



Ultra Low Power RF Communications

Ambient Power Enabled IoT Sensing

Presenter: Vytas Kezys, Chief Scientist, HaiLa Technologies, Inc.
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Massive IoT deployments: The Battery Problem



Solution: Ambient Power Enabled IoT



IoT sensing application example

Building automation

Mounted

Accessible for
battery changes

HVAC Efficiency

- Temperature/humidity
- Current monitoring (fan/pump)
- Pressure/airflow

Security & Emergency

- Access control
- Smoke/fire/CO2 detection

Comfort

- Lighting/air quality/occupancy

Requires ultra-long battery
life for lower CapEx/OpEx

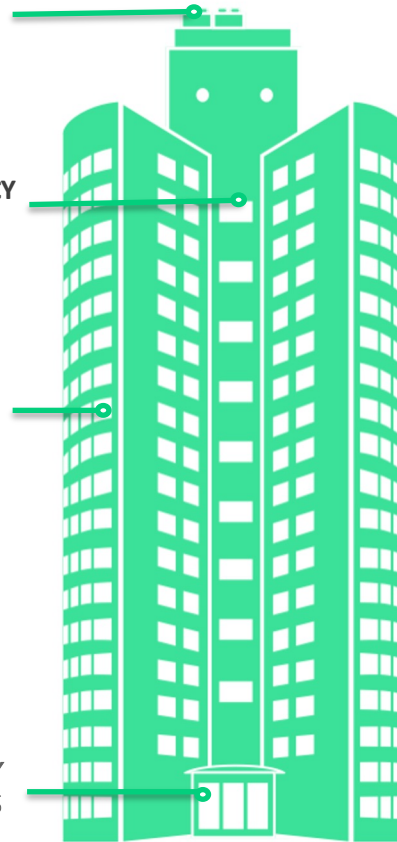


HVAC
SENSORS

EMERGENCY
SENSORS

COMFORT
SENSORS

SECURITY
SENSORS



INTEGRITY
SENSORS

Embedded

Non-accessible for
battery changes

Building Materials

- Mold/moisture detection
- Water leaks
- Electrical hotspots
- Strain gauges

Requires ambient power
(battery-free) IoT sensors
based on extreme low power
wireless communications



Wireless power efficiency challenges

**New, power-efficient sensor technologies
(e.g., silicon, MEMS)**

Battery life is often dominated by the radio sub-system

**Radio sub-system
power consumers**

Transmitter:

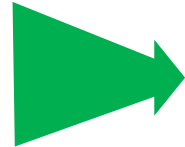
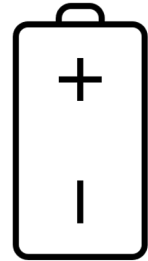
- Generation of a stable RF carrier + RF amplifiers
- Can be dominant power consumers especially at high transmission duty cycles

Receiver:

- Needed for channel sensing, synchronization via beacons, etc.
- Will be dominant power consumer at low transmission duty cycles



Ambient Power IoT: How do we get there?

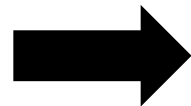


Reduce radio power consumption

Interim: Enable use of small, lifetime battery

Ultimate goal: Enable energy harvesting from ambient power sources

Today:
High power
radio solutions



Near future:
Ultra-low
power RF
technology

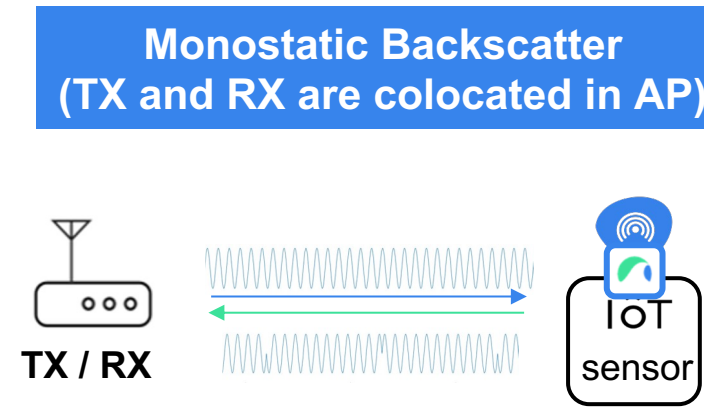
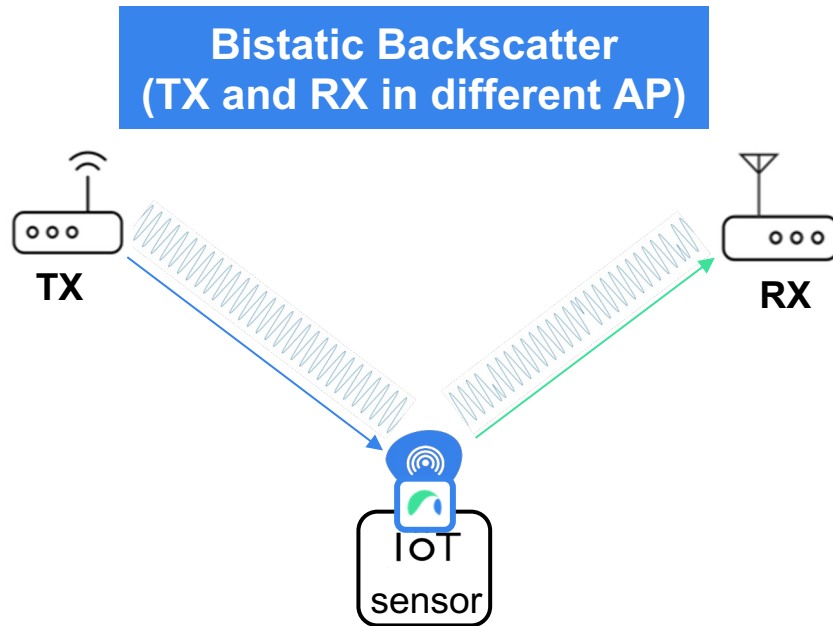


RX: Envelope detector or
channelized receiver with long sleep cycles

TX: Backscatter



Backscatter on Wi-Fi explained



Backscatter is a modulated reflection of an ambient RF signal, in this case a Wi-Fi signal

- A conventional transmitter (TX) sends standard Wi-Fi signal
- IoT sensor tag backscatters (reflects) the Wi-Fi signal on a different Wi-Fi channel with the sensor data embedded
- The reflected signal is received by a Wi-Fi device (RX) as a standard Wi-Fi signal
- IoT sensor tag data can be extracted at the receiver, the network edge or in the Cloud
- Can be configured as bi-static or monostatic



Ubiquitous Wi-Fi, IoT sensing, and ultra-low power RF

Optimized use of existing infrastructure: Wi-Fi

- Avoid yet another radio protocol
- Wi-Fi is ubiquitous
- It can be tailored to meet battery life longevity requirements for wireless IoT
- IEEE 802.11 AMP is an active group defining the path to ambient powered IoT over Wi-Fi

Infrastructure enhancements for backscatter on Wi-Fi

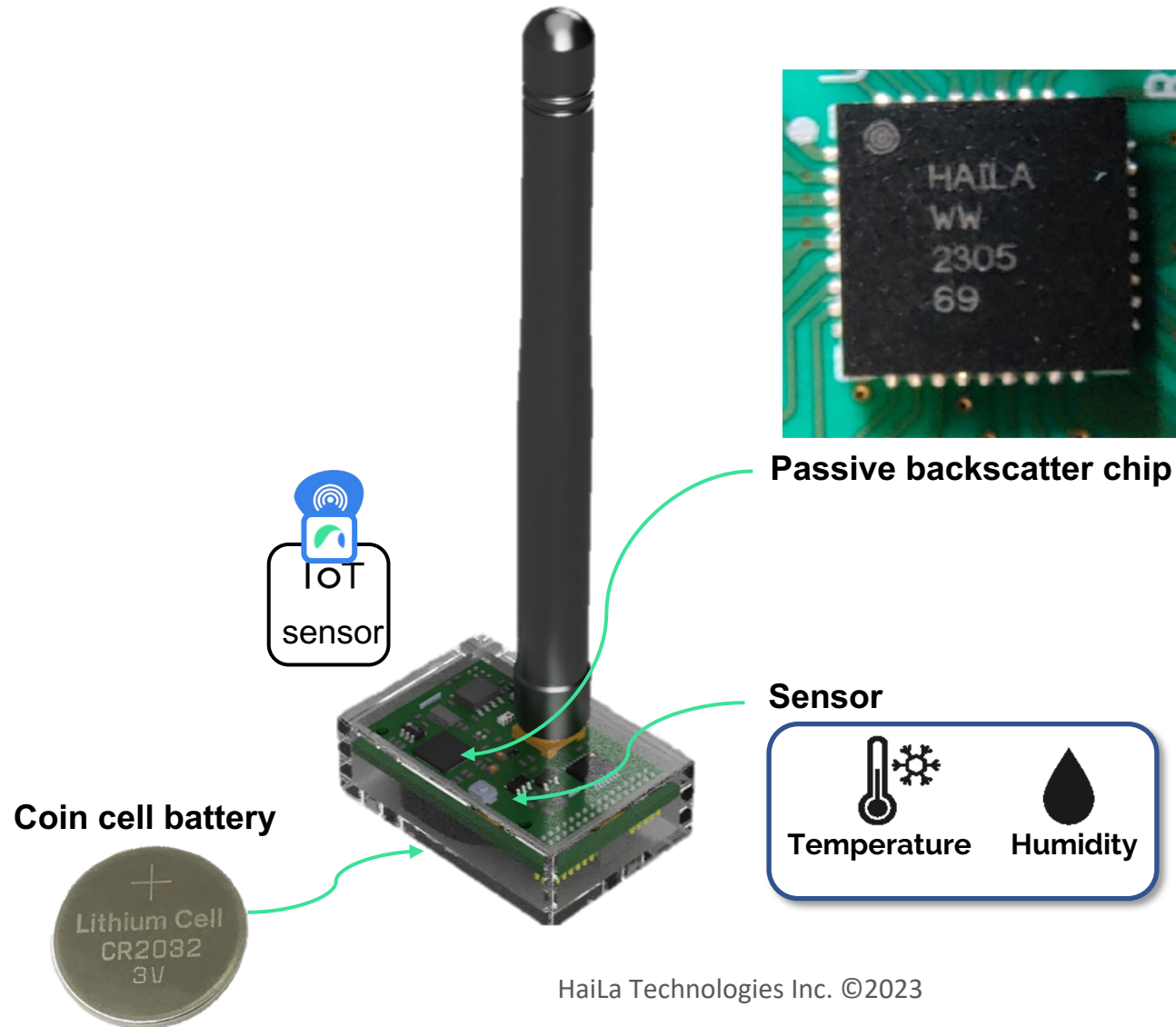
- Enhancing coverage
 - Macro diversity (more infrastructure)
 - Joint transmission (Wi-Fi 8)
 - Multi-antenna sensor tags
- Self-jamming cancellation

Expectations for backscatter on Wi-Fi

- Projected battery life of 20 years with 2-minute sensor updates



Demonstrating Wi-Fi backscatter for IoT sensing



Key Takeaways

Battery problem

Massive deployment of IoT sensors needs a solution to mitigate battery waste and eliminate altogether

Sensor radio power

Industry working towards lower power radios

Ambient IoT

Need a step-function improvement in radio designs to eliminate IoT sensor batteries

Ease of adoption

Leverage ubiquitous, existing, global wireless networks

New enabling technology

Passive backscatter over Wi-Fi



Thank You

