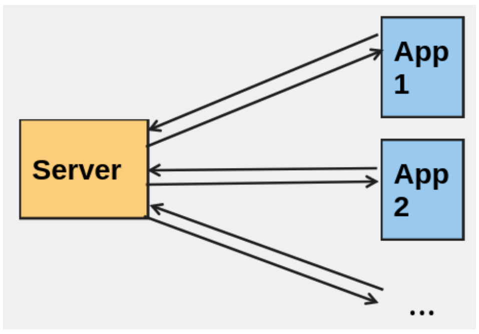
Fog Computing HW Docs

Alyssa Delali Könnecke, Dimitrios Peppas

1. Concept & Design

1.1 Architecture

For the client component, we decided to create a mobile app that sends its sensor data to a cloud server. The server, in turn, collects the data from all the apps and periodically sends the average of the recent sensor data of all users back. The idea is, that a bunch of users will use this app to be informed about the average sensor data (e.g. light, temperature etc.) in an area.

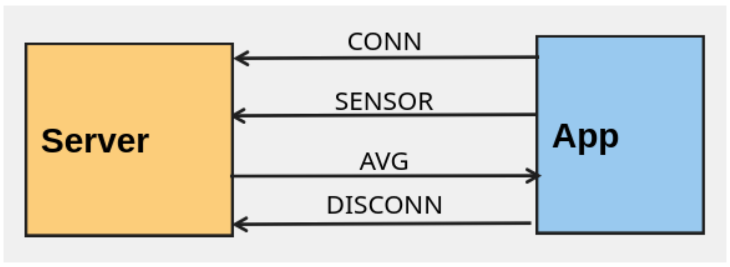


1.2 Protocol

To enable the communication between the two components, we relied on top of the *Websocket API*, as it is a simple and well documented protocol. We then build our own protocol on top of *Websockets*. Our protocol messages consist of 4 segments. The message type header, the unique ID of the client (we used UUID v4), a Unix timestamp that helps to order asynchronous messages and the message data. The segments are separated with the **#** symbol. There are 4 possible message types, which are the following:

- **CONN** *(CONN#24100602-9b43-4eed-a397-1ffc90518c37)* This is a message sent by the apps once a websocket connection is established. The app sends its ID, to identify the connection with the server. The server will use the ID to categorize messages from this connection and figure out if it has to send any undelivered messages.
- **SENSOR** *(SENSOR#24100602-9b43-4eed-a397-1ffc90518c37#1688847565#0.1)* This message is sent by the apps in order to transmit their sensor data. The timestamp shows when the sensor data was generated. In this case the sensor data are floating points, but it could be anything that can be encoded into a string.
- **AVG** *(AVG#1688847342#0.2)* This message is sent by the server to all the connected apps. It contains the timestamp on when it was calculated and the average data.
- **DISCONN** *(DISCONN#24100602-9b43-4eed-a397-1ffc90518c37)* The DISCONN message is sent by the client to gracefully disconnect from the server. The server will then close the connection and stop tracking this ID for undelivered messages.

In case any of the previous messages is failed to be delivered, each of the components has its own implementation of a message queue. When a new connection is established with CONN, it will send all the lost messages back.



2. Implementation

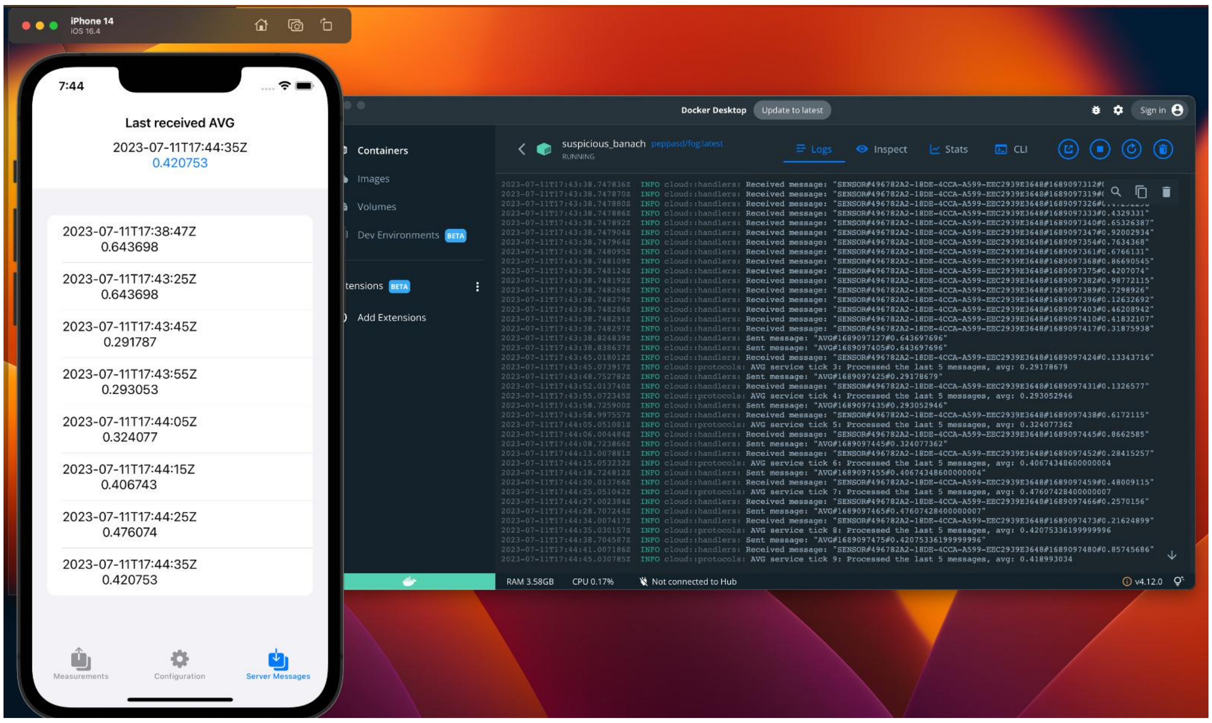
2.1 Cloud server

The cloud server has two endpoints. The root “/” endpoint implements a health check which also shows some database metrics and the “/ws” endpoint, which is the websocket endpoint for the apps to use. The server uses an sqlite database to save active connections, all received sensor data and queued messages (see */cloud/migrations/0_schema.sql* for the complete schema). Once it initializes, it spawns a service on a different thread, which calculates every 10 seconds the average sensor data of the last 5 messages and instructs the threads of active connections to send the result. If a message is delivered successfully, the server saves it as delivered. If a new connection is created, the server checks for all the queued messages that are marked as undelivered for the given ID and sends them all at once.

To deploy the app to the cloud, we used GoogleCloud Build to automatically build and contenairize the code from the GitHub repository, and then we used GoogleCloud Run to deploy the container.

2.2 iOS App

The iOS App contains the three views: Measurements, Configuration and Server Messages. Every client App has its own generated UUID. This UUID doesn’t change. The Measurements view shows the generated example measurements with the time when they’ve been generated and value. The value will be red if the message hasn’t successfully been delivered to the server, or green if it happened. In the Configuration view the user can see his UUID, a connection button and a button to delete the server and measurements values. These entries are saved in the UserDefaults which are in the system’s cache. The connect button starts the process of the connection or disconnection between the client and server. The Server Messages view shows the received messages from the server and at the top the currently last received server message. Client entries are generated every seven seconds and are directly tried to be sent. If the sending process doesn’t happen the entry will be marked red. Every red entry will be directly sent if the connection is reestablished.



Last received AVG

2023-07-11T17:44:35Z
0.420753

2023-07-11T17:38:47Z
0.643698

2023-07-11T17:43:25Z
0.643698

2023-07-11T17:43:45Z
0.291787

2023-07-11T17:43:55Z
0.293053

2023-07-11T17:44:05Z
0.324077

2023-07-11T17:44:15Z
0.406743

2023-07-11T17:44:25Z
0.476074

2023-07-11T17:44:35Z
0.420753

```
2023-07-11T17:43:38.747836Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097312#(
2023-07-11T17:43:38.747870Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097319#(
2023-07-11T17:43:38.747880Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097326#0
2023-07-11T17:43:38.747886Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097333#0.4329331"
2023-07-11T17:43:38.747892Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097340#0.65326387"
2023-07-11T17:43:38.747904Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097347#0.92002934"
2023-07-11T17:43:38.747964Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097354#0.7634368"
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2023-07-11T17:43:38.748109Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097368#0.86690545"
2023-07-11T17:43:38.748124Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097375#0.4207074"
2023-07-11T17:43:38.748192Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097382#0.98772115"
2023-07-11T17:43:38.748268Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097389#0.7298926"
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2023-07-11T17:43:38.748286Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097403#0.46208942"
2023-07-11T17:43:38.748291Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097410#0.41832107"
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2023-07-11T17:43:38.824839Z  INFO cloud::handlers: Sent message: "AVG#1689097127#0.643697696"
2023-07-11T17:43:38.838637Z  INFO cloud::handlers: Sent message: "AVG#1689097405#0.643697696"
2023-07-11T17:43:45.018012Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097424#0.13343716"
2023-07-11T17:43:45.073917Z  INFO cloud::protocols: AVG service tick 3: Processed the last 5 messages, avg: 0.29178679
2023-07-11T17:43:48.752782Z  INFO cloud::handlers: Sent message: "AVG#1689097425#0.29178679"
2023-07-11T17:43:52.013740Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097431#0.1326577"
2023-07-11T17:43:55.072345Z  INFO cloud::protocols: AVG service tick 4: Processed the last 5 messages, avg: 0.293052946
2023-07-11T17:43:58.725900Z  INFO cloud::handlers: Sent message: "AVG#1689097435#0.293052946"
2023-07-11T17:43:58.997557Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097438#0.6172115"
2023-07-11T17:44:05.051081Z  INFO cloud::protocols: AVG service tick 5: Processed the last 5 messages, avg: 0.324077362
2023-07-11T17:44:06.004484Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097445#0.8662585"
2023-07-11T17:44:08.723866Z  INFO cloud::handlers: Sent message: "AVG#1689097445#0.324077362"
2023-07-11T17:44:13.007881Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097452#0.28415257"
2023-07-11T17:44:15.053232Z  INFO cloud::protocols: AVG service tick 6: Processed the last 5 messages, avg: 0.40674348600000004
2023-07-11T17:44:18.724812Z  INFO cloud::handlers: Sent message: "AVG#1689097455#0.40674348600000004"
2023-07-11T17:44:20.013766Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097459#0.48009115"
2023-07-11T17:44:25.051042Z  INFO cloud::protocols: AVG service tick 7: Processed the last 5 messages, avg: 0.4760742840000007
2023-07-11T17:44:27.002384Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097466#0.2570156"
2023-07-11T17:44:28.707244Z  INFO cloud::handlers: Sent message: "AVG#1689097465#0.4760742840000007"
2023-07-11T17:44:34.007417Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097473#0.21624899"
2023-07-11T17:44:35.030157Z  INFO cloud::protocols: AVG service tick 8: Processed the last 5 messages, avg: 0.42075336199999996
2023-07-11T17:44:38.704587Z  INFO cloud::handlers: Sent message: "AVG#1689097475#0.42075336199999996"
2023-07-11T17:44:41.007186Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097480#0.85745686"
2023-07-11T17:44:45.030785Z  INFO cloud::protocols: AVG service tick 9: Processed the last 5 messages, avg: 0.418993034
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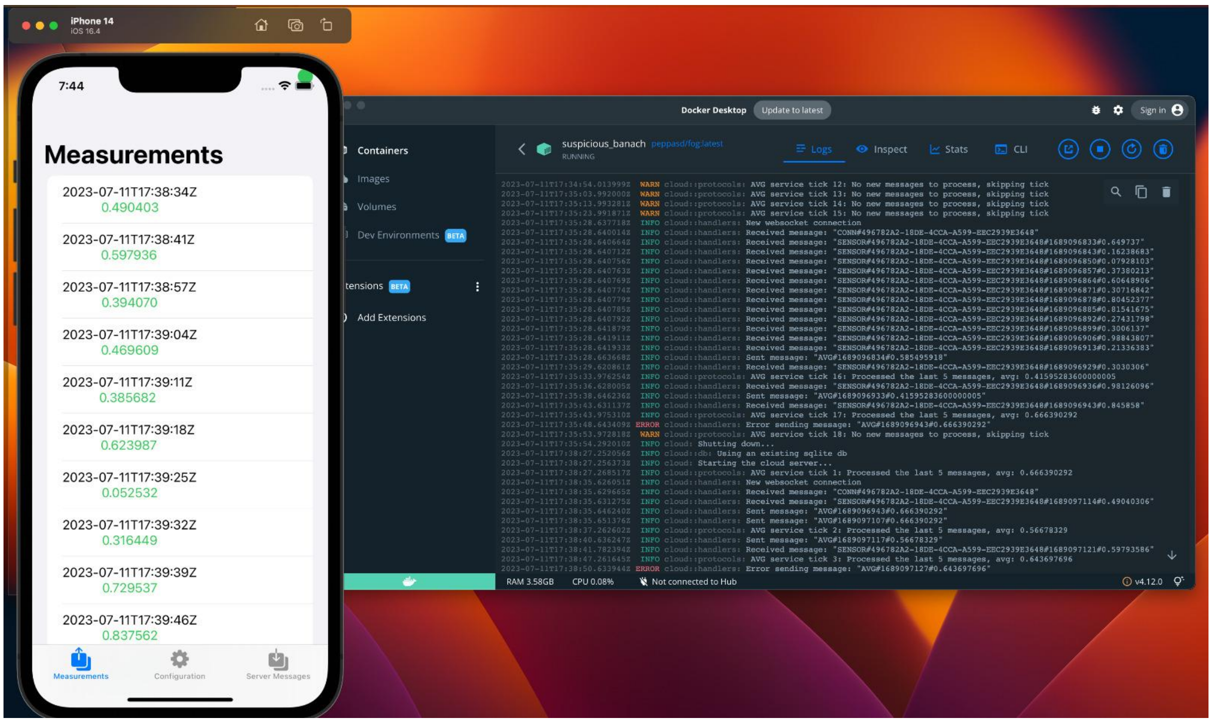
RAM 3.58GB CPU 0.17% Not connected to Hub v4.12.0

The app screen receiving AVG messages from the server and the server logs.



Measurements

2023-07-11T17:38:34Z
0.490403

2023-07-11T17:38:41Z
0.597936

2023-07-11T17:38:57Z
0.394070

2023-07-11T17:39:04Z
0.469609

2023-07-11T17:39:11Z
0.385682

2023-07-11T17:39:18Z
0.623987

2023-07-11T17:39:25Z
0.052532

2023-07-11T17:39:32Z
0.316449

2023-07-11T17:39:39Z
0.729537

2023-07-11T17:39:46Z
0.837562

```
2023-07-11T17:34:54.013999Z  WARN cloud::protocols: AVG service tick 12: No new messages to process, skipping tick
2023-07-11T17:35:03.992000Z  WARN cloud::protocols: AVG service tick 13: No new messages to process, skipping tick
2023-07-11T17:35:13.993281Z  WARN cloud::protocols: AVG service tick 14: No new messages to process, skipping tick
2023-07-11T17:35:23.991871Z  WARN cloud::protocols: AVG service tick 15: No new messages to process, skipping tick
2023-07-11T17:35:28.637718Z  INFO cloud::handlers: New websocket connection
2023-07-11T17:35:28.640014Z  INFO cloud::handlers: Received message: "CONN#496782A2-18DE-4CCA-A599-EEC2939E3648"
2023-07-11T17:35:28.640664Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689096833#0.649737"
2023-07-11T17:35:28.640712Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689096843#0.16238683"
2023-07-11T17:35:28.640756Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689096850#0.07928103"
2023-07-11T17:35:28.640763Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689096857#0.37380213"
2023-07-11T17:35:28.640769Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689096864#0.60648906"
2023-07-11T17:35:28.640774Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689096871#0.30716842"
2023-07-11T17:35:28.640779Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689096878#0.80452377"
2023-07-11T17:35:28.640785Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689096885#0.81541675"
2023-07-11T17:35:28.640792Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689096892#0.27431798"
2023-07-11T17:35:28.641879Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689096899#0.3006137"
2023-07-11T17:35:28.641911Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689096906#0.98843807"
2023-07-11T17:35:28.641933Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689096913#0.21336383"
2023-07-11T17:35:28.663668Z  INFO cloud::handlers: Sent message: "AVG#1689096834#0.585495918"
2023-07-11T17:35:29.620861Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689096929#0.3030306"
2023-07-11T17:35:33.976254Z  INFO cloud::protocols: AVG service tick 16: Processed the last 5 messages, avg: 0.41595283600000005
2023-07-11T17:35:36.628005Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689096936#0.98126096"
2023-07-11T17:35:38.646236Z  INFO cloud::handlers: Sent message: "AVG#1689096933#0.41595283600000005"
2023-07-11T17:35:43.631137Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689096943#0.845858"
2023-07-11T17:35:43.975310Z  INFO cloud::protocols: AVG service tick 17: Processed the last 5 messages, avg: 0.666390292
2023-07-11T17:35:48.643409Z ERROR cloud::handlers: Error sending message: "AVG#1689096943#0.666390292"
2023-07-11T17:35:53.972818Z  WARN cloud::protocols: AVG service tick 18: No new messages to process, skipping tick
2023-07-11T17:35:54.292010Z  INFO cloud: Shutting down...
2023-07-11T17:38:27.252056Z  INFO cloud::db: Using an existing sqlite db
2023-07-11T17:38:27.256373Z  INFO cloud: Starting the cloud server...
2023-07-11T17:38:27.268517Z  INFO cloud::protocols: AVG service tick 1: Processed the last 5 messages, avg: 0.666390292
2023-07-11T17:38:35.626051Z  INFO cloud::handlers: New websocket connection
2023-07-11T17:38:35.629665Z  INFO cloud::handlers: Received message: "CONN#496782A2-18DE-4CCA-A599-EEC2939E3648"
2023-07-11T17:38:35.631275Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097114#0.49040306"
2023-07-11T17:38:35.646240Z  INFO cloud::handlers: Sent message: "AVG#1689096943#0.666390292"
2023-07-11T17:38:35.651376Z  INFO cloud::handlers: Sent message: "AVG#1689097107#0.666390292"
2023-07-11T17:38:37.262602Z  INFO cloud::protocols: AVG service tick 2: Processed the last 5 messages, avg: 0.56678329
2023-07-11T17:38:40.636247Z  INFO cloud::handlers: Sent message: "AVG#1689097117#0.56678329"
2023-07-11T17:38:41.782394Z  INFO cloud::handlers: Received message: "SENSOR#496782A2-18DE-4CCA-A599-EEC2939E3648#1689097121#0.59793586"
2023-07-11T17:38:47.261645Z  INFO cloud::protocols: AVG service tick 3: Processed the last 5 messages, avg: 0.643697696
2023-07-11T17:38:50.633944Z ERROR cloud::handlers: Error sending message: "AVG#1689097127#0.643697696"
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RAM 3.58GB CPU 0.08% Not connected to Hub v4.12.0

The app screen sending SENSOR messages to the server and the server logs.

The concept was developed by the both of us, while the cloud server was developed by Dimitrios and the iOS app was developed by Alyssa.