



LoRa for IoT

May 2017

Semtech's Vision



**To be the global leader in *analog and mixed-signal* platforms
that enable *architectural* and performance *differentiation***

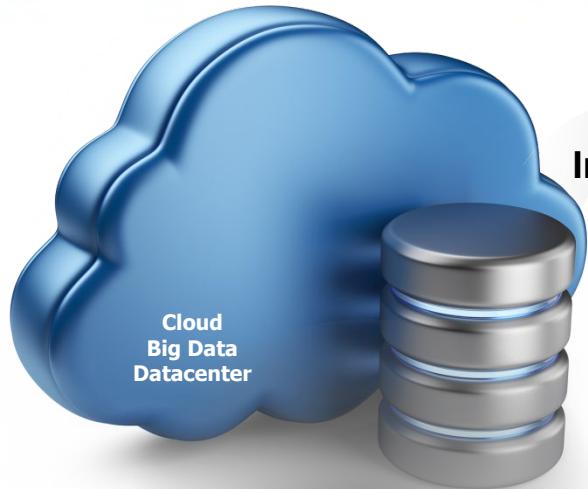
Achieve leadership positions in our target product segments

Deliver revenue growth exceeding high performance analog sector

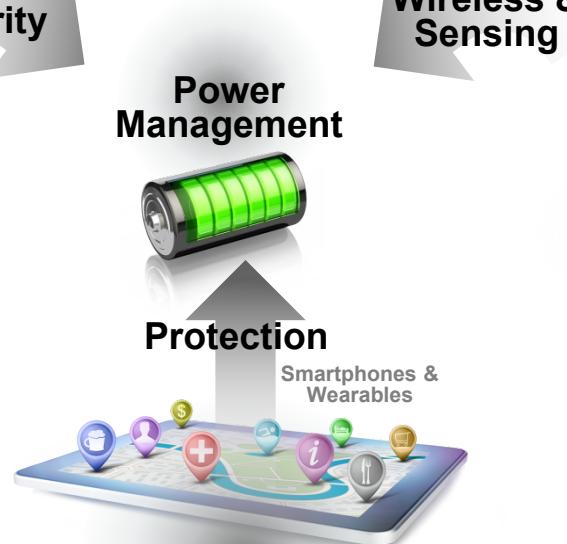
Attain the high end of Semtech's stated operating model



Three Key Markets



1. Increasing Bandwidth

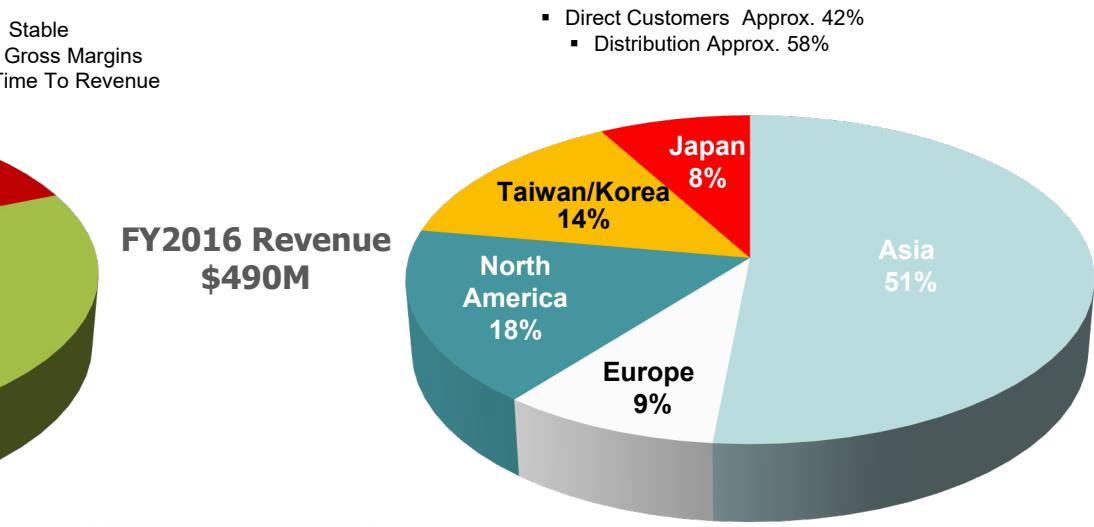
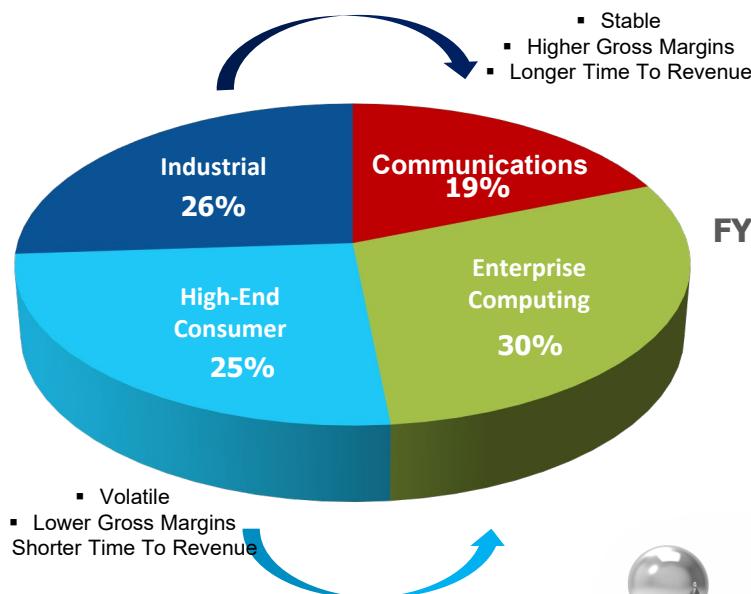


3. Increasing Mobility



2. Increasing Energy Efficiency

End Market & Geographical Balance



SMTA 1-Year Share Price

Semtech Corporation
NASDAQ: SMTC - May 10, 1:45 PM EDT

35.55 USD ↑1.30 (3.80%)

1 day

5 day

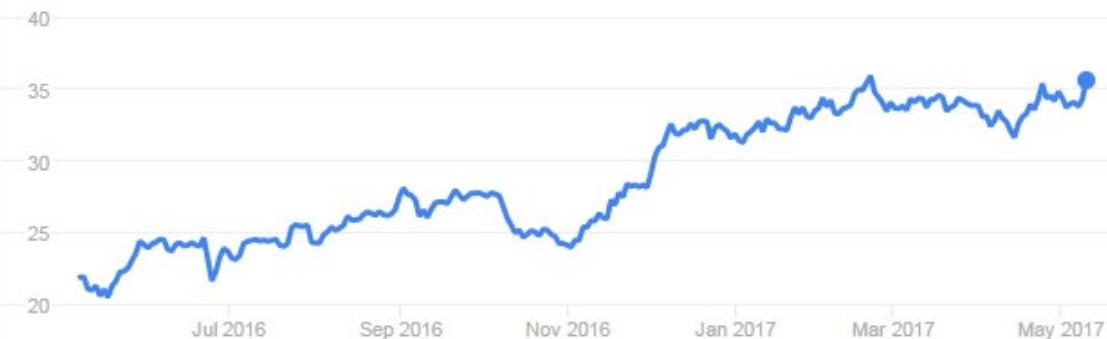
1 month

3 months

1 year

5 years

max



Open 34.75
High 35.85
Low 34.60

Mkt cap 2.37B
P/E ratio 42.97
Div yield -

A World of Solutions

-  Circuit Protection (TVS)
-  Power Management
-  Wireless Charging
-  Touch and Proximity Sensing
-  Wireless RF
-  Power Line Communications
-  Optical Networking, Storage & Computing
-  Video Broadcast
-  Security & Surveillance Video
-  High-Rel Discrete Semiconductors

Our products are in some of the most innovative systems and fastest growing markets today: communications, enterprise computing, high-end consumer and industrial equipment.





Wireless RF Products



The Ultimate Long Range Wireless Solution - LoRa®

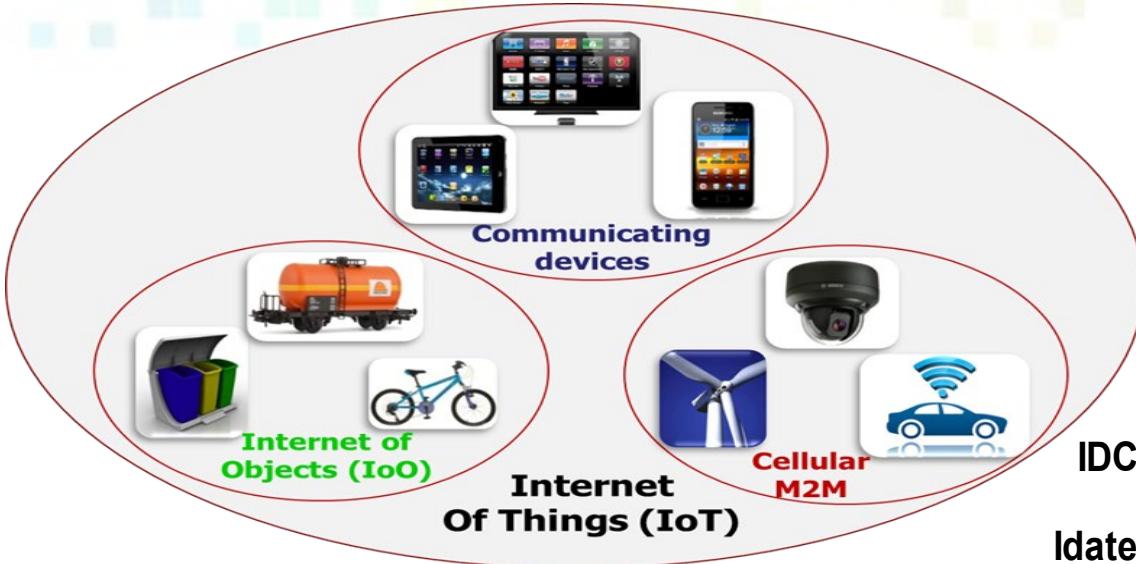
Delivering long range, robust performance and low current for maximum battery life

Integrated, long and short range wireless connectivity solutions for

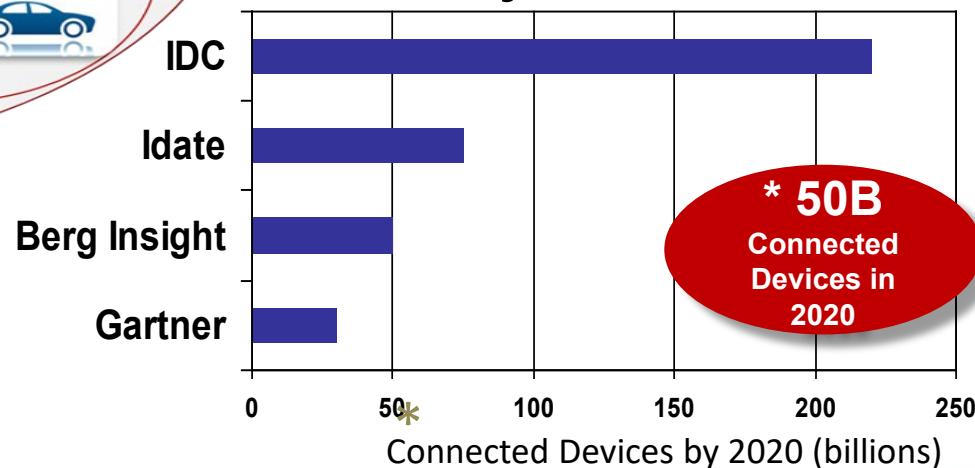
- automated wireless remote control
- meter readers
- wireless security systems
- building automation equipment
- Internet of Things (IoT)
- Geolocations
- and much more



IoT Segments

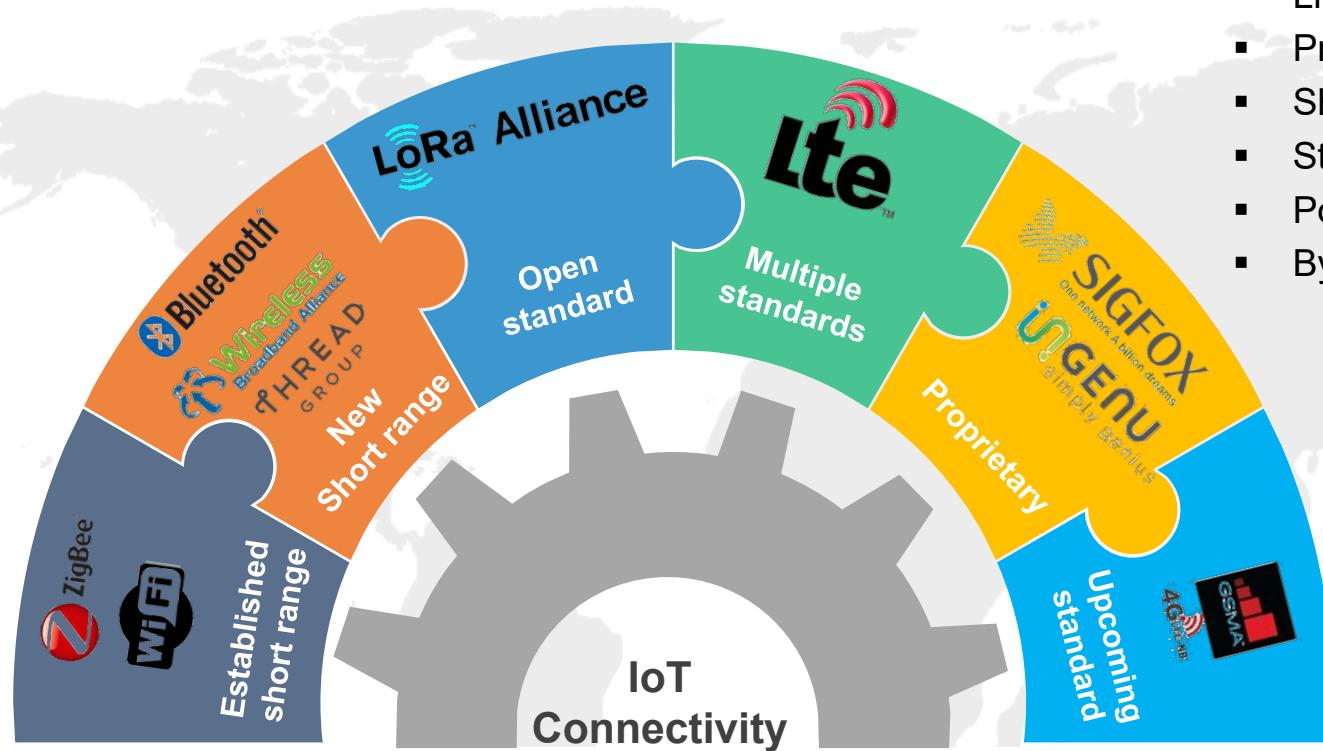


IoT Projected Volumes





IoT requires multiple open standards



- Licensed versus unlicensed
- Proprietary or (open) standard
- Short versus long range
- Stationary or moving objects
- Powered or battery operated
- Bytes versus MB's



Where Does LPWAN Fit



LAN

Short Range
Communicating Devices



35% SOM

- Well established standards**
- Good for:**
 - Mobile devices
 - In-home
 - Short range
- Not good:**
 - Battery life
 - Long range

LPWAN

Long Range w/ Battery
Internet of Objects



55% SOM

- Emerging PHY solutions**
- Good for:**
 - Long range
 - Long battery
 - Low cost
 - Positioning
- Not good:**
 - High data-rate

Cellular

Long Range w/Power
Traditional M2M



10% SOM

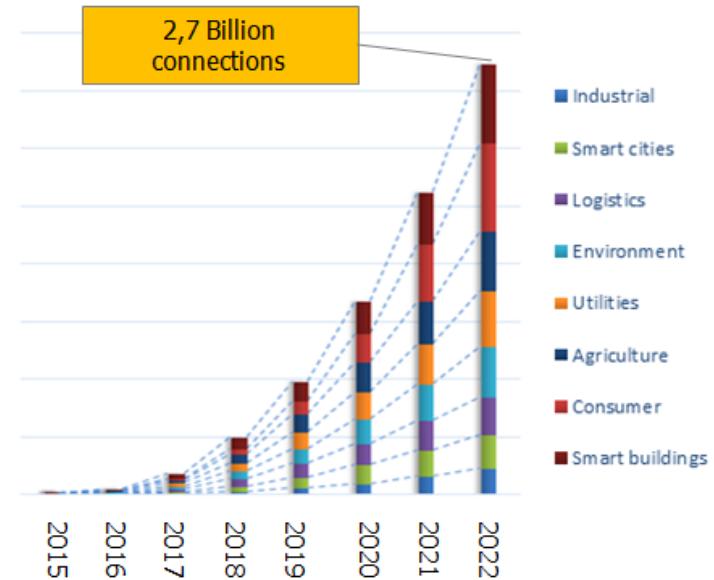
- Well established standards**
- Good for:**
 - Long range
 - High data-rate
 - Coverage
- Not good:**
 - Battery life
 - Cost



LPWAN Market Size & Focus



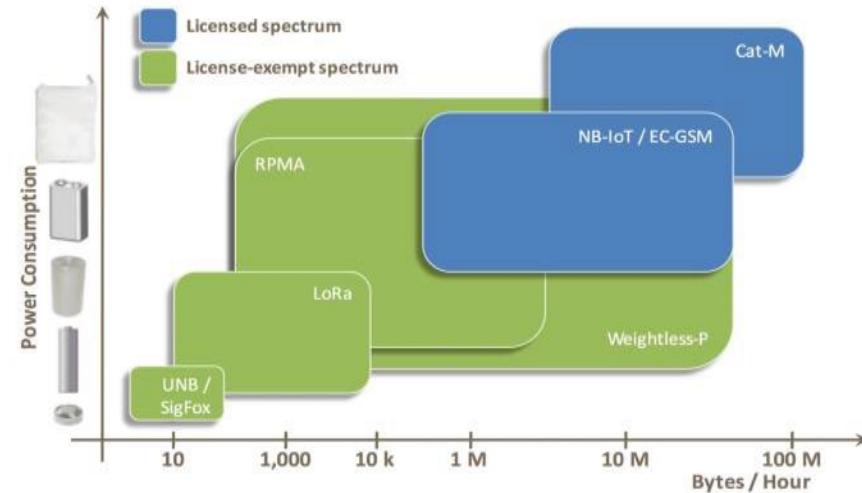
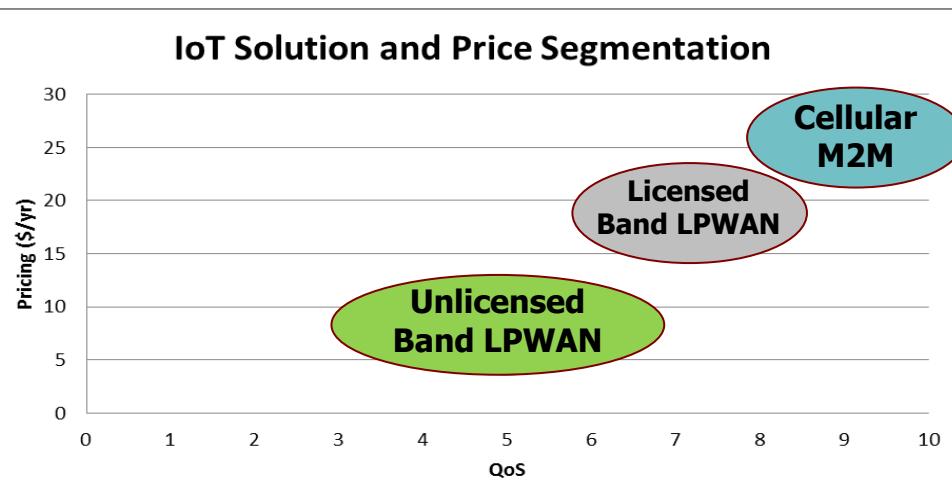
- Machina, Strategy Analytics and Analysys Mason
 - Excluding short range
- Turning point 2018
- The top three application categories for this revenue forecast (2022)
 - Agriculture and environment markets (25%)
 - Consumer applications, which include pet, bicycle tracking and wearable's (21%)
 - Smart buildings (18%)



Source: Analysys Mason, April 2015

Market Segmentation

- ❑ Network providers need solution and price segmentation to maximize revenue
- ❑ LoRa is complementary to GSMA and licensed band
- ❑ Will serve different applications

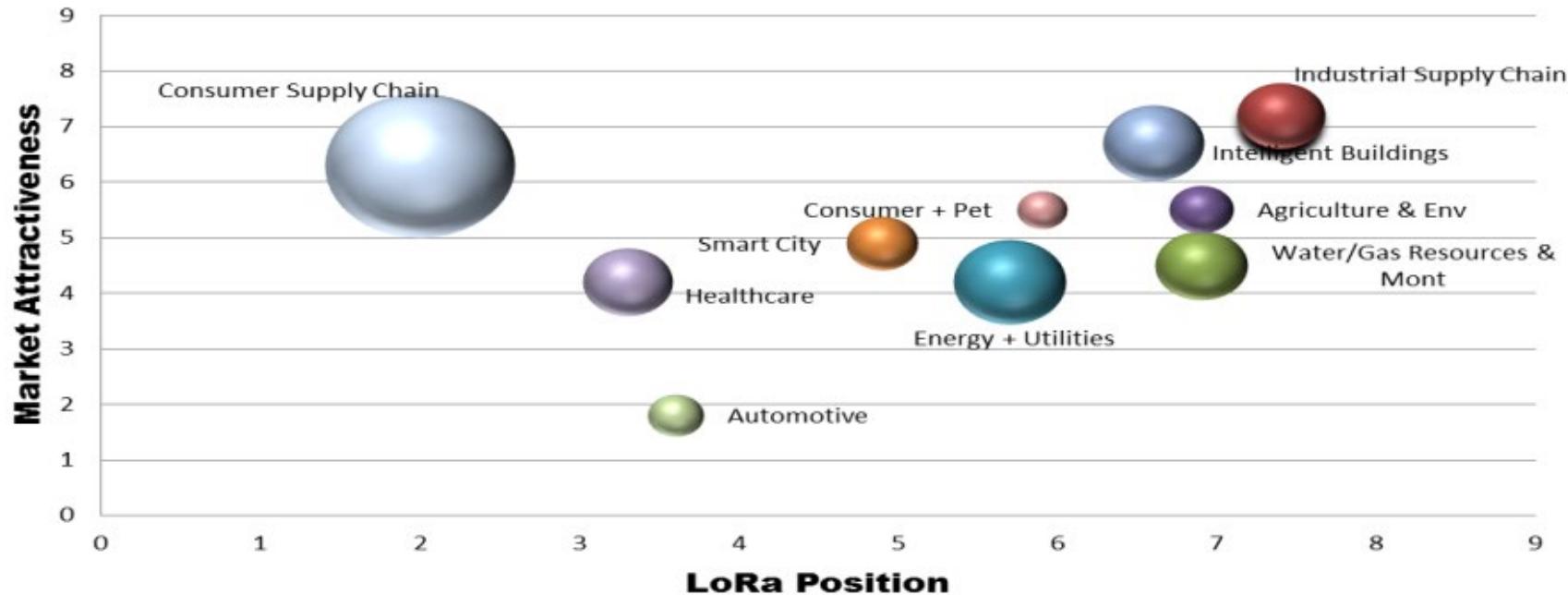




LoRaWAN Lead Markets



IoT Target Markets





What is LoRa?



**Semtech LoRa technology is the connectivity catalyst
to the largest volumes of Internet of Objects.**



Smart Energy

Safety

Smart Cities

Refuel

Services

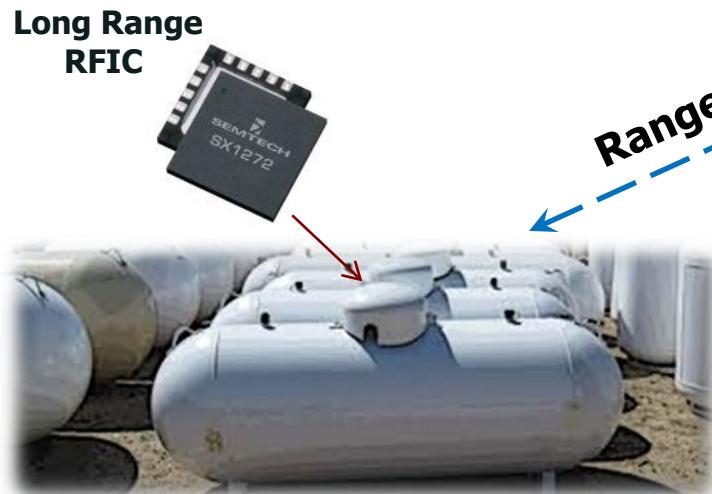
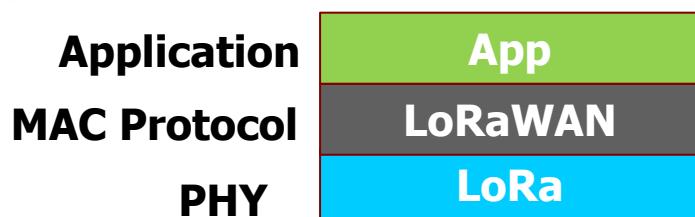
Trackin

We supply best in class Long Range Low Power RF chips.





What is LoRa?



Range >cellular at fraction of power



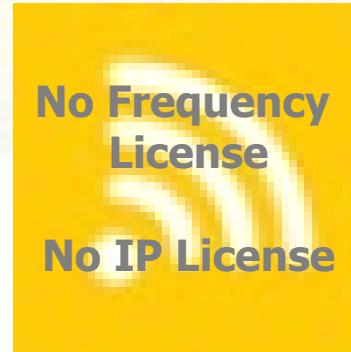
- = **5-10 year battery life**
- = **5x lower sensor cost than cellular**
- = **Low cost basestations (<\$100 to \$2500)**
- = **Rapid time to market**
- = **Mobile objects**
- = **Geolocation w/o GPS**



Open LoRa®

□ LoRa® PHY - Semtech

- Semtech developed
- Multiple sources available
 - Semtech
 - ST
 - Microchip
- Available in frequency bands from 400MHz through 1GHz



PHY



LoRa

□ LoRaWAN™ - LoRa Alliance

- Open standard maintained by the LoRa Alliance
- Defines frequency band usage by country, security, device classes, protocol, etc
- Supported by a broad ecosystem

□ Applications - Open Market

- Can be developed independently and run over any connectivity infrastructure as part of an integrated solution incorporating many technologies.

MAC Protocol

PHY

LoRaWAN

LoRa

Application

MAC Protocol

PHY

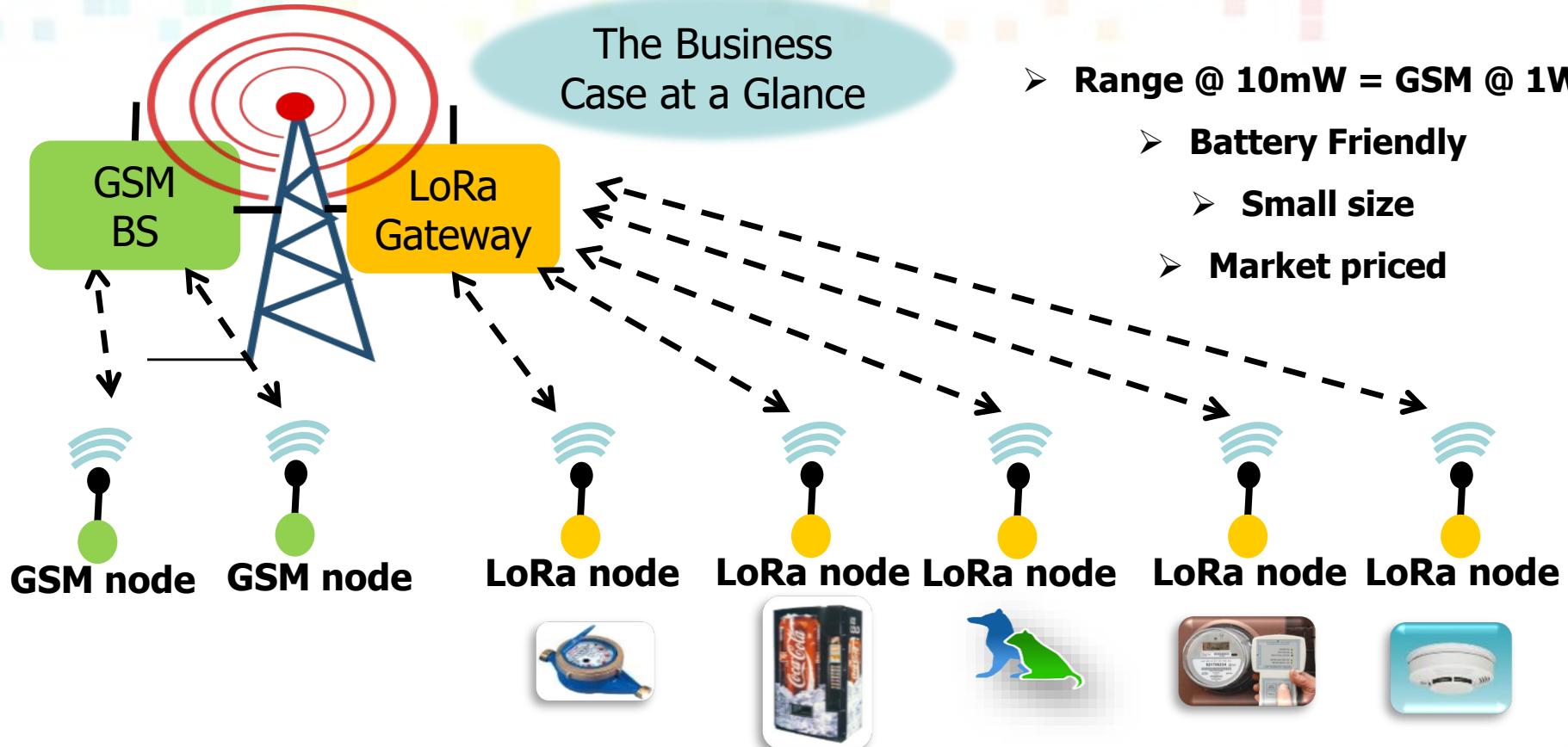
App

LoRaWAN

LoRa



LoRa Network Expands M2M Connectivity





LoRaWAN™ Network

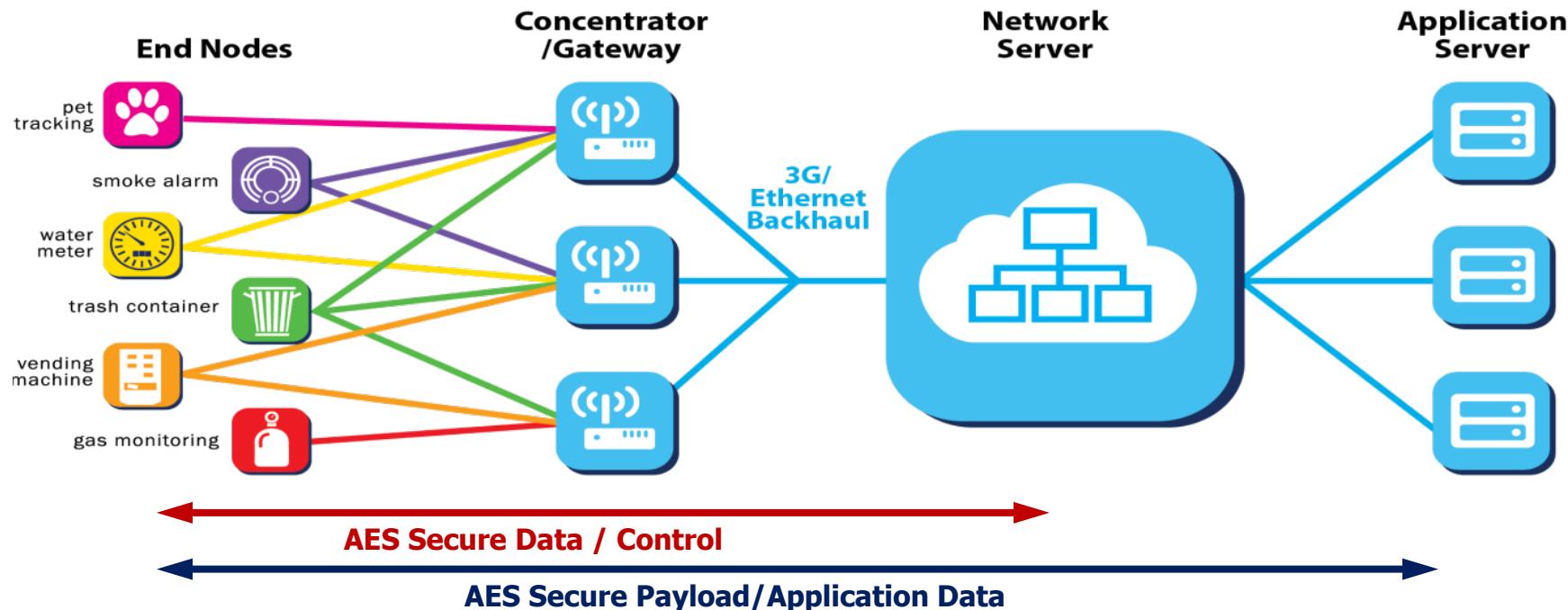


\$15-\$100

+\$100-\$2000 +
Site Access

+Backhaul

+\$.02-\$05/month
Offered as a Service





Device Classes: Optimized for Use Cases



Class name	Intended usage
A (« all »)	Battery powered sensors <ul style="list-style-type: none">• No latency constraint• Most energy efficient communication class.• Must be supported by all devices
B (« beacon »)	Battery powered actuators <ul style="list-style-type: none">• Energy efficient communication class for latency controlled downlink• Based on slotted communication synchronized with a network beacon
C (« continuous »)	Mains powered actuators <ul style="list-style-type: none">• Devices which can afford to listen continuously.• No latency for downlink communication



Device Classes & Examples



Class A: Smart City

Report status a few times per day
No planned actuation required
Extremely low energy



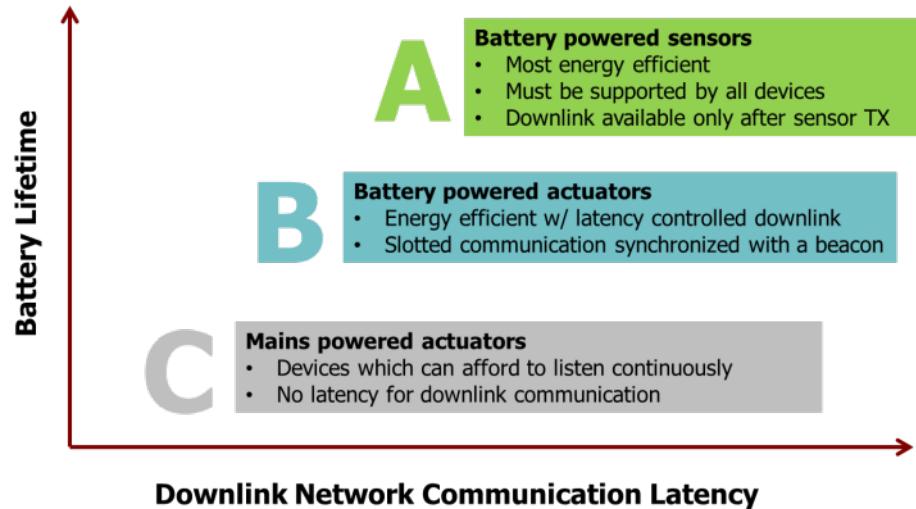
Class B: Irrigation

Turn valves on or off
with a few minutes latency



Class C: Smart Lighting

Constantly listens for network «ping»
for low-latency actuation





LoRa® Network Attributes



Key Features	Attribute/Benefit
157 dB link budget	Long range 
>15 km range	
Minimal infrastructure	Ease of deployment 
Concentrator/gateway with capacity	
>10 yrs battery lifetime	Long battery life 
RX - 10 mA, sleep <200 nA	
Unlicensed spectrum	
Low infrastructure cost	Low cost 
Low end-node cost	

- A long range star architecture with high capacity
- Supports both mobile and fixed nodes
- Supports variable data rates and multi-channel simultaneously

LoRa Alliance™

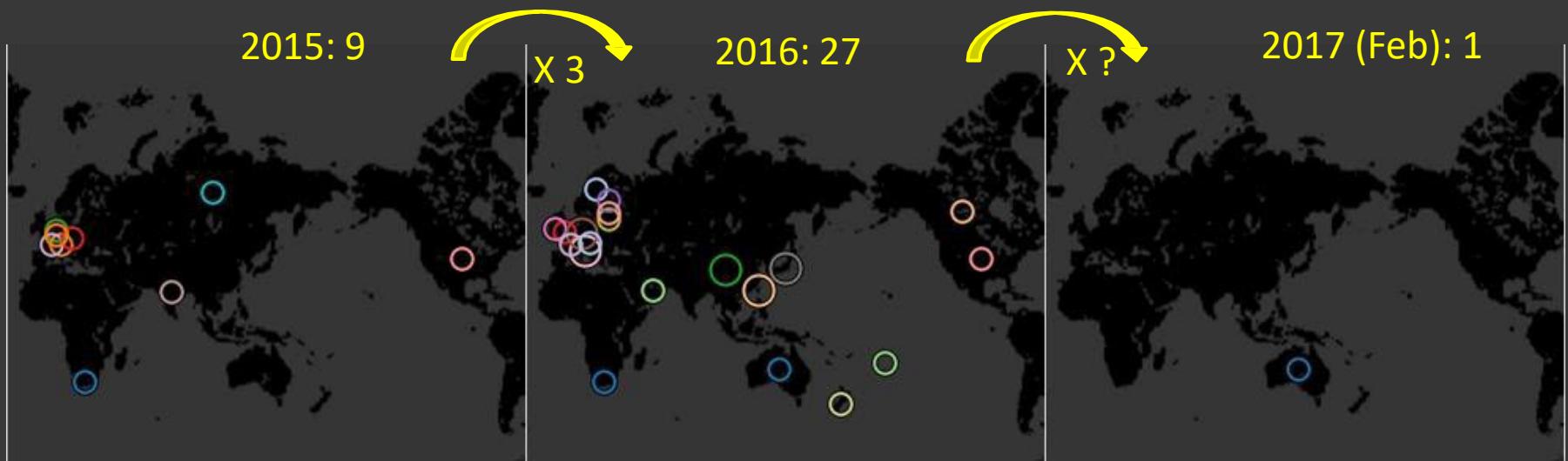
<https://www.lora-alliance.org/>

- Open & Non-Profit
- Founded: March-2015
- Board
 - IBM, Cisco, Bouygues, KPN, Orange, Semtech, Proximus, ZTE, ST, Actility, Kerlink, Agutek, Homerider
- Chairman
 - Geoff Mulligan
- Committees
 - Technical:
 - Marketing:
 - Strategy:
 - Certification:
- Member Status
 - 450+





LoRaWAN™ Public Networks Progression over time



37 Public IoT Networks are being Rolled-out over the world in just 2 Years!

Thriving IoT Ecosystem:
Consolidation
Worldwide

+50 countries

+150 Trials (approx)

>13X GROWTH
in 22 Months!

+450 Members

Membership
Adopter
Contributor
Sponsor

LoRa-Alliance.org



Major Public Operators - Announced



Comcast (US) – MachineQ Venture

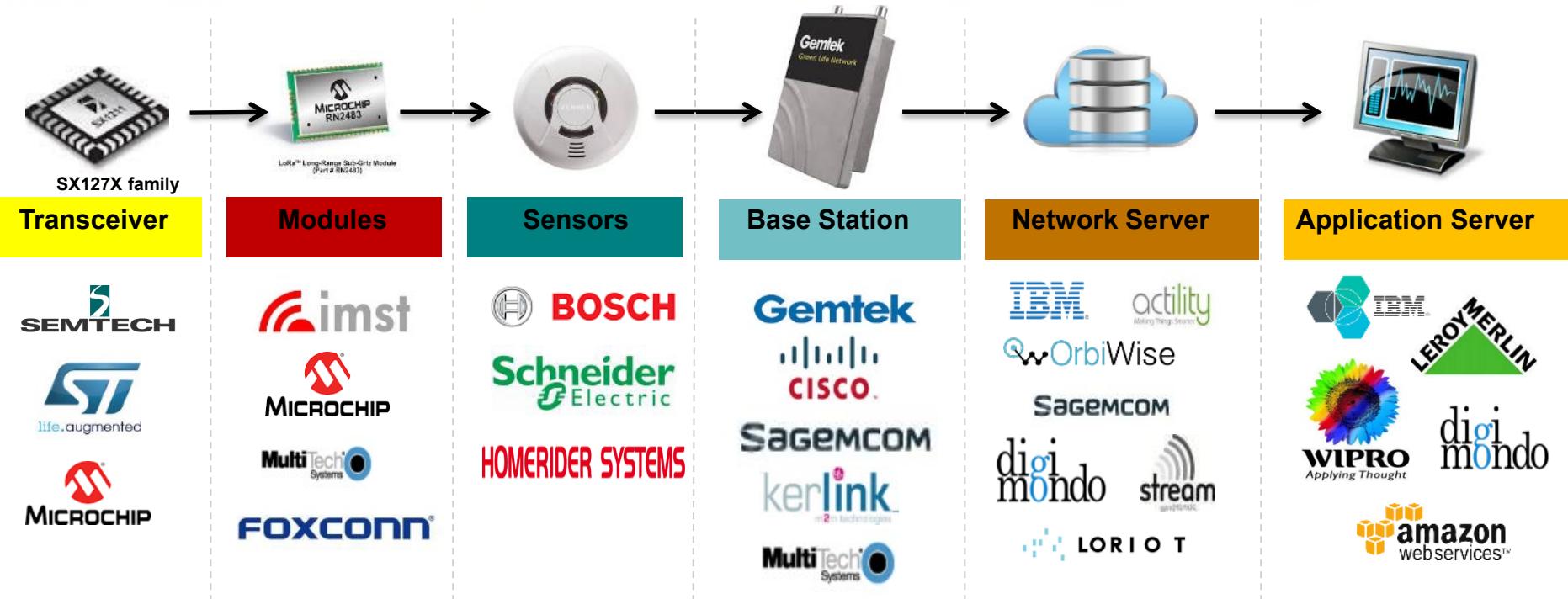
<http://corporate.comcast.com/news-information/news-feed/comcast-launches-enterprise-internet-of-things-trial-venture>

Comcast today announced machineQ™, a new business trial venture focused on building business-to-business solutions and a platform for the Internet of Things (IoT). As a part of machineQ, Comcast will work with select commercial partners in proof of concepts to use its network to enable partners to gather, transmit, and analyze data from connected devices distributed throughout their organizations.

Comcast will use Semtech Corporation's (NASDAQ: SMTC) globally-proven LoRa® Wireless Radio Frequency Technology to deploy network trials in Philadelphia and San Francisco later this year. These trials will focus on enabling use cases such as utility metering, environmental monitoring (e.g., temperature, pollution, noise), and asset tracking through LoRa Technology-enabled devices and network services.



Multiple Sourcing On Every Level



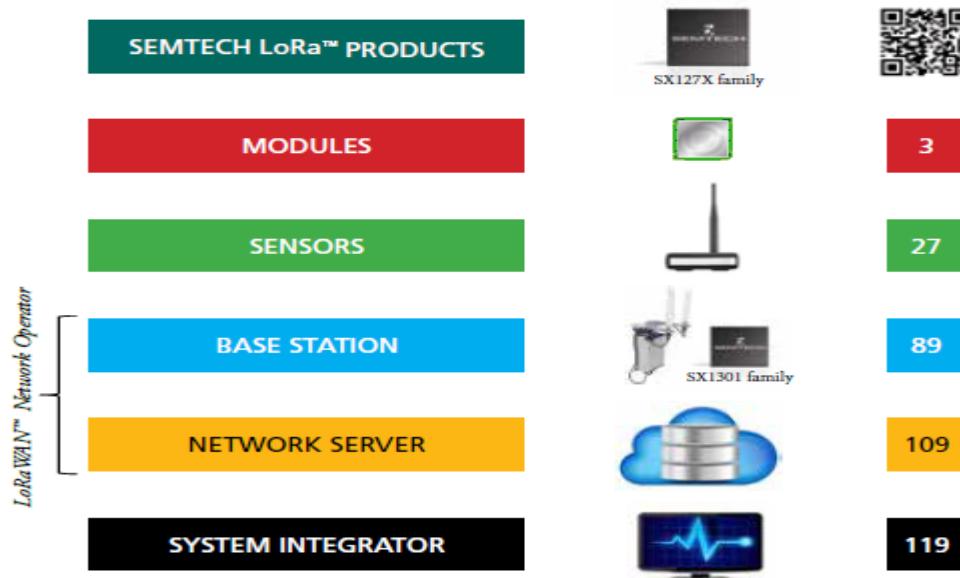


Rapidly Growing Ecosystem

Modules to Full Service Ntwk Builders



LoRa™ Valuechain





Gateway and Deployment Options



Picocell Gateway



Industrial Gateway



Tower-top Gateway



Features

Price	\$50-100
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Backhaul	Ethernet only
----------	---------------

Options	minimal
---------	---------

Features

Price	\$250-400
-------	-----------

Backhaul	Eth, cellular, WiFi
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Options	configurable
---------	--------------

Features

Price	\$1000-2000
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Backhaul	Eth, cell, sat, fiber
----------	-----------------------

Options	IP 67/68, lighting, batt
---------	--------------------------



Other Gateway Deployment Options



- **Multiprotocol Home Gateways (On the market)**
 - WiFi, Bluetooth, Zigbee, etc.
- **Integrated cable plant offerings (In advanced proto stage)**
 - Pole Mount
 - Strand Mount
 - Alpha Technologies
- **Possible future integration possibilities**
 - Integration with STB
 - Not to be confused with tracking the STB as and end point on a LoRa Network



Technology Comparison



Technology	2G	3G	LAN	LoRa
Range(I=Indoor, O=Outdoor)	N/A	N/A	O: 300m I: 30m	Same or better as 2G/3G
Tx current consumption	200mA-500mA	500mA – 1000mA	50mA	18mA
Standby current	2.3mA	3.5mA	NC	0.001mA
Energy harvesting (solar, other)	No	No	No	Possible
Battery 2000mAh (LR6 battery)	4-8 hours(com) 36 days(idle) 2 years(every hour)	2-4 hours(com) X hours(idle)	50 hours(com) X hours(idle)	120 hours(com) 10 year(idle) +15 years(every hour)
Minimum Revenue Annually	12 \$	20 \$	4 \$	4 \$



Technology Comparison Summary



Feature	LoRaWAN	Narrow-Band	LTE Cat-1 2016 (Rel12)	LTE Cat-M 2018 (Rel13)	NB-LTE 2019(Rel13+)
Modulation	SS Chirp	UNB / GFSK/BPSK	OFDMA	OFDMA	OFDMA
Rx bandwidth	500 - 125 KHz	100 Hz	20 MHz	20 - 1.4 MHz	200 KHz
Data Rate	290bps - 50Kbps	100 bit/sec 12 / 8 bytes Max	10 Mbit/sec	200kbps – 1Mbps	~20K bit/sec
Max. # Msgs/day	Unlimited	UL: 140 msgs/day	Unlimited	Unlimited	Unlimited
Max Output Power	20 dBm	20 dBm	23 - 46 dBm	23/30 dBm	20 dBm
Link Budget	154 dB	151 dB	130 dB+	146 dB	150 dB
Battery lifetime - 2000mAh	105 months	90 months		18 months	
Power Efficiency	Very High	Very High	Low	Medium	Med high
Interference immunity	Very high	Low	Medium	Medium	Low
Coexistence	Yes	No	Yes	Yes	No
Security	Yes	No	Yes	Yes	Yes
Mobility / localization	Yes	Limited mobility, No loc	Mobility	Mobility	Limited Mobility No Loc



Why LoRa™?



- Unlicensed spectrum - anyone can build a network**
- Extreme immunity to interference**
- Long Range (hence the Lo Ra)**
- Much better indoor penetration than mobile networks**
- Very long battery life - 10 years in many instances**
- Highly scalable - If you need to increase capacity you just drop in another gateway...no planning required at all. The network self-configures.**
- Low data rate - built specifically for Internet of Things sensors applications**
- Bi-directional**
- Location - can provide location based services using only the LoRa network. No GPS device required in the end device**

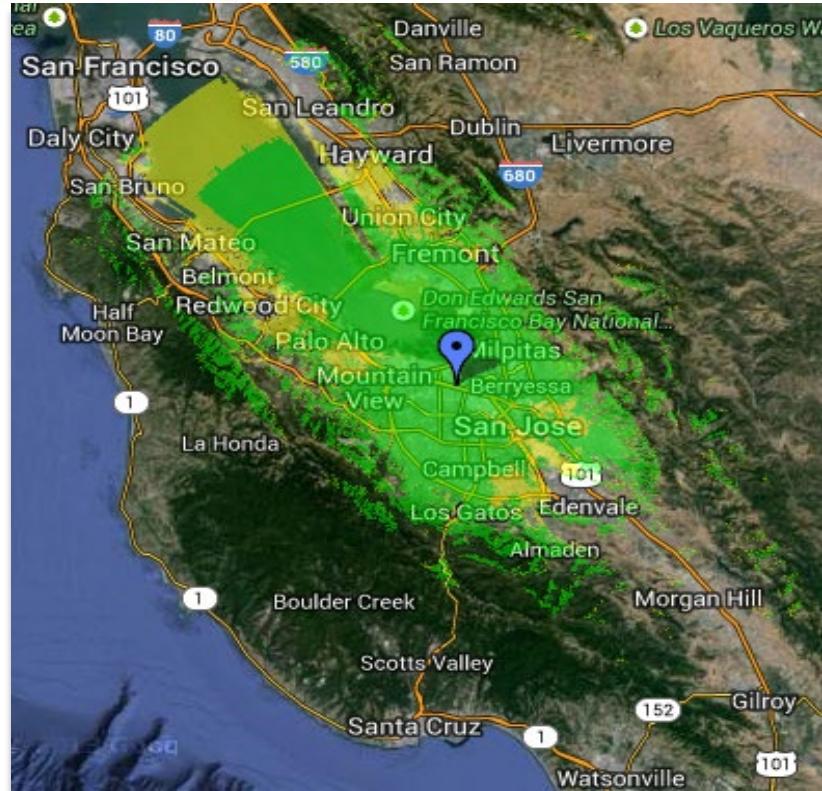




LoRa® Range and Coverage

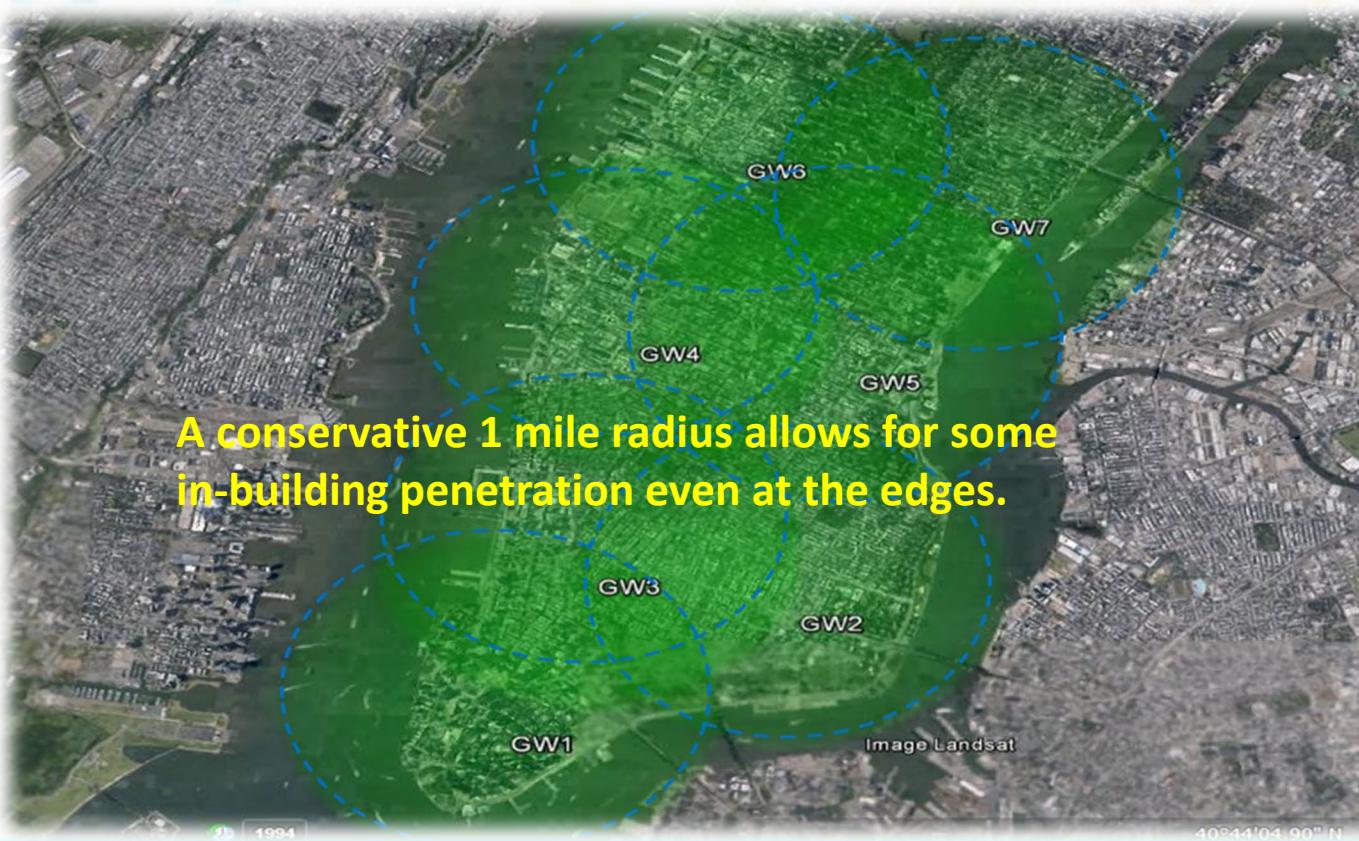


- Coverage map from a single gateway/concentrator
 - Cisco Webex building in San Jose
- >30miles (50km) from San Jose to San Bruno



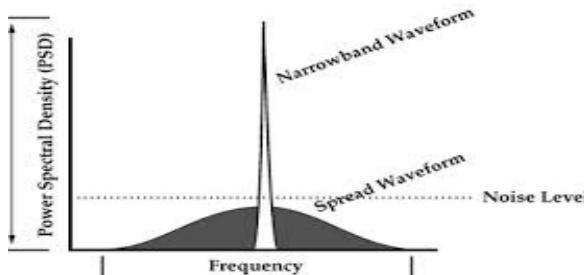
NYC Field Test

7 Gateways cover all of lower Manhattan

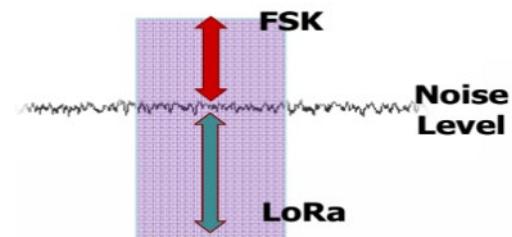
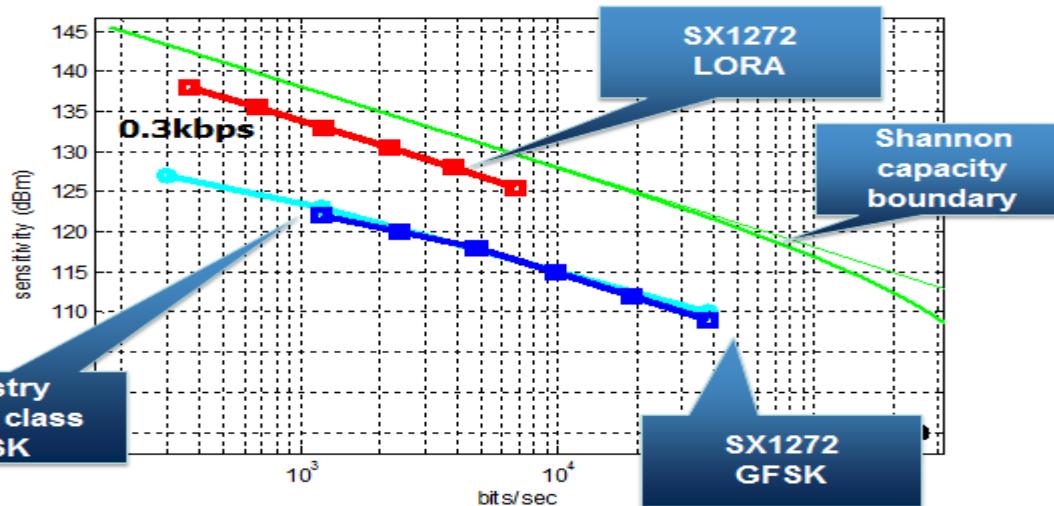




LoRa® Spread Spectrum Modulation – Noise Immunity



Interfere	LoRa Co-Channel	FSK Co-channel
CW/FSK/GFSK	-5 to -20	+8 to +10



-132dBm @ 1 kbps
No TCXO #
No LNA

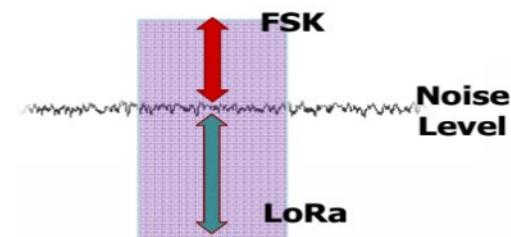


LoRa Parameters and Interference Immunity



Parameter	Range	Effect	Change (125kHz)
Spreading Factor (SF)	7-12	DR	300bps – 9.6kbps (125kHz)
		Sensitivity	-138dBm to -121dBm
Bandwidth (BW)	125K typ 10-500kHz	DR vs sensitivity	300bps – 22kbps
Error correction	4/5 to 4/8	DR, time on air	
Freq	138M-1GHz		Frequency agnostic

Interfere	LoRa Co-Channel	FSK Co-channel
CW/FSK/GFSK	-5 to -20	+8 to +10

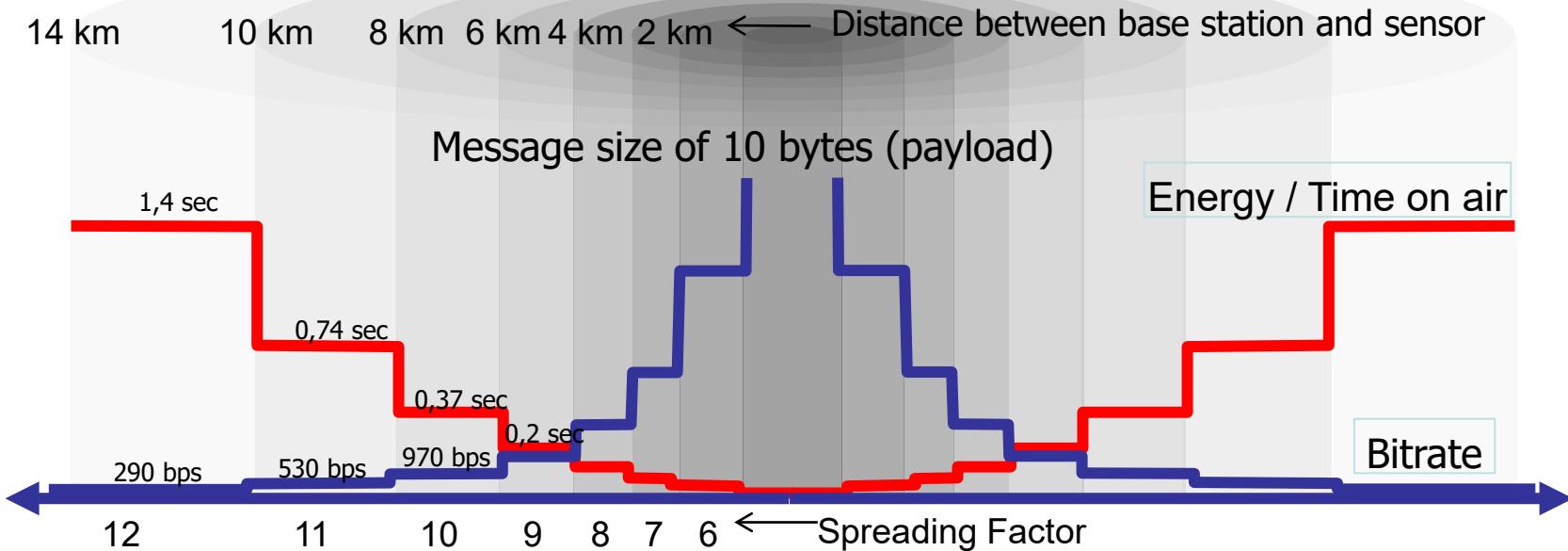




ADR – Energy Savings + Scalability

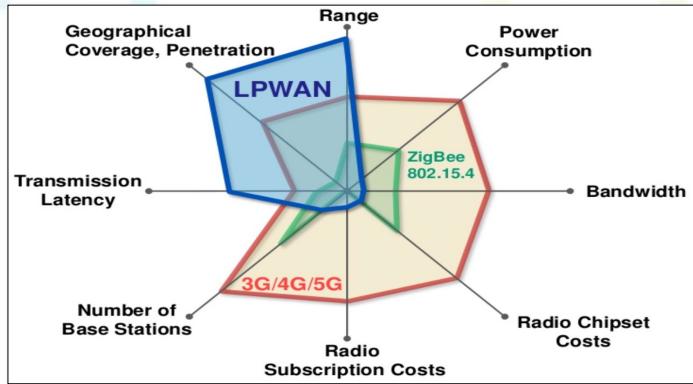
Higher Spreading Factor	Lower Spreading factor
Robustness against interference	Increased payload
Optimal link budget (Signal to Noise)	Lower time on air
Increased network range	Increased capacity

2D simulation (flat environment)

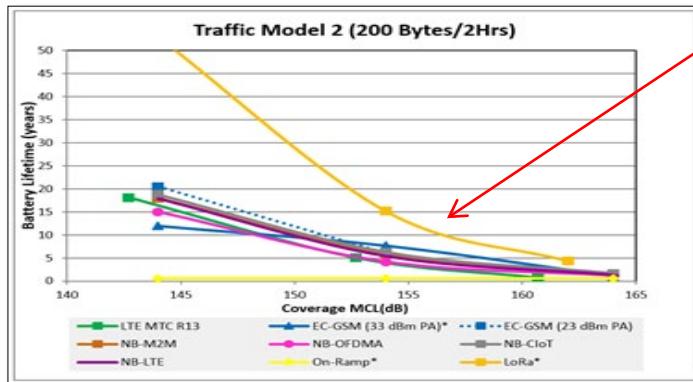




Unique sustainable differentiators



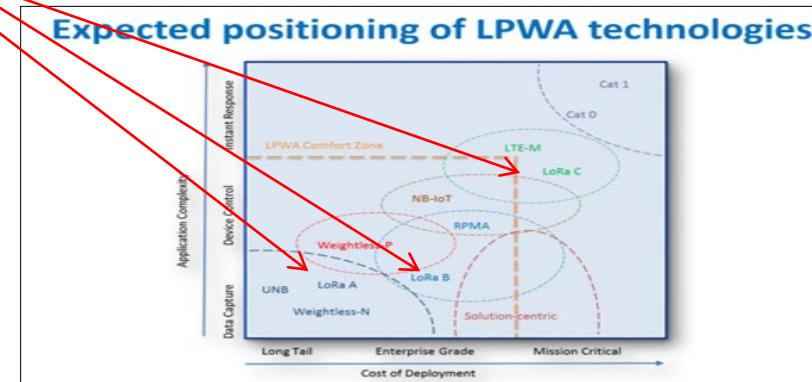
Current Analysis – November 2015



GSMA LPWA – CLP15 September 2015



- Complementary to GSMA standards
- Best in class power consumption
- Device classes enable access to all use cases
- Not impacted by mobility
- Designed for scalable capacity (ADR + Cloud)
- Secure
- Cost effective
- Geolocation



Machina Research – December 2015



Network Derived Geolocation



- ❑ LoRaWAN uniquely supports network derived geolocation
 - This is due to the choice of chirp spread-spectrum modulation
 - Other IoT technologies, such as narrow band, do not allow for geolocation without GPS
 - Based on DTOA + Hybrid techniques & map matching enhancements improve accuracy
- ❑ Majority of applications (estimate over 60%) benefit from location
 1. One off – e.g. to determine an installation or fixed location
 2. Recovery – e.g. a regular heart beat and enable ‘tracking mode’ when needed
 3. Tracking – e.g. supply chain, mobile assets, animals etc.
- ❑ Increasing \$ for Network operator or location service provider
 - High value-added feature for network operators- even on the lowest cost sensors
 - Increased network operator revenue while reducing total cost of solution to end customer
 - Potential for improved penetration compared to GPS/GNSS without resorting to WiFi etc.



Geolocation Competitive Advantages



Lowest possible power

- No processing of location in the sensor (no GNSS receiver, CPU)
- No 'time on air' required to transmit the location data
- Location possible with the smallest possible LoRaWAN packet



Lowest possible cost

- No GNSS (or other hardware) in the sensor
- Smaller battery as no sensor power used in getting location
- Smallest size (electronics, battery, enclosure)



Lowest environmental impact

- Sensor hardware is minimised (electronics, battery, case size etc.)
- Many sensors will be fitted with lifetime battery





LoRa Sustainable Advantages



Deployment Models

- Private & multi-user
- Deployment scenarios – tower vs in-home
- Flexible back-haul



Rapidly Growing Ecosystem

- Varying business models
- Multi-sourcing
- Standardization and interoperability
- Leaders + new market entrants



Asset Tracking

- Low cost, no GPS
- Killer app
- No competing tech
- Enables new verticals

Public Network Deployment Options



Deployment	Pro	Con
Tower	Coverage, deployment speed	Recurring OpEx costs
Viral - home	Low cost deployment	QoS for industrial, and coverage
Customer Assets	Coverage, low cost, opportunistic ramp up. No reoccurring costs	Valid only with single customer with high volume of assets
Hybrid – Tower+Viral	Optimal for coverage, cost, and speed of deployment tradeoffs	Most resource consuming approach

LoRa Public Network Implementation Process



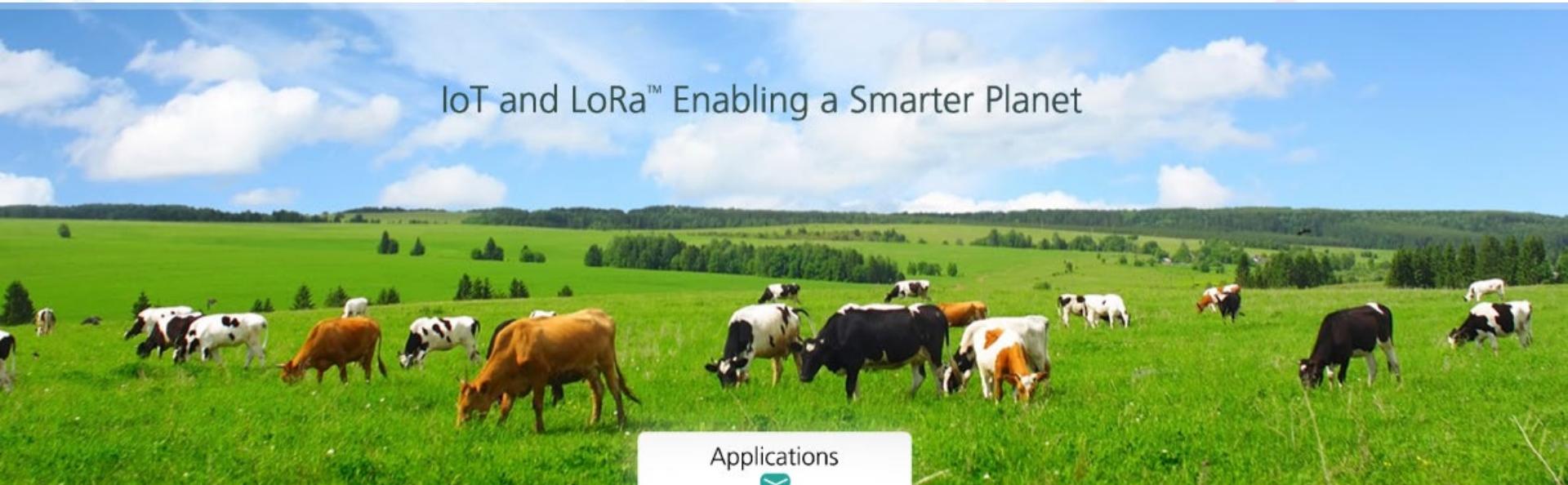
- Define priority use cases**
 - This drives network deployment requirements – outdoor, light indoor, deep indoor
- Identify likely deployment scenarios**
 - Tower top only
 - Tower top + Indoor
 - All of the above + viral consumer (i.e. FON model used for WiFi)
- Range testing in likely deployment environment(s)**
- Identify potential partners for outdoor gateway deployments**
- Network modeling exercise to plan gateway locations**
- Cost model of network build**
 - Gateways and servers
 - Backhaul and site access leasing
 - Buy and resell end points, user supplied end points or package endpoints as part of monthly plan



Verticals and Application Examples



IoT and LoRa™ Enabling a Smarter Planet



Applications
✉



SMART CITIES



SMART HOME
AND BUILDING



SMART ENVIRONMENT



SMART METERING



SMART AGRICULTURE



SMART INDUSTRIAL
CONTROL



RETAIL AND
LOGISTICS



SMART
HEALTHCARE



Low Power WAN: Addressable Market



SMART ENVIRONMENT & INDUSTRIAL

- Forest fires
- Air pollution
- Earthquake sensors
- Avalanche and flooding
- Heating and AC
- Equipment status
- Factory control

75M

TRACKING

- Motor bikes
- Cars
- Bicycles
- Kids
- Pets
- Insurance – valuable assets
- Find My Stuff

250M

SMART METERING

- Electric
- Water
- Gas
- Infrastructure & production

450M



SMART CITY

- Smart parking
- Traffic sensors & control
- Street lighting
- Infrastructure monitoring
- Trash and waste containers
- Public events –location services
- Advertising displays

200M

AGRICULTURE

- Irrigation control
- Environment sensing
- Animal tracking
- Animal sensing – ovulation, birth

25M

SECURITY/SMART HOME

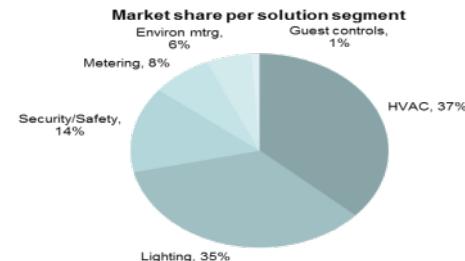
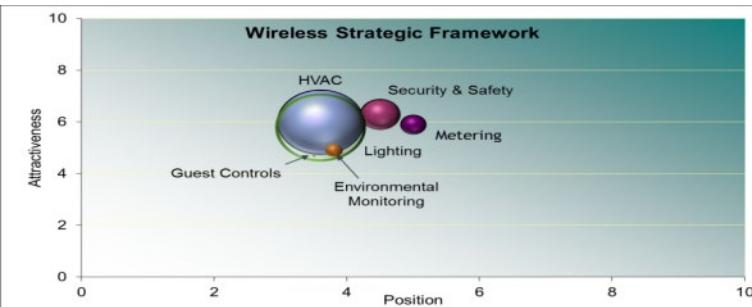
- Smoke detectors
- Security systems
- Smart appliances
- Heating control / monitoring

250M



Intelligent Building

- ❑ In Top 3 of all MNO's
- ❑ 75% reduction in capex and opex
- ❑ TAM - 465M sensors, 45% penetration in 2022 = 191M sensors
- ❑ Strong link to reducing insurance premiums
- ❑ Significant reductions in operating costs
- ❑ Intelligent building sub-segments
 - HVAC, security/safety, lighting, metering, environmental monitoring, control



Established companies	New entrants
Johnson Controls	Ecobee
Schneider	Entouch Controls
Siemens	Golden Power
Ingersoll Rand	Millennial Net
Invensys	Nest
Honeywell	RCS
	TCS Basys
	Thermokon
	Viconics
	Vigilent



Smarter Buildings

Bill each user separately



Clean after 100 door openings



Send heart beats, battery status and alarms



Clean after 5 hours of high CO2 level



LPWAN: Use Case Oxygen Tank Monitoring

LP WAN Value:

- 5 YR Battery life
- Endpoint cost
- Recurring charge cost



Huge efficiency gains are realized by tank monitoring

Tanks are replaced at predetermined intervals regardless of need

Sensor batteries need 5 years = same as tank life

- Cellular unsuitable

Low Power WAN makes business case

- Recurring charges $\frac{1}{4}$ of cellular

Bouygues Telecom contracted for 5M tanks in France using Low Power WAN Network

LPWAN: Use Case Propane Tank Monitoring

LP WAN Value:

- 10 YR Battery life
- Endpoint Cost
- Reduces access cost
- Wide Area needed



Amerigas is one of the nations largest propane dealers w/over 2M tanks on the east coast of NA

2014 propane demand cause shortages and delivery delays of up to 3 weeks

Current system for estimating tank levels results in an average of 50% tank levels across the board

W/real time monitoring, tank levels would rise to 75% and connection to SAP would avoid shortages

Currently monitoring is done only in extreme cases due to cost

ROI is realized thru inventory cost reduction, avoiding shortages, and reduced waste in labor allocation.



LPWAN: Use Case Smart Parking

LP WAN Value:

- Battery life
- Low node cost
- Wide Area



Enables street level sensors and mobile apps to effectively manage complex parking in cities

- Better user experience via parking finder apps
- More revenue for cities

The average American spends \$1300/yr on parking

Data driven decisions are made by cities / over 50 cities deploying smart parking systems

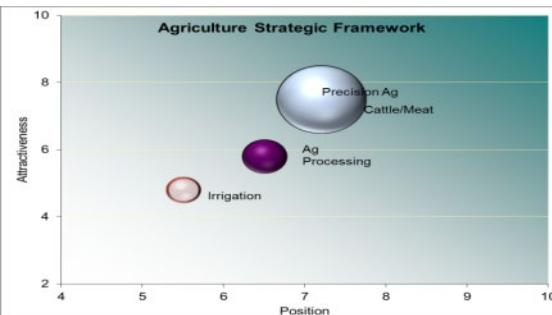
“Parking” is an increasing urban issue to solve thru data and analytics



Ag Market



- Many farms don't have cell service
- Battery lifetime and long range are key
- High value of assets, lower cost = more sensors
- Strong success with market leaders
- Agriculture market subsegments
 - Precision farming
 - Irrigation and pivots
 - Cattle and meat
 - Ag processing



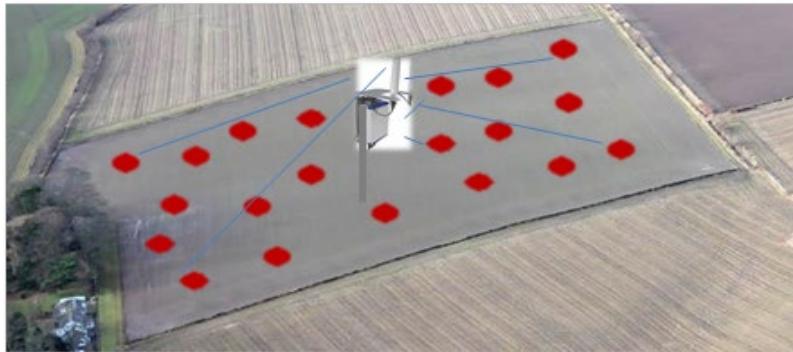
US Ag Market Segments	US Market Size
Irrigation and precision farming	TAM = 100M, SAM = 20M
Ag processing	TAM = 50M, SAM = 10M
Cattle & meat prod	TAM = 190M, SAM = 40M
Total	TAM = 340M, SAM = 70M



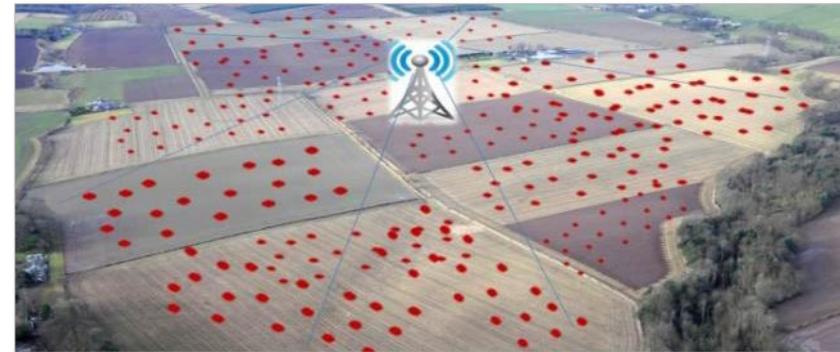


Agriculture - Irrigation

	Current Solutions	LoRa®
No. of fields	1	900
Coverage Area	0.5 mile radius / 0.75 Sq. miles	15 mile radius / 706 Sq. miles
Solution Cost	High	Low
Ease of use	Complex	Out of the box
Battery longevity	1-2 years	> 5 years



0.5 MILE Radius / 0.75 sq. miles /20 sensors



15 mile radius / 706 sq. miles /18k sensors



LPWAN : Use Case Irrigation

LP WAN Value:

- 5 YR Battery life
- Wide Area / height
- Low cost sensors



Toro, Hunter, and Rainbird are leaders in irrigation systems

Current system valve controllers have limited range and are hard wired

Cost and maintenance of hard wired systems are extremely high

All 3 leaders are designing wireless systems to monitor soil condition

There are over 15k golf courses in the US

LP WAN makes a business case by eliminating repeaters as control panels are not elevated



LPWAN: Use Case Localization / Asset Tracking

LP WAN Value:

- 10 YR Battery life
- Endpoint cost
- Reduces access cost
- Wide Area needed



Ability to track and locate industrial assets

Trimble / RF Code deploying more than 6M sensors annually

Agriculture:

- Large yards:
- Variable assets:
- Powered assets:
- Flower growers:

Tools and equipment
Fertilizer, Cotton bales
Tractors, vehicles
Tracking production thru POS

Environmental:

- Landfill:
- Kodak:
- Waste:
- Railway:
- Shipping

Regulated. Waste disposal tracking
Chemical container mgmt.
Container mgmt.
Container mgmt.
Container mgmt



LPWAN: Use Case Pet/People Tracking



LP WAN Value:

- 2 YR Battery life
- Wide Area
- Low cost sensors



Walt Disney spent \$1B for crowd control, data collection, and wearable technology

- One industry leader provides >2M tracking devices for theme park and event tracking

LoRa with location provides a cost effective, long life way to track pets and/or people



LPWAN: Use Case Oil / Gas Exploration



LP WAN Value:

- Solar powered GW repeater
- Wide Area
- Long range



In some cases cellular access is unavailable for remote oil / gas exploration sites

LP WAN allows for solar powered gateway repeaters to act as an interconnect to the cellular backhaul

Low cost, long range sensors can act to fill the void of rural connectivity

LP WAN repeaters can be placed on a pole using unlicensed RF bands – extremely low cost

Technology available today without touching base stations – range extension w/cellular backhaul



Supply Chain



Supply Chain - Trash



Partner

- **Enevo - Sensors and analytics for trash and recycling pickup optimization**

Benefit

- **40% reduction in collection costs**
- **50% reduction in collection**
- **Aesthetic city benefits to ensure pickup if containers are full ahead of schedule**

Supply Chain - Delivery



Partner

- **Insigma - Sensors and analytics for coolers**

Benefit

- **\$B lost to beverage supplier yearly due to out of stock**
- **\$50 'expense' if truck stops at store which doesn't need stocking**
- **Coolers or compressors stolen in some countries**



LPWAN : Use Case Smart Vending



LP WAN Value:

- 5 YR Battery life
- Endpoint cost
- Wide Area needed



Vending in process of being automated and monitored remotely

Monitoring provides visibility and accountability resulting in increased profits

- Efficient restocking
- JIT inventory management
- Preventive maintenance
- Location (theft prevention)

ROI includes labor and fuel efficiencies

Remote vending leader(s) have multiple pilot projects