University of CINCINNATI

CLU – Connected Locking Unit

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Problem

People need access to scalable, modular locking systems for…

- Public storage
- Handoff solutions
- Private delivery

Solution – Main Features

CLU is a smart lock. It is special because of its "collective awareness" – users can locate and control different locking units, or CLUs, on the app.

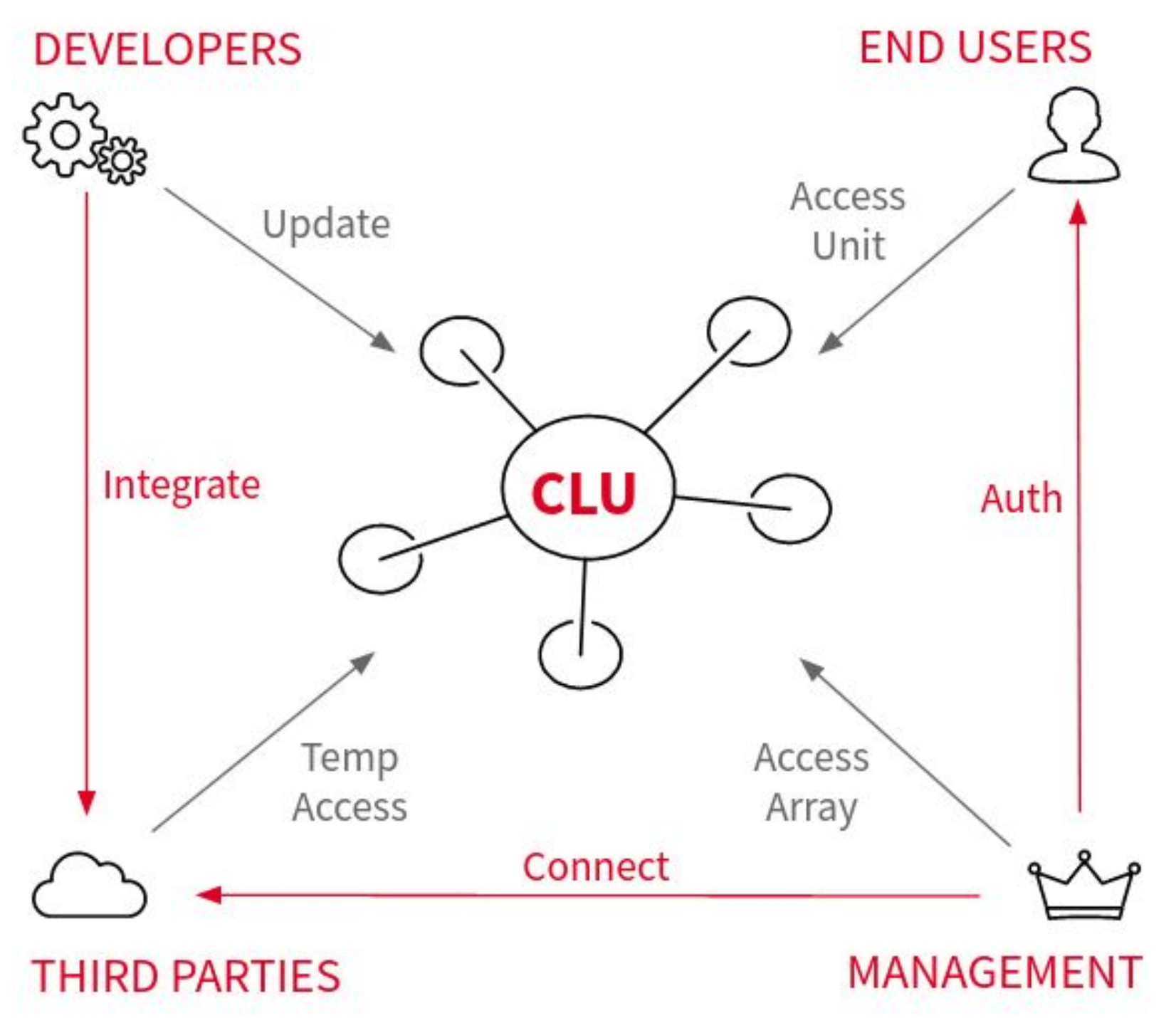
It is connected: via a mobile app and is controlled by users and monitored by admins.

It is modular: it is intended to be used and scaled as a collection of multiple units by the same customer.

Components List & Budget

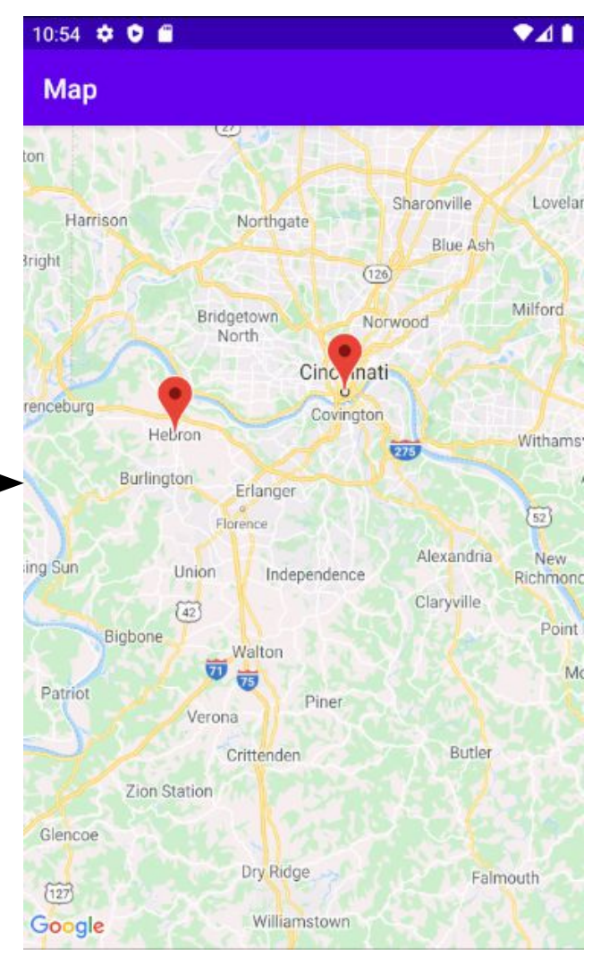
Fixed Costs	Price
Cloud Server (est.)	$ 100.00
Open Source Software	$ -
Google Play Store Registration (est.)	$ 25.00
Total Fixed Costs	**$ 125.00**
Variable Costs - Electronics	
Beaglebone Black Wireless	$ 81.50
Electric Door Lock	$ 12.11
GPS Antenna	$ 16.00
GPS Breakout	$ 42.75
GPS Connector Adapter	$ 4.23
Reed Switch	$ 1.45
Magnetic Ring	$ 0.95
LCD Screen	$ 18.95
Total Variable Costs per Unit - Electronics	**$ 177.93**
Total Cost for 2 Units Manufactured	**$ 480.86**
Container Options (Purchased 1 each)	
Iron 16"x12"x23" Storage Locker	$ 63.89
12V 4L Mini Fridge	$ 47.91

User Diagram / Flow Chart

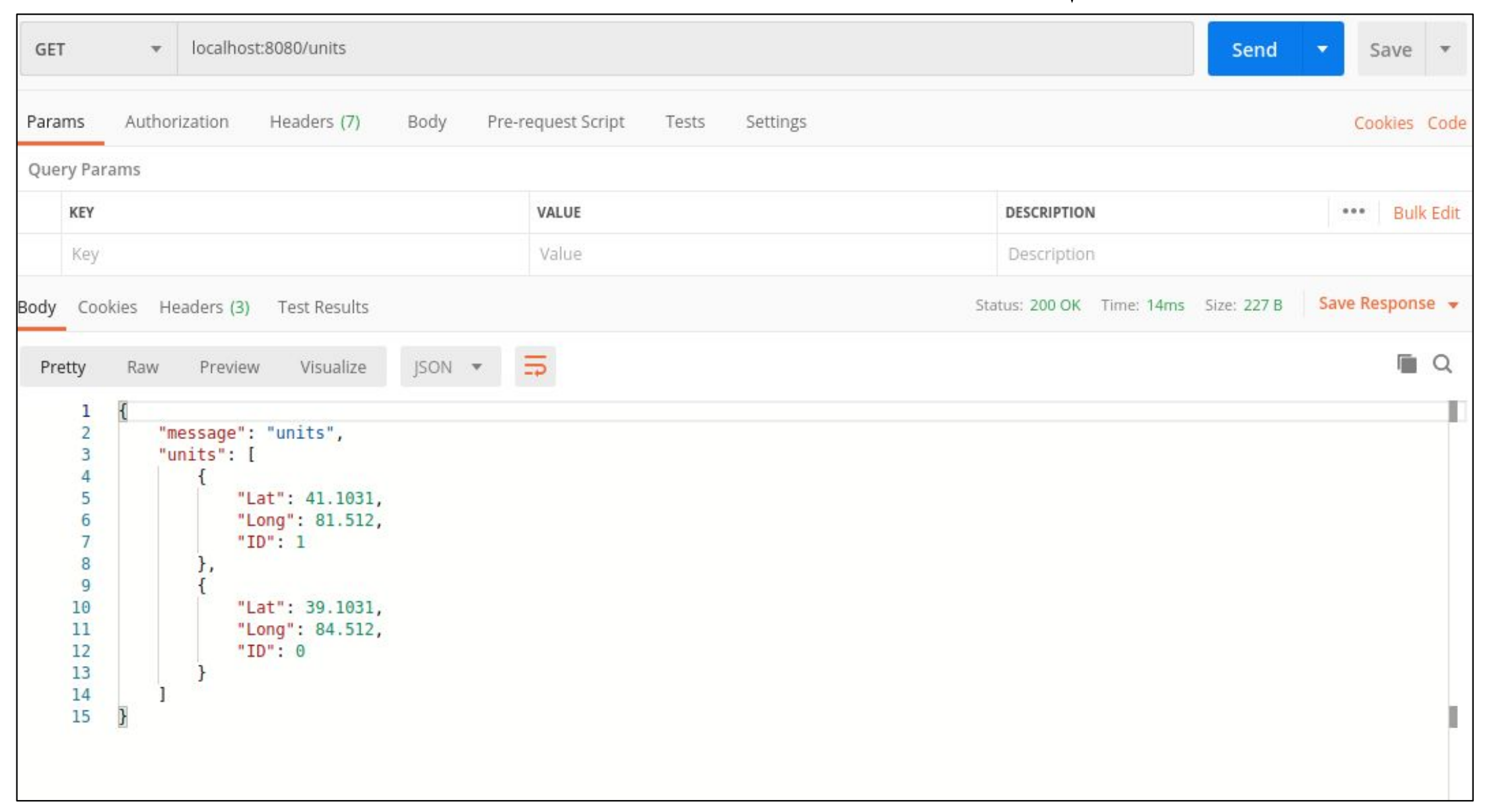


User Interface

Emulated Android app showing two CLUs (red pins) on Google Maps



API call to list CLU records



GET localhost:8080/units

Params | Authorization | Headers (7) | Body | Pre-request Script | Tests | Settings

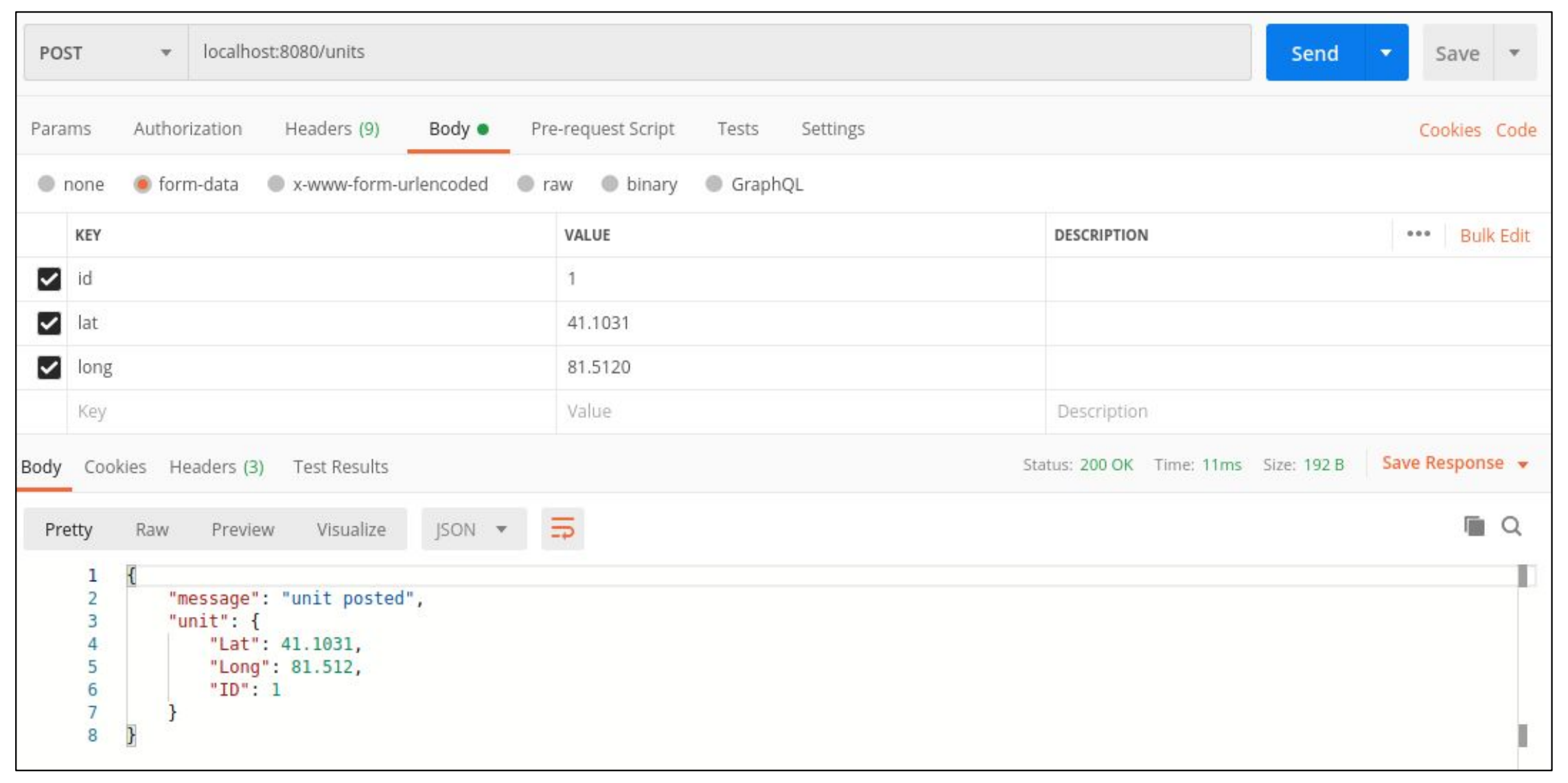
Query Params

KEY	VALUE	DESCRIPTION
Key	Value	Description

Status: 200 OK Time: 14ms Size: 227 B

```
{
    "message": "units",
    "units": [
        {
            "Lat": 41.1031,
            "Long": 81.512,
            "ID": 1
        },
        {
            "Lat": 39.1031,
            "Long": 84.512,
            "ID": 0
        }
    ]
}
```

API call to create a CLU record



POST localhost:8080/units

Params | Authorization | Headers (9) | Body | Pre-request Script | Tests | Settings

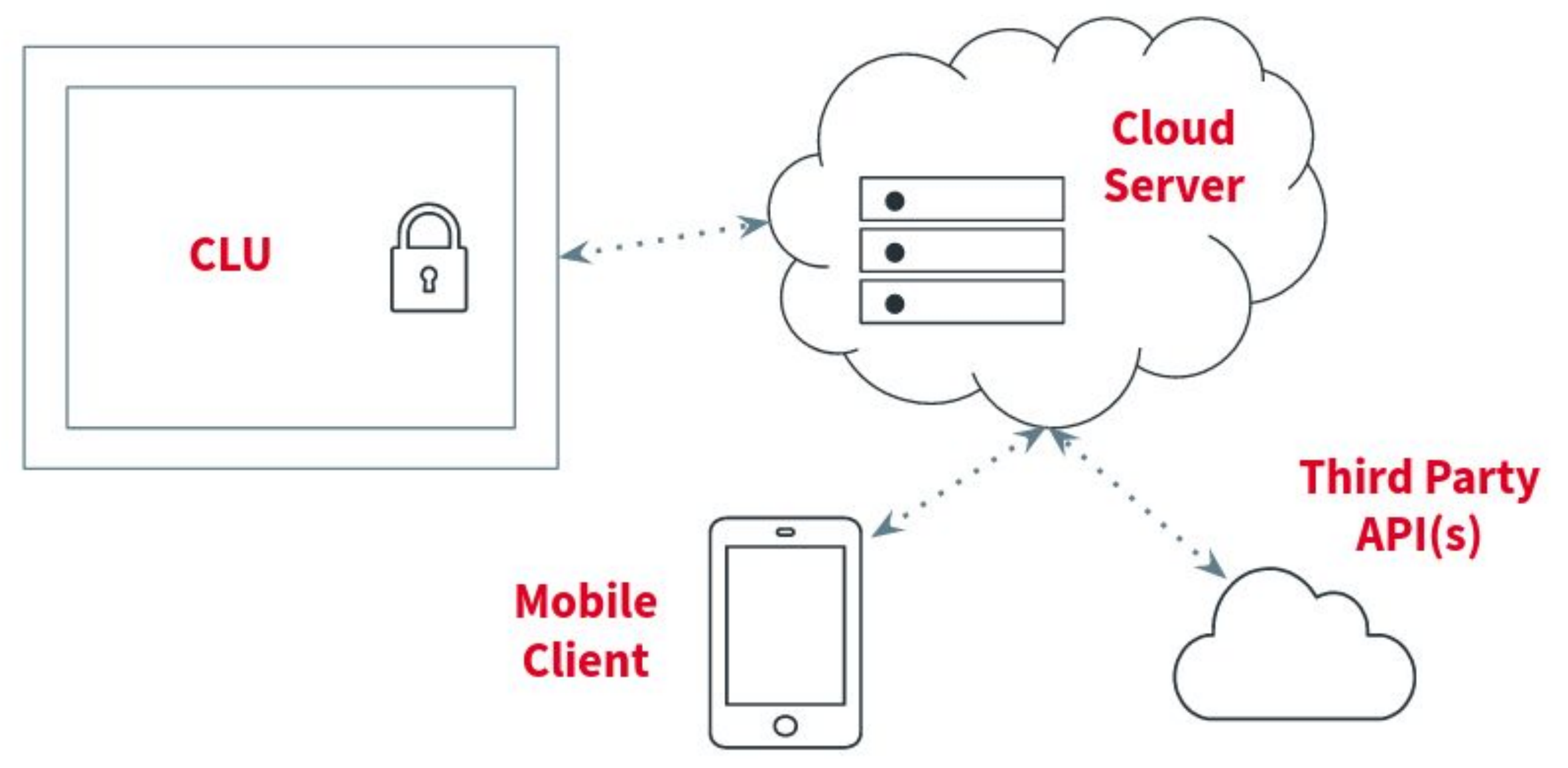
none [✓ form-data] x-www-form-urlencoded raw binary GraphQL

	KEY	VALUE	DESCRIPTION
✓	id	1	
✓	lat	41.1031	
✓	long	81.5120	
	Key	Value	Description

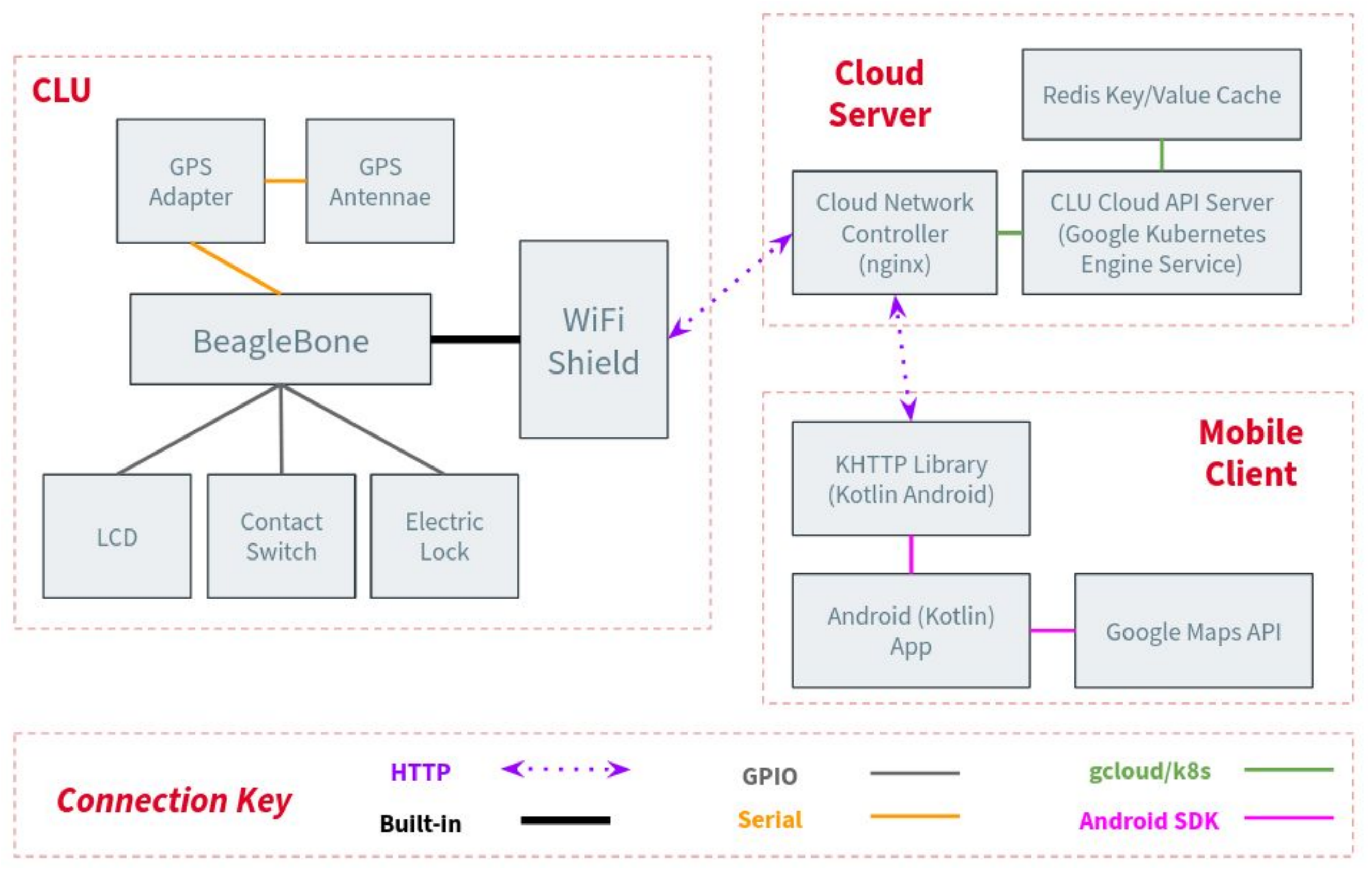
Status: 200 OK Time: 11ms Size: 192 B

```
{
    "message": "unit posted",
    "unit": {
        "Lat": 41.1031,
        "Long": 81.512,
        "ID": 1
    }
}
```

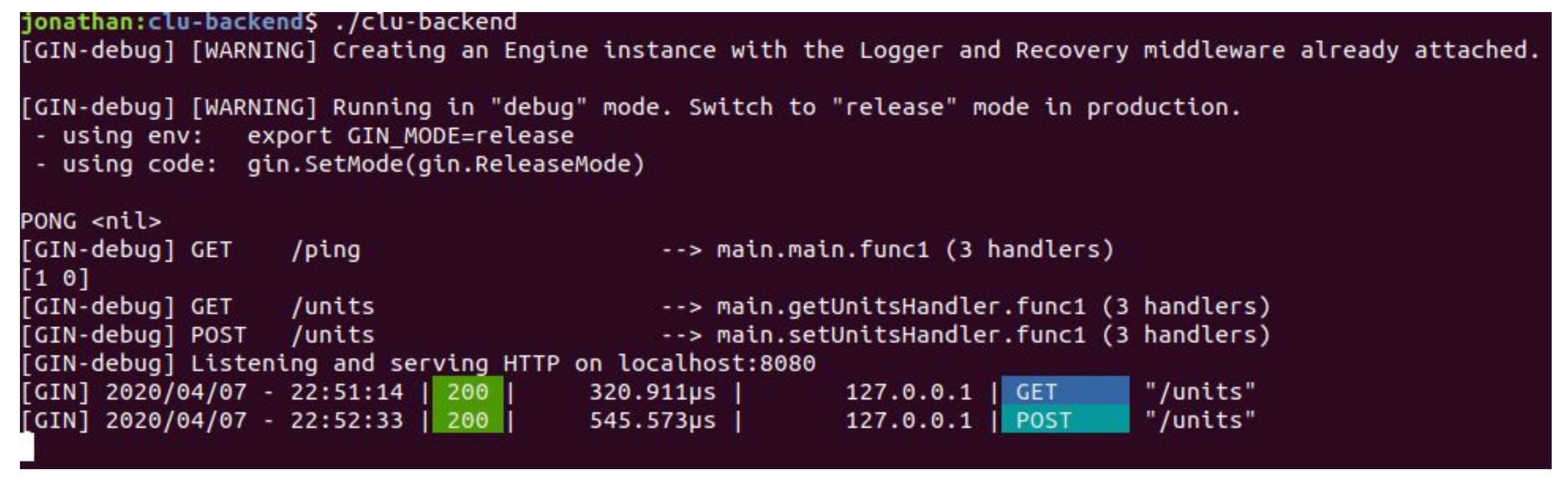
Black Box Diagram



White Box Diagram



Live API Server



```
jonathan:clu-backend$ ./clu-backend
[GIN-debug] [WARNING] Creating an Engine instance with the Logger and Recovery middleware already attached.

[GIN-debug] [WARNING] Running in "debug" mode. Switch to "release" mode in production.
 - using env:   export GIN_MODE=release
 - using code:  gin.SetMode(gin.ReleaseMode)

PONG <nil>
[GIN-debug] GET    /ping                     --> main.main.func1 (3 handlers)
[1 0]
[GIN-debug] GET    /units                    --> main.getUnitsHandler.func1 (3 handlers)
[GIN-debug] POST   /units                    --> main.setUnitsHandler.func1 (3 handlers)
[GIN-debug] Listening and serving HTTP on localhost:8080
[GIN] 2020/04/07 - 22:51:14 | 200 |     320.911µs |       127.0.0.1 | GET      "/units"
[GIN] 2020/04/07 - 22:52:33 | 200 |     545.573µs |       127.0.0.1 | POST     "/units"
```

Standards

- RoHS
- Data encryption
- SSL verification (Future)
- UL (Future)
- IP67 Waterproofing (Future)

Challenges

Design

- Originally proposed a locking refrigerator. By making scope more specific, simplified project and broadened possible uses.

Hardware Prototyping

- Purchased multiple parts that didn't work – it was good that we tested them individually!
- COVID-19 delayed shipment of many needed parts and restricted our access to prototyping tools we needed (e.g. 3D printing)

Software Development

- Needed to reduce complexity for POC, not able to implement SSL verification or 3rd party integration

Conclusion & Future Work

Conclusion

- The goal of designing a connected, modular, scalable locking system was achieved.
- The goal of prototyping the system was not achieved due to the COVID-19 crisis.

Future Work

- Integrate hardware after parts received
- Deploy Android app to Play Store
- Move from test stack onto paid GCP cloud service (enables Redis and cluster networking)
- Retrofit containers (3D printing) and affix locks and sensors
- Achieve desired standards