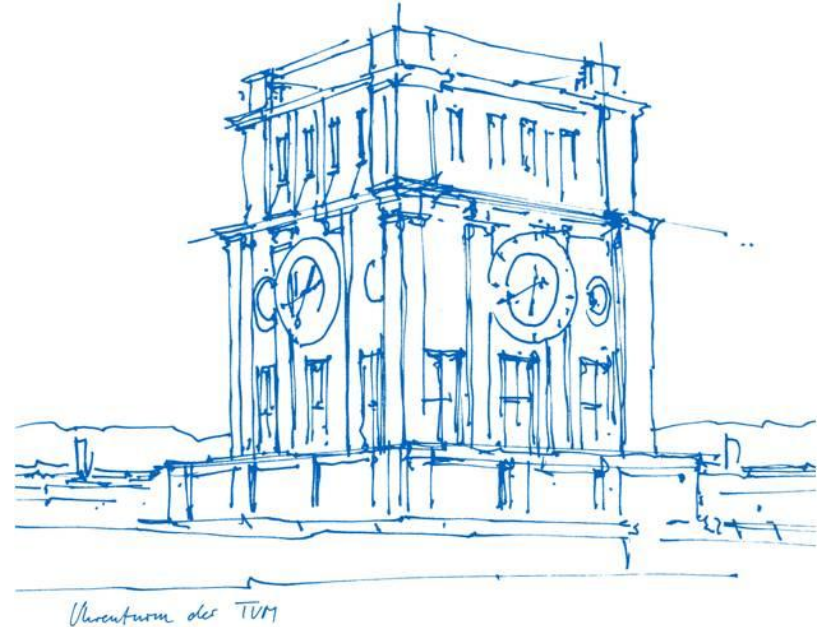


Mobile Solar Panels

Final Demo

Eric Armbruster, Florian Freund, Sebastian Klinke

Garching, 29.07.2022



Motivation

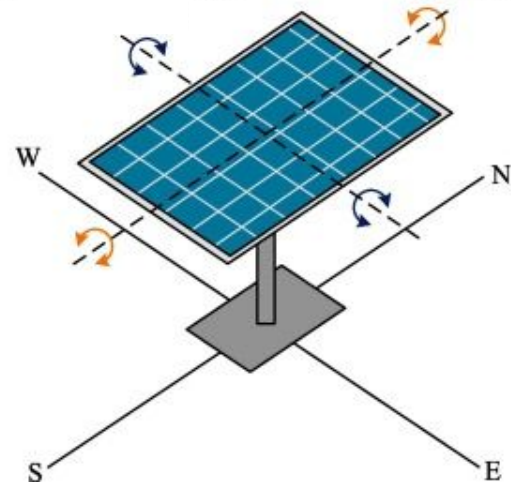
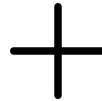


+ Transportable

Motivation



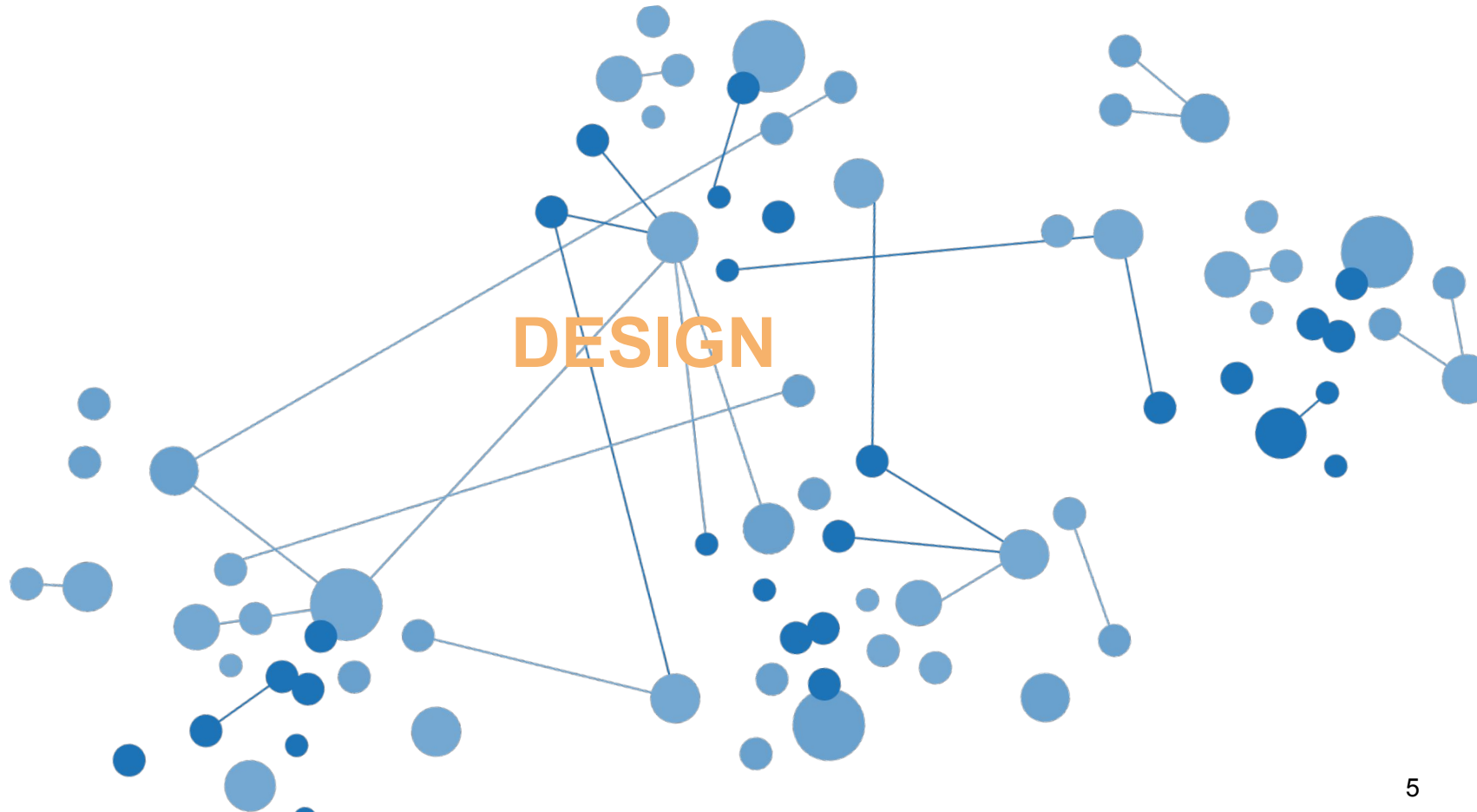
+ Transportable



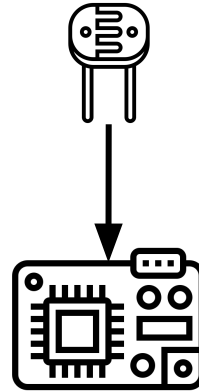
+ Rotatable

Motivation

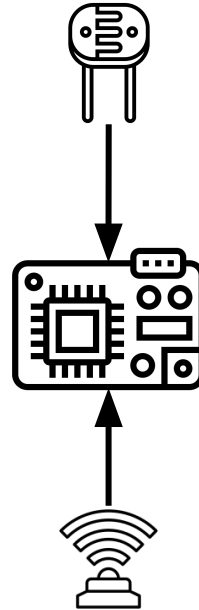




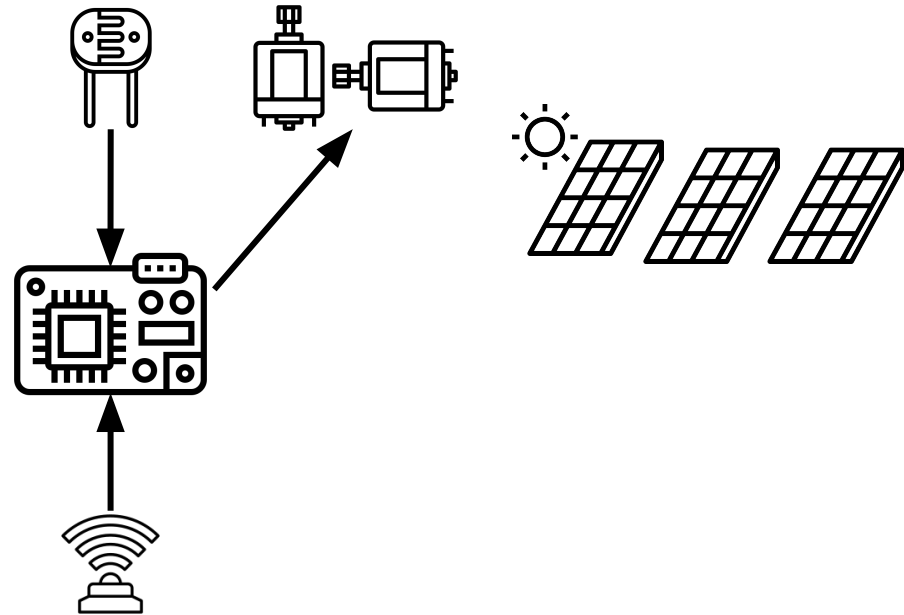
Setup



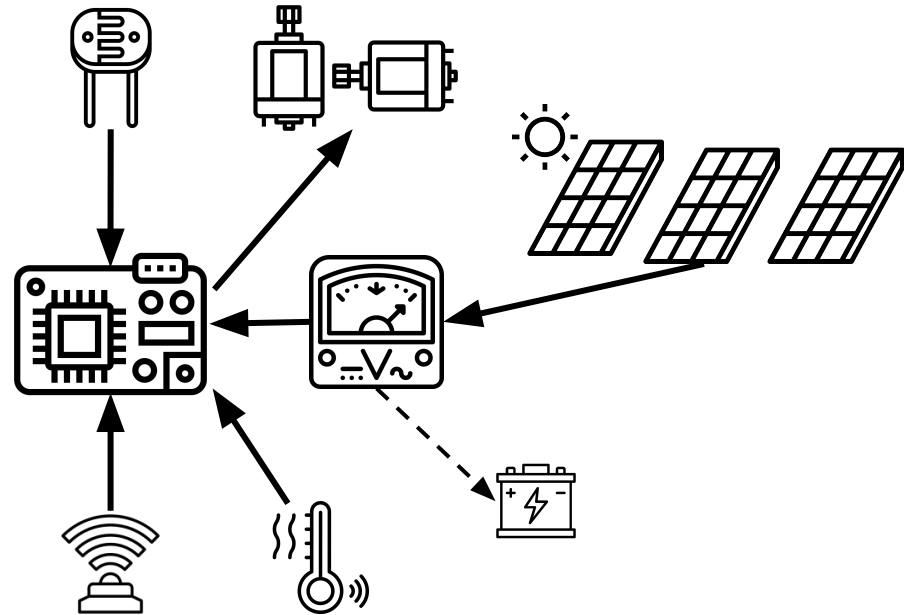
Setup



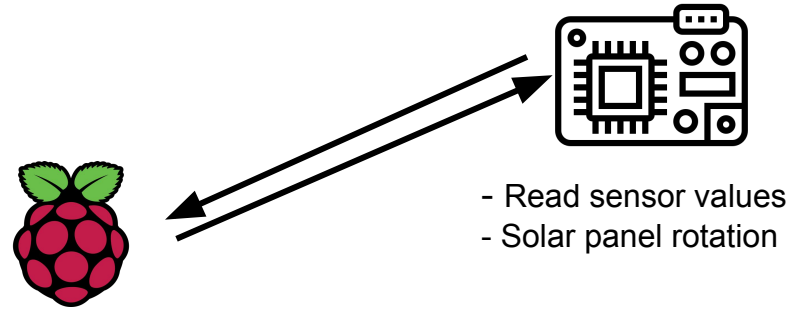
Setup



Setup

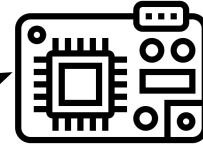
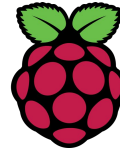


Overview



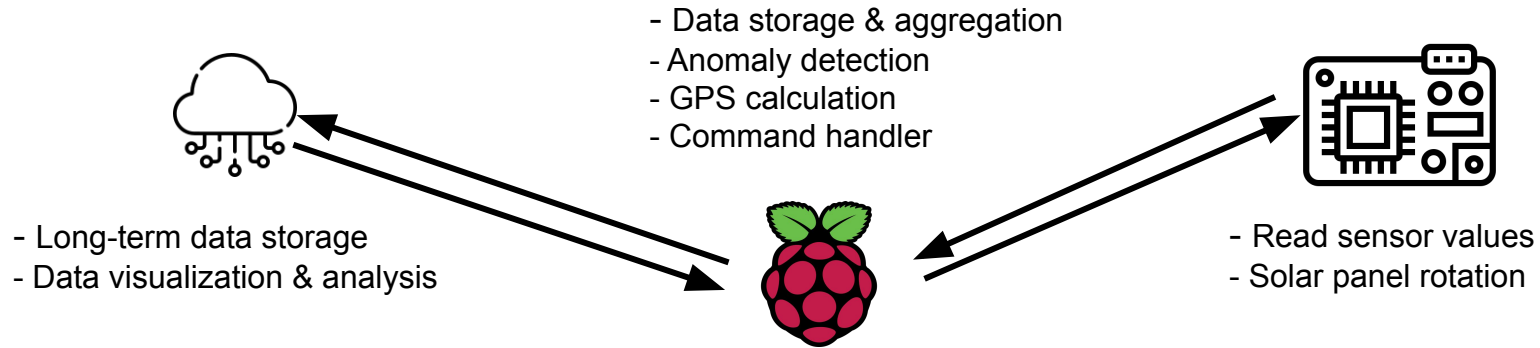
Overview

- Data storage & aggregation
- Anomaly detection
- GPS calculation
- Command handler

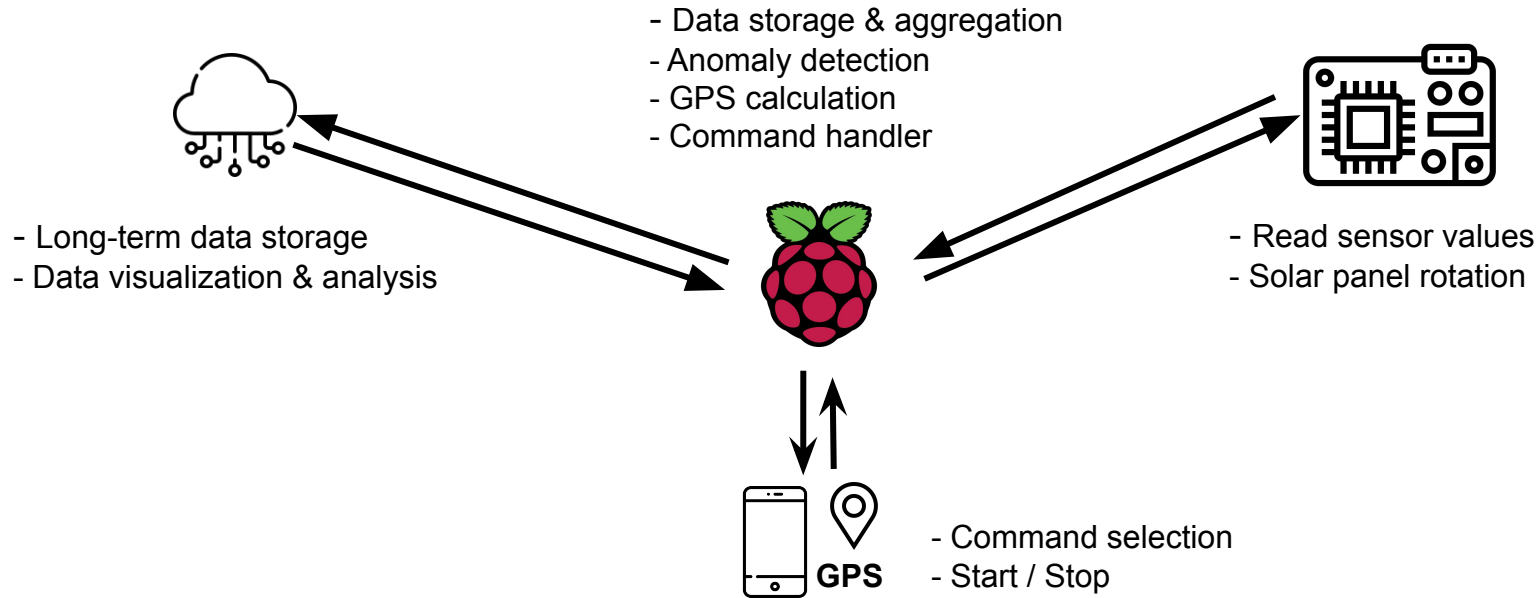


- Read sensor values
- Solar panel rotation

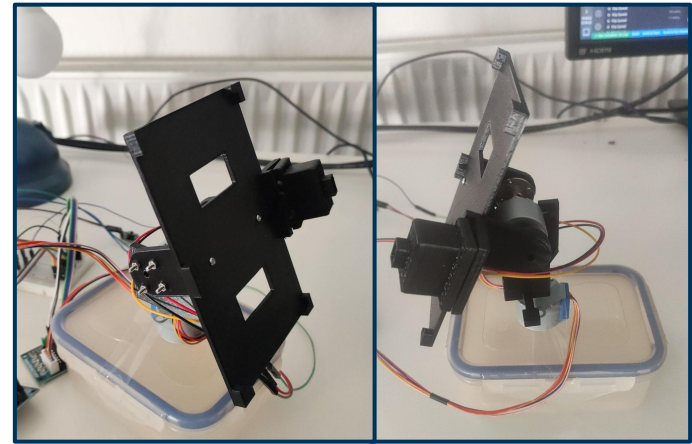
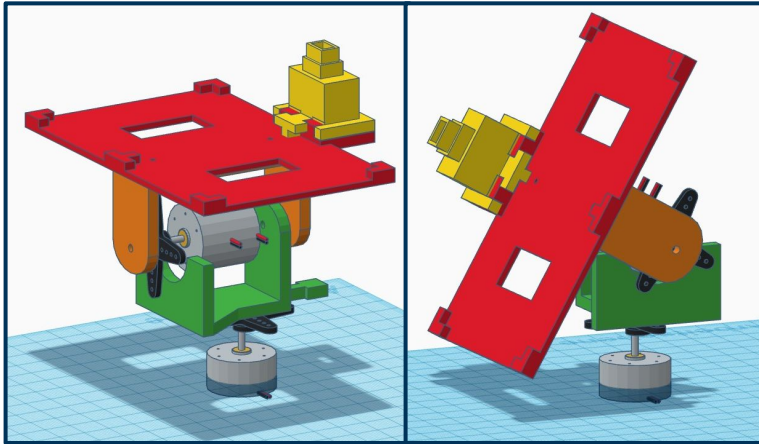
Overview



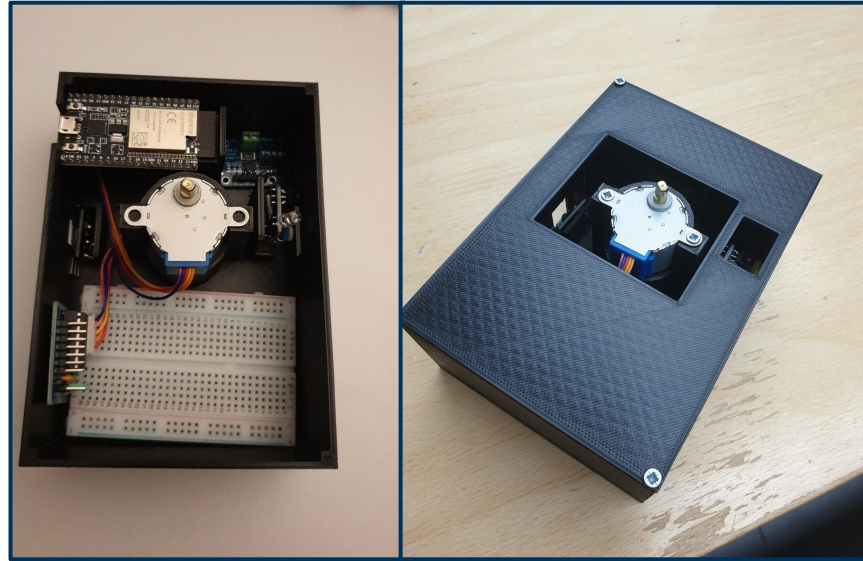
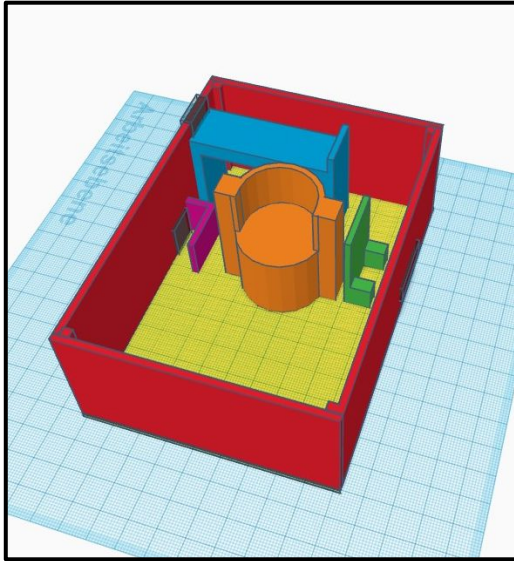
Overview



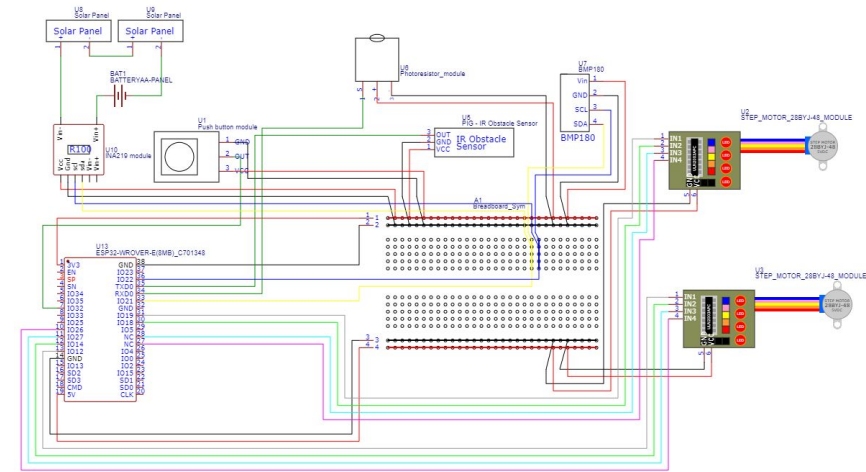
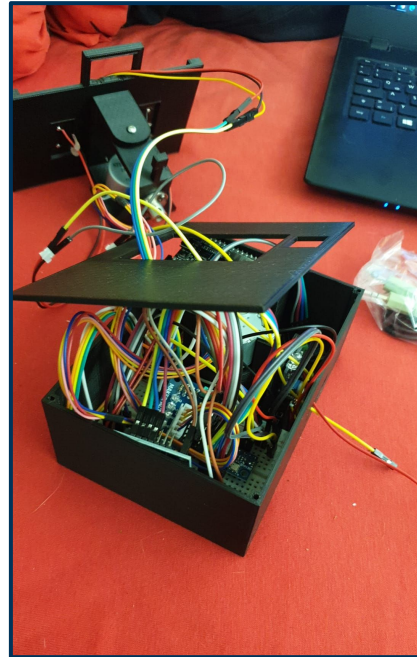
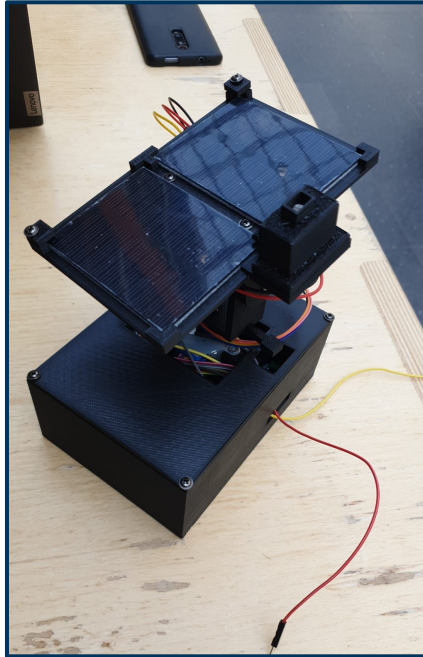
Prototype: Solar Panel Mount



Prototype: Base Platform



Prototype: Wiring



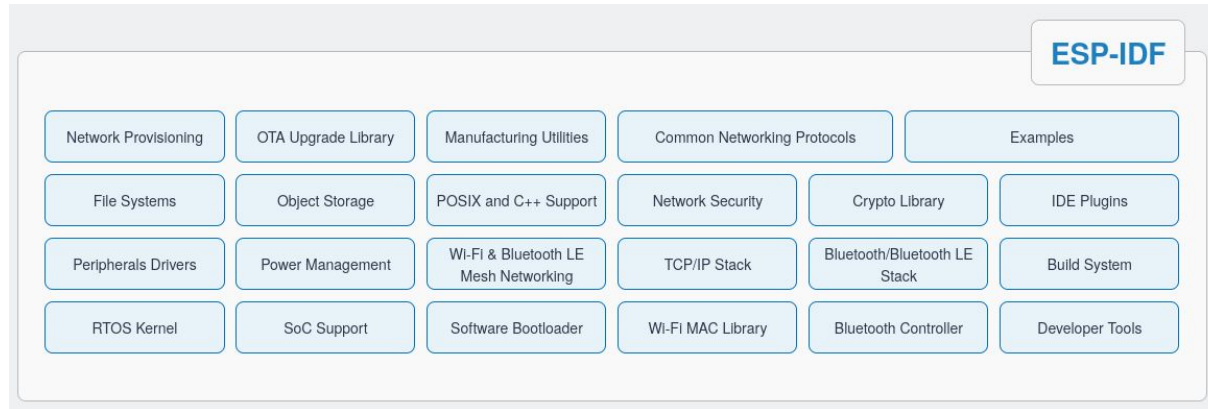


IMPLEMENTATION



Espressif IDF

- IoT Development Framework from Espressif
- Full hardware support
- RIOT does not support: Multithreading, Bluetooth



Source: <https://www.espressif.com/en/products/sdks/esp-idf>



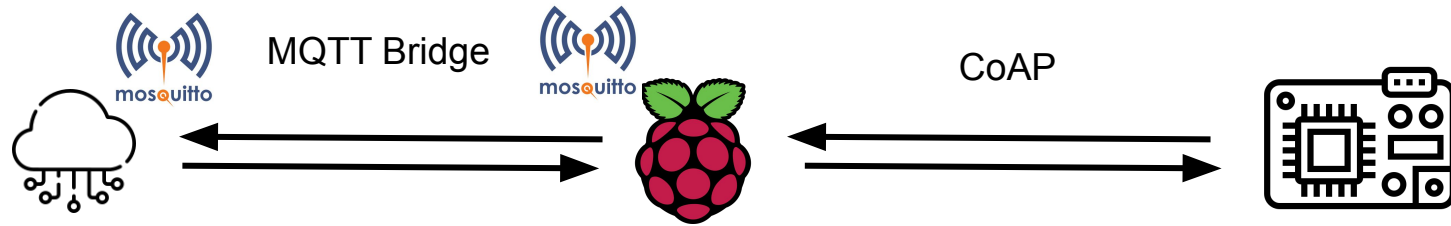
Espressif IDF and Rust

- Rust bindings
- Memory safety guarantees at compile time
- It's cool 😎 and we learn something new!



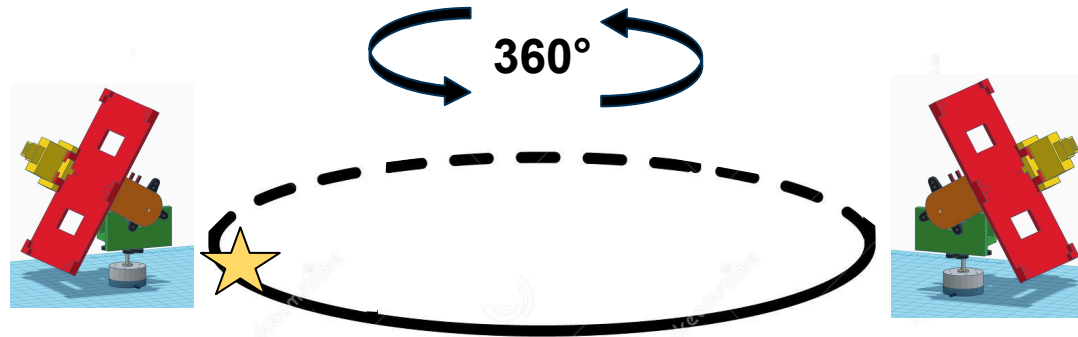
<https://hackaday.com/wp-content/uploads/2015/12/rust.jpg?w=800>

Communication: MQTT and CoAP



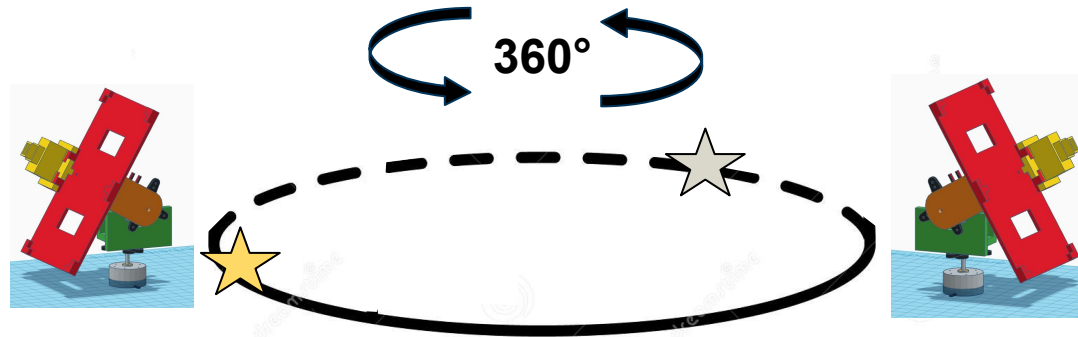
Initial Orientation

- ★ Initial position
- ★ Best horizontal position
- ★ Best (vertical) position



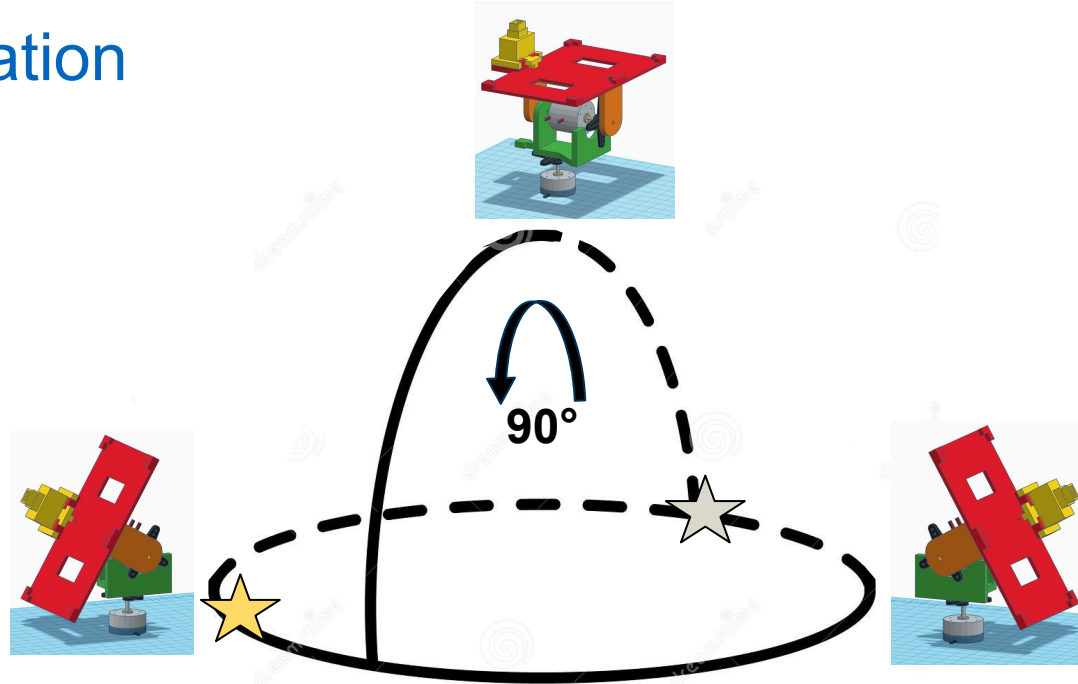
Initial Orientation

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- ★ Best horizontal position
- ★ Best (vertical) position



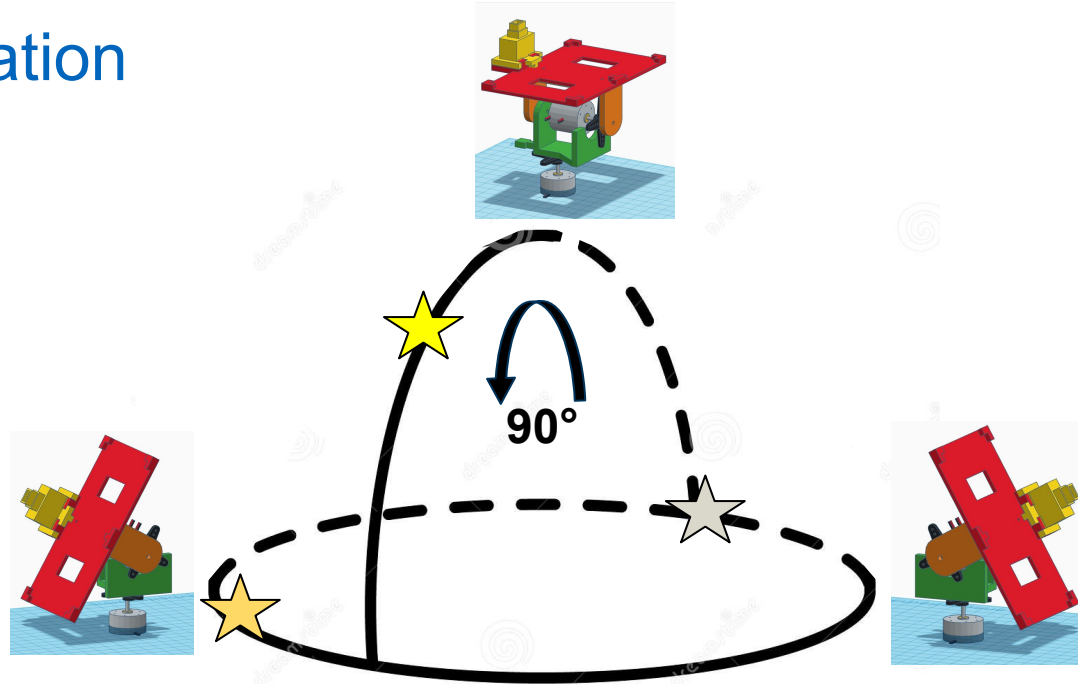
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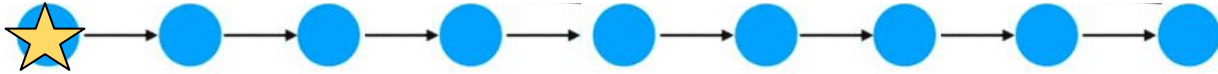





Initial Orientation

- ★ Initial position
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- ★ Best (vertical) position

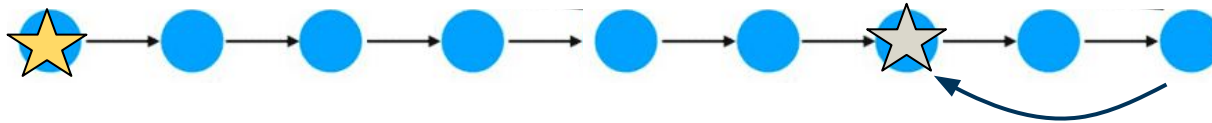





Sun tracker



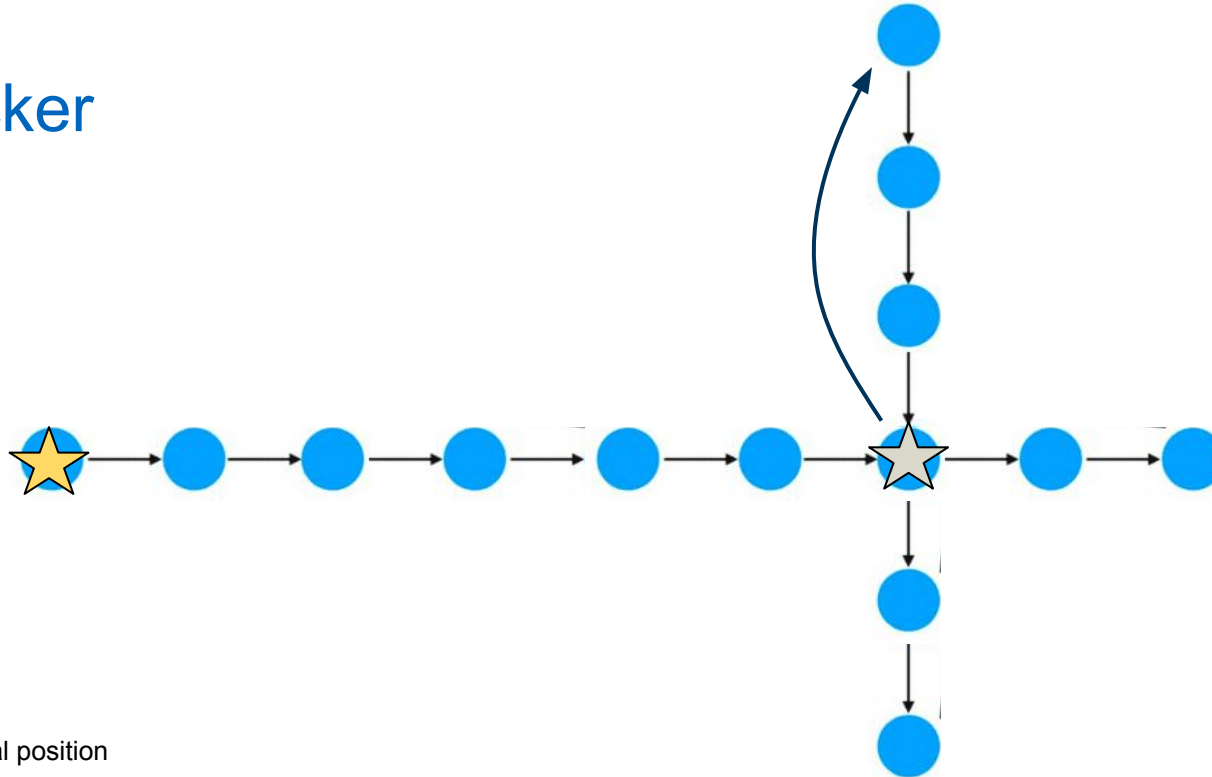
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-  Best (vertical) position




Sun tracker



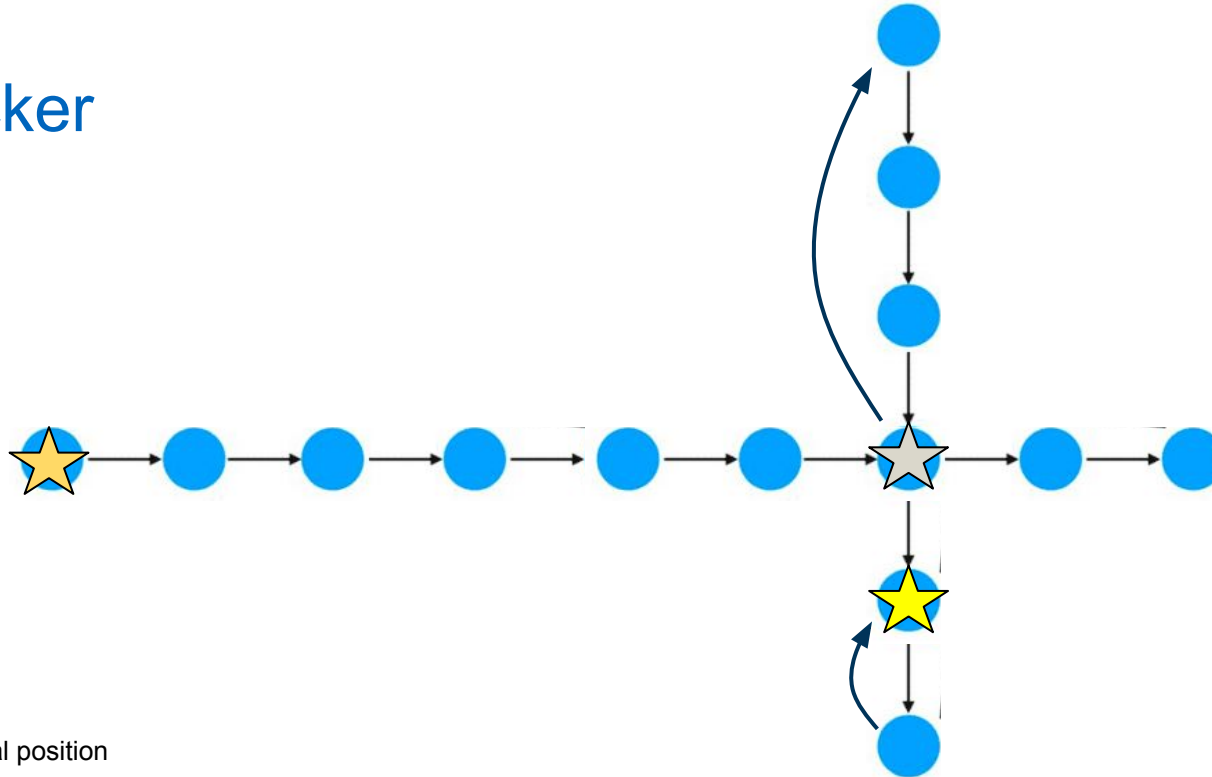
-  Initial position
-  Best horizontal position
-  Best (vertical) position




Sun tracker



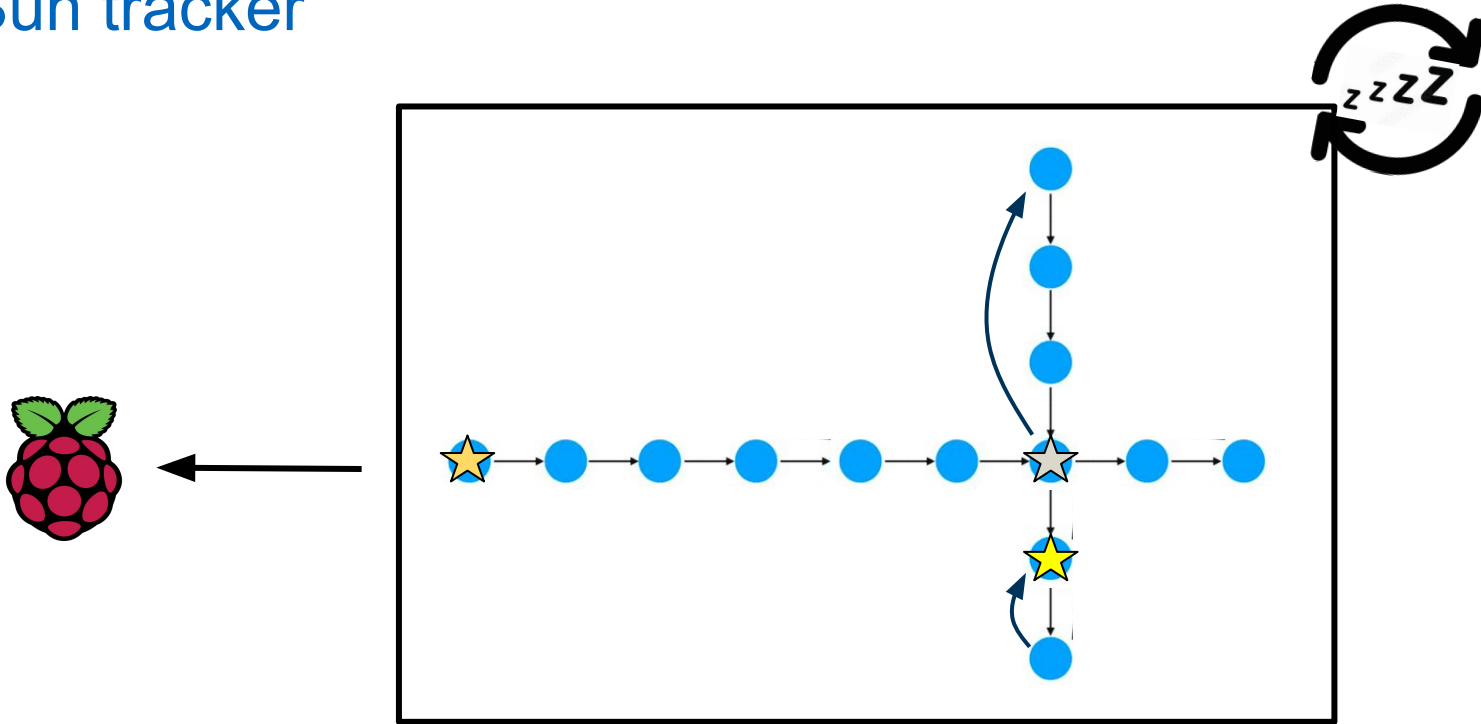
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Sun tracker

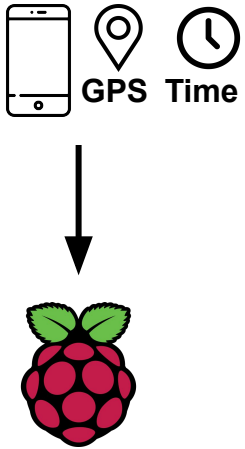


-  Initial position
-  Best horizontal position
-  Best (vertical) position

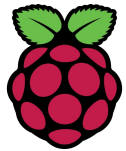
Sun tracker



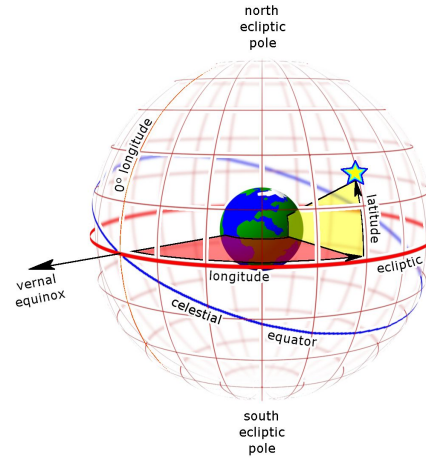
GPS Alternative



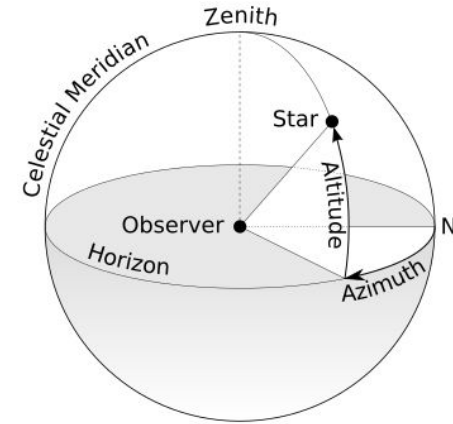
GPS Alternative



Ecliptic
coordinate system



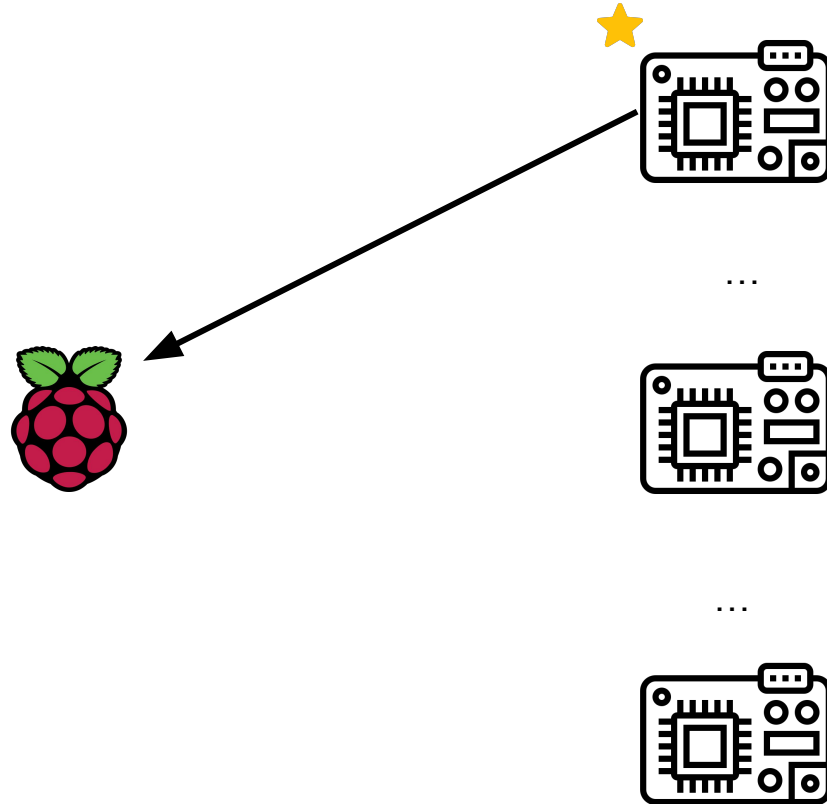
Equatorial
coordinate system



Horizontal
coordinate system

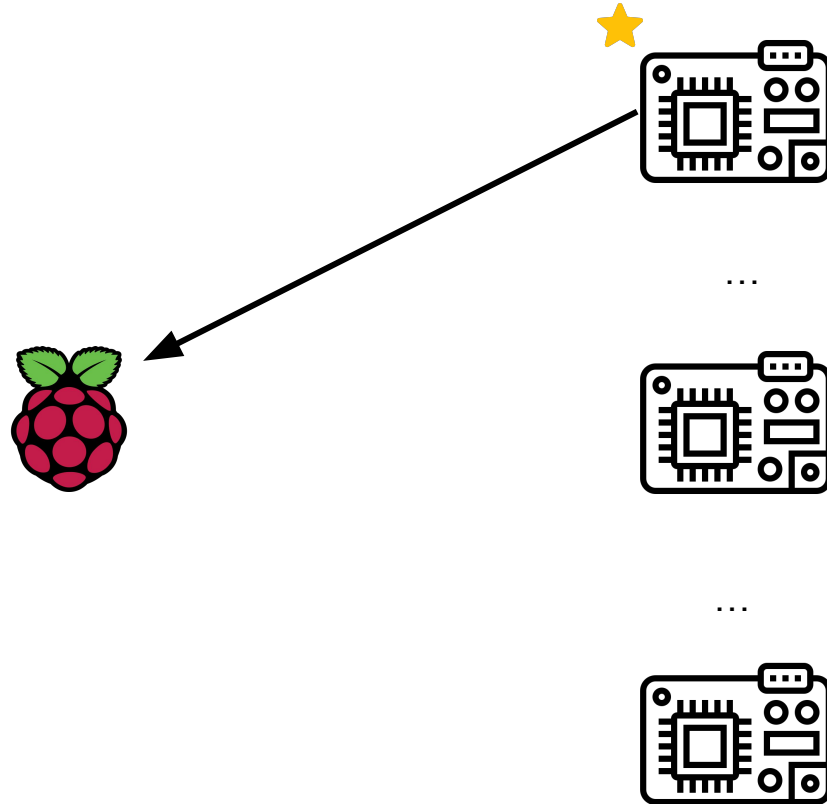
Leader Follower Reuse

1. Every IoT device
 - is assigned a role
 - initializes its rotation



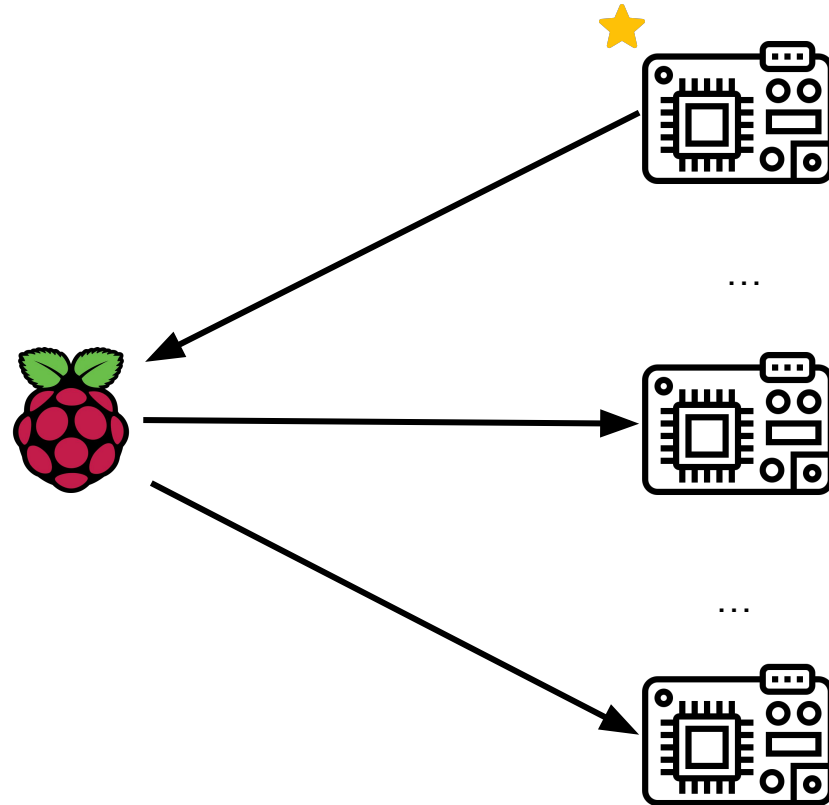
Leader Follower Reuse

1. Every IoT device
 - is assigned a role
 - initializes its rotation
2. Leader
 - Probes next rotation offset
 - Leader forwards rotation offset to edge



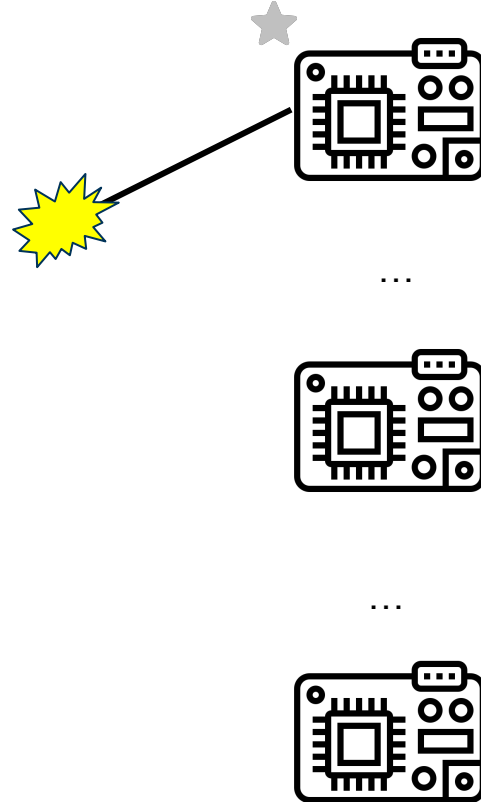
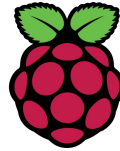
Leader Follower Reuse

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 - initializes its rotation
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 - Probes next rotation offset
 - Leader forwards rotation offset to edge
3. Edge device forwards to followers



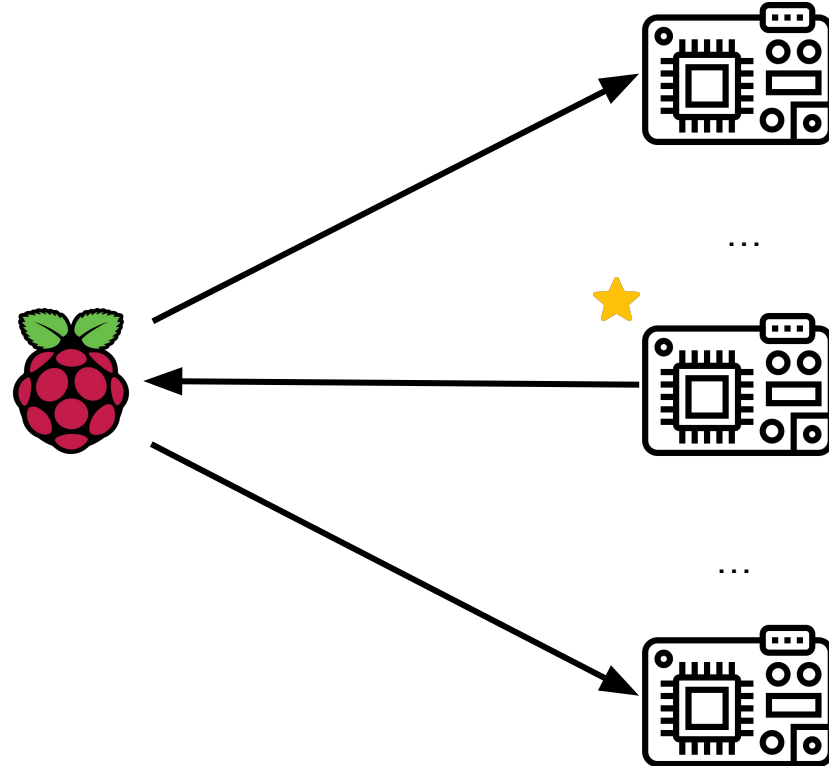
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4. Leader role can be reassigned when current leader is unresponsive

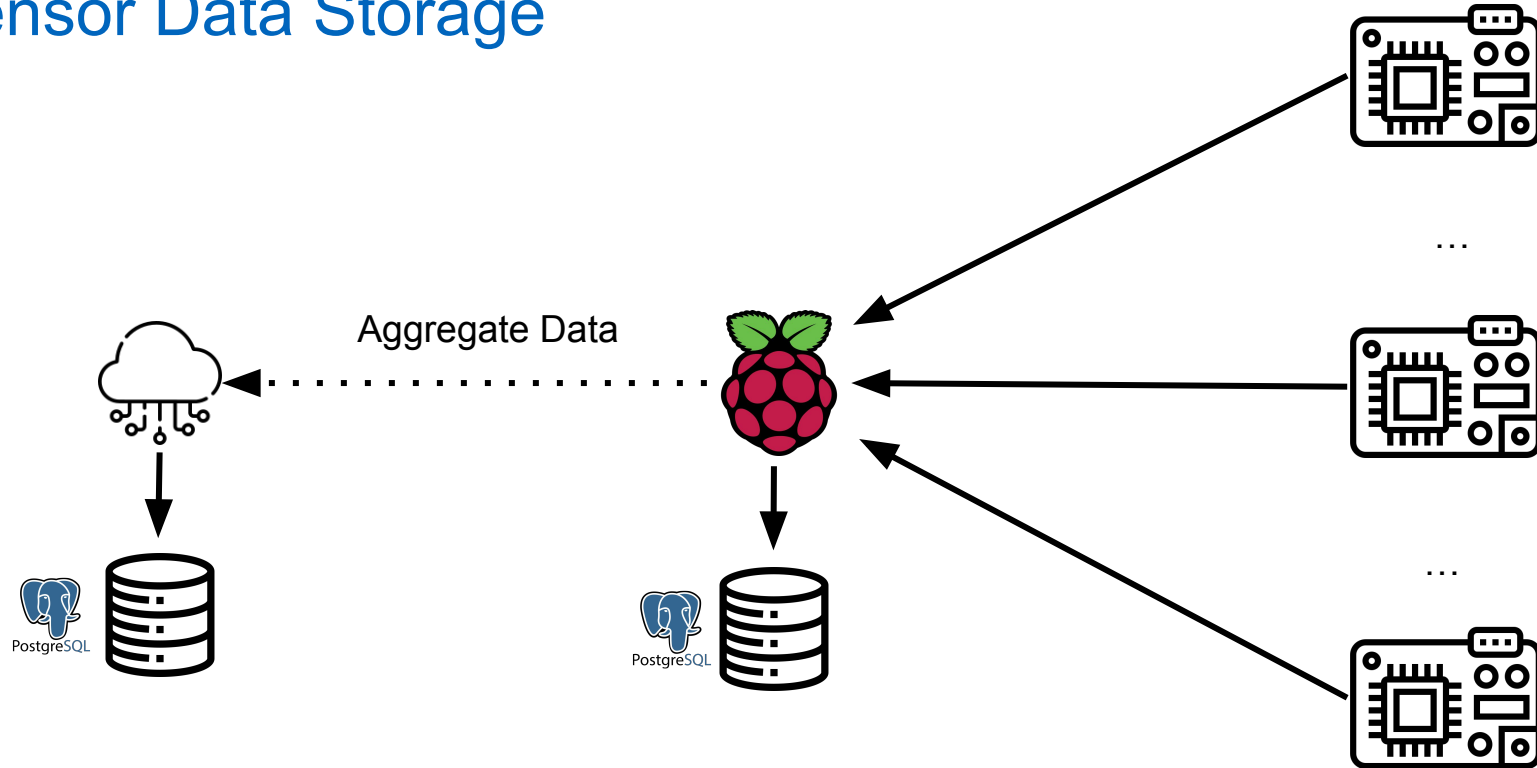


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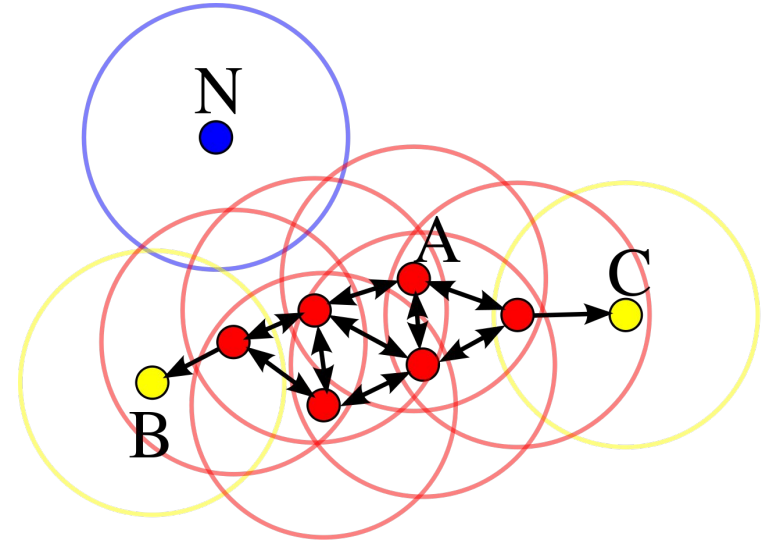


Sensor Data Storage



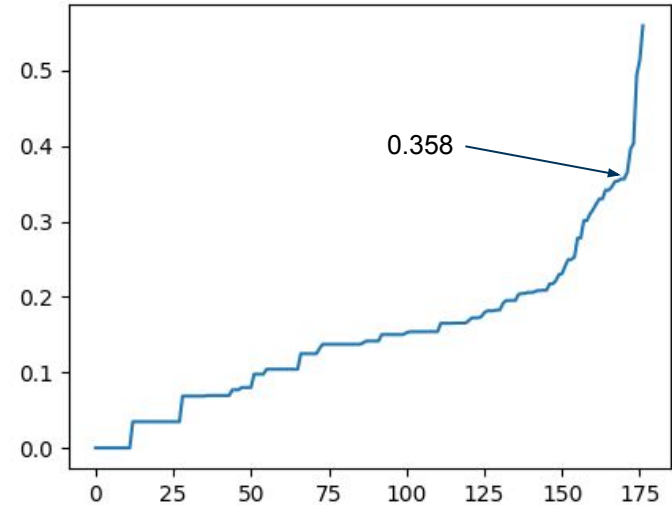
Anomaly Detection: DBSCAN

- unsupervised
- can find arbitrarily shaped clusters with noise (outliers)
- no hyperparameter for number of clusters required!!



Anomaly Detection: DBSCAN

- generated anomalies data manually
- determined ϵ through [1] (knee plot)
- **but:** too many false positives

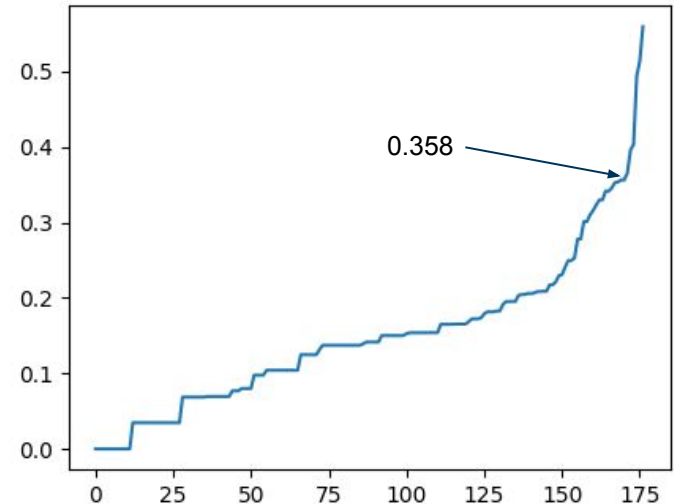


[1] Rahmah, Nadia, and Imas Sukaesih Sitanggang. "Determination of optimal epsilon (eps) value on dbscan algorithm to clustering data on peatland hotspots in sumatra." *IOP conference series: earth and environmental science*. Vol. 31. No. 1. IOP Publishing, 2016.

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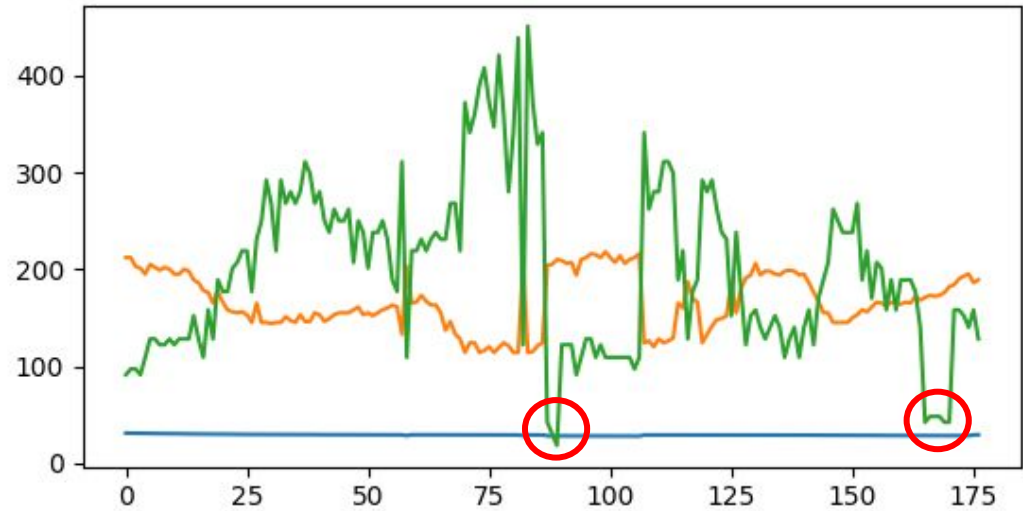
- **better results:**
 - manually determined $\epsilon = 0.6$
 - but likely overfitting



[1] Rahmah, Nadia, and Imas Sukaesih Sitanggang. "Determination of optimal epsilon (eps) value on dbscan algorithm to clustering data on peatland hotspots in sumatra." *IOP conference series: earth and environmental science*. Vol. 31. No. 1. IOP Publishing, 2016.

Anomaly Detection: Threshold Based

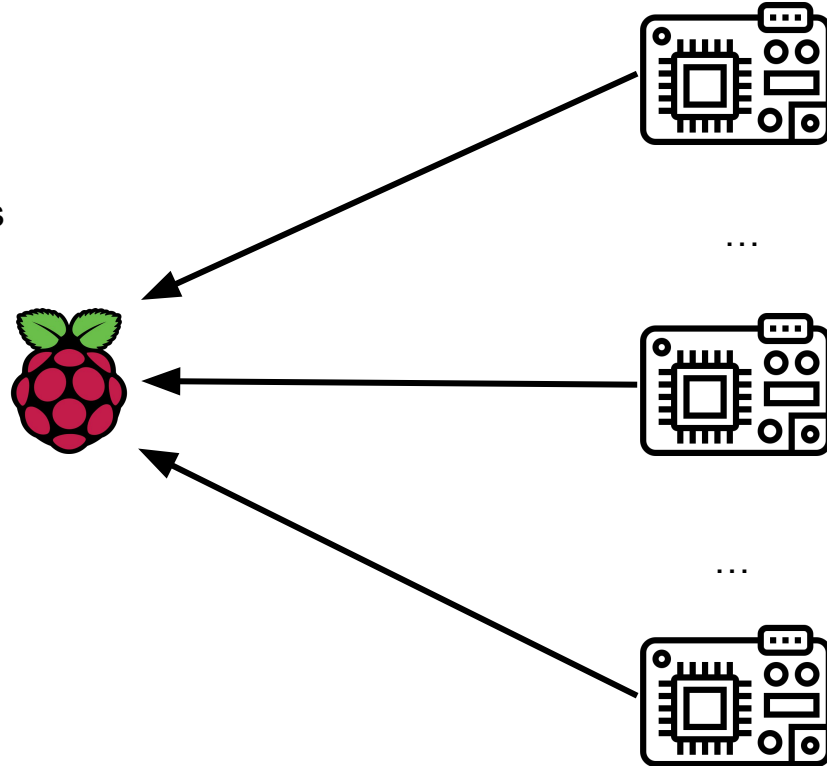
- at least detect basic cases, e.g. no power generation
- simple, but thresholds are always a bit arbitrary





Edge Performance

- Can the Raspberry Pi handle **1000** parallel requests within reasonable time?
- Usual sensor request interval: 60 seconds



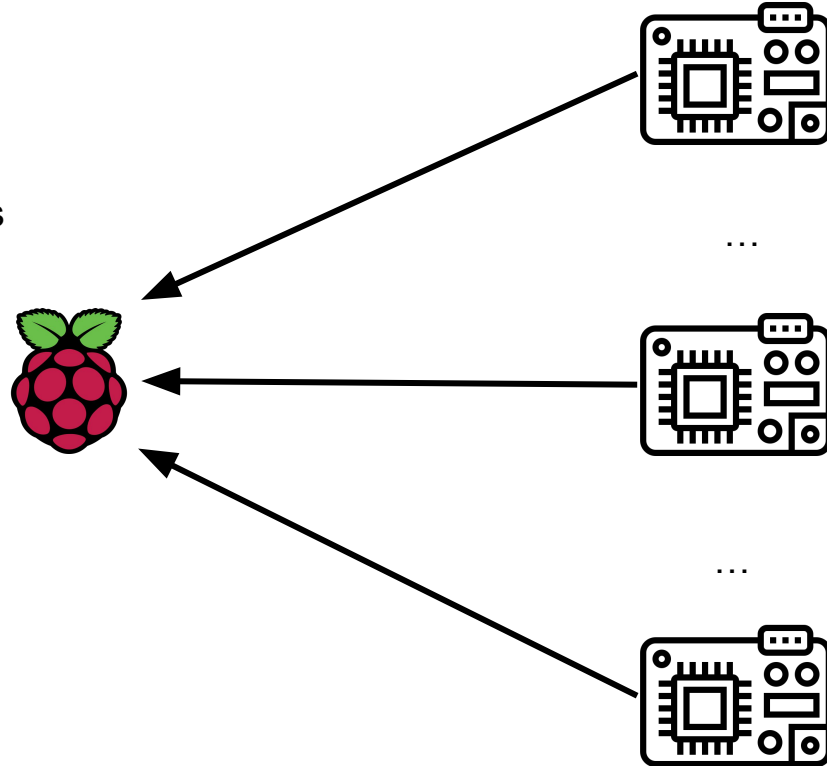
Edge Performance

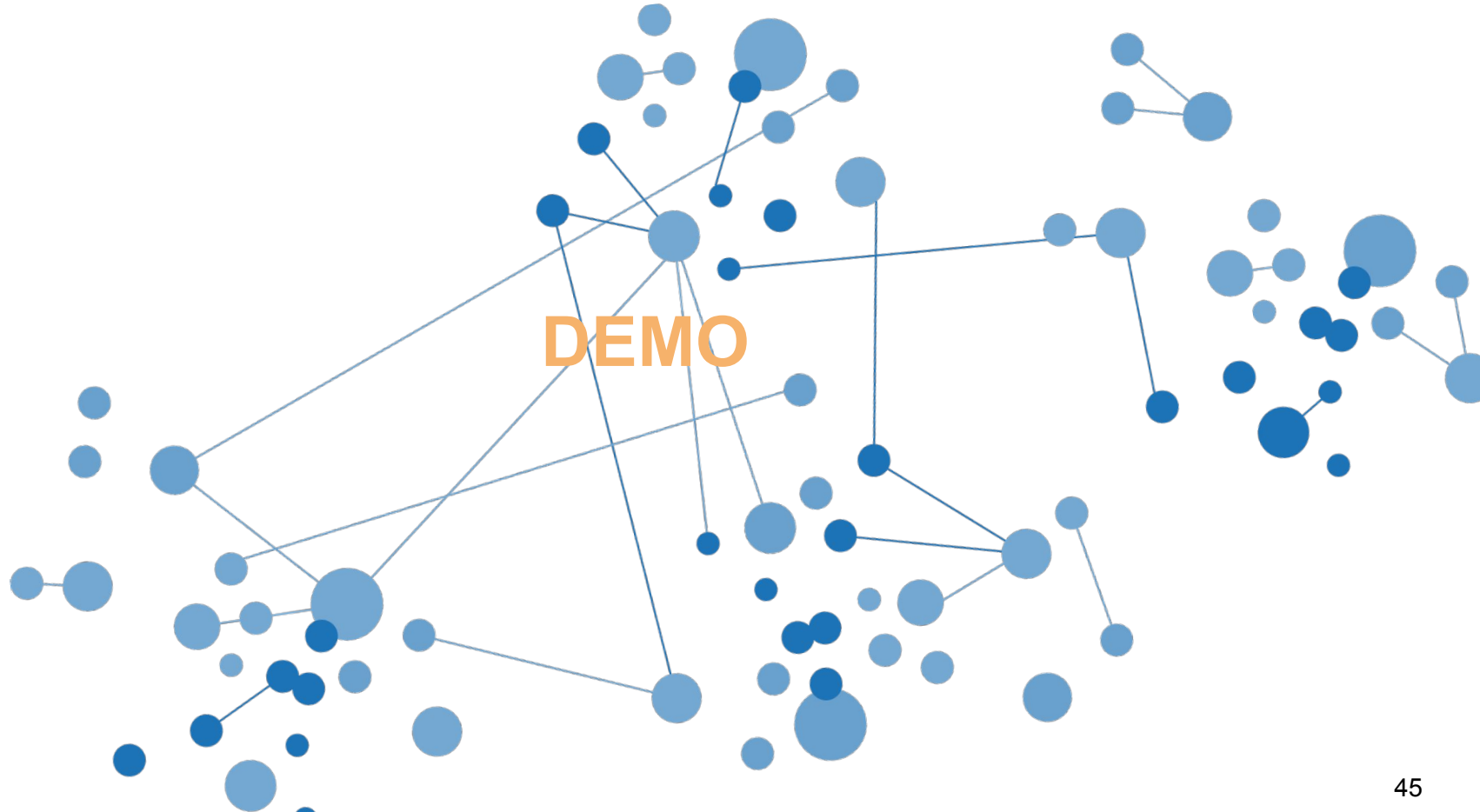
- Can the Raspberry Pi handle **1000** parallel requests within reasonable time?
- Usual sensor request interval: 60 seconds

1000 simultaneous requests average:
5.38 s



5.38 ms per request \ll 60 s





Smartphone Control

Click one of the buttons to start the Mobile Solar Panels with or without your current coordinates or stop it for now. The currently active command is:

None

Start using current location

Start without location

Stop

Smartphone Control

Click one of the buttons to start the Mobile Solar Panels with or without your current coordinates or stop it for now. The currently active command is:

LightTracking

Start using current location

Start without location

Stop

Start without coordinates was successful