud Run?

- Cloud Functions are easier
  - Work with console, provide source code

- But Cloud Run is more flexible
  - Use containers
  - Not limited to specific runtimes

- Judges are faculty, and faculty can be... idiosyncratic
  - "I need my solution in Rust/Cobol/obsolete version of otherwise supported language."
  - "I have an executable file I'll need to use."

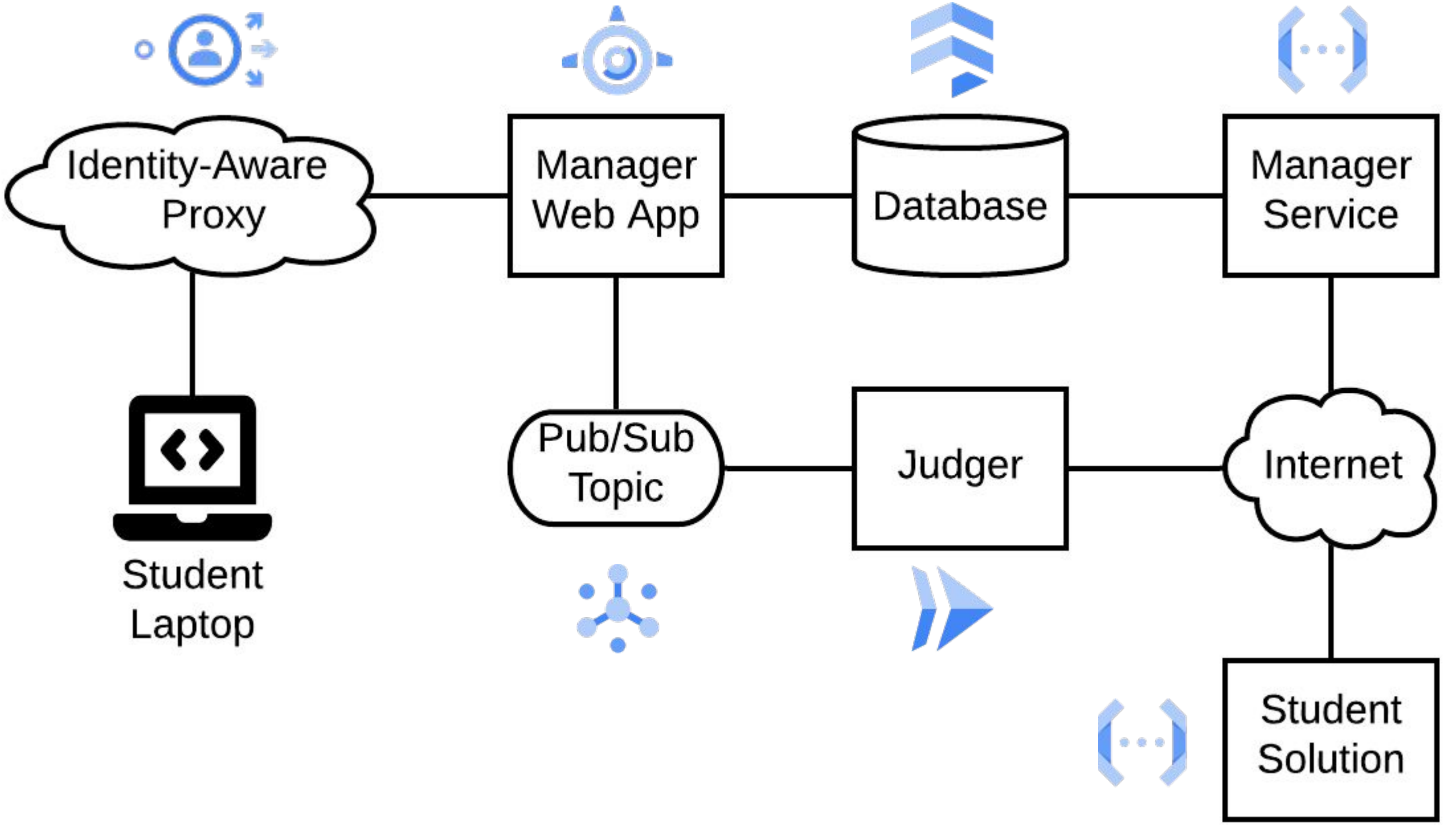
Manager platform

- Compute
  - App Engine for website
    - Authenticate with Identity-Aware Proxy
  - Cloud Function to accept judges results

- Events
  - Web requests from people for App Engine
  - Web service request from judgers

- State: Cloud Firestore
  - Record submission
  - Add results to a subcollection

Overall coupling



Permissions

- Manager must allow-list students in IAP
- Manager can read/write to Firestore database and publish to Pub/Sub topic
- Manager must allow judges to subscribe to topic
- Manager function accepts HTTP submissions from judgers (authentication not required)
- Players accept HTTP requests from anyone

Permissions

- Manager must allow-list students in IAP
- Manager can read/write to Firestore database and publish to Pub/Sub topic
- **Manager must allow judges to subscribe to topic**
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- Players accept HTTP requests from anyone

Contest problem

- Play the simplest possible game: **guess a number**
  - Given minimum and maximum, and history of guesses
  - Respond with a whole number guess

- Don't worry about the judging system for now (we're the student who has to write a player)

- You can try it out and submit your solution to example judging system https://serverlessworkshopdemo.appspot.com/

Starting input example

```
{
  "minimum": 1,
  "maximum": 10,
  "history": []
}
```

Example output

```
6
```

Yes, this is the JSON representation of a whole number

Second example move request

```
{
  "minimum": 1,
  "maximum": 10,
  "history": [
    {"guess": 6, "result": "higher"}
  ]
}
```

Hands-on codelabs at

https://serverlessworkshop.dev

Wrap-up

Serverless Technologies Used

- Functions as a service (Cloud Functions/Run)
  - Student solution
  - Manager web service
  - Judgers (may prefer Cloud Run)

- Platform as a service (App Engine)

- Reliable messaging (Pub/Sub)

- NoSQL database (Firestore)

- User auth as a service (Identity-Aware Proxy)

Serverless application design: TL;DR

- Identify the data that must be maintained
- Note the events that can change that state
- Specify compute needed for each even
- Choose appropriate platforms for each
- Build each part as independently as possible
  - Should be possible to test each part without the rest of the system

Thank you! Questions via chat.

Visit https://severlessworkshop.dev/

Serverless Application Architecture

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