Curriculum

1. The Internet of Trillions of Things (IoT2)
2. Wiliot Overview
3. Auto-ID & Location Building Blocks
4. Bluetooth RF Fundamentals
5. Auto-ID Carriers Compared
6. What you Need to Know to Deploy
7. Getting to Know Your Kit

Bluetooth RF Fundamentals

Orientation

- Some History
- iBeacon & security
- Scan Rates & Duty Cycles
- W-EID
- Background Scanning
- Signal Physics
  - Signal Strength, Shape, Measurement, Fluctuation & Attenuation
  - Link Budget
  - Materials
  - Orientation

The Mother of Bluetooth

UNITED STATES PATENT OFFICE

2,292,387

SECRET COMMUNICATION SYSTEM

Hedy Kiesler Markey, Los Angeles, and George Antheil, Manhattan Beach, Calif.

Application June 10, 1941, Serial No. 397,412

6 Claims. (Cl. 250—2)

This invention relates broadly to secret com- nunication systems involving the use of carrier vaves of different frequencies, and is especially iseful in the remote control of dirigible craft, uch as torpedoes.

An object of the invention is to provide a nethod of secret communication which is rela- ively simple and reliable in operation, but at he same time is difficult to discover or decipher.

Briefly, our system as adapted for radio control f a remote craft, employs a pair of synchronous ecords, one at the transmitting station and one it the receiving station, which change the tuning f the transmitting and receiving apparatus rom time to time, so that without knowledge of he records an enemy would be unable to deter- nine at what frequency a controlling impulse vould be sent. Furthermore, we contemplate mploying records of the type used for many ears in player pianos, and which consist of long olls of paper having perforations variously posi- ioned in a plurality of longitudinal rows along he records. In a conventional player piano rec- rd there may be 88 rows of perforations, and n our system such a record would permit the ise of 88 different carrier frequencies, from ne to another of which both the transmitting nd receiving station would be changed at in- ervals. Furthermore, records of the type de- cribed can be made of substantial length and nay be driven slow or fast. This makes it pos- ible for a pair of records, one at the transmit- ing station and one at the receiving station, to un for a length of time ample for the remote ontrol of a device such as a torpedo.

The two records may be synchronized by driv-

Fig. 2 is a schematic diagram of the ap ratus at a receiving station;

Fig. 3 is a schematic diagram illustrating starting circuit for starting the motors at t transmitting and receiving stations simulta ously;

Fig. 4 is a plan view of a section of a rec strip that may be employed;

Fig. 5 is a detail cross section through a r ord-responsive switching mechanism employed the invention;

Fig. 6 is a sectional view at right angles to t view of Fig. 5 and taken substantially in t plane VI—VI of Fig. 5, but showing the reco strip in a different longitudinal position; and

Fig. 7 is a diagram in plan illustrating h the course of a torpedo may be changed in a cordance with the invention.

Referring first to Fig. 7, there is disclosed mother ship 10 which at the beginning of ope tions occupies the position 10a and at the e of the operations occupies the position 10b. T mother ship discharges a torpedo 11 that trav successively along different paths 12, 13, 14, and 16 to strike an enemy ship 17, which initi ly occupies the position 17a but which has mo into the position 17b at the time it is struck the torpedo 11. According to its original cou the enemy ship 17 would have reached the po tion 17c, but it changed its course following t firing of the torpedo, in an attempt to evade t torpedo.

In accordance with the present invention, t torpedo 11 can be steered from the mother sh 10a and its course changed from time to time necessary to cause it to strike its target.

Hedy Lamarr’s Patent for Frequency-hopping spread spectrum

wiliot

History

- Started in 1997
  - Intended for short-range PC-peripheral communication,
  - Pioneered by Ericsson
- Named after medieval King of Denmark
  - Harald Bluetooth
- First 1.0 specification (BR, 1999),
  - Gets traction in audio wireless application
- Nokia releases Wibree in October 2006
  - Foundation of 4.0 (Low Power, LE PHY)
- Bluetooth Smart formally adopted into the Bluetooth v4.0 core specification in June 2010
- iPhone 4S first Bluetooth Smart Ready device October 2011

Bluetooth

ERICSSON

NOKIA

wibree™

Apple's iBeacon Standard

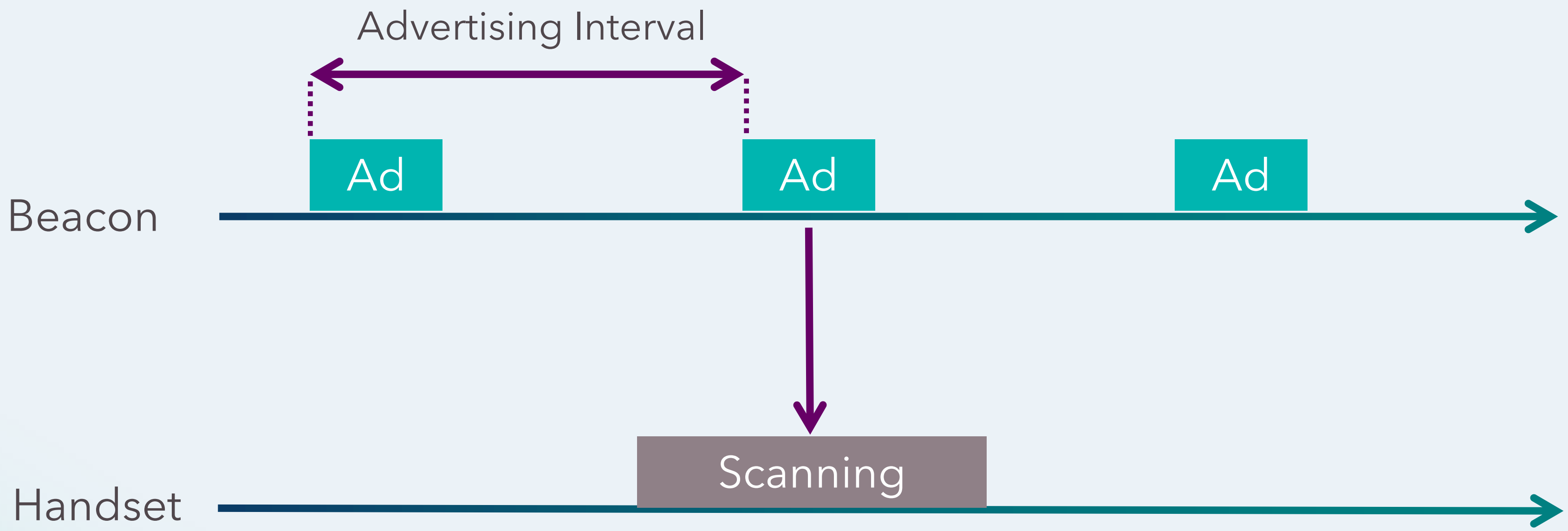
- OEM Specific Profile
- Licensed under MFI
- 1.0 Launched in 2013
- Triggers for Apps
- ...

iBeacon is in the clear

- Data is unencrypted
- Prone to Spoofing
  - IDs can be replayed
- Privacy Issues – Unauthorized Tracking

Transmit and Receive Duty Cycle

Advertising versus Scanning Interval



Duty Cycle Examples

Beacon Types - Transmission

- iBeacon 600/min (a minute)
- Wiliot Battery Assisted Pixel Tag 15/min
- Wiliot (Battery Free) Pixel
  - 120 /min – when Energy source is Close
  - 1/min – when energy source is close

Bluetooth Scan Rate – Pacing Reception

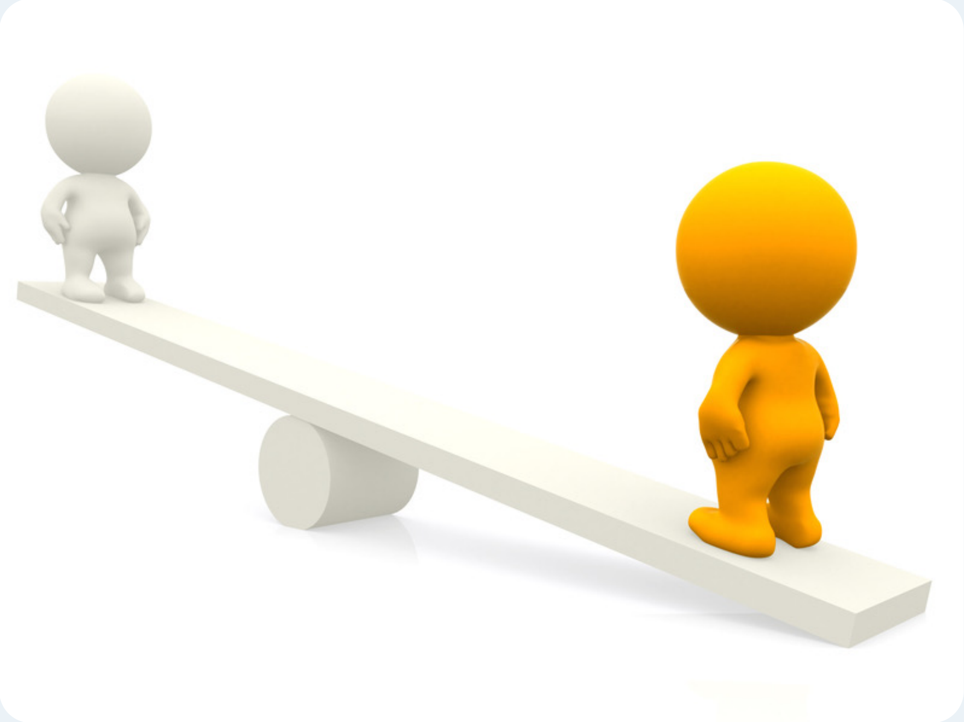
- Phone OS scan rate +
- Wiliot App – 10 seconds
- Works with Wiliot Bridge
  - Duty Cycle 5 ms TX + 10 ms RX
  - Pacing - Upload to cloud every 60 seconds
  - Adjustable via Wiliot Cloud
  - For earlier hardware - Nordic nRF Connect app / Energous App

Cloud Sample Rate

- Will be configurable / priced based on frequency

Role of the Mobile OS

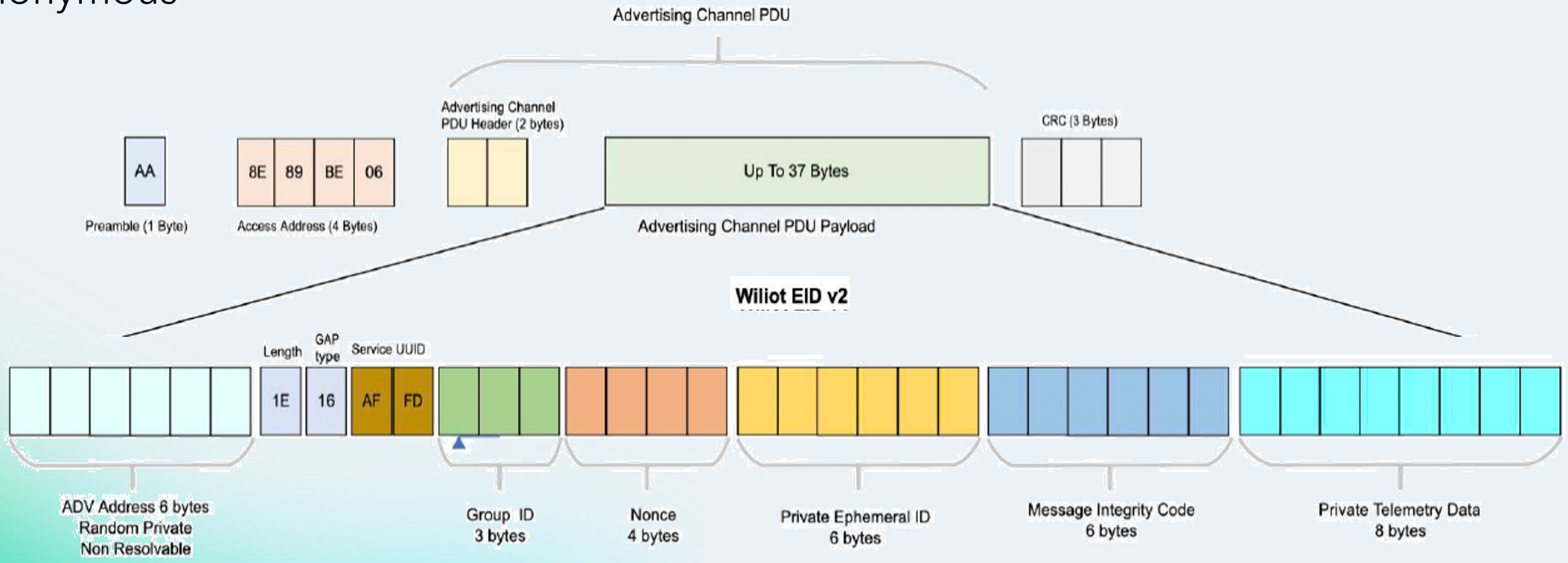
- Support of Bluetooth Hardware
- Balance
  - Battery use with responsiveness
  - RSSI fidelity with smoothing
  - Privacy management with opportunity
  - Scheduling and exhuming background and killed processes with resources
  - Notifications with user experience



Bringing apps back from the dead

Wiliot Ephemeral ID Format

- Transport Identity and Sensor (Telemetry) data
- Encryption and authentication
- Anonymous



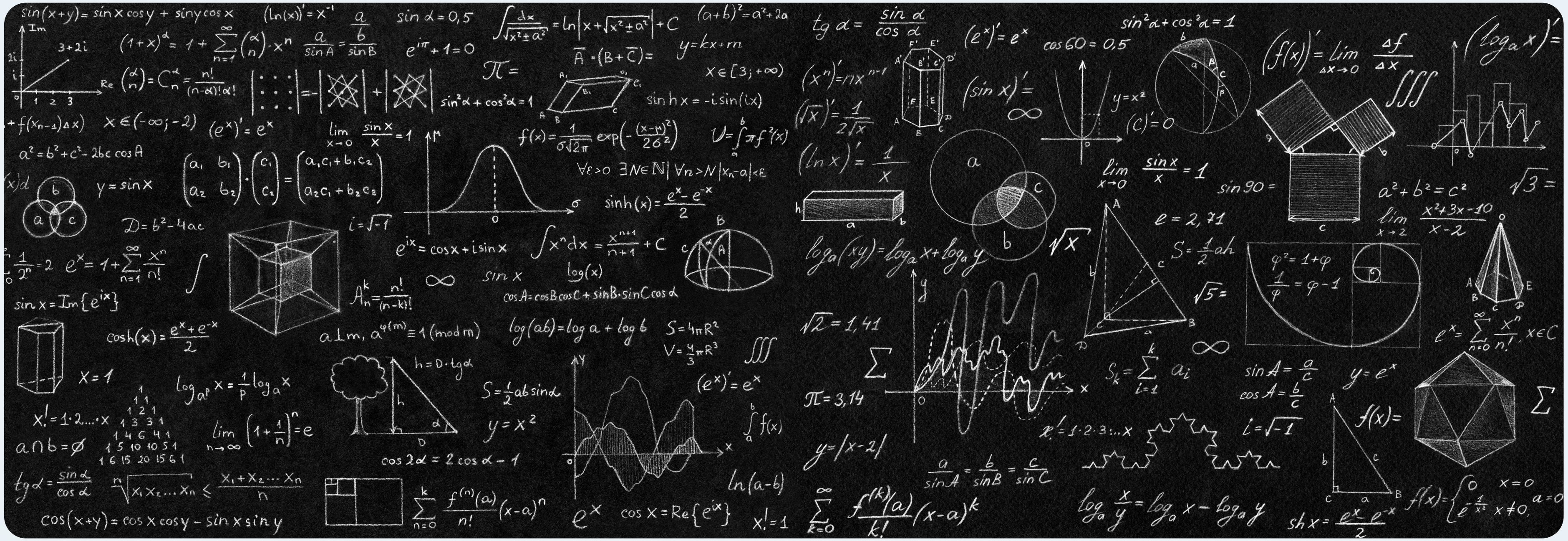
Harvesting and Applications

- **RF Scavenging**
  - Opportunistically recycling the RF ambient energy (cellular, Wi-Fi, Bluetooth, TV/FM radio)
  - Intermittent signal not generated on purpose from devices
  - Weak and persistent signals from broadcast towers (future)
  - Can't guarantee latency – stochastic application

- **RF Energy Transfer**
  - Energy source deterministic in terms of power levels and time
  - Needs intentional radiators (e.g. gateways)
  - Easier to predict latency – deterministic application

- **Wiliot technology can work with both scavenging and energy transfer**
  - Choice is determined by application requirements
  - Need to consider system architecture requirements

Some Physics

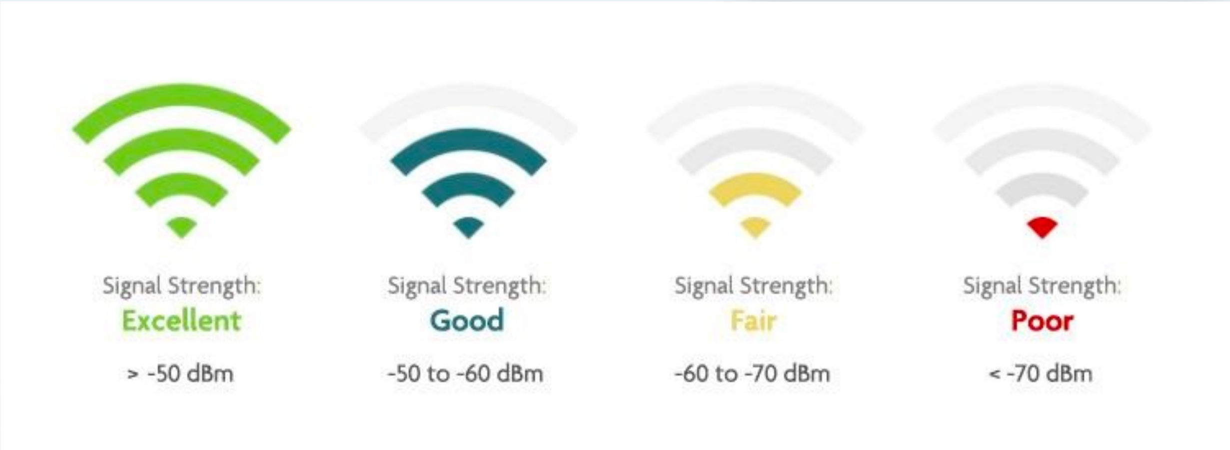


- Signal Strength, Shape, Measurement, Fluctuation & Attenuation
- Link Budget
- Materials
- Orientation

RSSI

Power of the radio signal

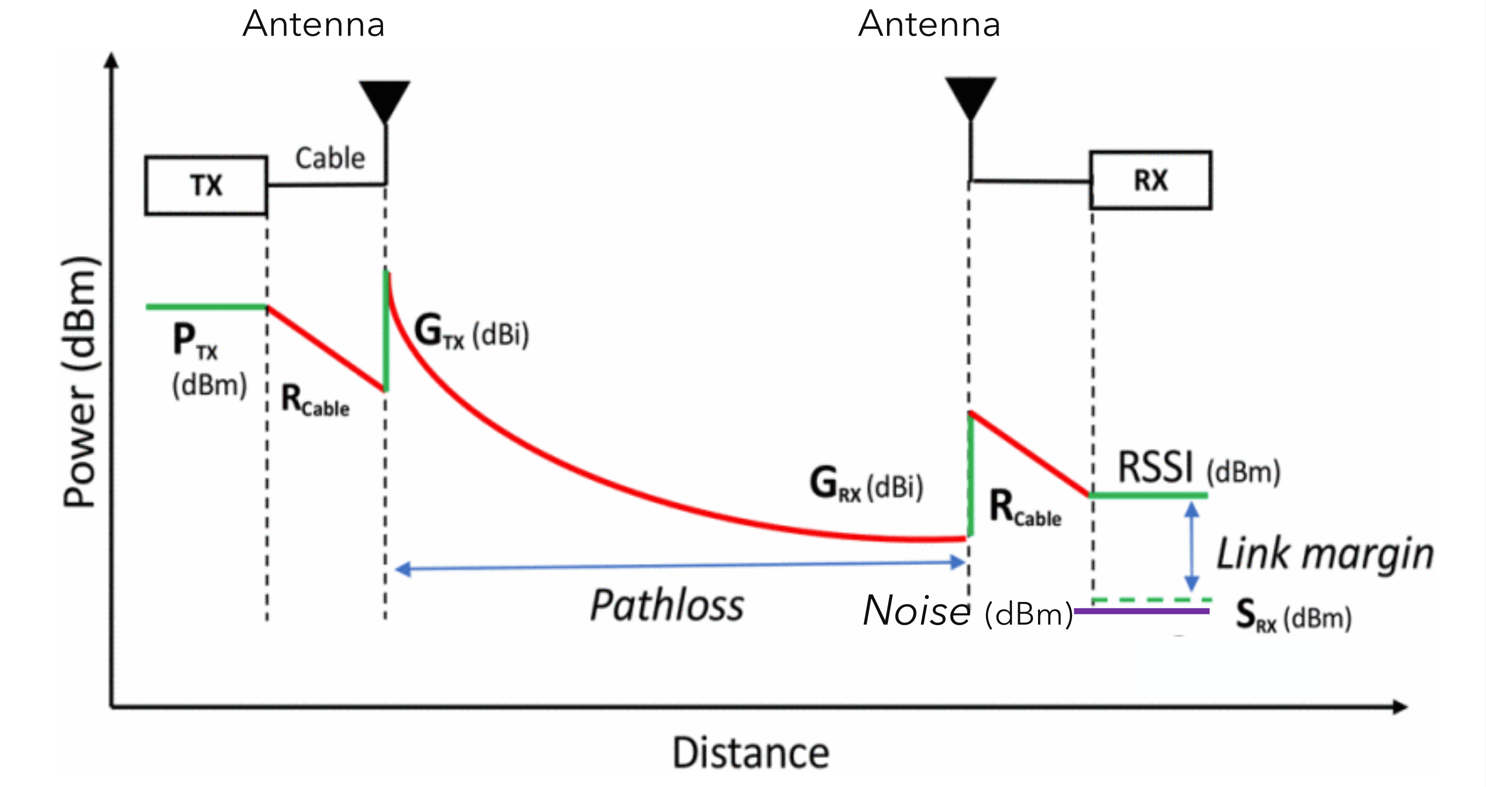
- RSSI = Received Signal Strength Indicator
- An abbreviation for the power ratio decibels (dB) of the measured power referenced to one milliwatt (mW).
- 0 dBm corresponds to a power of 1 mW



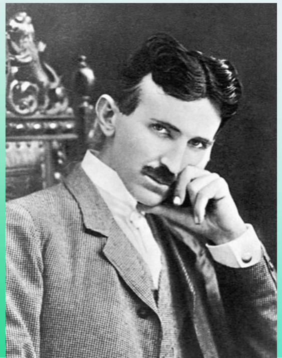
Radio Communication Crash Course

The Radio Link Budget

- The link budget is the total of all power gains and losses in the telecommunications system from the sender ("Tx") through free air space to the receiver ("Rx")
- The lowest power level at which the receiver can still receive or demodulate is known as receiver sensitivity S_{Rx}.
- dBm are units for power level

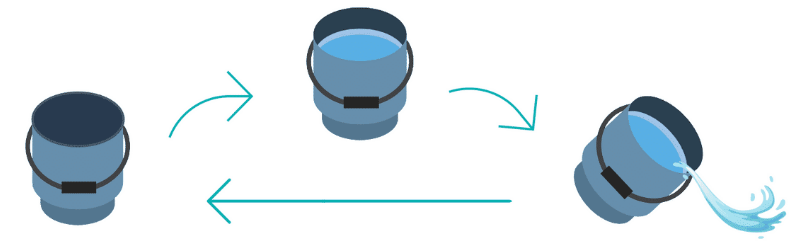


Misbahuddin, L. "Compromise of 915 MHz LoRa Transmission Parameters in A Single-hop Uplink," COSITE), 2021



The Harvesting Duty Cycle

- Wiliot Battery Free Tags Broadcast once they have harvested enough energy
- … to boot-up, calibrate the radios, compute, sense, encrypt and transmit



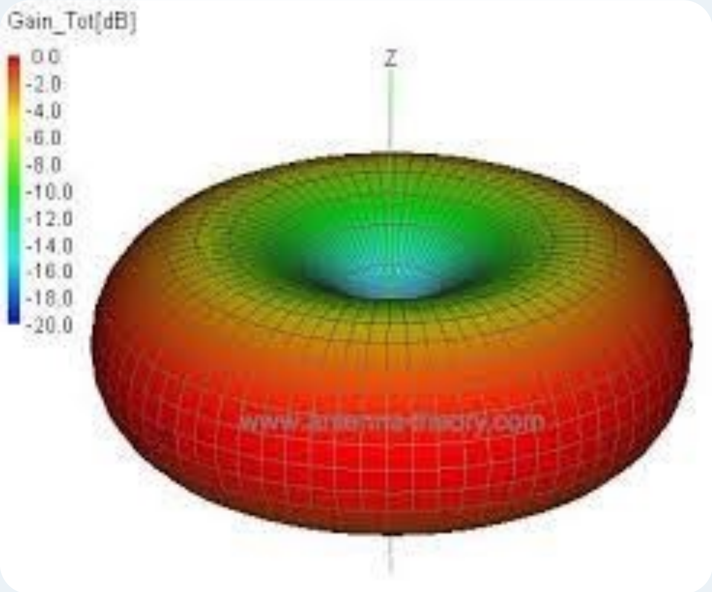
- The more energy, the faster this cycle continues
- Energy is driven by:
  - strength of the transmitter, antenna gain/efficiency
  - distance, energy transmission duty cycle, frequency of the signal, environment
  - correct calibration of the radio/materials the tag is on

Signal Shape

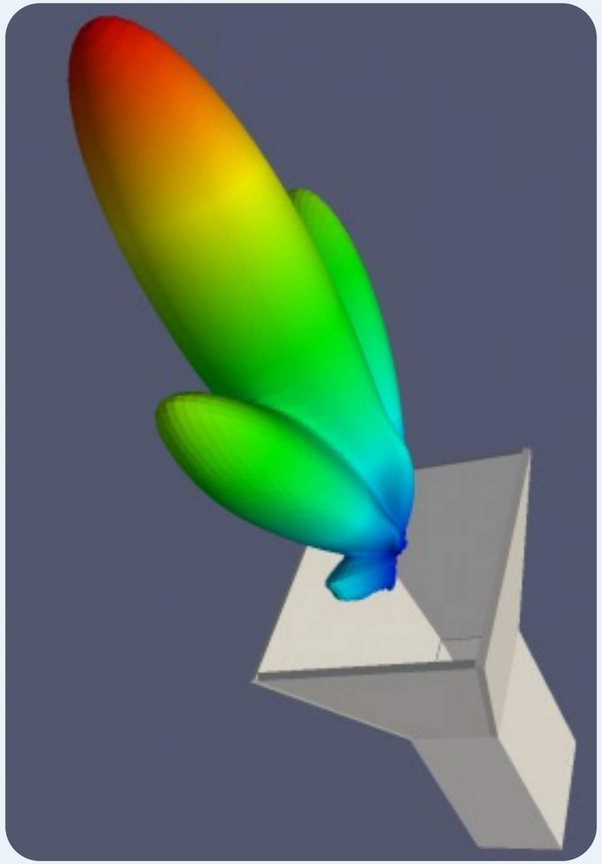
Omni-Directional

Directional

Signal Shape



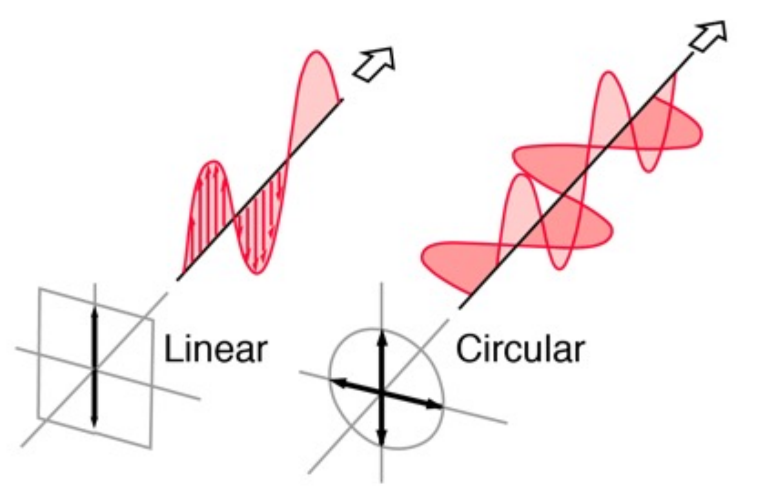
Omni Directional
Antenna Gain pattern



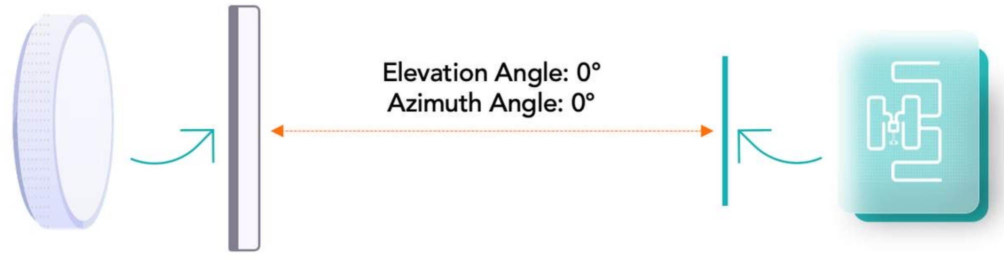
Directional antenna
gain pattern

Orientation Matters

- RF Energy harvesting is impacted by the antenna of the energy source and the antenna of the harvester/tag
- Bridge antenna polarization
  - Linear travels further
  - Circular – tags and readers can be at different heights



- Angle of Elevation (Up & Down) & Azimuth Angle (Left & Right)

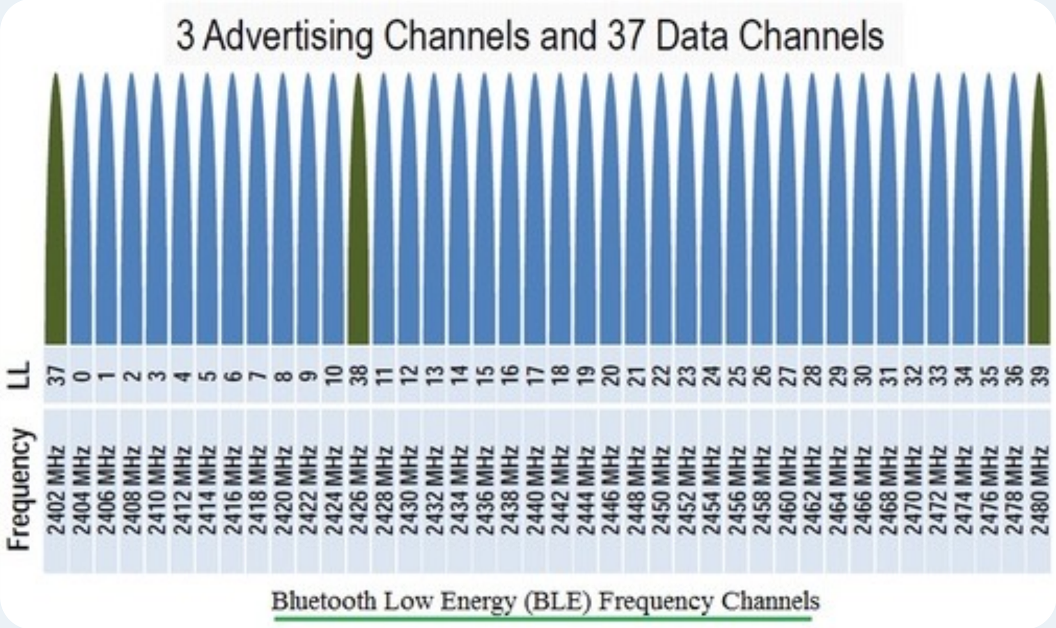


https://www.everythingrf.com/community/circular-polarization-vs-linear-polarization-for-rfid-applications

Noise Matters

If there is a lot of conflicting RF Signals

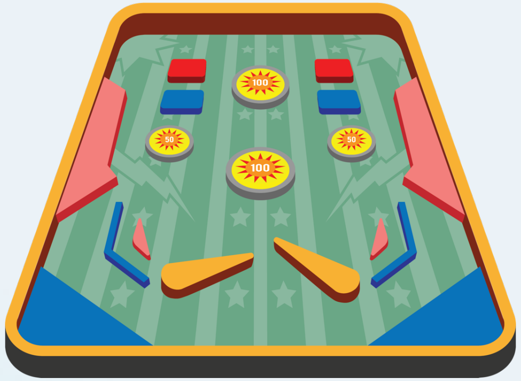
- Weak tag signals can be drowned out by strong ones
- Battery-free calibration can be confused
- Wi-Fi & Bluetooth broadcast on 2.4GHz ISM Band
- Energizing coexists on advertising channels with single band bridges and can be configured to coexist or not on dual band bridges



www.rfwireless-world.com/Terminology/BLE-Advertising-channels-and-Data-channels-list.html

Obstacles Matter

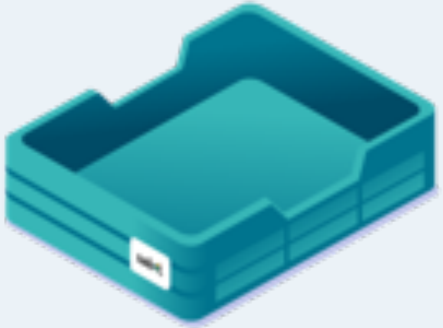
- Metal Surfaces reflect
- Wavelength / frequency changes behavior – 2.4 MHz tends to bounce more
- Metal can block
- Or it can reflect so that the signal gets to the right place – Useful in storage cabinets, refrigerators, shipping containers



Obstacles Matter

- Some surfaces absorb radio signals more than others: foam, certain paint
- Wood can be an absorber

Surfaces Matter



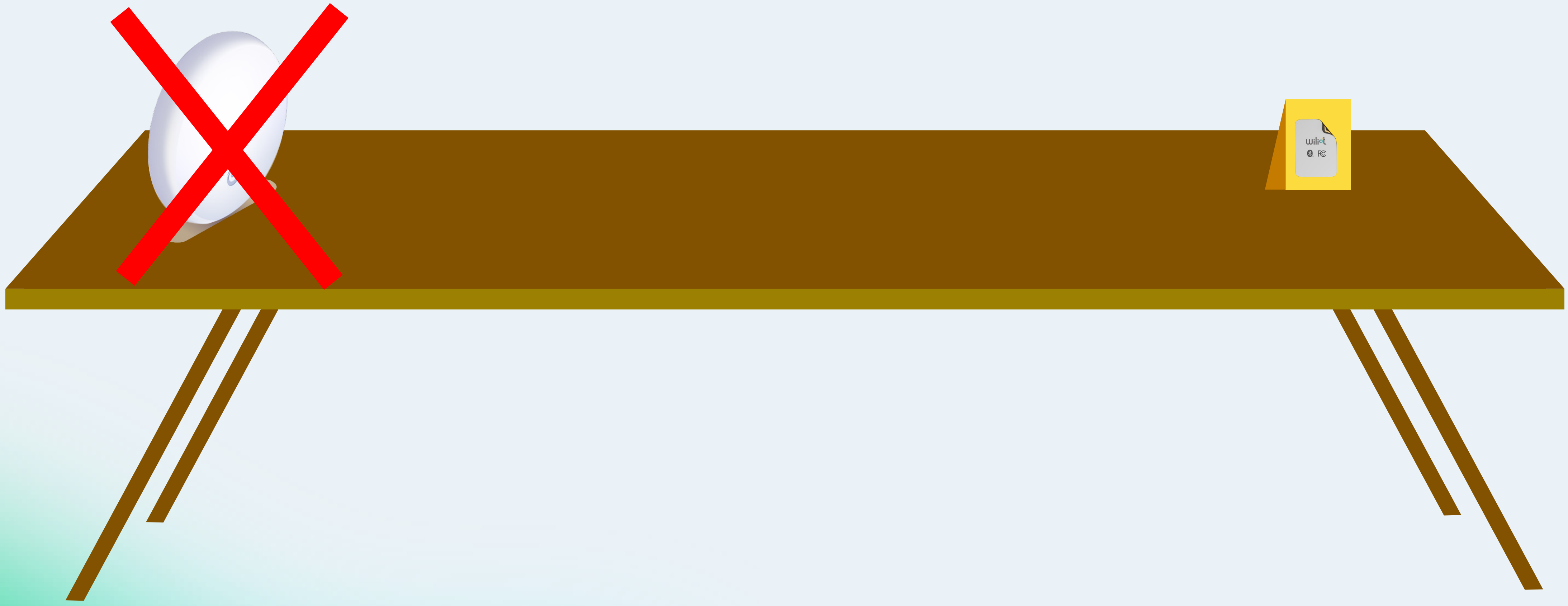
- Glass
- Metal
- People, Animals, Birds
- Fabric
- Wood
- Liquids

Default SKU
In Kits

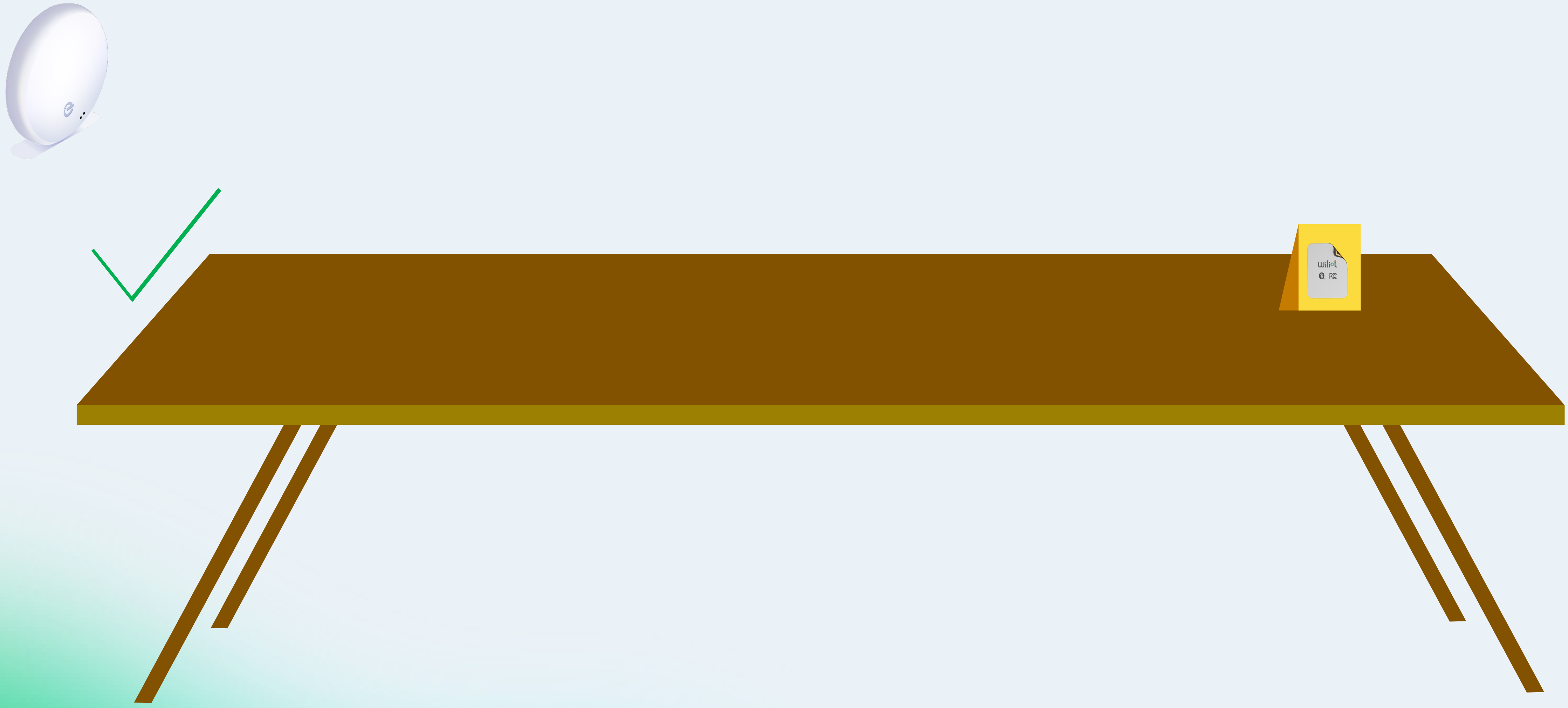
Plastic SKU

Custom SKU or
Spacer Required

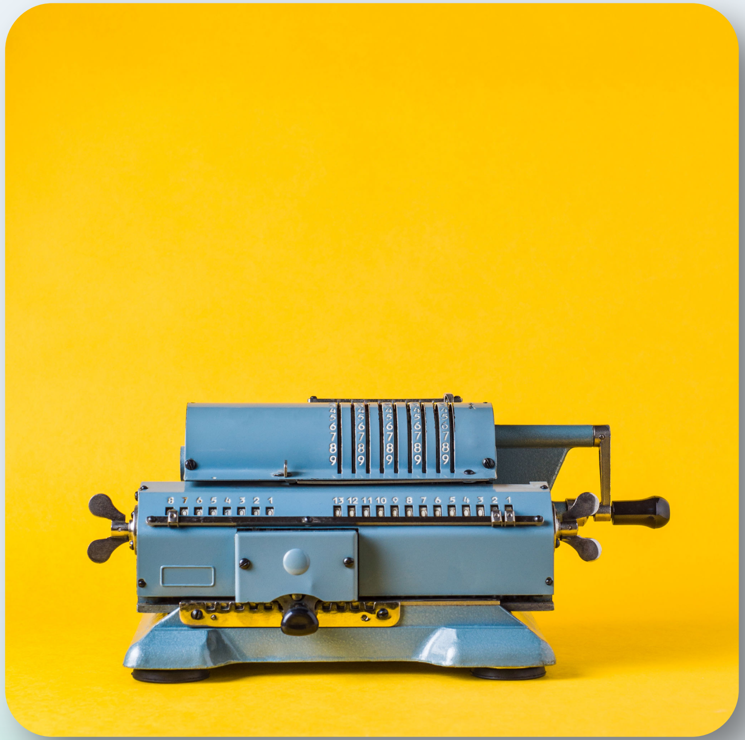
Surfaces & Paths Matter



Surfaces & Paths Matter



Summary



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wiliot

How we work together

Our shared vision

Avery Dennison and Wiliot share a vision for the future of the IoT – an Internet of Trillions (IoT2) – where almost everything is connected to the internet; not just phones, computers, and homes, but also food, medicine, clothing, and nearly everything else. By providing every item with a digital identity IoT2 transcends the current limitations of today's IoT to take global manufacturing and supply chains to another dimension helping to eliminate waste and providing unparalleled transparency.

As the world's largest UHF RFID manufacturer, Avery Dennison is well positioned to bring Wiliot's Bluetooth enabled tags to the market.

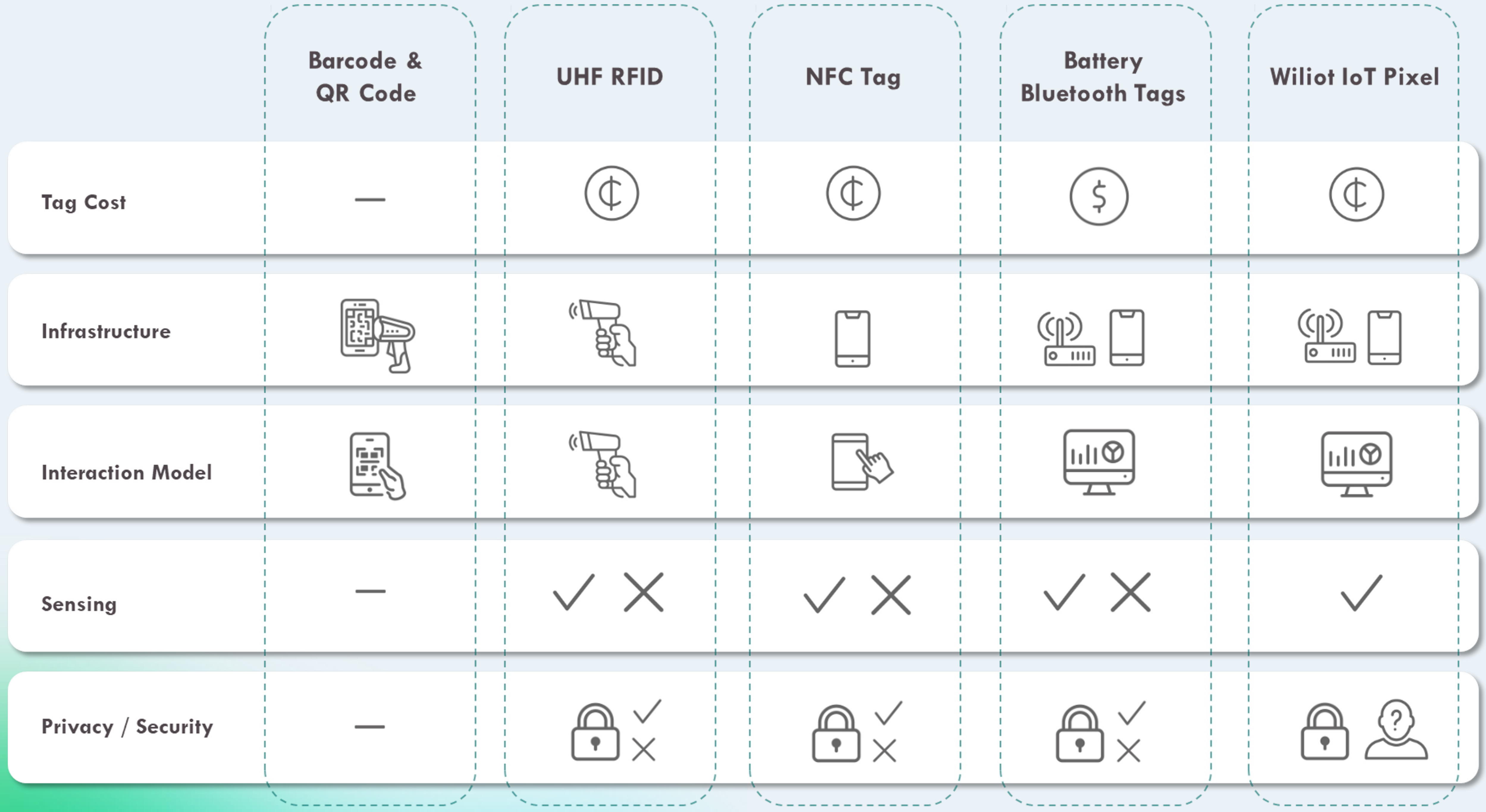
- Industry leader in antenna design, manufacturing, inlay assembly, and quality control processes
- Experts in RFID market adoption process across multiple industries

Our partnership

Avery Dennison and Wiliot have developed a strategic partnership dedicated to scaling the IoT to the next level, from billions to trillions of things – creating a new era of IoT that benefits people and the planet.

Avery Dennison provides Wiliot with specific R&D expertise, and the ability to scale inlay manufacturing capacity by 200% in the next 12 months. By integrating Wiliot sensing services (SaaS) with our atma.io connected product cloud, it will enable tag sensing information to be added to the end-to-end item-level data of a connected product.

BLE vs. UHF RFID, NFC & QR


Barcode & QR Code
UHF RFID
NFC Tag
Battery Bluetooth Tags
Wiliot IoT Pixel
Tag Cost
Infrastructure
Interaction Model
Sensing
Privacy / Security

Typical Reading scenarios: UHF RFID vs BLE

Handheld (UHF is better)

- UHF RFID
  - Versatil mobile device. Solicited read, high density. Common use case: inventory stock take
- Wiliot
  - Slower response on high density. Not optimized for reading in motion

Portal/Tunnel (Both are equally good)

- UHF RFID
  - High density / High speed checkpoint. Higher cost. Solicited read
- Wiliot
  - Easier to deploy, lower cost. Multiple checkpoint scenarios. Unsolicited read

Overhead continuous reading (Wiliot tags are better)

- UHF RFID
  - Overhead, antenna arrays, complex reading infrastructure. Pour location accuracy
- Wiliot
  - Unsolicited read, permanent reading, simple reading infrastructure. Continuous inventory with item location

Customer interaction: NFC vs BLE

Wiliot BLE

- Unsolicited, no customer intervention required
- Home appliance interaction (any BLE enabled device)
- Longer distance (2-10m) with the appropriate infrastructure
- Security requires customer settings on multiple devices

NFC Tags

- Solicited, customer tap required
- Close proximity (5-10 cm)
- Higher privacy, direct user interaction control

Next generation Wiliot tags will target future use cases around consumer interaction

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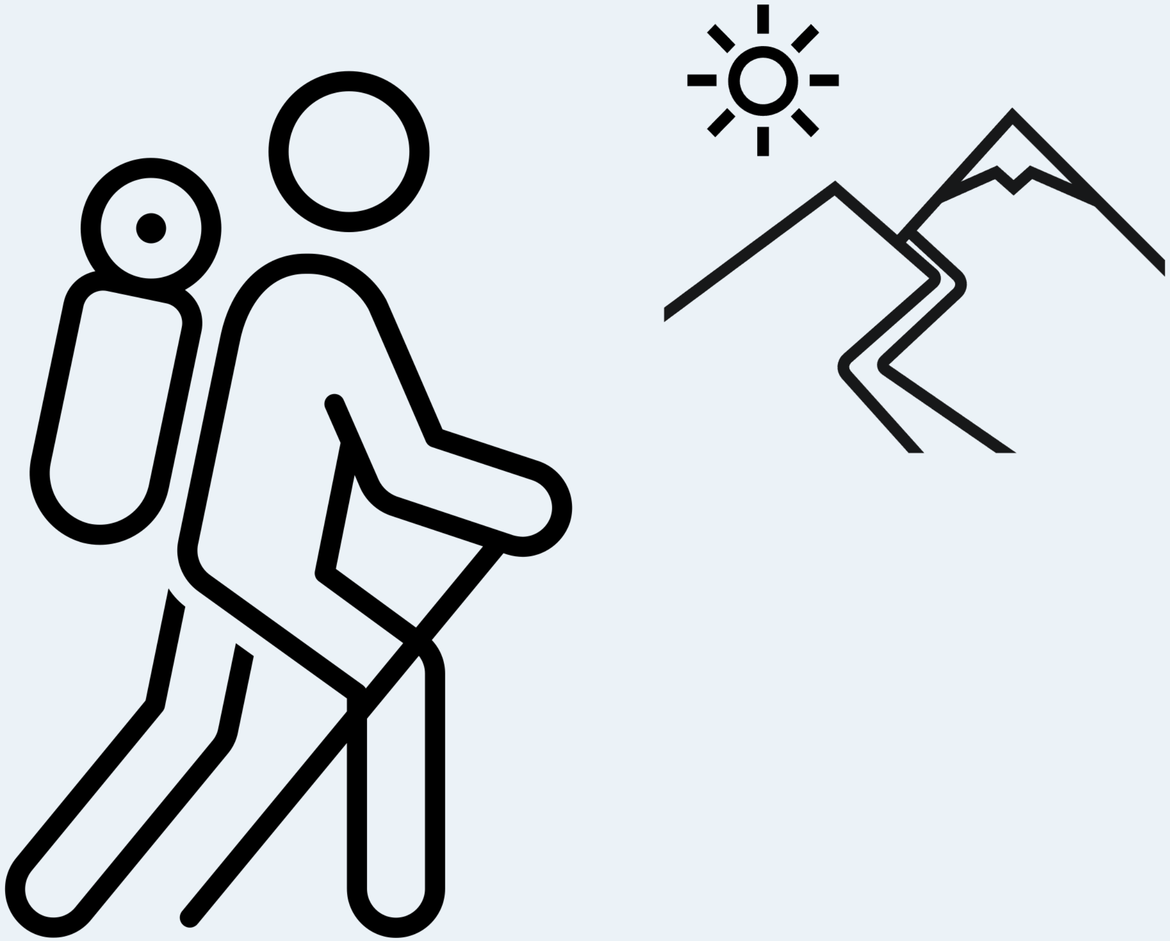
Training Agenda

RFID Journal Live

- Wiliot Mobile App
- Wiliot Architecture
- Wiliot Signal Flow
- Wiliot Portal
- Building an Application
- Example Deployment
- Support Links



Great Journeys Start with Small Steps

Wiliot Mobile App

- Use the App to:
  - See Devices
  - Updating Bridge Firmware (Single and Dual Band)
    - Over the air updates on roadmap

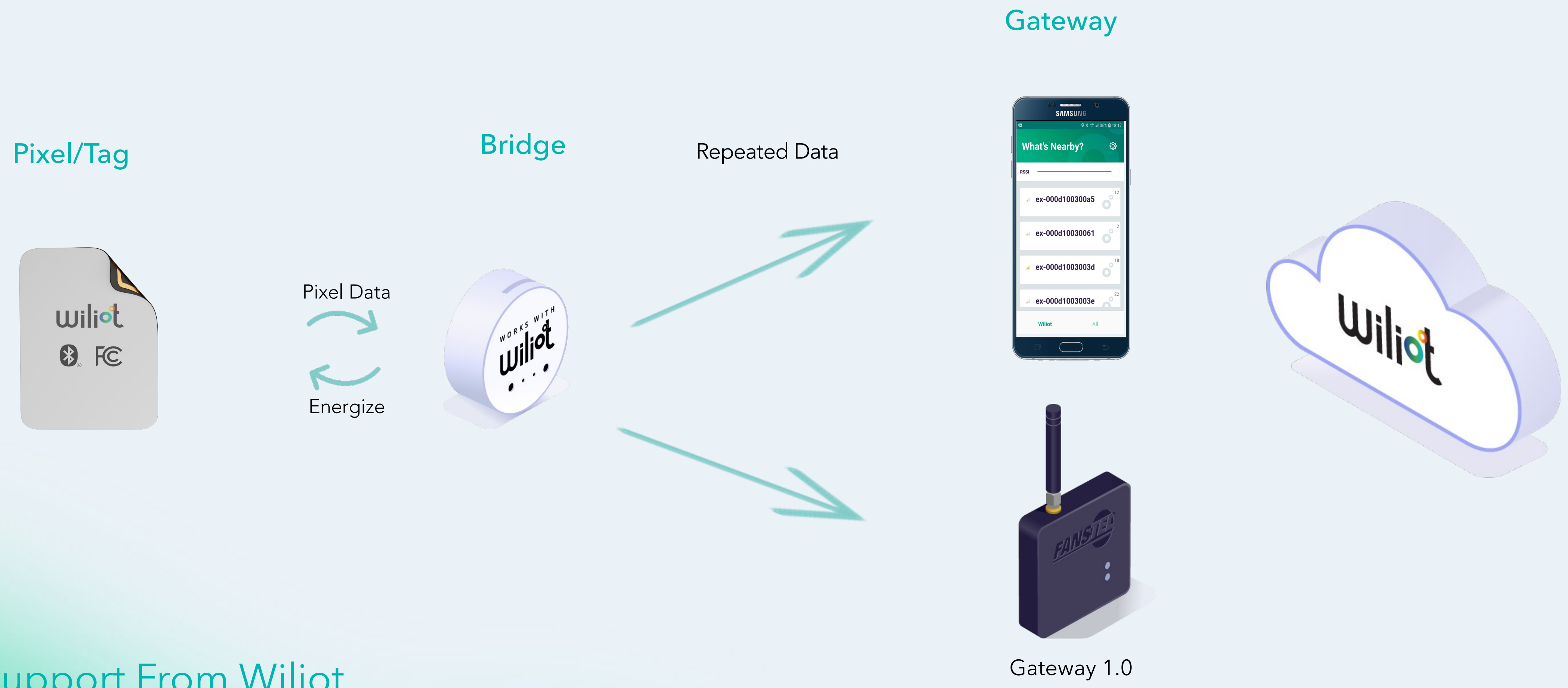
- Note:
  - At this time Wiliot App does not allow for configuration changes Future Release to address
    - Navigate to the Management portal from you phone to accomplish this

- Wiliot App does not currently update FW or make configuration changes for Energous devices

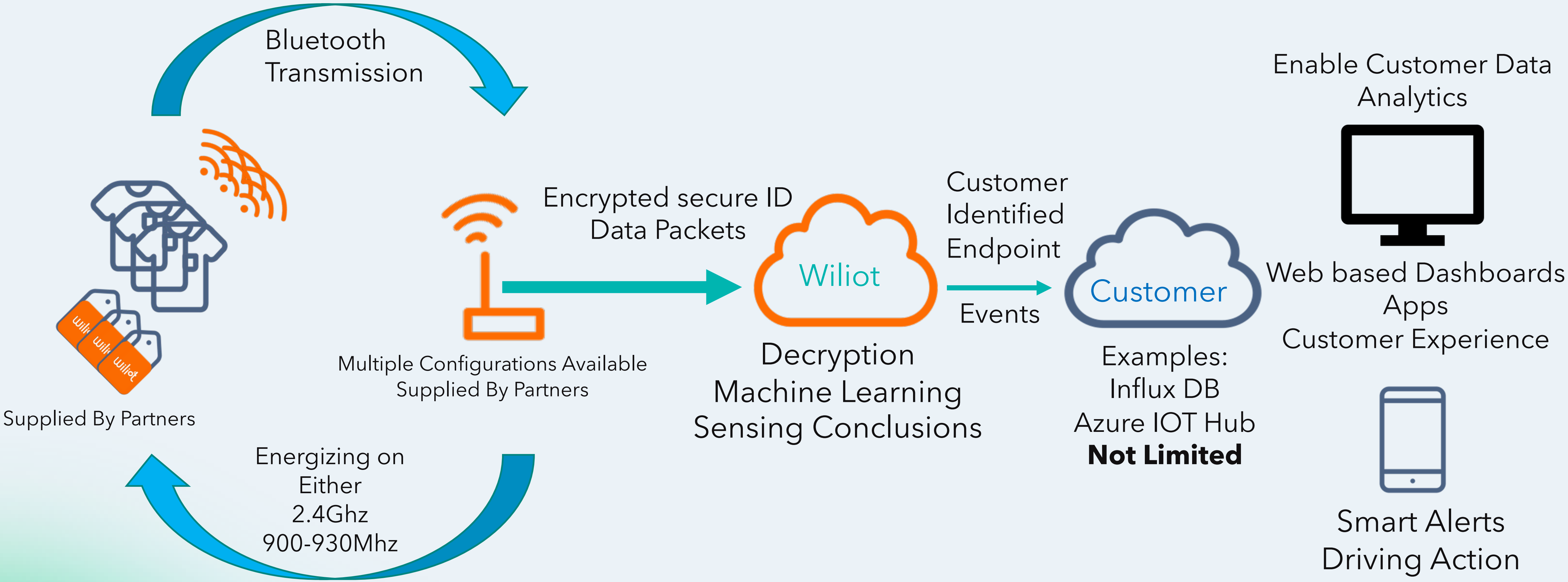
Support Link
[App Install and Guide]
[Updating Bridge Firmware using the App]

Gateway

Three Tier Architecture : Pixel → Bridge → Gateway



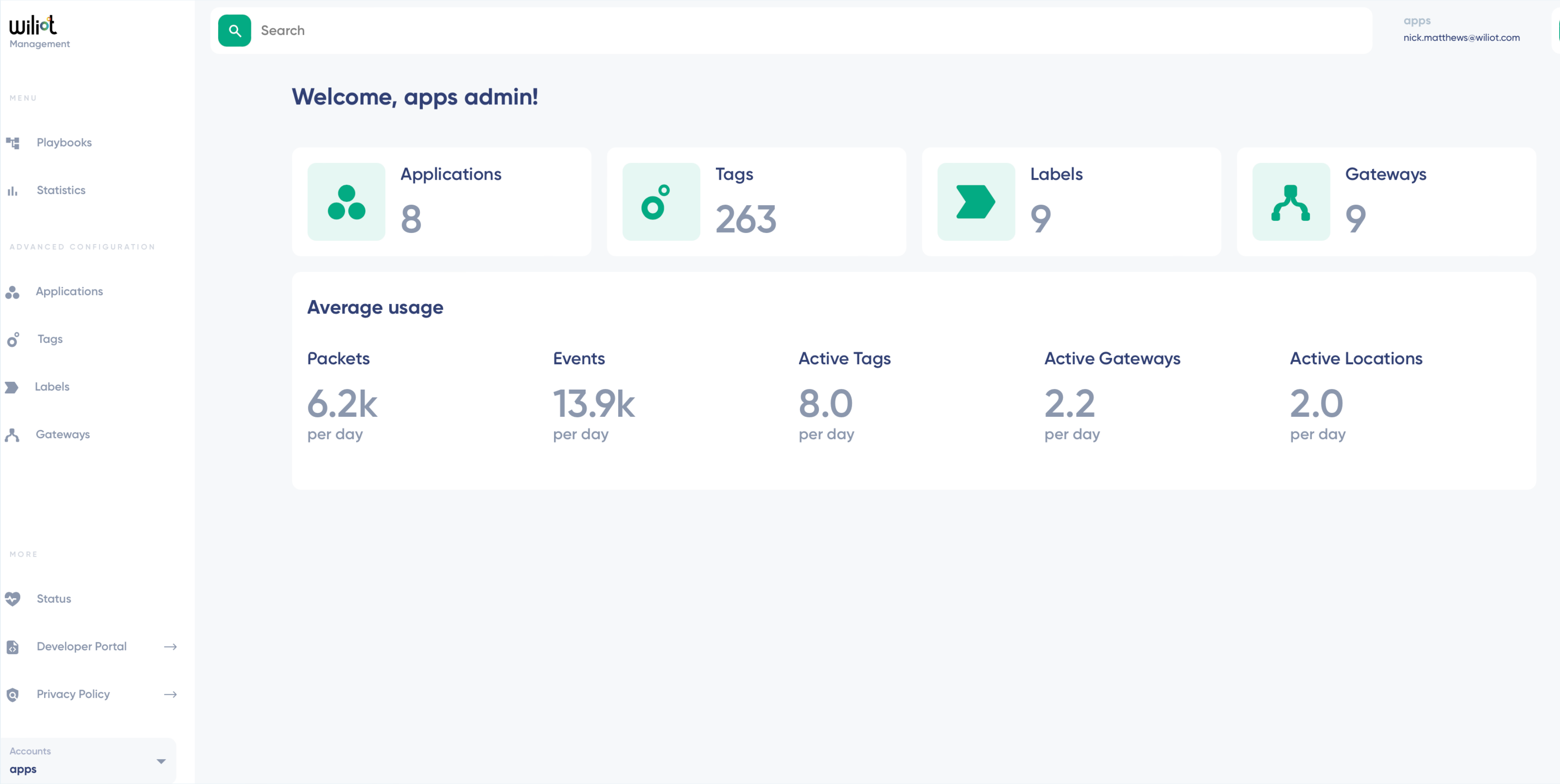
Support From Wiliot


Bluetooth
Transmission
Supplied By Partners
Multiple Configurations Available
Supplied By Partners
Encrypted secure ID
Data Packets
Wiliot
Decryption
Machine Learning
Sensing Conclusions
Customer
Identified
Endpoint
Events
Customer
Examples:
Influx DB
Azure IOT Hub
Not Limited
Enable Customer Data
Analytics
Web based Dashboards
Apps
Customer Experience
Smart Alerts
Driving Action
Energizing on
Either
2.4Ghz
900-930Mhz

Wiliot Management Portal

- Tool for:
  - Creating Labels
  - Associating Tags
  - Creating Applications
  - Managing Gateways and Bridges
  - Confirm Device Functionality
  - Manage Users
  - Manage Events
- How to use the Portal
  - POC
  - Small Deployment

- Account in UI is equivalent to Owner



Support link

[Management-Portal Tags]

[Management Portal -User Management]

[Management Portal –Controlling Event Generation]

Building an Application

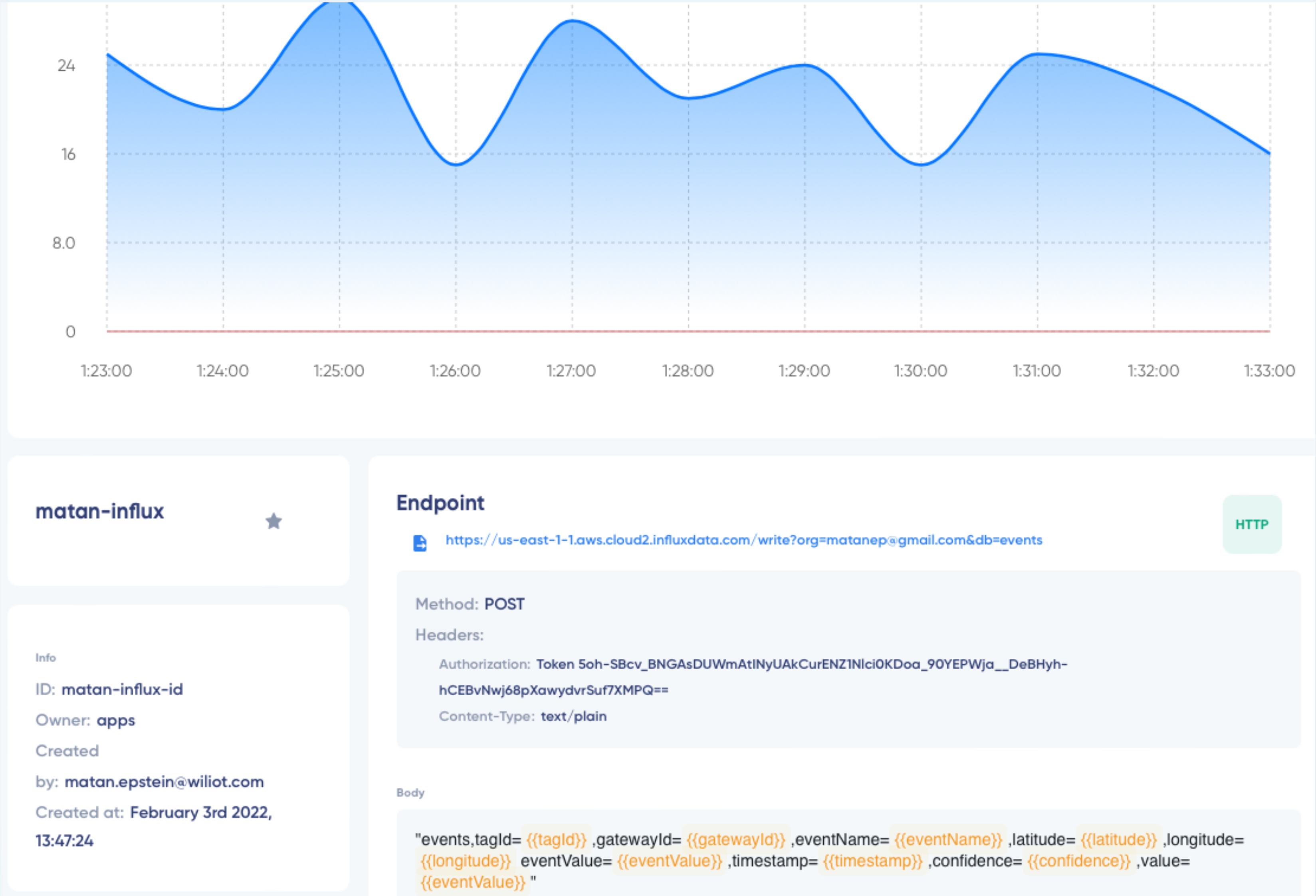
[Cloud 2 Cloud Applications]

Applications tell Wiliot Cloud what you would like to do with events.

You will need

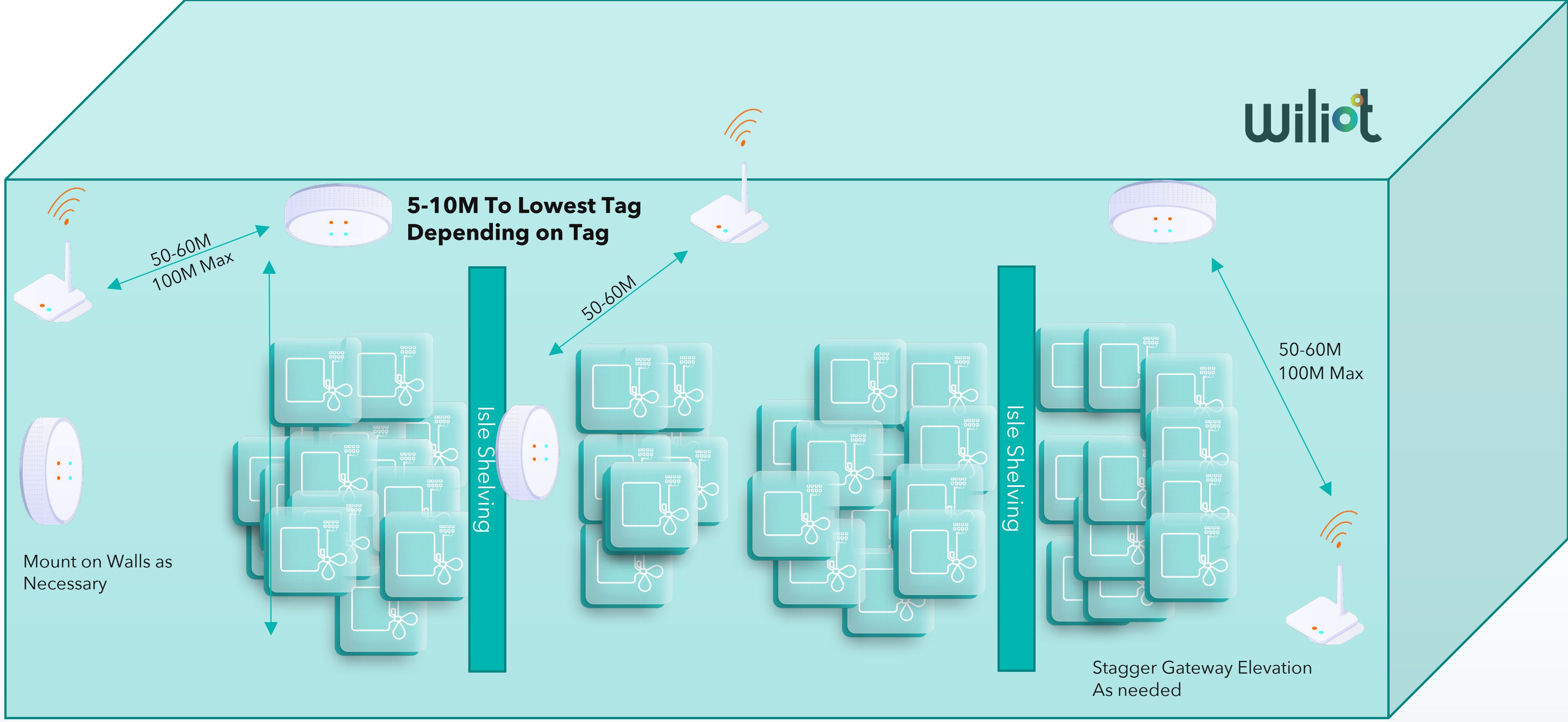
- An Endpoint (Destination)
  - Where you send the data
    - HTTP
    - MQTT
- Establish your Filter
  - What data you would like to send (Tailoring Event)
- Presentation
  - How you want the data to look

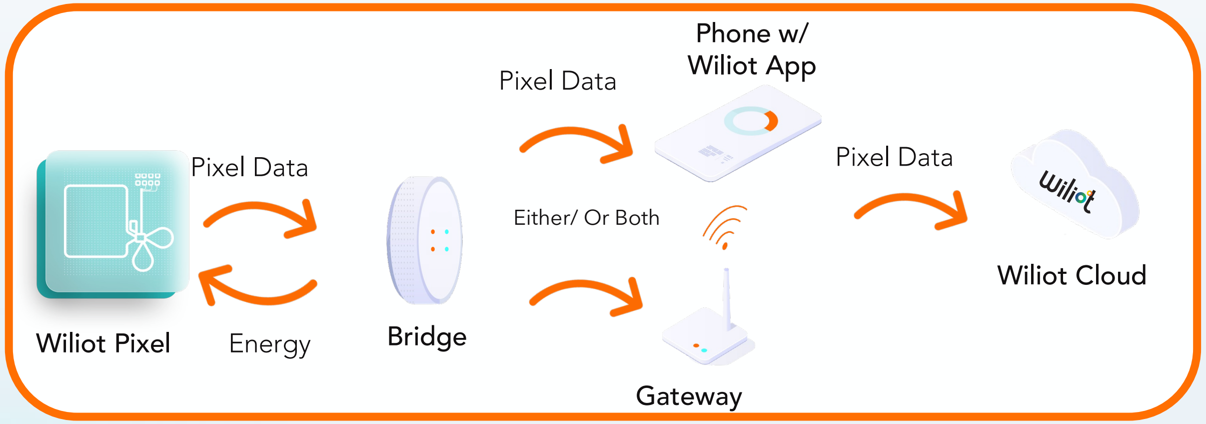
[DEBUG Application]



Inventory Monitoring

- Single Zone
- Density of HW depends on environment
    - Square Footage
    - RF Environment
    - % of Material Needed to Monitor
    - Access to Power
- DBUG Dashboard
- Test the dashboard you have built
- Monitor temperature changes





Troubleshooting and Debug Steps

Email: Support@wiliot.com

Knowledge Database: Support.wiliot.com

Training Questions/Recommendations:
Training@wiliot.com

In case you missed it:
Getting Started
Wiliot 101

Q&A