

Sensors Expo 2011

Implementing RF Energy Harvesting for Building and Industrial Automation

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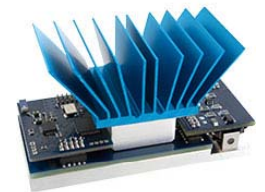
Why Energy Harvesting?

- Wiring installation est. at \$250 / node (commercial buildings)
- Wired devices need expensive termination equipment
- Wiring changes are disruptive
- Batteries represent liability
 - Repeated maintenance cost
 - Impact of early failure

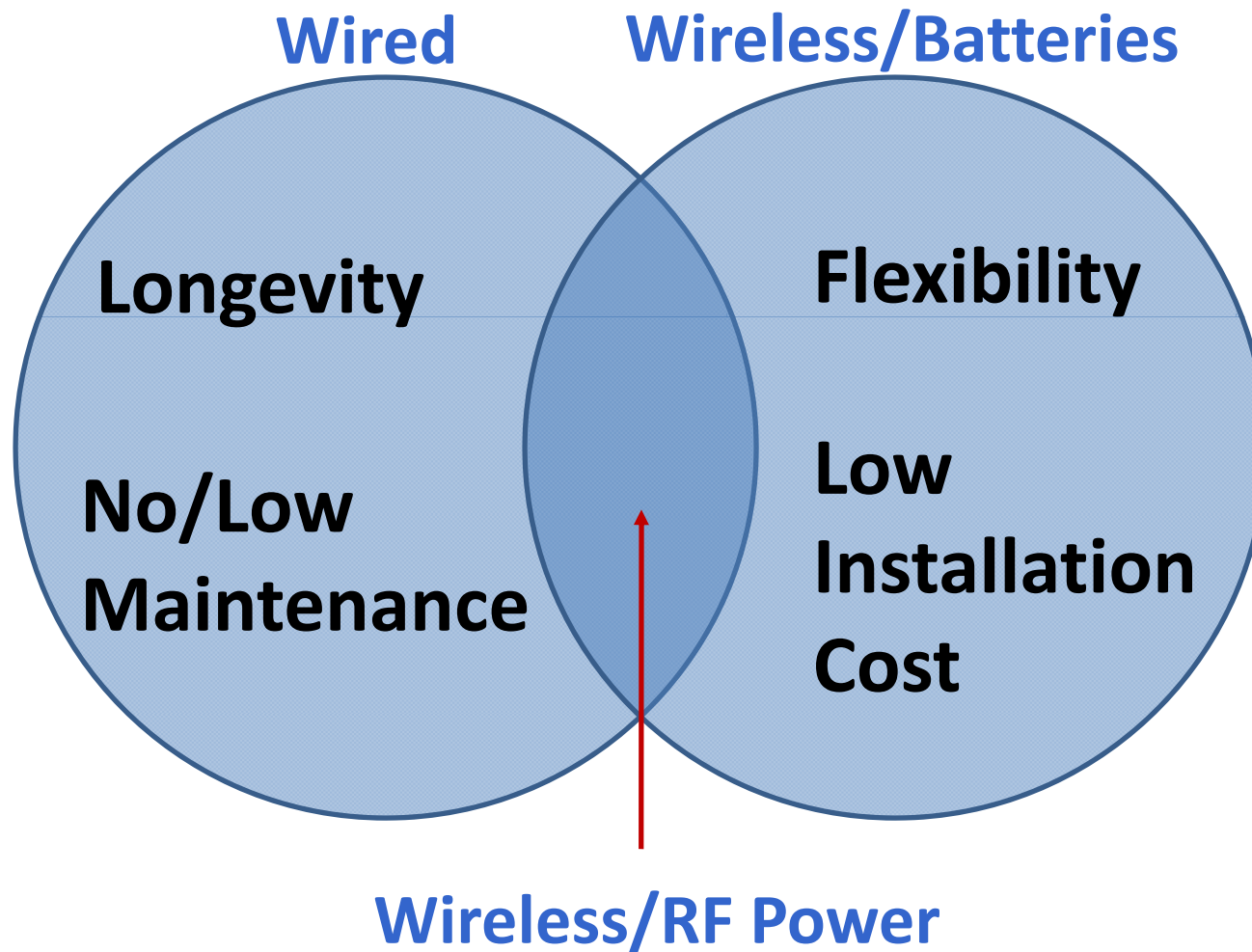


Why RF-based Wireless Power?

- Light / solar energy not always sufficient
- Temperature diff. not always available
- Vibration (e.g.60Hz) not always desired
- RF-based wireless power
 - Send power over distance - μW , low mW
 - Overcomes lack of light, temp diff., or vibration
 - Controllable: continuous, scheduled, on-demand



RF-power enables benefits of wired and battery-based systems



System Cost Comparison

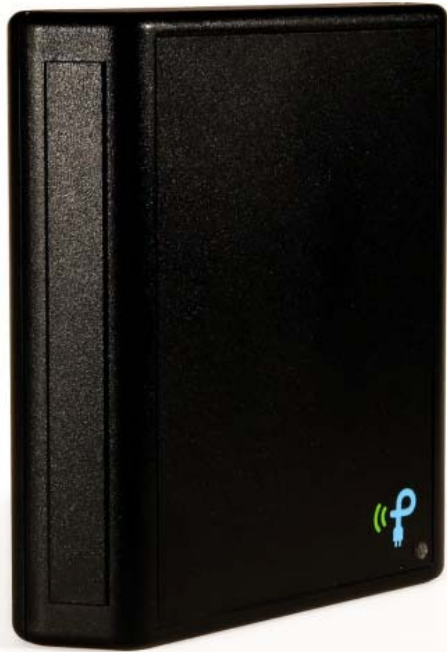
Standard Wired Sensors

▪ Sensor – Device	\$150	– temp and humidity
▪ Sensor – Wiring	\$250	– single unit
▪ Sensor – Installation	\$ 25	– single unit
▪ Controller – wiring	\$ 25	– per node (= \$300 / 12)
▪ Controller – equipment	\$ 80	– wired temp port
▪ Controller – equipment	\$ 80	– wired humidity port
Total	\$610	– per node

RF-Powered Wireless Sensor System

▪ Wireless Sensor – device	\$200	– temp / humidity
▪ Wireless Sensor – installation	\$ 25	– per node
▪ Transmitter – device	\$ 50	– per node (= \$250 / 5)
▪ Transmitter – wiring	\$ 20	– per node (= \$100 / 5)
▪ Transmitter – installation	\$ 10	– per node (= \$50 / 5)
▪ Access point – device	\$ 30	– per node (= \$600 / 20)
▪ Access point – installation	\$ 5	– per node (= \$50 / 20)
Total	\$340	– per node

RF Power Source



Wall Mount

- Multi-room / large area coverage
- Directional antenna
- 3W EIRP
- 60 degree pattern

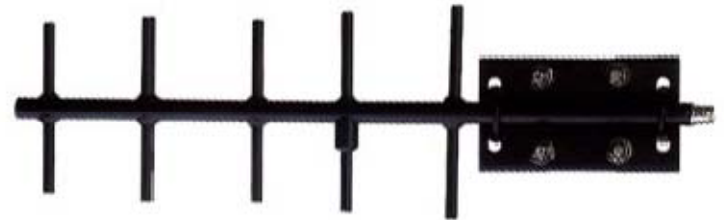


Plug in (planned)

- Room-based power
- Simple deployment
- Low cost
- 1W EIRP
- 180 degree pattern

Antenna Considerations

- Directional
 - longer range
 - better performance
 - larger form factor
- Omni-directional
 - shorter range
 - variable performance
 - small form factor, especially PCB/chip antennas



Batteries vs. Battery-less for RF-power

- Depends on requirements
 - Battery-less: variable transmit intervals
 - Battery: fixed transmit intervals
- Rechargeable battery-based systems provide additional flexibility
 - System start-up, mesh connections, etc.
- Battery technology must be capable of storing extremely low energy levels
 - NanoAmp charge current at maximum range

Lifetime Power® Sensor System

Powercaster® Transmitter

- Power: One-to-many wireless power source
- Data: Transmits unique ID code



Lifetime Power® Wireless Sensors

- Measure environmental data – temperature, humidity, light, etc.
- Transmit data to BAS Gateway
- Battery-free or battery-operated – charged by RF transmitter



Building Automation System Gateway

- Receives wireless sensor data
- Range of standard BAS protocols and interfaces
- Supports up to 100 sensors and 800 sensor points



Lifetime Power[®] Sensor System

Powercaster[®] Transmitter

One-to-Many
Power Source



TX91501

915 MHz



RF-Powered Wireless Sensors

2.4 GHz



Temperature
Humidity
(WSN-1001)



Light



Diff. Pressure

Building Automation System Gateway

BAS



Ethernet or Serial



WSG-101

Wireless Access Point
(for up to 100 devices)

Battery-less Sensors

Lifetime Power® Wireless Sensors



- Powered wirelessly (915MHz)
 - No batteries, no wires
 - Power range of 60+ feet line of sight
- Range of sensor types
 - Temp / Humidity
 - Light
 - Diff. Pressure
- Data transmit range of ~120ft
 - 2.4GHz, 802.15.4 radios
- Serial Interface (USB)
 - Configuration from Gateway
- Both antennas internal

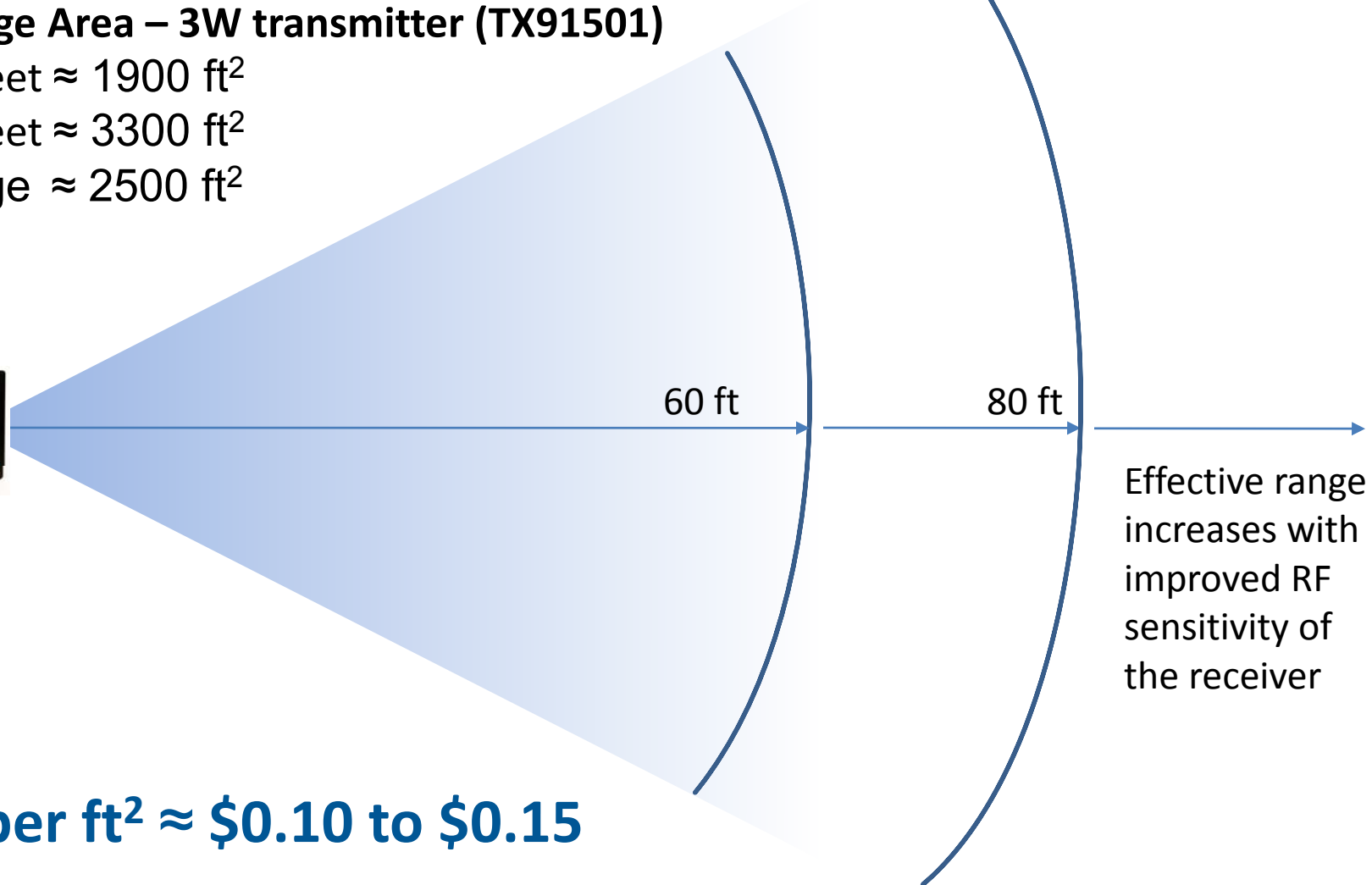
Intentional Transmitter Coverage

Coverage Area – 3W transmitter (TX91501)

@ 60 feet $\approx 1900 \text{ ft}^2$

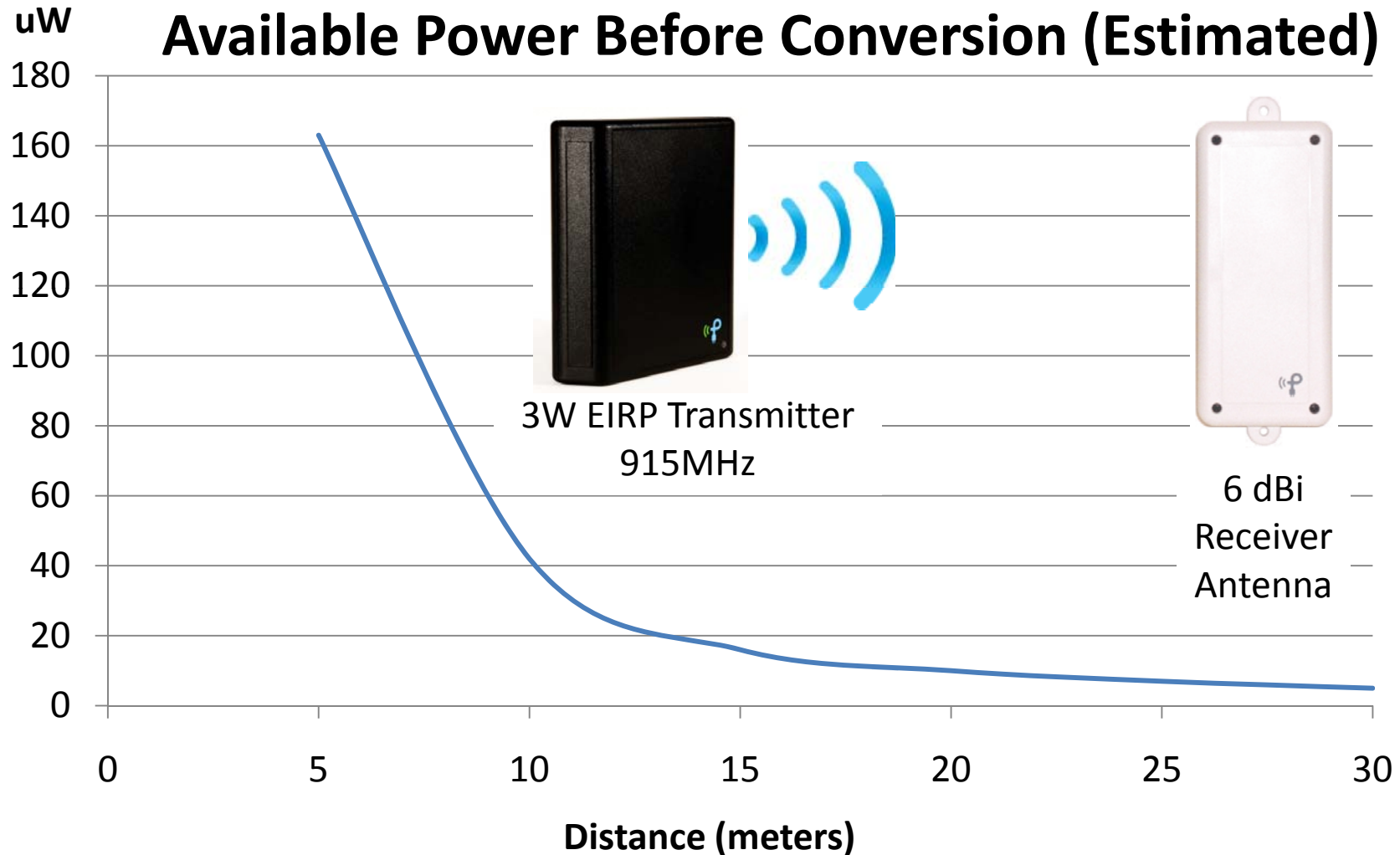
@ 80 feet $\approx 3300 \text{ ft}^2$

Average $\approx 2500 \text{ ft}^2$

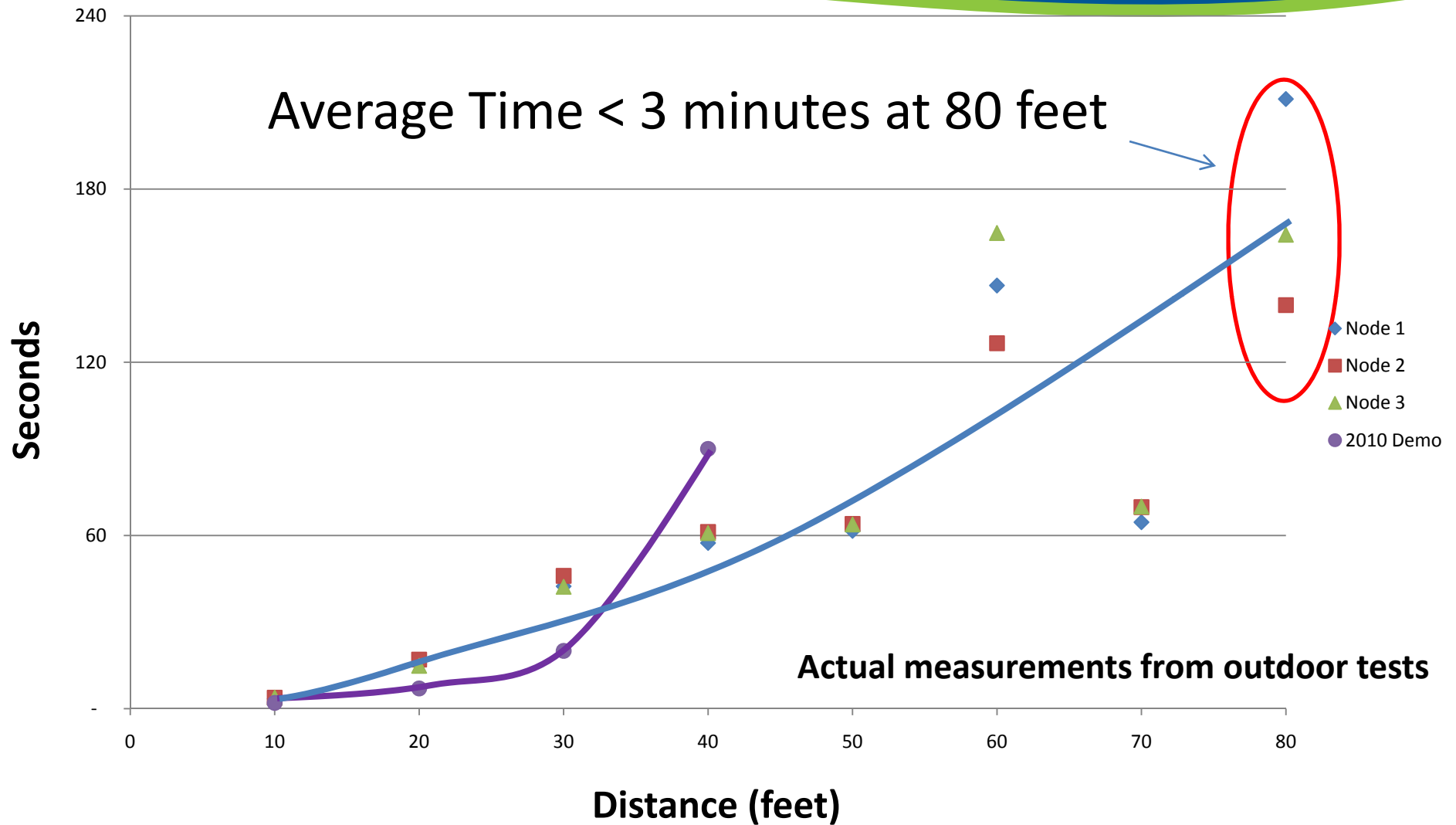


Cost per $\text{ft}^2 \approx \$0.10$ to $\$0.15$

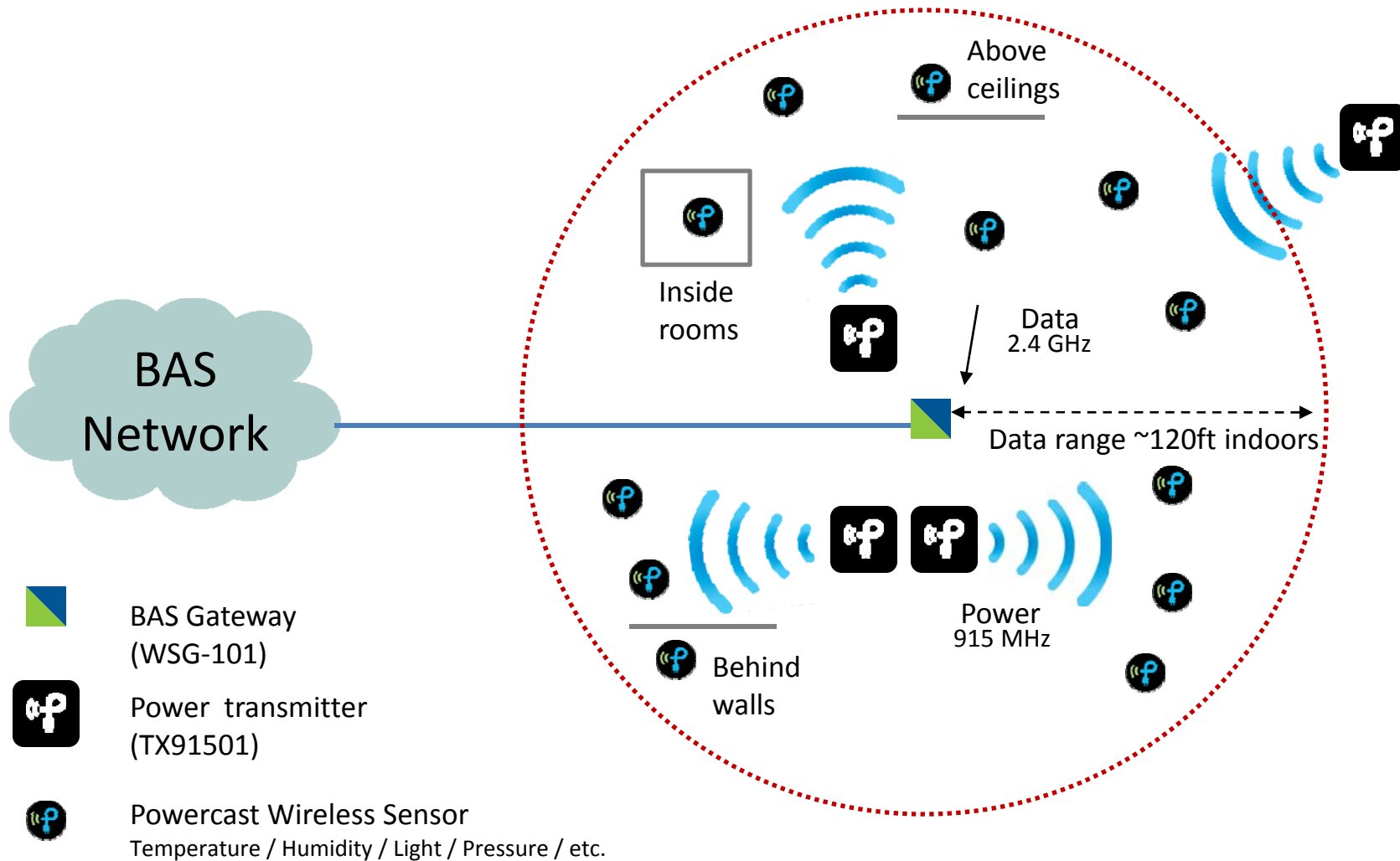
Intentional Transmitter Power



Time Between Packets (Actual)



System Deployment Example

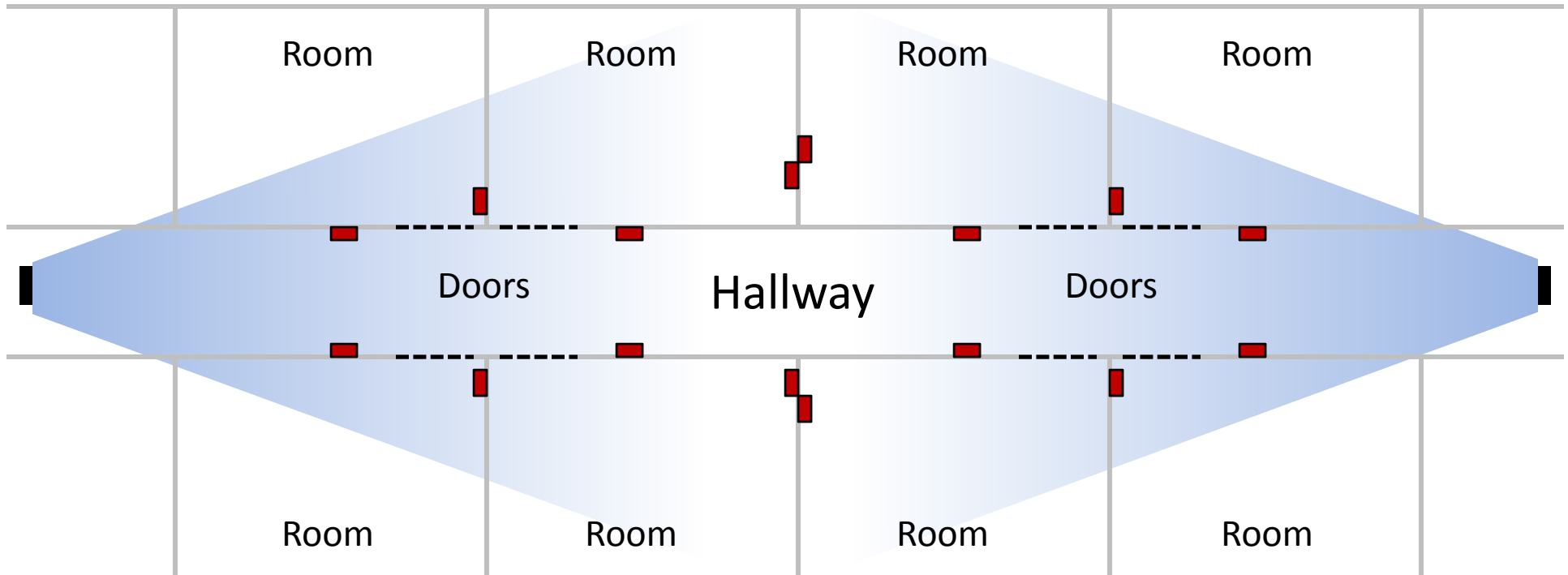


Wireless Sensor Deployment

■ Sensor locations

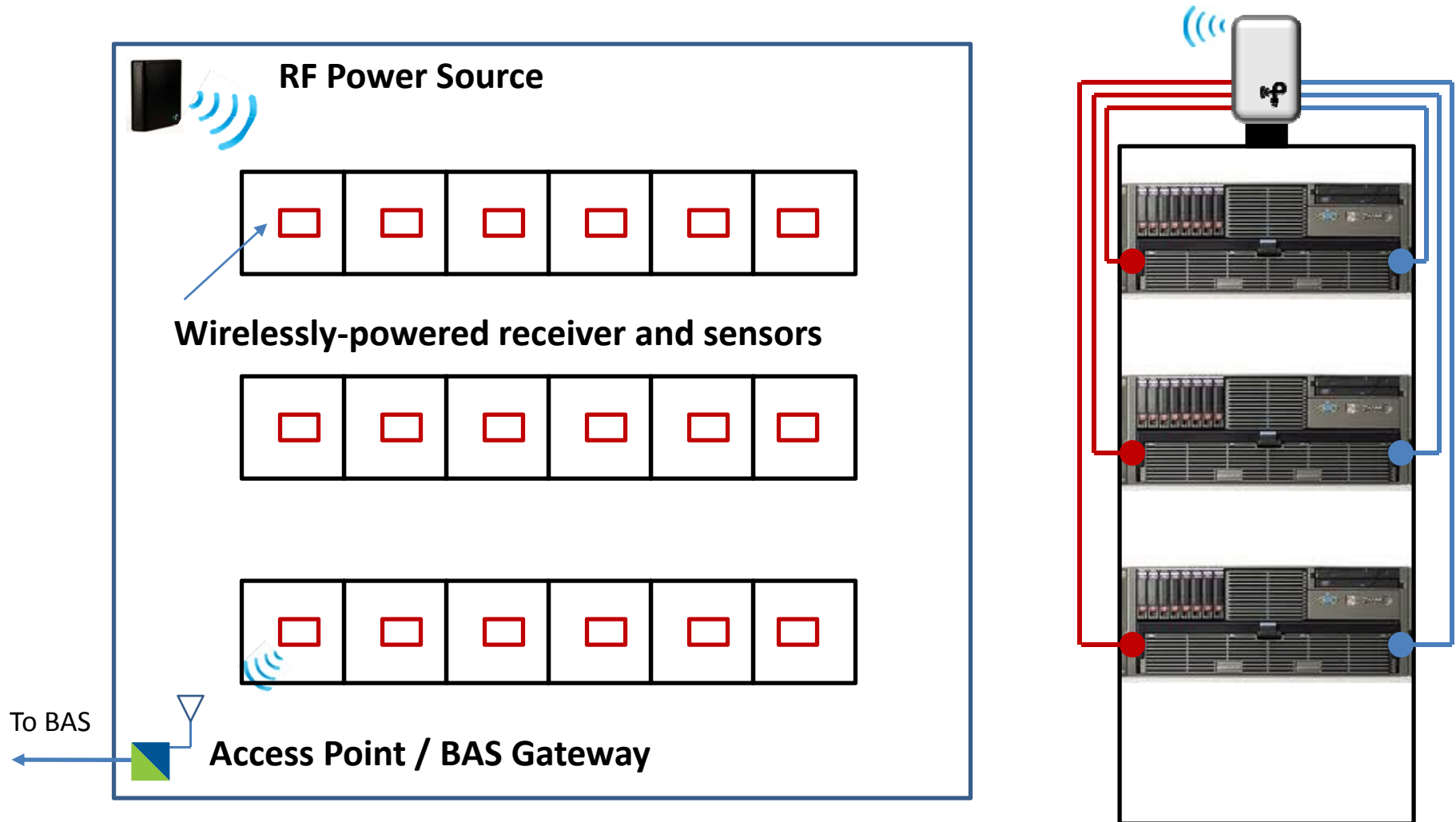
■ RF transmitter (ceiling mount)

Offices, Hospitals, Hotels, Apartments, etc.



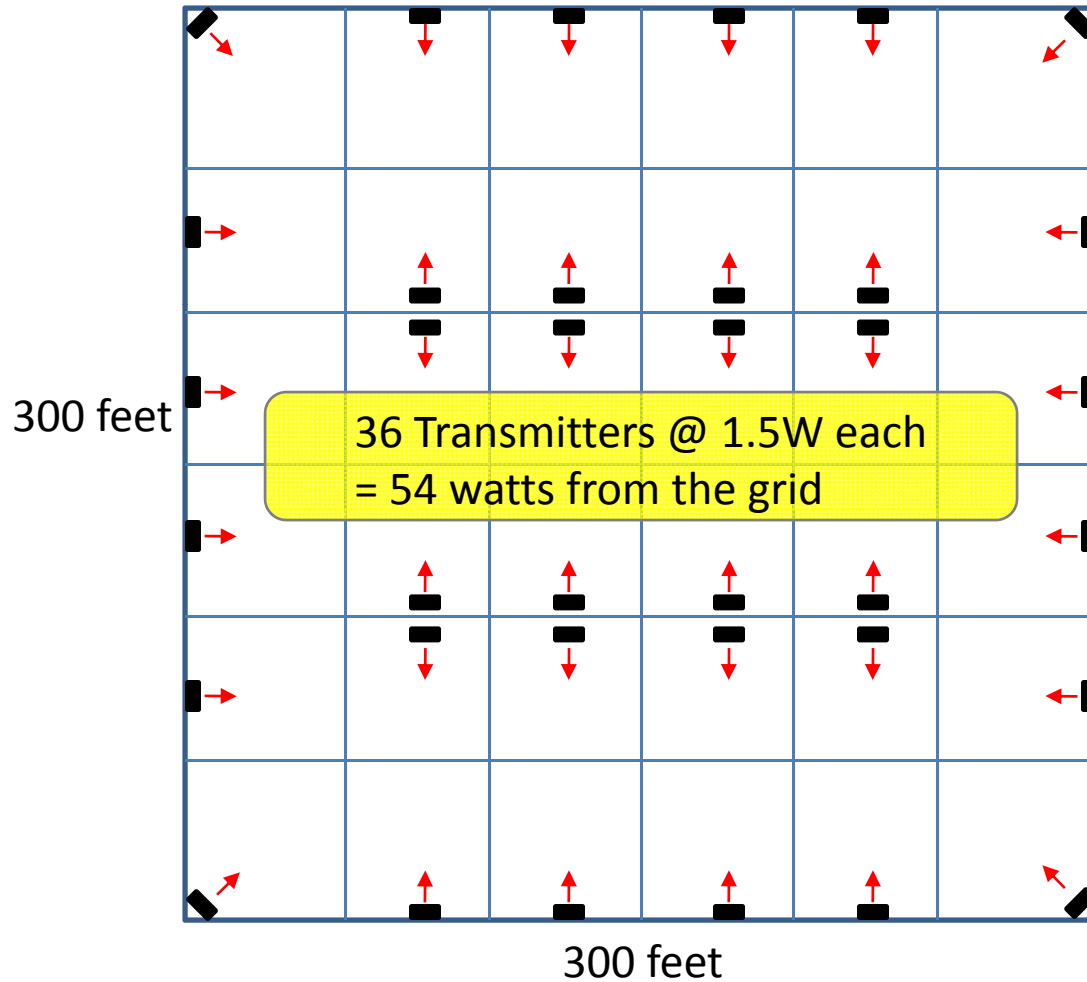
- Using multiple transmitters creates a wireless, micro-power grid.
- Unlimited receivers can be used within range of a power transmitter.

Data Center Monitoring

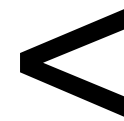


Transmitter Energy Example

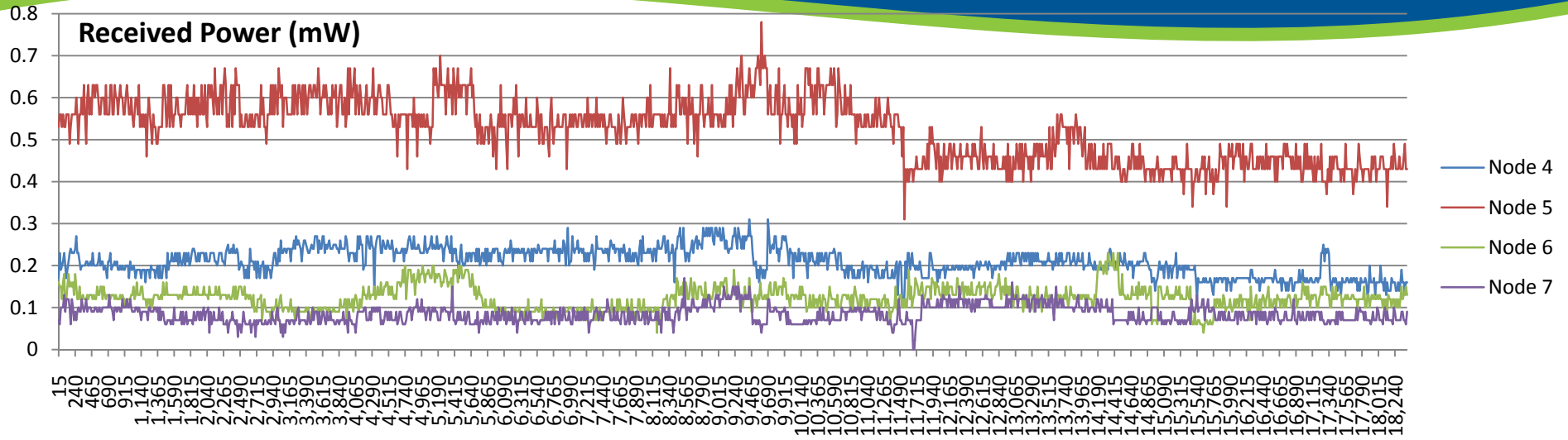
90,000 ft² Data Center



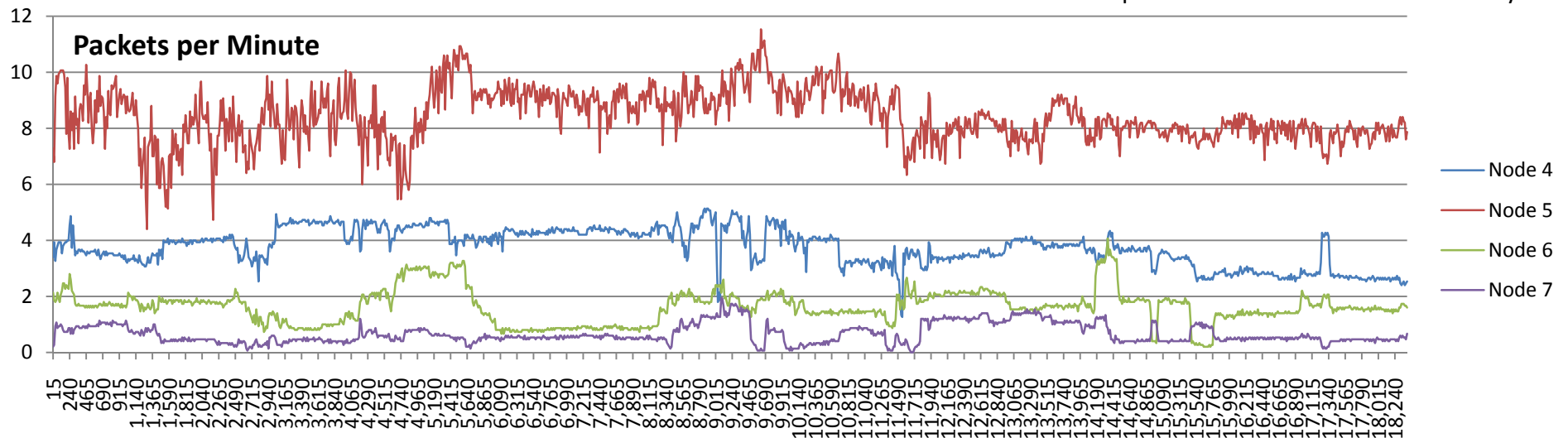
■ Powercast TX91501 Tx, 3W EIRP



Deployment: Data Center Trial



Data samples: 15 minute intervals over 13 days



RF-Power for Substation Monitoring



- One-to-Many scenario
- Relatively short range
- 24 x 7 x 365 power
- Minimal weather issues

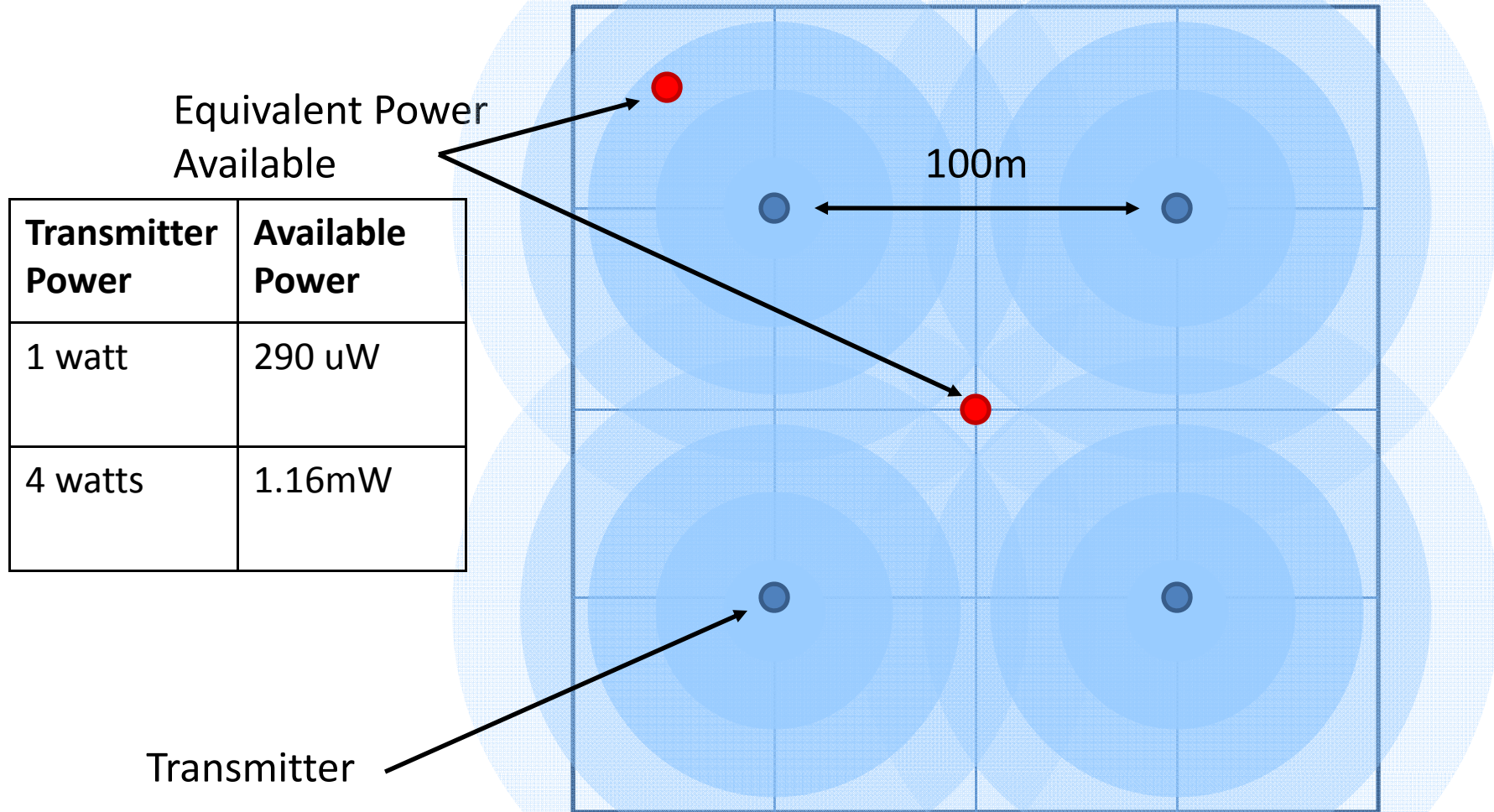
Low Frequency for Range/Power

- Longer range
- Acceptability of antenna size
- Lower transmitter power
- Higher received power
- Omni-directional Tx/Rx
- Freedom of placement



Low Frequency Example

200m x 200m area



Summary

- RF-powered system for building automation is available, practical, and deployable.
- RF-power combines benefits of wired and battery-based systems
- Sensors can be placed in hard to service areas, even where other EH sources not available
- Packet rates of several minutes or less are sufficient for many control applications

Questions

Thank You!

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Emerging
Technology



Gold Level Winner

P2100
Powerharvester®



TX91501
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P2110
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