JouKo – Design Principles and System Architecture

21.11.18

JouKo = Flexible Power Usage at Home,

FlexHomeElPower

Design Principles

- It is easy to connect a JouKo device in between two 3-phase and 5-wire electric lines to any dry room at home.
- The relatively recent European 3-phase lines have 5 pieces of 2.5 mm2 copper conductors : phase 1-3 , Protective Earth (PE) and Zero/ Neutral.
- The PE line must be led reliably and without additional resistance through JouKo and fulfill the Electrical Safety regulations.
- The electrician must be able to screw 10 pieces of conductors endings to JouKo. It must not be possible to draw the lines loose and the connection must withstand bendings. It must be easy to attach JouKo on a wall.
- JouKo devices of a home connect cybersecurely to the data cloud with one radio. JouKo can switch on and off remotely one 3-phase line with a max. current of 16 A each phase.
- After a power shortage JouKo restarts automatically. JouKo withstands the most common levels of overvoltage spikes on the power lines , caused by lightnings.
- If there are two JouKos, they can exchange information wirelessly. JouKo can measure the 3 powers (in Watts) flowing through it as averages of 5 minute intervals.
- There has to be economical (low cost) JouKo alternatives. The monthly radio network cost must be low.

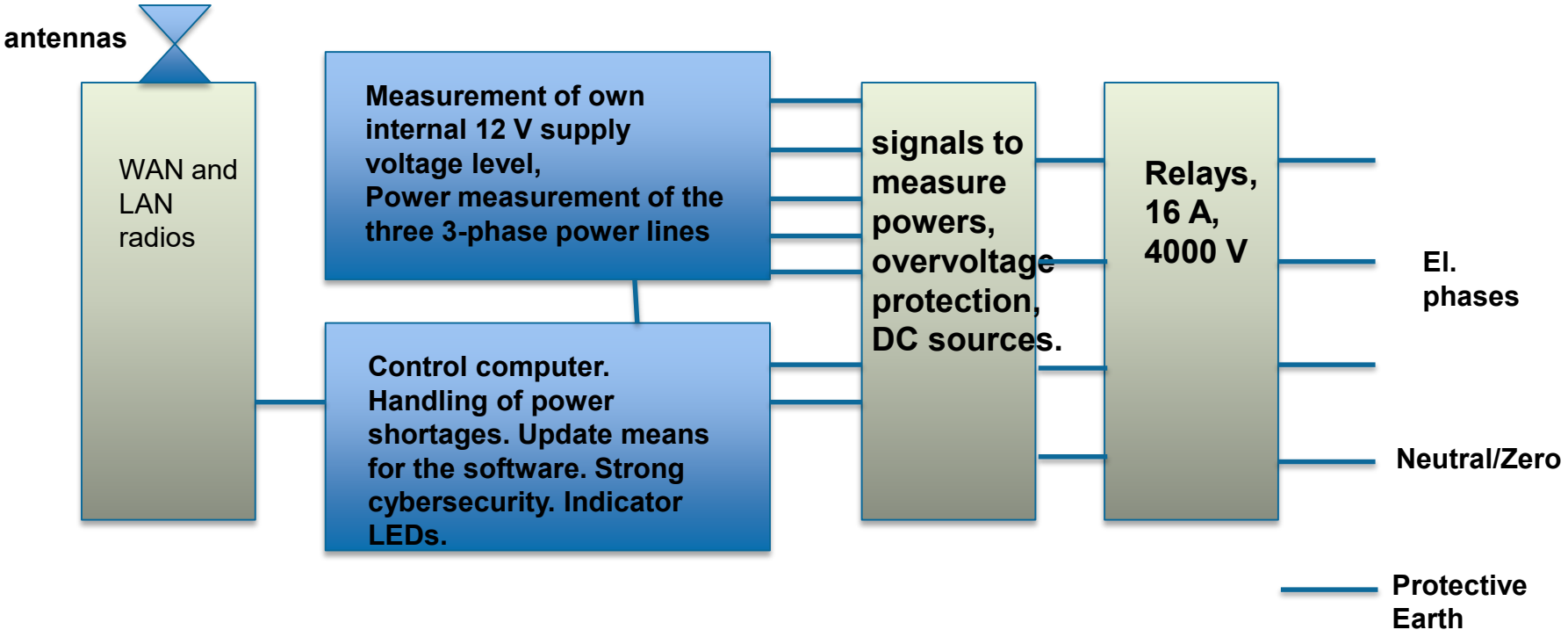
Radio tests before deciding the schematics

- The project performed transmission tests at our Mikkeli University campus and in open outdoors.
- Of low capacity IoT radio networks we tested the LoRaWAN (one partner operates a network in Finland). The monthly fee is around 0.7 Euros.
- Because the geographical coverage of LoRaWAN is under 100%, the natural network for the countryside usage was GSM. We found a low cost GSM 2G radio modem.
- Just before the project Bluetooth had specified the BT5 with an enhanced range. It has been achieved by reducing speed, and by signal processing. The modern BT versions are cybersecure.
- Another modern and rather cybersecure radio is ZigBee. We did not however encounter high enough cybersecurity measures in the low cost 434 or 867 MHz license free radios.
- We performed quantitative transmission tests with LoRaWAN, BT4, BT5 and ZigBee. The characteristics of the GSM 2G modules were known beforehand.

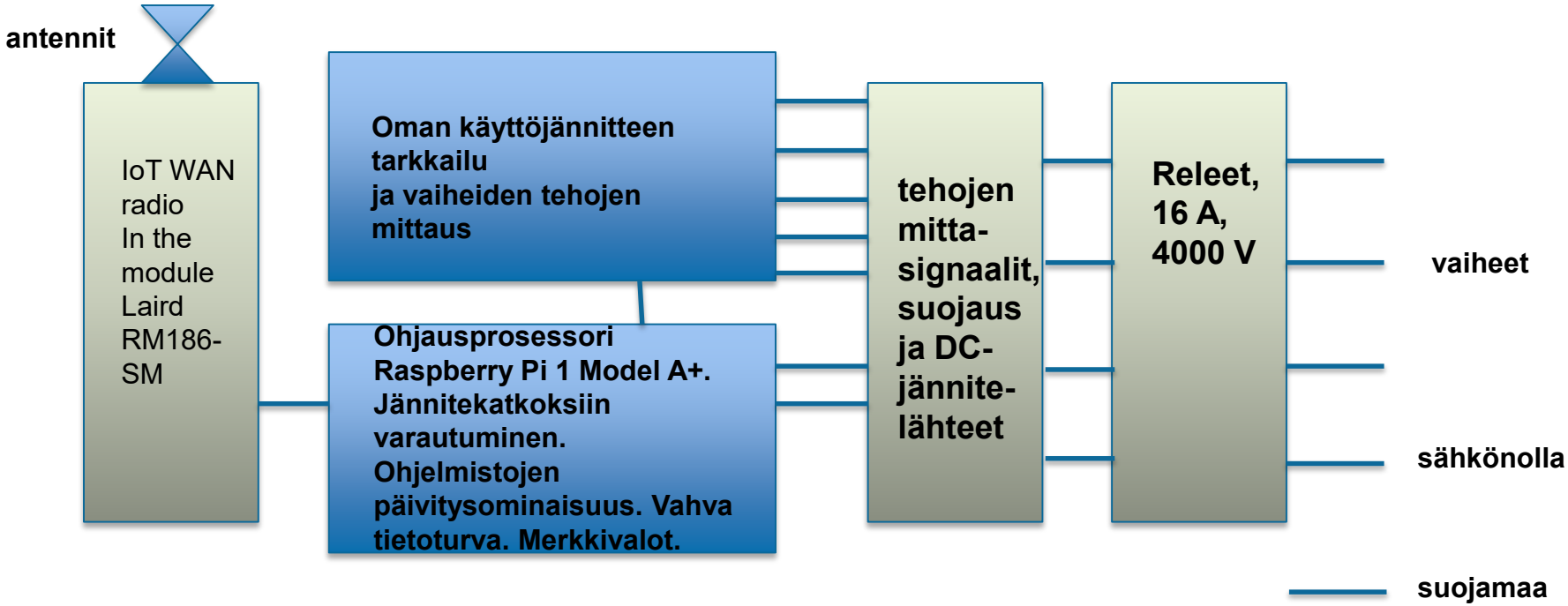
Radio test results

- The BT5 tests were performed with Nordic Semic DevKits. We achieved a range of 252 m in a disturbance free open space. BT5 beat ZigBee in range. When there were also WLAN signals present, we achieved 185 m with BT5 in an open space. We selected BT5 and ZigBee became a backup technology. In buildings with conductors the ranges drop. We studied WLAN network planning methods that work also with BT. During the project the BT specs were updated and enable now a third station in between to go around large conductors.
- From a light wooden house to another one we measured a range of 17 m with BT5.
- Seven different test environments emulating home environments were realised at the campus.
- We used a portable LoRaWAN base station. LoRaWAN performed fine with all 7 test environments. In extreme situations the LoRaWAN signal was 17 dB smaller than the thermal noise. This demonstrates the successfull design of the spread spectrum signals. We believe that from inside typical buildings (with door and window openings) LoRaWAN works to 5 km from a base station that has a proper outdoors antenna and when the base station is situated relatively high. The frequency is 867 MHz in Europe.
- GSM generation 2 has signals at under 1.9 GHz. Coverage to buildings is good.

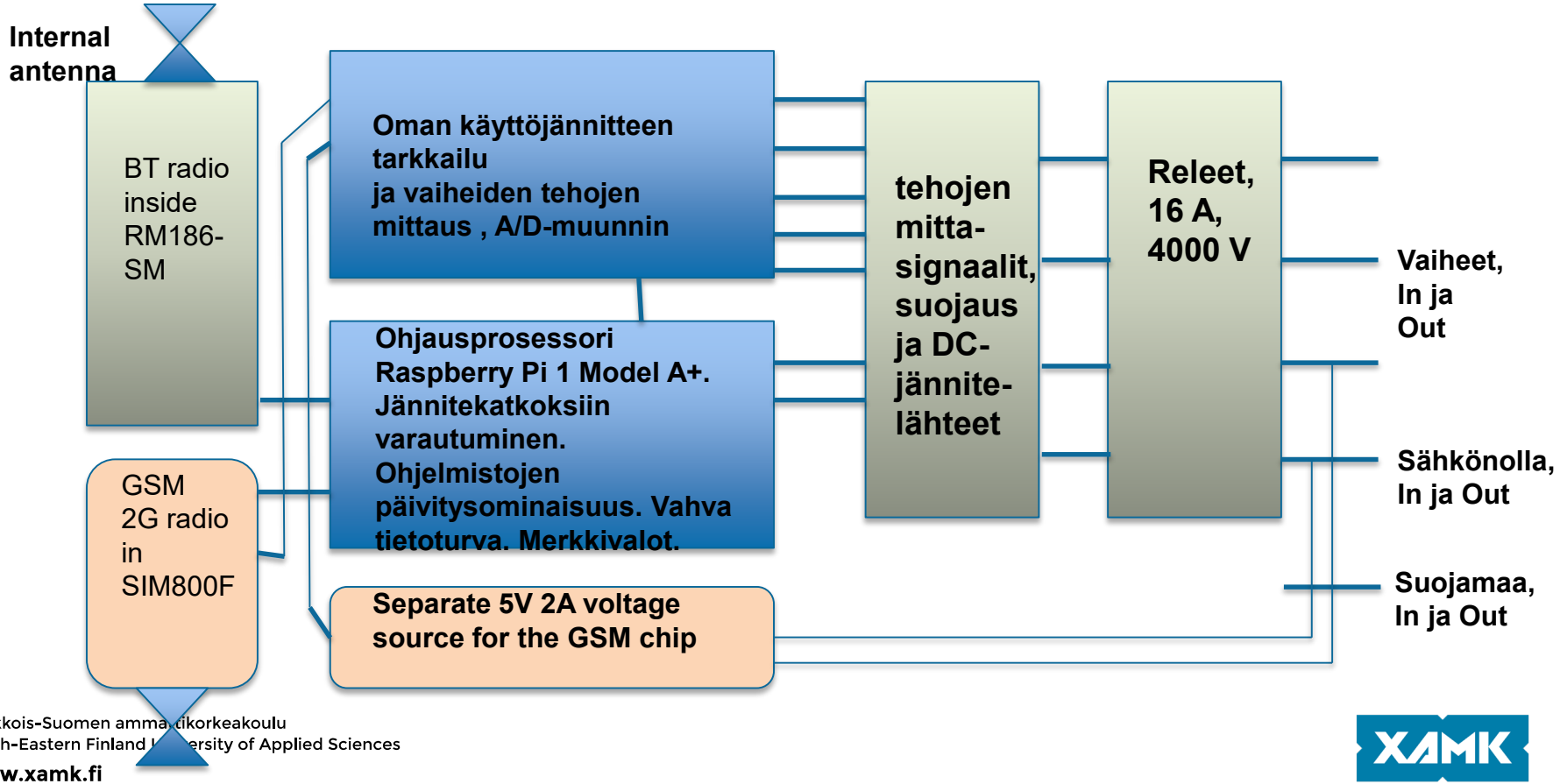
Generic architecture



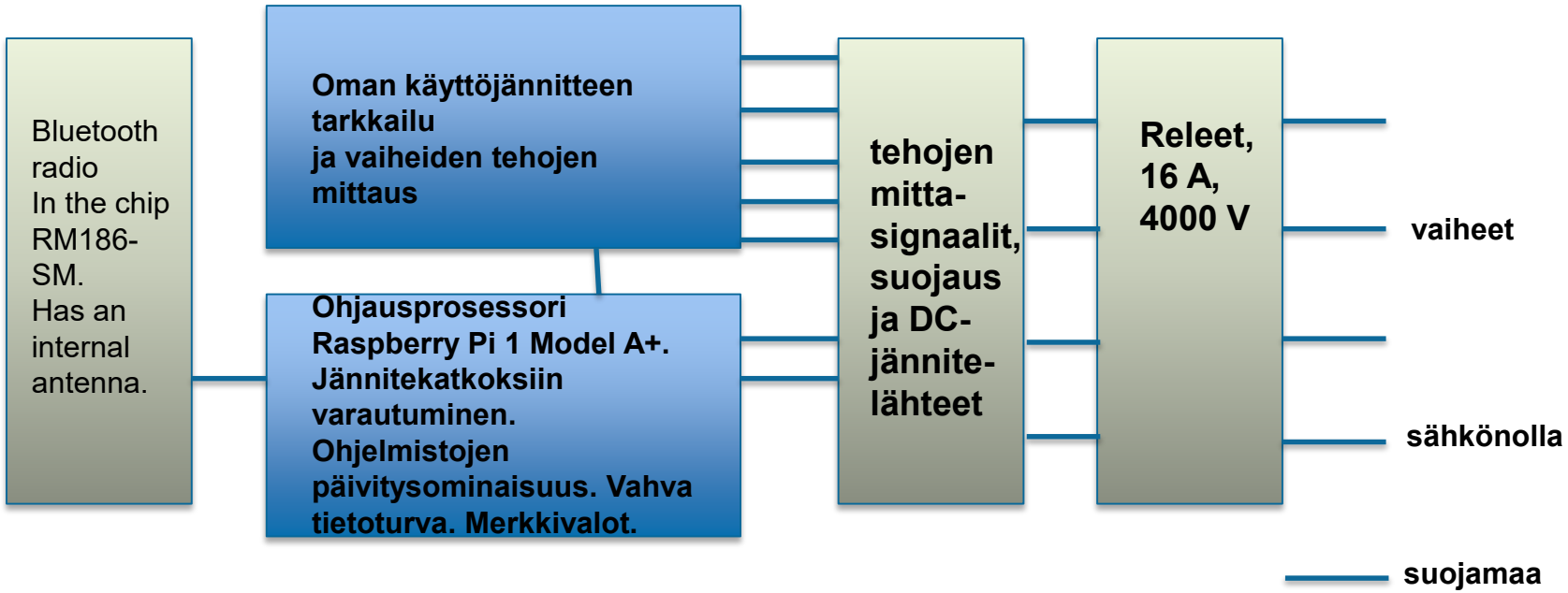
City device , to LoRaWAN networks



JouKo Countryside Central device to the GSM 2G (GPRS)



Countryside Switcher (BT slave) , communicates with the Control device



Solutions minimizing the cost

- All versions utilise the 15 Euro (100 pieces) radio module Laird RM186-SM which contains the level U.S. Secret encryption engine. It has a LoRaWAN radio and a Bluetooth radio with an internal antenna and is programmed with an extended Basic programming language.
- All versions utilise the 18 Euro Linux computer board Raspberry Pi 1 Model A+. Also Raspberry Zero works if You can buy them in quantities. The development was made faster by the USB and HDMI connectors.
- All versions use the same printed circuit board. When the version is the Coutryside Control unit , You just solder in also the GSM 2G chip and add a separate 5V voltage source inside the enclosure. A fast acting current limiter is also added.
- The switch for updating the Linux applications SD card (Raspberry switch) is a low current type.
- The printed circuit board fits into the 10 Euro enclosure from Hammond. Our prototypes used a slightly larger box.

* The assembly work to a house is extremely fast.

Tunne huominen – All for the future.