Low-Power Wide Area Networks for IoT.

A LoRa pilot network for smart agriculture.

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April 8, 2017

Ladies first

- You can chat: hangout -> rt.laplante -> /bot eguz

IoT Drivers

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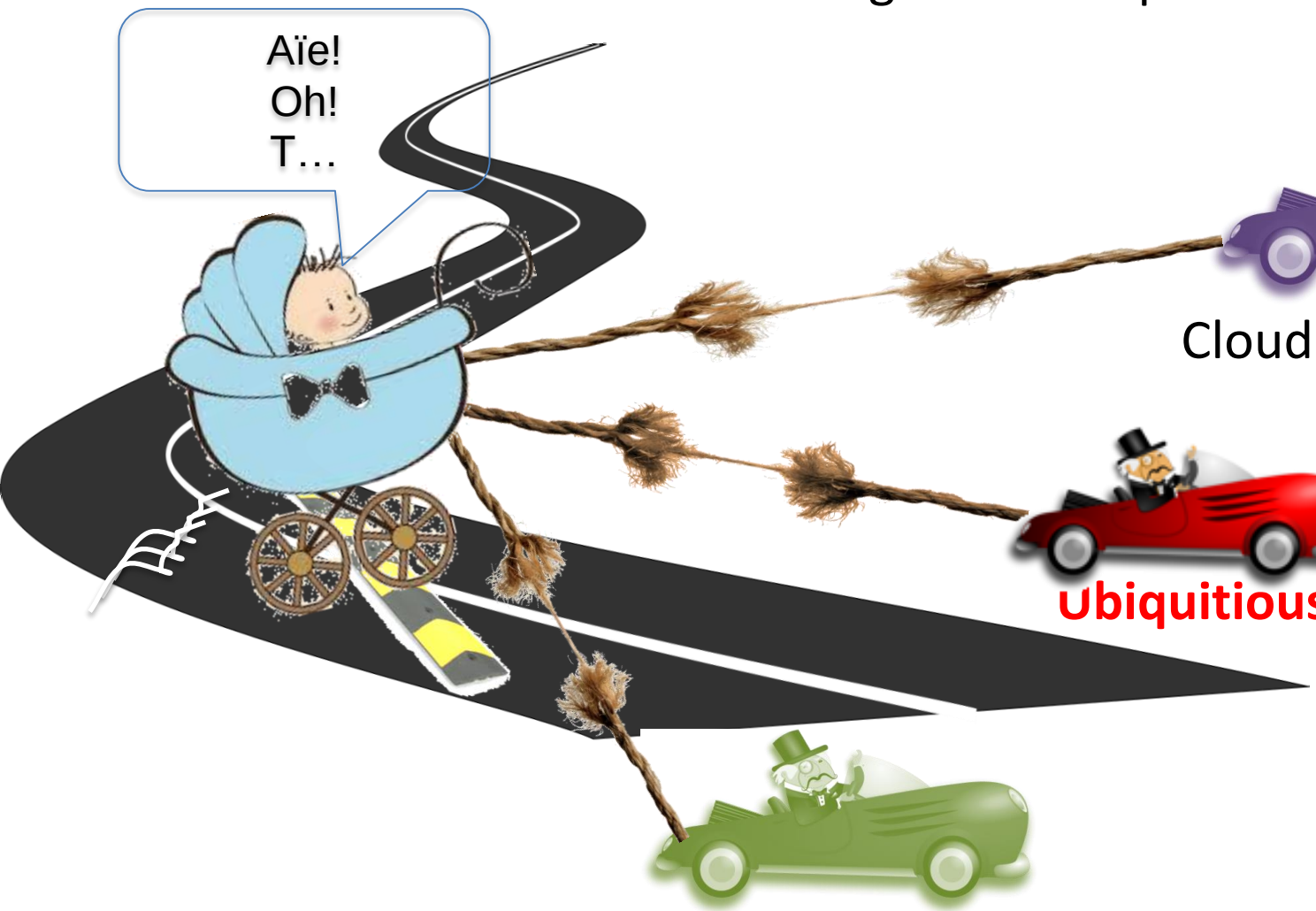

Cloud - Data analytics

Ubiquitious connectivity

Miniaturization -
Computer Economics

IoT architecture

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Physical Realm

Connectivity

virtual Realm

Sensor

Actuator

Node

Network

Data storage

Network

Data analytics
(Visualization, forecast, Decision making, etc.)

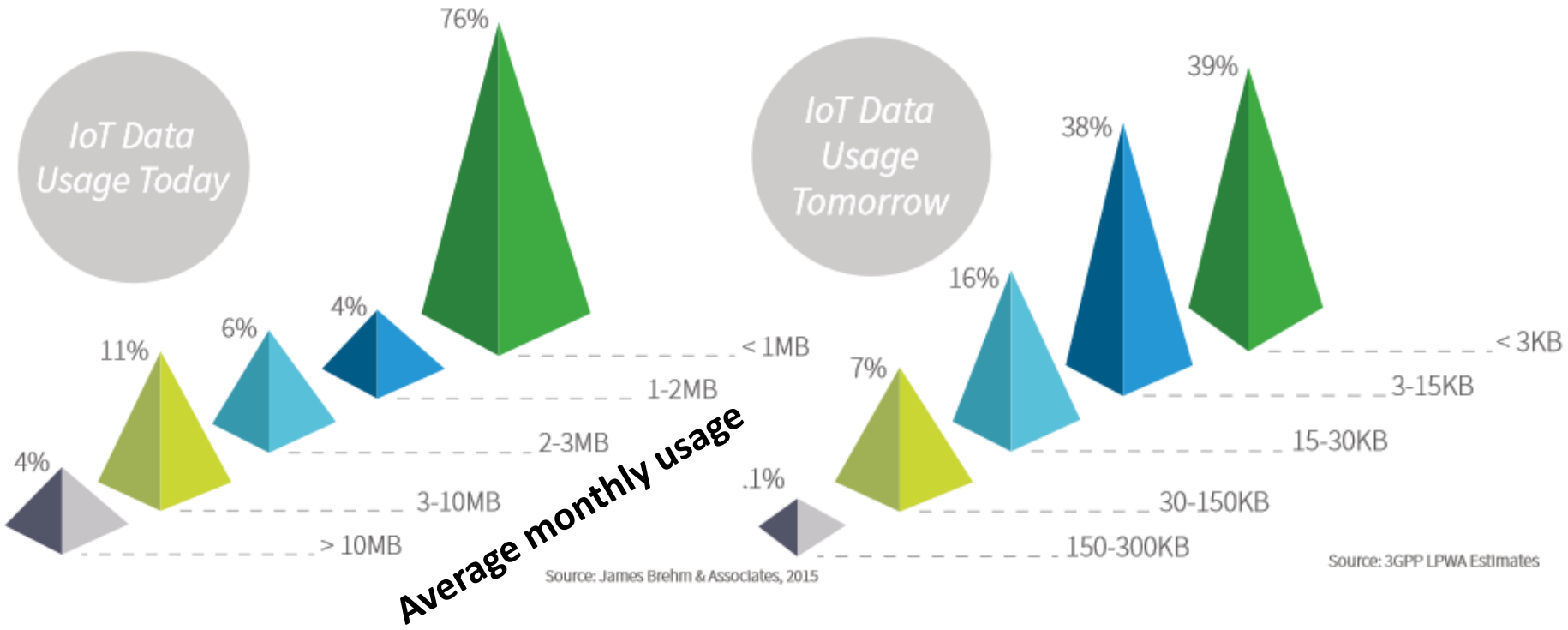
Electronics, mechanics, control, embedded systems…

???

cloud services, statistics, big data, data mining, App dev, …

Connectivity constraints: IoT data usage

- How to bring the Internet to the physical objects?
- Existing technologies?
  - It is no more about throughput



Connectivity constraints: New context and challenges

- **Difficult physical accessibility and limited access to power sources**
  - **Wireless required**
  - **Need for autonomy and long battery life operation**
- **Wide area coverage with a large number of communicating objects**
  - **Scalable technology**
  - **Cost efficiency**
- **Very loose bandwidth and latency requirements**
  - **Adapt radio and access mechanisms accordingly**

Existing wireless solutions

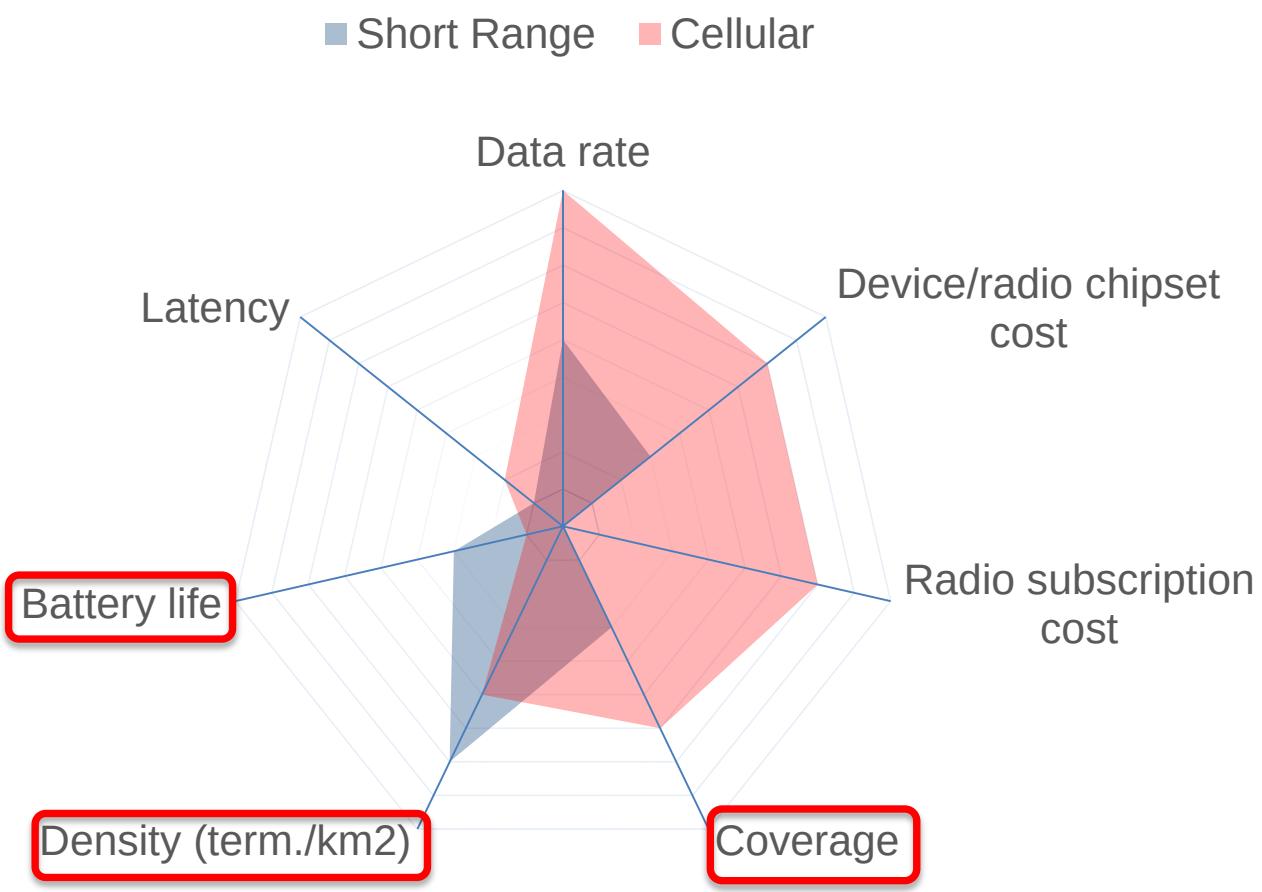
Short range

- Standard:
  - RFID,
  - NFC,
  - IEEE 802.15.4 family (ZigBee, 6LoPAN),
  - IEEE 802.11
- Proprietary:
  - Z-Wave,
  - CSRMesh

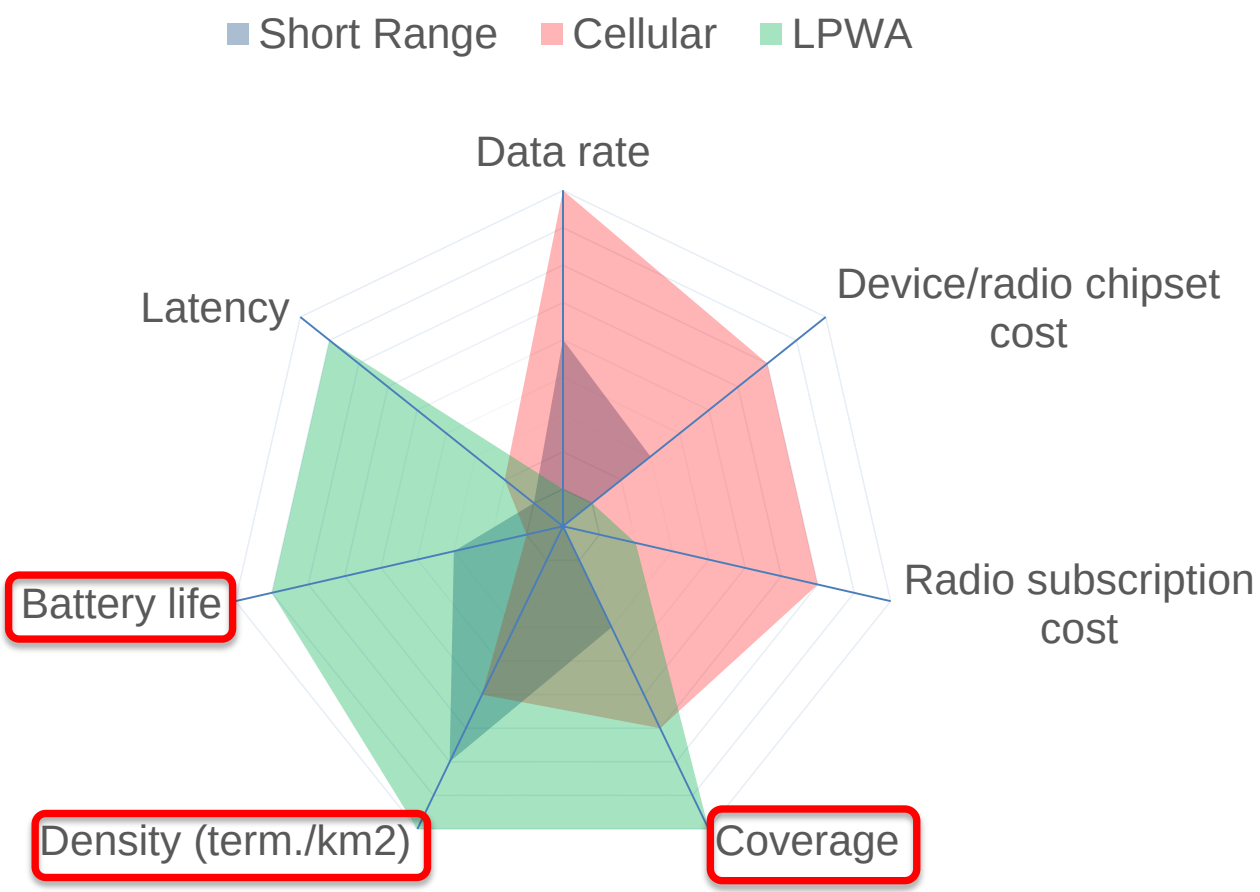
Cellular

- 2/3/4G

Existing wireless solutions



LPWA (Low Power Wide Area) niche



LPWA characteristics

- **Trade off between data rate and LPWA capabilities**
- **High Coverage range due to high sensitivity**
  - Bluetooth: -90 dBm
  - ZigBee: -120 dBm
  - LPWAN: < -140dBm
- **Uplink > downlink**
- **Cellular architecture similar to xG**
  - ~ Star topology with radio gateways as BSs
    - Tens of gateways to cover a city (10 for Amsterdam, 300 planned for Lebanon)
  - ~ Gateways act like (GGSN) bridging of wireless to IP core.
  - Lighter management
- **Suitable for services with relatively low ARPU**

LPWA technologies

	LoRa	sigfox	INGENU	NB-IoT 3GPP
Freq. bands (MHz)	169, 433, 915, 868	868(EU), 902(NA)	2400	2G & LTE
Bandwidth (kHz)	EU: 8x125	0.1/0.6	40x1 MHz	200KHz
ISM band	✓	✓	✓	×
Duty cycle (%)	0.1 or 1	0.1 or 1	×	×
Bi-directional	✓	✓	×	✓
TX up (dBm)	EU: 14	EU: 14	20	23
Modulation up	CSS/FSK	DBPSK	RPMA	QPSK
Data rate up (kbps)	0.3-37.5	0.1/0.6	0.01-8	65Kbps
Latency (duty cycle)	s	s		<10s
Nodes/BS up	1M	1M	100k	50k
Range (km)	2-15	10-50	15	15
Deployment	Private/MO	SIGFOX		MO
Certification	LoRaWAN	SIGFOX	INGENU	3GPP

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LPWA technologies usage

- **11% of IoT connections in 2025 will use LPWA connections such as Sigfox, LoRa and LTE-NB1 (Machina Research, August 2016)**

Local Area Network Short Range Communication	**Low Power Wide Area** (LPWAN) Internet of Things	**Cellular Network** Traditional M2M
40%	**45%**	**15%**
Well established standards In building	Low power consumption Low cost Positioning	Existing coverage High data rate
Battery Live Provisioning Network cost & dependencies	High data rate Emerging standards	Autonomy Total cost of ownership

LoRaWAN Alliance

- **LPWAN in Lebanon**
  - OGERO planning to launch LoRa
  - Operators waiting for NB-IoT

LISA: Long-range IoT for Smar Agriculture

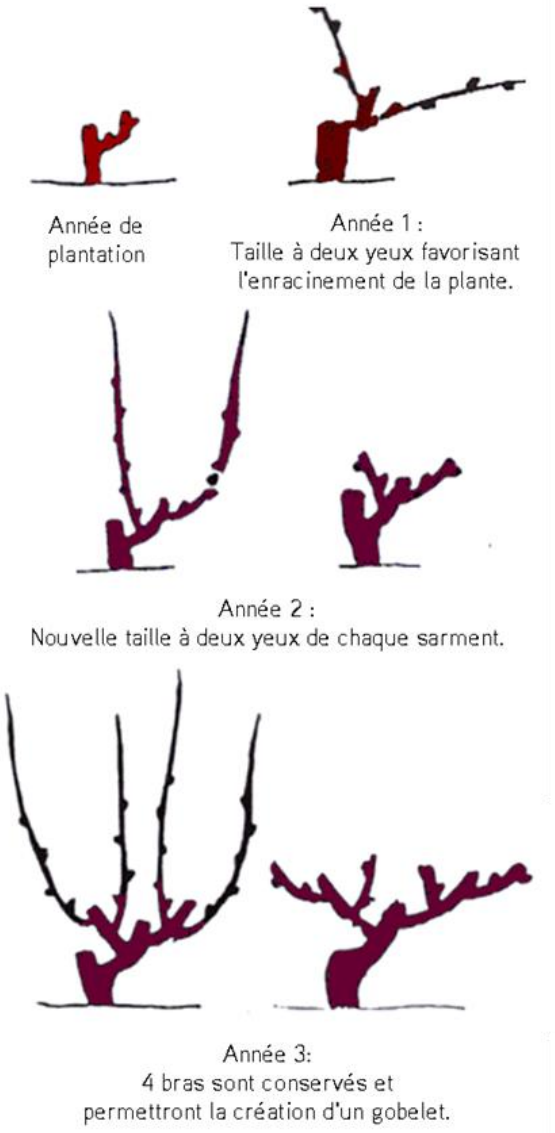
- **Project launched at ESIB-USJ since in Sept. 2016**
- **Twofold objectives**
  - Deploy LoRa in agricultural environment
  - Automate measurement process for agriculture research
- **IoT for agriculture**
  - FAO report:
    - 70% more food for 9.6 billion people in 2050.
    - More stress on fresh water (70% consumed by agriculture)
  - Smart farming: use technology to enhance processes and optimize the yield per unit of farming land.

LISA use case

- **Microclimates under vine (temperature, moisture, light)**
  - With different pruning lengths aiming to adapt the pruning techniques to local environment conditions
  - This will help in determining the maximum production that can be attained without sacrificing the grapes quality.
- **Current measurements are done manually by master students**
- **LISA will deploy a LoRa based IoT network to automate measurements in Bekaa.**

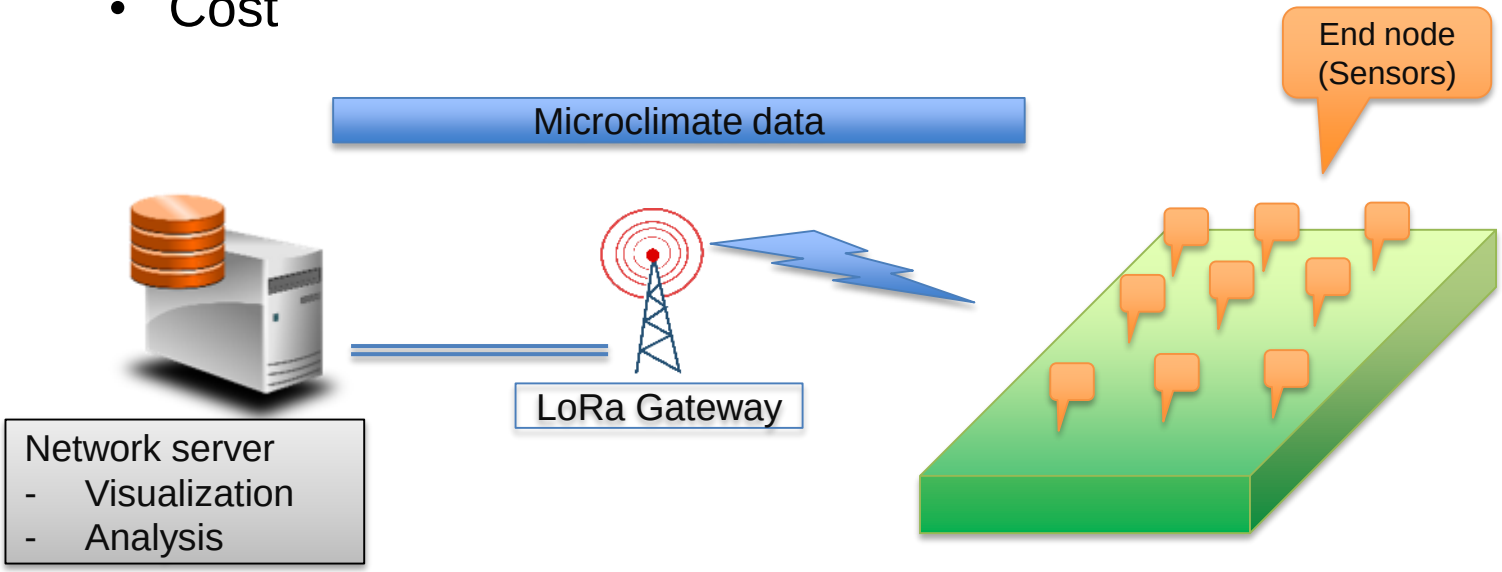
LISA use case

E1	E2	E3	E4	E5	E6
E2	E3	E4	E5	E6	E1
E3	E4	E5	E6	E1	E2
E4	E5	E6	E1	E2	E3
E5	E6	E1	E2	E3	E4
E6	E1	E2	E3	E4	E5

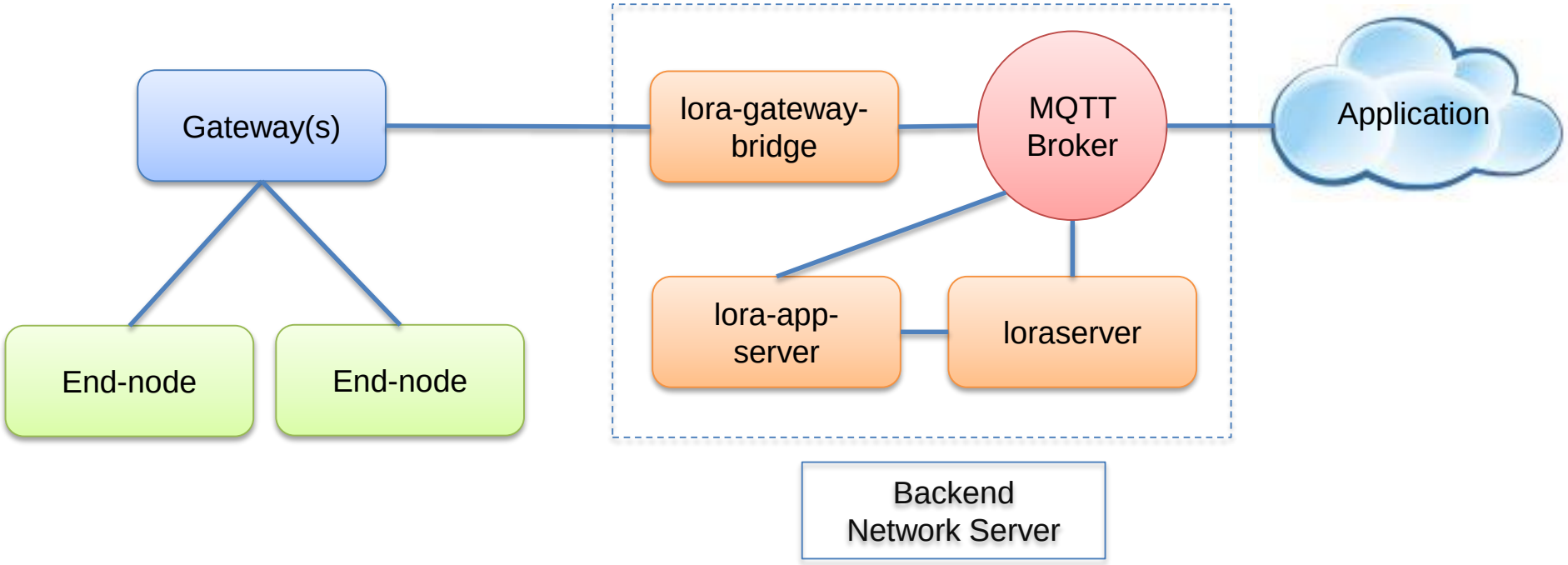


LISA use case

- **Challenges**
  - Autonomy
  - Packaging
  - Radio coverage
  - Sensors calibration for accurate microclimate measurement
  - Cost

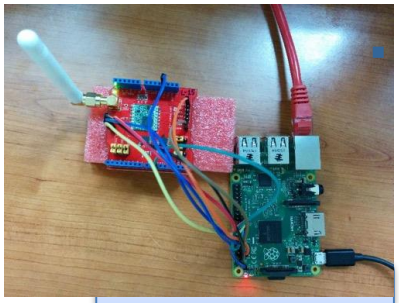


Platform architecture

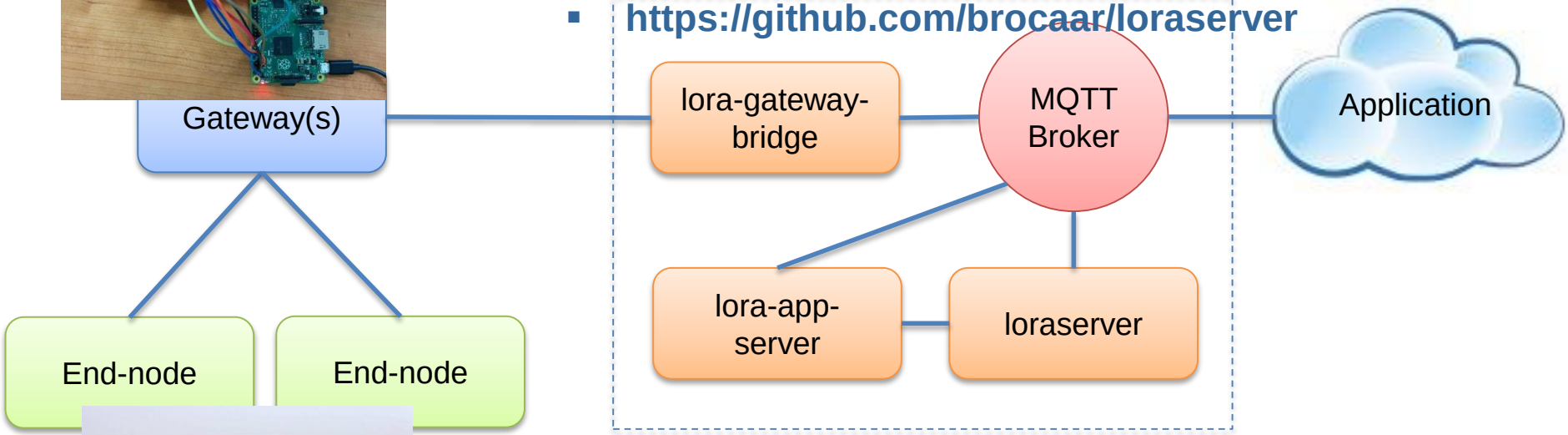


Lab Prototype

- Dragino Shield, Raspberry Pi
- Single Channel Packet Forwarder
- Multiple servers



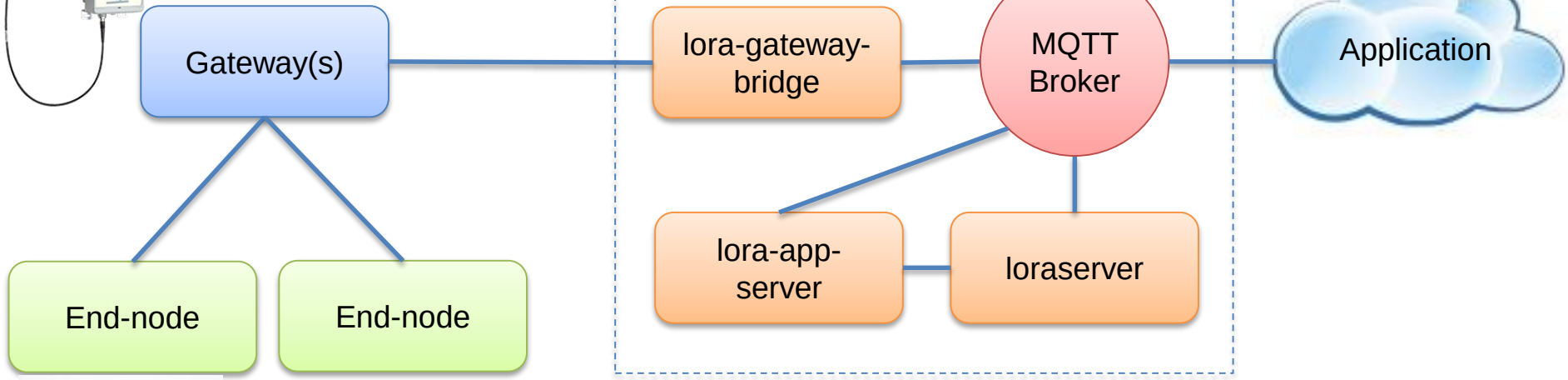
- Open-source LoRaWAN backend
- https://github.com/brocaar/loraserver

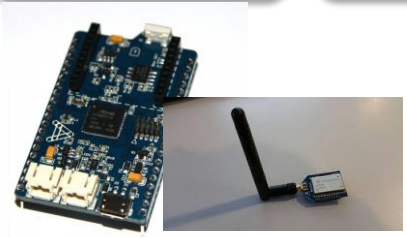


- Arduino Mega
- Dragino shield
- 868 MHz Antenna
- Arduino-LMIC (IBM): duty cyle, Up/Down, SF7-12, Over-the-air activation (OTAA / joining)

Deployment platform – A cell at ESIB

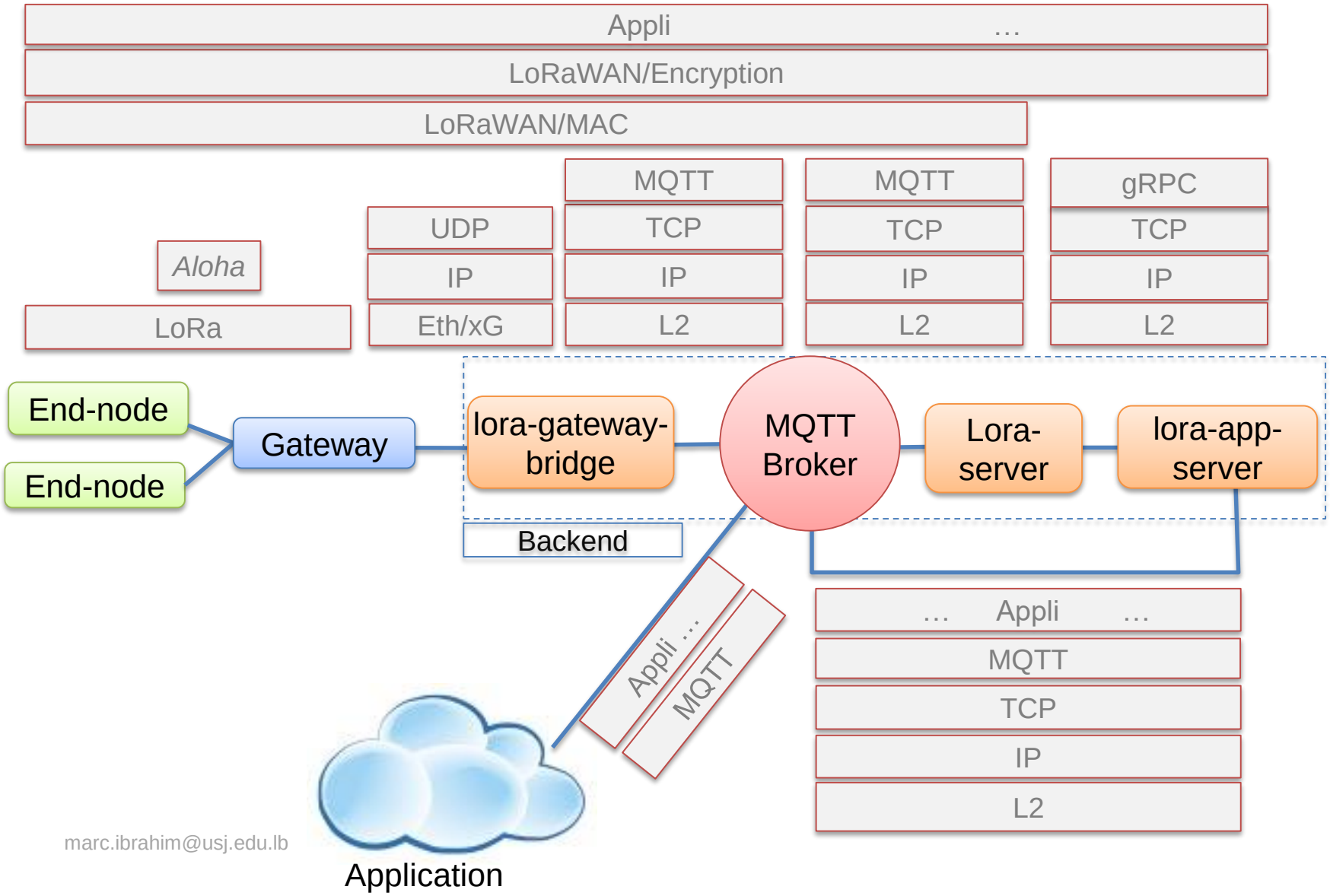
- Outdoor gateway
- Multiple channels
- Linux
- Outdoor
- GPRS (accessed via a VPN)
- GPS



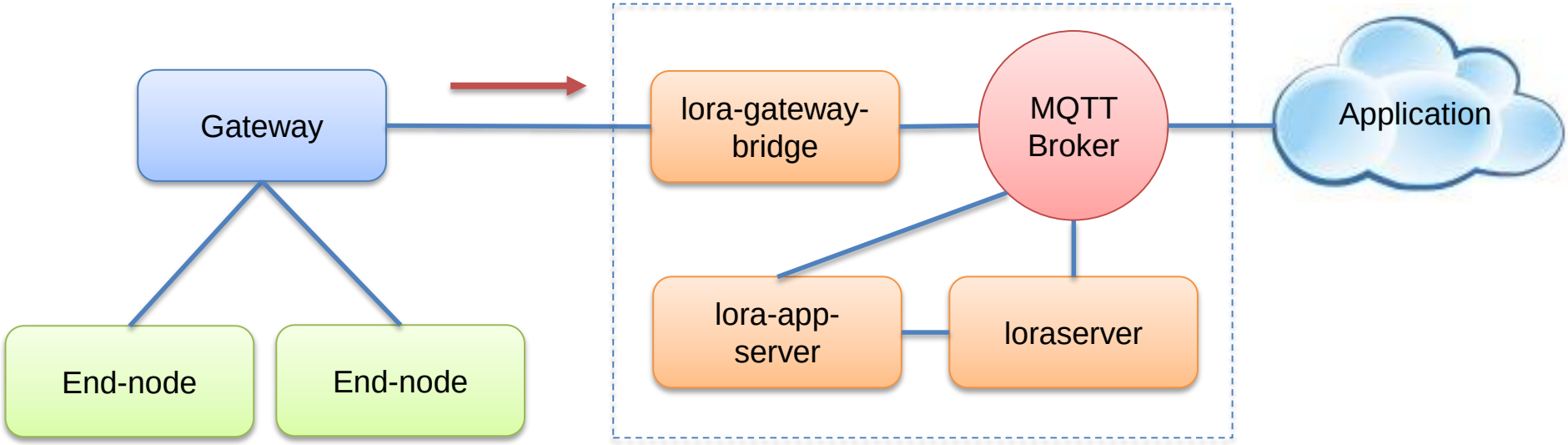


- Autonomo
  - Lorabee
- Low power controller
- Deep sleep capability

Platform protocol architecture



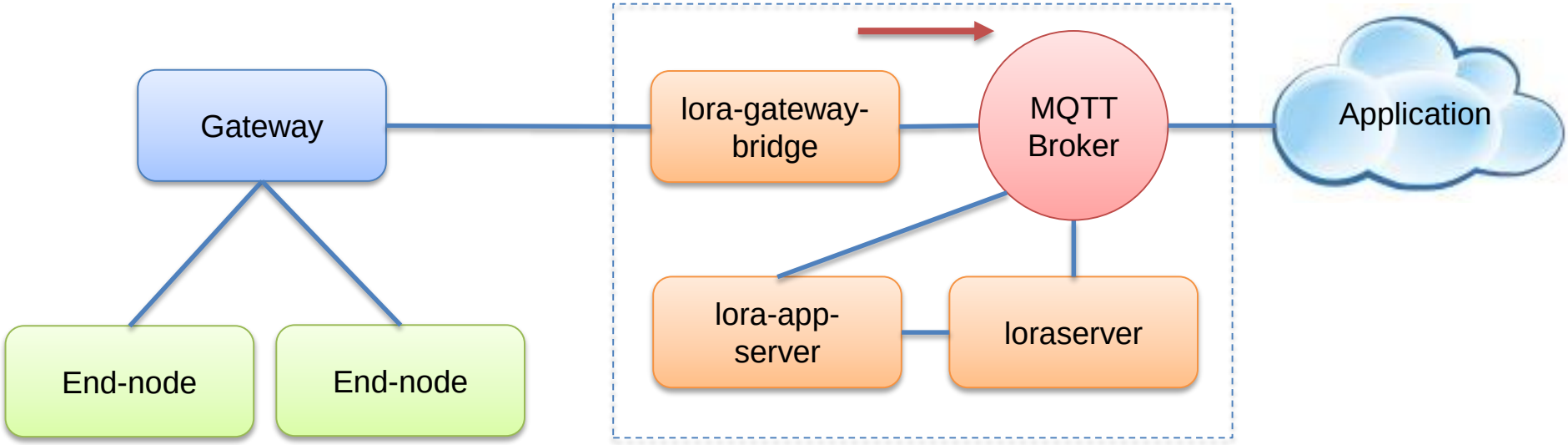
Gateway to Bridge



- **JSON/UDP/IP message with encrypted payload**

```
{"rxpk":[{"tmst":150701988,"freq":868.1,"chan":0,"rfch":0,"stat":1,"modu
":"LORA","datr":"SF7BW125","codr":"4/5","rssi":-
44,"lsnr":9.0,"size":46,"data":"QAf56VqA/BEB+Ae4VsNk5kRsry0pYUDpBEXQmLXn
H6+AH8gOKEv9/xd1y8PrSQ=="}]}
```

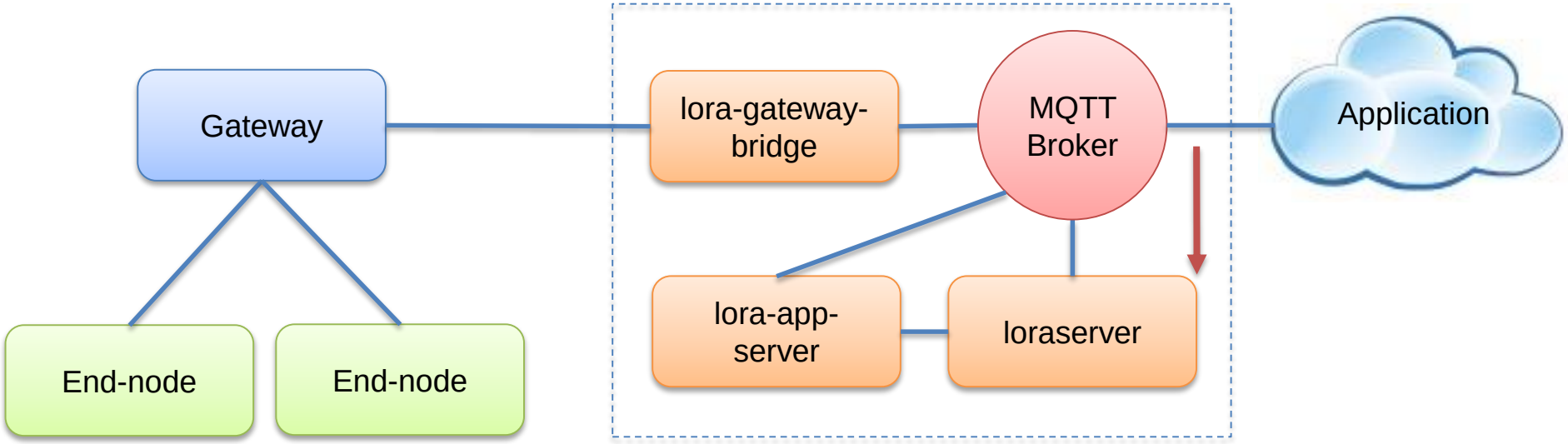
Bridge to Broker



- **MQTT message with encrypted payload**

```
Publish Message
Topic: gateway/b827ebffffd562ed/rx
Message: {"rxInfo":{"mac":"b827ebffffd562ed","time":"0001-
0101T00:00:00Z","timestamp":3554957965,"frequency":868100000,"channel":0
,"rfChain":0,"crcStatus":1,"codeRate":"4/5","rssi":-
40,"loRaSNR":9,"size":46,"dataRate":{"modulation":"LORA",
"SpreadFactor":7,"bandwidth":125}},"phyPayload":
"QAf56VqA/BEB+Ae4VsNk5kRsry0pYUDpBEXQmLXnH6+AH8gOKEv9/xd1y8PrSQ=="}
```

Broker to loraserver



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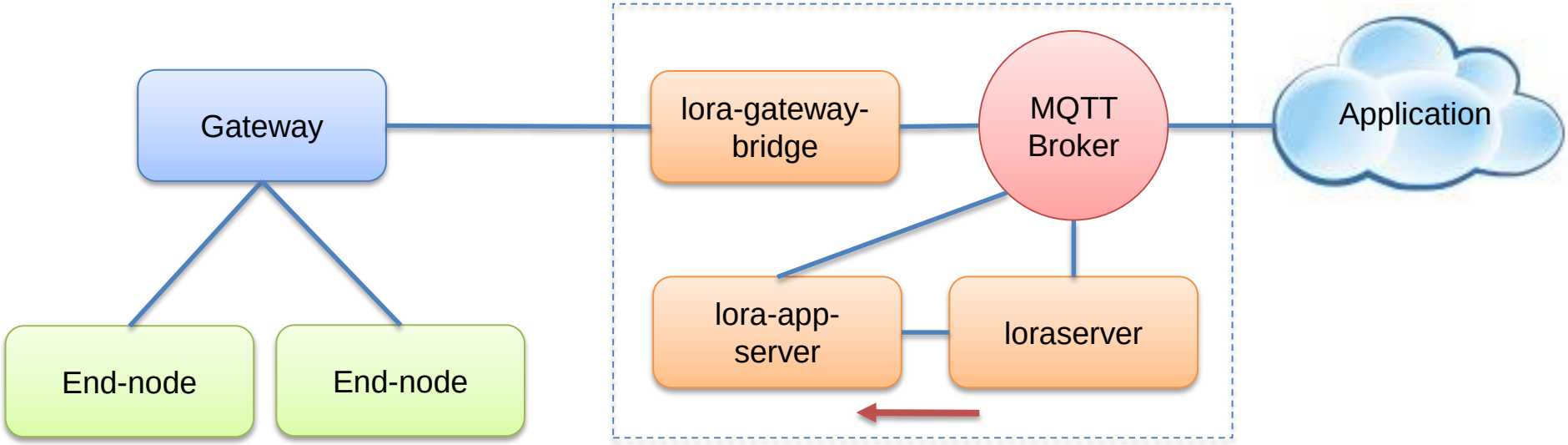
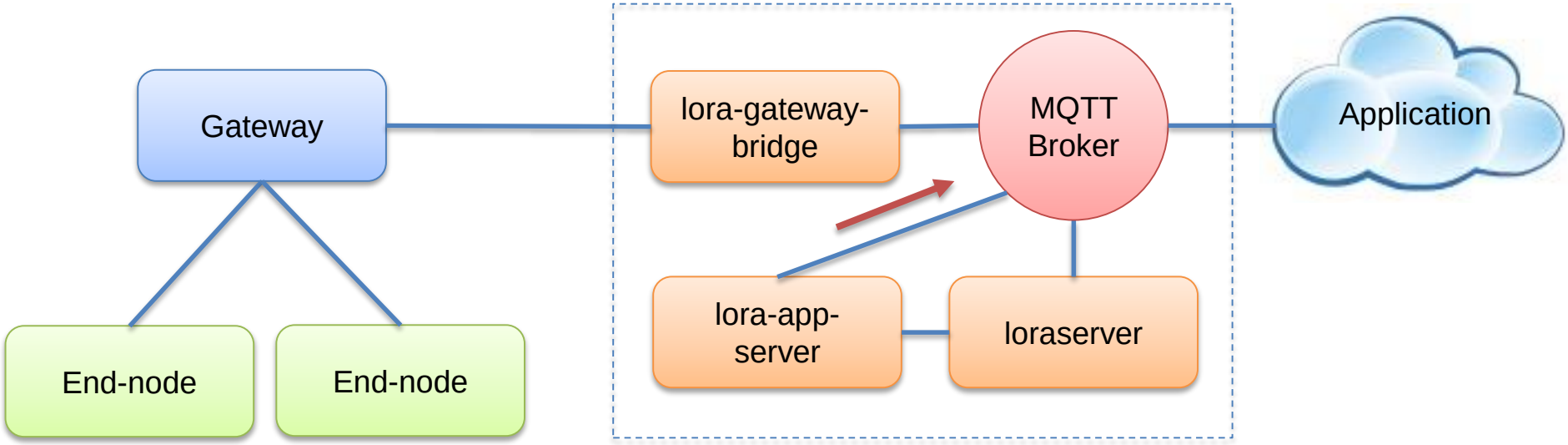
```

loraserver to lora-app-server



- **gRPC message**
  - Authenticate DevAddr
  - Get node session
  - Verify integrity
  - Decrypt payload
  - Identify application

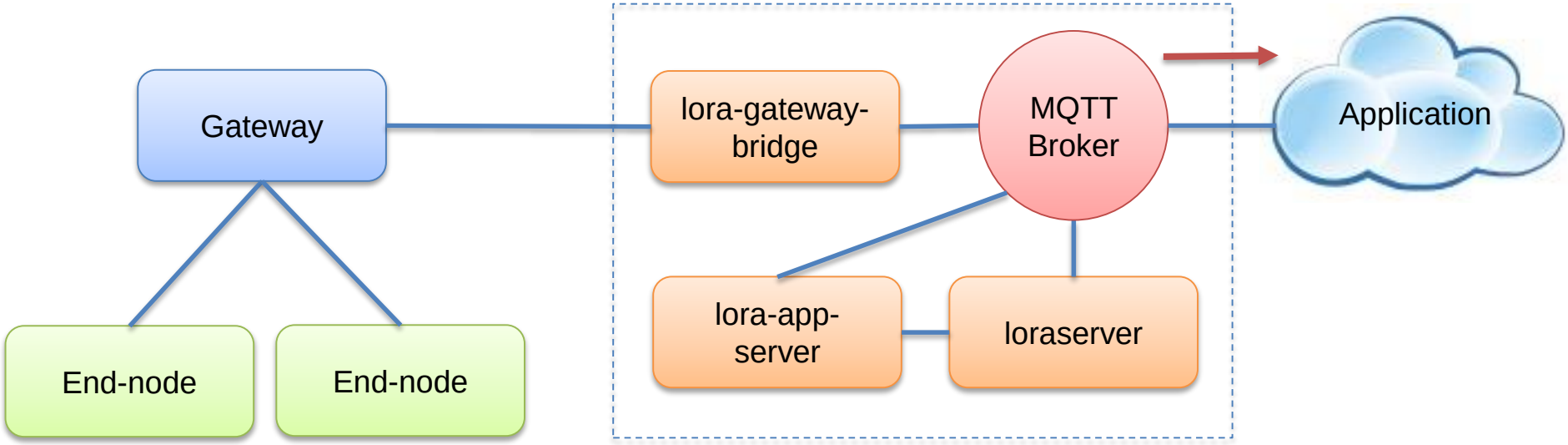
lora-app-server to Broker



- **MQTT message with decrypted/encoded payload**

```
Publish message
Topic: application/70b3d57ed000087f/node/00000000374de57c/rx
Message: {"devEUI":"00000000374de57c","time":"0001-01-
01T00:00:00Z","fPort":1,"gwCount":1,"rssi":-
40,"data":"eyJMIjogMTAyMiwgIk0iOiA2OTYsICJUIjogMjMuNTZ9"}
```

Broker to Application



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```
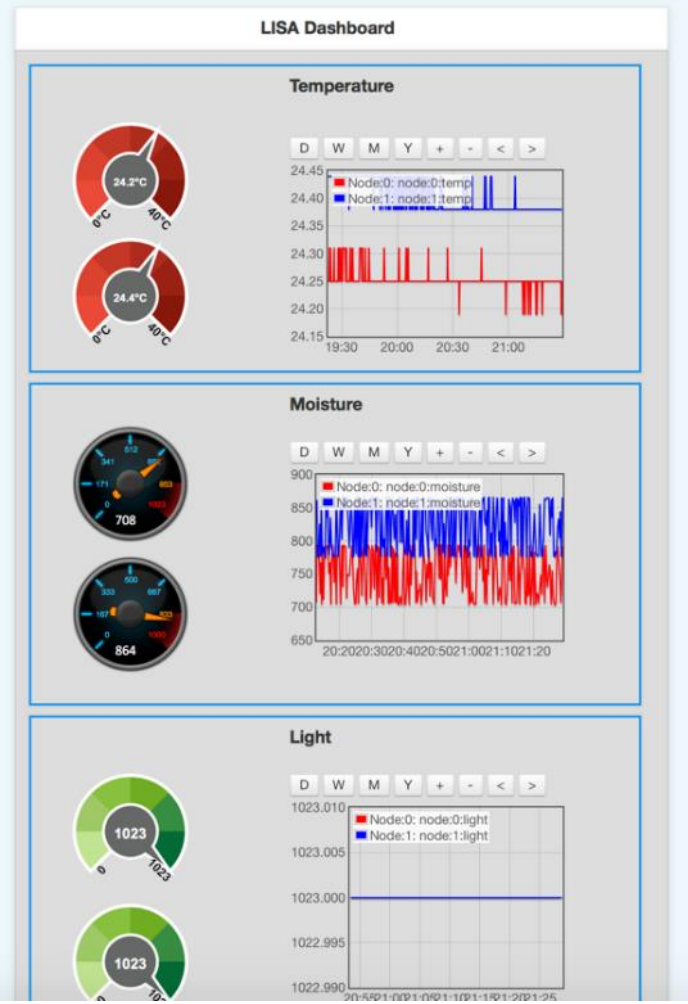
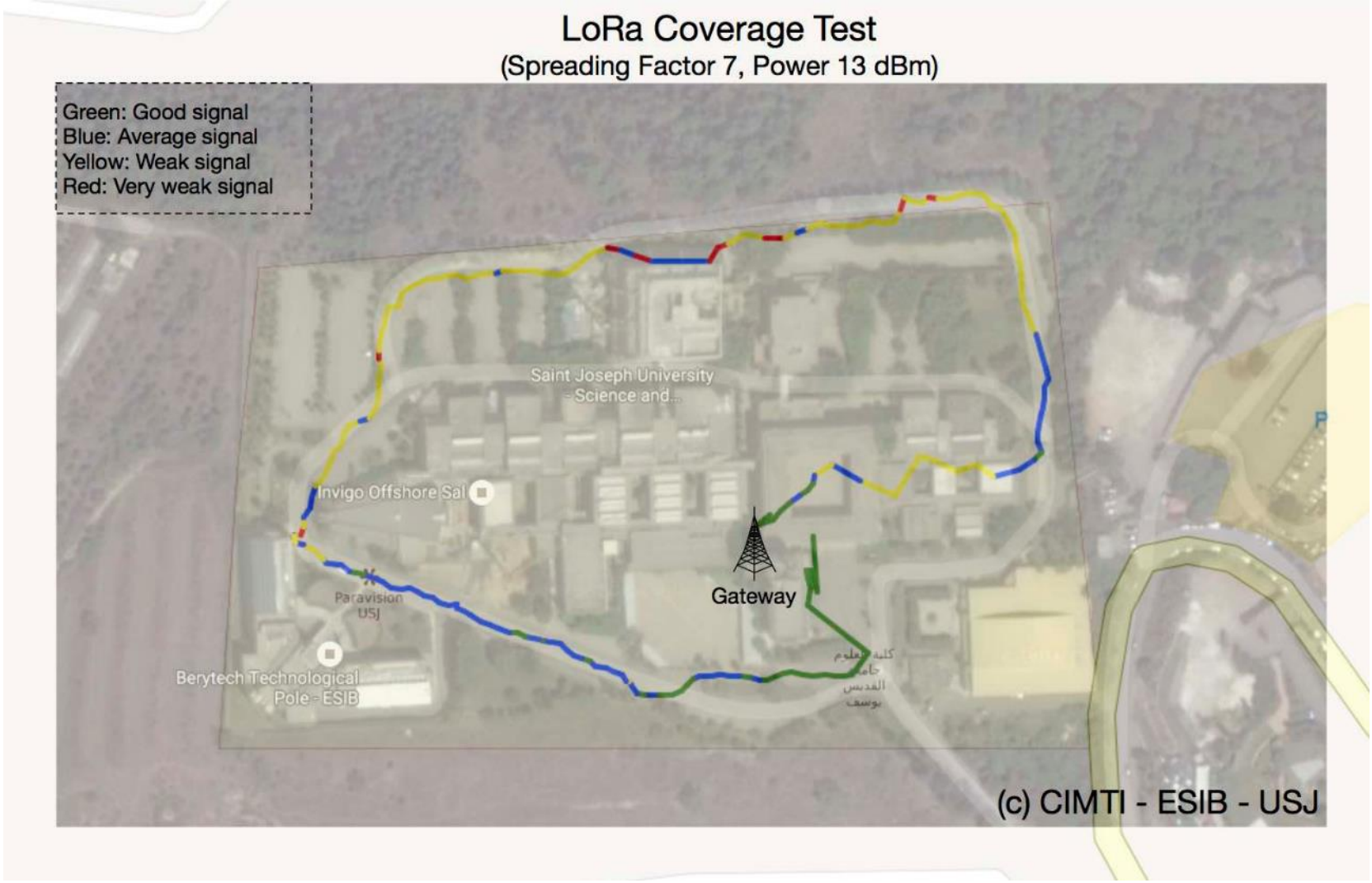

Application Examples

- **MQTT Libraries**
  - https://eclipse.org/paho/
- **IoT Cloud**
  - Emoncms (api, dashboard, app, …)
  - AWS IoT, …



Radio measurements



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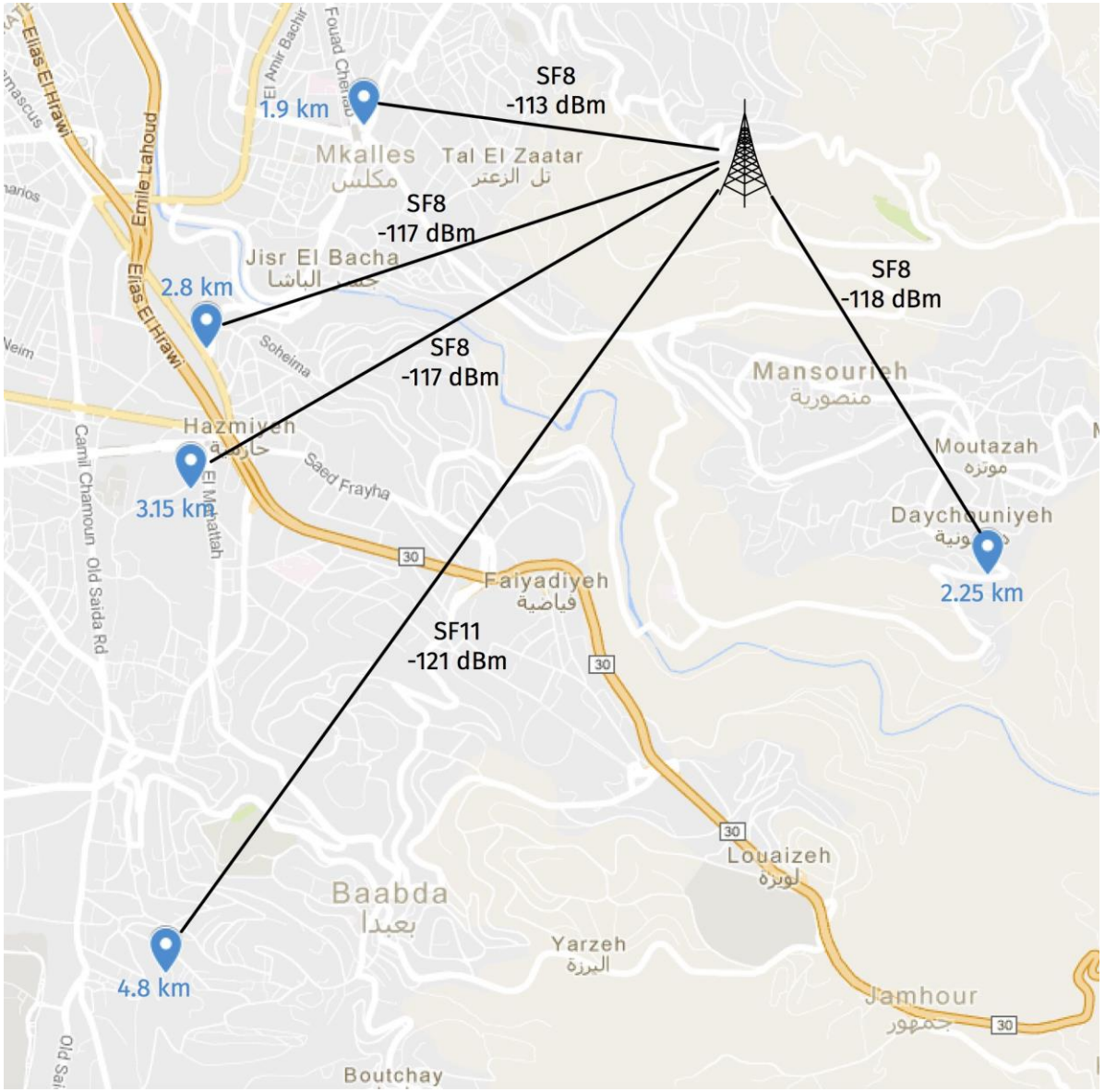

Current initiatives in Lebanon related to agriculture

- **Agrytech**
  - Agri-food innovation
  - Startup acceleration program
- **FOSS4I**
  - FibreOptics Sensor Systems for Irrigation applications
  - Irrigation optimization through Fiber Optic Sensors System (Fiber LPWAN!)
  - CERN collaboration

Interact with our platform

- https://emoncms.org/dashboard/view?id=37655
- **Play with MQTT and view LoRa messages**
  - Install a MQTT app
  - Connect to 212.98.137.194 port 1883
  - Subscribe to topic #
  - Enjoy!
- **Twitter: @allo_laplante**
  - The node twitting temperature
- **Hangout**
  - New conversation with **allo_laplante**
  - Type /bot eguz

Thank you

marc.ibrahim@usj.edu.lb