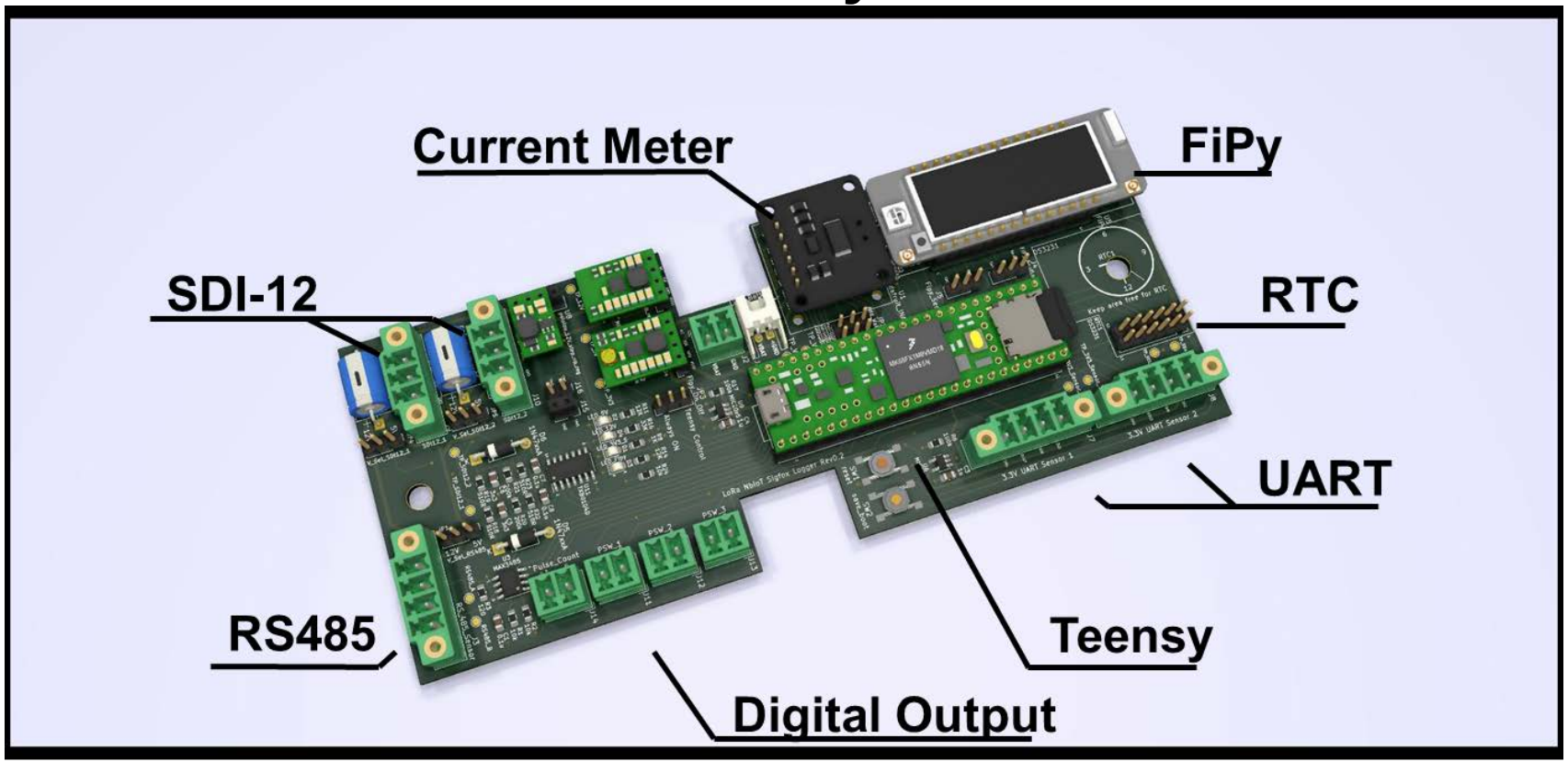
Microcontrollers beyond Arduino: a stationary and a mobile environmental monitoring system

Daniel Beiter, Tobias Vetter, Markus Morgner, Carlo Seehaus, Stephan Schröder, and Theresa Blume

Microcontrollers

- Advancements in electronics driven by automotive, mobile and IoT applications led to the development of very powerful, small and low power microcontrollers.
- This is why we decided to leave the realms of ATMega 8-bit systems (such as Arduino) and move towards ARM Cortex 32-bit systems.

Microcontrollers beyond Arduino



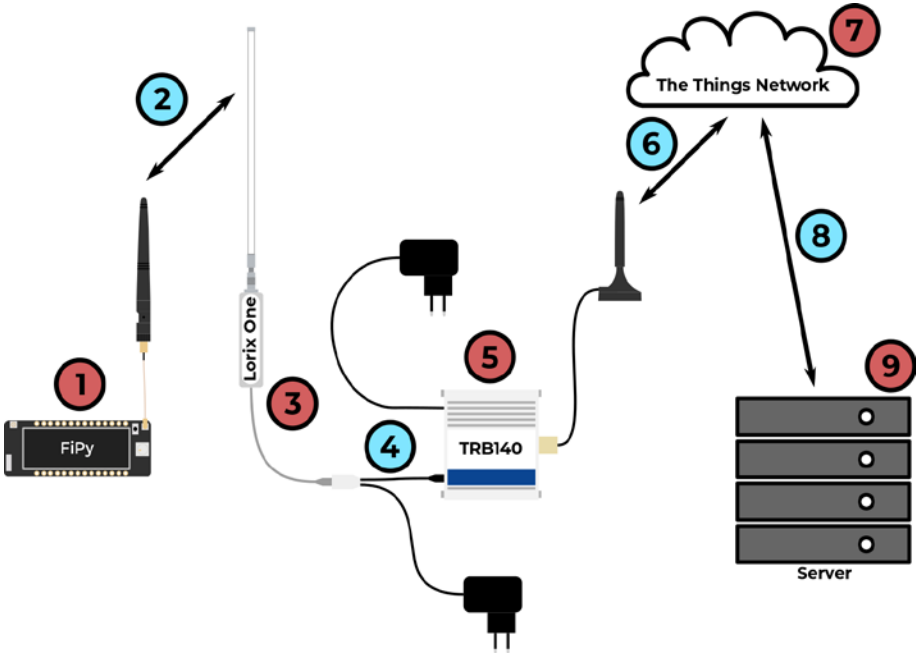
Specifications

	Arduino Uno	Teensy 3.5
Processor	AVR ATmega328P (8 bit)	Arm Cortex M4F (32bit)
Clock	16 MHz	120 MHz (variable)
Flash	32 KB	512 KB
RAM	2 KB	256 KB
Digital IO	14 Pins	58 Pins
Interrupts	2 Pins	58 Pins
UARTS	1	6
I2C	1	3
Consumption	~35mA	~ 1mA/MHz

	FiPy
Processor	Xtensa LX6 (32 bit)
Flash	8 MB
RAM	520 KB + 4 MB
Digital IO	22 Pins
Interrupts	2 Pins
UARTS	2
I2C	1
Wireless Interfaces	Bluetooth, WiFi, Sigfox, LoRaWAN, LTE CAT NB1/M1
Consumption	~380mA (LTE)

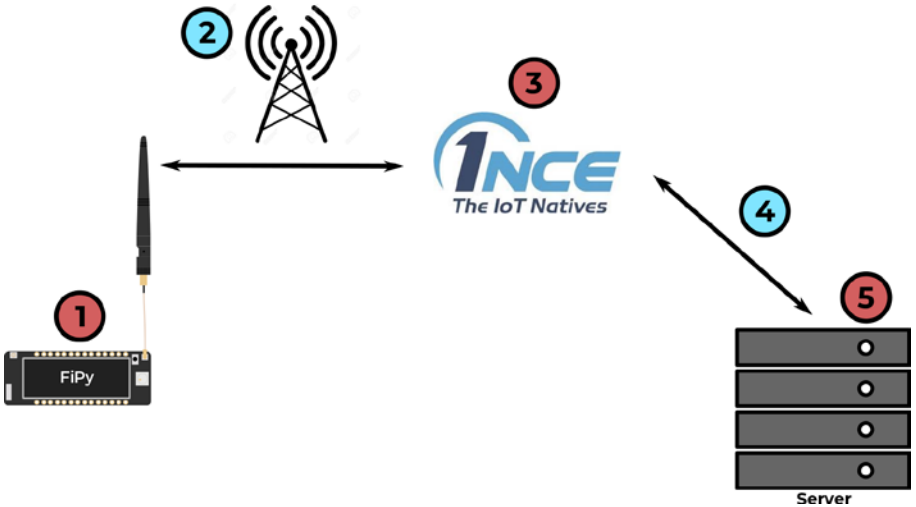
Remote Data Transmission

LoRaWAN Ecosystem



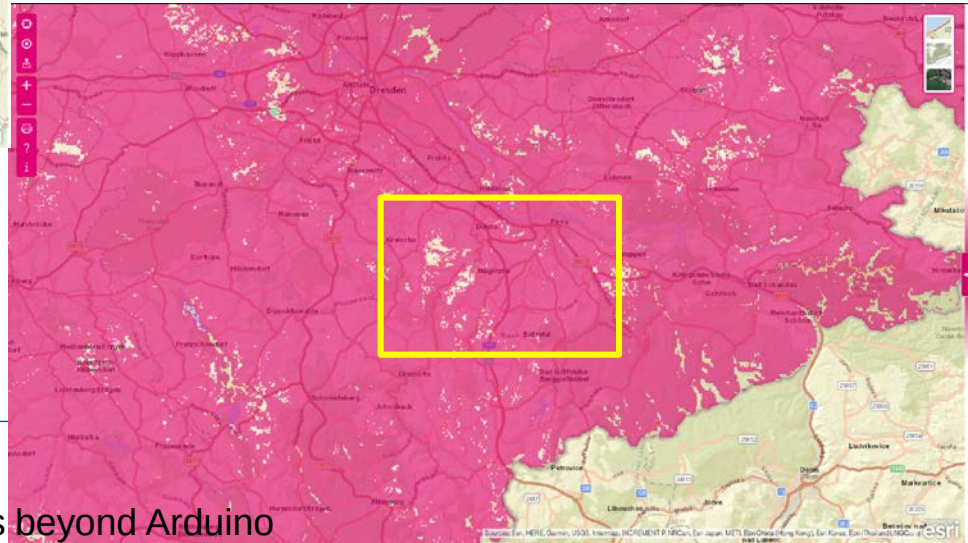
1. **FiPy – LoRa-Node:** has LoRa capability and provides the interface between the device and the LoRaWAN network
2. **LoRa radio:** the transmission standard that allows long range communication with low power consumption for the node
3. **Lorix One – LoRa-Gateway:** forwards all received LoRa transmissions to a specific target (or vice-versa)
4. **Ethernet:** connects the LoRa-Gateway with the mobile network gateway
5. **TRB140 – mobile network gateway:** forwards all received packages to the specified target (or vice-versa)
6. **Mobile network:** establishes the connection to the internet
7. **The Things Network – IoT Platform:** serves as target for the LoRa transmissions
8. **Internet :** Message Queuing Telemetry Transport (MQTT)
9. **Server – Data Storage:** Running MQTT Client (Python)

LTE CAT-NB1 Ecosystem

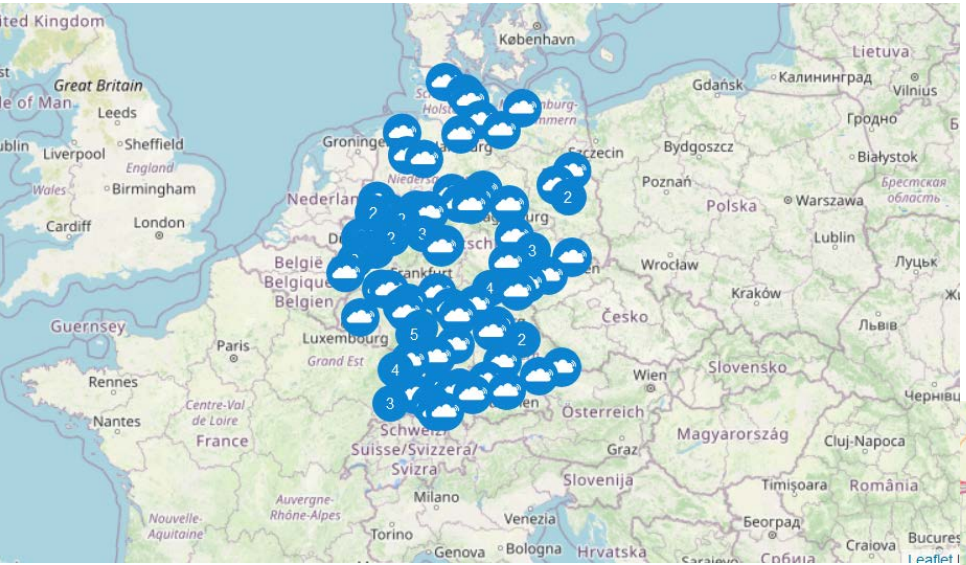


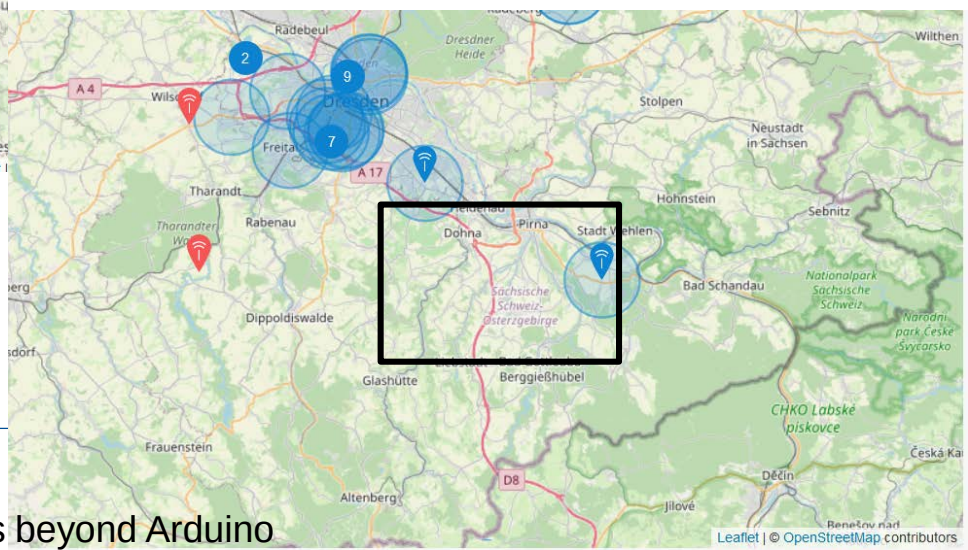
1. **FiPy – LTE CAT NB1:** provides the interface between the device and the mobile network (not to confuse with LTE)
2. **Mobile network:** Direct connection to provider via mobile network base stations
3. **LTE CAT NB1 provider:** runs servers to receive and forward data to customer
4. **Virtual Private Network:** VPN that allows the server to be in the same network as the device; maintained by the provider
5. **Server – Data Storage:** Running TCP or UDP server to send and receive data (Python)

LTE CAT-NB1 Coverage (Telekom)



The Things Network Coverage (Community)





Lessons learned

- ARM 32-bit Microcontrollers (Teensy) are worthy successors of AVR Atmega328 (Arduino Uno)
- Breaking up modules allows for better performance and control (signal routing and power consumption)
- LTE (CAT1 NB1) is preferable to LoRaWAN if coverage can be guaranteed.