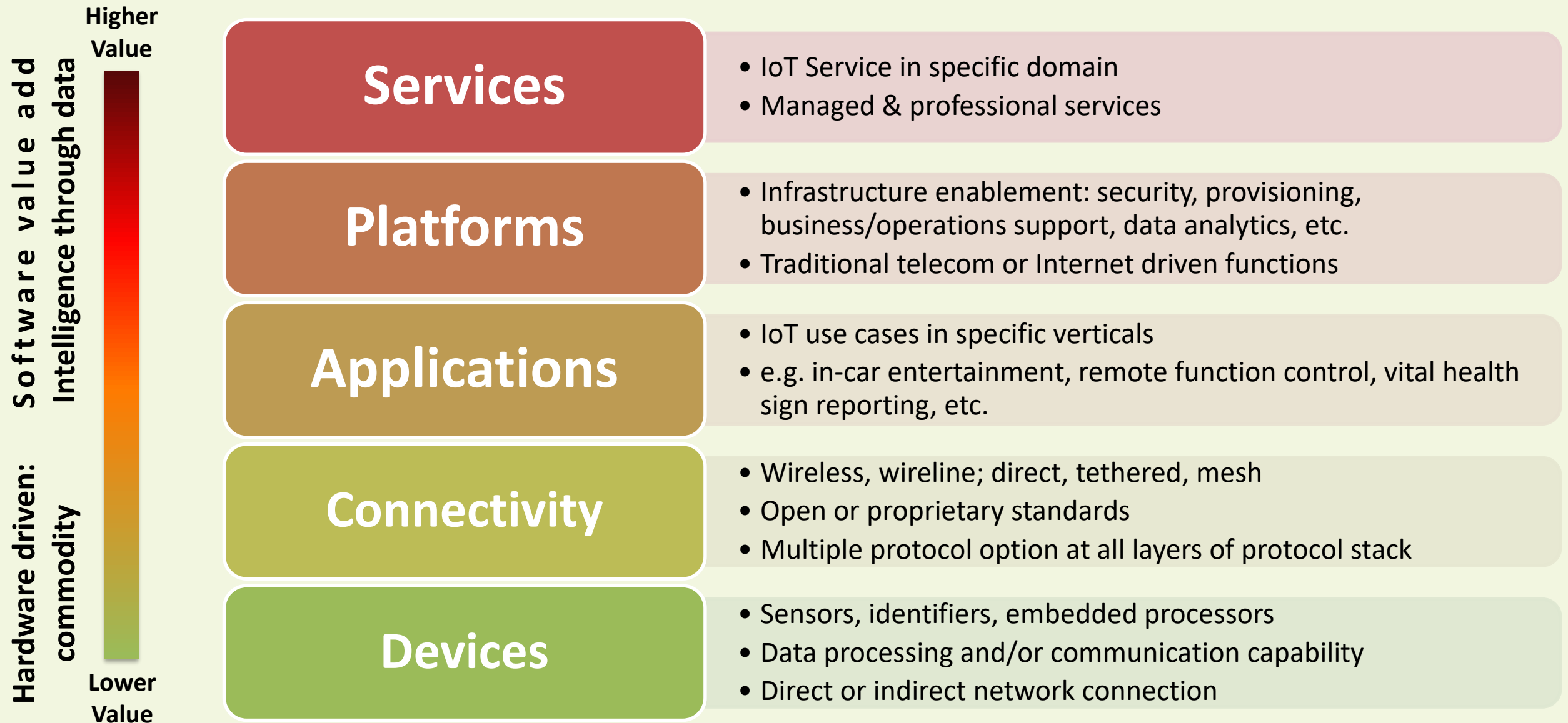


X O N Δ PARTNERS

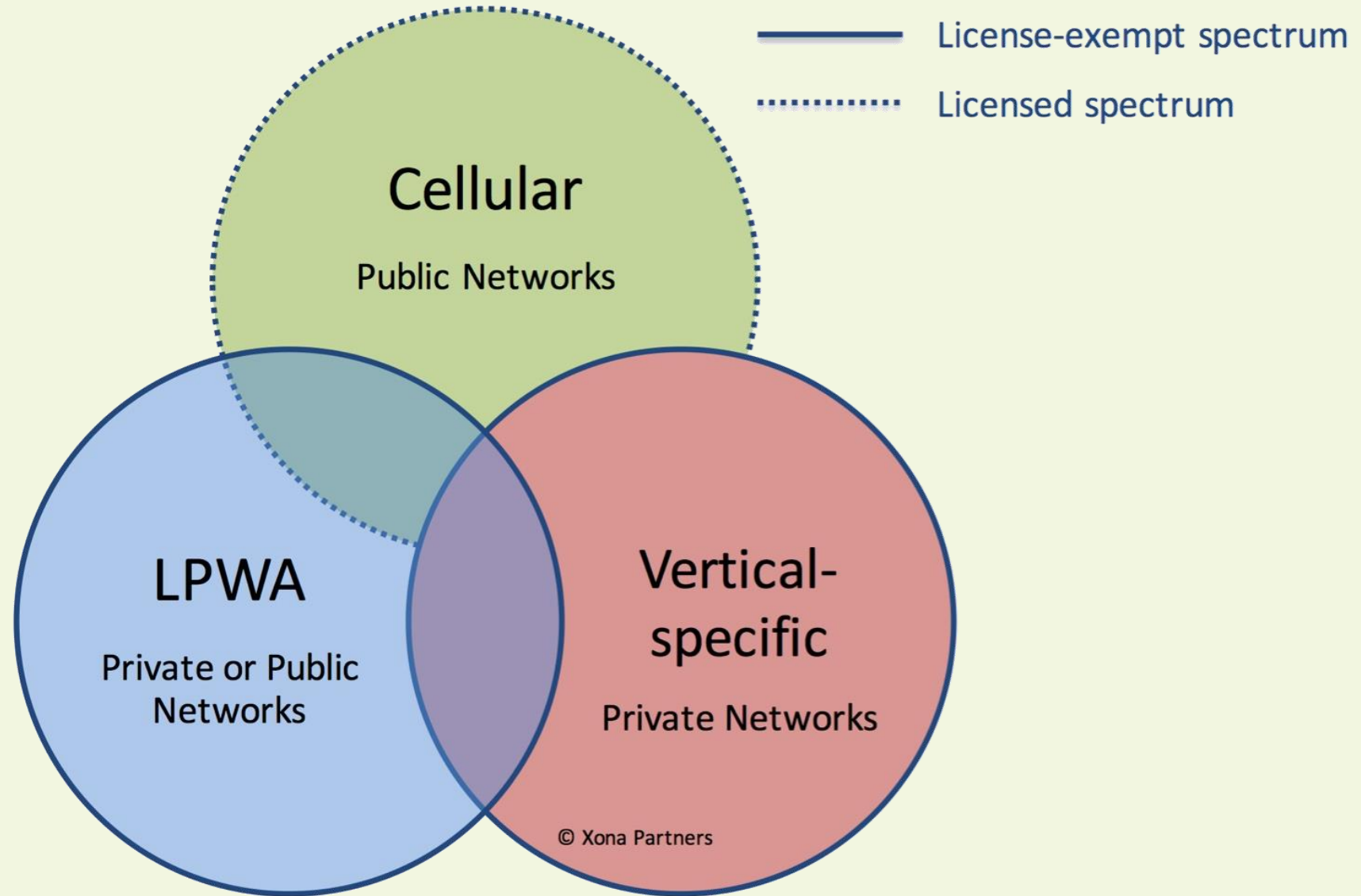
Building the Business Case for Low-Power Wide-Area (LPWA) IoT Connectivity Networks

IoT613 - April 18, 2018

IoT The Value Chain



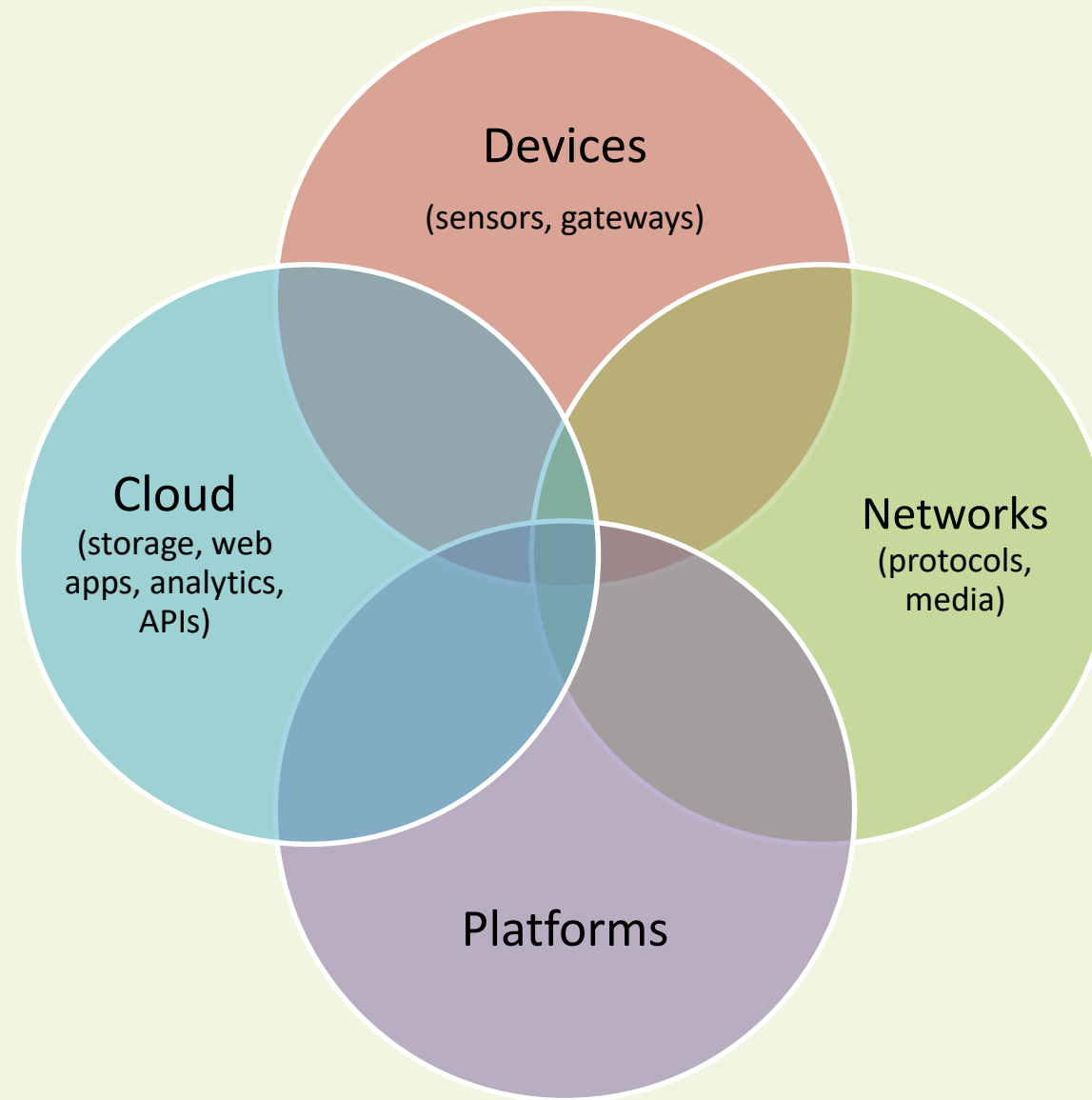
The Connectivity Ecosystems



The Technologies



IoT Network Elements



Commercial Platforms, e.g.:

ThingWorx

Xively

Axeda

ProSyst (Bosch)

Open Source Platforms:

Sentilo

Kura

Node-RED (IBM)

Technologies (eg):

- LoRa

- C-UNB

- Weightless

Data Protocols:

- MQTT

- CoAP

- 6LoWPAN

Device Management:

- TR-069

- OMA-DM

- OMA Lightweight M2M

- OSGi

Wide-Area IoT Use Cases



Aircraft data to airlines
& suppliers



Global security tracking



Movement monitoring
of elderly persons



Bike tracking



Real-time parking data



Diabetes monitoring



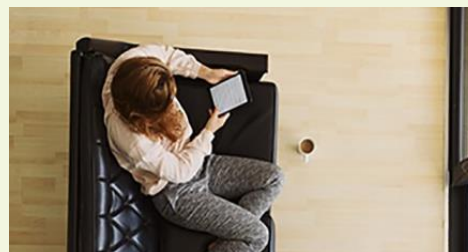
Connected alcohol
immobilizer



Car rental process
management



Industrial gas monitoring



Home security



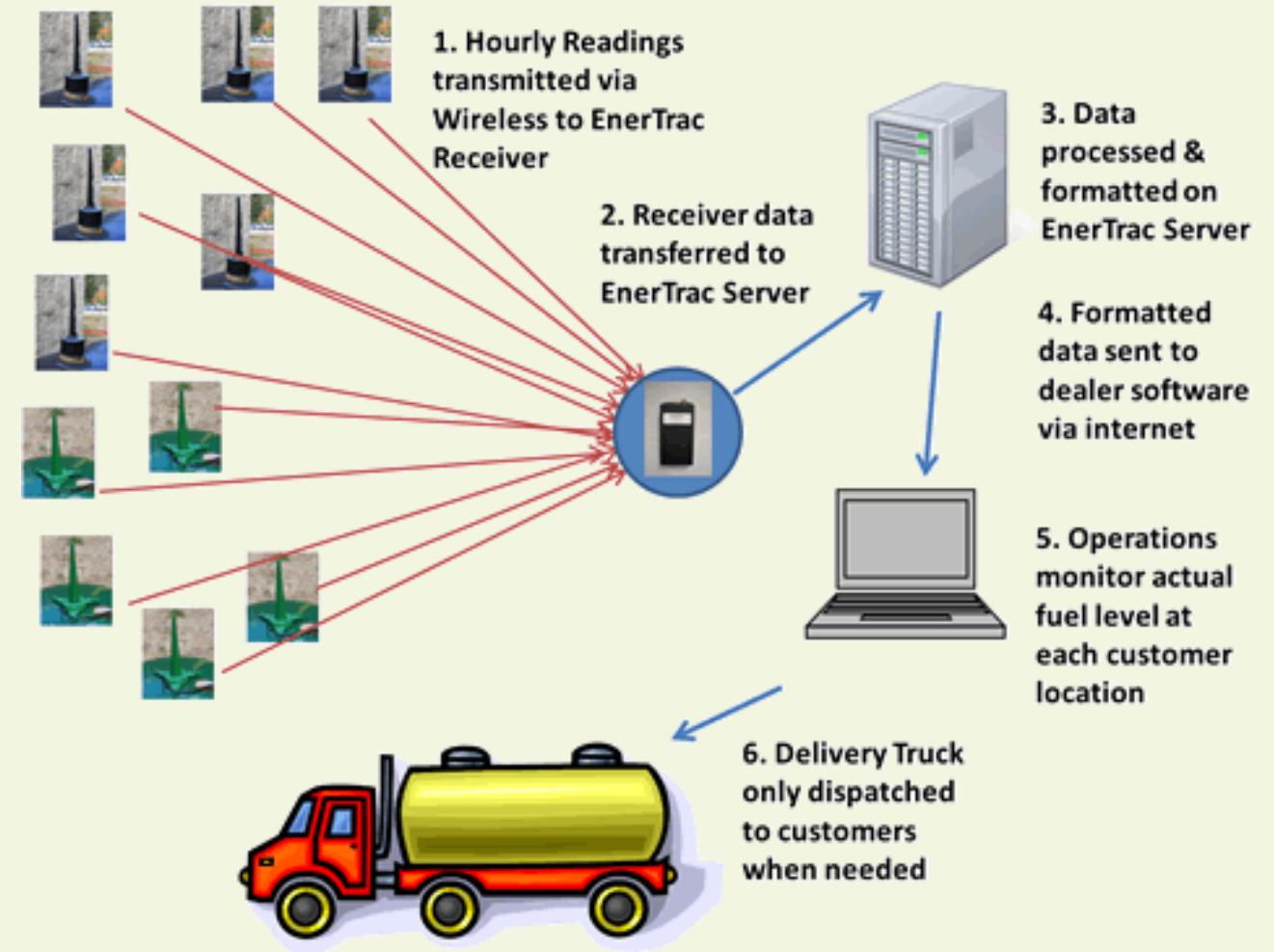
Electric vehicle charging
station connectivity



Compressor waste bins

Propane Tank Level

- › Network: 150+ Base stations covering ~40,000 sq. miles in the US
 - 20,000 Semtech LoRa sensors to track propane and oil tank fuel levels
 - Monitor cost: \$40; monitoring fee: \$2.45 / mo
- › Services
 - Tank monitoring & automation (propane, heating oil)
 - Water metering (to come)
 - Water irrigation (to come)
- › Data Aggregation Platform
 - Scalable Cloud-based server farm
 - Multiple Platforms for data access (Web Services/FTP)
 - Value add applications, metrics



Value proposition: On average, oil delivery drivers visit each customer six times per year. They typically make the delivery runs when the tanks are filled at 50%, which is at a cost per delivery of \$50-100. With IoT, they can deliver at 20% capacity, saving two deliveries per customer per year. If they have between 10,000-15,000 tanks, that's \$1-\$1.5 million a year in savings. <http://www.senetco.com/>

Smart Parking



The system serves the disabled, EMS, and police. It verifies the occupant to distinguish between allowed and infringing vehicles.



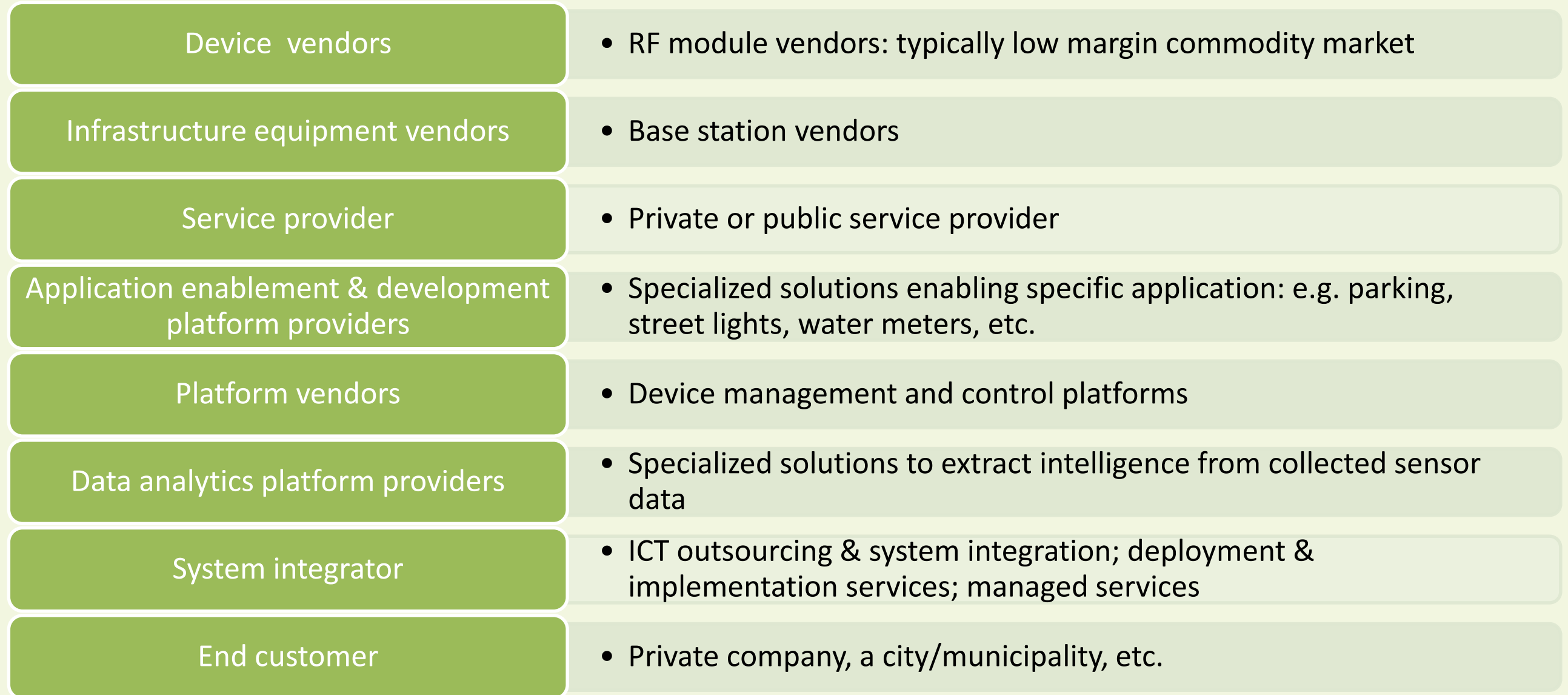
Commercially operational since November 2012.
(2,000 spots; planned expansion to 50,000)



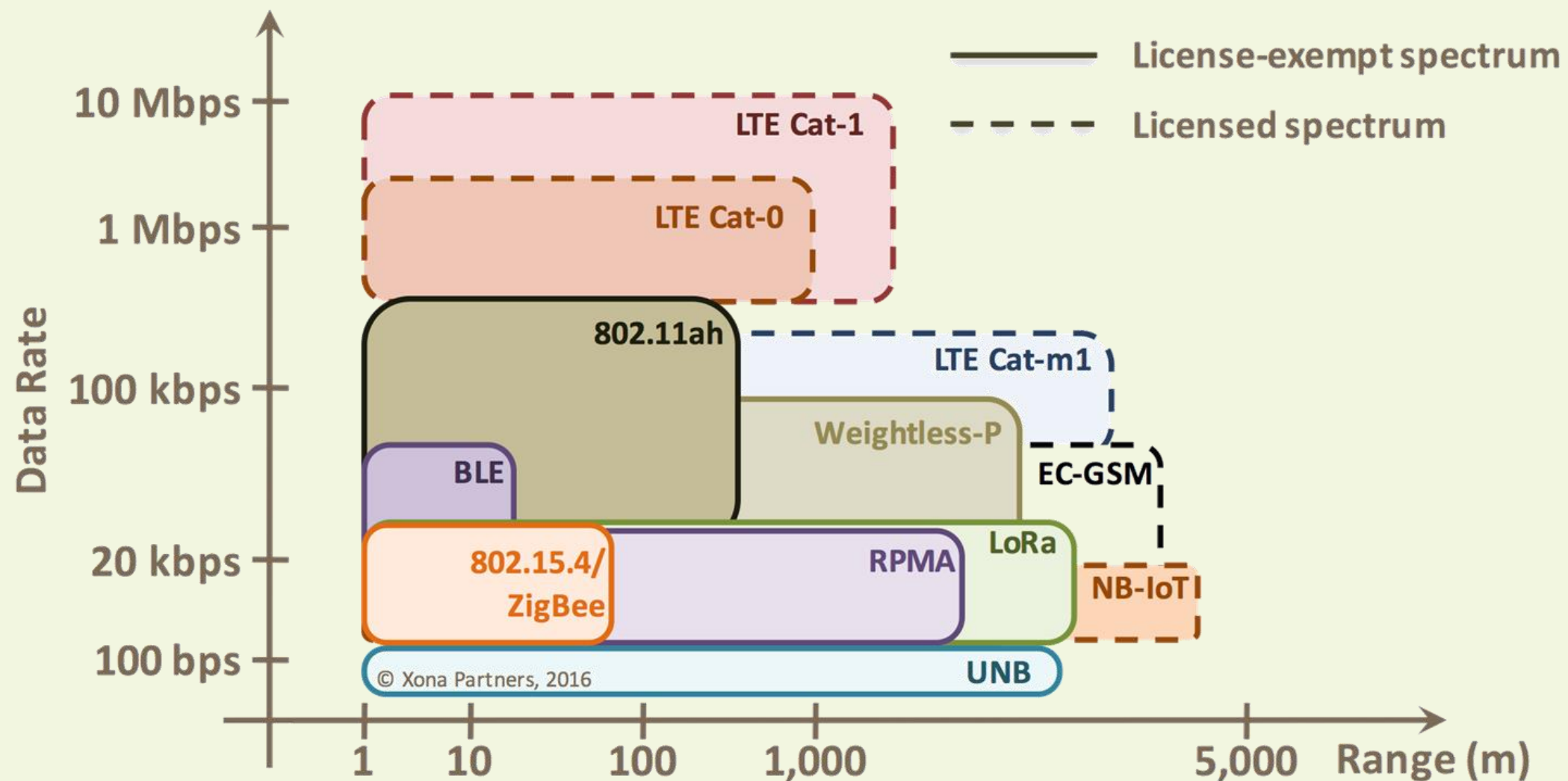
The system guides drivers to vacant parking spots and warns not to enter saturated areas.



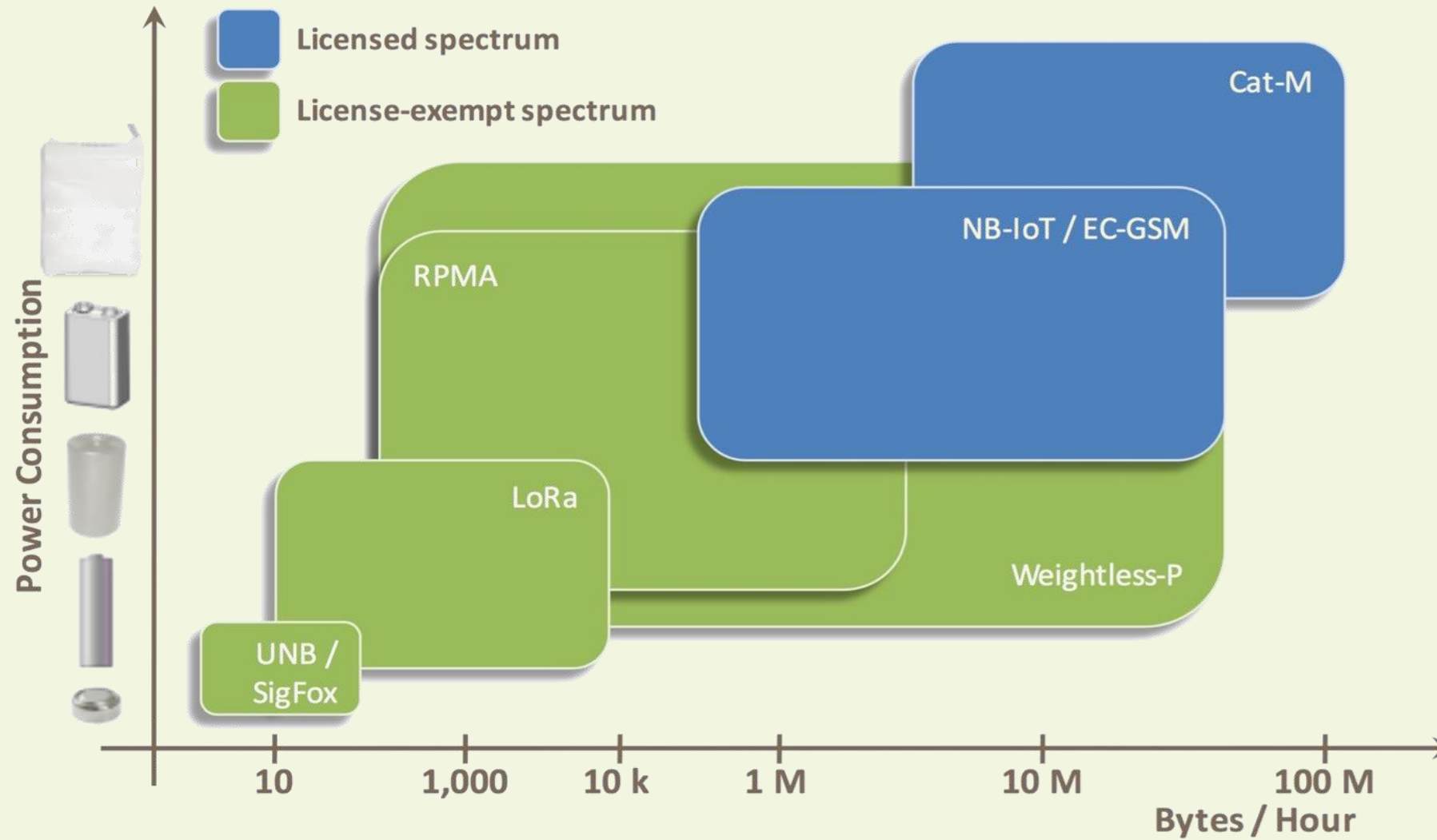
LPWA Value Chain



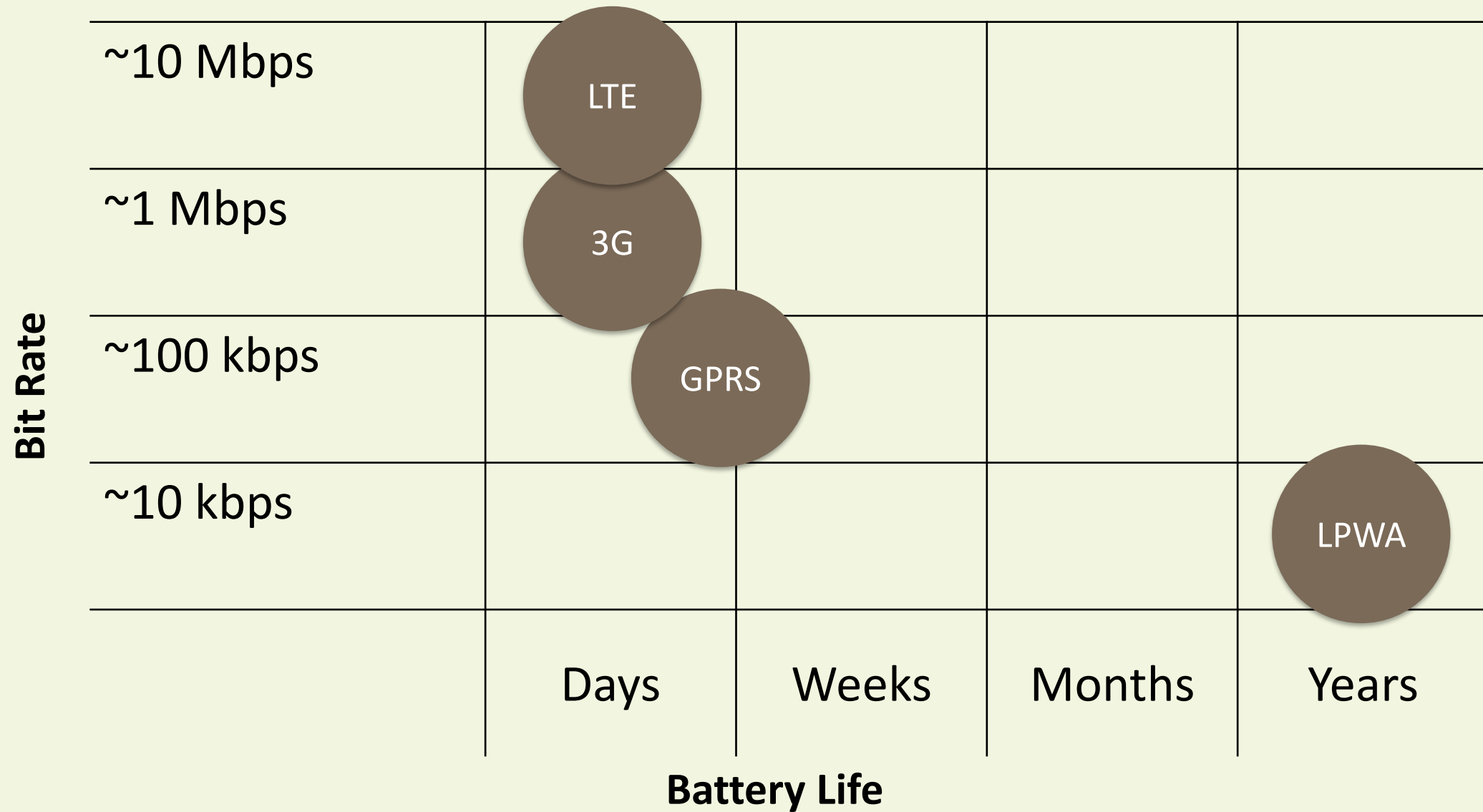
Performance



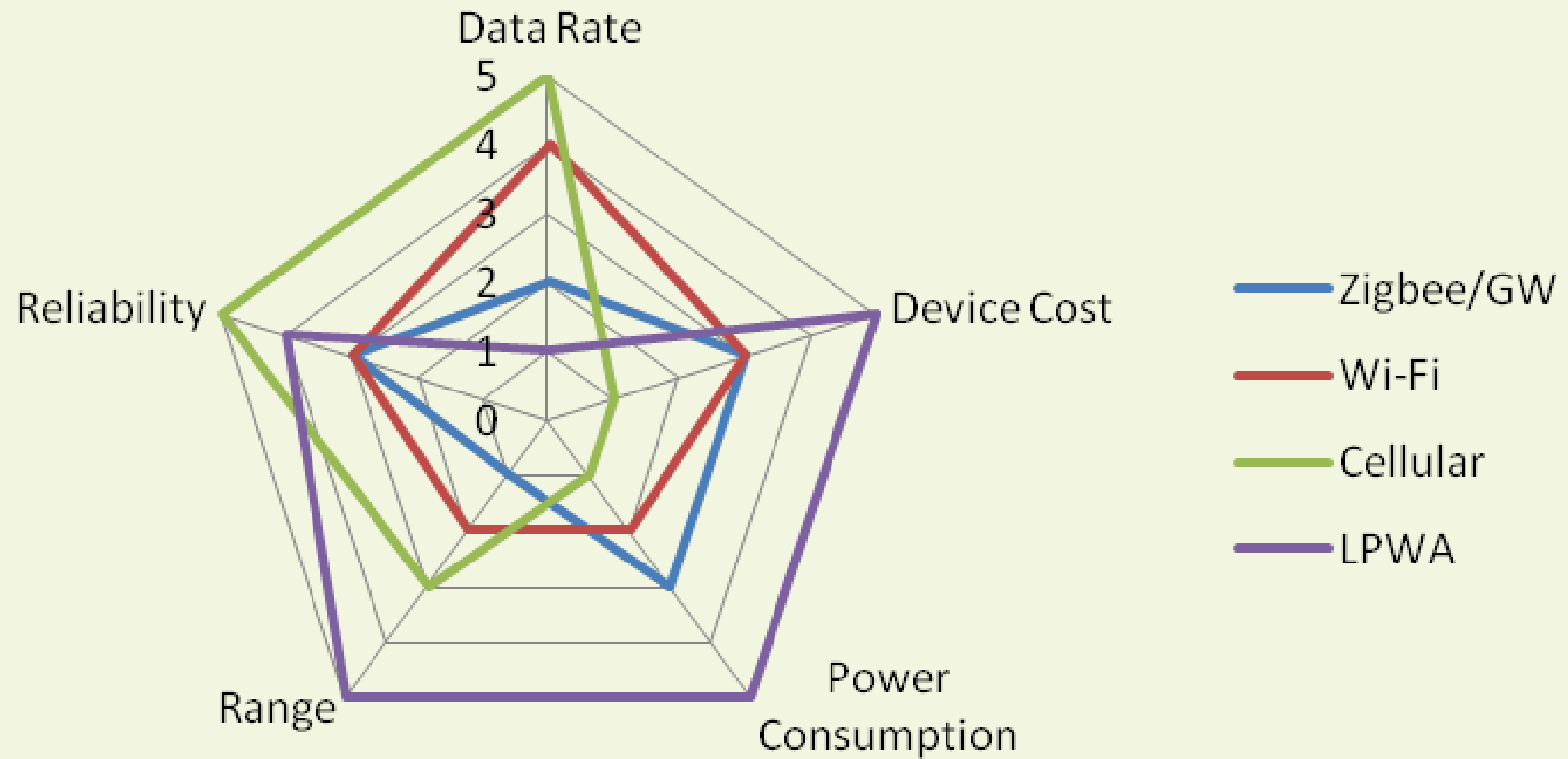
Power Optimization







































































Bit Rate vs. Power Consumption



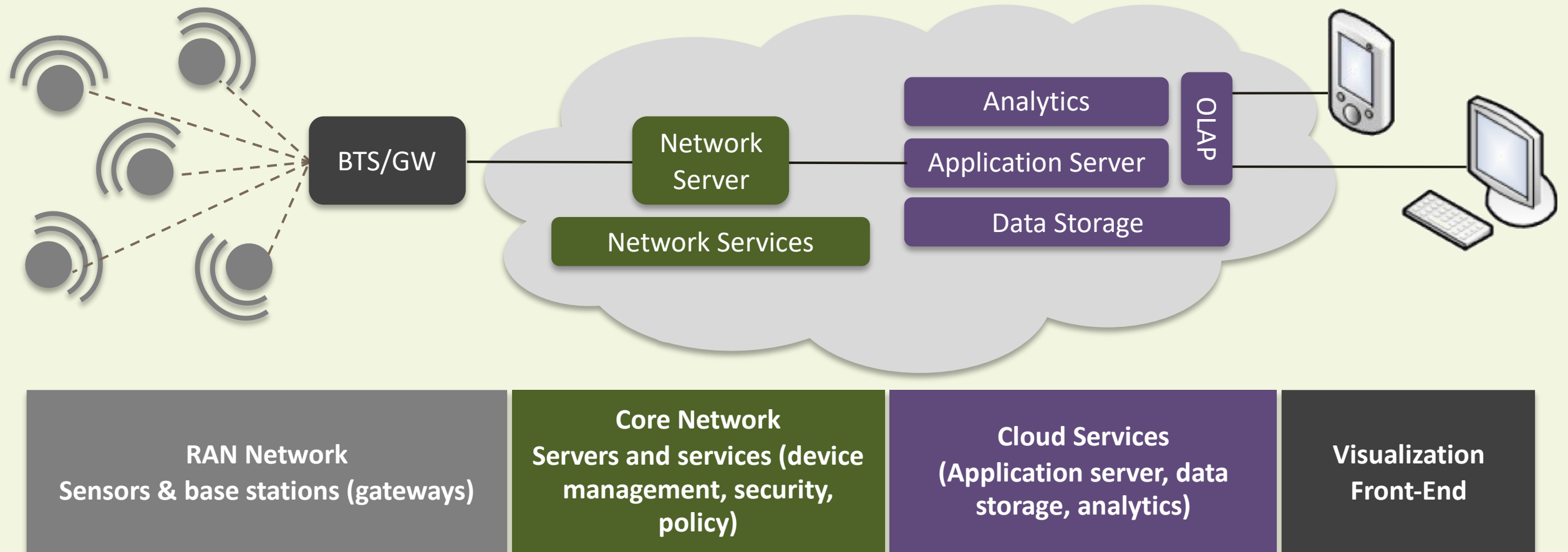
Technology Comparative Analysis



Comparative Analysis of LPWA Technologies

	Symmetric DL/UL	Multicast / Broadcast	Message Ack	Battery operation	Power control	Location services	Handover support	Firmware upgrade
LoRa								
UNB/SigFox								
Weightless-P								
RPMA								
Telensa UNB								
LTE Cat-1								
LTE Cat-m1								
LTE NB-IoT								
 : Supported  : Not supported  : Partial support; optional support  : Not required								

LPWA Network Overview



Wide-Area IoT Connectivity Requirements (examples)

- › Battery operation for 7 to 10 years
- › Send less than 1,000 bytes of data a day, many less than 500
- › Extremely low cost modem hardware (under \$10)
- › Low network fees: less than \$1 per month, some will require less than \$0.25 per month
- › New business models, pricing schemes, e.g. bill based on data vs. connection; urgency of data
- › Exceptional range: good building penetration for indoor devices; wide area coverage
- › Secure service; assured privacy
- › Scalable to support large number of devices: efficient air interface protocol

Characteristics of IoT Connectivity

- › **Long sales cycle:** many industrial and commercial users are slow to adopt new technologies, especially when the business case is not proven
- › **Design & integration:** engineering services to incorporate IoT connectivity
- › **Incumbent value chain:** barrier to entry from existing stakeholders with technologies optimized for specific applications
 - e.g. Scada systems have low latency to meet near-real time performance requirements
 - e.g. Dedicated solutions for aviation applications (5.1 GHz) or public safety (4.9 GHz)

Private vs. Public Networks

Private Networks

- › Operate own network
- › Unlicensed spectrum
- › Capex + Opex model
- › Single application

Public Networks

- › Shared common network
- › Licensed spectrum
- › Opex model
- › Multiple applications

The Service Provider Business Case

$$\text{Profit} = \text{Revenue} - \text{Cost}$$

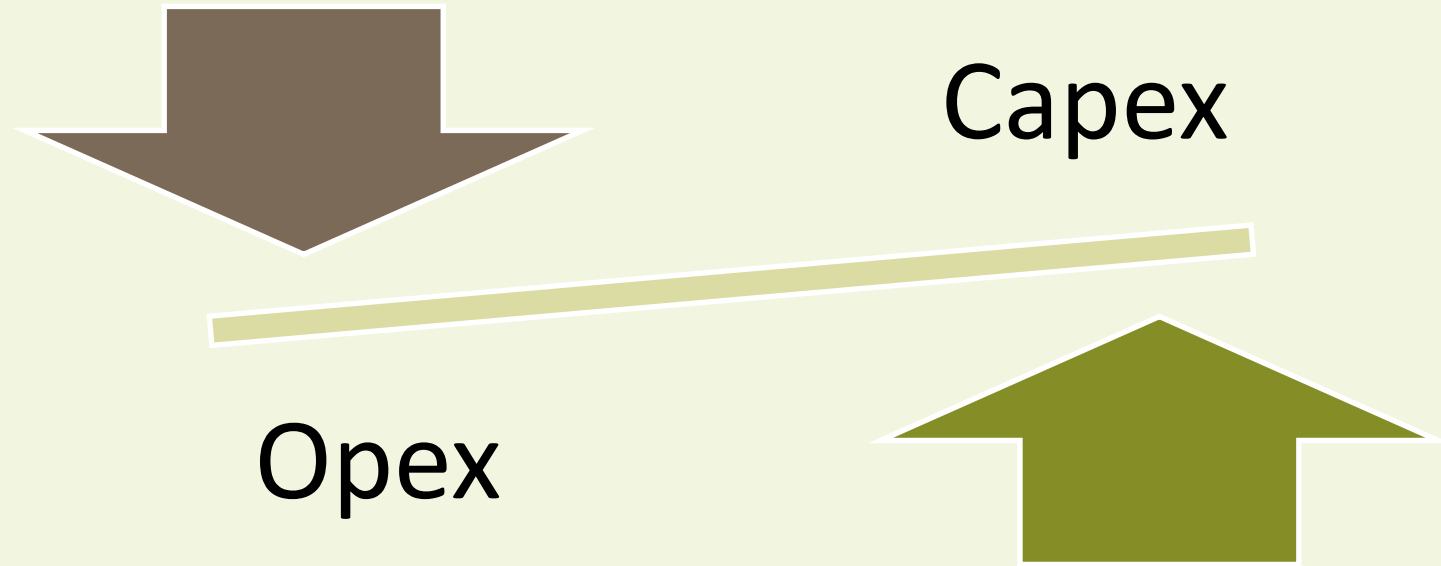
› Revenue

- Business models
- Service revenue: device management, analytics

› Cost

- Capital expenses
- Operational expenses

Business Transformation

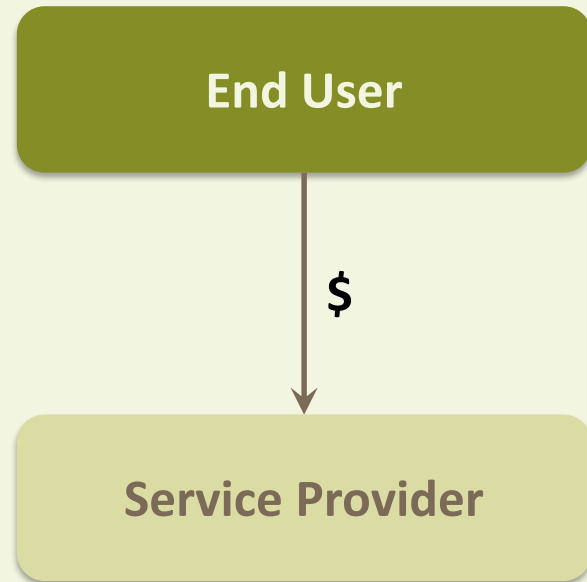


**Anything as a Service:
XaaS!**

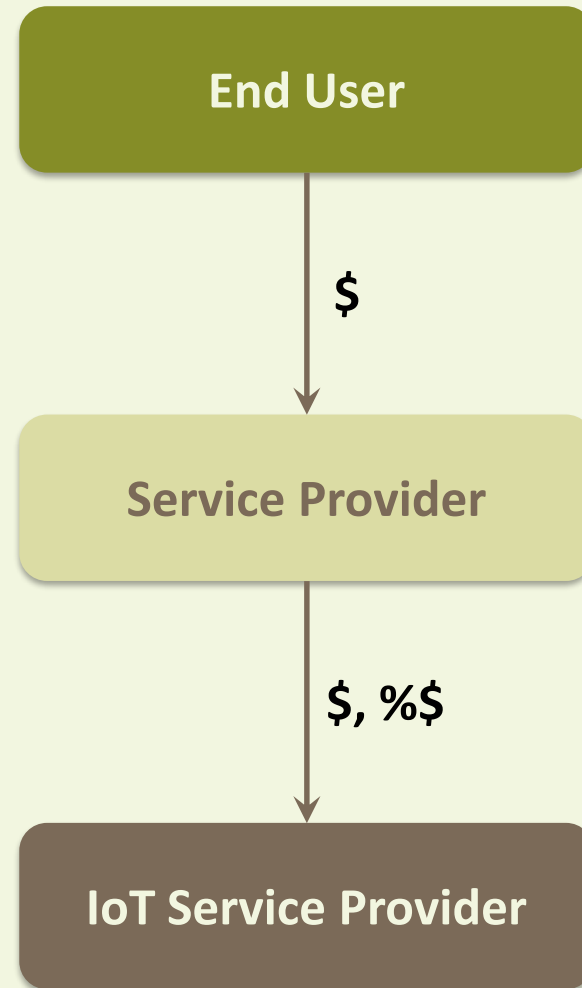
- › New business models
- › New revenue streams
- › Interaction with end user

Value Chain

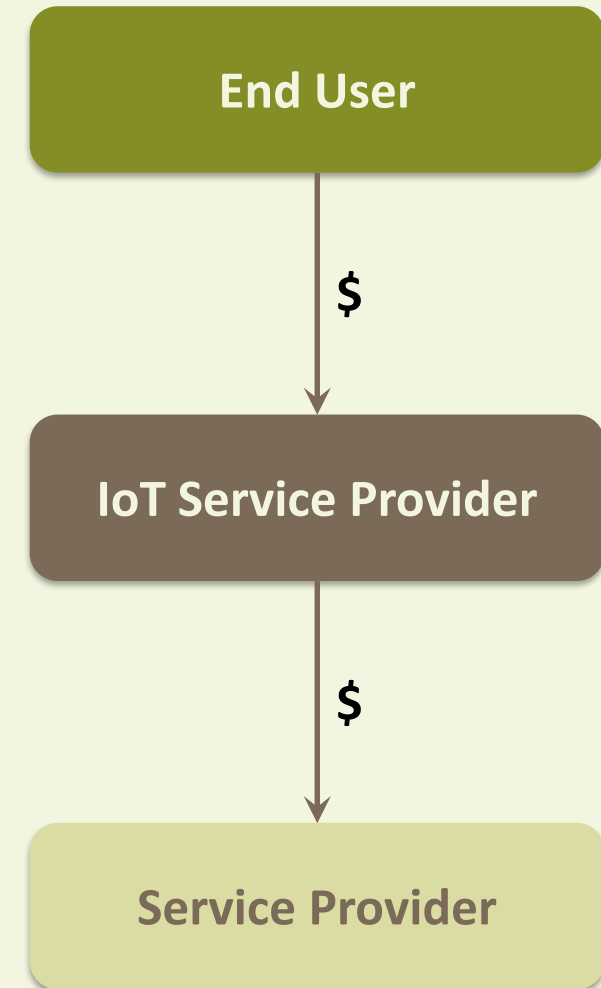
Traditional Model



IoT Model (1)



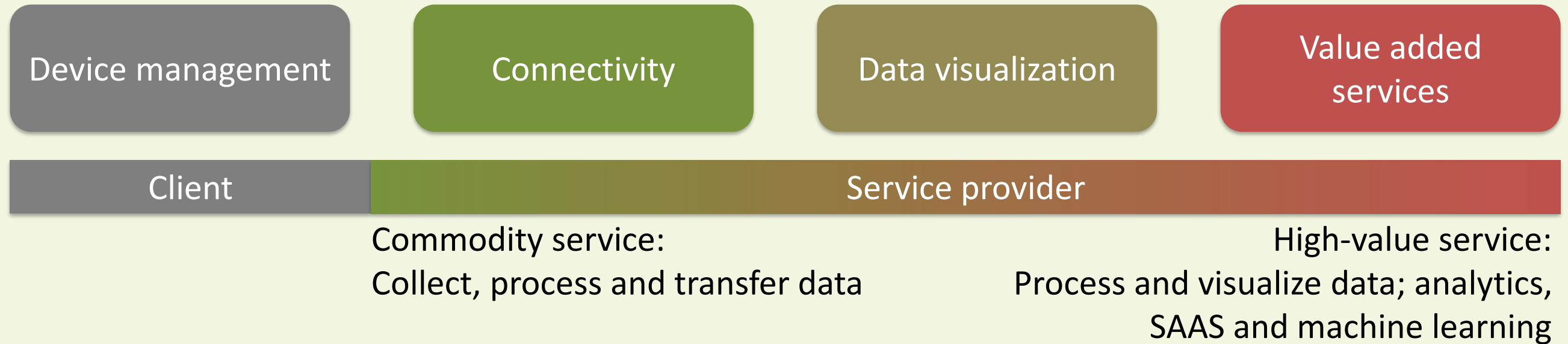
IoT Model (2)



Business Models

Business model	Revenue Type			Example
	One-time	Recurring	Use-based	
Transactional	✓			Private network
Revenue sharing		✓		New service: asset tracking
Cost savings		✓		Energy savings
Product sharing			✓	Asset rental, lease
Product as a Service		✓		Predictive maintenance
Performance as a Product			✓	Pay per event

Revenue Opportunities for Service Providers



› Commoditization of connectivity

- Low connectivity revenue per device (e.g. ~\$2-\$3 / device / year)
- Increase revenue and market power through end-to-end and support solutions

Value of IoT

Value Creation



- ☐ Address needs in real-time
- ☐ Predictive capabilities
- ☐ Continuous product update
- ☐ New service enablement

Value Capture



- ☐ Opex model: e.g. revenue share
- ☐ Personalization, customization
- ☐ Integration across value chain

Pricing Example: Incumbent Service Provider

AT&T Button

- › \$30/device
- › 1,500 clicks / 3 years
- › AWS 1-Click



AT&T Data Plans

- › Based on monthly data consumption
 - 500 KB: \$0.99
 - 1 MB: \$1.5
 - 2 MB: \$2
 - 5 MB: \$4
 - 10 MB: \$6
 - 25 MB: \$8
 - ... 10 GB: \$60

Pricing Example: LPWAN Service Provider

- › Standard contract allows for 140 messages per day (~1 every 10 minutes) and 12 bytes per message
- › Subscription cost: up to ~\$20/year per sensor

**Scalability is critical to enable the LPWA business case but so are additional services:
connectivity is a commodity**

Capital Expenses

Radio access	<ul style="list-style-type: none">• Access gateways, antennas and cables• Site acquisition, permitting• Installation, test and commissioning• Radio planning & design• Project management• Spare parts• Devices
Core network	<ul style="list-style-type: none">• Network server• Design services• Implementation, test and commissioning
IoT backend and applications	<ul style="list-style-type: none">• Cloud infrastructure• Setup fees• Application expenses

Operational Expenses

Radio access	<ul style="list-style-type: none">• Site lease• Backhaul• Power• Warranties and vendor support• Staffing expenses for radio network<ul style="list-style-type: none">• Field staff• Engineering services
Core network	<ul style="list-style-type: none">• Product licensing expenses• Staffing expenses: engineering services; support and maintenance
IoT backend and applications	<ul style="list-style-type: none">• Recurring application expenses• Storage expenses• Cloud support expenses

Determining Cost

› Access Network

- Service area → design for coverage
- Application requirements → design for capacity

› Core networks and backend systems

- Scalability: number of devices, amount of data,...

Application Requirements

- › Transmission profile
 - How many bytes, how often
 - Unidirectional, bi-directional
- › Deployment location: indoor, outdoor
- › What information to store
- › Device density
- › Power requirements: battery, on-grid
- › Cost
- › Device management

Application Requirements

Application	Bytes	Frequency (message/day)
Electricity meters	100	24
Gas meters	70	2
Water meters	96	1
Fault circuit indicator	96	1
Smart transformer	50	4

Service Area

Scenario	Population	Coverage area (sq. km)	Devices (water meters)	Coverage Radius (km)
Rural township	25,000	326	6,250	8.2
Small / medium city	135,000	64	38,500	2.4
Large city	725,000	292	242,000	1.5

- › LoRa Technology
- › 5,000 devices per gateway

Access Network Capex

Category	# Devices	Coverage GW	Capacity GW	Required GWs	Capex
Rural township	6,250	10	2	10	\$100,000
Small / medium city	38,571	5	8	8	\$80,000
Large city	241,667	53	49	53	\$530,000

Access Network Opex

› Recurring expenses

- Sites lease
- Backhaul
- Power
- Vendors warranties & support
- Network operation and maintenance

› Amortization period: 5 – 10 years

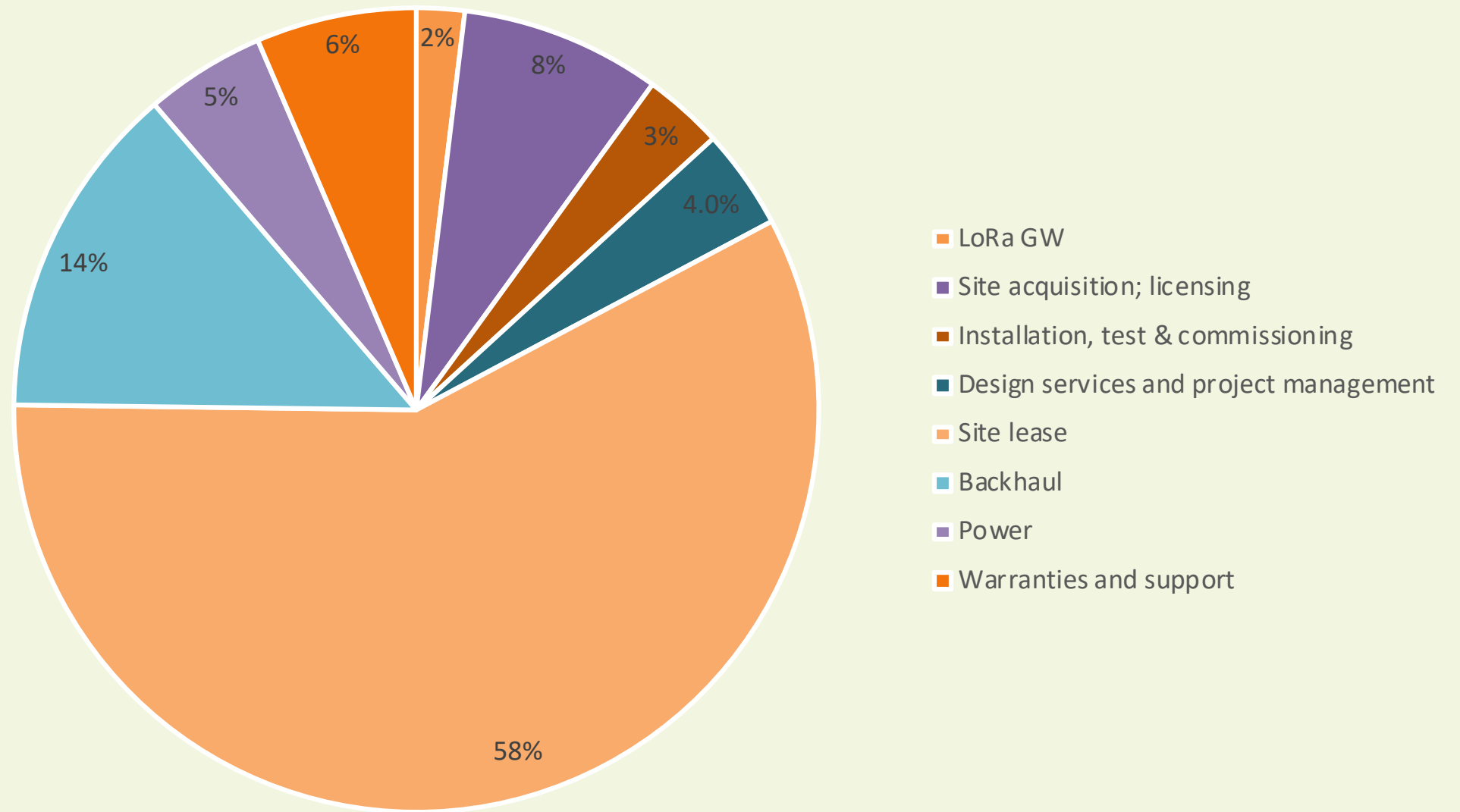
- Inflation, time value of money

› Opex = \$5,000 /site/year

- \$35,000 /site for 7 years, no inflation

Category	Required GWs	Opex
Rural township	10	\$350,000
Small / medium city	8	\$280,000
Large city	53	\$1,855,000

Total Cost of Ownership for a Radio Access Site



Additional considerations?

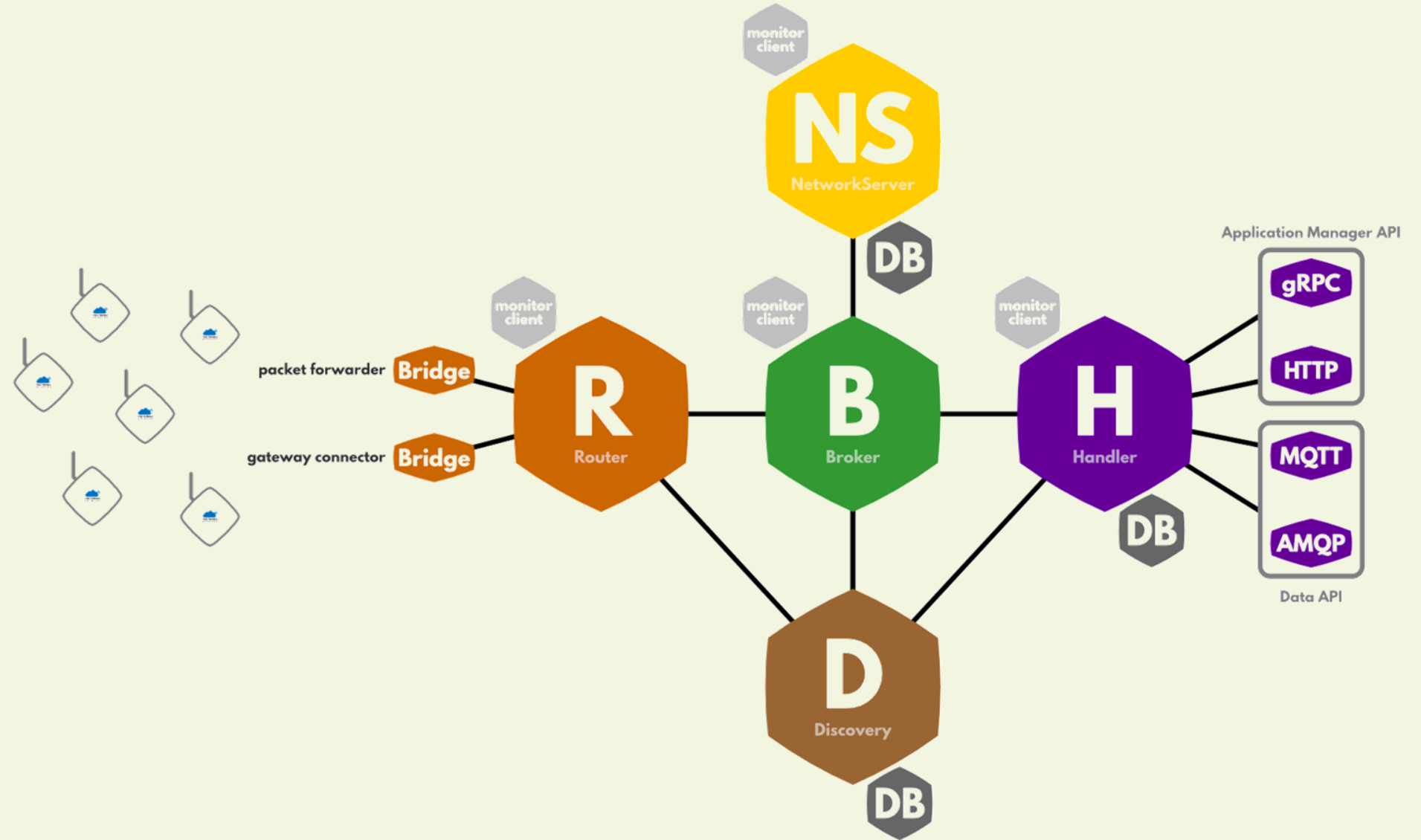
- › Licensing
- › Spectrum

Core Network Sizing

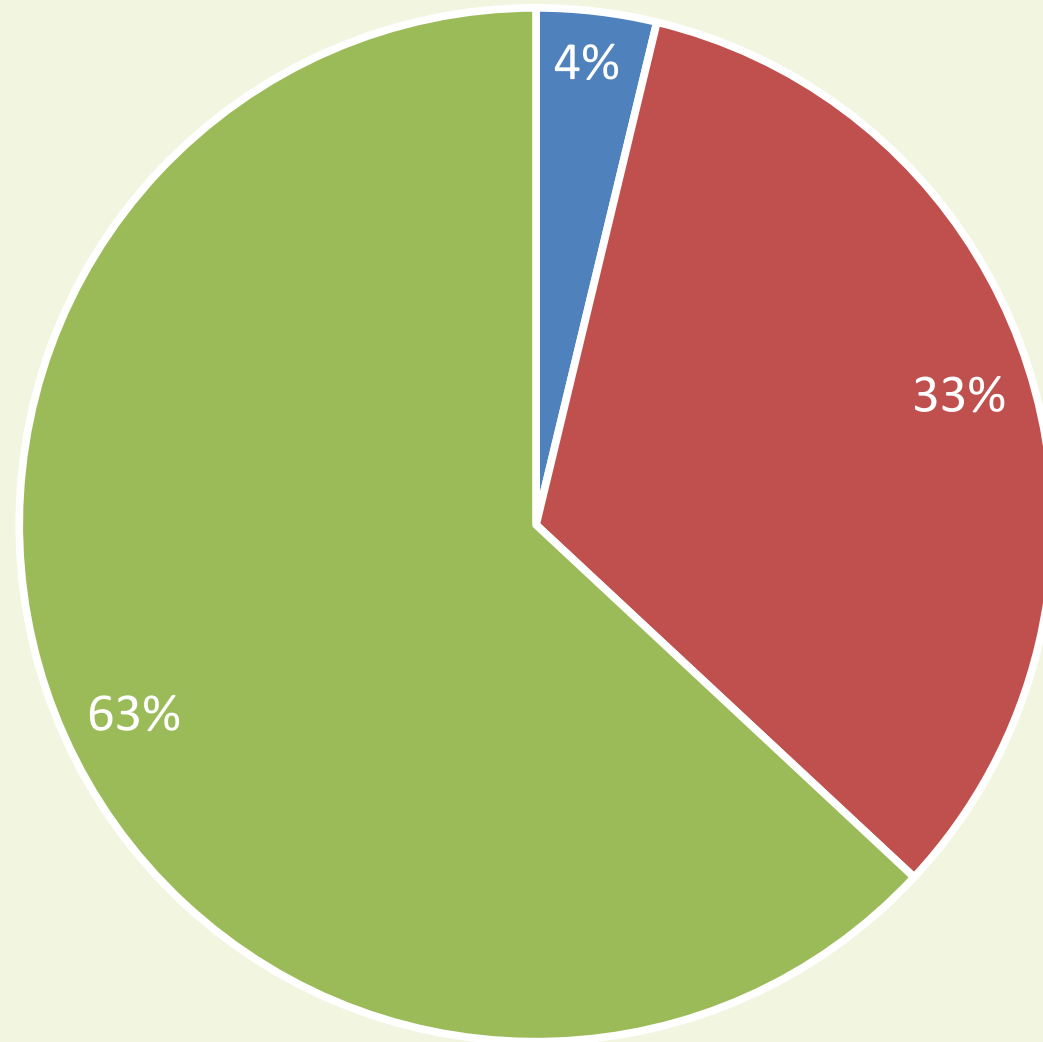
› Dependencies

- Gateways
- Devices
- Data
 - # of messages
 - Size of message
- Other?

› Own vs. lease



Network Cost Distribution



› %'age of core decreases as networks get larger

- Capital Expenses
- Radio Operating Expenses
- Core Operating Expenses

LPWAN Cost Metrics

	Total cost of infrastructure ownership amortized per device	Breakeven monthly price between public and private networks
Rural township	\$1,203	\$10.2
Medium city	\$197	\$1.7
Large city	\$66	\$0.55

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