



Workshop: Build a Distributed Serverless Application

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Google Cloud

Slides and exercises online at

<https://serverlessworkshop.dev>

Welcome to the workshop!

You will build a loosely-coupled, event driven, distributed serverless system today

So get your laptops ready!

Today's agenda

1. Would you like to play a (dumb) game?
2. What is serverless, anyway?
3. Problem description
4. General architecture of solution
5. The Google Cloud console
6. Three hands-on codelabs
7. Recap

The game

- Contestants play a number guessing game
 - *Guess a number from 10 to 50. You already guessed 17, but the answer is higher. You also guessed 38, but the answer is lower.*
 - **Is it 25?**
- You will build and deploy a serverless guesser
- See how to architect entire contest judging and scoring system
 - Multiple serverless components
 - Loosely connected via messaging
 - With a NoSQL data store
- Codelabs cover every part of above

Serverless computing

Spoiler alert: *There are still servers. **Don't tell anybody!***

- But they are the cloud platform's problem, not yours
- You don't have to provision, manage, monitor, or scale them
- And many serverless options scale down to zero when idle

There are different flavors of serverless computing

- Container based - the platform handles the kernel and scaling, you handle support systems (like libraries)
- Managed - you bring your application code, the platform handles everything else

This workshop uses *managed* serverless

You are responsible for your application code

- **The cloud platform** handles all supporting software, monitoring platform health, and scaling
- Important - many platforms can scale to zero
 - So idle times don't have any compute costs

Your code may be unloaded, reloaded or loaded into multiple hosts at any time

- So you can't save any state in memory or on disk
- And you may have startup latency at times

Common characteristics of serverless

Stateless software

- External data stores are used when needed

Many pieces, loosely coupled

- Handle one task, trigger other pieces as needed for more

Event-driven

- Code runs when something happens
- A web request, a storage event, a message delivered

Asynchronous communications

- Send requests but don't wait for responses

The Problem: Programming Contests

- Participants are given a set of problems to code
 - In the form "read an input file, produce an output file"
- Contestants code solutions, test with provided sample data and (we hope) their own test data
- Solutions are turned in (physical media, email, etc.)
 - Judges compile and test solutions with multiple data sets
- Contestants are told whether they passed, failed, timed out, or crashed

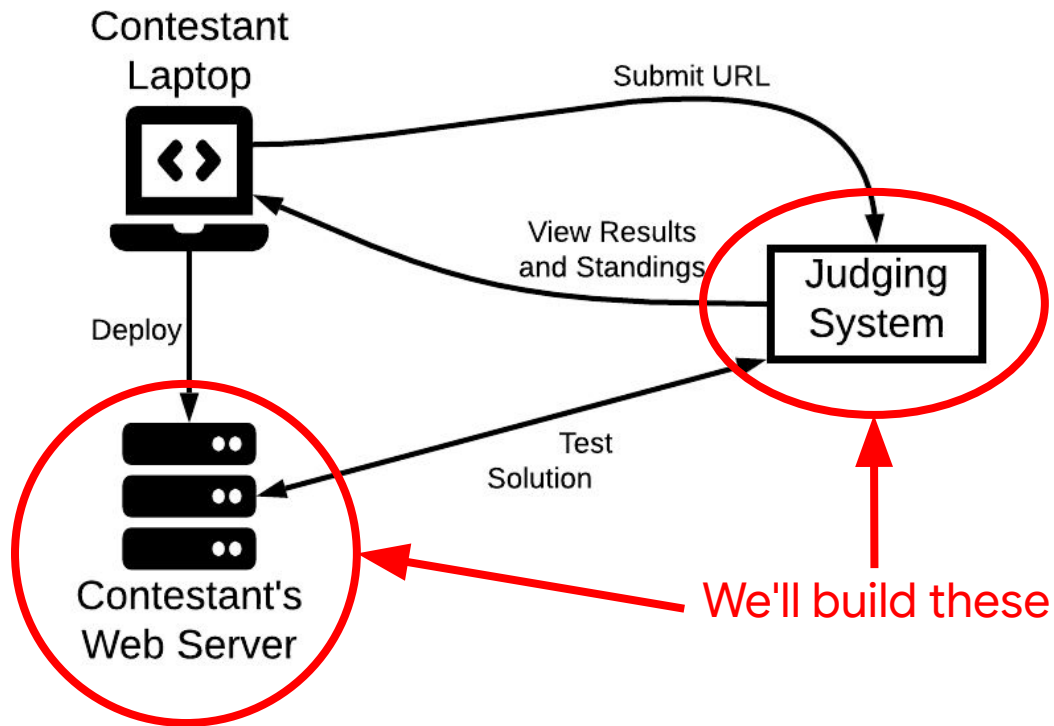
Running the submissions is a mess

- Keeping track of what was submitted, and when
 - Especially if physical media is involved
- Avoiding malicious code on the test machines
 - Or just dangerously buggy code
- Dealing with different machine configurations

Solution: don't submit programs

- Run the solutions on the **contestant's** infrastructure
 - Provide input, receive output?
 - Sounds like an HTTP(S) request
- Contestants deploy their solutions to the web
 - Provide a URL to the judges
- Judges run the code multiple times via web requests
 - (Need to slightly randomize test data so contestants don't read their logs and hard code answers)

High-level System Diagram



Is this practical?

Can we expect contestants to manage and deploy to their own web servers?

- **No**, if they have to handle system configuration and administration
- **Yes**, if they use a lightweight managed serverless platform
 - The shortest path from ***works on my machine*** to running successfully on the internet

We will start the workshop with this part of the problem

- ***Contestant deploys solution to the web***

We will go on to the more complex judging system afterwards

We'll use Google Cloud Platform

That doesn't mean other cloud platforms couldn't be used

- They have many similar offerings
- But the steps and details would be different

Want to try this out on another platform after the workshop?

- Fork the repository and adapt it as needed
- **Let us know - we're interested!**

Workshop resources

- Your laptop with an internet connection and a modern web browser
- A Google account
 - Might be able to use a G Suite account, but administrators can disable Cloud Console access
 - **Set up a plain vanilla Google account to avoid roadblocks**

Workshop materials

These slides - serverlessworkshop.dev/slides.pdf

Source code:

github.com/GoogleCloudPlatform/serverless-game-contest

Codelabs:

Player - serverlessworkshop.dev/player

Questioner - serverlessworkshop.dev/questioner

Manager - serverlessworkshop.dev/manager

serverlessworkshop.dev

The Player

Slides and exercises online at

<https://serverlessworkshop.dev>

GCP Projects

- All GCP resources live in **projects**
 - Resources in the same project can usually interact with each other
 - You can enable resources in different projects to interact
 - You can restrict resources in the same project from interacting
- Contestants and the judging system would, in practice, be in separate projects, owned by different entities
 - **But to keep things simple, we will create and use one project for everything in this workshop**
 - We will discuss how it could be separated, though

Google Cloud Developer Console

Google Cloud Platform

Home

Marketplace

Billing

APIs & Services

Support

IAM & admin

Getting started

Security

COMPUTE

App Engine

Compute Engine

Kubernetes Engine

Cloud Functions


Cloud Run

Welcome!

Get started with Google Cloud Platform


TOUR CONSOLE

Top Products




Compute Engine

Scalable, high-performance virtual machines




Cloud Storage

A powerful, simple and cost effective object storage service



Cloud SQL


A fully-managed MySQL/PostgreSQL database service



App Engine

A platform to build web and mobile apps that scale automatically


Explore



API


Google APIs

Enable APIs, create credentials, and



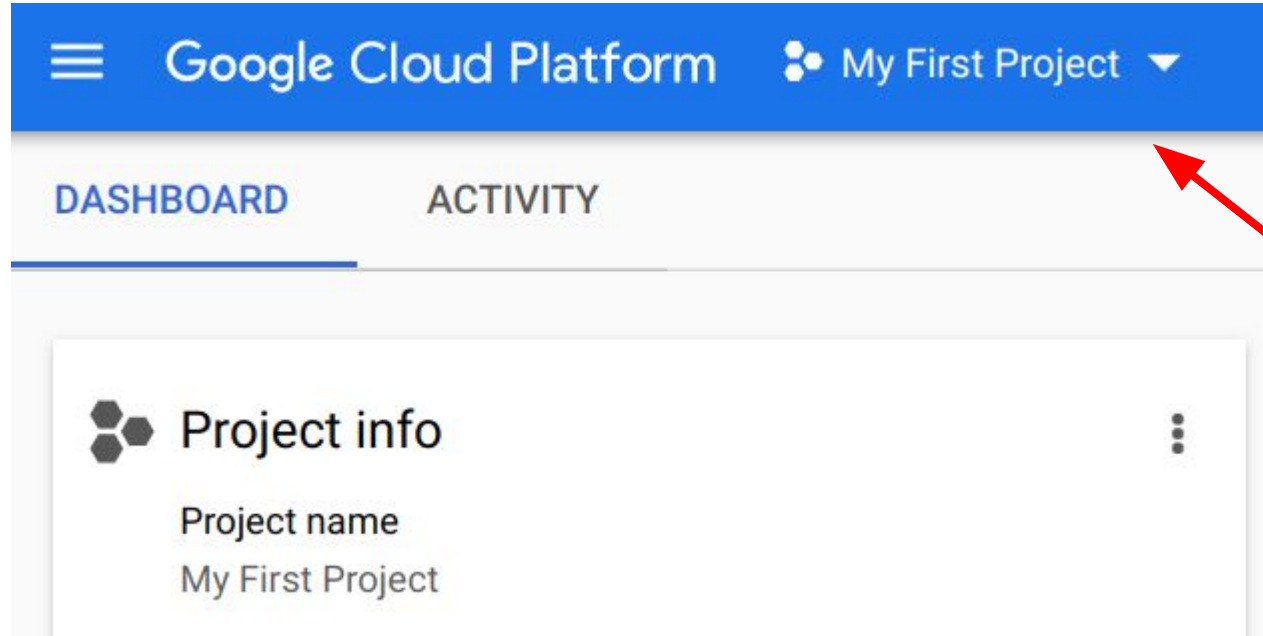
Documentation

Explore Google Cloud Platform



Create an empty project

Creating a Project - Click the drop-down

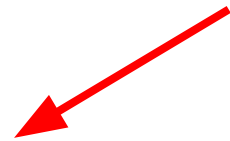


Click NEW PROJECT

Select a project



NEW PROJECT



 Search projects and folders

RECENT

ALL

Name

ID



My First Project 

a-project-id

Call it whatever you like

For example "*yourname-serverless-workshop*"

Notifications



Create Project: serverless-workshop

Just now



Create Project: My First Project

6 days ago

Click the notification when ready to open the project

The project name will be in URLs, which will show in contest results, so pick a name you're okay with others seeing!



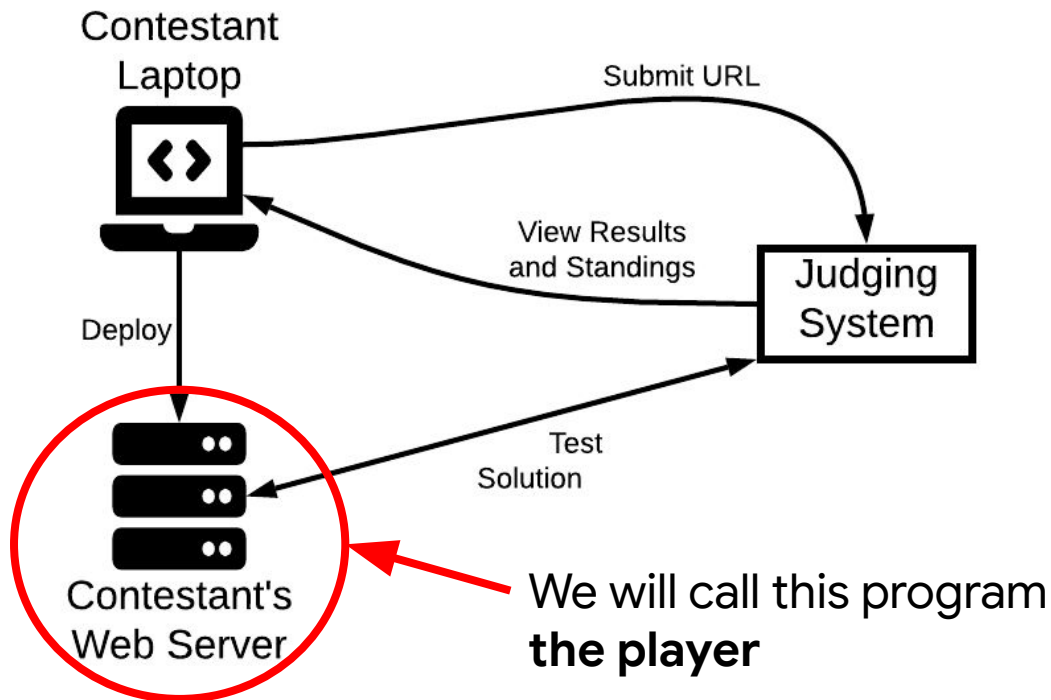
Google Cloud

Start simple - the game player

- Contestant writes a program that accepts an HTTP request representing the game state
- Responds with a game move
- Deploys program to the internet
- Submits the program for judging by providing the URL

We will address the more complex judging system after working out the basics with this program

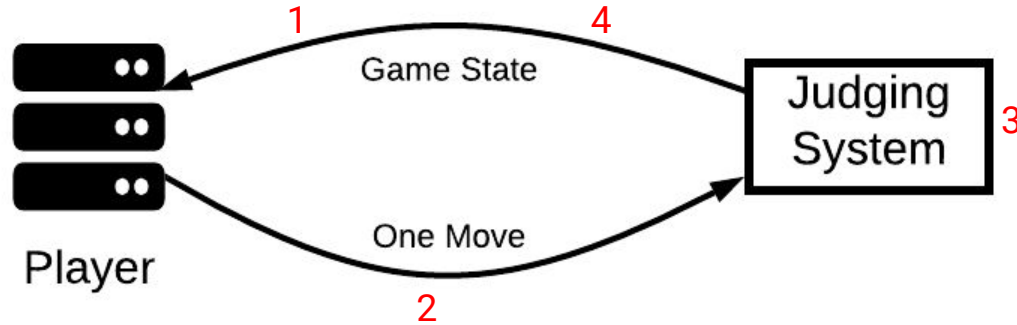
Recall the High-level System Diagram



Player platform: Google Cloud Functions

- Managed serverless platform
 - Provide a program
 - Specify a triggering event (web request)
 - Platform runs the program when the event occurs
- Benefits of Cloud Function platform
 - No system administration, just write a program
 - Scales as needed automatically
 - Scales to zero when idle

How the judging system plays a game



1. Sends initial game state to player
2. Gets a move in response
3. Updates the game state, make the opponent's move if needed
4. Sends the new game state to get the next move

Example game: Tic-tac-toe first move

- Initial game state is an empty board
- Represented in JSON:

```
{"marks-so-far": [], "your-mark": "X"}
```
- Player responds with JSON representation of a move:

```
{"row": 2, "column": 2}
```

(Contest says rows and columns numbered 1, 2, 3)

Judging system processes move

- Makes a move of its own
- Asks player for another move, given new game state:

```
{"marks-so-far": [  
    {"mark": "X", "row": 2, "column": 2},  
    {"mark": "O", "row": 1, "column": 1}],  
  "your-mark": "X"}
```
- Player responds with another move

```
{"row": 1, "column": 2}
```
- Play continues until player wins, loses, fails, or crashes

Coupling?

The player is nearly completely uncoupled from the judging system

- Only connection is HTTP requests over public internet

That's important, because each contestant builds a separate player

- Don't want to have them sharing resources with each other, or with the judging system

In general, **minimizing coupling between components** makes system design, deployment, and maintenance more flexible and secure

Rules for *our* game

1. The simplest possible game: **guess a number**
2. Given minimum and maximum, and history of guesses
3. Respond with a whole number guess

We don't worry about the judging system for now (we're the contestant who has to write a player).

- You can 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"}  
  ]  
}
```

Time to Build and Deploy the Solution

Hands-on codelab at

<https://serverlessworkshop.dev/player>

Want to try it out?

The system being built for this workshop has a live version available:

<https://serverlessworkshopdemo.appspot.com/>

You can submit the player you just wrote to be judged there

Player recap

The player does only one simple thing:

- Make a move given the existing game state

The player does not keep state

- It doesn't know its previous moves, it has to be told when a new move is requested

Moves are made in response to a web request

- Cloud function platform invokes the player code when a request arrives

A rare Cloud Function "gotcha"

- You write an entire **program**, but each event triggers only one **function** in it
 - Mental model may be "when the event happens, my program is loaded and the function is called" but that's **not correct**
 - Actual behavior when event happens is "if my program has already been loaded, just call the function, otherwise load it and then call the function"
- So global actions from one event **may or may not** affect handling future events
 - Subtle effects from initialization code and memory leaks are possible

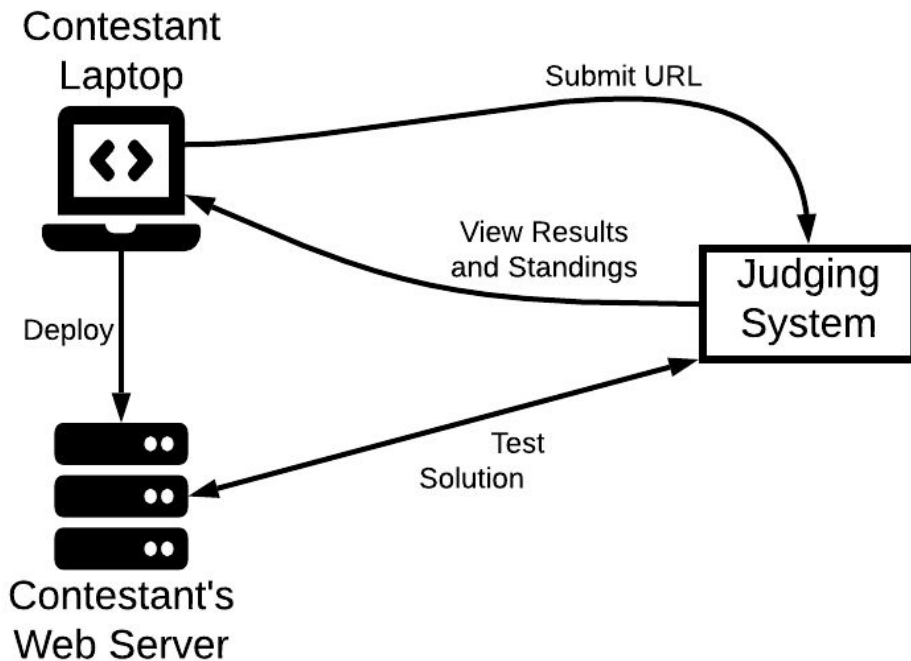
The Judging System

Part 1

Slides and exercises online at

<https://serverlessworkshop.dev>

Recall the High-level System Diagram



Looks like a monolith

Judging
System

- Traditional approach might be a single web server app
 - Interacts with contestants
 - Plays games against submitted solutions
 - Track scores in persistent data
- Would restrict flexibility in design and future expansion
 - Game judging components are often created by multiple parties, with different playing scenarios
 - Using a different game requires rebuilding whole system
 - Every submitted solution would have to wait for games to be played, or have concurrency programmed in

Look at the needs one at a time

- First - **Something** needs to play the game against submissions
 - Call this a **questioner**
 - Needs to know the player URL
 - Plays the game against the player on its own
 - Needs to know what to do with the result of play
- So build the questioner as an independent component
 - Provide the player URL and another URL to send the result of play for recording
 - Easy to run multiple questioners against each submission
 - **Use asynchronous request** to trigger start of play

Platform choice - Cloud Functions

- Any compute service could do, but we have a program that does a single task, which is a good fit for Cloud Functions
- Trigger asynchronously, though
 - Cloud functions can be triggered by a variety of events
 - This one should trigger on a message being published to a Pub/Sub topic by the rest of the judging system

Google Pub/Sub

Reliable messaging system

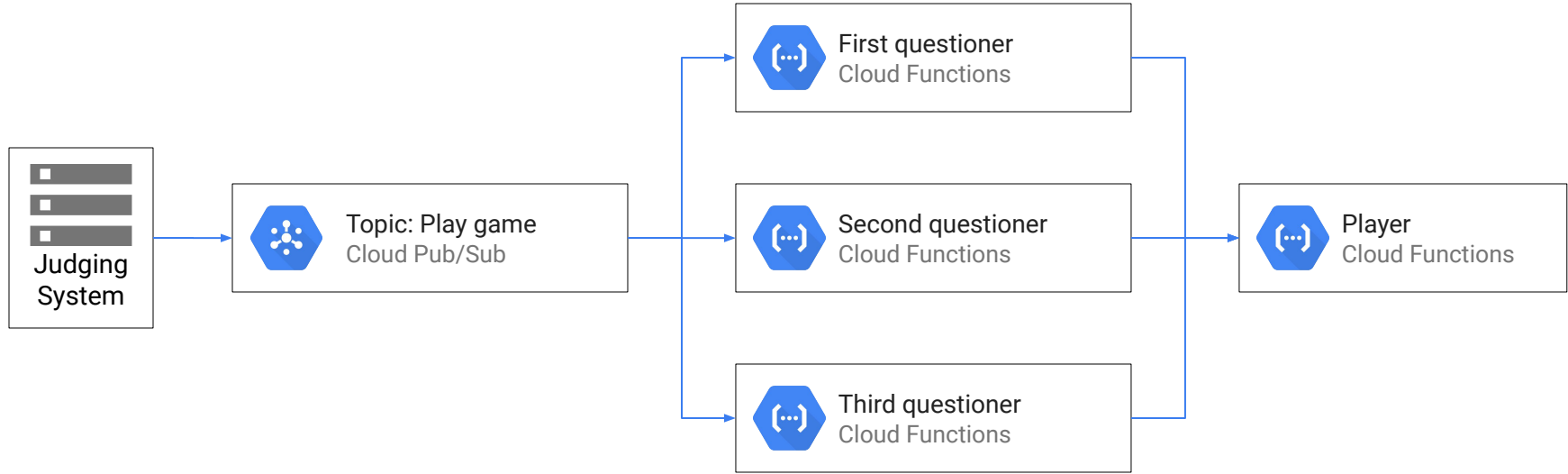
Messages belong to **topics**

- Messages are **published** to a topic
- Programs **subscribe** to a topic to get all messages
- Can be one-to-one, one-to-many, or many-to-many

Asynchronous, reliable delivery

- Messages will be delivered to every subscriber **at least once**
- Delivery order is not guaranteed

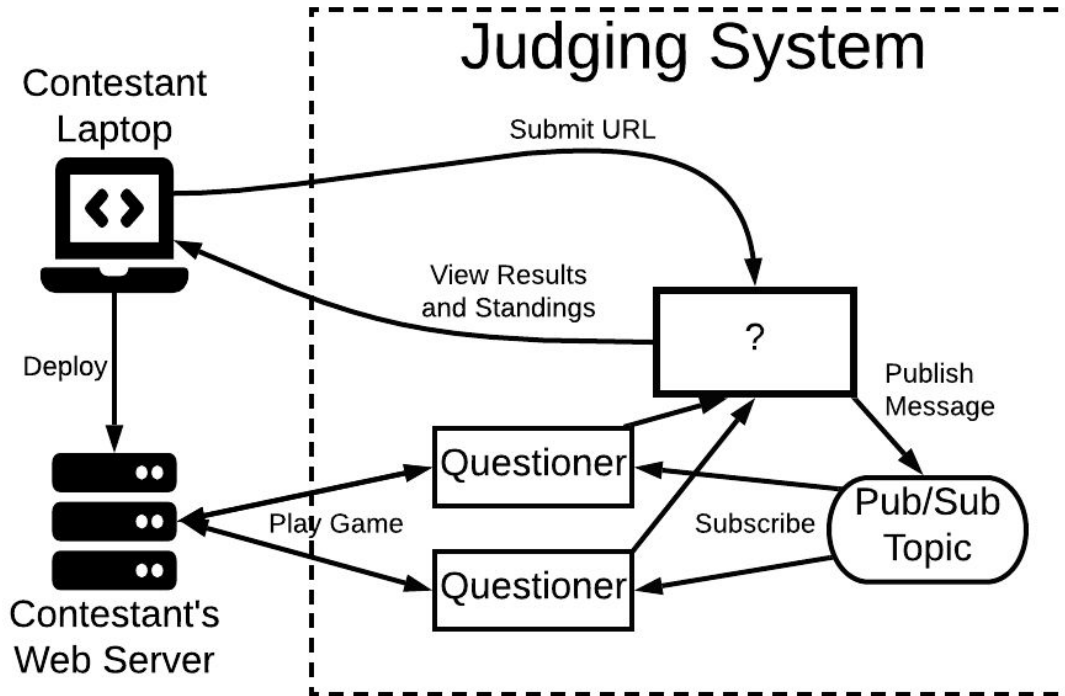
Triggering via Pub/Sub



Why not just send HTTP request?

- HTTP requests are synchronous
 - Invoker sends the request and waits for a response
 - We don't want our main program to have to wait
- Pub/Sub is asynchronous
 - Invoker publishes a message, returns immediately
 - Pub/Sub delivers the message to every subscriber
 - (And waits for each subscriber to finish, if needed)

Factor out the Questioner(s)



Message body

```
{  
  "player_url": "some-url",  
  "result_url": "another-url",  
  "contest_round": "a random ID",  
  "secret": "a shared random string"  
}
```

Coupling?

- Questioner ↔ Player?
 - HTTP requests and responses only
- Judging system ↔ Questioner?
 - Questioner must be able to subscribe to Pub/Sub topic that judging system publishes to
 - If components are in separate projects, permission to other project must be explicitly granted
 - Results sent from the questioner to the judging system via HTTP POST to a provided URL

Time to Build and Deploy the Solution

Hands-on codelab at

<https://serverlessworkshop.dev/questioner>

Questioner recap

Another event-driven cloud function

- But triggered asynchronously instead of via a web request

Pub/Sub trigger lets us send one message that many questioners subscribe to

Questioners create results that need to be saved, but they aren't responsible for doing the saving

- They're told to send them to URL
- Reduces system coupling

The Judging System

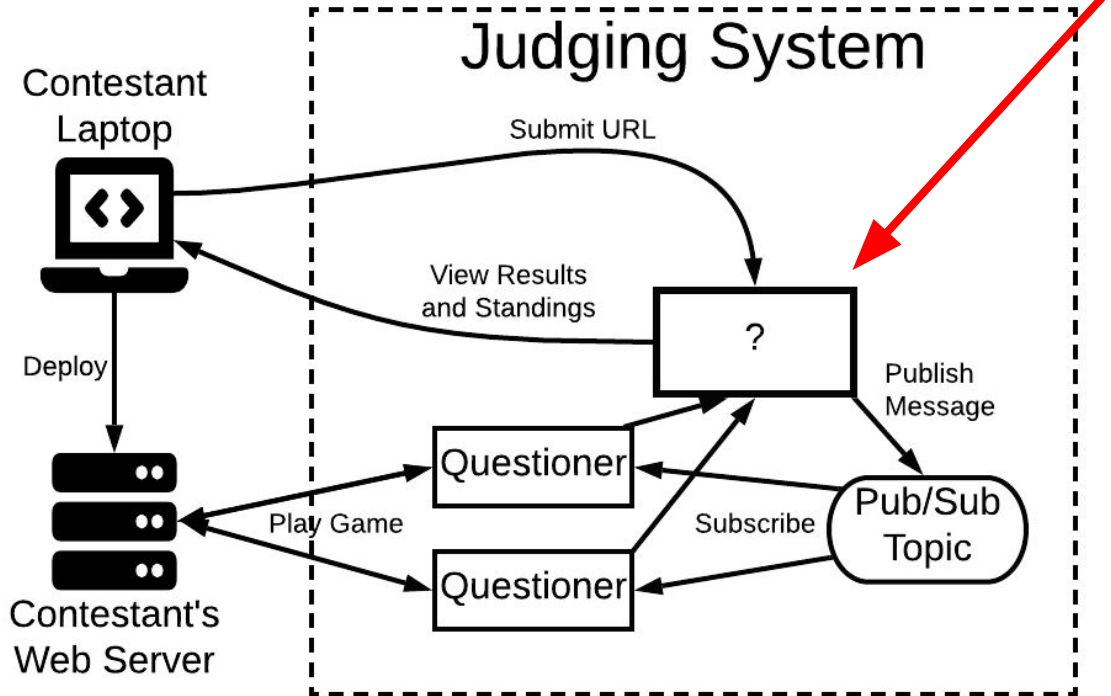
Part 2

Slides and exercises online at

<https://serverlessworkshop.dev>

The system so far

Call the remaining judging system the **manager**



What does the manager do?

1. Displays current results on a web page
2. Lets contestants submit solutions
3. Invoke questioners by publishing messages
4. Accept results from questioners

Interact with
people

Interact with software

Can we partition it further?

Smaller pieces are easy to create and maintain

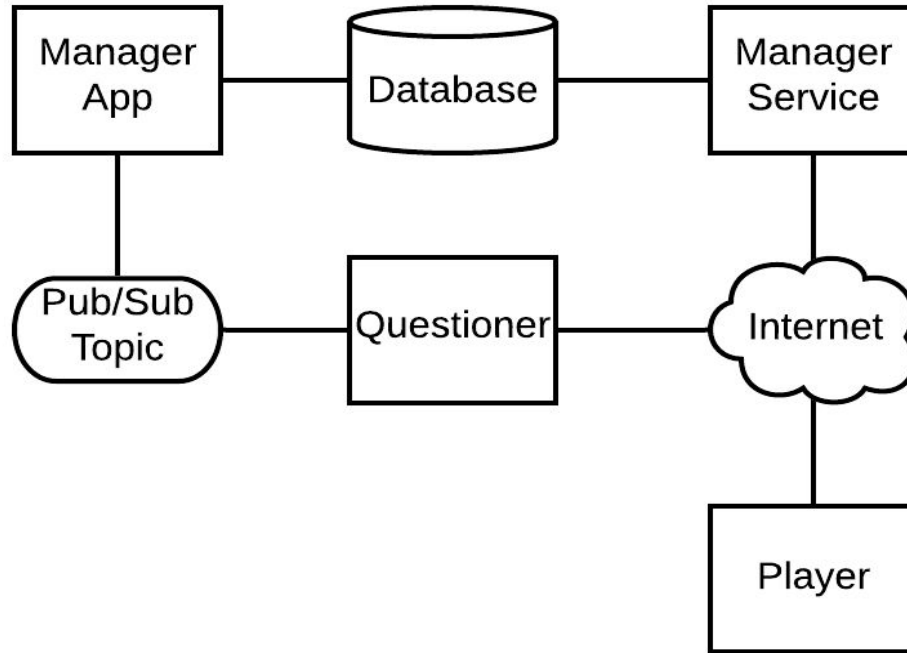
Break manager into two parts

1. Web **application** people interact with
2. Web **service** that accepts results from questioner software

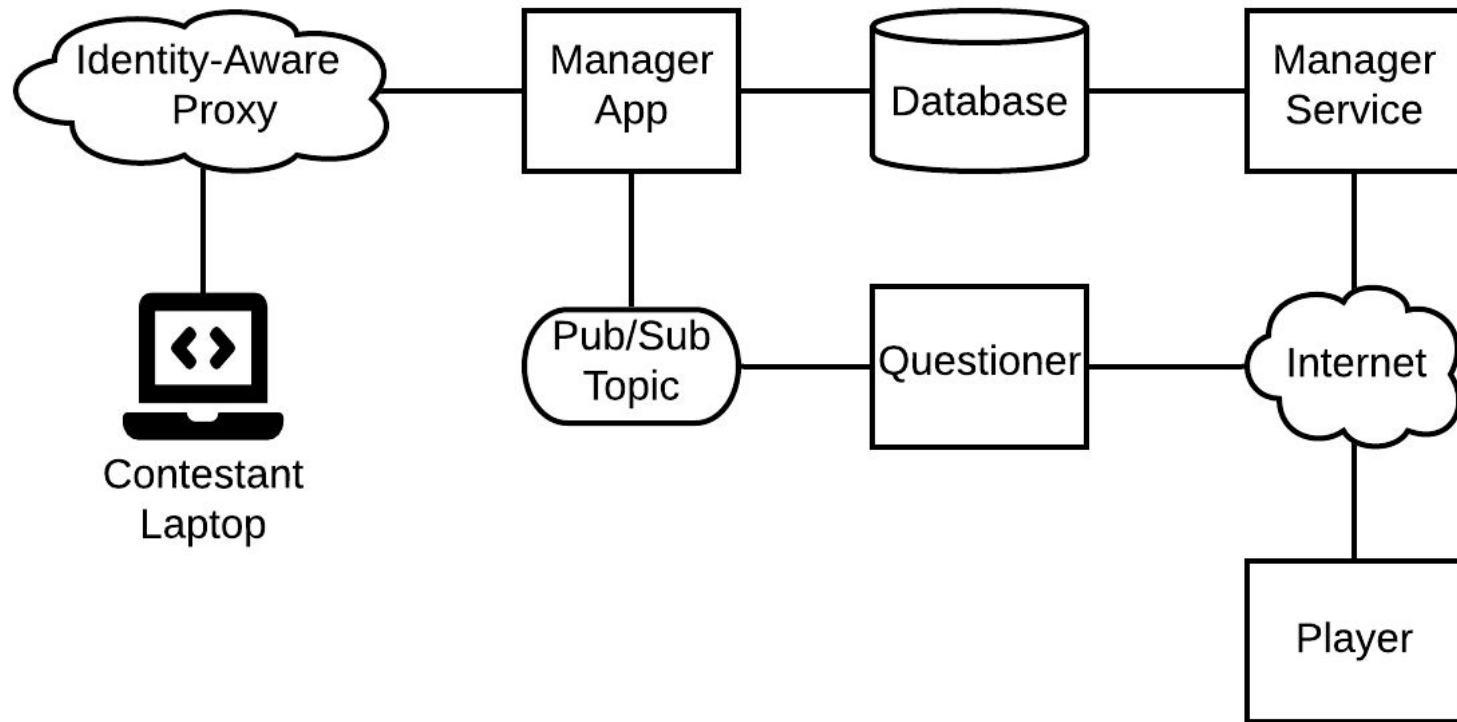
Connect via a shared **database**

1. Web app adds submissions to database
2. Web service adds results to submissions

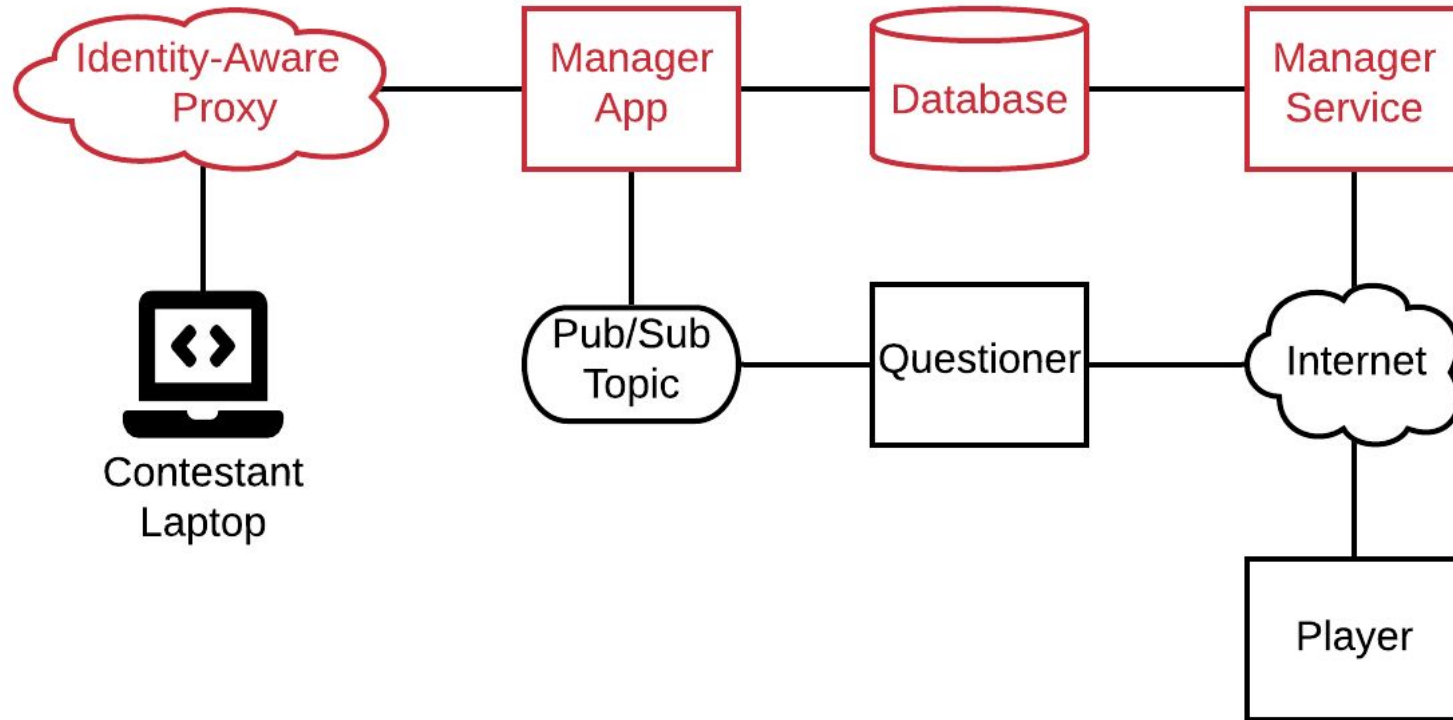
System Coupling



Add front-end user authentication



Left to deploy



Time to Build and Deploy the Solution

Hands-on codelab at

<https://serverlessworkshop.dev/manager>

Recap

Created a distributed serverless system

- Different portions owned by different entities
- Player owned by a contestant
- Manager owned by the contest runners
- Questioners delegated from the contest runners

Used several serverless tools

- Function as a service (Cloud Function), platform as a service (App Engine), reliable messaging (Pub/Sub), NoSQL database (Firestore), user authentication as a service (Identity-Aware Proxy)

Thank you!

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