Kiezbox
Berlins Emergency Wi-Fi Mesh

Jan Knittel - @hbug:matrix.org | knittel[at]mailbox.org

Kiezbox

Kiez

['ki:ts]

"Is a German word for a city neighbourhood, a
relatively small community within a larger town.
The word is mainly used in Berlin and northern Germany."

https://en.wikipedia.org/wiki/Kiez

Box

['bäks]

"Well.."

▓ What?

Berlin wants an emergency network for its citizens in case of blackouts

- Berlins last big power outage was only in 2019
  - it lasted for 31 hours and 31.500 households were affected
- vulnearable people are hit the hardest
  - people with low mobility and/or electronic medical devices
- primary goal is to connect citizens with various emergency services

▓ Why?

In case of blackouts

- emergency services still have some means of communication
  - very long power outage also can affect them
- the citizens are mostly on their own
  - the cellular network only holds battery capacity for a few (2-4) hours
  - still need communication with emergency services, volunteer aid and friends

Who?

Technologiestiftung Berlin - ts.berlin

- publicly funded 2.5 years project (mostly by the state of berlin)
- the foundation is responsible for implementation
- small team and just one developer doing the hardware

Me

- joined janunary this year, one year into the project
- did some work with Freifunk and some other OpenWrt projects
- hardware near programming, until now none for upstream OpenWrt :(
- other embedded (Linux) and security stuff

▓ The Idea

Place devices with Wi-Fi AP at stategic points

- connect them via some kind of mesh network
- equip them with a big battery
- supply them with (solar/wind) power
- put them on stategic roofs around the city
- relay messages from citizens to emergency services
- optionally allow direct communication between citizens

▓ Wait a minute ...

... this just sounds like Freifunk with extra steps

▦ Wait a minute ...

... this just sounds like Freifunk with extra ~~steps~~

▓ Wait a minute ...

... this just sounds like Freifunk with extra **batteries**

... there are some additional and external requirements.

▨ General conditions of the project

Defined in the beginning in agreement with the funders

- develop an emergency communication network for the case of blackouts
- deploy between 12-20 of these devices in a test district
- design to be reproduced in other cities

... what about when there is no emergency

- collect some sensor data when device is not in use
  - like air quality, temperature, noise, wind and rain?

▨ Fixed requirements

The devices

- should have two distinct modes
  - emergency mode
  - default operation mode
  - switch between them in case of an emergency
- as low cost as possible
- easy to reproduce
  - open source hardware and software
  - proper documentation and instructions
- able to be adapted to different conditions
  - partially modular
- low maintenance and setup effort
  - both for software and hardware

▓ **Fixed requirements**

▓ **Emergency Mode**

- Wi-Fi for citizens and emergency services in case of blackouts
  ◦ last at least four days without connection to mains power
- easy interface for citizens to send emergency messages
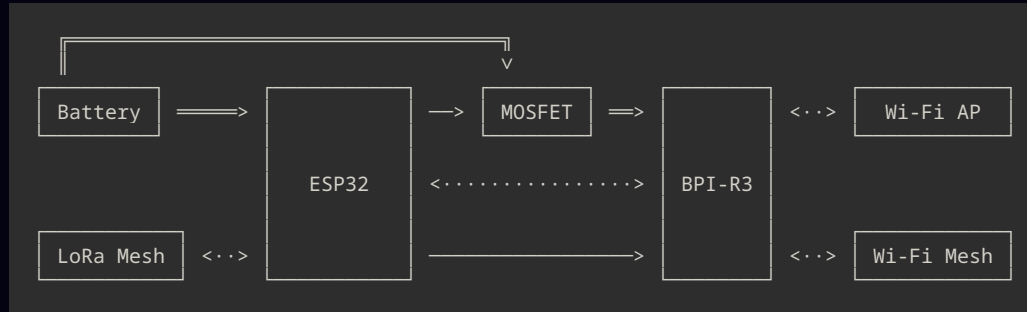
Fixed requirements

Default Mode

- collect sensor data for interested parties
- share the network with interested parties
- dont have negative effects on emergency mode

▦ Current state of hardware

- Banana Pi R3 | CORE
  - Wi-Fi Mesh @2.4GHz
    - multiple directional antennas
    - not @5GHz because 802.11s clashes with DFS
  - emergency Wi-Fi AP @both
- esp32 | OOB
  - does the LoRa Mesh
  - handles mode selection
  - switches power to the CORE
  - collects sensor and system health data

Simplified schematic:

```
        ┌─────────────────────────────────────┐
        │                                   v
  ┌───────────┐        ┌─────────┐    ┌─────────┐        ┌─────────┐   <···>   ┌───────────┐
  │  Battery  │ ═══>   │         │ ─> │ MOSFET  │ ═══>   │         │           │  Wi-Fi AP │
  └───────────┘        │  ESP32  │    └─────────┘        │ BPI-R3  │           └───────────┘
                       │         │ <················>    │         │
  ┌───────────┐        │         │                       │         │   <···>   ┌───────────┐
  │ LoRa Mesh │ <···>  │         │ ──────────────────>   │         │           │ Wi-Fi Mesh│
  └───────────┘        └─────────┘                       └─────────┘           └───────────┘
```

Labels: `==` > power `--` > control `..` > communication

▨ **Current state of software**

- custom OpenWrt image
- some project specific packages
  - mostly just initializing the devices (via uci-defaults)
- some image specific config files
  - configure e.g. the main SSID, districts, devices and device password
- mostly stateless
  - there is only one image
    - containing the config for every device
  - sysupgrades doesn't need to keep any config/data
  - fallback autoconfiguration for 'unknown' devices
- many things are work in progress
- ... and also subject to change

Current state of the network

- 802.11s for mesh
- segmented network by district
  - badman-adv for mesh on layer 2
  - works fine on the small test network
- currently evaluating routing on layer 3
  - babel seems promising in tests
- main goals
  - keep complexity low
  - small set of stable features and services

▓▓ Current cost of hardware

Material for a small quantity prototype, purchased in germany

```
bpi-r3              120 Euro
antennas (3+1)      120 Euro
AGM Battery 100Ah   120 Euro
solar (100-150W)    100 Euro
MPPT + cable         80 Euro
esp32 + pcb          20 Euro
lora + antenna       20 Euro
misc electonics      70 Euro
outdoor casing       30 Euro

total               680 Euro
```

▓▓ Possible additional costs ...

- roof mounting hardware ~350 Euro ... because german laws
- legal contracts ~?
- more sensors ~?
- transport costs ~?

Next steps

- finalize network structure
- additional quality and throughput tests
- include some monitoring and admin interface
- include a stable A/B update mechanism
- improve and automate build and infrastructure
- a lot more ... 1 year left
- release source and docs

Open questions

- Which firmware/library for LoRa mesh ?
- What p2p messaging could we use ?
- Is building directly on OpenWrt the right approach ?
  - base it on gluon and modify that ?
- What other problems do you see ?
- Ideas for applications of default mode ?

- Are there still questions ?

... or even better

- Answers ?

Thats it ...

🟩 Stuff

project website - german only :/	slides	presenterm

```
ping -c 3 -p $(echo "Hi there (:" | xxd -p) nsa.gov
```