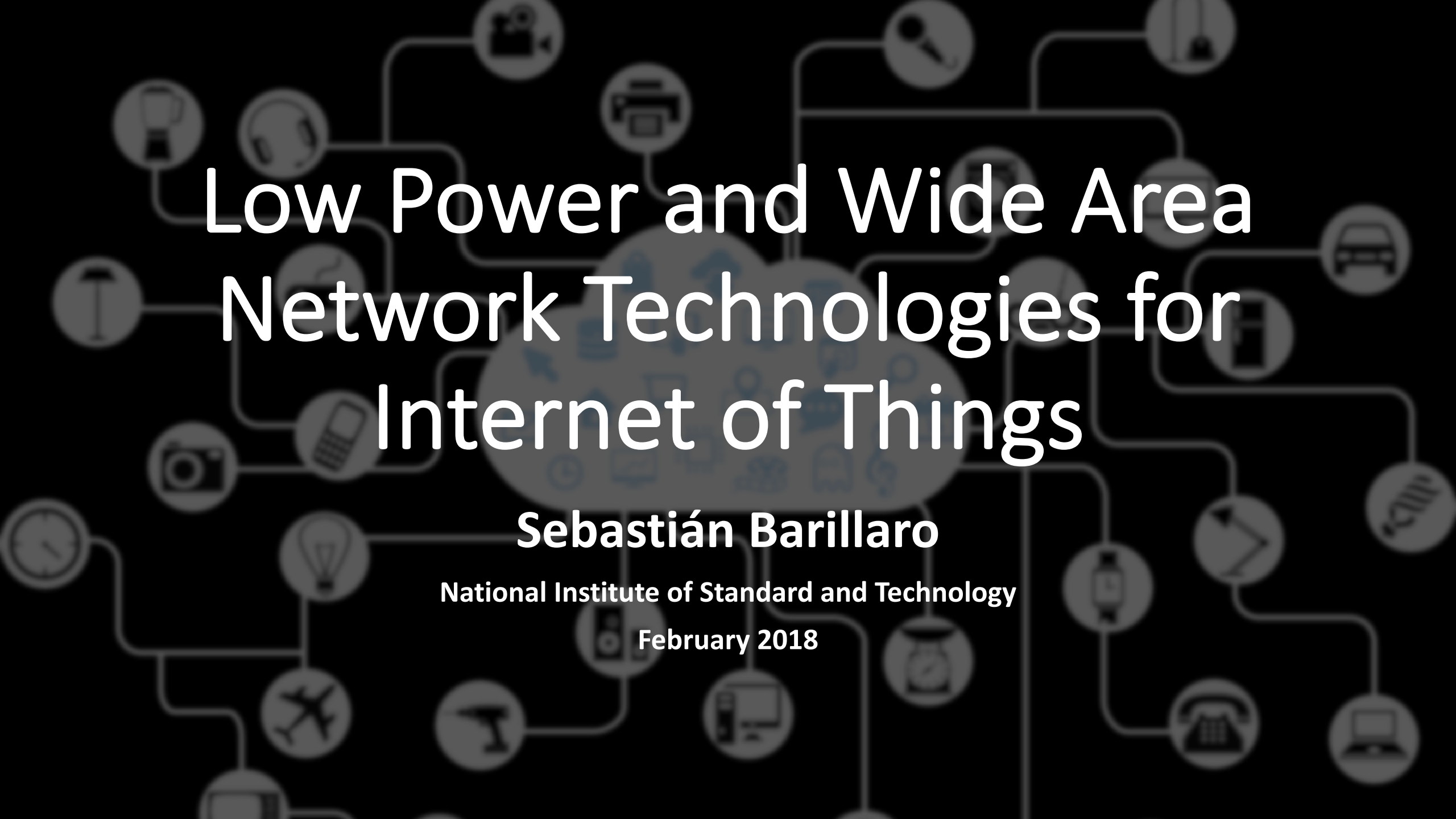

Low Power and Wide Area Network Technologies for Internet of Things

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National Institute of Standard and Technology

February 2018

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Host: Dr. Raghu Kacker

LPWAN IOT LABORATORY

Information Technology Laboratory

Computer Security Division + Applied and Computational Mathematics Division

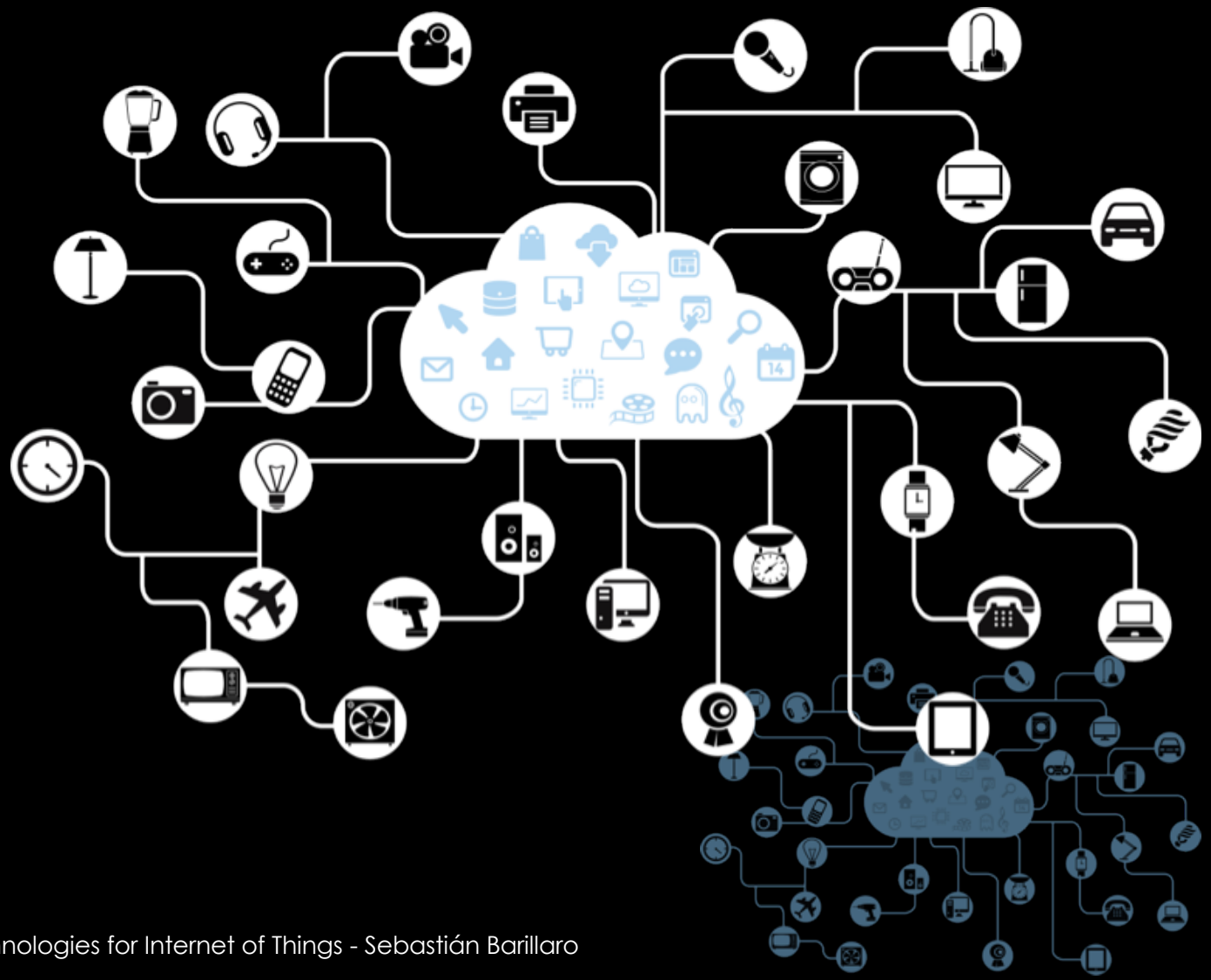
- Sebastián Barillaro
- Lee Badger
- Rick Kuhn
- Raghu Kacker

INTERNET OF THINGS

There are so many definitions of IoT as people talking about.

Let's agree in one concept: Things connected.

Again, we have lot of technologies to choose for connecting these *things*. Most of them are wireless.



- There are well defined technologies for most common network requirements.

How we connect all those *Things*?

0.1 m
Proximity
Area Network

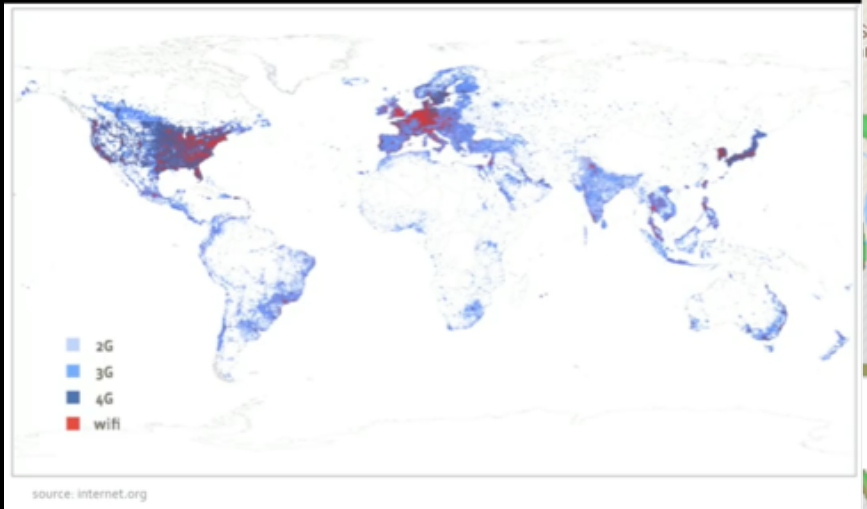
10 m
Personal
Area Network

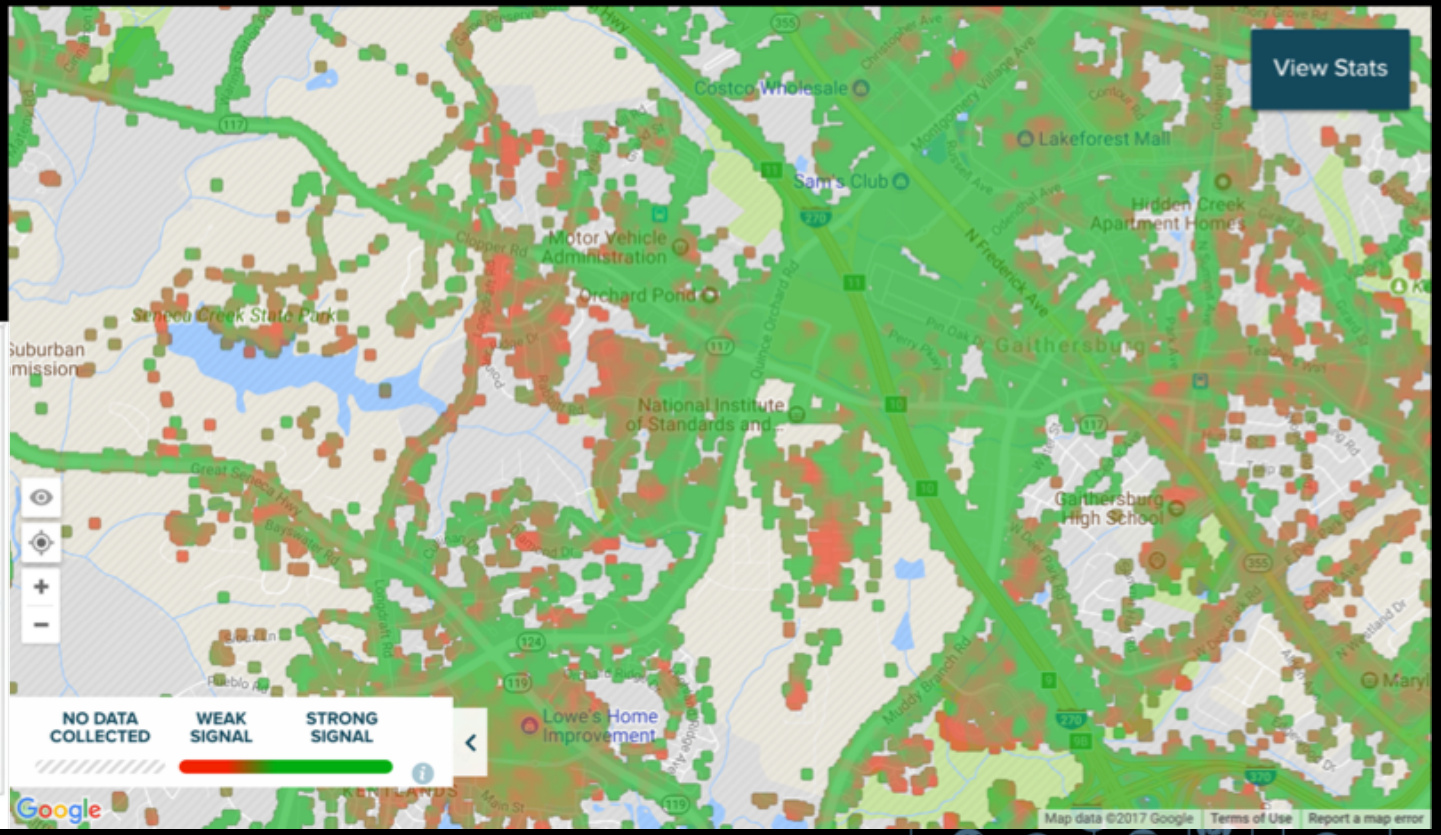
100 m
Local
Area Network

20,000 m
Wide
Area Network

Wide Area Network

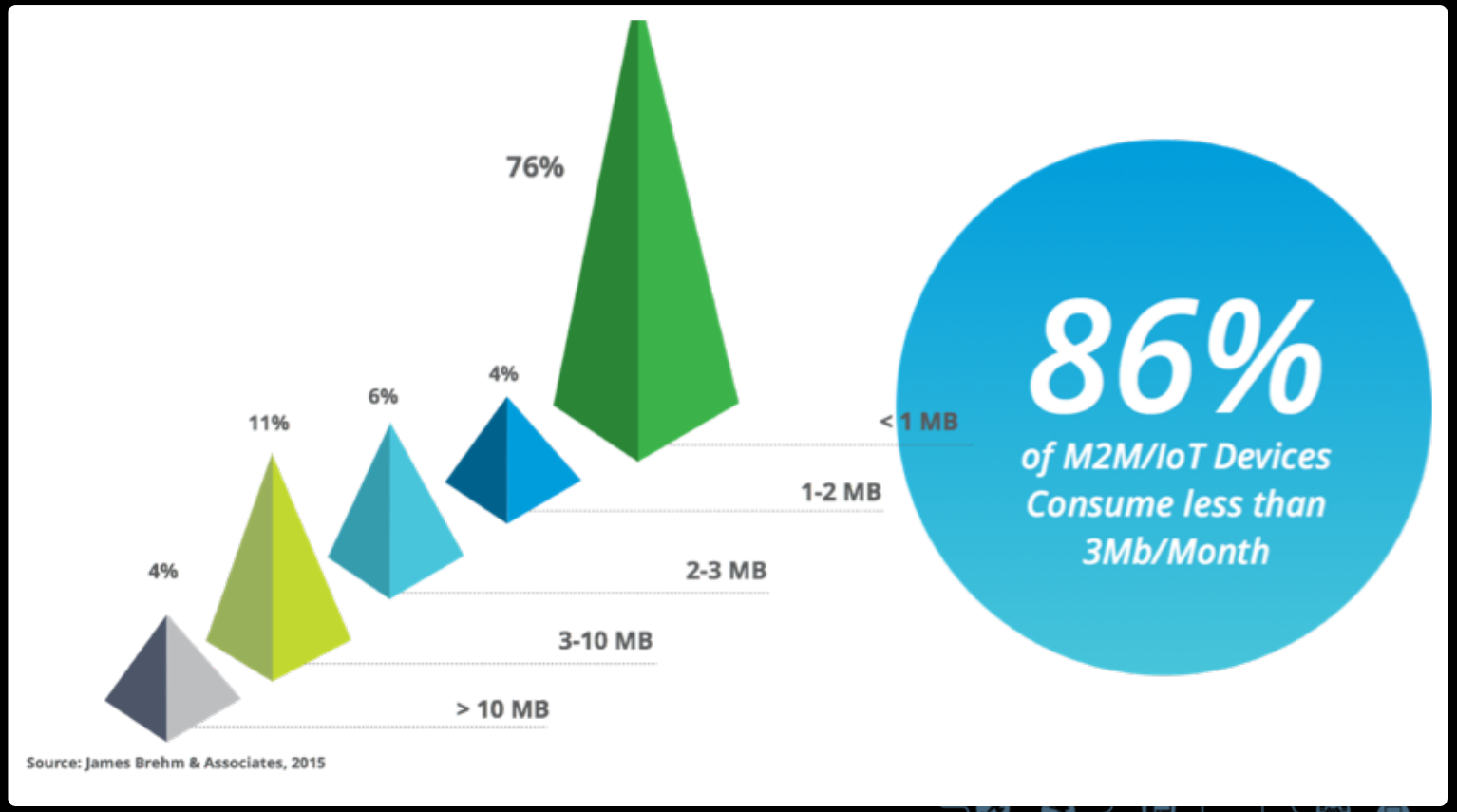
- Cellphone network is the most adopted technology
- It works in a licensed frequency
- High power consumption
- High data rate
- Telecommunication companies decide where to deploy





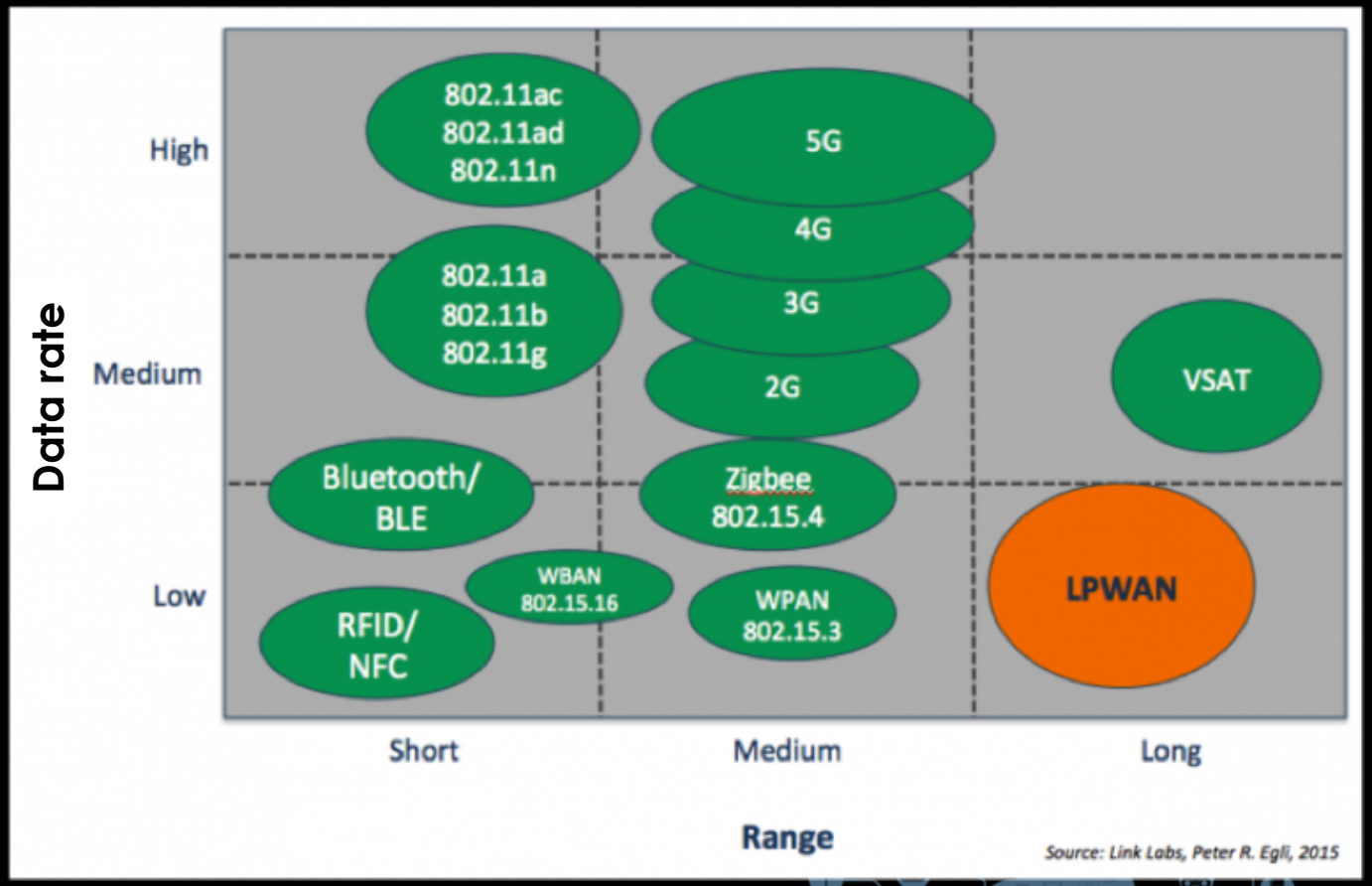
Do we need more same technology?

- Users never owns the network
- Users depend on 3rd party
- Users have to pay a fee
- Battery drains quickly



Range vs Data rate

- Most of network technologies focus on data rate.
- Cellphone technology is not really wide. It has big coverage because there are towers everywhere.
- It is necessary a real Wide Area Network Technology.
- LPWAN: A set of software and hardware communication protocols that allow communication among two or more points in a wide area with low energy costs.



TECHNOLOGY CHARACTERISTICS

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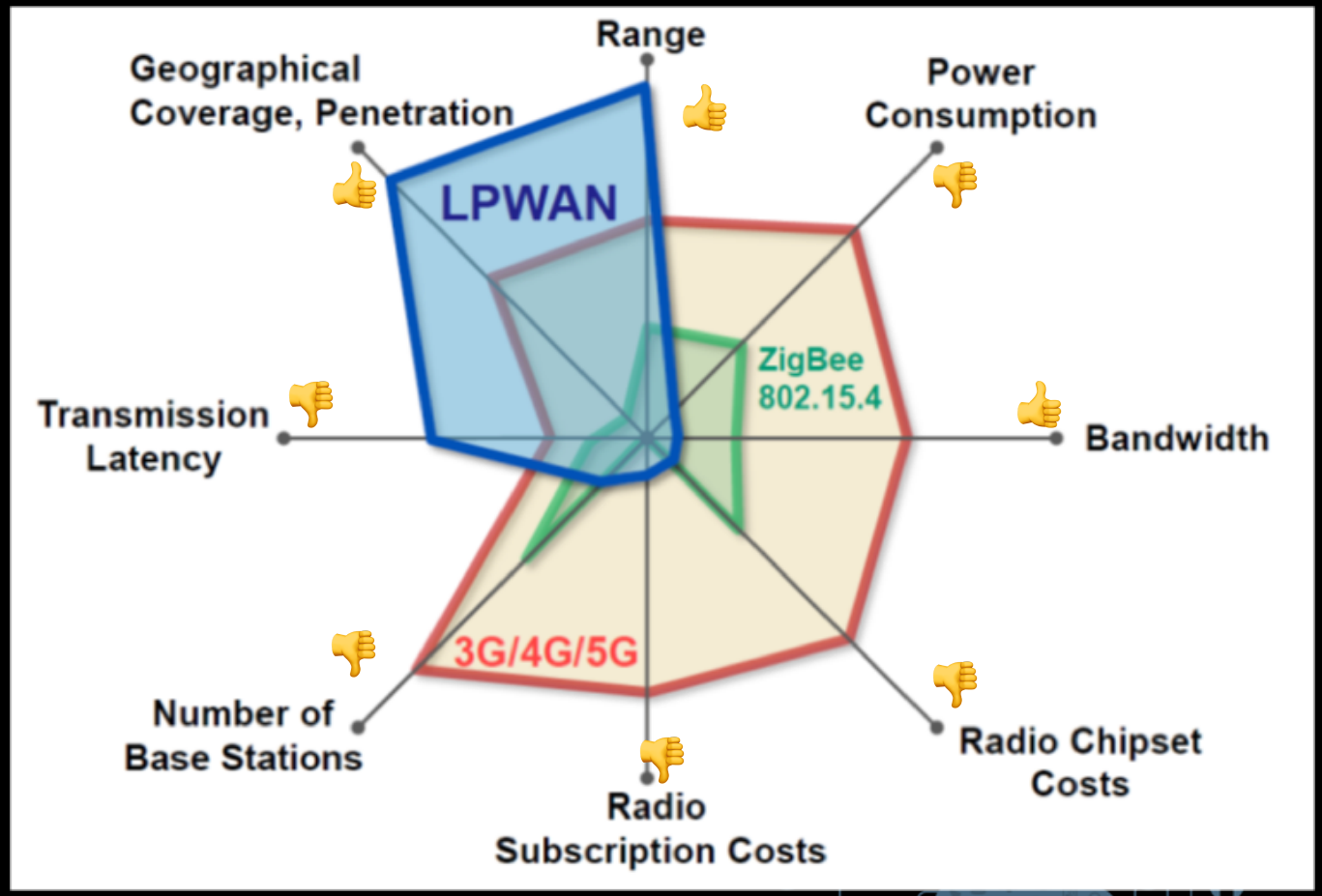

👍 The more is good
👎 The more is bad

LPWAN Options

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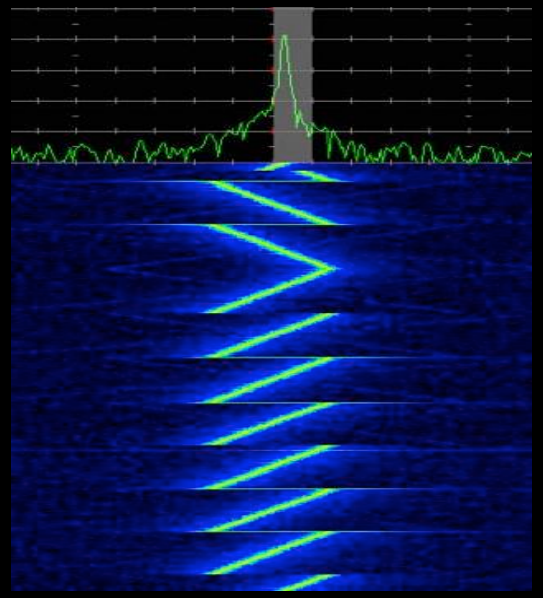
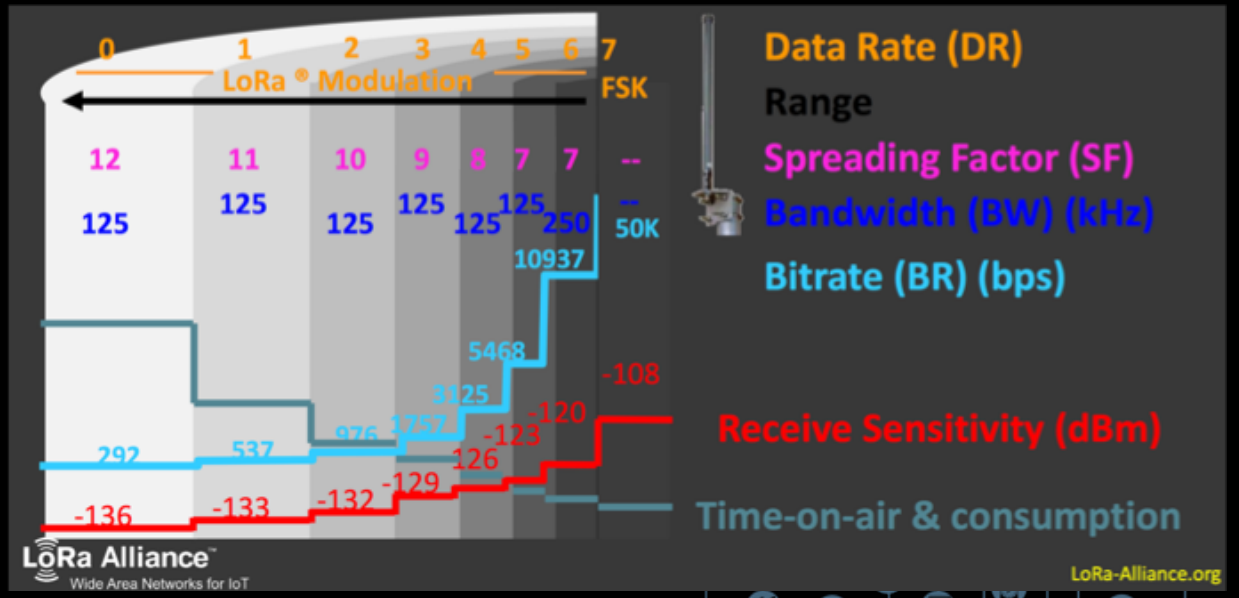
LoRa + LoRaWAN

- LoRa is a patented (EP2763321 from 2013 and US7791415 from 2008) technology developed by Cycleo (Grenoble, France) and acquired by Semtech in 2012.
- LoRaWAN is a media access control layer protocol for managing communication between LPWAN gateways and end-node devices, maintained by the LoRa Alliance. Version 1.0 of the LoRaWAN specification was released in June 2015. Version 1.1 released October 2017.

LoRa

- LoRa is a proprietary, chirp spread spectrum (CSS) radio modulation technology for LPWAN used by LoRaWAN, Haystack Technologies, and Symphony Link.
- Processing gain = increased receive sensitivity
- Enables longer range at expense of lower data rate
- ISM Band
  - EU: 868, 434 MHz Band
  - US: 915 MHz Band





LoRaWAN

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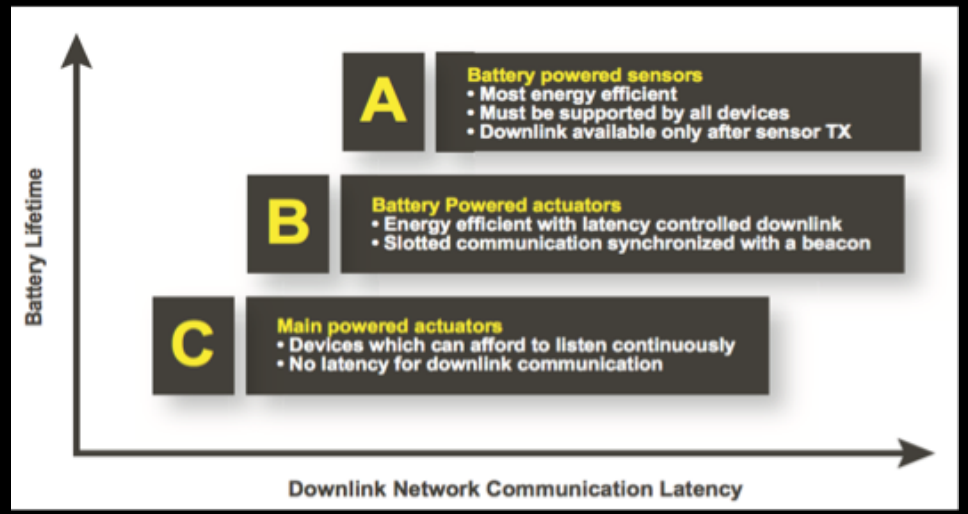
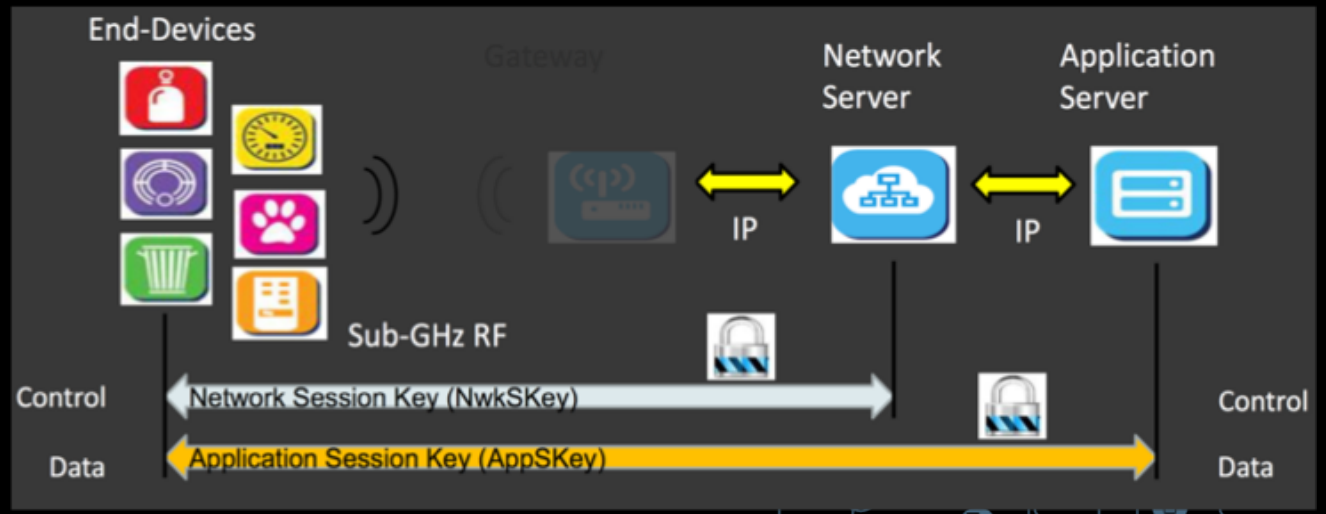
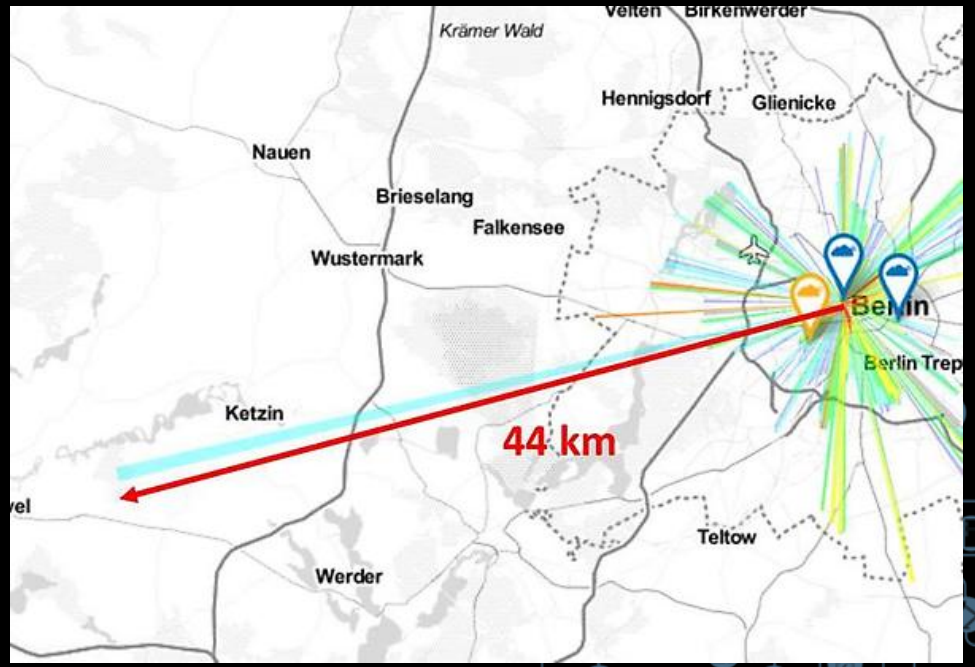




REMOTE MONITORING OF STATION CLOCKS

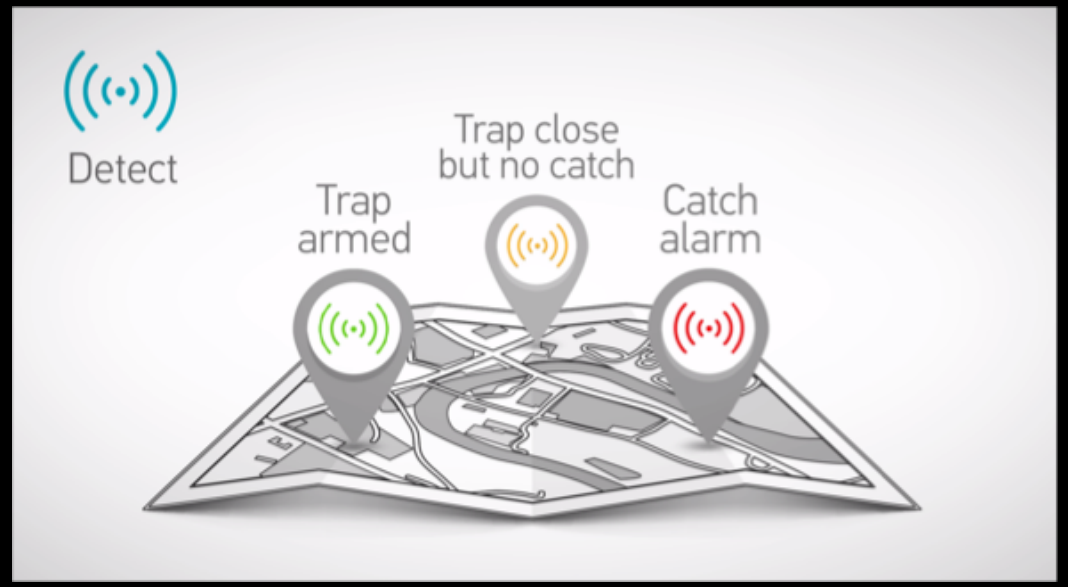
Deutsche Bahn (DB) is currently conducting several pilot studies on remote monitoring of station clocks using LoRaWAN ™. On the one hand runs a trial with 50 watches, which were retrofitted with a surveillance solution. Two other watches were equipped with sensor technology in cooperation with the Berlin tech startup Relayr, which will be tested at the Berlin S-Bahn stations Bellevue and Jannowitzbrücke. Finally, on a third clock with the software startup GreyRook, a new approach to the time synchronization of station clocks is being developed.

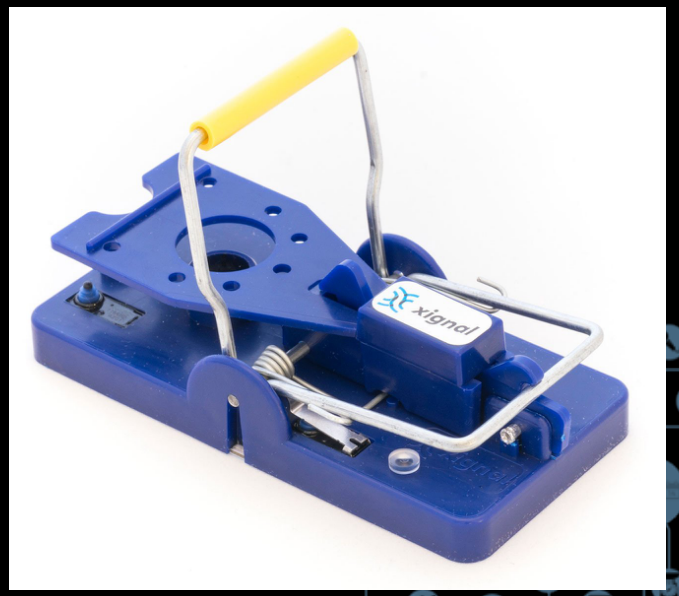


XIGNAL

Xignal is the solution for now and the future.
Intelligent and sustainable pest control.

Xignal detects the status of the mouse and rat trap: armed, unarmed or unarmed with catch. With the advanced LoRa technology the communication runs via your private or public network. By a push notification on your mobile or tablet you get online 24/7 reports about rodent activities. So you can directly respond and control the activities of rodents.



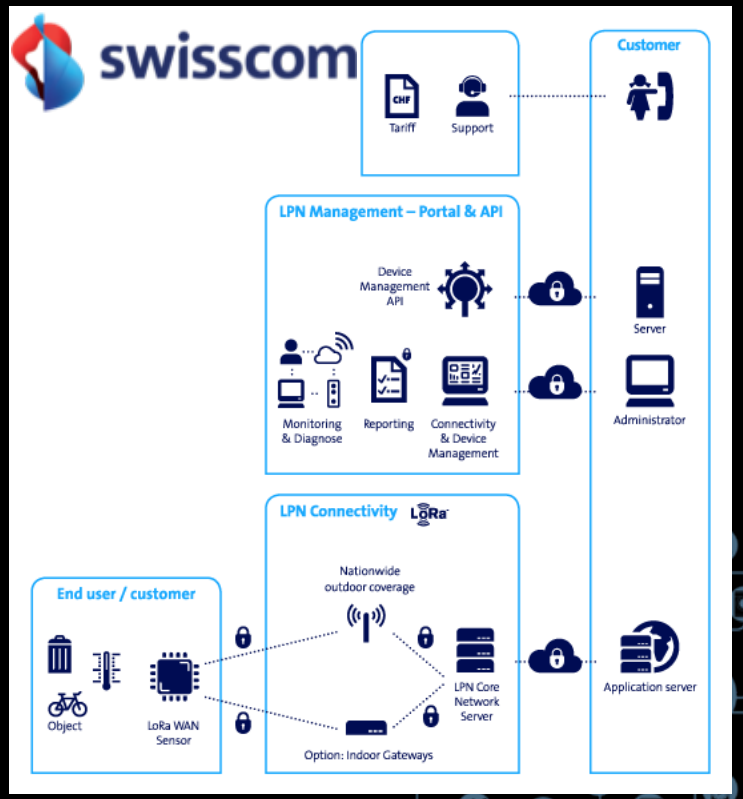


Swisscom Low Power Network Connectivity powered by LoRa

The Swisscom Low Power Network powered by LoRa™ is a complementary network designed to meet the unique needs of IoT based applications that require the communication of only small amounts of data

Zurich City Police: M2M Solution

To ensure that the roads are cleaned on schedule and released for traffic again, the world's largest technoparty relies on tight organisation. Zurich City Police relies on an M2M solution from Swisscom for this, allowing them to inform Love Mobiles that fall out of line and throw the sequence into confusion in real time and control them accordingly.



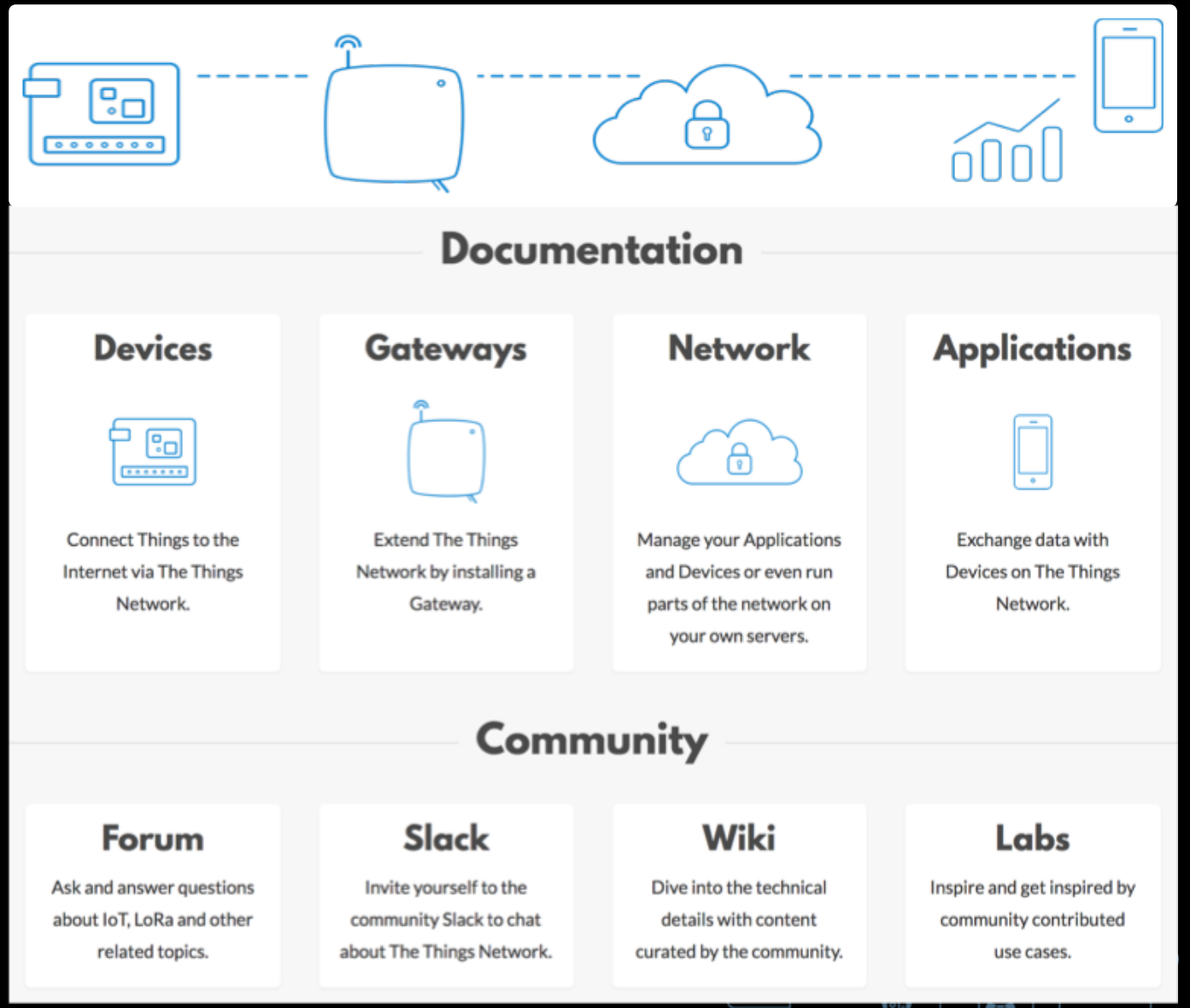
MACHINEQ

MachineQ, Comcast's Enterprise Internet of Things Service.

Comcast today (July 18th) announced plans to expand its enterprise Internet of Things (IoT) service, machineQ™, to 12 major U.S. markets. MachineQ is an IoT network service and platform that uses Low Power Wide Area Network (LPWAN) technology based on the globally-adopted LoRaWAN™ protocol to build and deploy solutions for businesses and municipal organizations. The service is rolling out in Atlanta, Baltimore, Boston, Denver, Detroit, Indianapolis, Miami, Minneapolis/St. Paul, Oakland, Pittsburgh, Seattle, and Washington D.C.

The Things Network

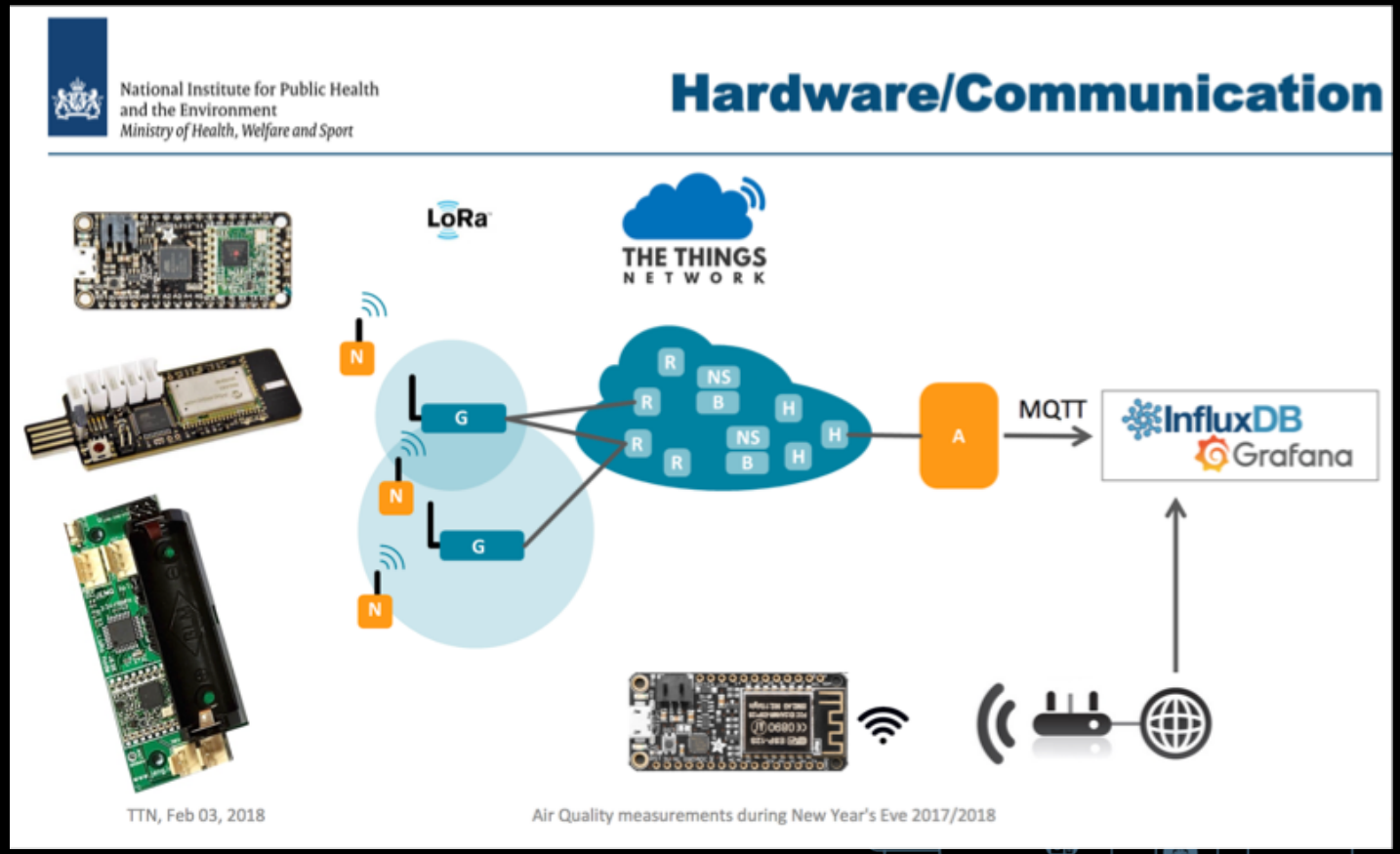
The Things Network is about enabling low power Devices to use long range Gateways to connect to an open-source, decentralized Network to exchange data with Applications and Platforms.



National Institute for Public Health and the Enviroment.

Air Quality (RIVM)

- A number of sensor kits was prepared by RIVM for assembly by interested citizens.
- The kits were distributed during a symposium on citizen science and during workshops in the cities of Amsterdam and Amersfoort.
- Measurements were also organized by several groups of people and the data was shared with RIVM.
  - Apeldoorn
  - Venlo
  - Several individuals
- Most sensors connected to the internet using WiFi, some 25% communicated using LoRa.



Gale A. Brewer, Manhattan Borough President

*…We can build an IoT network that embodies the values of responsible tech, and has **empathy, openness, and public service** at its core…*

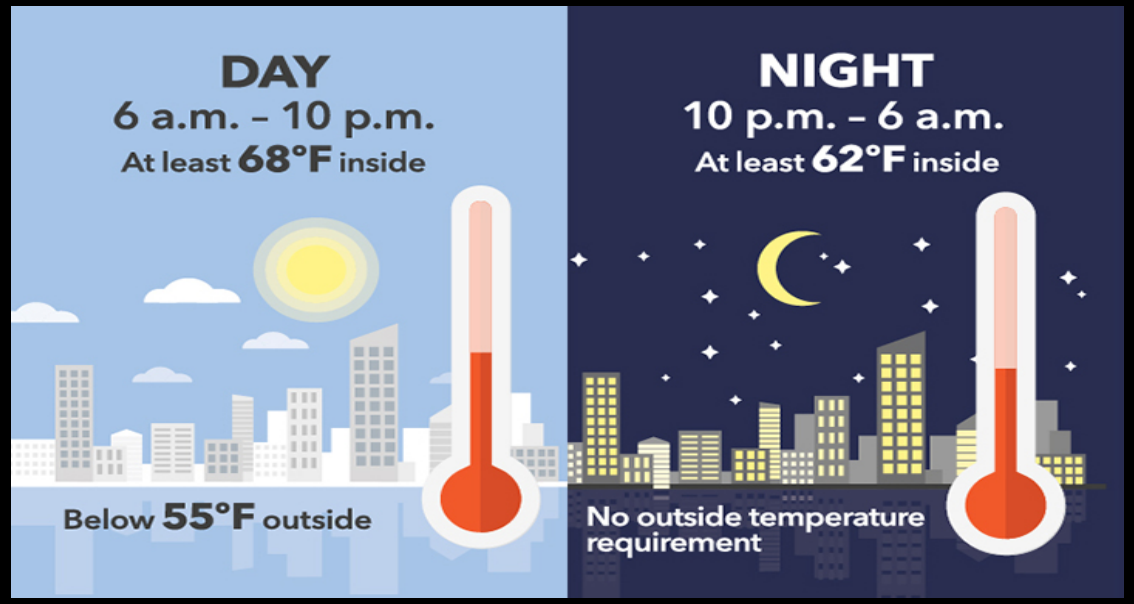
…Each LoRa gateway powered by "The Things Network" that goes on-line in my borough will quickly become essential to our thousands of not-for-profit organizations, and startup incubators and accelerators…

… To help expand the network, I'm installing two MultiTech Gateways, one for our Harlem storefront office on West 125thStreet and one for our downtown office next to the Brooklyn Bridge and City Hall…

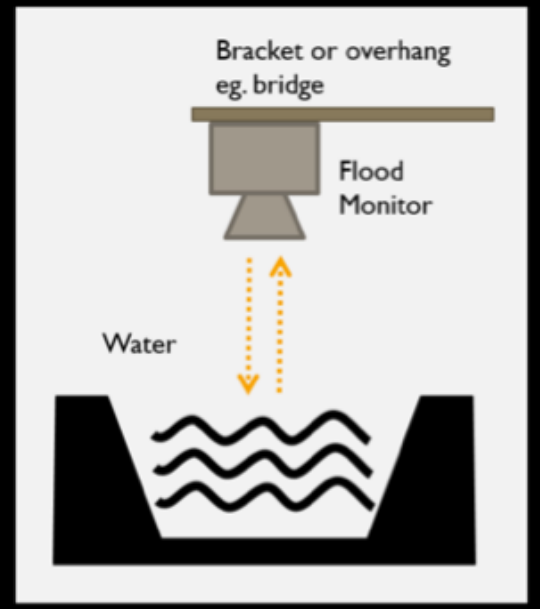
Heat Seek

At Heat Seek its our mission to make the city a safer, warmer place to live for all New Yorkers.

Heat Seek helps tenants resolve their home heating issues by providing the **objective, reliable temperature data** they need to expose the problem and hold their landlords accountable. Working closely with tenants, tenant organizers, public interest attorneys, and city officials, we install proprietary temperature sensors and offer technical expertise to assist tenants in documenting when their landlords fail to provide adequate heat during the wintertime.

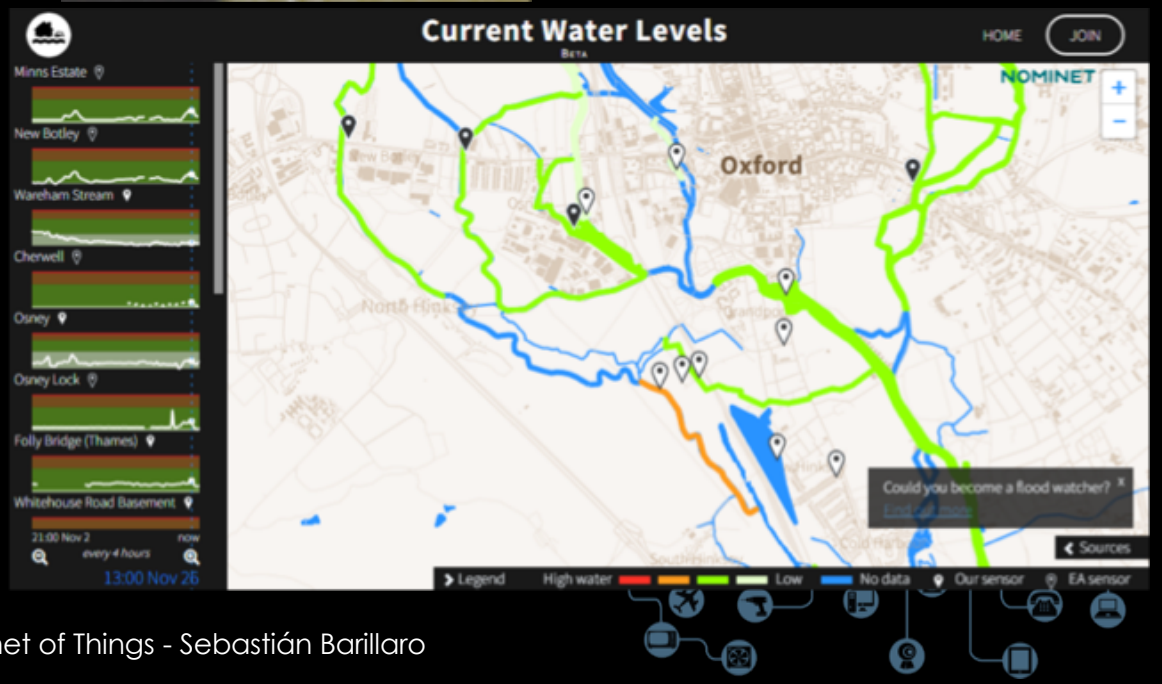


Flood Network



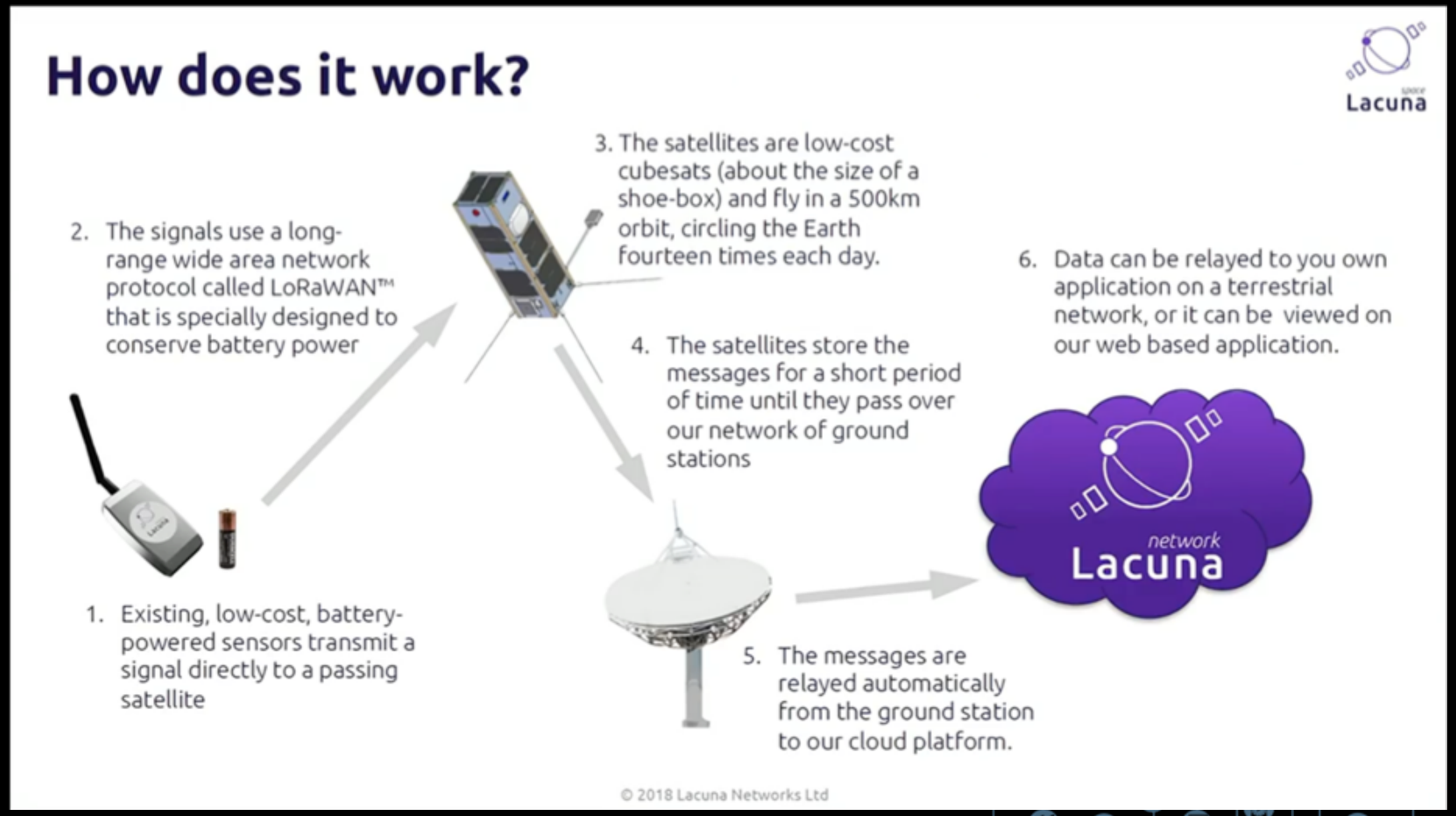
Install a Flood Sensor- Using brand new LPWAN technology you can collect data on water levels in nearby streams via the Internet. Our low-cost wireless sensors harness the power of the *Internet of Things* to give you updates about waterways, rivers, ditches and even groundwater. They are powered by battery and can connect wirelessly to a gateway which instantly sends the data to show on your map.

With a subscription you and a group of members can be alerted by SMS or email as water levels change. You can manage your data and devices more closely and analyse the data, choosing whether to publish as open data.



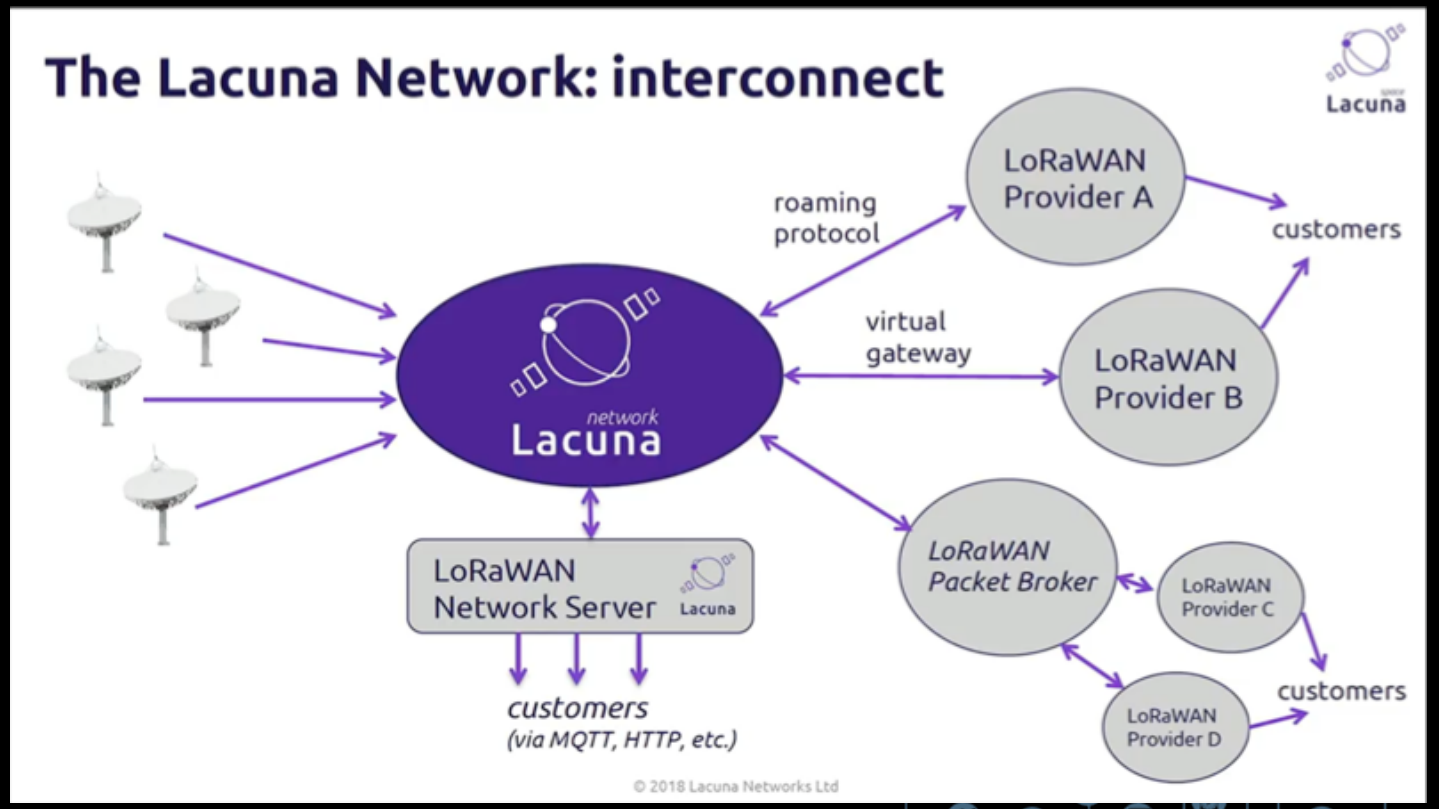
Lacuna Space

Low-cost, simple and reliable global connections to sensors and mobile equipment. It just works everywhere, and all the time, so you can focus on using your data.



Lacuna Space

Lacuna Space is currently based out of the European Space Agency's Business Incubation Centre on the Harwell Campus – at the heart of the UK's space applications development community – and we also have an office in the Netherlands where we work closely with The Things Network in Amsterdam. We also have developers and collaborators working in France and Switzerland … its a growing company with ambitions out of this world, *literally* …



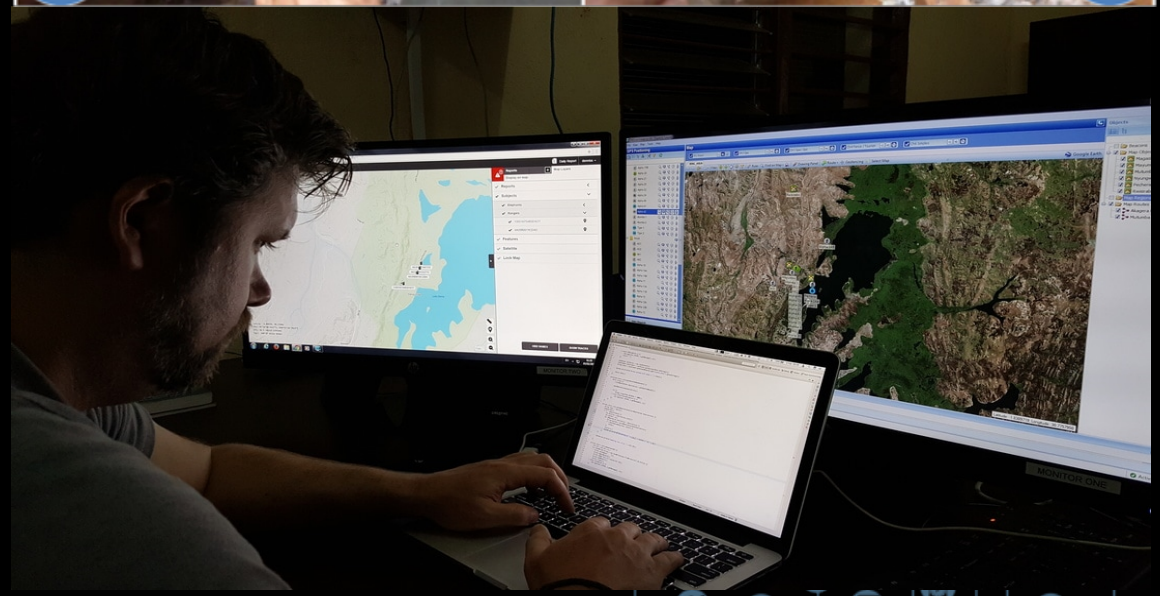
Internet of Life

The Smart Parks solution provides National Parks with a new tool to protect wild life and to improve park management.

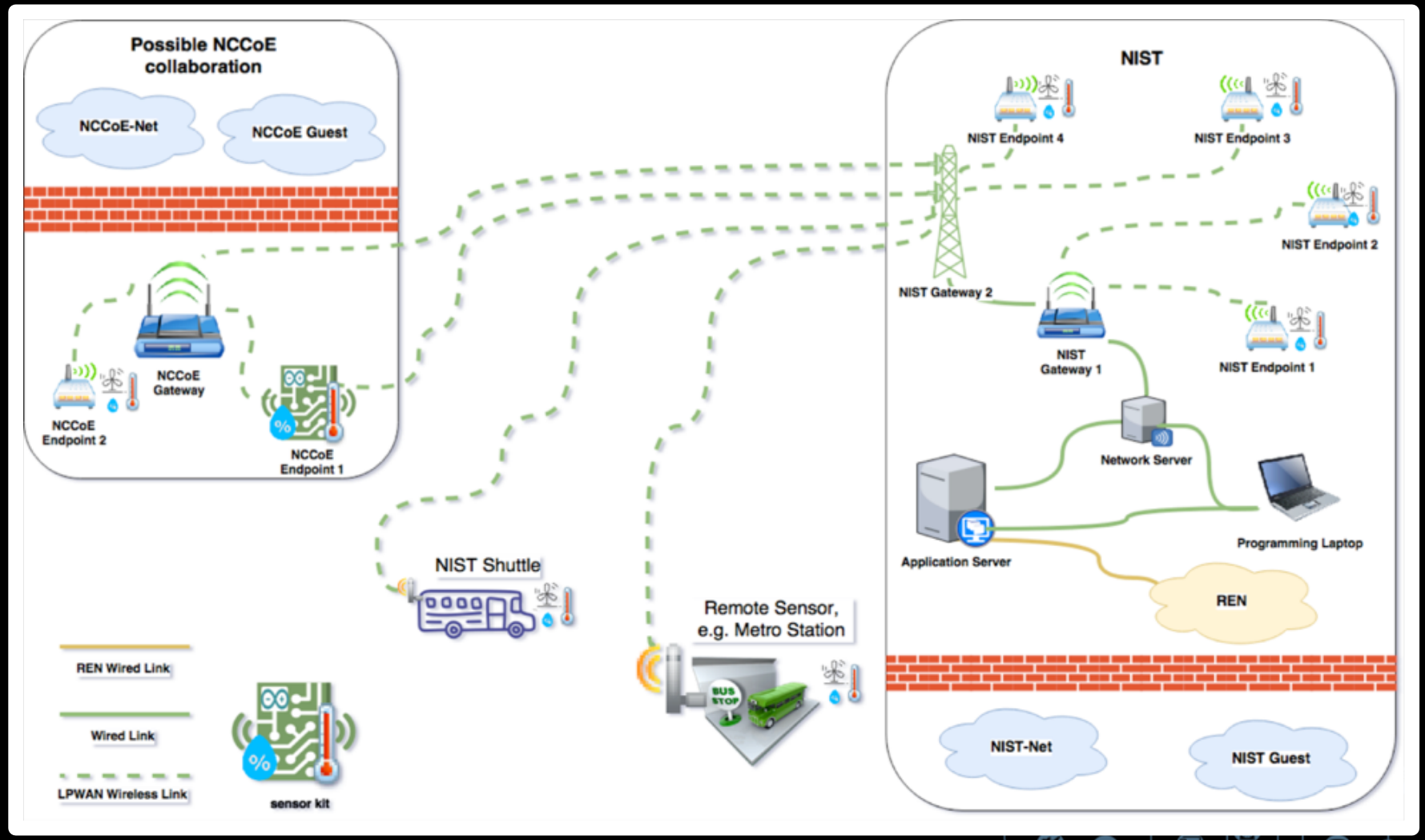
Since most National Parks have no basic 3G or 4G internet coverage, we start by covering the conservation area with a state of the art communication network to collect data from sensors we distribute across the park. We provide sensors to securely track wild life and to protect the area with gate sensors. The data is processed and presented in an easy to use web application. This is called Situational Awareness and is very important in modern wildlife conservation.

Internet of Life

- Covering **1.122 km2**, (almost Montgomery County Area) including **black rhinos** and over 12.000 other large mammals with 12 gateways
- Highest tower is **40 meters**, lowest tower is 8 meters
- Highest tower location is situated at **+1.800 meters** above sea level
- Installed over **80 trackers**, collecting over **100.000 location updates per day**
- Already collected over **1.500.000 location updated** in 3 months
- System has **0% downtime** since first installation
- Total time of development and deployment is **8 months** only

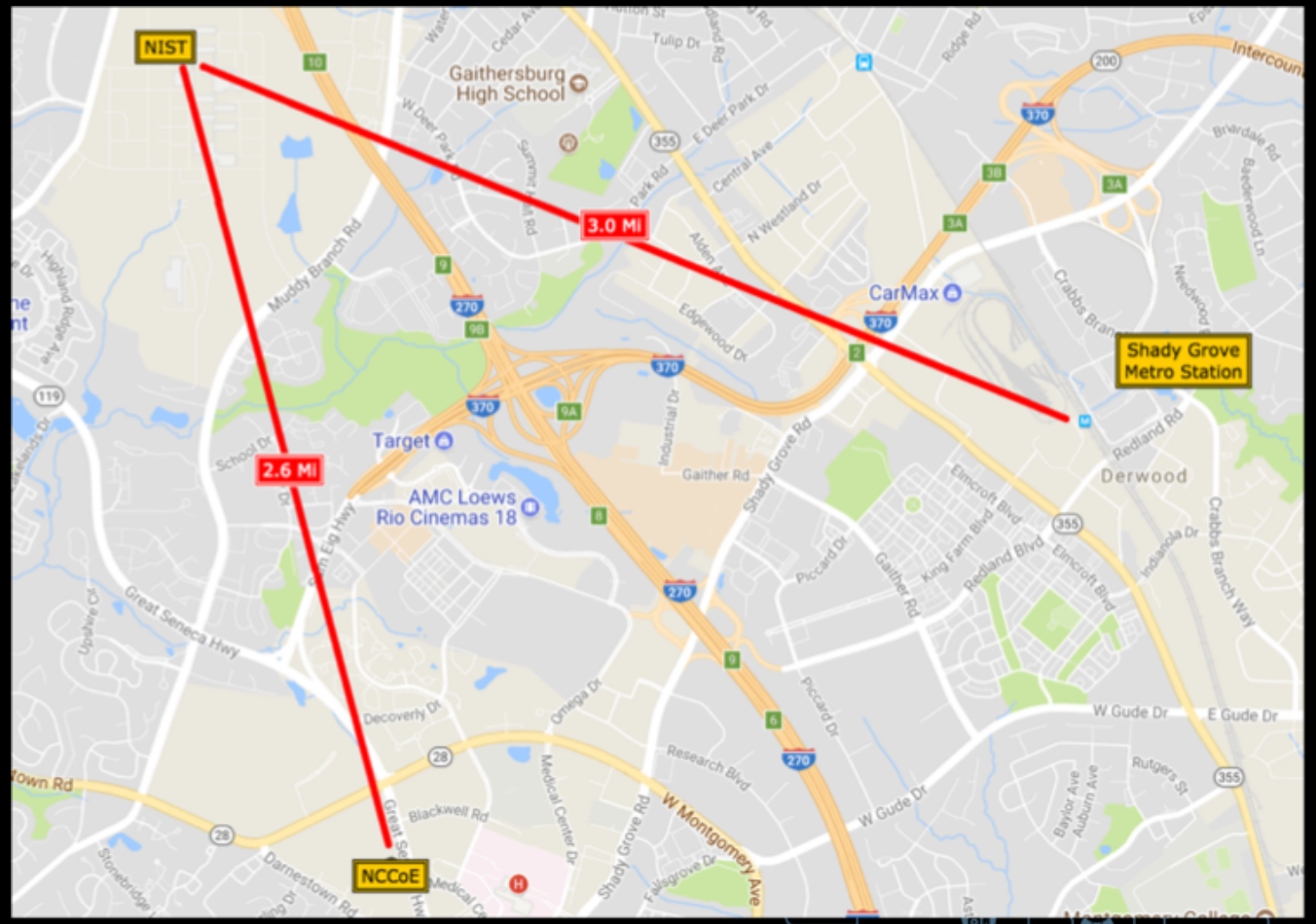


NIST IoT-LPWAN Laboratory Project



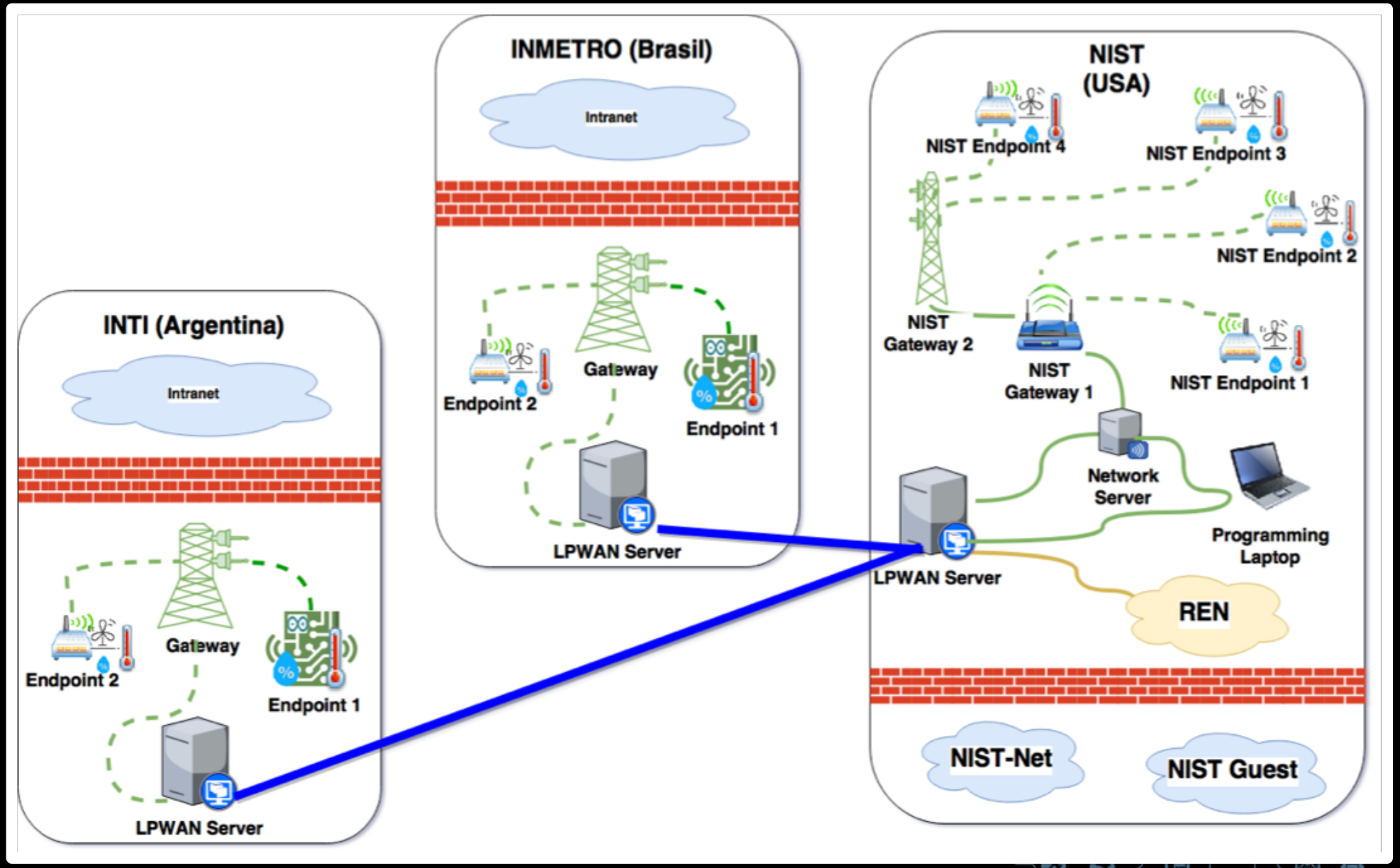
NIST IoT-LPWAN Laboratory Project

A real wide laboratory
does not fit in a room.



SIM IoT-LPWAN INTER-NETWORK

Preliminary



BRAINSTORMING TIME!

- How will you use LPWAN?

REFERENCES

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- https://flood.network
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