Multi-tier Wireless Mesh Networks in Remote Sensing

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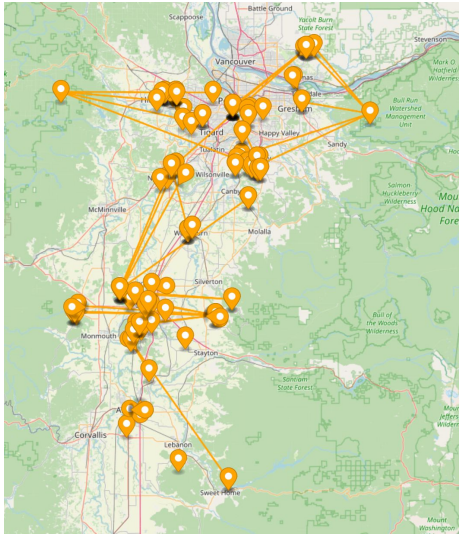
Monitoring wildfires (and other natural hazards)

- Effectively detecting and monitoring wildfires requires collecting heterogeneous data in remote locations
- Current solutions (satellites) have low spatial and or temporal resolutions
- We leverage existing amateur radio and ISM band infrastructure to build distributed, multi-tier sensor networks in wildfire-prone regions
  - Open-source and community-owned
  - Reconfigurable and self-healing
  - Tie a multitude of protocols together

Amateur Radio Emergency Data Network (AREDN)

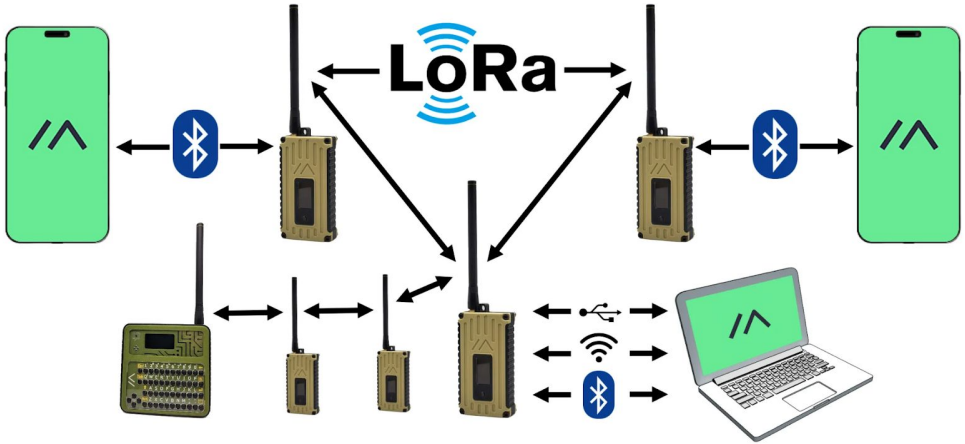
- the internet (but for HAMs)
- self-healing redundant mesh
- community driven
  - repurposes commercial equipment
- various use cases



What is Meshtastic?

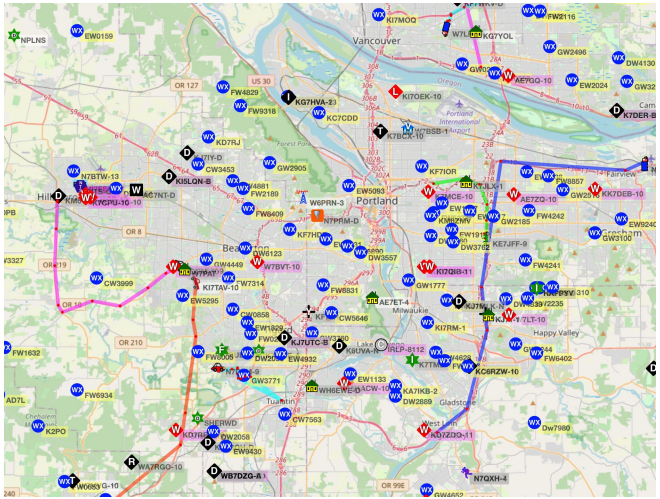
Meshtastic is an open source, off-grid radio communication platform that uses LoRa radios to allow communication in areas that may be hard to reach.

- No licenses needed
- Radios rebroadcast received messages
- Devices can be connected through personal devices to send messages (phone, computer, etc.)

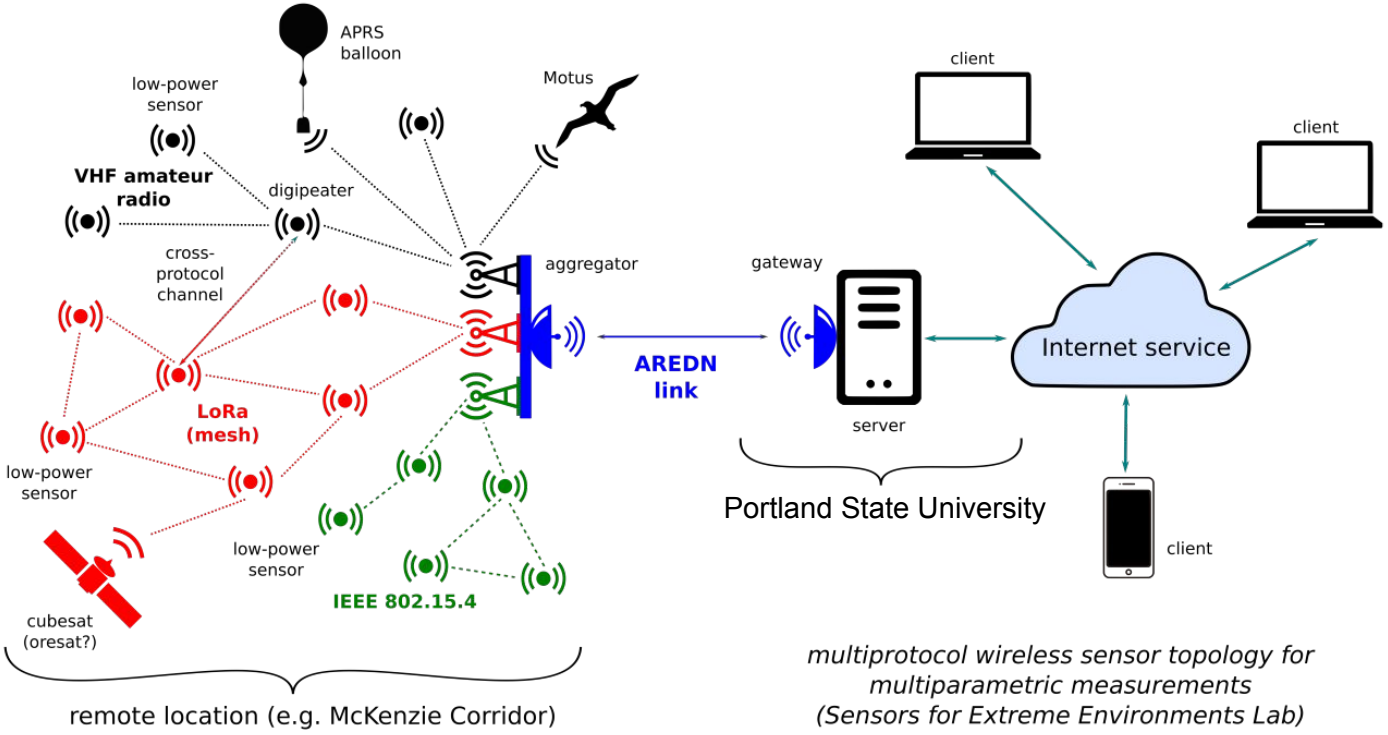


Automatic Packet Reporting System (APRS)

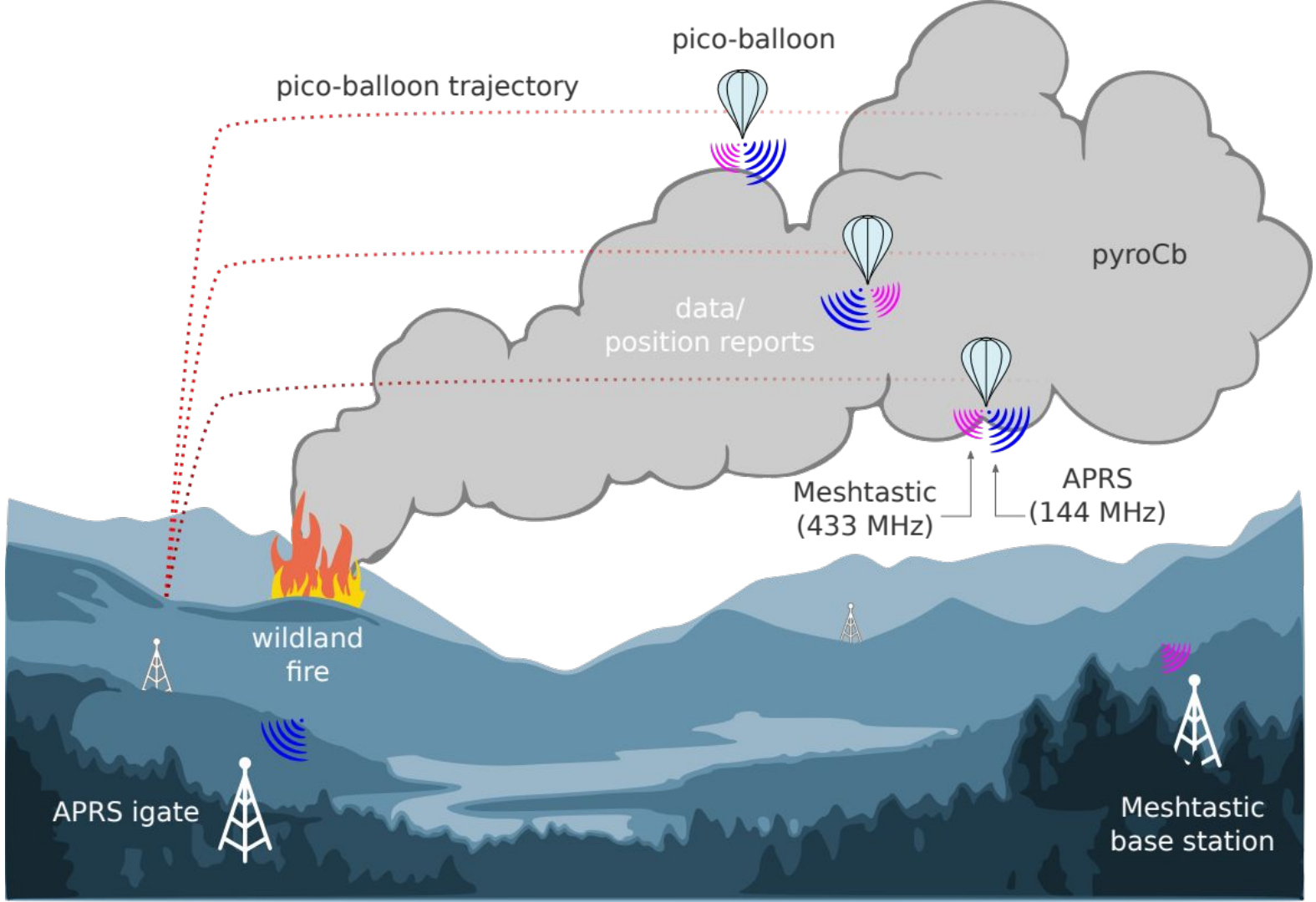
- unconnected broadcast fashion
- Digipeaters
- first use was in 1984
- old, established
- use in hospitals, emergency response



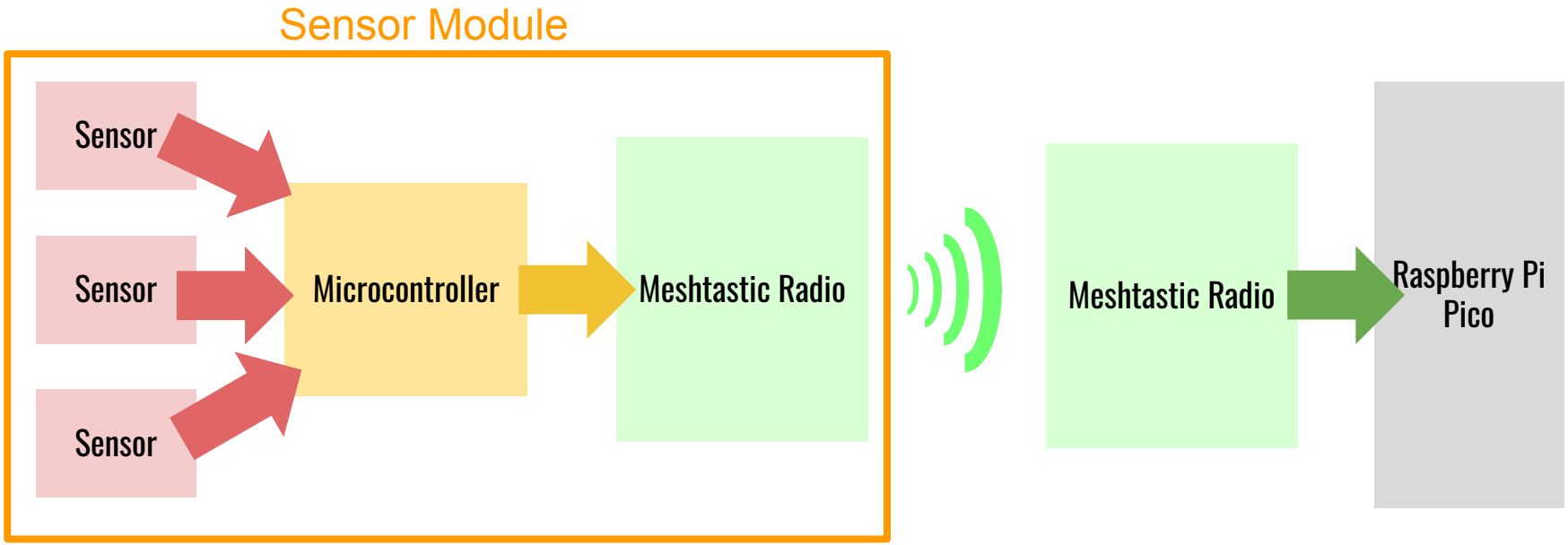
Network topology



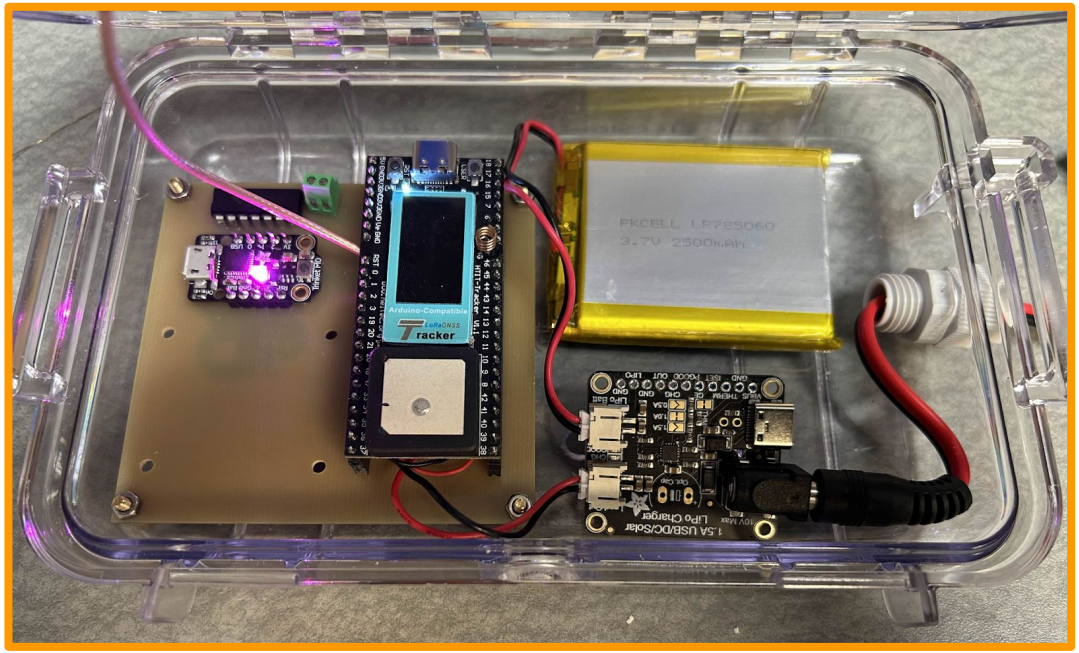
multiprotocol wireless sensor topology for multiparametric measurements (Sensors for Extreme Environments Lab)

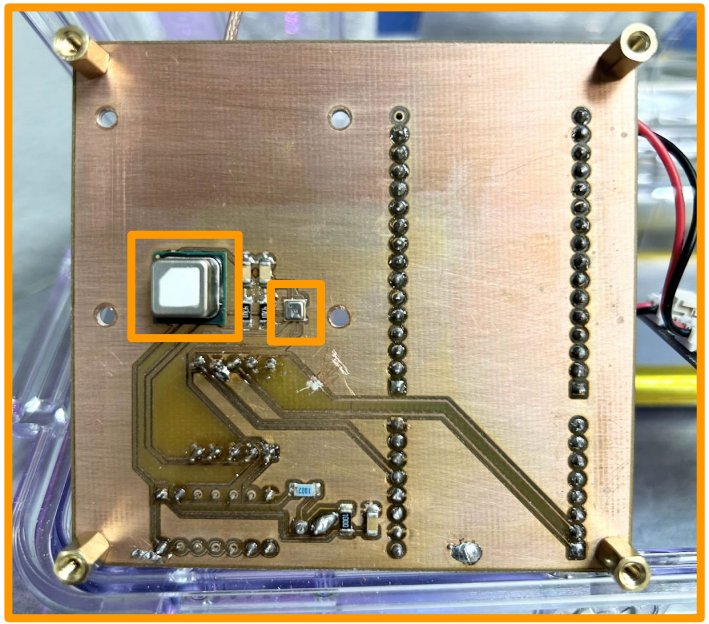

pico-balloon
pico-balloon trajectory
pyroCb
data/
position reports
Meshtastic
(433 MHz)
APRS
(144 MHz)
wildland
fire
APRS igate
Meshtastic
base station

How We're Using Meshtastic

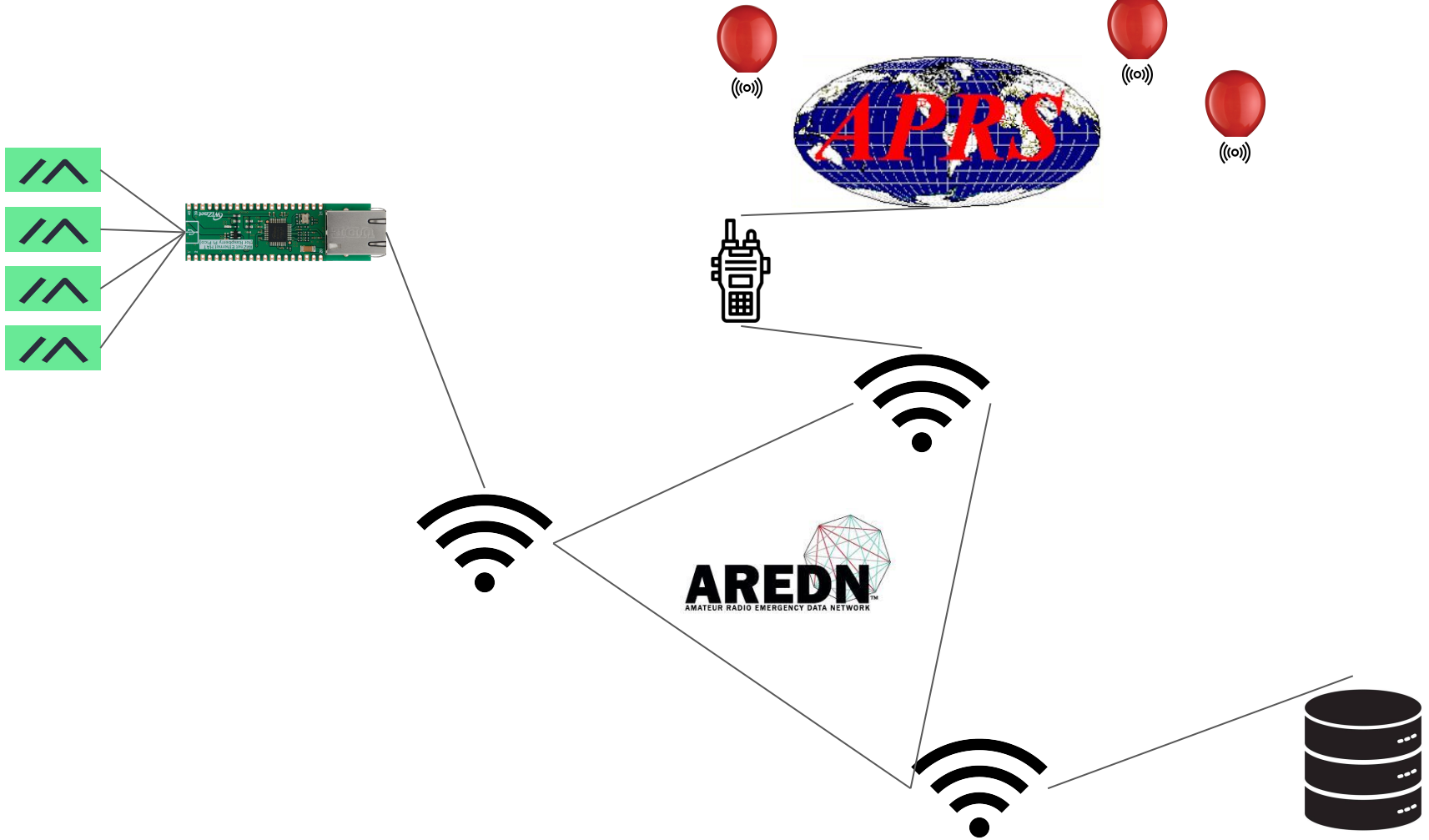


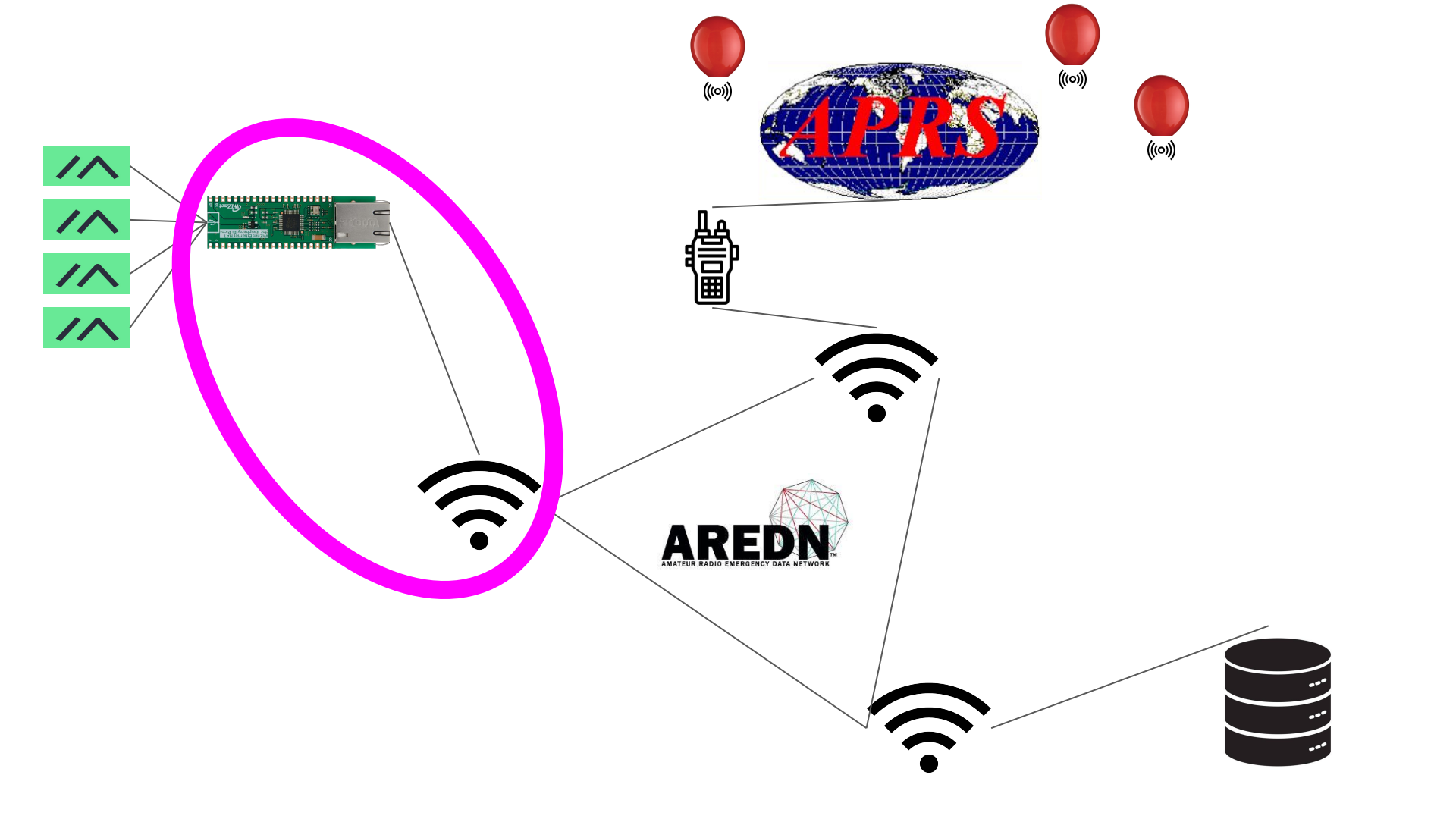
Pictures of Sensor Module





*Sensors are highlighted in orange


APRS
AREDN
AMATEUR RADIO EMERGENCY DATA NETWORK


APRS
AREDN
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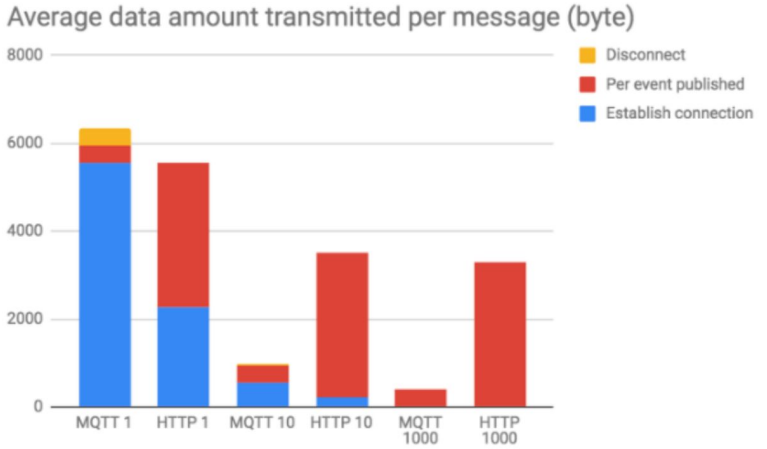
IoT Technologies in Remote Data Collection

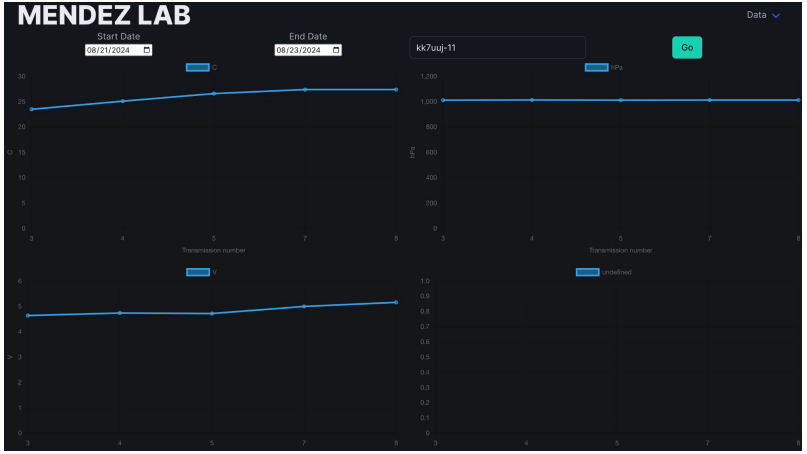
- “MQTT clients are very small, require minimal resources so can be used on small microcontrollers”
- publish/subscribe
- infinitely* scalable
- super low bandwidth
- why not HTTP?



Title: Average data amount transmitted per message (byte)
Source: Google Cloud Blog

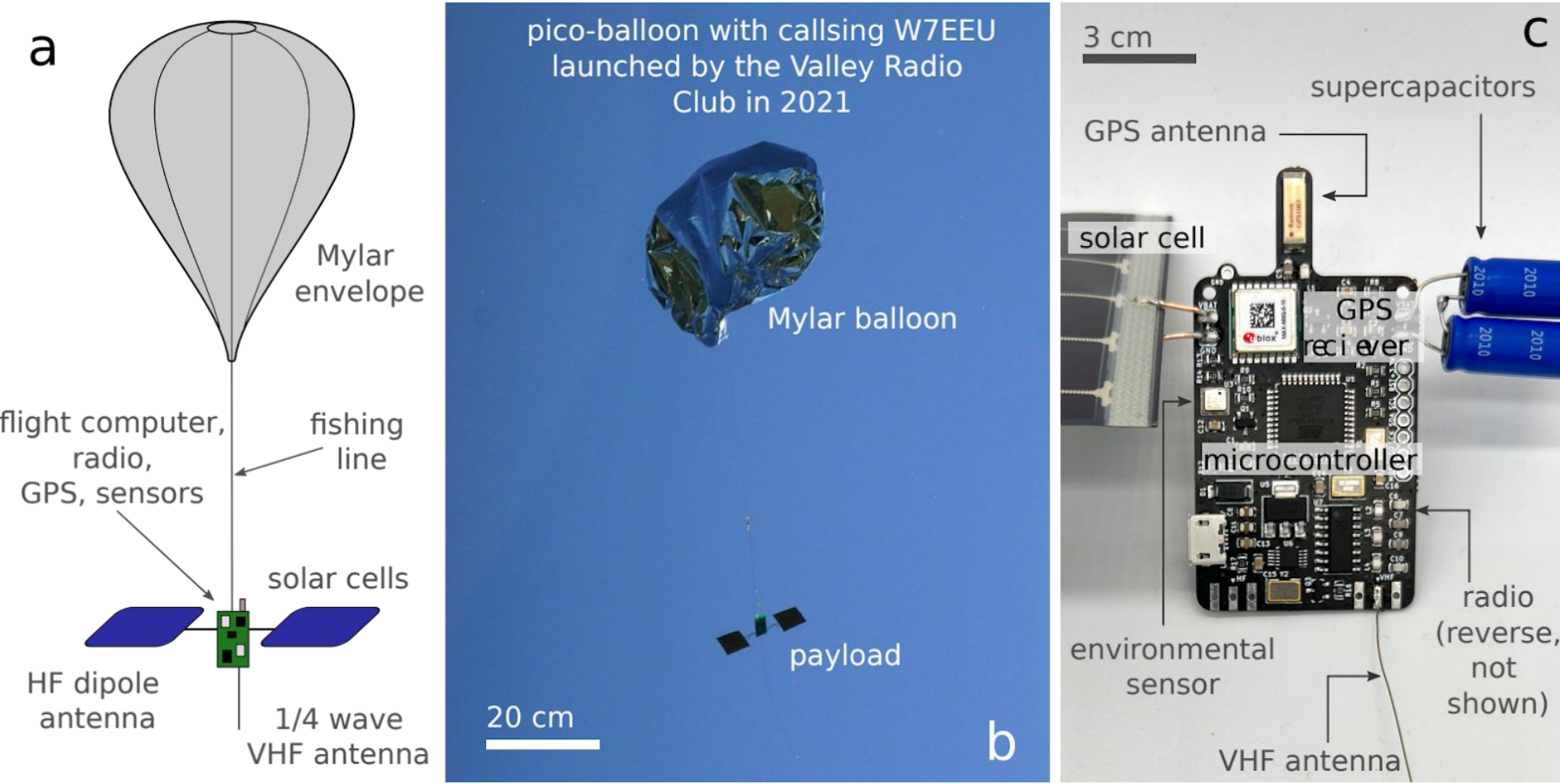
Data Logging

- MQTT → database
- APRS → database
- database → website (AREDN + tunnel)
- real time data logging and visualization



What’s next?

- robustness: enable deployment
- leveraging MQTT two-way communication for on-the-fly changes
  - eg. data sampling rate
- possible alerts: first responders?


a
Mylar envelope
flight computer, radio, GPS, sensors
fishing line
solar cells
HF dipole antenna
1/4 wave VHF antenna
pico-balloon with callsing W7EEU launched by the Valley Radio Club in 2021
Mylar balloon
payload
20 cm
b
3 cm
c
supercapacitors
GPS antenna
solar cell
GPS receiver
microcontroller
radio (reverse, not shown)
environmental sensor
VHF antenna