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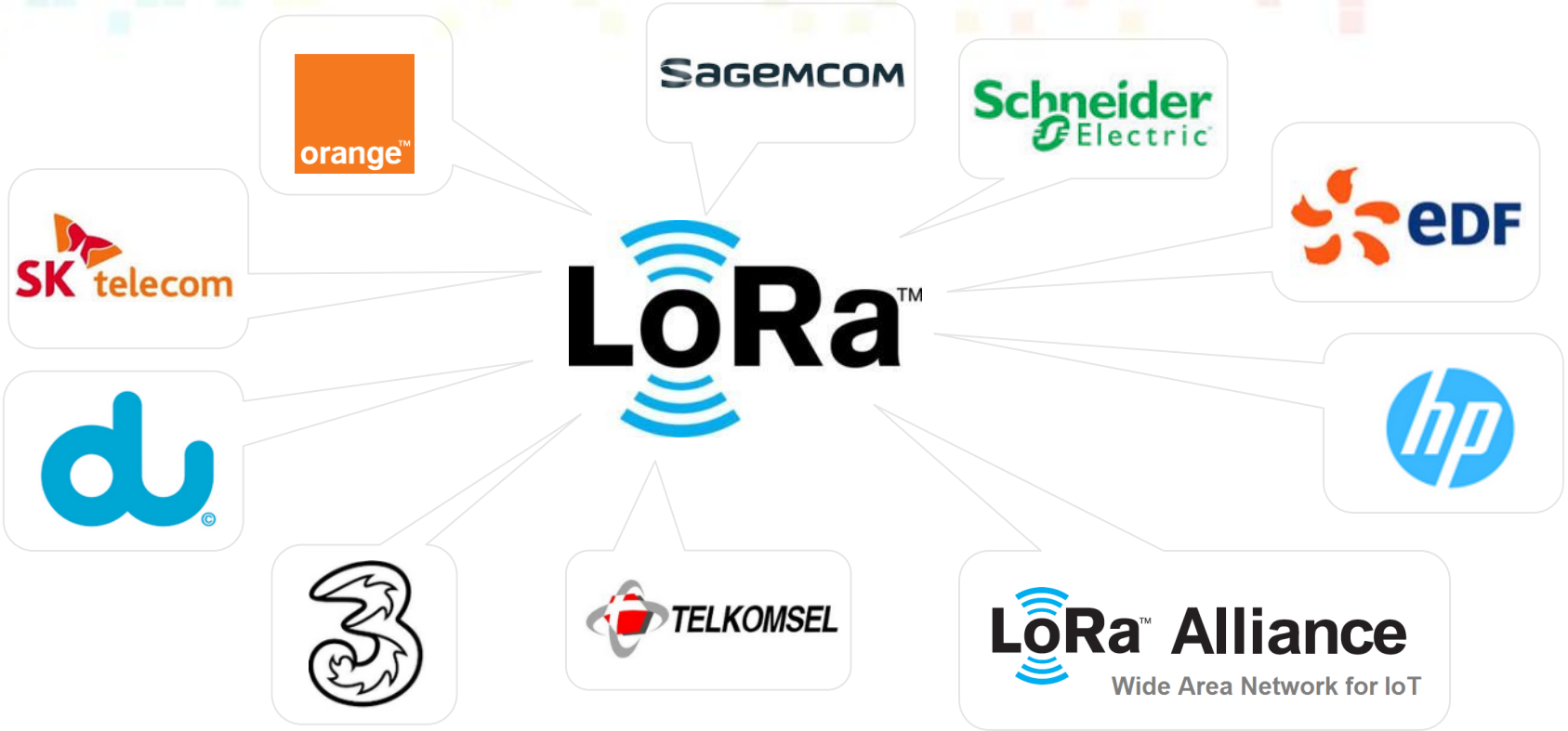
LoRa®

The leading provider for carriergrade LPWA Network

Latest news



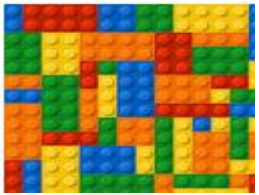
LoRa is rapidly becoming the defacto LPWAN standard

The Road To Low Power Wide Area

Multimedia & Voice

M2M

Internet of Things

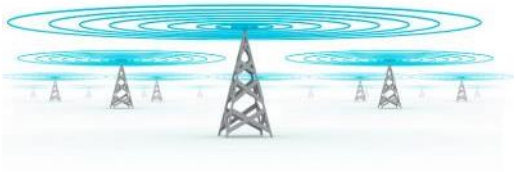


5G GB's/month 4G MB's/month 3G KB's/month 2G bytes/month LPWA

Where Does LPWAN Fit

	Local Area Network Short Range Communication	**L**ow **P**ower **W**ide **A**rea (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
	Bluetooth 4.0 · ZigBee · Wi Fi	LoRa	GSM · 3G+ / H+ · 4G

LoRa® Network Features



Long Range

- Greater than cellular
- Deep indoor coverage
- Star topology

Max Lifetime

- Low power optimized
- 10-20yr lifetime
- >10x vs cellular M2M

Multi Usage

- High capacity
- Multi-tenant
- Public network

Low Cost

- Minimal infrastructure
- Low cost end-node
- Open SW

Differentiators & Benefits

True Location

- In/out door
- Accurate
- No Battery Impact

Bidirectional

- Acknowledge
- Scalable Capacity
- Broadcast

LoRaWAN

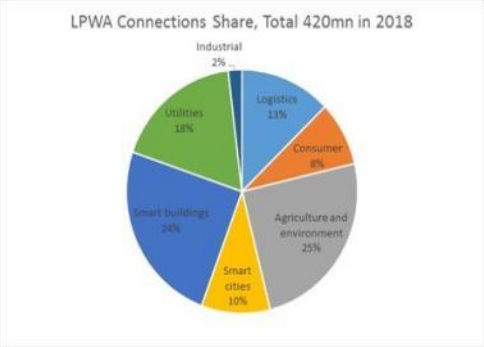
- Global Standard
- True Mobility
- Seamless
- Roaming

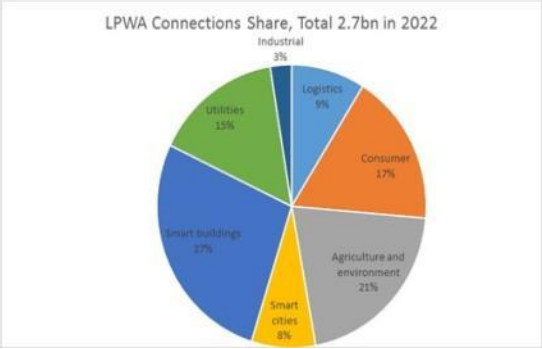
Security

- Unique ID
- Application
- Network

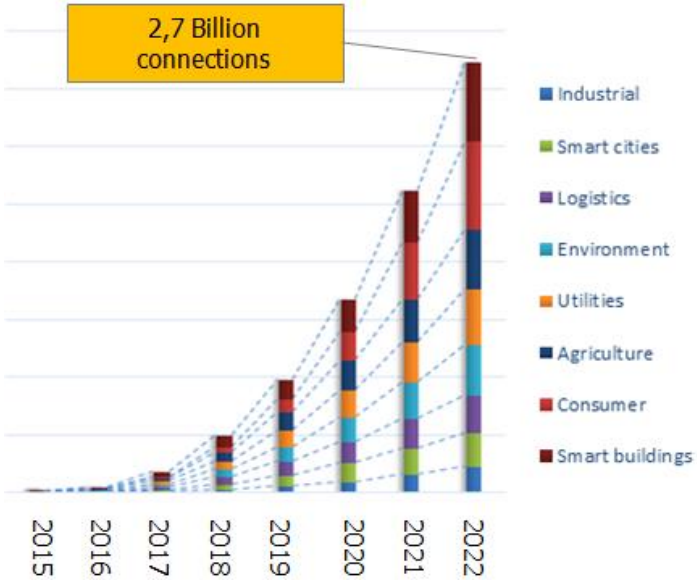
LPWAN Market Size & Focus

- **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%)

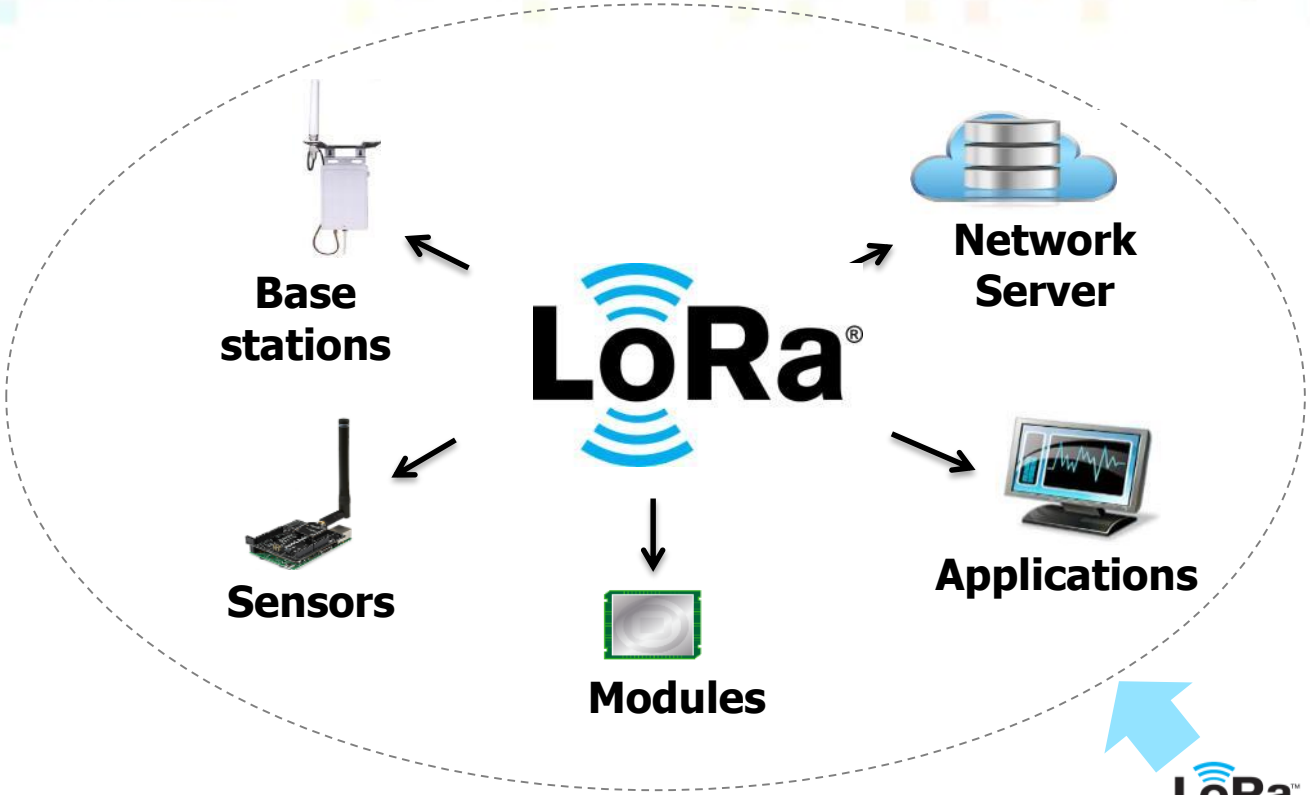




Source: Analysys Mason, April 2015

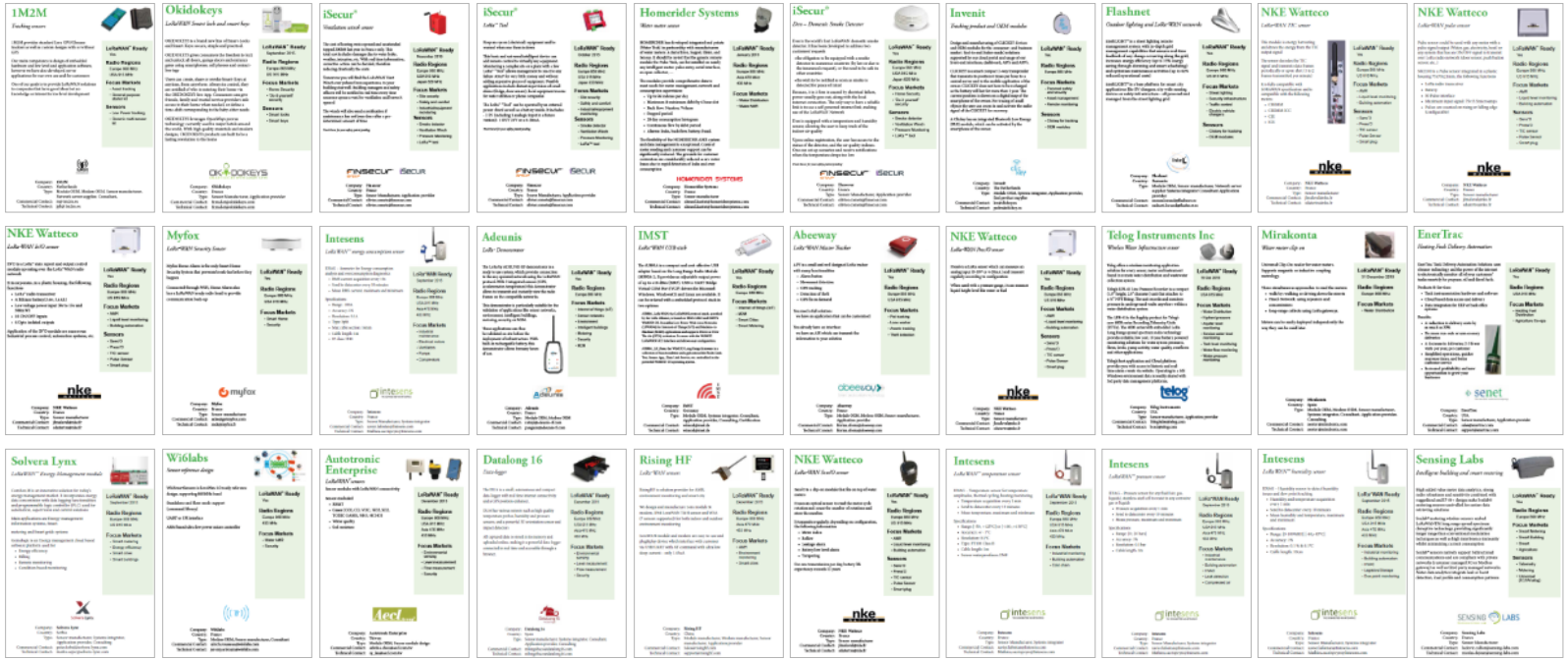


Building Blocks



LoRa™ Alliance
Wide Area Network for IoT

LoRaWAN Solutions



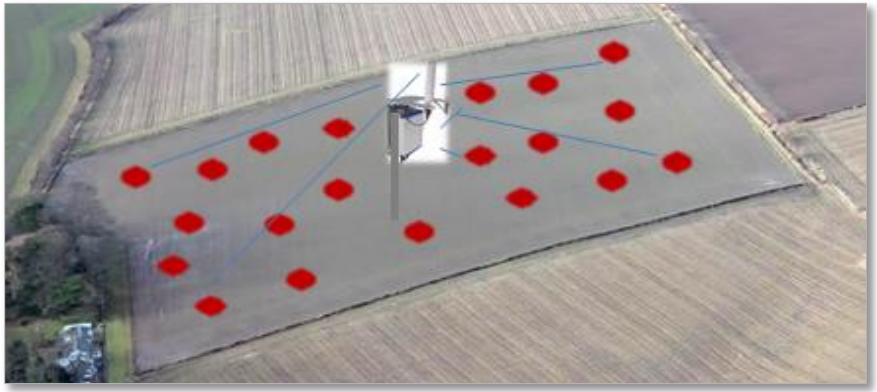
Examples

- Agriculture
- Smart Building
- Supply Chain

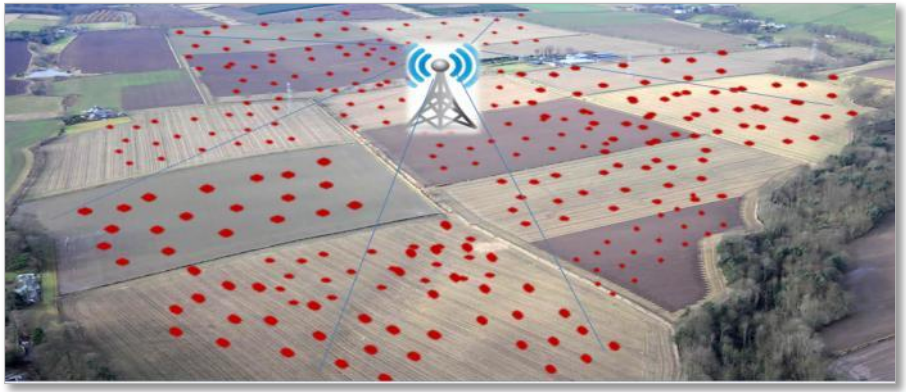
Agriculture - Irrigation

	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



Smarter Buildings

Bill each user seperately

Clean after 5 hours of high CO2 level

Clean after 100 door openings

Send heart beats, battery status and alarms

Supply Chain – Parcel delivery

Pick up: 4/21/15 (7:57 pm)

Driver goes to Port of Redwood City

Nearest Tower: 9 Miles / Skeggs Peak

75.2^0

Why carriers prefer LoRa®

Carrier Grade Selection Criteria

Security

Scalability

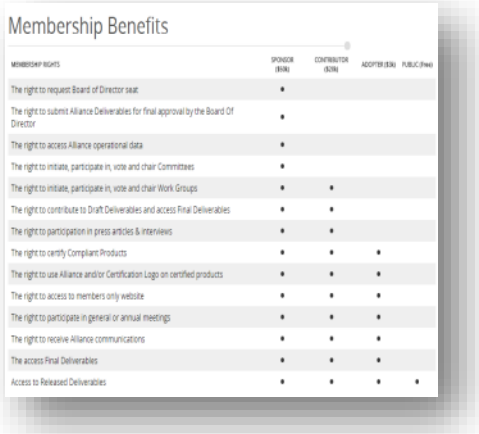
Standardization

LoRaWAN™

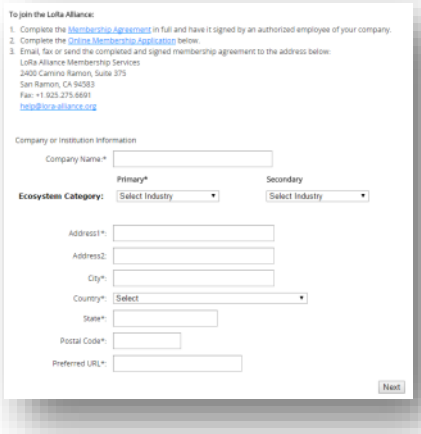
www.lora-alliance.org

Alliance Activities

Explore



Sign Up



Get Exposure

- Become a member
- LoRa Alliance All Member Meeting: https://www.lora-alliance.org/News-Events/Events
- LoRa Alliance Challenge: https://www.lora-alliance.org/News-Events/Global-IoT-Challenge
- Participate in events: IoT World, European Utility Week, CES, MWC, …

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Thank you

Back Up Slides

Technical Positioning

Differentiator		LoRa	Sigfox	Ingenu	Short Range	LTEM	CiOT
Protocol		Open Standard	Proprietary	Proprietary RPMA	Zigbee BLE Wifi	Qualcom	Huawei Neul
Location		25 m	✗	✗	✗	200 m	unclear
Power	Tx Rx Sleep	120 mA/20 Dbm 10 mA 0.001 mA	120 mA/20 Dbm 10 mA 0.001 mA	750 mA 300 mA 0.072 mA	35 mA / 8 Dbm 26 mA 0.003 mA	800 mA / 30 Dbm 50 mA 3.5 mA	Unclear
Range	Indoor Outdoor	3 Km 30 Km	3 Km 30 Km	3 Km 30 Km	150 m 30 m	1.7 Km 20 Km	Unclear
Link Budget		156 Db/290 Bps	156 Db/100 Bps	172 Db/240 Bps	108 Db	147 Db	
Sensitivity		-134 dBm	-126 dBm	-142 dBm	-100 dBm	-117 dBm	
Security		✓: 128 AES	✗	✓	✓	✓	Unclear
Interference immunity		good	bad		bad	moderate	unclear

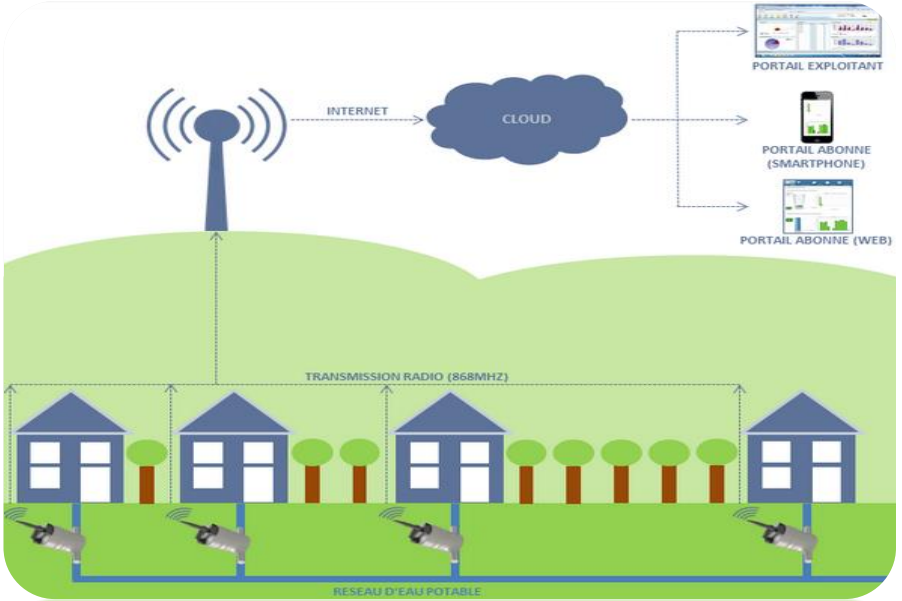
Competitive Positioning

Differentiator		LoRa	Sigfox	Ingenu	Short Range	LTEM	CiOT
Moving objects		✓	✗	✗	✗	✓	unclear
Capacity		✓ : adaptive	1.3 M	< 500K	< 1000		Unclear
Hosting		In country	France	Custom	Custom	Custom	Unclear
Business model		Eco system	License 40% share	Custom	Custom	Carrier	Carrier
Installed base		> 5 million	< 200.000	< 500.000	> 200 M	0	0
Message size	Up Down	Up to 50 Kbs Up to 50 Kbs	12 Bytes 8 Bytes	Unknown			
Bi directional		✓	Very limited 20 Sec latency	✓ >3 sec latency	✓		
Broadcast		✓	✗	✓	✓		

Typical LoRa Use Cases

Smart Metering

- Type of application – Deep Indoor, Fixed objects
- Markets – Water, Gas, Electricity
- Critical business issues
  - Legislative compliance
  - Meter reading
  - Leak detection, also in network
  - Reduce flow to manage consumption
  - Shut down flow for safety and damage control
  - Manage disconnections/reconnections
  - Manage updates for pricing
  - Increase public awareness



Industrial Asset Monitoring

- Type of application – indoor fixed objects
- Markets - maintenance and supervision of machine status
- Critical business issues
  - Warranty management
  - Predictive maintenance
  - Avoid outage
  - Respond to temperature or air quality alerts
  - Stop machine from control room
  - Accessibility to assets

Logistics & Supplychain

- Type of application – outdoor mobile objects
- Markets – parcels, containers, pallets, valuable goods…
- Critical business issues
  - Reduce cost and optimize execution
  - Enhance customer service
  - Lost and found
  - Management and cost of return goods
  - Quality of goods during transportation

Safety & Security

- Type of application – indoor/outdoor objects and people
- Markets – lone worker, smoke & intrusion detection access control
- Critical business issues
  - Health & Safety compliance
  - Building security
  - Time and attendance management
  - Home security
  - Jamming

Fill rate monitoring

- Type of application – indoor & outdoor mobile objects
- Markets – gas tank, cylinders, waste containers, tyres
- Critical business issues
  - Customer service levels
  - Logistic cost
  - Complaints management
  - Predictive forecasting
  - Alerts management

Smart Cities

- Type of application – indoor & outdoor fixed objects
- Markets – parking, streetlights, intelligent traffic mgt, air quality
- Critical business issues
  - Carbon footprint
  - Traffic management
  - Citizen satisfaction & safety
  - Reduced budgets
  - Assisted living

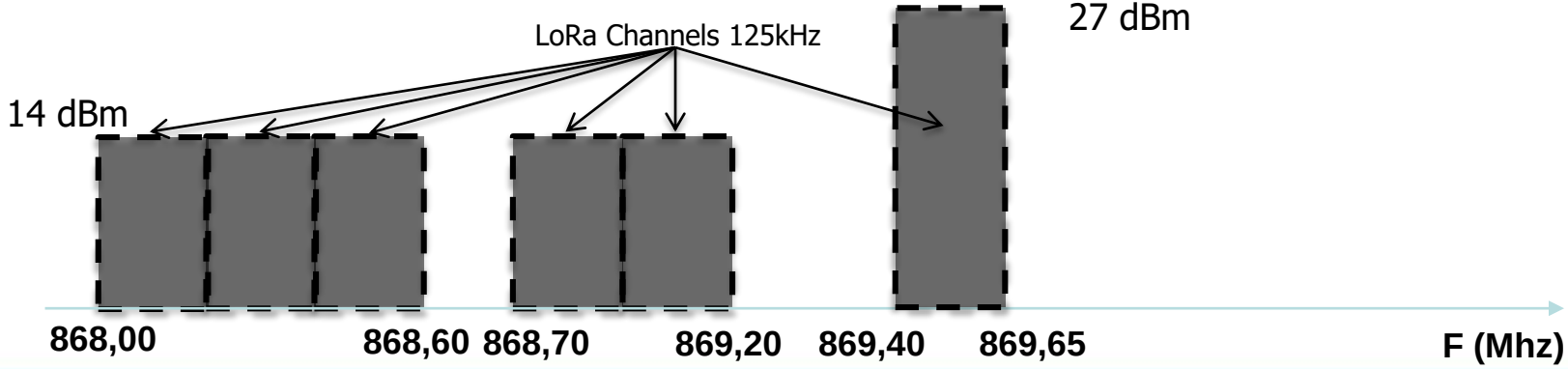
The basics of LoRa

What is an LPWAN network

- New enabling networks Low Power Wide Access Network
  - Low cost and small chipsets
  - Extreme low power consumption
  - Long range
  - Low throughput
- LoRa by Semtech
  - Technology available to MNO's and sensor/module manufacturers : radio technology based on Direct Spread Spectrum for secure, bidirectional and flexible payload messages
  - Growing feature footprint for example to enable location determination
- LoRa Alliance: Strategic non-profit partnership to drive optimal value creation
  - Define and manage the LoRaWAN specification
  - Ensure inter-operability and standardization
  - Drive the development of a global eco system and strategic partnerships

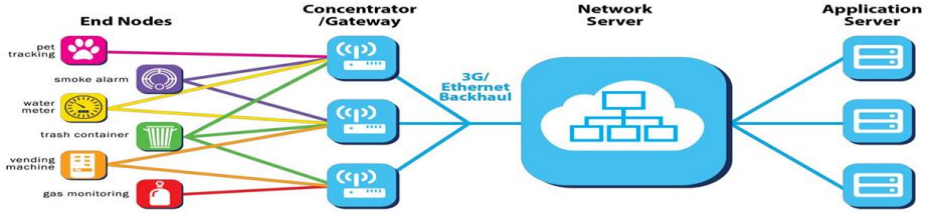
Using License Free Bands

- ISM (Industry, Science, Medical) band, no licensing required
- Frequency band 863-870 Mhz in Europe
- However strict rules to adhere to:
  - UpLink : 25 mW (14 dBm), 1% duty cycle per hour (< 36 seconds transmission)
  - DownLink : 500 mW (27 dBm), 10% duty cycle per hour (< 360 seconds transmission)
- The 863-870 Mhz band will be available long term and will be extended to 863-875,6 Mhz increasing capacity
- Usage regulation is redefined every 4 years, next end of 2015

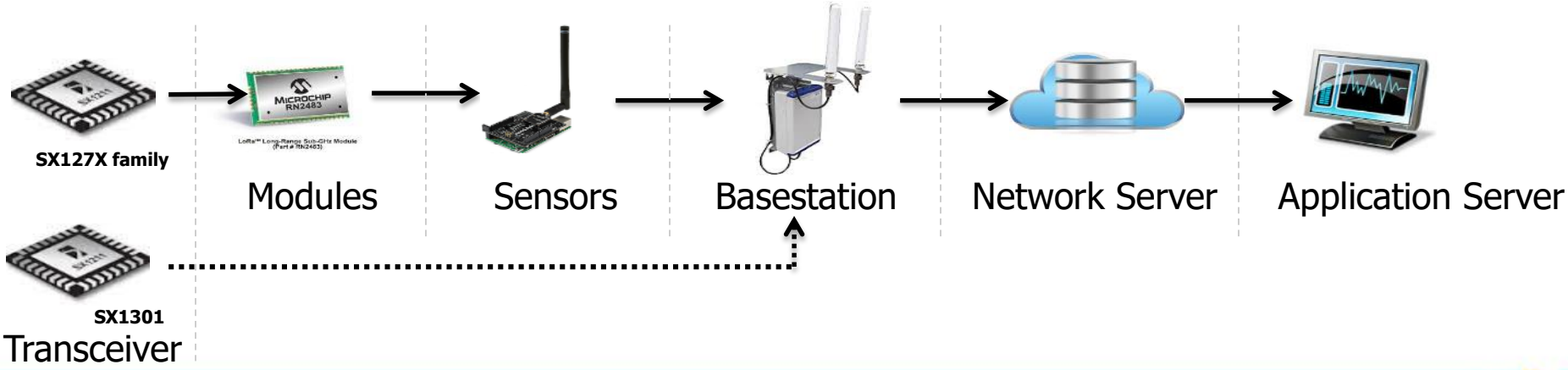


LoRa Valuechain

- ❑ Module Manufacturers
- ❑ Sensor Manufacturers
- ❑ Base Station Manufacturers
- ❑ Network Server Providers

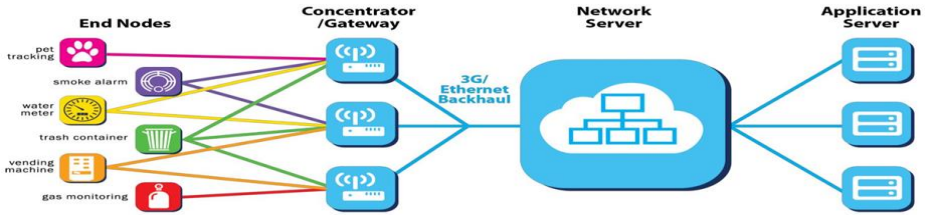


- Public Network Operator
- Private Network Operator



LoRa Network Server

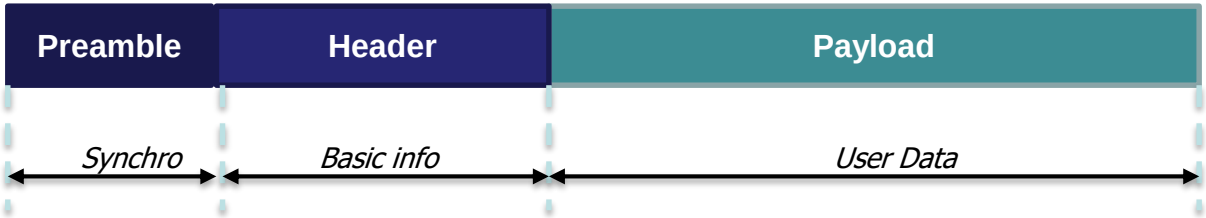
- Network Server : handles all data traffic:
  - Processes all traffic received from gateways
  - Manage radio configuration: Adaptive Data Rate (Spreading Factor)
  - Message management: authentication, authorization, accounting
  - Location determination (DTOA): license required
  - Manages acknowledgements (if required)
  - Manages downlink messages including multicast
  - Collects data for the Operations Support System (network managment)
  - Interfacing towards application servers (API)



Spectrum usage

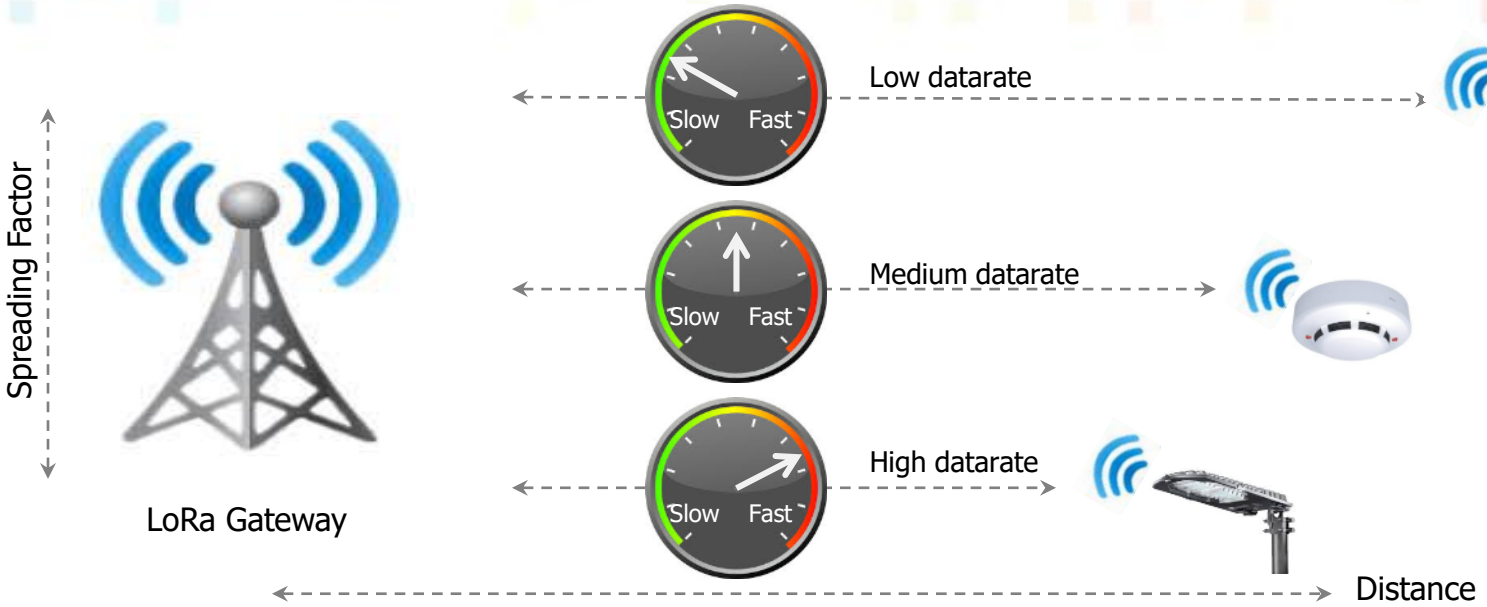
- Basic Radio Transmission
  - Messages are received by multiple base stations to deal with local interference resulting in optimal Quality of Service
- Spread Spectrum
  - Each string of bytes (a message) is increased with a redundant string for optimal Quality of Service. This ensures excellent demodulation of messages at the base stations even in an environment with high noise floors and other interferers
- Adaptive Data Rate
  - A unique, and variable, spreading factor is used to increase the robustness of a message
  - The Spreading Factor can vary between SF6 to SF12
    - The higher a spreading factor the better the robustness of a message as the distance between sensor and base station (range) can be longer
    - A lower spreading factor results in decreased robustness against interference, however due to faster transmission (Time on Air) one can send bigger messages resulting in lower power consumption
  - The network manages these spreading factors automatically

Protocol and message structure



- Chirp (chirp) : synchronization preamble to allow for recognition of message
- Header : basic information for message size and error correction
- Payload (flexible) : user data ranging from 1 to 242 bytes

A smart connexion for smart sensors

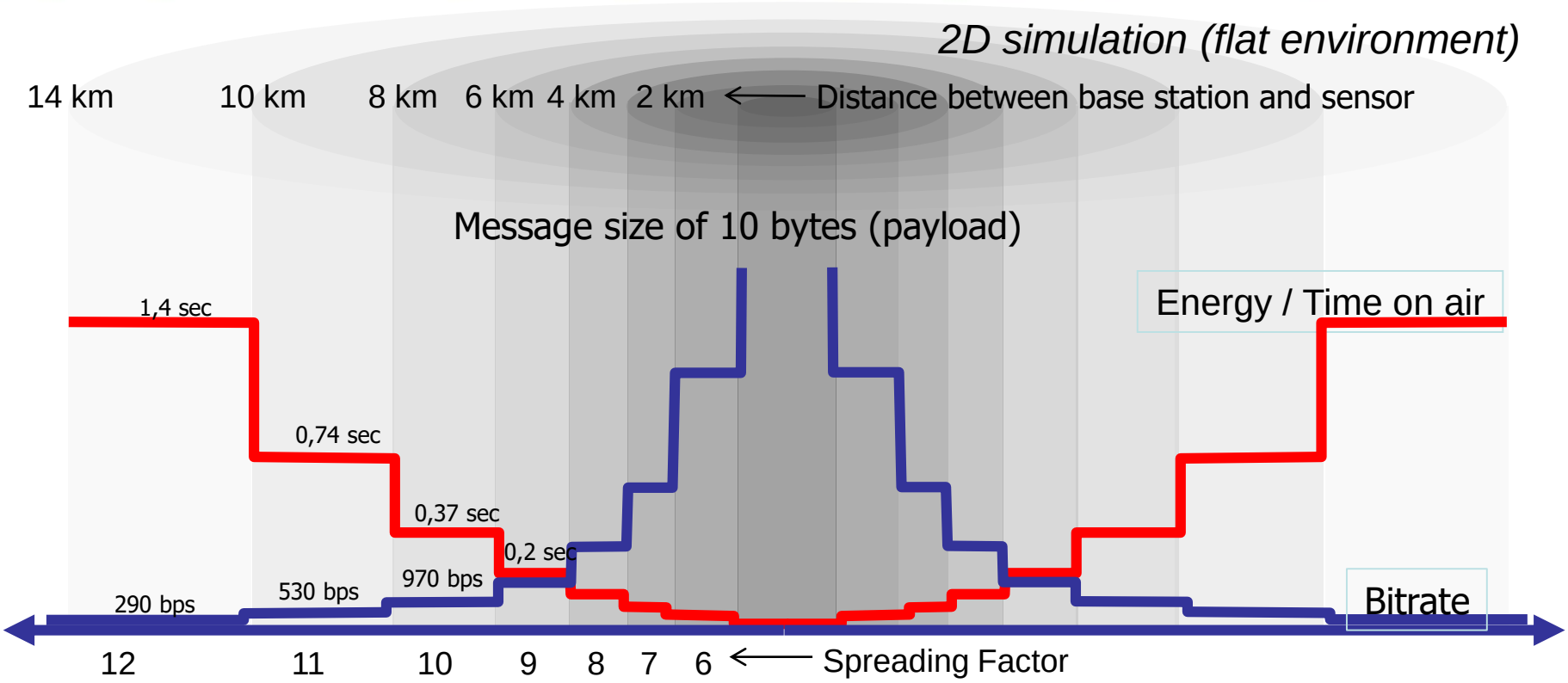


- Dynamic datarate to deal with outdoor, indoor and deep indoor
- Best datarate to reach gateway is set dynamically and automatically
- Power consumption is optimized automatically
- End result is the best mix between datarate, range, power

Future proof scalability

- Datarate is set based on range, visibility, height whilst speed and time on air are optimised
- Best datarate to reach gateway is set dynamically and automatically
- Interference reduction
- End result is optimal deployment growing with market needs

Unlimited growth enabled by ADR



Adaptation to use case

Spreading factor	Time on Air	Data rate	Sensitivity
6	33 ms	9380 bps	-127.5dBm
7	56 ms	5469 bps	-130.0dBm
8	100 ms	3125 bps	-132.5dBm
9	200 ms	1758 bps	-135.0dBm
10	370 ms	977 bps	-137.5dBm
11	740 ms	537 bps	-140.0dBm
12	1400 ms	293 bps	-142.5dBm

Values correspond with a payload of 10 bytes

- All LoRa chipsets are compatible with a G(FSK) modulation allowing for data rates up to 50 kbit/s

Huge advantages for growing demand

- Adding gateways scales capacity by 6-8X
- Optimizes channel usage
- Saves battery
- Increased Quality of Service
- Extremely robust for interference
- Optimized penetration for deep indoor and underground
- Increased payload
- Reduced time on air
- Ability to deal with exisiting or new agglomoration
- Allows for femto cell growth path

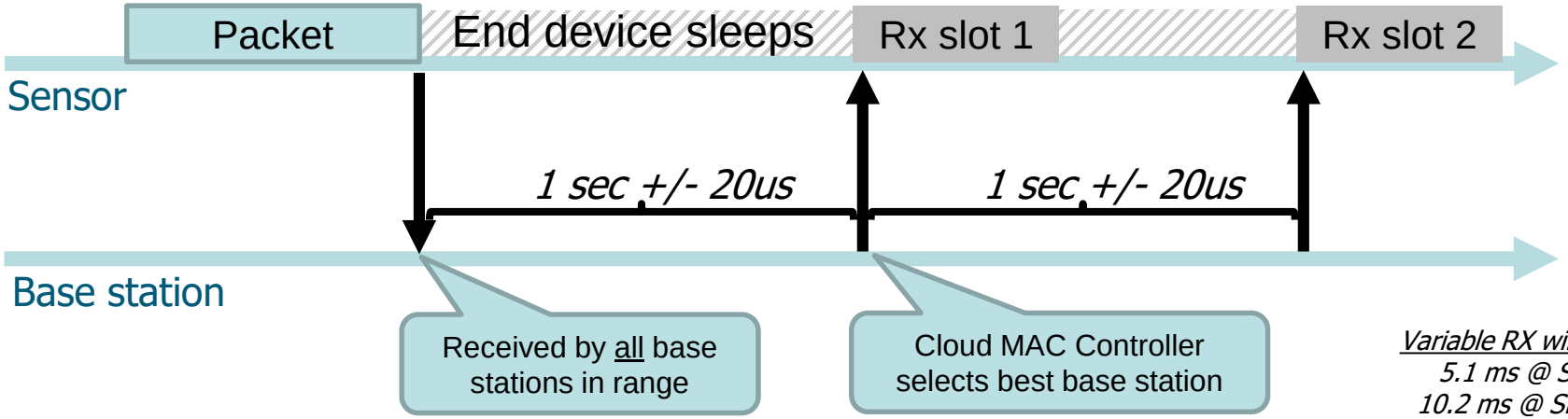
Higher Spreading Factor	Lower Spreading factor
Robustness against interference	Increased payload
Optimal link budet (Signal to Noise)	Lower time on air
Increased network range	Increased capacity

Device Classes for any use case

Class name	Intended usage
A (« all »)	Battery powered sensors • No latency constraint • Most energy efficient communication class. • Must be supported by all devices
B (« beacon »)	Battery powered actuators • Energy efficient communication class for latency controlled downlink • Based on slotted communication synchronized with a network beacon
C (« continuous »)	Mains powered actuators • Devices which can afford to listen continuously. • No latency for downlink communication

Bidirectional communication, class A

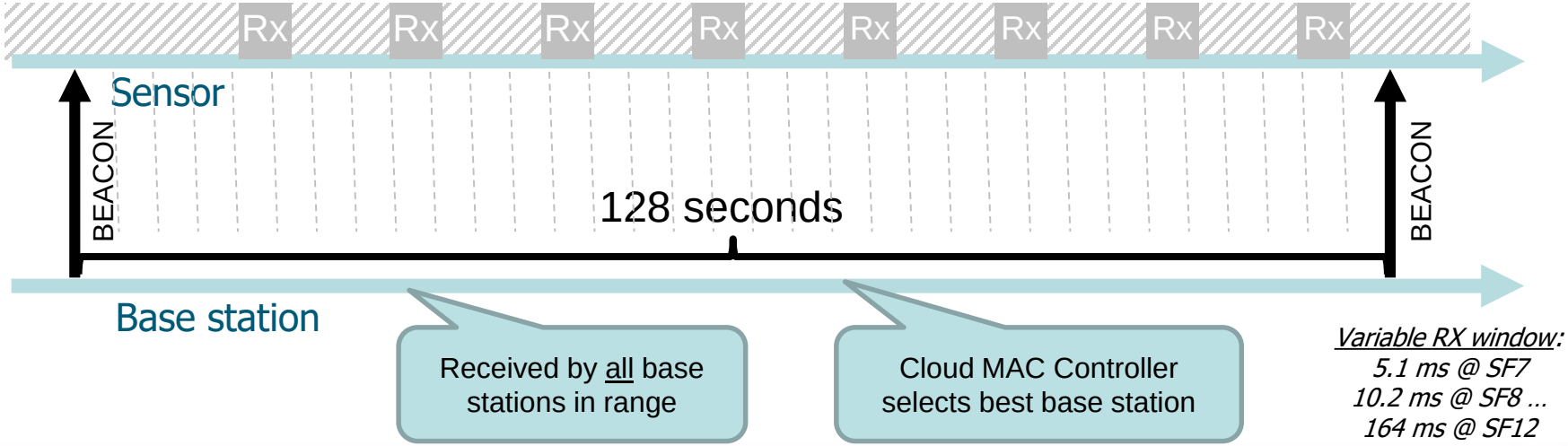
- Downlink messages are optional and initiated by an Uplink message
- Each Uplink message opens 2 windows Downlink
  - Acknowledgement, MAC commands, apllication commands



Variable RX window:
5.1 ms @ SF7
10.2 ms @ SF8 …
164 ms @ SF12

Bidirectional communication, class B

- Downlink messages are optional
- Classe B: all sensors are synchronized with the gateways and have regular Downlink windows
- Coordinated Sampled Listening (CSL): Network may send downlink packet to node at any Rx slot



Embedded Security

- Multi level encryption to ensure optimal protection
- Encryption using AES 128 algorithm, following 802.15.04 standard
- Three security keys
  - Primary security per sensor (objectId/@MAC-Id)
  - Dedicated network key per operator (MIC : network integrity)
  - Service provider key (not shared with operator) decryption in final application only
- Full protection against
  - Replay of messages through counters, both Uplink and Downlink
  - Identity of sender
  - Content of message

Unique differentiators – for integrators

- Long range resulting in attractive subscription cost
  - 2 km in dense city environments
  - 15 km rural
- Low power consumption
  - Battery operated sensors with > 10 years lifespan
  - Extended battery life through reduced transmission time (ADR)
- Variable payload allows for adaptation to use case
- Bidirectional communication in three device classes
- Sensor management through unicast, multicast and broadcast
- Controlled Quality of service
- Low latency for downlink messages
- Robust against interference and noise
- Support mobile objects even at high speed
- Location determination
- Multi level security
- LoRa Alliance- open source LoRaWAN
  - Roaming, Interoperatability and standardisation
  - Strong supporting eco system

Unique differentiators – for operators

- Long range resulting in lower capex and opex
  - Attractive subscription models serving many use cases
  - Re-use of existing 2G antenna's lowering deployment cost
- Optimal Total Addressable market
  - Bidirectional communication in three device classes
  - Low latency for downlink messages
  - Robust against interference and noise
  - Support mobile objects even at high speed
  - Location determination
  - Multi level security
  - Variable payload to increases use case applicability
- Adaptive data rate
  - Lower time on air
  - Grow network coverage in sync with market demand
- Sensor management through unicast, multicast and broadcast
  - Required for subscription management
- Controlled Quality of service

Location Determination

Importance of Location

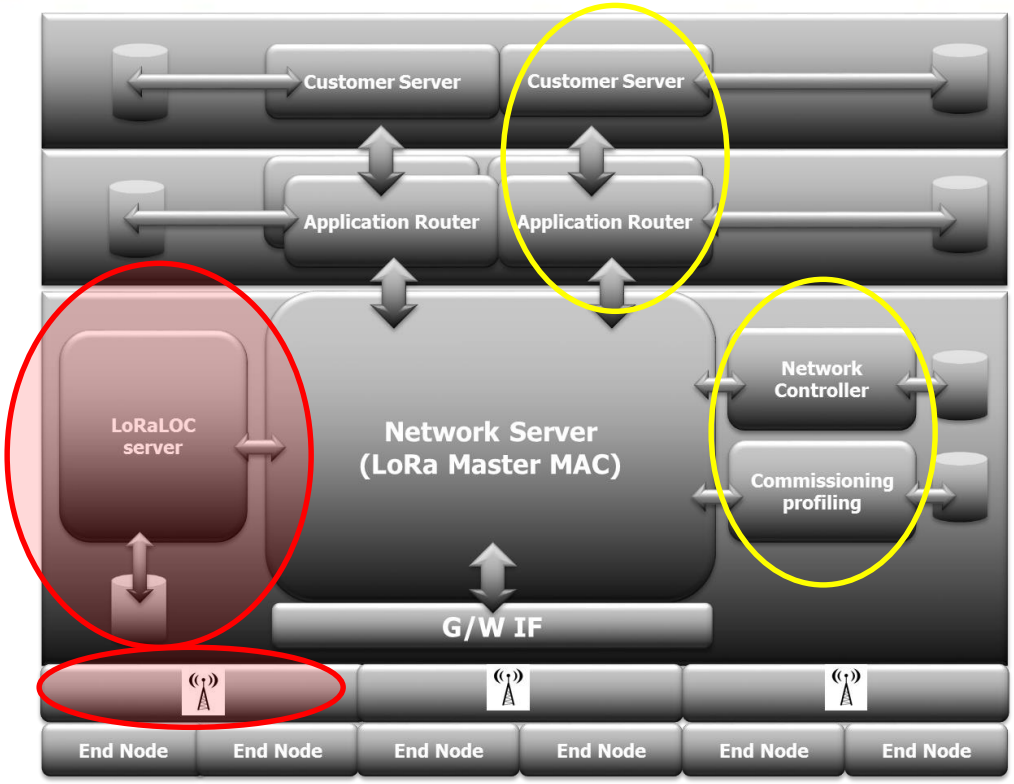
- **Unique LPWAN feature**
  - Indoor/outdoor
  - No battery impact, longer life span
- **Applicable to majority of applications**
  - One off – determine installation location
  - Recovery – regular heart beat and high SLA when needed
  - Regular determination – all across supply chain and mobile assets in many market segments
- **High value add**
- **Replacing existing capabilities**
  - GPS – BOM and battery cost reduction ($5-$10)
  - Wifi – mainly Google ($0.50 USD / 1000 additional elements, up to 100,000 daily)

Location Roadmap

SEMTECH

Definition	Algorithm	POC	Model	Pilot
❑ System	❑ Mathematical	❑ LOC Gateway	❑ Algorithm V1.0	❑ 2nd Gen Gateway
❑ Gateway	❑ Conditions	❑ City deployment	❑ Performance test	❑ LoRaLOC rollout
❑ Requirements	❑ Location classes	❑ Data collection	❑ Data collection	❑ End-Customer trail
	❑ Simulation	❑ Preliminary report	❑ Final report	❑ Qualification report
❑ **Q-3 2014**	❑ **Q2-2015**	❑ **Q4-2015**	❑ **Q1-2016**	❑ **Q2-2016**

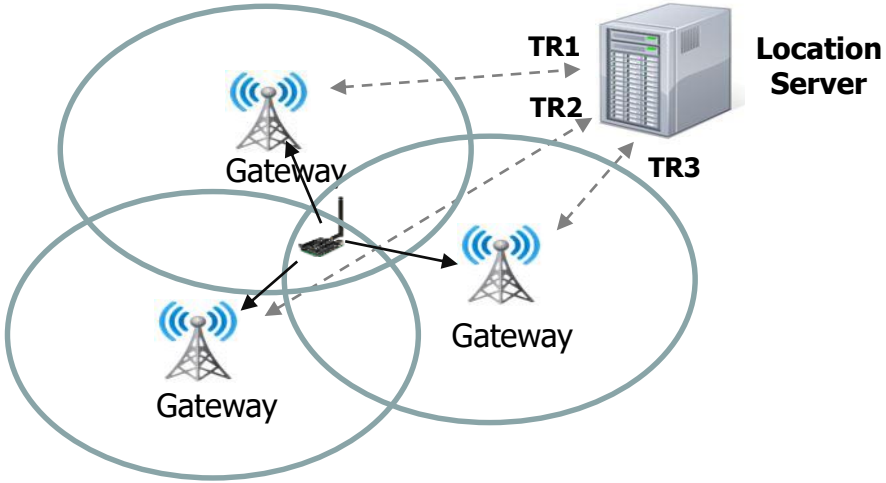
System design



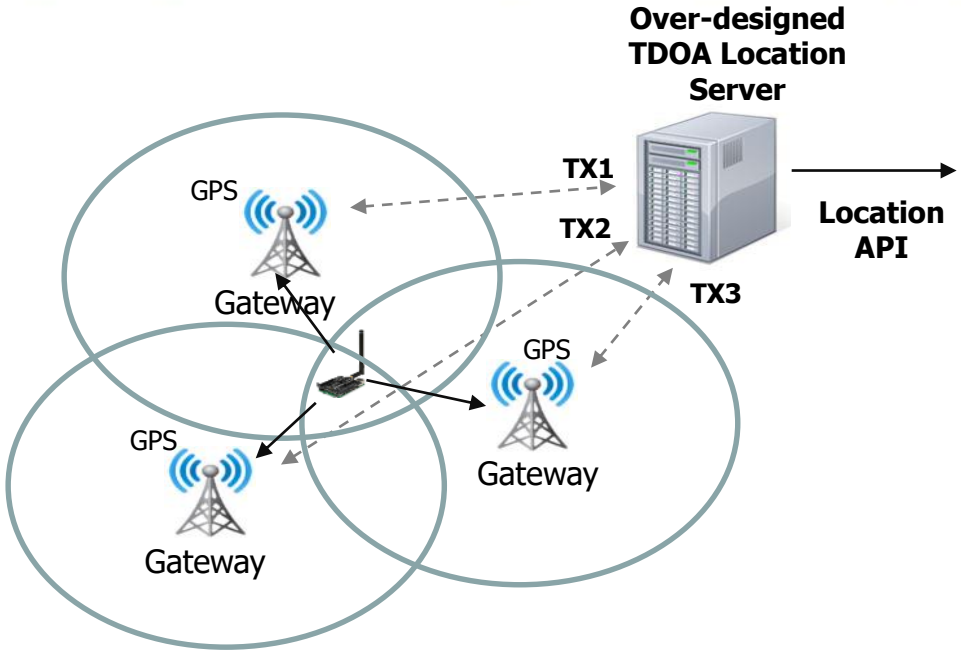
- Semtech LoRa Location License:
  - Semtech Location server
  - Reference design for localization gateway
- Network Server Provider:
  - Network Controller including Adaptive data rate management for localization
  - Commissioning including localization profile
- Network Operator
  - Application Router sending localization data to customer server
- Customer Server
  - Provide geo localization of devices through webserver and applications

Location ready without GPS

- LoRa uses Differential Time Of Arrival (DTOA) for location calculation
- Triangulation based location determination
  - Outdoor accuracy < 50 M
  - Indoor accuracy < 75 M
- Supports mobile sensors even when moving fast (fading/multipath)



Network infrastructure



- Localization is performed on data transmissions from sensors
- Gateways are synchronized in time with GPS
- Accurate timestamps are added to received data, along RSSI, frequency error, pointing direction of antenna
- For each message to locate, a localization server collects the multiple receptions and solves for 2D position

FAQ - LoRa

- How much data can be transmitted - What is the data througput with LoRa
- What is the latency – how fast will data be delivered
- Capacity - how many sensors can be supported
- Capacity – what is the future strategy for ISM
- Capacity – how much data can LoRa handle
- Security – how is security and privacy managed
- Penetration – how deep indoor does LoRa work

How much data can be transmitted

Uplink :

	Overhead	Max Payload
LoRa	17 bytes	Up to 242 bytes

	Time on Air (for 12 bytes sent)	Data rate (for 12 bytes sent)
LoRa SF7	62 ms	1556 bits/s
LoRa SF12	1,48 sec	64,74 bits/s

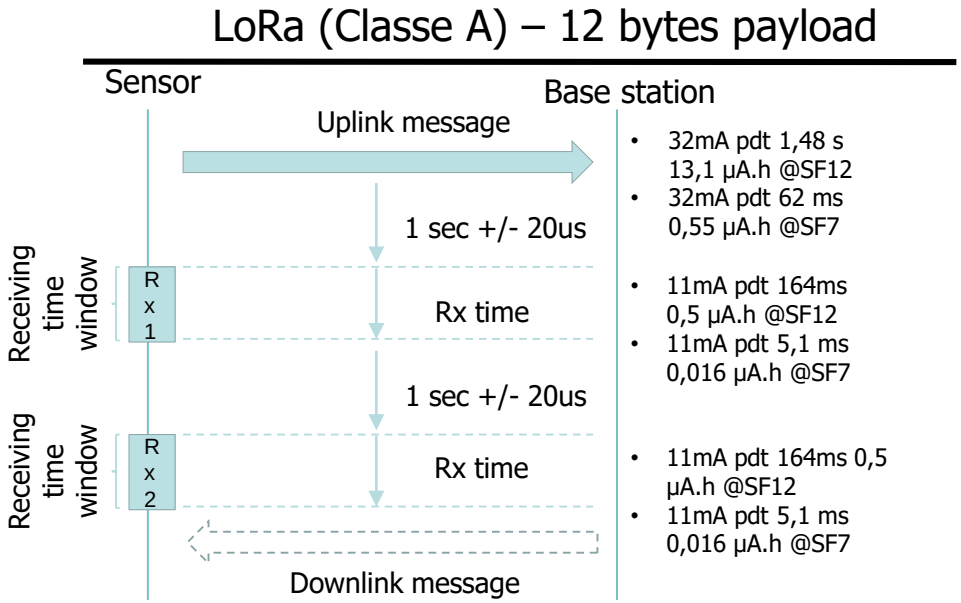
Downlink :

	Overhead	Max Payload
LoRa	15 bytes	Op to 242 bytes

	Time on Air (for 8 bytes sent)	Data rate (for 8 bytes sent)
LoRa SF7	56 ms	1142 bits/s
LoRa SF9	185 ms	346 bits/s

- The payload with LoRa is flexible using the adaptive data rate
  - Packet size ranging for 1 to 242 bytes
- Data throughput (data rate) is managed by network
- Time on air (data rate) is not fixed to optimize spectrum usage

Latency – how fast is data delivery



- Uplink latency (sensor to network)
  - Adaptive data rate depending on signal quality
  - Time on air varies from 62ms to 1,48s
- Downlink latency (network to sensor)
  - Device class driven
  - Device class A – after an Uplink message the sensor listens 1 - 2,2 seconds for a downlink message
  - The network latency (backhaul) depends on operator, typically milli seconds

Is there a capacity limit

- Radio networks have limited capacity
  - All radio channels in the same frequency band (868MHz) are occupied (6 channels of 125 KHz for LoRa)
  - When saturated the adaptive data rate does not allow further optimization (channel and spreading factor)
  - Theoretical capacity calculation
    - Gateways are not a limiting factor : 36 simultaneous demodulations (6 channels times 6 spreading factors)
    - Time on air (use of spectrum) depends on distance to base station
    - Highest concentration of sensors will be in urban areas
      - 70% of sensors on Spreading Factor 12 – longest range
      - 20% of sensors on Spreading factor 10
      - 10% of sensors on Spreading factor 8 – shortest time on air
    - Example for 10 bytes payload per message and 1 gateway every 1 Km
      - Maximum capacity per gateway per day 515 000 messages
      - Maximum capacity per Km2 per day 164 000 messages
    - For use case with 4 messages per day per sensor : 41 000 sensors maximum per km2
- Example for Paris : population density is 21.347 per km2
  - Maximum number of messages of 10 bytes is (164.000/21.347) 8 messages per inhabitant per day
- Increased density of base stations will grow capacity rapidly and provides scalability for operators

How much data can LoRa handle

- LoRa technology has been built from scratch to serve the IoT
- The adaptive data rate means change speed of transmission when there is a better quality of the radio signal
- The closer a sensor is to a base station the better the quality of the radio signal
- Outdoor sensors typically have better signal quality as indoor or underground placed sensors
- The faster the speed of the radio transmission, called data rate, the shorter the sensor consumes battery power
- Faster transmission increases the capacity of the band as more messages can be transmitted
- LoRa can handle from 300bps up to 9,4kbps
- The ADR is automatically managed by the network

Optimal security management

- Network encryption is AES 128 (as per the 802.15.04 standard)
- Multi level security management
  - One security key per sensor
  - Network security key per operator (MIC : integrated key)
    - re-use of the standard encryption as per the 802.15.04 : CCM standard
    - encryption key only known to operator (always)
  - Solution provider security key different for each partner and only known to the partner
    - encryption of payload to ensure security up to the processing partner server
  - Message counter – protection against piracy and identity theft

Underground or deep indoor

- Attenuation is higher when sensors are placed underground or deep indoor, up to the level that radio signals do not
- Signal strength is influenced by concrete walls, metal and even human bodies
- Each building has its own specific constraints
- If in doubt local measurements need to proof applicability
- Network coverage is mostly expressed in % coverage of territory and % coverage of population
- In difficult environments additional base stations will resolve coverage issues (keep in mind ADR is needed)
- The link budget of LoRa, defining the sensitivity of the network, is very close to the physical limit which leaves no room for competitors to be much better

FAQ – LoRa Alliance

- Are there variations of LoRaWAN

Currently LoRaWAN R1.0 is published, enhancements of the standard is driven by the Technical Committee of the Alliance to which all members contribute

- What is the process for upgrades to LoRaWAN

The Technical committee drives the future of the LoRaWAN standard and publishes fixes and new releases when they become available

- How does roaming work with LoRaWAN
- Are there exisiting Quality of Service and SLA's for LoRaWAN
- How does hand-over work with LoRaWAN
- Why do carriers prefer LoRaWAN

Roaming ready

- Roaming is driven by a working group in the Strategy Committee in the Alliance
- Roaming : a sensor joins another network as its Home Network
- Technical optimization – use additional base stations in other networks
  - Location determination
  - Faster transmission
  - Lower latency
  - Lower power consumption
- Roaming tariffs are not mandatory and bilateral, through the LoRa Alliance
- Network security keys enable proper management of roaming
- Message counters are available to allow for proper clearing
- Commercial offers including roaming are at each operators discretion

Quality of Service

- All data communication is executed at best effort - technology needs to be robust
- Operate in different frequency bands
- Limit time on air to avoid collision through ADR
- Increase the link budget through higher spreading factor (up to + 20 dB)
- Reconstruction of messages even if only parts are received
- Automatic band hopping if needed
- Balanced link budget for UL and DL
- Several device classes to increase QoS when needed

Service Level Agreements

- QoS and SLA are network operator responsibilities and defined by each operator as these depend on network deployment strategies and customer contracts
- Through deployment strategies LoRa Network Operators can deliver high service levels in terms of coverage
- LoRaWAN is open and standard protocol guaranteeing compliance throughout the value chain
- Certification guarantees legal compliance and device class for optimal connectivity and clear coverage maps
- Service Level Agreement
  - Interoperability and roaming
  - Strong encryption to protect data
  - Test house involved for certification of sensors
    - SRD 863-870 MHz : 300-220 (EMITECH)
    - LoRaWAN compliant
    - ETSI/FCC compliance

How does handover work

- Handover like in GSM Networks does not exist with LoRa Networks
- Communication is not continuous, sensors transmit only when needed and receive responses accordingly
- Messages are received by one or more base stations and forwarded to a network server for further processing
- Message transmission time is very limited (< a few seconds)

Why carriers prefer LoRaWAN

Benefits of scale and experience leading to reduced Capex & Opex

- ❑ MNO’s have access to tower locations
- ❑ MNO’s have experience in rolling out networks
- ❑ ADR enables to grow coverage with market demand

Optimized Quality of Service

- ❑ Experience in managing and mantaining data com networks
- ❑ ADR (adaptif data rate) allows for densification without capacity constraints
- ❑ For outdoor applications the majority of use cases can operate under SF 7 or SF 8, thus extreme low power consumption and high capacity