Gluing the IoT world with Java and LoRaWAN

The SkopjePulse.mk case

Panche Chavkovski

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netcetera

Who am I?

Panche Chavkovski

Senior Software Engineer @ netcetera
jug.mk Leader
Codefu.mk administrator
Hardware & IoT enthusiast
TTN SK Initiator

http://pance.mk/ and @hsilomedus

SkopjePulse

Problems

- **extreme air pollution**
- Excessive urban noise
- Flash floods

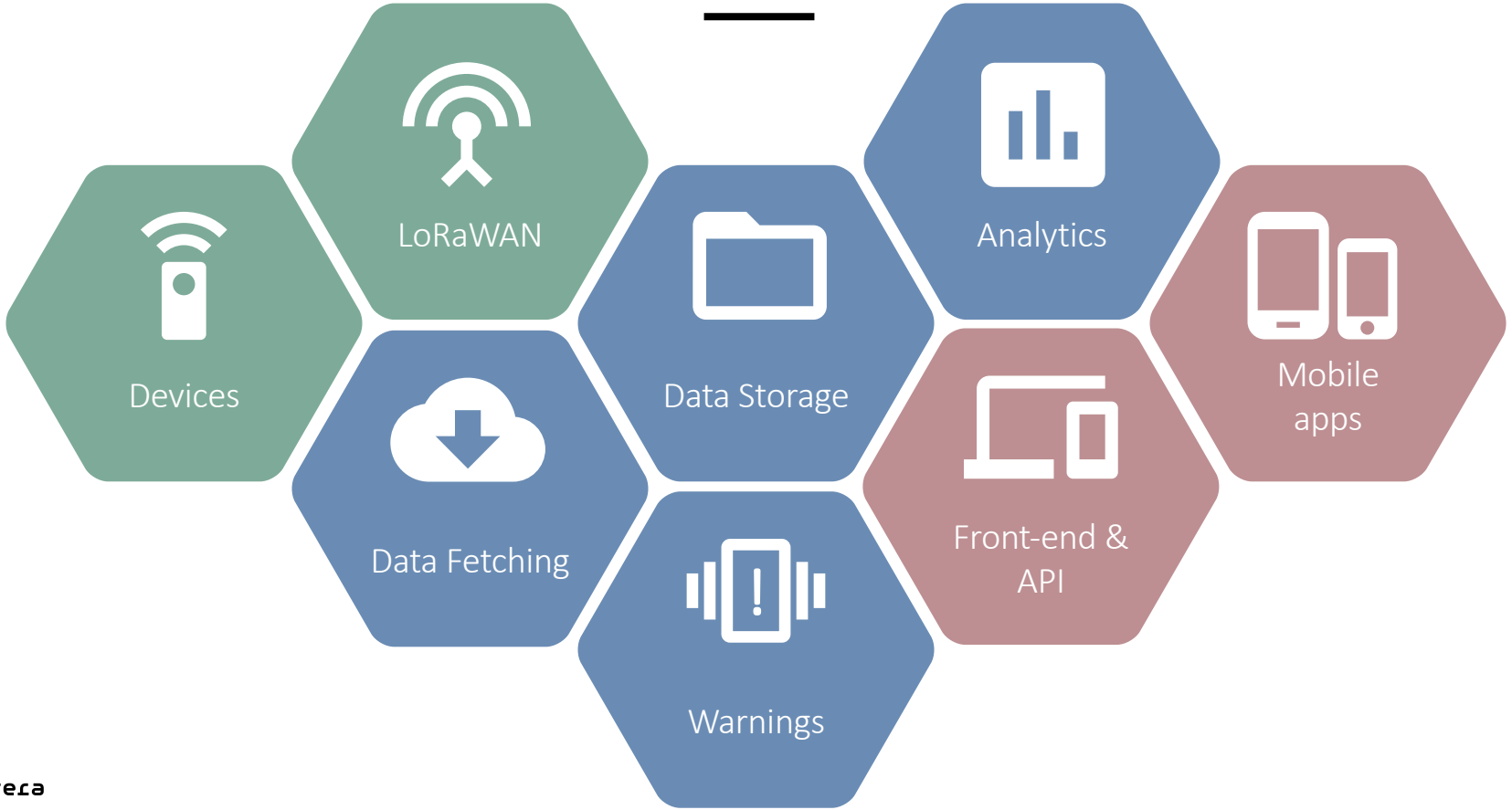
No clear means for improvement

Solution

- Leverage technology
- Crowd-sourced sensor network
- Data analysis and availability
- Warnings
- Clearer insights
- Data-driven basis for action

https://skopjepulse.mk/faq

System overview



LoRaWAN

LoRa & LoRaWAN

Long **Ra**nge

- Based on FSK & CSS, multiple channels
- Low Power
- Low Cost
- Long range
- Free ISM bands: 433, **868**, 915 MHz
- Proprietary by Semtech

Long **Ra**nge **W**ide **A**rea **N**etwork

- MAC layer on top of LoRa
- IoT communication standard

- Standardized stack
- Driven by LoRa Alliance

Features


Fully bi-directional
Easy commisioning
Network scalability
End-to-end security
Built-in positioning

Limitations

Low speed (default BW)

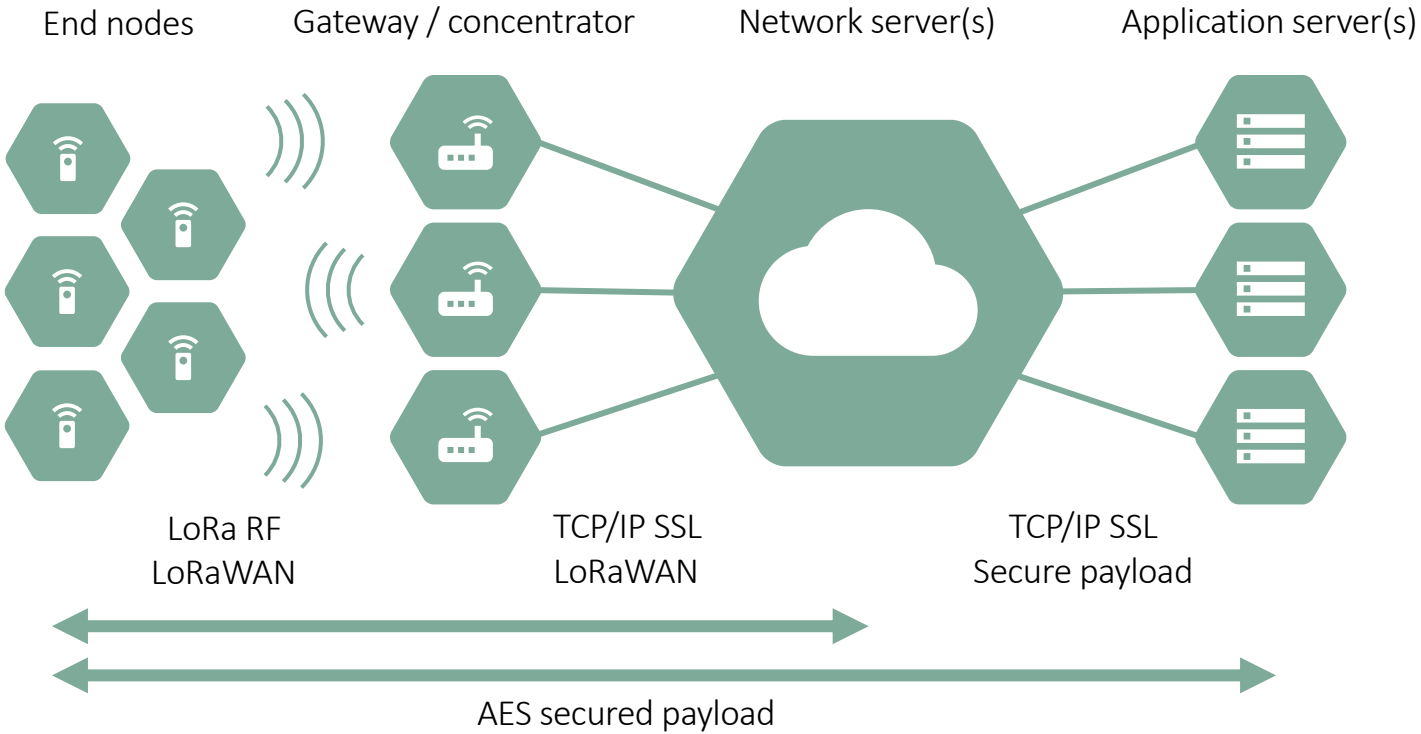
- SF12: 250bps with the farthest distance and the longest air-time
- SF7: 5470bps with the shortest distance and the shortest air-time

Small package sizes: ~1-20bytes

Less frequent

- 2-200 uplinks per day
- 1-10 downlinks per day

LoRaWAN architecture



LoRaWAN devices

Different classes

- **Class A**, rare async devices (current): one uplink with two downlink windows
- Class B, always on, timed: beacon downlink windows
- Class C, always on, always listening.

Network sign on:

- Over The Air Authorization (OTAA): App EUI and Key
- Authorization By Personalization (ABP): App / Network keys and Device address

TheThingsNetwork

Global, crowdsourced Internet Of Things data network

- Community driven with local initiators and teams
- Provided network and back-end
- Free for fair use
- Can be elevated to SLA (private – public partnership)
- Multiple integration options
- LoRaWAN as base technology

https://www.thethingsnetwork.org/

How to use TTN

Registration

https://console.thethingsnetwork.org/

- Applications
- Devices
- Keys, UIDs, Credentials

Integrations

- MQTT
- HTTP
- Data storage
- Amazon AWS
- Cayenne
- EVRYTHNG

Devices

The start up kit

Microchip RN2483 (LoRaWAN stack)

RFM95W (LoRa transceiver)

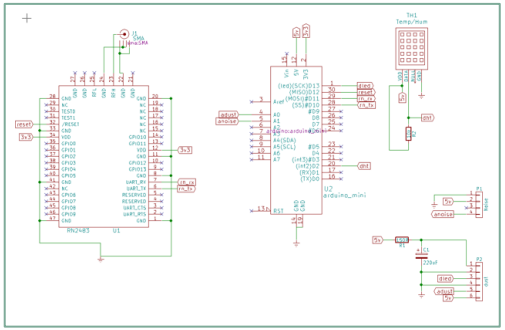
Arduino (MCU)

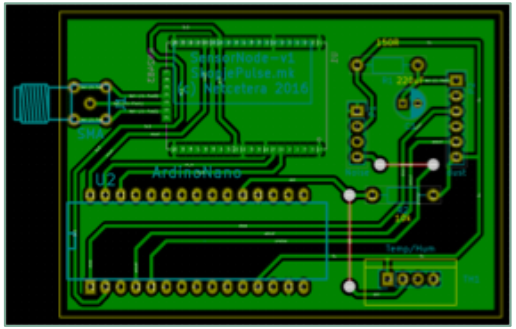
KiCad

El. Design & PCB CAD Software

KiCAD usage

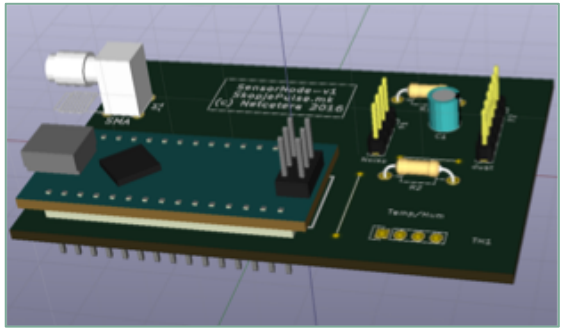
Scheme design





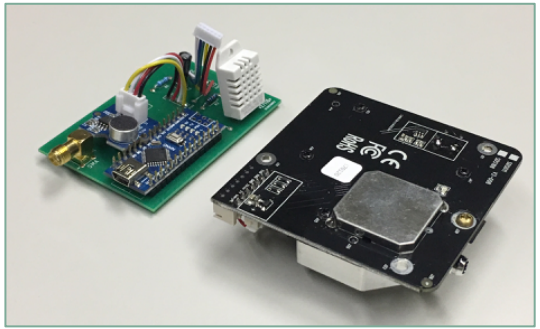
PCB design

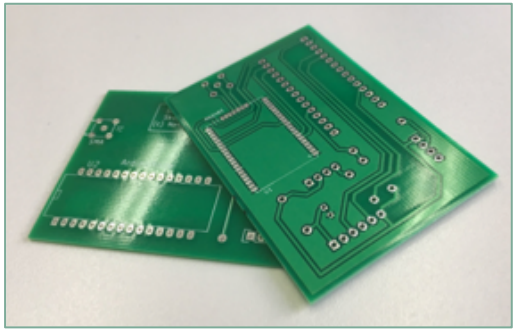
3D render and gerbers



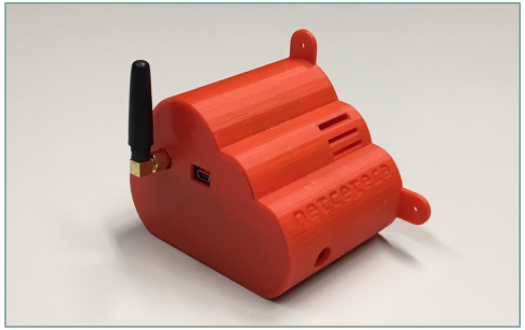
Assembly

Solder and connect





PCB fabrication



3D printed enclosure

Make it work

Code

- Arduino or other embedded code
- Restricted environment
  - 32KB flash
  - 2KB RAM
  - 16MHz CPU
- Perpetual non-observed execution

Beware

- Select and inspect used sensors
- Test and / or calibrate
- Check for factory defects
- Plan for hardware wear-out and lifespan
- Don’t assume anything

System design

Rules to go by

Decouple

- Data transceiver
- Data Store
- Web and API
- Analytics & processing

Aim for and produce

- Robustness
- Scaling
- Fallbacks
- Data sanity

Our approach

SpringBoot framework

- Self contained web server / application
- Modular
- Starter packs for needed spring pieces
- Less configuration, more conventions
- Light(er)weight
- Container and orchestrator friendly (Cloud native)

Data fetching

Communication first!

(almost) No overhead

- Use binary protocols if possible
- Always on connection
  - reconnect fast
  - plan for fallback

React first, store later!

Get closer to the data source.

Our approach

TheThingsNetwork MQTT Integration

Spring Boot + Eclipse Paho client + Gson

- *@Component* client implementing *MqttCallback*
- Connect in *@PostConstruct*
- *@Scheduled(fixedrate = …)* watchdog *@Component*

Details on MQTT URL, credentials and message formats:
https://www.thethingsnetwork.org/docs/applications/mqtt/api.html

Data storage

IoT data

IoT data is almost always impartial and time-series based

Use data store that is designed for sorted time-series

- Utilize recent data caches or TTLs
- Don’t hold on redundancies
- Always just append data
- Never aggregate, but process and store
- Design to live with eventual consistency

Our approach

Cassandra DB 3.7

Spring Boot + Cassandra Driver Core + Extras

- Cassandra *Cluster* wrapped in *@Service*
- *InstantCodec* for java.time interoperability
- *QueryBuilder*
- No data filtering.

* spring-data-cassandra seemed like a poor choice.

Analytics

Averaging data

Situation

- A lot of (impartial) data
- Observed system load
- Possible downtime
- Retroactivity

Our approach

- Side-running SpringBoot microservice
- Runs a few times a day
- Checks first
- Calculates last two days, week and month
- Uses intermediary data
- Uses simple heuristic

Warnings

Early warning system

Keep a track on what's happening

- Periodically fetch the recent data
- Analyze, produce and save current state
- Notify if the state has changed significantly
- Don't spam
- Periodically cleanup

Our approach: **SpringBoot + SpringSocial + Firebase**

Front-end & API

Provide and visualize the data

Interactive cockpit and data explorers

- **D3js** client side visualizations
- **Leaflet.js** + **OpenStreetMap** (+ **Stamen designs**)

Provide open to use API

- **SpringBoot** + **SpringMVC** + **SpringSecurity**
- Set rules to avoid easy DOS
- Log usage
- Circuit breakers

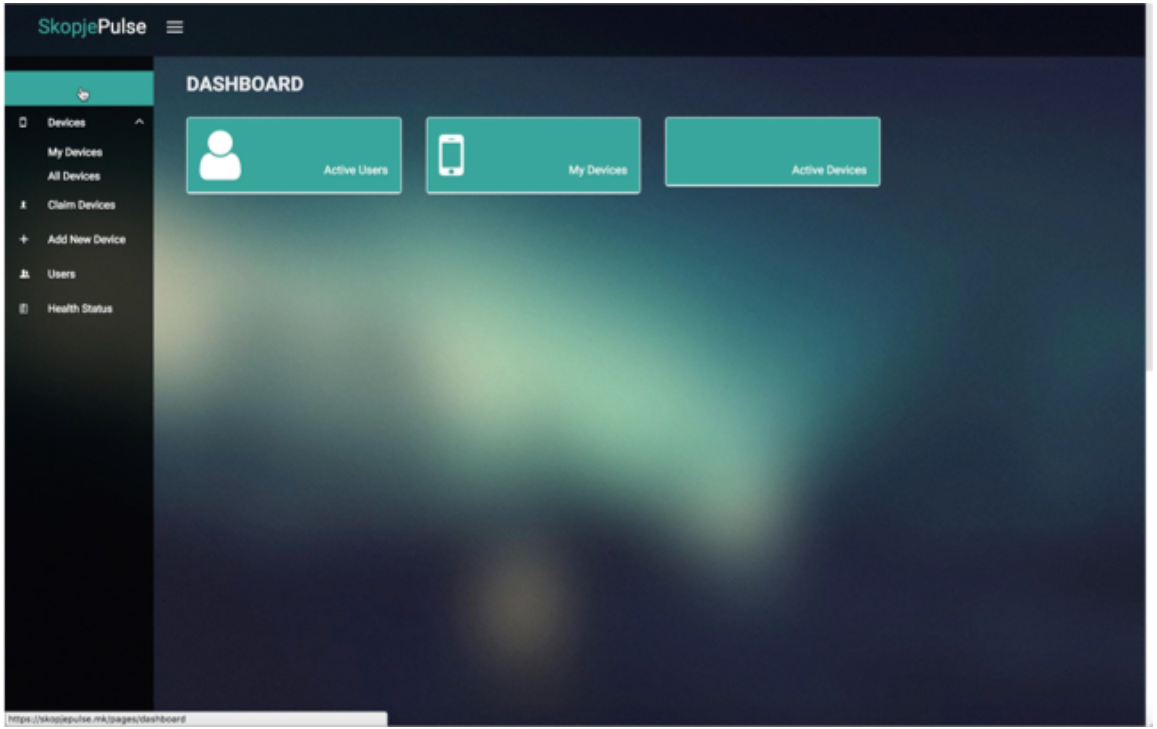
https://skopjepulse.mk/new

Control the system

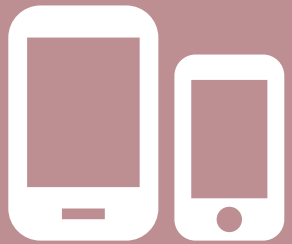
SPA for device and user management

- **Angular2**
- **ng2-admin**

System health dashboard



Mobile apps



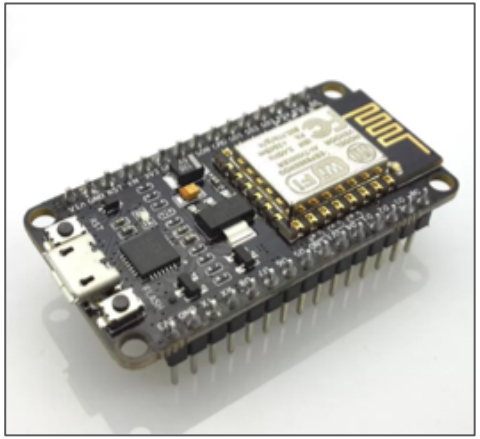
Native Android and iOS apps

Extras

WiFi devices

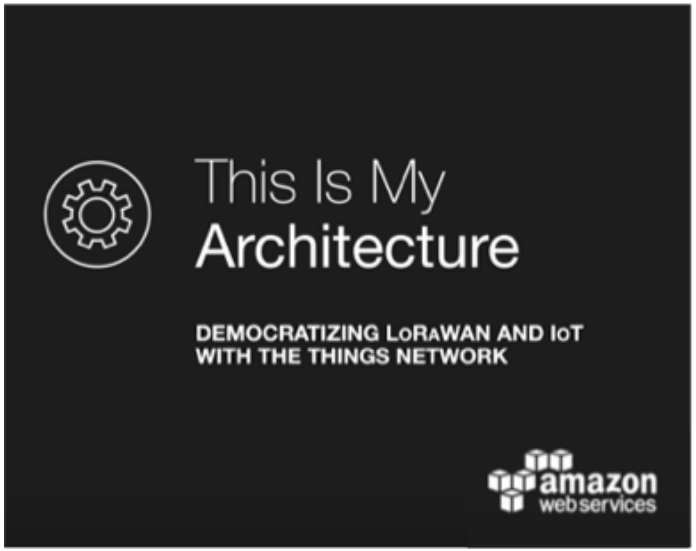
Where you ***really*** can’t do LoRaWAN

- ESP8266 powered device
- HTTPS communication
- provision device address securely
- implement own address -> key mapping



More: http://pance.mk/index.php/securing-esp8266-communication/

AWS This is my architecture



http://tiny.cc/awsttn

Discussion

Thank you

https://skopjepulse.mk/

https://www.netcetera.com/home/stories/expertise/20170203-SkopjePulse-IoT.html

https://thethingsnetwork.org/

https://console.thethingsnetwork.org/

http://kicad-pcb.org/

https://www.thethingsnetwork.org/docs/applications/mqtt/api.html

http://tiny.cc/awsttn