

WELCOME TO LoRaWAN™ LIVE



**Creating
Valuable**

IoT

Connections



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CEO Keynote

Donna Moore, CEO and Chairwoman
LoRa Alliance™



**Creating
Valuable**

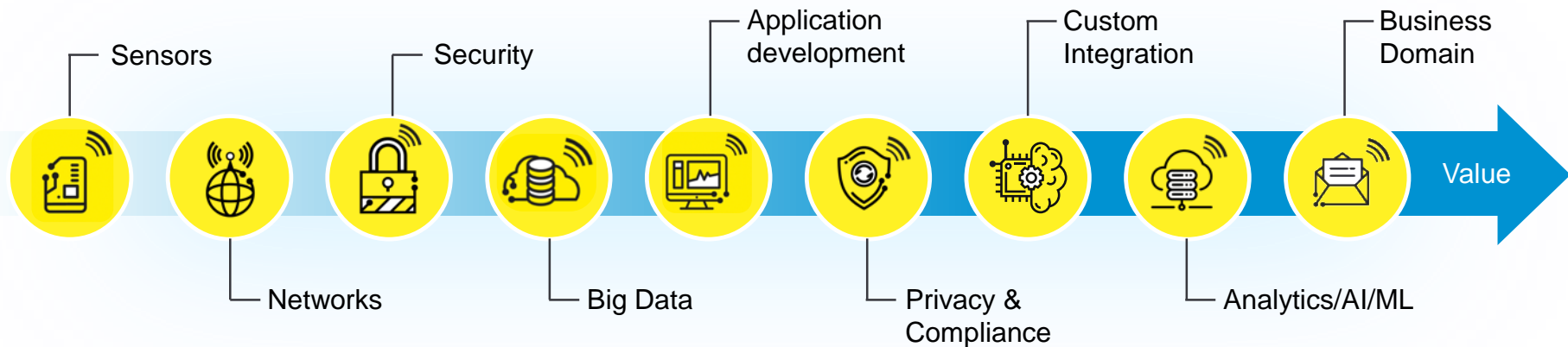
IoT

Connections



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SUCCESS IN IoT PROJECTS NEEDS EXPERTISE IN



SUCCESS IN IoT PROJECTS NEEDS LoRaWAN™ AND THE LoRa ALLIANCE

Working with the LoRa Alliance and LoRaWAN technology gives members access to the largest and most dynamic LPWAN ecosystem



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Creating Valuable IoT Connections | lora-alliance.org



LARGEST LPWAN TECHNOLOGY ALLIANCE

LoRa Alliance™

Sponsor & Contributor Members

+ >300 Adopter Members



2015

2019

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LoRaWAN™ ECOSYSTEM — COMPLETE IoT SOLUTIONS

Silicon to Solutions



Chipsets



Modules



Devices



Gateways



Servers



Operators



Cloud
Platforms/
Data
Management



Solutions



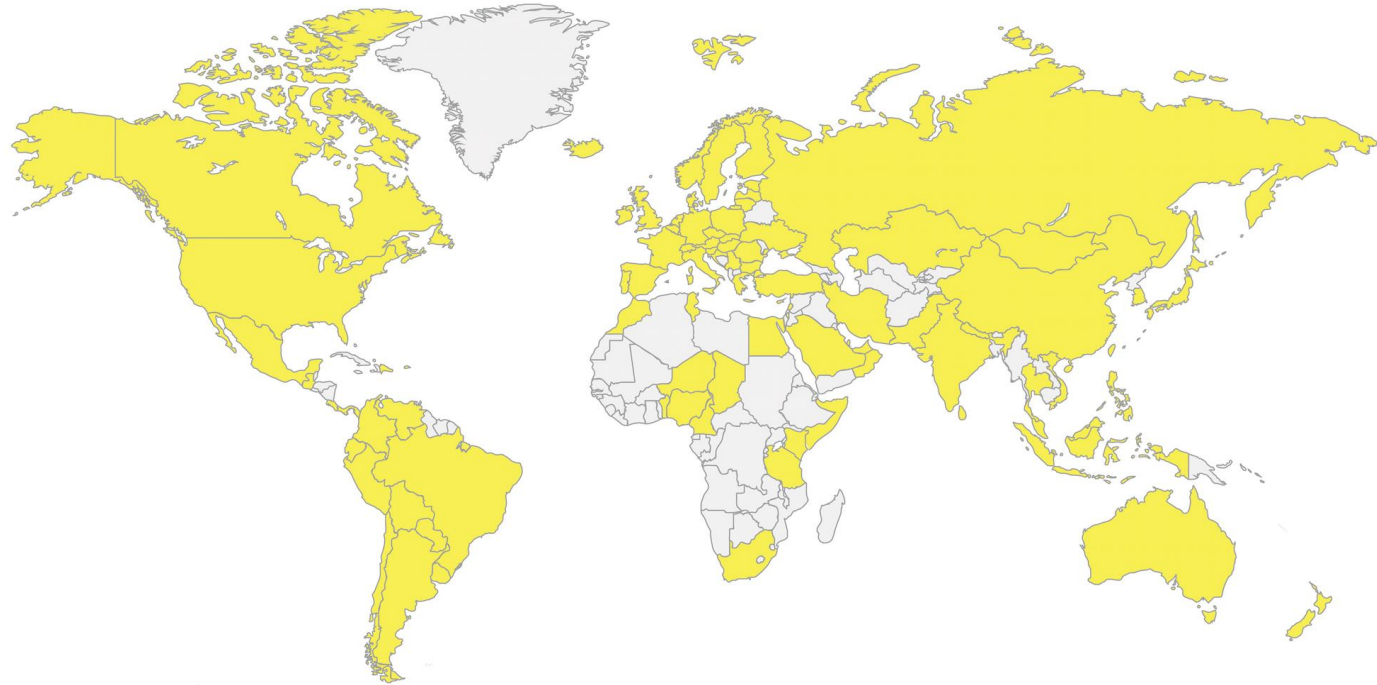
System
Integrators

OUR GROWTH CONTINUES

LoRaWAN™ Network Coverage: 60% Growth in 2018

100+
LoRaWAN
Network
Operators

100+
Countries with
LoRaWAN
Deployments



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LIASONS AND COLLABORATIONS



IoT Connectivity
Alliance



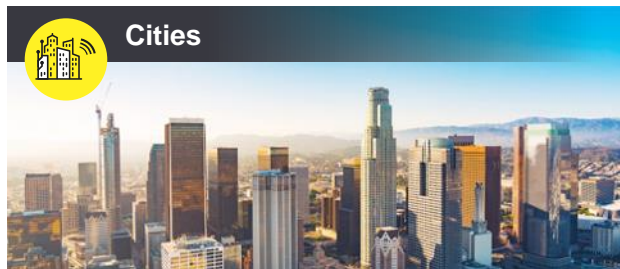
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WIDE RANGE OF VERTICAL MARKET DEPLOYMENTS



Differentiators & Benefits



Flexible
Deployment
Options



Future
Proof



Geolocation



Secure

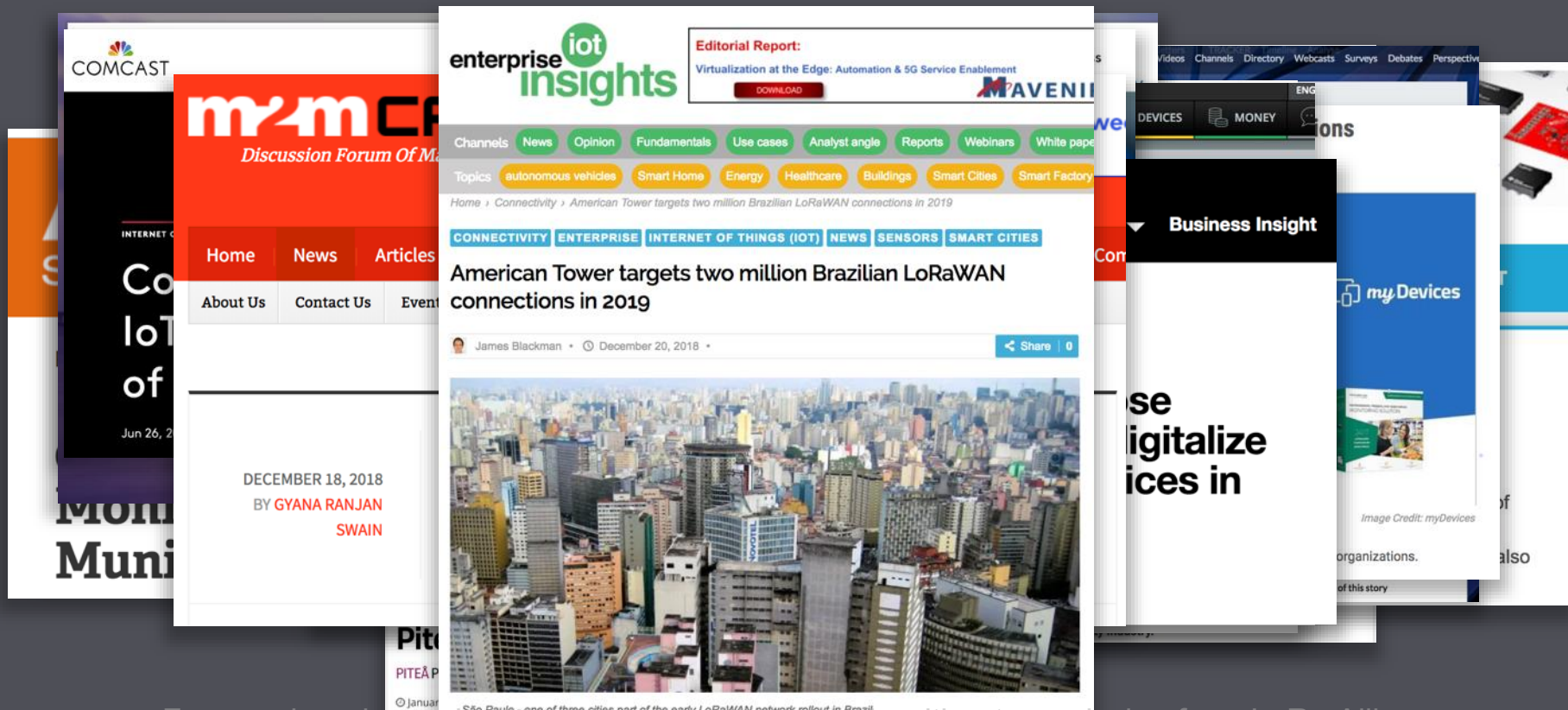


Coverage



Energy
Efficiency

SUCCESSFUL DEPLOYMENTS ARE HAPPENING NOW



São Paulo - one of three cities part of the early LoRaWAN network rollout in Brazil

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LoRaWAN™ LIVE: LoRaWAN IN ACTION!



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BECOME A MEMBER! LEARN MORE ABOUT THE ALLIANCE



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DON'T MISS OUT!

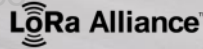


lora-alliance.org | [@loraalliance](https://twitter.com/loraalliance)

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LoRaWAN™

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Connections



@LoRaAlliance



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WELCOME TO LoRaWAN™ LIVE

Ali Hosseini, Marketing Committee Co-Chair, LoRa Alliance™



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MOMENTA
VENTURES

VENTURE INDUSTRIALISTS

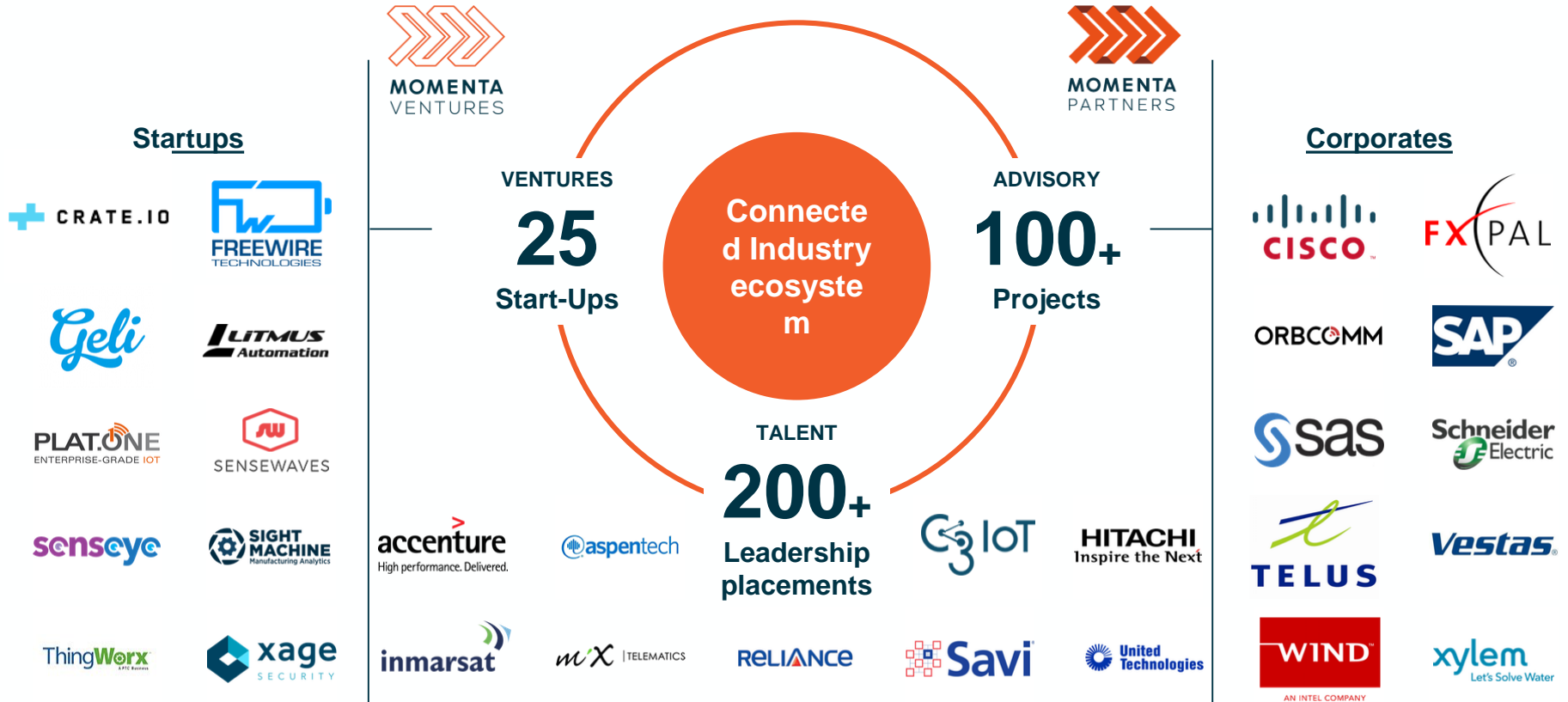
Venture Capital Perspectives of
LoRaWAN™ and the IoT Market

Ken Forster
Managing Director

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Connected Industry Growth Partners



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We are Venture Industrialists



1 Deep Industry Practitioners

A deep bench of **20+ Connected Industry leaders** across the US and Europe including the former **CTO of GE Oil & Gas**, **CTO of IBM Watson**, **Chief Architect at Schneider Electric** as well as founders of leading startups



2 Experienced Growth Partners

Industry-recognized Advisory, Talent and Ventures practices; **integrated, end-to-end to exclusively focus on Connected Industry Digitalization**



3 Purpose-Driven, Disciplined Investors

We invest with purpose, precisely cultivating and accelerating growth toward a healthy exit – **We call this orchestrated exits**

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Connected Industry Fund, Ecosystem building ('full stack')

Investing at the intersection of Vertical Solutions and Enabling Technologies

Market size 2020 CAGR 2015 - 2020

\$64B

40%

By 2020

- 50% of IoT spending will be driven by discrete manufacturing, transportation and logistics, and utilities
- Vertical solutions and analytics layers will have captured 60% of the growth from IoT

Vertical Solutions



Energy



Manufacturing



Smart Spaces



Supply Chain & Logistics

Market size 2020 CAGR 2015 - 2020

\$85B

30-40%

By 2020

- The IT spend on edge infrastructure will reach up to 18% of the total spend on IoT infrastructure

Enterprise Platforms



Edge Products



EDGE COMPUTE



NEXT GEN GATEWAYS & WIRELESS NETWORKS

Source: The Boston Consulting Group, IDC

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Growing our impact and influence



6 companies
2 exits

21 companies
1 exit



Insight



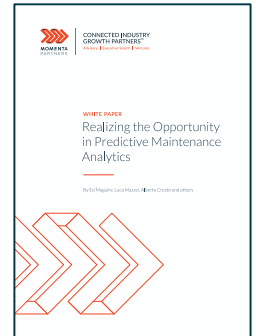
Podcasts



Webinars



Whitepapers



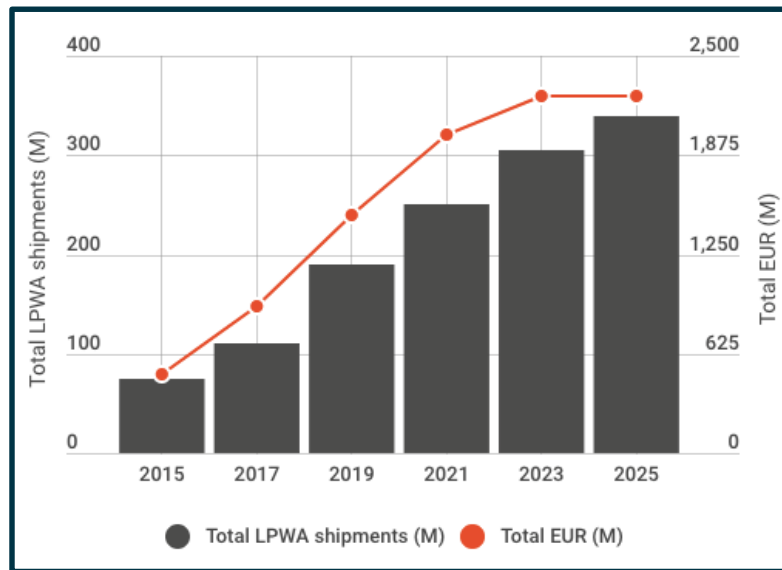
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Why invest in Low Power, Wide Area Networks?

High growth, strong fundamentals, underserved by traditional VC



- LPWA networks are the DNA of IoT, enabling innovative solutions
- Global LPWAN market to grow from \$1bn in 2016 to \$24B in 2021, 89% CAGR
- LPWAN units shipped rising from 109M in 2017 to 339M in 2025
- One billion LPWAN sensors to be deployed by 2020
- Space underserved by traditional Venture Capital due to HW + Infrastructure bias



Source: MarketsandMarkets, LoRa Alliance, IDATE, Business Intelligence

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Why invest in LoRaWAN?

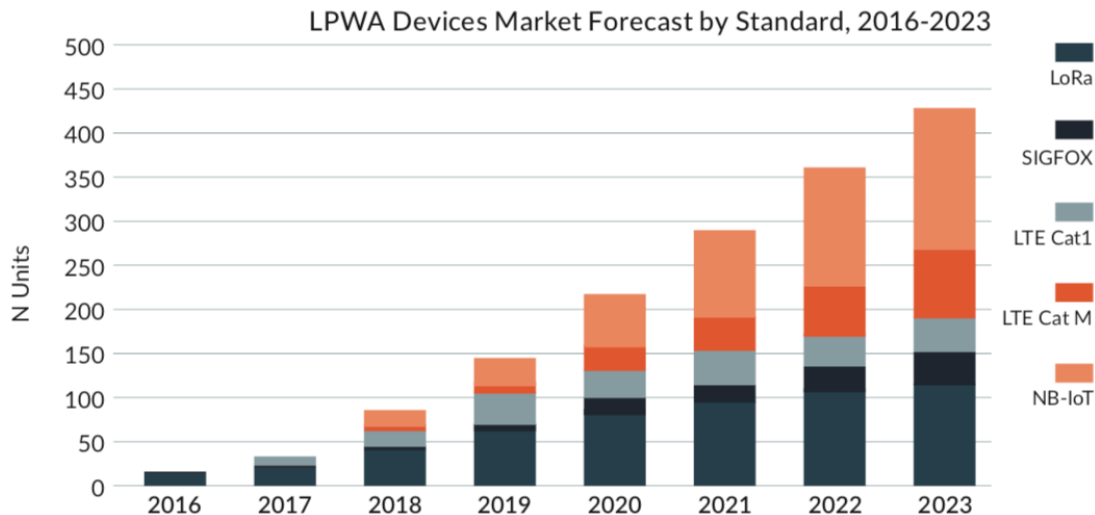
Strong initial traction, competition slow, market share opportunities

LoRaWAN is De Facto Standard

- 80M+ connected devices
- 60K+ developers (TTN)
- 10K+ networks
- Backed by giants
- Supported by this alliance

Licensed Spectrum offerings validate/complement

- NB-IoT: 116 operators actively investing, 59 deployed/commercial networks
- LTE-M: 47 operators actively investing, 19 deployed/commercial networks



Source: Takeshi Niwa, Techno Systems Research (TSR)

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LoRaWAN uniquely-positioned to benefit from investment

Flexible deployment and business models inspire innovation, strong ecosystem



BUSINESS MODEL FLEXIBILITY

Different business models in terms of network deployment that give freedom of choice to B2B customers (public, private and community networks)



CRITICAL MASS

Availability: Already deployed in very large volumes globally making it the most deployed LPWAN technology as of today



OPEN ECOSYSTEM

Open-source protocol is based on industry collaboration, allowing us to achieve a stronger technology that is truly future-proof



VAST APPLICABILITY

Strength and coverage in all key vertical markets with numerous, sustainable use cases

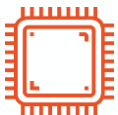
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LPWAN Ecosystem Investment Thesis

Expand Supply Side

Invest in end devices to drive more compelling edge capabilities and increase device/sensor shipment volumes

Sensors



Devices



Networks



Gateways



Drive the Demand Side

Invest to create pull that builds 'high visibility' value on top of edge devices and data from endpoints

Precision Agriculture



Smart Cities



Distributed Energy



Asset Tracking



Deploy at Enterprise Scale

Invest in capabilities that support the deployment of devices at scale

Data Attestation



Deployment Services



Monitoring



App. Building Blocks



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Announcing our LPWAN Fund

LPWAN Ecosystem Fund

- \$25M (min.), \$50M (target)
- Strategic Investor led
- Global
- Seed and Series A
- \$500K to \$1.5M investments
- First Closing: February
- First Investment: February

MOMENTA VENTURES
LPWAN Ecosystem Investments

Venture Capital for LPWAN-powered Solutions in Connected Industry

Investment Focus

Edge Device Manufacturers

Industry Solutions

- Energy
- Manufacturing
- Smart Spaces
- Supply Chain

Enterprise Enablers

- Applications
- Management
- Security

Profile

Type: Multi-Strategic

Sourcing

- LPWAN Stakeholders
- Ecosystem Alliances
- Momenta Partners

Sourcing Advantage

Unique access, insights, and impact to see the best deals via Momenta ecosystem, create investment opportunities, have a point of view on where opportunity exists before others

Competitive Advantage

Momenta will provide direct acceleration, mentoring and talent placement through its deep industry Acceleration Partners

Global Focus

Headquartered in Switzerland, global investments

accelerate Enterprise Use

in companies that support and for the deployment of devices

Why Invest in LPWAN?

- Global LPWAN market to grow to USD 24bn in 2021, CAGR of 90%
- Three billion LPWAN connected devices forecast by 2021
- Space underserved by traditional Venture Capital

Inflection Point

The LPWAN market is consolidating across unlicensed and licensed spectrum standards, creating hyper-growth opportunities. LoRaWAN is the de facto standard complementing emerging 5G offerings.

LPWA Devices Market Forecast by Standard, 2016-2023

Year	LoRa	4G LTE	5G NR	NB-IoT	LTE Cat M	4G LTE	5G NR	NB-IoT	LTE Cat M
2016	10	10	10	10	10	10	10	10	10
2017	20	20	20	20	20	20	20	20	20
2018	40	40	40	40	40	40	40	40	40
2019	80	80	80	80	80	80	80	80	80
2020	160	160	160	160	160	160	160	160	160
2021	320	320	320	320	320	320	320	320	320
2022	640	640	640	640	640	640	640	640	640
2023	1280	1280	1280	1280	1280	1280	1280	1280	1280

Investor Benefits

Investors will gain visibility to high-potential sub-sectors, technology innovators and startups in core growth areas that would not be seen until much later. This will inform product portfolio development, distribution strategy and investments as well as provide de facto early access to companies of particular strategic interest for commercial partnerships and acquisition.

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Networks **Devices** **Precision Agriculture** **Smart Cities** **Device Management** **Deployment Services**

Gateways **Distributed Energy** **Asset Tracking** **Monitoring** **Data Attestation** **App Building Blocks**

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Connect with us



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Stephen Berard

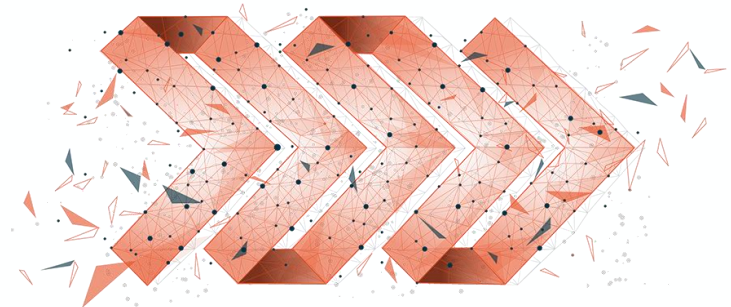
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CONNECTED INDUSTRY GROWTH PARTNERS™



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LoRaWAN™ Around the World

David Smith, CTO, MultiTech & LoRaWAN Ambassador



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LoRaWAN Worldwide

What is so complicated?

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The world is a big place

- There are 195 different countries in the world today, plus several dozen additional other entities
 - 193 are members of the United Nations
 - The ITU (International Telecommunication Union) manages common spectral use for the UN
 - Frequency assignment authority is granted to **governments**
 - Many small or developing countries have no frequency assignment authority in place

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Deployment & Operation

So what do you need?

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To successfully deploy a LoRaWAN Network

- An understanding of intended offered services and supported use cases
- Know which Target countries or regions to deploy in
 - For each Target country or region you need:
 - Regulatory compliance
 - LoRaWAN Channel plans
 - Back end cloud entities

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LoRaWAN™ Resources

How can we help?

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Regional Parameters Work Group

- What do we do?
- Regional Parameters Work Group creates, manages and maintains the OTA operation of LoRaWAN worldwide
- Specifies operating procedures for every supported region for every supported class of operation
- Develops mechanisms to spur rapid deployment of interoperable endpoints
- Defines new capabilities to expand market footprint

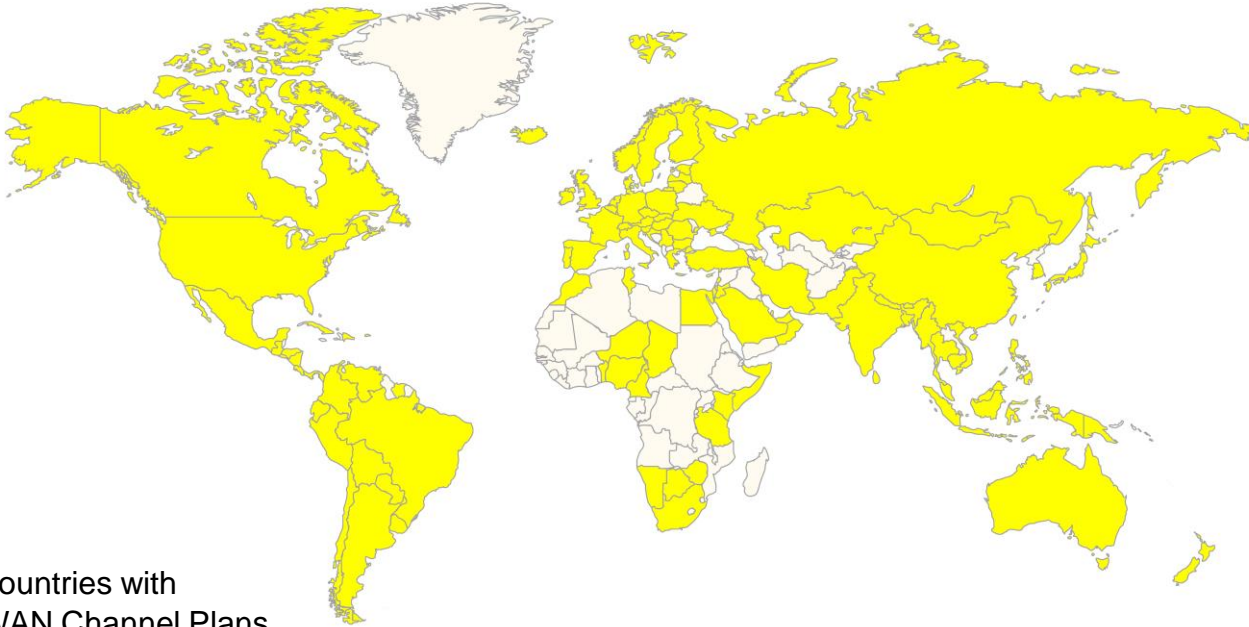
Reference Documents

- Channel Plans and more...
- **Regional Parameters Specification:**
 - Specifies the physical layer operation of LoRaWAN
 - Specifies details of Class A, B and C operation
 - Provides channel plans that are mapped to countries and regions
 - Next release is planned for next AMM in San Diego
- **Regional Regulation Summary:**
 - Provides a wealth of information on a per-country basis
 - Newly switched to the ISO 3166-1 Country name codes
 - Document is updated regularly

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LoRaWAN Around the World

LoRaWAN CHANNEL PLAN COVERAGE



135 Countries with
LoRaWAN Channel Plans

>100 Countries with LoRaWAN Deployments

January 2019

All information contained herein is current at time of publishing - LoRa Alliance is not responsible for the accuracy of information presented



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Important Regional Changes

- Spectrum allocations change over time
- Areas where additional spectrum will be added:
 - **European Union:**
 - Added SRD portions are 870-874.4 MHz and 915-921 MHz
 - Not all EU members will implement due to local use conflicts
 - Will take some time before actually being available
 - **Australia:**
 - Added portion is 928-933 MHz
 - Additional spectrum has a several year transition period
 - New frequencies have different regulatory requirements

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Upcoming Developments

- Cool new stuff we are working on
- World-wide Wake-up
- LoRaWAN in licensed bands
- LoRaWAN in Space
- Superplans

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**QUESTIONS?
THANK YOU.**

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NFC Forum – LoRa Alliance Liaison: Example of Firmware Upgrade Problematics

Daniel Merino



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NFC Technology at the glance

An interactive technology enabling engagement with IoT devices



- Near Field Communication, a short range wireless technology

- Operating at 13.56MHz
- Based on the RFID HF standard (ISO14443 & ISO15693)



- Interactive and zero power, enabling convenient connection to the IoT
→ NFC-enabled mobile phone can engage with items by a simple tap



- NFC is developed by the NFC Forum
 - Interoperability between devices
 - Standardized use cases (web link, Bluetooth handover,...)



- Fast growing deployment in Mobile phone
 - In 2018, two in three phones to come with NFC



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→ as a short range radio, NFC can complement to the LoRaWAN technology

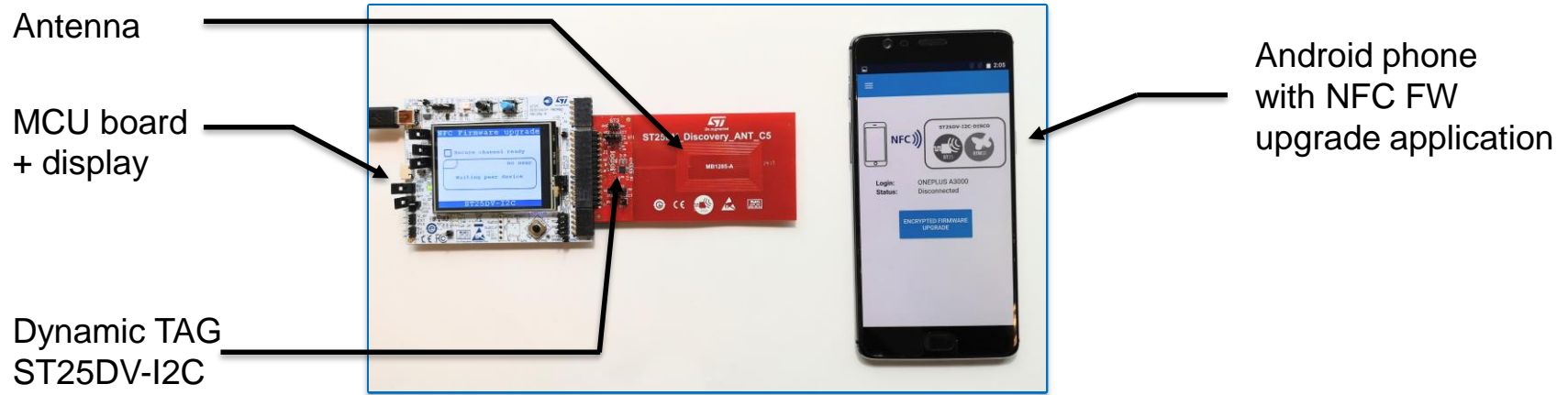
Practical Firmware Upgrade with NFC



- The Dynamic NFC Tag is connected to the end-device microcontroller with an I2C link.
- The Dynamic NFC Tag and the Phone / Reader exchange data with contactless short range NFC technology.

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NFC Demo Brief Overview



- The firmware file of 95kByte is transferred in 45 seconds (depending on phones).
- All the transmission is encrypted.
- If the phone is removed from the field and back, the transmission resumes.

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Look for the Logo:
Tested & Certified



ATC LoRaWAN Network in Brazil – What We Have Experienced So Far

Daniel Laper, New Business Development, American Tower Brazil



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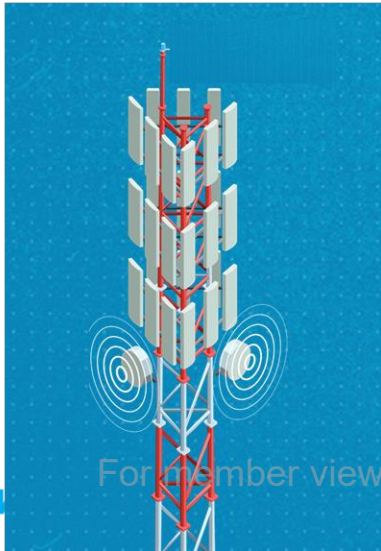
American Tower

Tower company leader

in Brazil, with ~30-35%
marketshare

Main provider

of telecom infrastructure
in the country



Global Presence

17 countries

170.000+ sites in the world

19.000+ sites in Brazil



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Brazil – The Largest Country In Latin America

BRAZIL

THE LARGEST COUNTRY
IN LATIN AMERICA



At **208M** people
we are **35%** of
LATAM
population



34%
of GDP



40%
of land area



37%
of the
cellular
subscribers
(**236,5 MM**)



19MM
M2M
simcards

Source: World Bank / Brazilian Development Bank (BNDES) National IoT Plan / IBPT / Teleco

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The Local Market Is Excited

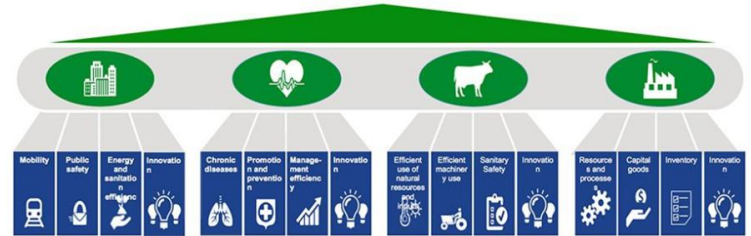
NEWS

Brazil's national IoT strategy gets the green light

By Malek Murison - March 28, 2018

The Brazilian government plans to start implementing a national IoT plan, according to the country's Ministry of Science, Technology, Innovation, and Communications (MCTIC).

McKinsey's IoT strategy plan could boost Brazilian economy by \$200 billion with a focus on healthcare, agribusiness, smart cities and industry



McKinsey's IoT strategy plan could boost Brazilian economy by \$200 billion

📅 25 June 2018 | Consultancy.lat

A plan by management consultancy McKinsey & Company in conjunction with a local innovative IoT solutions firm has been adopted by the Brazilian Government. The "Action Plan for Brazil" says that the widespread adoption of IoT technologies throughout the country could add up to \$200 billion to the Brazilian economy by 2025.

Latest news



Te
up

Source: Brazilian Development Bank (BNDES) National IoT Plan

https://www.bndes.gov.br/SiteBNDES/bndes/bndes_en/Institucional/Press/Noticias/2019/20190111_bndes_internet.html

<https://internetofbusiness.com/brazil-national-iot-strategy/>

<https://www.consultancy.lat/news/400/mckinseys-iot-strategy-plan-could-boost-brazilian-economy-by-200-billion>

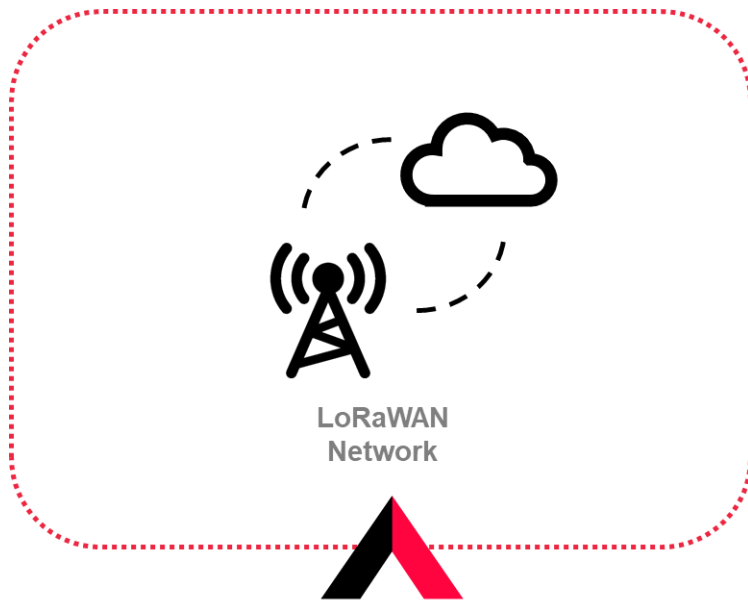
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ATC LoRaWAN Network in Brazil

Shared infrastructure network provider



Devices



LoRaWAN
Network



Applications

Pilot Phase: Set/17 to Mar/18

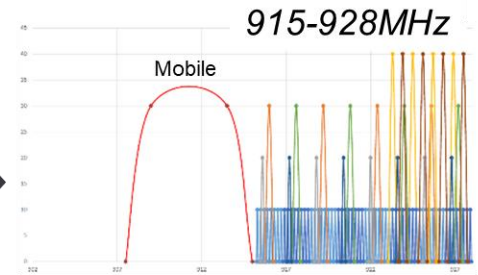
Coverage of São Paulo, Rio de Janeiro and Belo Horizonte, main national metro areas



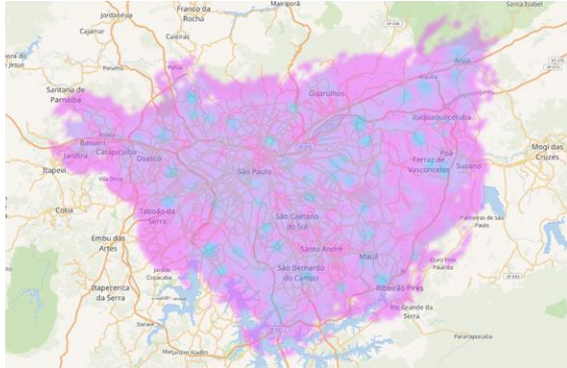
24% of Brazilian GDP
~35MM people
More than 15 use cases tested

ATC LoRaWAN Network uses AU915 channel plan as defined for Brazil in the LoRa Alliance regional parameters doc

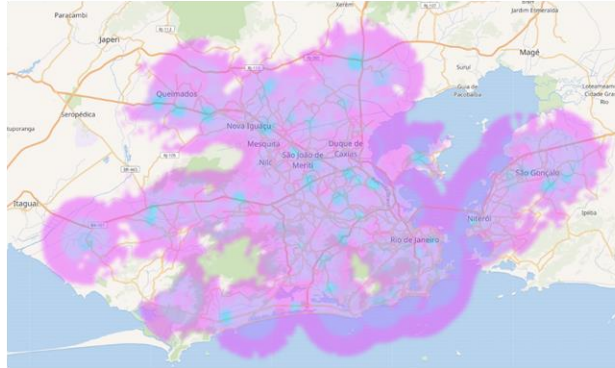
* compatible with several LatAm countries (AR, PA, CO, PE)



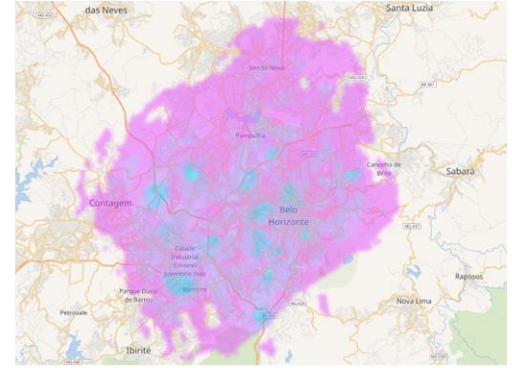
São Paulo



Rio de Janeiro



Belo Horizonte



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ATC LoRaWAN Brazil Network Commercial Launch: Oct/2018

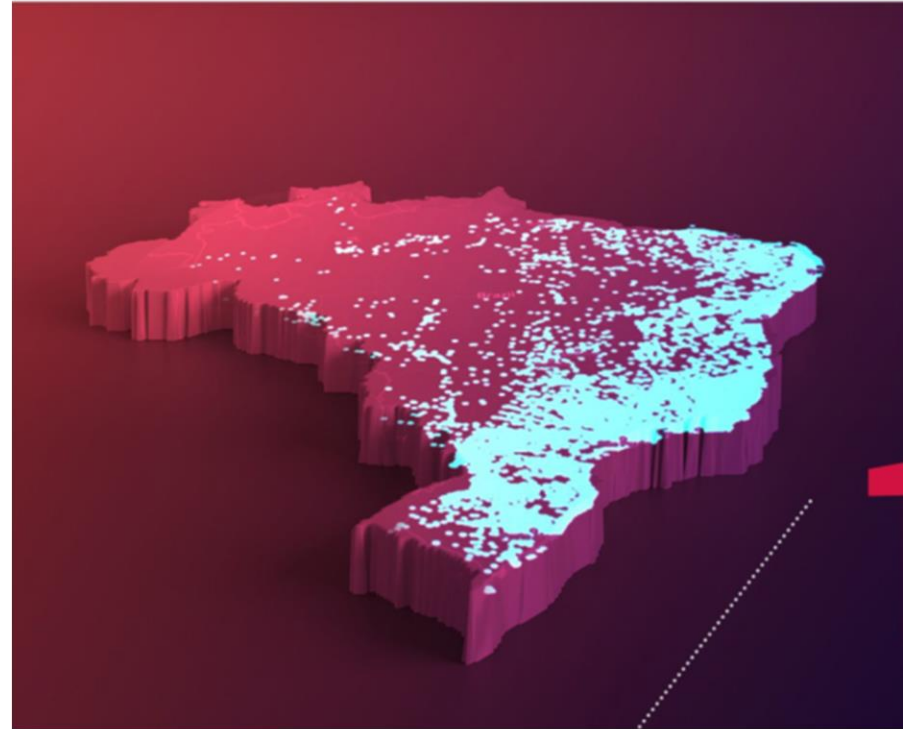
More than 35% of the Brazilian GDP already covered

2019 plan:

- Market opportunities/GDP
- Main roads
- Innovation poles

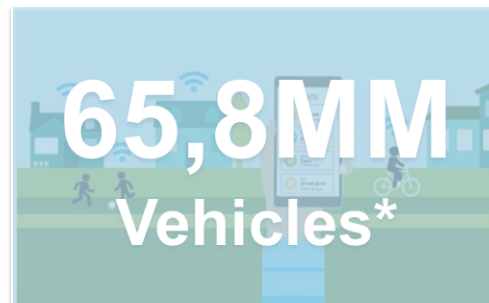
~ 80 cities

~ 50% of GDP

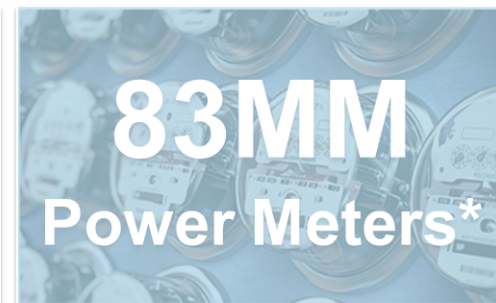


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Main Verticals & Some Interesting Numbers



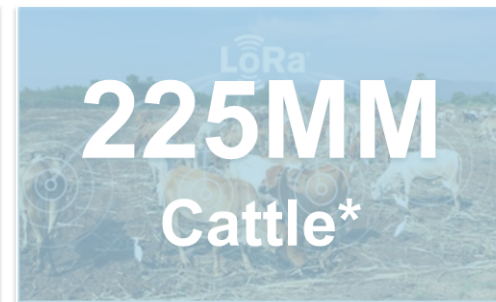
Fleet Management & Asset Tracking



Metering



Smart cities and places



Agribusiness



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Source: Brazilian Development Bank (BNDES) National IoT Plan / VERT / Telecom

*Estimated number of each one of those assets in the country (Brazil)

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Use case fleet tracking and stolen car recovery



Rede de IoT da American Tower já trafega mais de 3 milhões de mensagens/dia

Convergência Digital - Carreira
Convergência Digital* - 11/09/2018

A American Tower informa, por meio de comunicado divulgado nesta terça-feira, 11/09, que superou a marca de **300 mil dispositivos** conectados à sua infraestrutura de rede IoT/LoRaWAN. Em período de testes e com lançamento comercial previsto para o quarto trimestre, a rede que fornece cobertura de longo alcance e baixo custo, encontra-se em processo de ajustes finais. Atualmente a rede já trafega mais de **3,0 milhões de mensagens por dia**, cobrindo as regiões metropolitanas das cidades de São Paulo, Rio de Janeiro e Belo Horizonte, o que corresponde a cerca de 24% do PIB brasileiro.



**Sep/2018:
300k
devices**

**3MM
messages
/day**

**Exp. 2019:
1MM
devices**

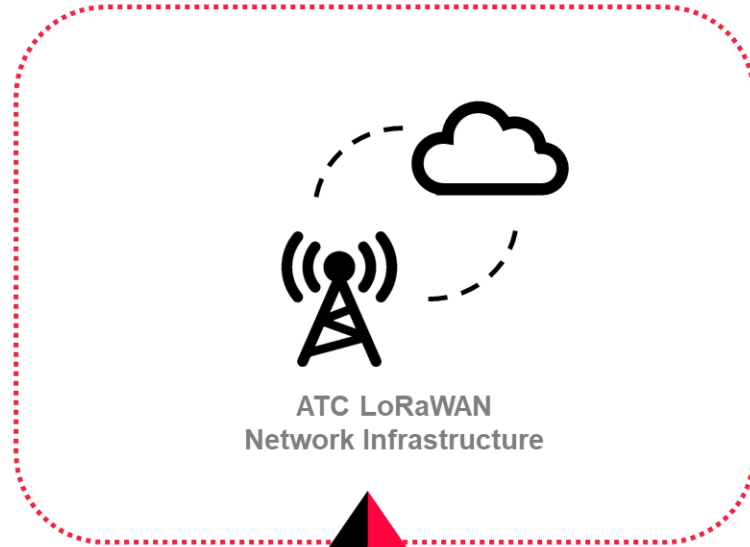
"A conquista desse expressivo resultado se deve à parceria estratégica da American Tower com a Maxtrack, especializada em rastreamento e telemetria no Brasil e usuário da infraestrutura da rede IoT/LoRaWAN. Temos como objetivo ampliar significativamente essa cobertura e alcançar, até meados de 2019, mais de 80 cidades brasileiras, aproximadamente 55% do PIB do país. Apenas para essa parceria e segmento são esperados **mais de 1 milhão de dispositivos ativados** e conectados à rede LoRaWAN até o final desse período. O crescimento vertiginoso nunca visto antes em uma rede como essa só está sendo possível porque o ecossistema do padrão LoRaWAN está pronto, tanto no nível de rede como no nível de dispositivos", afirma Abel Camargo, Diretor de Estratégia e Novos Negócios da American Tower Brasil.



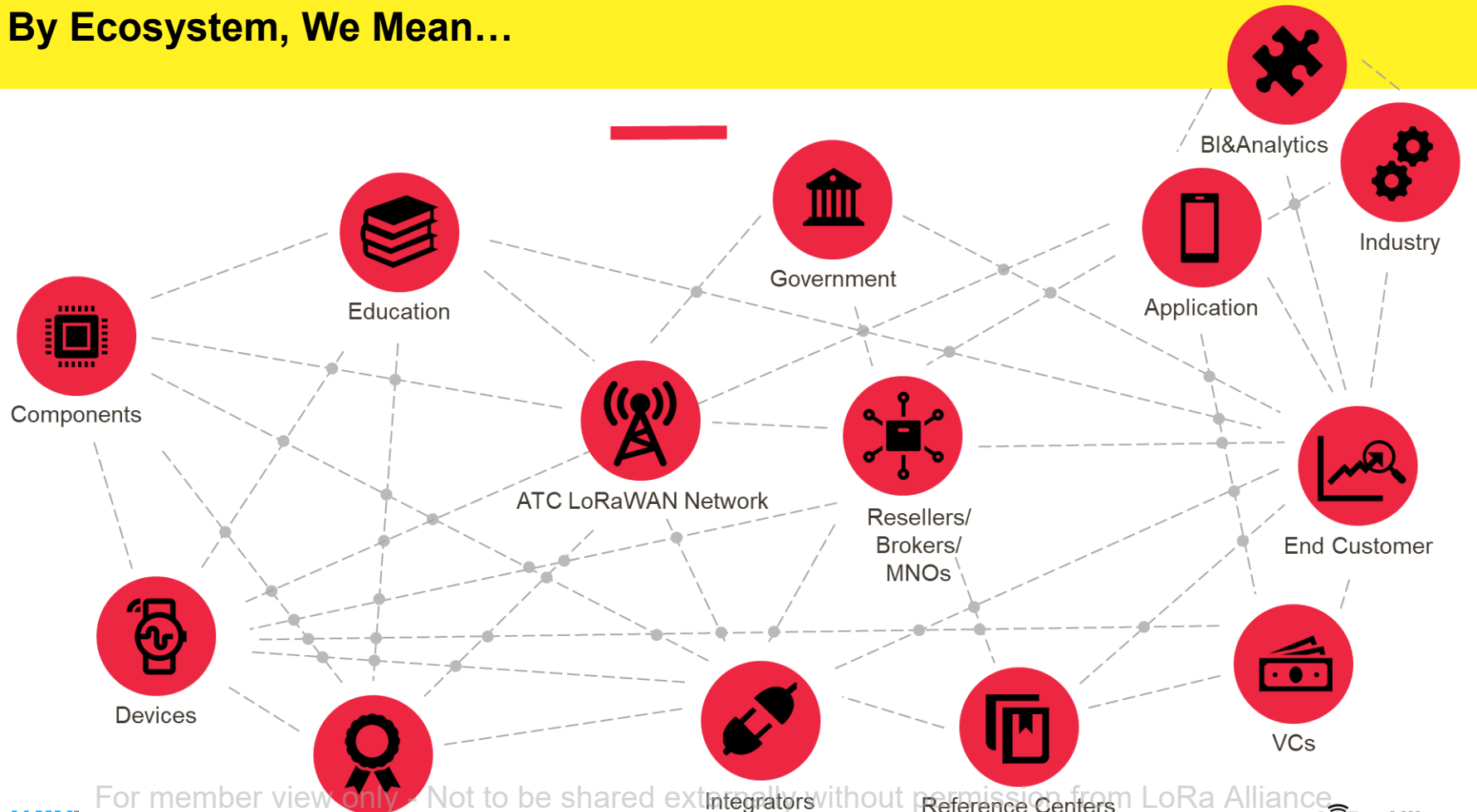
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ATC LoRaWAN Network in Brazil

The network is not enough, the ecosystem must be strong



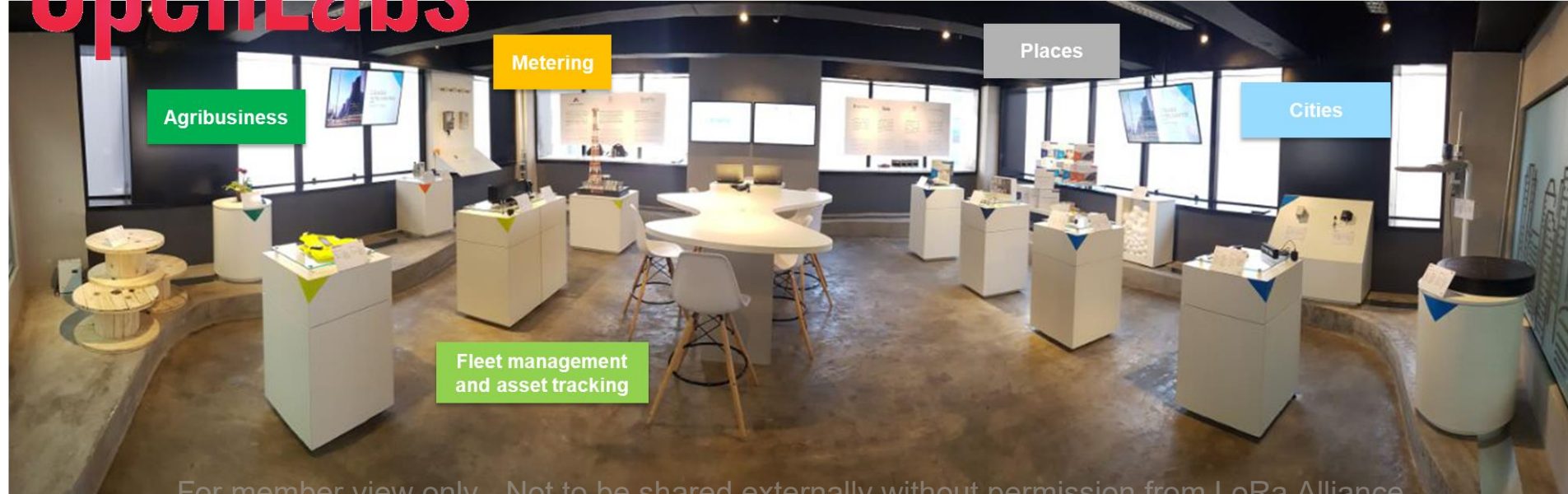
By Ecosystem, We Mean...



IoT Open Labs

IoT OpenLabs

A place to experience, learn and develop
LoRaWAN solutions and business



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IoT Open Labs – Main Pillars & Media



Education



**Experience
Center**



Events



Marketplace

American Tower cria centro nacional de desenvolvimento de IoT para suportar rede LoRa



Convergência Digital - Carreira
Por Roberta Prescott* - 02/05/2018

A [American Tower do Brasil \(ATC\)](#) está apostando em internet das coisas (IoT, na sigla em inglês). Tanto que está construindo uma rede usando a tecnologia LPWAN (low power wide area network) no padrão LoRa (long range) e em frequência não-licenciada (banda ISM, 900MHz). A companhia será fornecedora da infraestrutura de rede compartilhada no atacado e, para fomentar o mercado, anunciou o IoT Open Labs, um centro de experiência e desenvolvimento que tem parceria da ATC com a Everynet e BandTec Digital School.

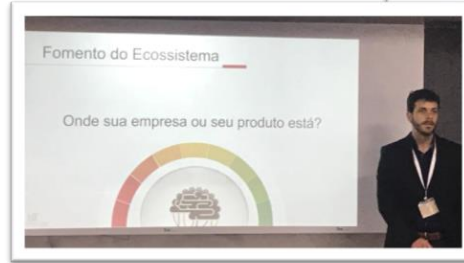
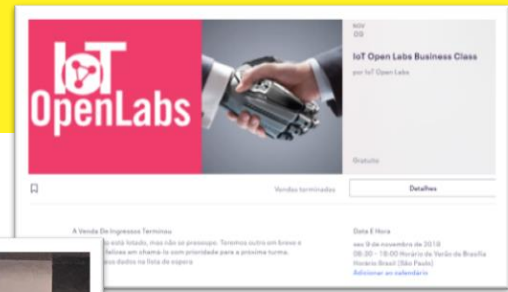
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Creating Valuable IoT Connections



IoT Open Labs Events

**Knowledge Class:
Business and technical
workshops with all
ecosystem
representatives**



The Real Challenge!

What is the opportunity you are willing to address?

Ready for start

Have you developed your solution? Are your devices and applications ready?

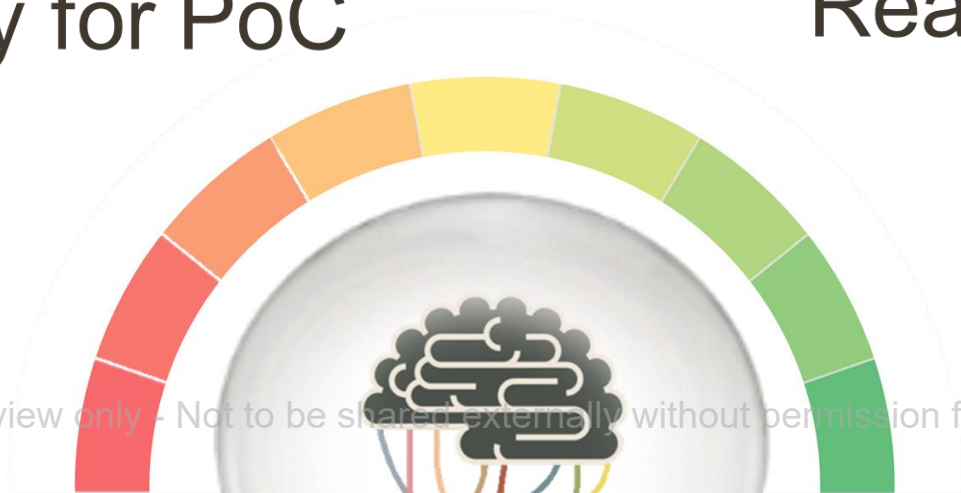
Ready for PoC

Have you certified your devices? Is the solution fine-tuned? Is the business model defined?

Ready for sale

Are you ready to deliver 100? 1.000? What about 1.000.000?

Ready for scale



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Thank you!

Daniel Laper
American Tower Brazil

daniel.giorgini@americantower.com



Deploying LoRaWAN™ Solutions in Healthcare

Brian Bielawski, Director of Business Development, Mydevices



Creating Valuable

IoT

Connections

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Why Deploy LoRaWAN Solutions in Healthcare?

- LoRaWAN solutions quickly, efficiently, and reliably monitor high-risk patients and a multitude of healthcare systems around the clock to ensure safety while delivering substantial time and money savings.



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Key LoRaWAN Features for Healthcare

Quick & Easy Setup



Solutions install within minutes and capture readings instantly

Real-Time Data



Monitors patients and critical systems around the clock

Efficient Wireless Sensors



Low-power, long-range devices can be placed in difficult to reach areas

End-to-End Security



AES 128-bit encryption ensures HIPAA-compliant data protection

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Real LoRaWAN Solution Application – Healthcare Refrigeration



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- The Joint Commission (TJC)
- Food & Drug Administration (FDA)
- Center for Disease Control (CDC)
- Environmental Protection Agency (EPA)
- State and Local Health Departments



Public Health
Prevent. Promote. Protect.

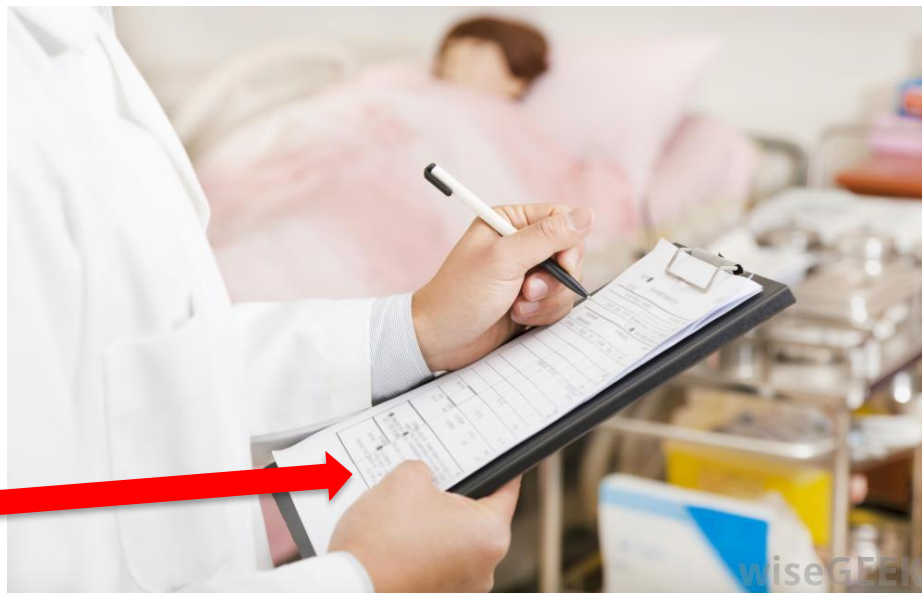
Manual Monitoring is Time Consuming & Expensive

St. Luke's Hospital of Kansas City, MO

COSTLY MANUAL MONITORING

# of units monitored	100
# of readings each day (per unit)	6
# of readings per month (all units)	18,000
# of minutes to check one unit	1
Avg. employee hourly rate	\$65.00
Cost per reading	\$1.08

Total cost per month to monitor
OVER \$233K/yr.



St. Luke's Hospital of Kansas City, MO

SIGNIFICANT ROI

	Before	After
# of units monitored	100	100
# of readings each day (per unit)	6	72
# of readings per month (all units)	18,000	216,000
# of minutes to check one unit	1	n/a
Avg. employee hourly rate	\$65	n/a
Cost per sensor per month	n/a	\$9
Cost per reading	\$1.08	\$0.004
Total cost per month to monitor	\$19,500	\$900

**SAVE OVER
\$2,000
per refrigerator
per year**

TOTAL SAVINGS = \$223,200 PER YEAR

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Testimonial – St. Luke's



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Temperature



Patient Tracking



Open/Close



Water Leak



Waste Bin



Parking



Air Quality



Pest Control

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LoRaWAN Solutions: Beyond Healthcare

Solutions meet the unique needs of any size facility across multiple vertical markets



Smart Agriculture



Smart Cities



Smart Buildings



Supply Chain/
Logistics



Utilities



Industrial

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Q&A

Brian Bielawski

Director of Business Development

Email: bbielawski@mydevices.com

Phone: (818) 436-3436

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Simulating LoRaWAN Devices

Jan Jongboom Principal Developer Evangelist, Arm



**Creating
Valuable**

IoT

Connections



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Who Am I?



Jan Jongboom

Principal Developer Evangelist, Arm
Doing LoRaWAN for the last 4 years

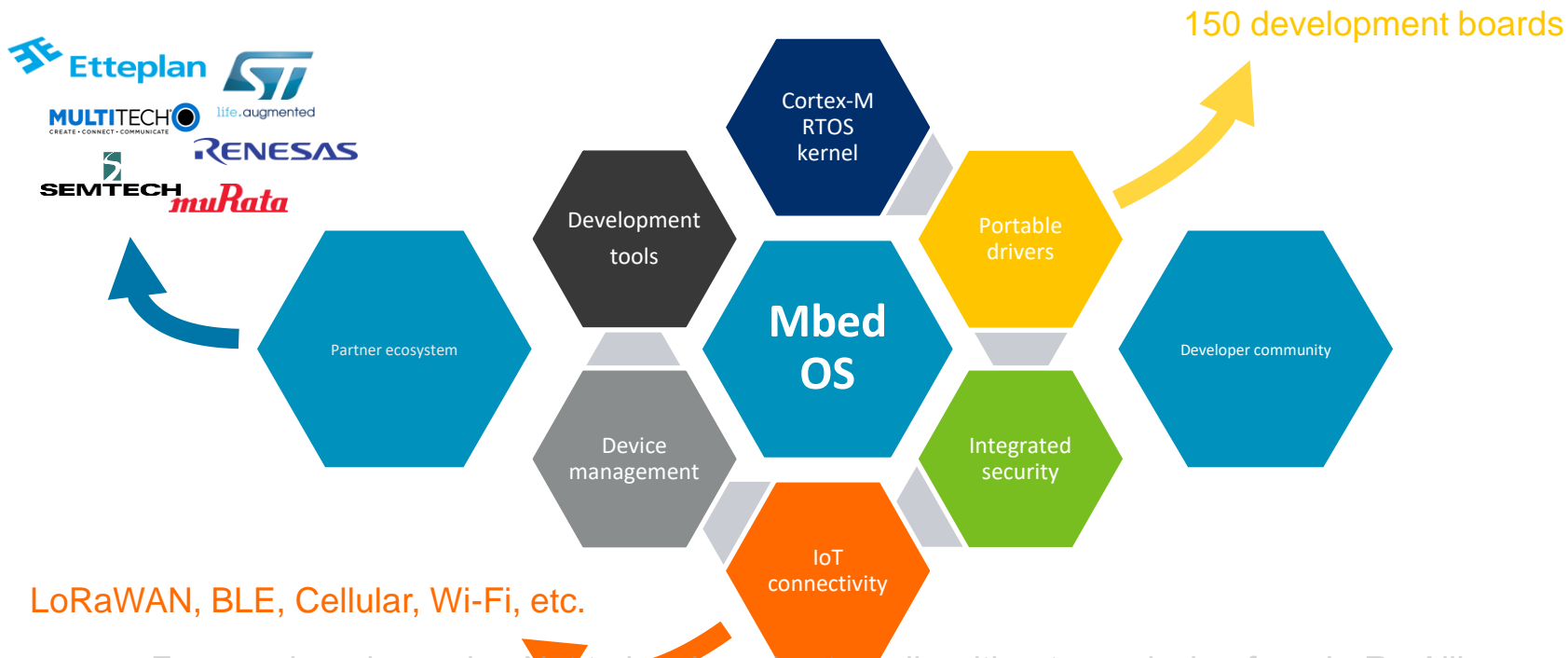
Arm

Semi-conductor company
21 billion processors sold last year
LoRa Alliance Contributor member

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arm MBED

A free, open source Platform OS targeting IoT end node devices



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LoRaWAN is Great, But...



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Testing Hard Connections

Device connected to multiple gateways with varying backhaul performance

Adaptive Data Rating

Rapidly moving devices

Uncalibrated crystals



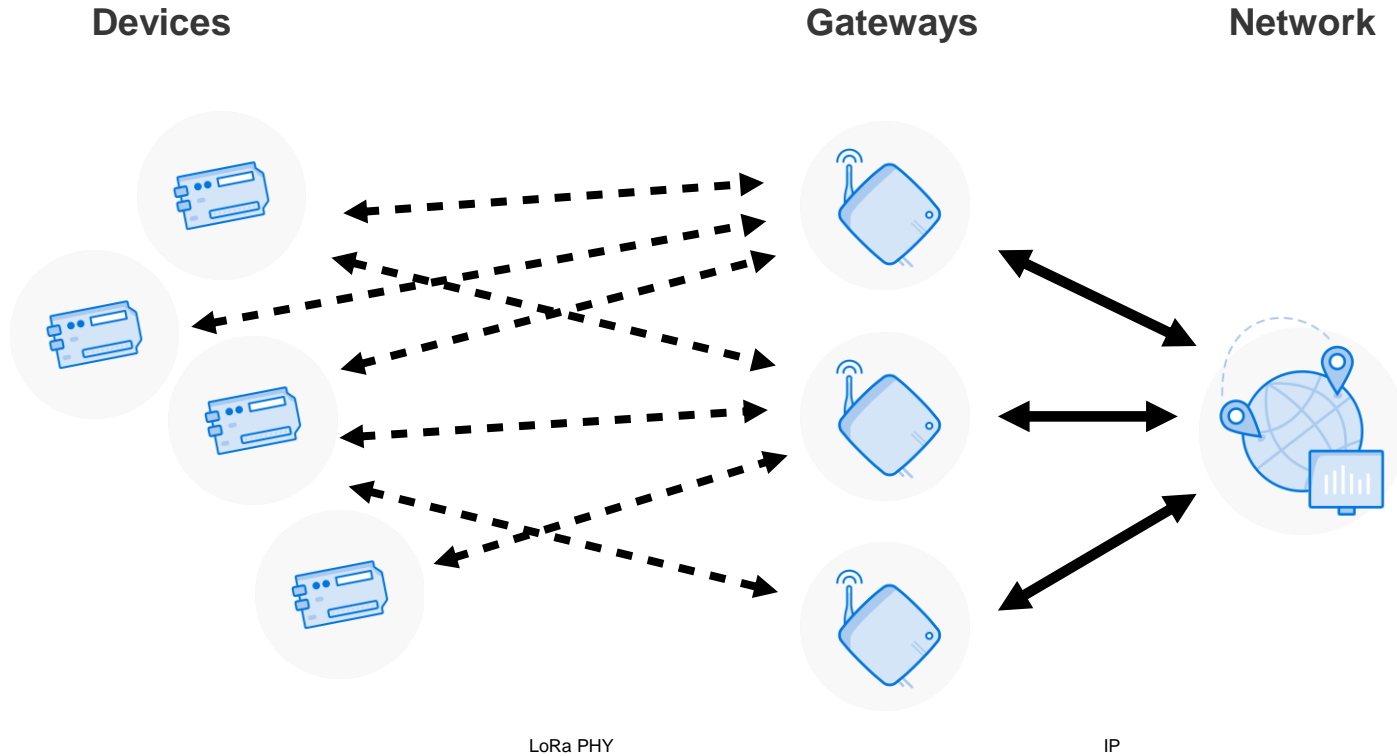
<http://www.redwoodcomm.com/product/01.php>

Can we do better?

Removing **LoRa** from LoRaWAN

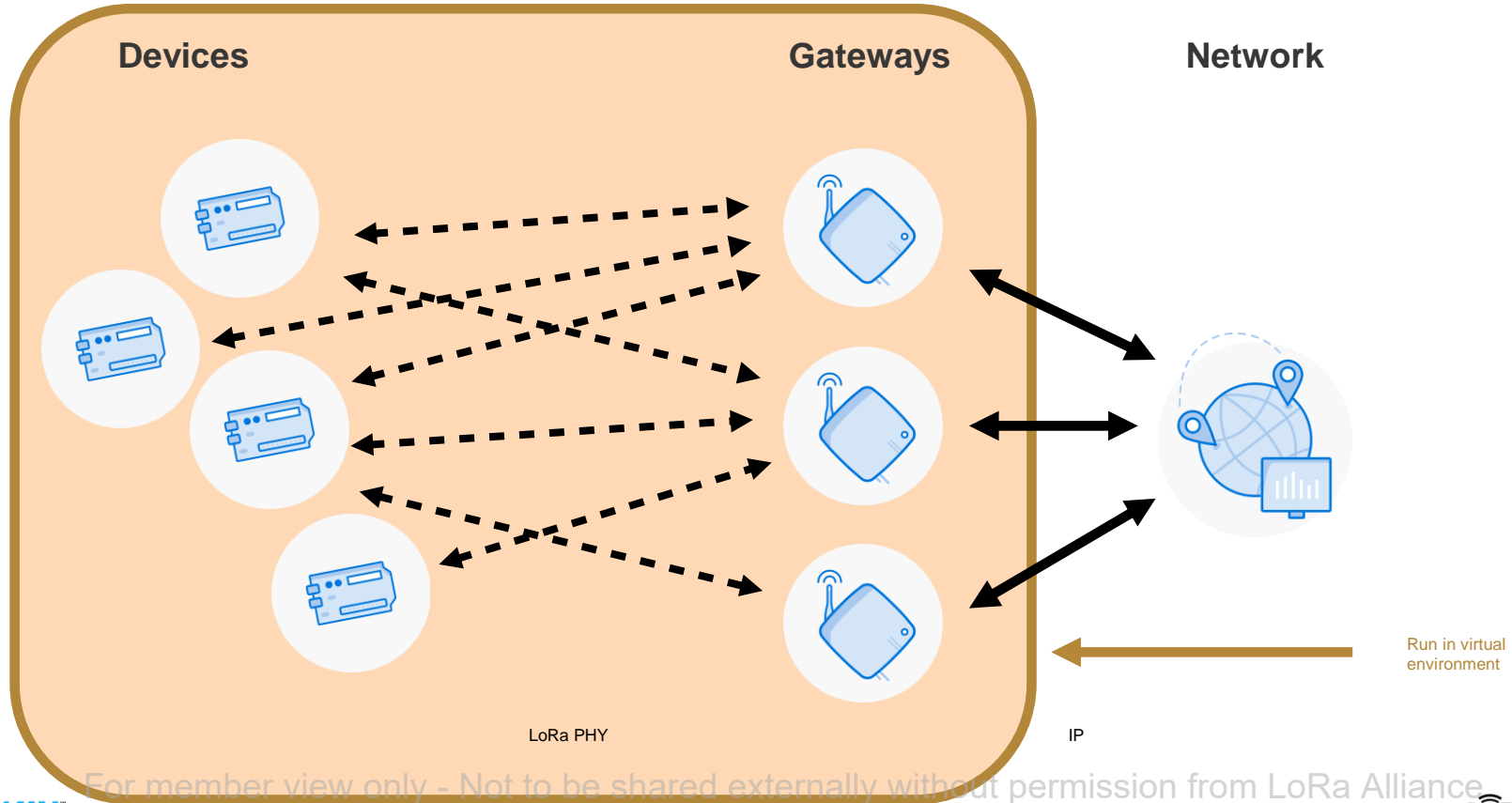
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Device To Network



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Device To Network



Benefits

Run application in seconds

**Full control over gateway parameters
(RSSI, gateways within reach)**

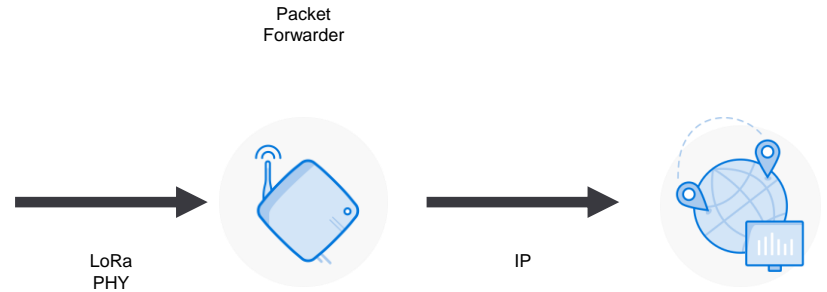
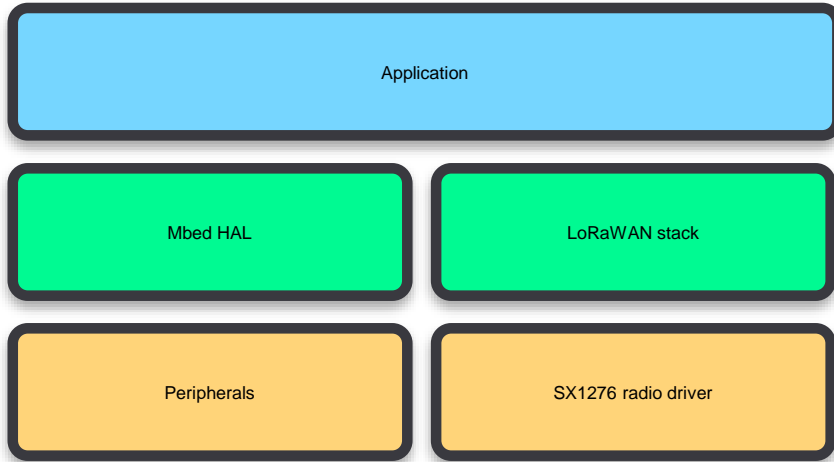
Still LoRaWAN: end-to-end encryption, spreading factors, channel hopping

No changes required on network side

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How

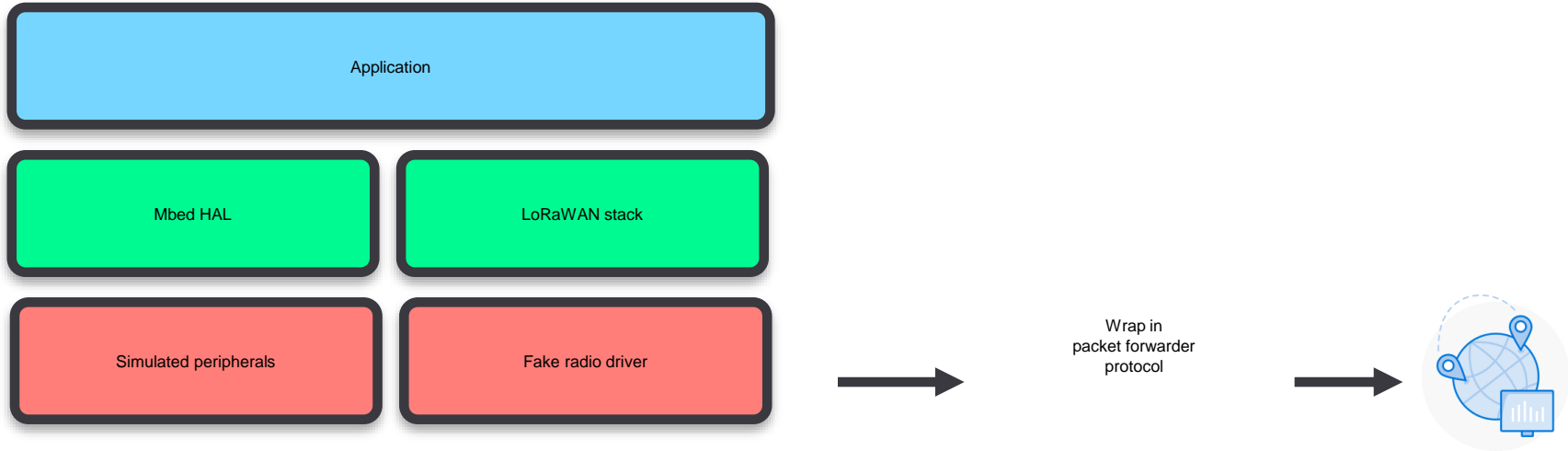
Device



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How

Device



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```
iTerm2 Shell Edit View Session Scripts Profiles Toolbelt Window Help
1. bash
janjon01:~/repos/internal-training-lora-2019 (saml21) $ mbed-simu
lator . --launch-headless --disable-runtime-logs
```

The Things Network Console

https://console.thethingsnetwork.org/applications

CONSOLE COMMUNITY EDITION Applications Gateways Support armmbd

Applications > sxsw2018 > Devices > jan-is-cool23 > Data

Overview Data Settings

APPLICATION DATA pause clear

Filters uplink downlink activation ack error

time	counter	port
------	---------	------

Frequency Hopping

time	frequency	mod.	CR	data rate	airtime (ms)	cnt	
▲ 15:26:08	868.1	lora	4/6	SF 8 BW 125	102.9	12	dev addr: 26 02 29 B0 payload size: 17 bytes
▲ 15:25:58	867.5	lora	4/6	SF 8 BW 125	102.9	11	dev addr: 26 02 29 B0 payload size: 17 bytes
▲ 15:25:48	867.9	lora	4/6	SF 8 BW 125	102.9	10	dev addr: 26 02 29 B0 payload size: 17 bytes
▲ 15:25:38	867.1	lora	4/6	SF 8 BW 125	102.9	9	dev addr: 26 02 29 B0 payload size: 17 bytes
▲ 15:25:28	868.1	lora	4/6	SF 8 BW 125	102.9	8	dev addr: 26 02 29 B0 payload size: 17 bytes
▲ 15:25:17	867.5	lora	4/6	SF 8 BW 125	102.9	7	dev addr: 26 02 29 B0 payload size: 17 bytes
▲ 15:25:07	867.5	lora	4/6	SF 8 BW 125	102.9	6	dev addr: 26 02 29 B0 payload size: 17 bytes
▲ 15:24:57	868.3	lora	4/6	SF 8 BW 125	102.9	5	dev addr: 26 02 29 B0 payload size: 17 bytes
▲ 15:24:47	868.3	lora	4/6	SF 8 BW 125	102.9	4	dev addr: 26 02 29 B0 payload size: 17 bytes

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```
LoRaWAN information:
Gateway ID:          ac:de:48:00:00:11:22
Packet forwarder host: router.eu.thethings.network
Packet forwarder port: 1700
Make sure the gateway registered in the network server running the *legacy packet forwarder*
Application started in headless mode
[DBG ][LSTK]: Initializing MAC layer
Mbed LoRaWANStack initialized
Adaptive data rate (ADR) - Enabled
[DBG ][LSTK]: Initiating OTAA
[DBG ][LSTK]: Sending Join Request ...
[DBG ][LMAC]: Frame prepared to send at port 0
[DBG ][LMAC]: TX: Channel=0, TX DR=5, RX1 DR=5
[DBG ][LRAD]: transmit channel=868100000 power=13 bandwidth=7 data rate=7
Connection - In Progress ...
[DBG ][LSTK]: Transmission completed
[DBG ][LSTK]: Transmission completed
[DBG ][LMAC]: RX1 slot open, Freq = 868100000
[DBG ][LRAD]: ][LMAC]: RX1 slot open, Freq = 868100000
[DBG ][LSTK]: OTAA Connection OK!
Connection - Successful
[DBG ][LMAC]: RX2 slot open, Freq = 869525000
Temperature: 30.545845
[INFO][LMAC]: RTS = 4 bytes, PEND = 0, Port: 15
[DBG ][LMAC]: Frame prepared to send at port 15
[DBG ][LMAC]: TX: Channel=2, TX DR=5, RX1 DR=5
[DBG ][LRAD]: transmit channel=868500000 power=13 bandwidth=7 data rate=7
4 bytes scheduled for transmission
[DBG ][LSTK]: Transmission completed
[DBG ][LMAC]: RX1 slot open, Freq = 868100000
[DBG ][LMAC]: RX2 slot open, Freq = 869525000
Message Sent to Network Server
```

The Things Network Console

Applications > sxsw2018 > Devices > jan-is-cool23

Overview Data Settings

DEVICE OVERVIEW

Application ID **sxsw2018**

Device ID jan-is-cool23

Activation Method **OTAA**

Device EUI <> ⇄ 00 A7 7C 67 D2 B1 7F B3 ⓘ

Application EUI <> ⇄ 70 B3 D5 7E D0 00 AA DF ⓘ

App Key <> ⇄ 🔒 ⓘ

Device Address <> ⇄ 26 02 20 F9 ⓘ

Network Session Key <> ⇄ 🔒 ⓘ

App Session Key <> ⇄ 🔒 ⓘ

Status ● 6 seconds ago



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```
[DBG ][LRAD]: transmit channel=868300000 power=13 bandwidth=7 datarate=8
[DBG ][LSTK]: Transmission completed
[DBG ][LMAC]: RX1 slot open, Freq = 868300000
[DBG ][LRAD]: ][LMAC]: RX1 slot open, Freq = 868300000
[DBG ][LMAC]: RX2 slot open, Freq = 869525000
[DBG ][LSTK]: Packet Received 30 bytes, Port=200
Message Sent to Network Server
Received message from Network Server
Received 30 bytes on port 200
[DBG ][LWUC]: handleMulticastSetupReq mcIx=0
[DBG ][LWUC]: mcAddr: 0xffffffffe
[DBG ][LWUC]: NwkSKey:
14 03 0c 50 ec 13 2d 1f 90 0d 2e f5 f7 04 fb 1c
[DBG ][LWUC]: AppSKey:
99 5f 57 c6 cb b7 4a bc 13 d7 6d 4e 46 a8 62 25
[DBG ][LWUC]: minFcFCCount: 0
[DBG ][LWUC]: maxFcFCCount: 255
[INFO][LMAC]: RTS = 2 bytes, PEND = 0, Port: 200
[DBG ][LMAC]: Frame prepared to send at port 200
[DBG ][LMAC]: DC enforced: Transmitting in 2024 ms
2 bytes scheduled for transmission on port 200
[DBG ][LMAC]: TX: Channel=2, TX DR=4, RX1 DR=4
[DBG ][LRAD]: transmit channel=868500000 power=13 bandwidth=7 datarate=8
[DBG ][LSTK]: Transmission completed
[DBG ][LSTK]: Awaiting ACK
[DBG ][LRAD]: ][LSTK]: Awaiting ACK
[DBG ][LMAC]: RX1 slot open, Freq = 868300000
[DBG ][LSTK]: Ack=OK, NbTrials=0
```

```
Message Sent to Network Server
[]
```

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Recap

Radio is hard!

Feedback loop on embedded is long

Simulation is here to save us



<https://github.com/janjongboom/mbed-simulator>

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Thank you

Getting started with Mbed OS

<https://github.com/ArmMbed/mbed-os-example-lorawan>

Simulator

<https://labs.mbed.com>

Contact and slides

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<http://janjongboom.com>

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