Frugal IoT - Update - December 2024

Mitra Ardron 11 December 2024

This is the first of what I hope are regular updates on the Frugal IoT project. I'm sending it out to people I've talked to or messaged about the project and feedback is very much welcome. Feel free to add comments or questions.

I apologize in advance if I include too much, or too little, technical detail depending on whether you are an engineer; an NGO with field experience, or a potential funder as I'm just doing one update for all of you !

I started thinking about this project in July 2024 after conversations with a number of NGOs and social enterprises in SE Asia all of which had a similar theme, the need for affordable sensors. The "Internet of Things" (IoT) had fulfilled some of its promise in the west, and even in richer parts of their countries, but not in resource-constrained environments such as smallholder agriculture or value added food production in LMICs (Low & Middle Income Countries).

The solution is to make sensors affordable, not the $200 each commercial ones available in the west, but closer to $20-30. I believe that in order to make that work at scale, it needs to be an Open-Source freely available and modifiable system that is developed in collaboration with organizations who need the functionality, and welcomes other developers to experiment and extend it.

I wrote up the Frugal-IOT concept paper / white-paper in July, and started talking to potential collaborators of various kinds. In six months the project has come a long way, but of course not as far as I'd like.

It has changed a little, but not much. The technical explorations, and conversions with engineers, have confirmed that price points in the low tens of USD are possible, as long as the cost of enclosures, power, and data backhaul can be minimized. Conversations with potential users have confirmed the need, and zeroed in on some very similar requirements.

I've built a framework, and developed enough parts of it that I'm hoping to do some field trials in the second half of January 2025.

Needs assessment

Conversations with NGO's and Social Enterprises have also confirmed the need, and a series of write-ups have been done documenting the needs. For example:

- Magi farm - who run a Black Soldier Fly (food waste to chicken food system)
    - need humidity and temperature monitoring for their distributed mini-farms.
- Kopernik - a design and innovation lab have needs for a number of projects:

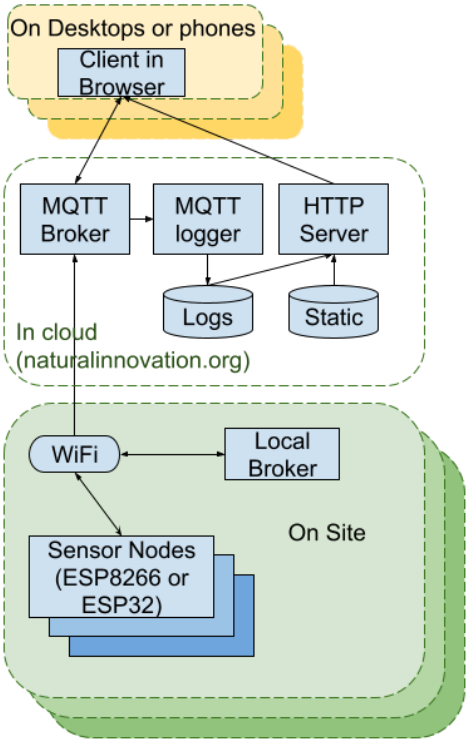
    - Moisture testing for Seaweed farmers
    - Seawater monitors to test waters for suitability for seaweed growing
    - Soil Moisture and ideally NPK for regenerative forestry projects
    - Temperature and humidity for solar dryers
- Rikolto - who support regenerative agroecology need
    - Monitors for piles of fermenting cacao beans
    - Soil moisture and temperature for coffee growing
    - Soil moisture, and ambient temperature / humidity and possibly weather stations for per-urban agriculture.
- Liquify - who build ground water recharge wells need
    - Depth measurement to determine amount of water being recharged
- Anitech - developing sensors for agriculture needs:
    - Soil; storage; transportation and weather sensors that are more affordable so they can support lower income farmers.

Technical development

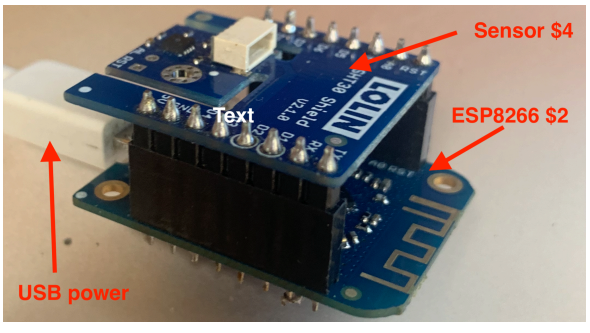
The technology stack is progressed fast - but there is lots more to do.

The basic architecture consists of:

- Affordable **sensor nodes** based on off-the-shelf boards and sensor components.
- Optional **Local hub** so the system can operate when the net is down.
- WiFi, LoRa or cellular **connection** to the internet.
- **MQTT Broker** that can relay large volumes of messages
- **MQTT Logger** that can selectively store data for later analysis
- **HTTP Server** providing access to the Broker (current) and Logger (past) data
- HTML / CSS / Javascript **User interface** that can be viewed on Phone or Desktop browsers.



Going through these elements of the architecture.



Nodes

A framework has been created and tested for the nodes, it is intended to make sensor and actuator development easy.

The framework has been tested on powerful ESP32 (USD $7) and significantly cheaper ($2.00) ESP8266 development boards. A number of sensors have been added to it, including SHT30 ($4) and DHT11 ($2) (Ambient temperature and humidity), It has been tested initially with a basic relay board (under $2) for output.

Simple control code can run on the node, and directly control other nodes, for example when temperature rises in one location, a separate node could turn a relay on to control a fan.

Next Steps:

- Test with standard off the shelf enclosures - such as household plastic storage containers at approx $1 or less each.
- Develop power alternatives - currently it runs on USB but support for batteries is easy on the ESP32 and possible on the ESP8266.
- Add a few more sensors - especially soil moisture & conductivity; depth; and gas sensors (O2 and CO2).
- Run field trials in the second half of January.

It is important to note that making the device affordable means cutting corners, for example, printed cases for a project like this run about $10, while a plastic household box is USD0.50 and common electrical boxes are somewhere in between at $2. Field tests will be essential to find out which corners should be cut. It should be expected that tests will fail - and inform decisions as to where it is worth increasing costs.

Net connection

The test boards run natively on WiFi which will work for some requirements, especially close to habitation. Simple WiFi configuration has been integrated so that field staff can use their phones to configure it.

Next Steps:

- Obtain and test LoRa boards for longer range requirements, especially test the cheaper ones to see if they perform acceptably.
- Obtain and test cellular boards for remote requirements. These can be expensive so need to find a cheap one that actually works well.

Optional Local Hub

This has just been researched, but no development started as its lower priority.

MQTT Broker

Installed and configured on the internet - this is simple enough that we may only need one.

MQTT Logger & HTTP Server

An MQTT Logger has been developed and is working - it records changes for any number of variables that it is configured for. An HTTP server has been integrated with it, to serve up files of logged data, and the HTML, CSS, Javascript. Since all these files are static, it should scale well, but this will need testing and potentially improving.

Everything should work well with multiple servers and loggers and be easily deployed, for example on AWS, so that nobody needs to depend on our development system.

User Interface - HTML / CSS / Javascript.

A user interface has been built, it runs in phone or desktop browsers. It uses static files and connects to the MQTT Broker for current data, so should be light on peoples cellphone data plans. It is very much a work in progress, to test capabilities, but can already display a graphical UI of current sensor readings and control variables on the nodes, and show them on a chart.

Next Steps:

- Complete the chart capabilities which are currently pretty basic.
- Make it look a lot prettier, and in the process easier to navigate
- Add in security functionality to control what data can be viewed and in particular what can be changed.

Demonstrations and participation

All the code is Open Source and on Github and developers are welcome to experiment and build on it. There are currently repositories for the Node, Client, Logger and Server with `README's` that should help developers.

Point a desktop browser at http://naturalinnovation.org:8080 , select the "dev" organization, and "Lotus Ponds" project. Usually I have one or more nodes hooked up, and after a few seconds it will display the sensors and as they change will show current readings. If you click on the graph icon next to one or more sensors it should be graphed. It is not very pretty yet as I have been focused on functionality first.

Since this is my test server, it will be down at times, and may not always have any sensors connected. I'll be happy to schedule a demo if you contact me.

This will be made to work well on mobiles, but for now is mostly tested on desktop.

If you have suitable hardware (e.g ESP8266 or ESP32 development boards), the Github repository has instructions on downloading and flashing the node software to it. Please let

me know if you run into any problems as your participation is also a way to debug the instructions !

The project needs ….

Developers

If you have IoT, C++, Javascript, or hardware skills we could definitely use help. There are a lot of open tasks on the Github repo, but please reach out, and I'll help you through the learning curve.

Potential users

As developers there is simply no way we can quickly learn enough about the specific requirements of for example smallholder farmers in Indonesia to be effective, so a key part of the project design is to always work with the end user/beneficiary indirectly, for example through regenerative agriculture support organizations.

We'd love to talk to more people working in the field, it doesn't have to be agriculture, but it should be something in line with one or other SDG, i.e. improving people's lives in LMICs.

Funders

Currently I (Mitra) have funded it all myself. To purchase different hardware for testing and evaluation. To travel, to run field trials all costs money. Ideally as the project grows, I'd also like to find a community coordinator / developer to manage the development and they will probably need paying. A small grant would go a long way to support this project.

In particular if you are a funder supporting, for example, regenerative agriculture or agro-ecology, we'd like you to consider whether funding a single technology development team would be more cost-effective than funding each of your grantees to develop very similar solutions.

Conclusion

In conclusion - I think we've come a long way in under six months, I look forward to field trials, hopefully next month, and the inevitable (project and technical) redesign that follows such trials. I'd love to hear from any of you that would like to be involved in some way. Please reach out at mitra@mitra.biz or on Whatsapp +15104231767