Wireless Power and IoT

WCA

October 21st, 2020

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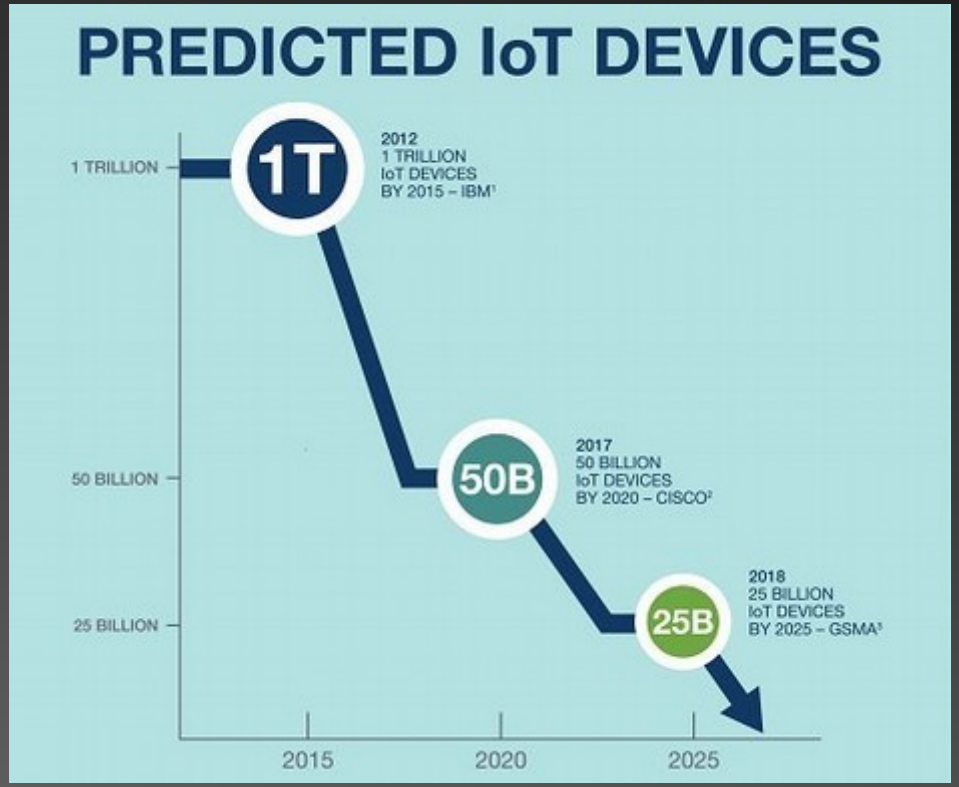
Co-founder & Chief Science Officer
Etherdyne Technologies, Inc

Internet of Things (IoT)

Sensor for Grain Bin

Smart Lighting

IoT Growth



- IoT growth has slowed.
- Batteries have 3-10 year lifespan.
- Battery replacement problem.

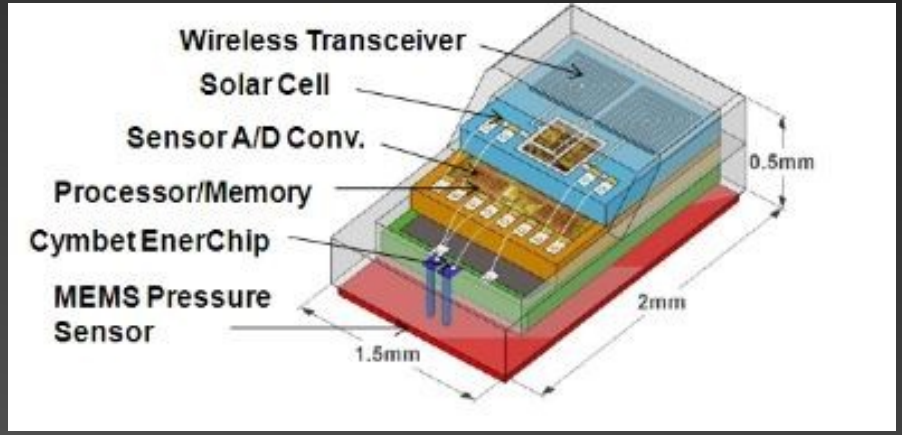
Constraints on IoT Power

Wires
- Limit sensor placement
- Not suitable for flexing or rotating structures
- Can interfere with structural integrity, aerodynamics, etc.
- Increase installation cost

Batteries
- Require periodic replacement
- Limit device duty cycle & response time
- Limit power budget for RF communication
- Incompatible with high temperatures
- Increase device cost

Wireless Power

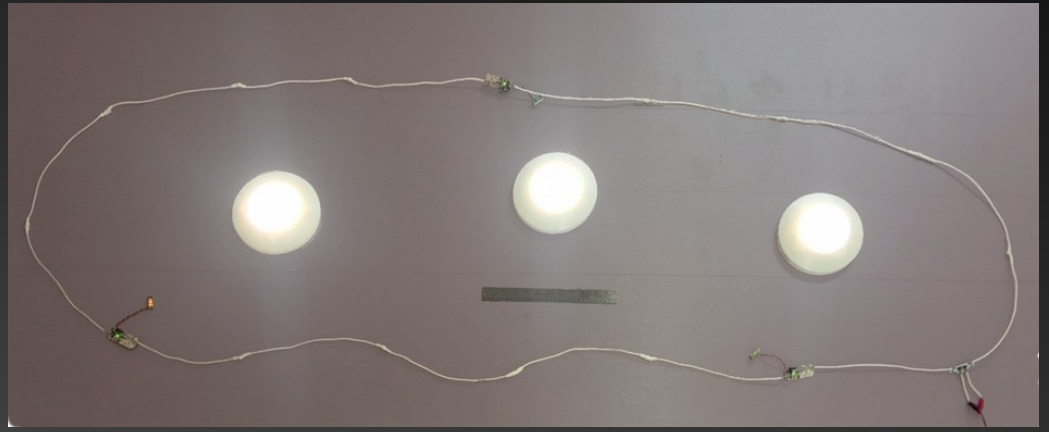
Energy Harvesting



https://www.nanalyze.com/2015/10/cymbet-solid-state-batteries-with-energy-harvesting/

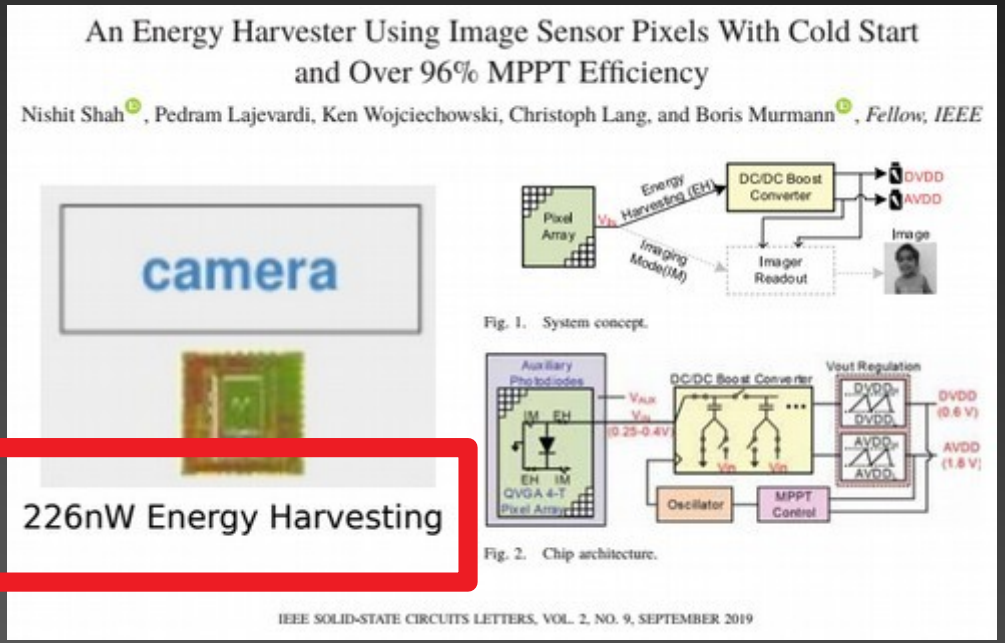
- No power source needed.
- Limited by power in environment.

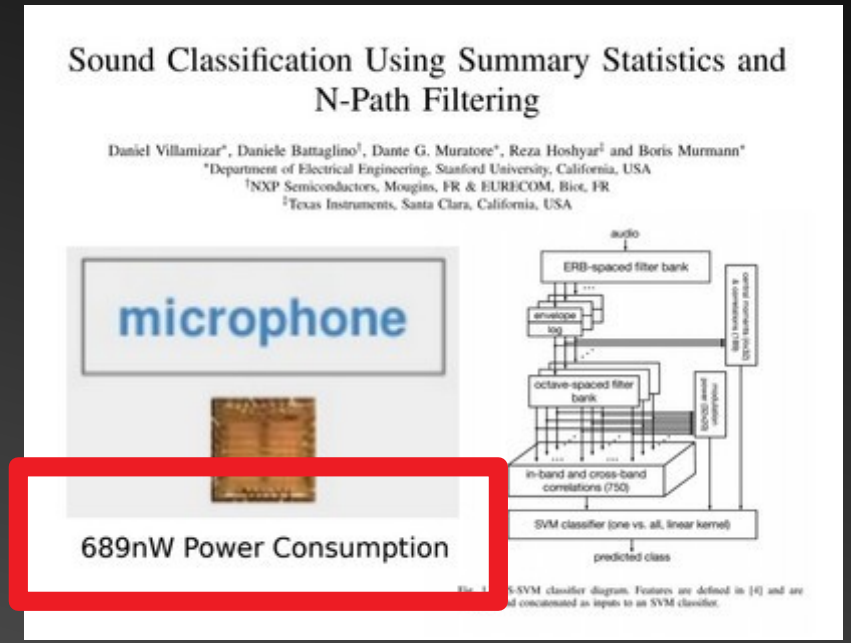
Wireless Power Transfer



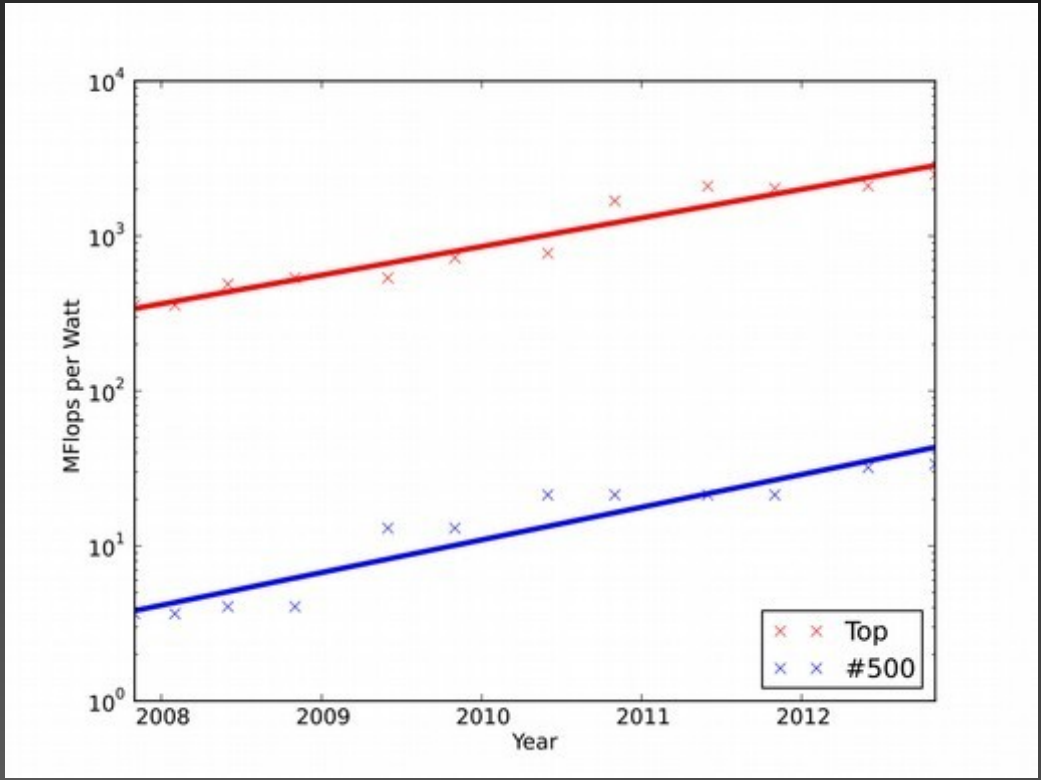
- Requires installation of power source.
- Higher power possible.

Low Power

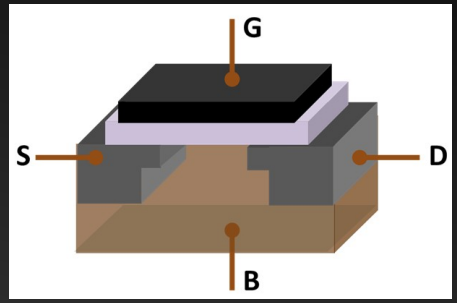

An Energy Harvester Using Image Sensor Pixels With Cold Start and Over 96% MPPT Efficiency
Nishit Shah, Pedram Lajevardi, Ken Wojciechowski, Christoph Lang, and Boris Murmann, Fellow, IEEE
camera
226nW Energy Harvesting
Pixel Array
Energy Harvesting (EH)
Imaging Mode(IM)
DC/DC Boost Converter
DVDD
AVDD
Image
Imager Readout
Fig. 1. System concept.
Auxiliary Photodiodes
DC/DC Boost Converter
Vout Regulation
QVGA 4-T Pixel Array
Oscillator
MPPT Control
Fig. 2. Chip architecture.
IEEE SOLID-STATE CIRCUITS LETTERS, VOL. 2, NO. 9, SEPTEMBER 2019


Sound Classification Using Summary Statistics and N-Path Filtering
Daniel Villamizar, Daniele Battaglino, Dante G. Muratore, Reza Hoshyar and Boris Murmann
microphone
689nW Power Consumption
audio
ERB-spaced filter bank
envelope
log
octave-spaced filter bank
in-band and cross-band correlations (750)
SVM classifier (one vs. all, linear kernel)
predicted class

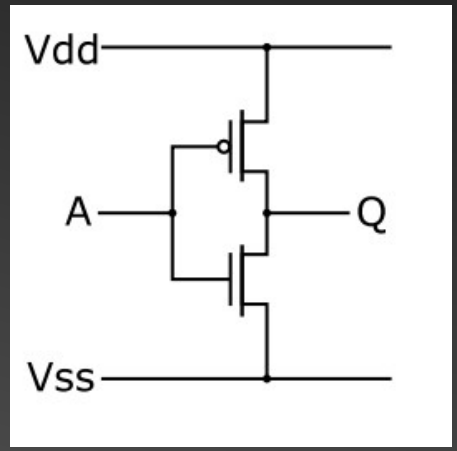
Computing Performance per Watt



https://en.wikipedia.org/wiki/Performance_per_watt



https://en.wikipedia.org/wiki/MOSFET



https://en.wikipedia.org/wiki/CMOS

Higher Power Applications

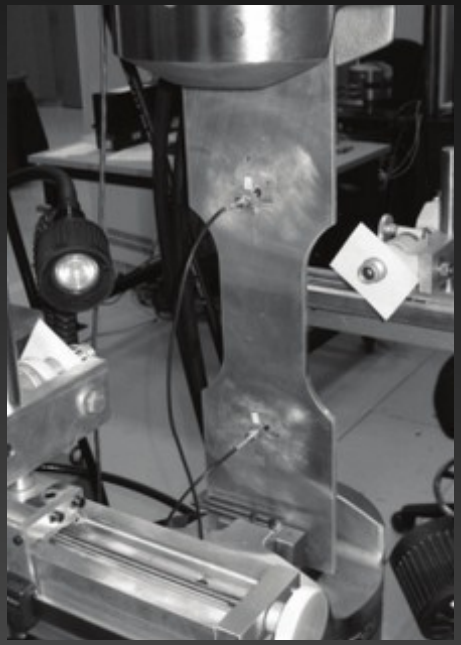
Infrared Beam Sensor

http://www.kk-tokuden.co.jp/pro/Web/azbil/hp7c/hp7c.html

Smart Vent Actuator

https://www.consumerreports.org/cro/news/2015/01/heating-vents-that-direct-warmth-where-you-want-it/index.htm

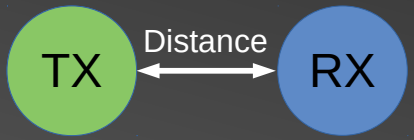
Ultrasonic Crack Sensor



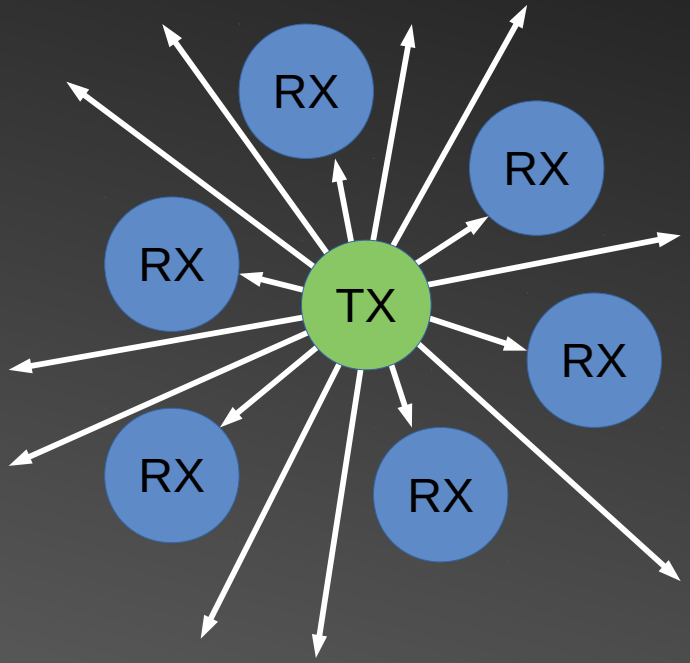
Derriso, et al. Crack Detection Using Combinations of Acoustic Emission and Guided Wave Signals from Bonded Piezoelectric Transducers

One-to-One vs. One-to-Many WPT

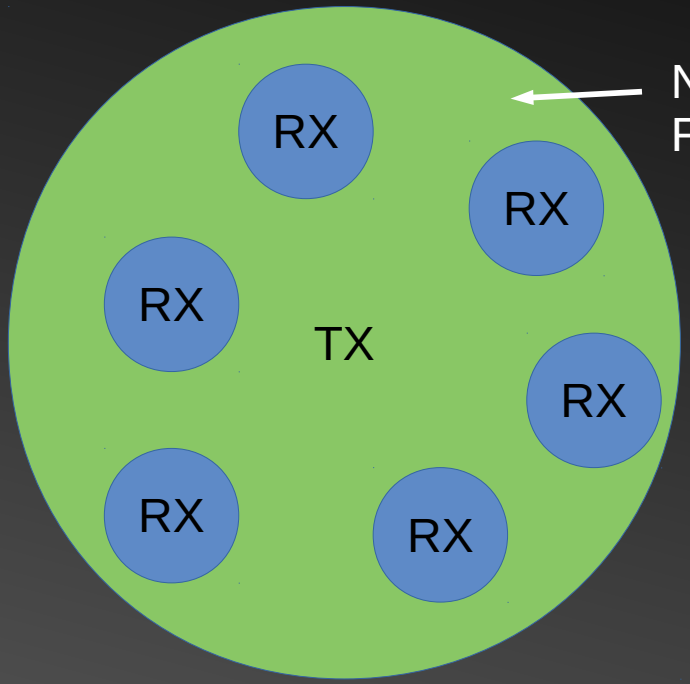
One-to-One:
efficient



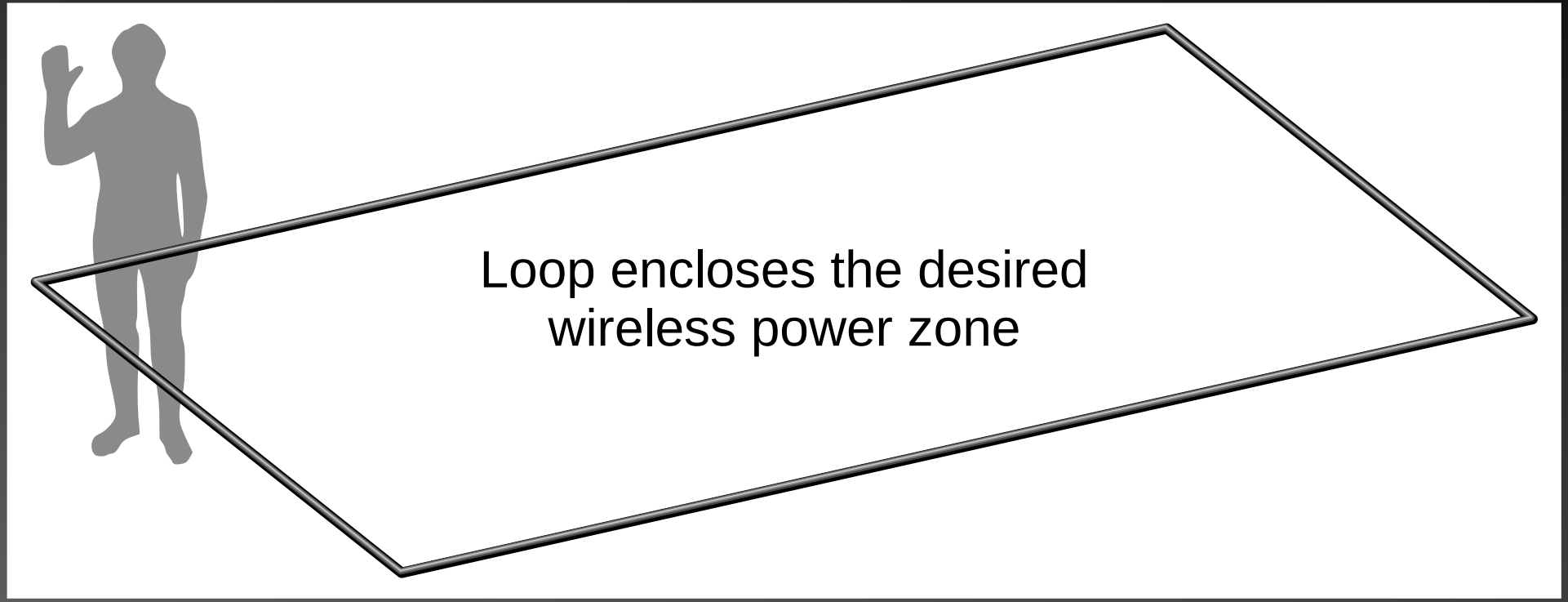
One-to-Many:
(radiative, inefficient)



One-to-Many:
(non-radiative, efficient)

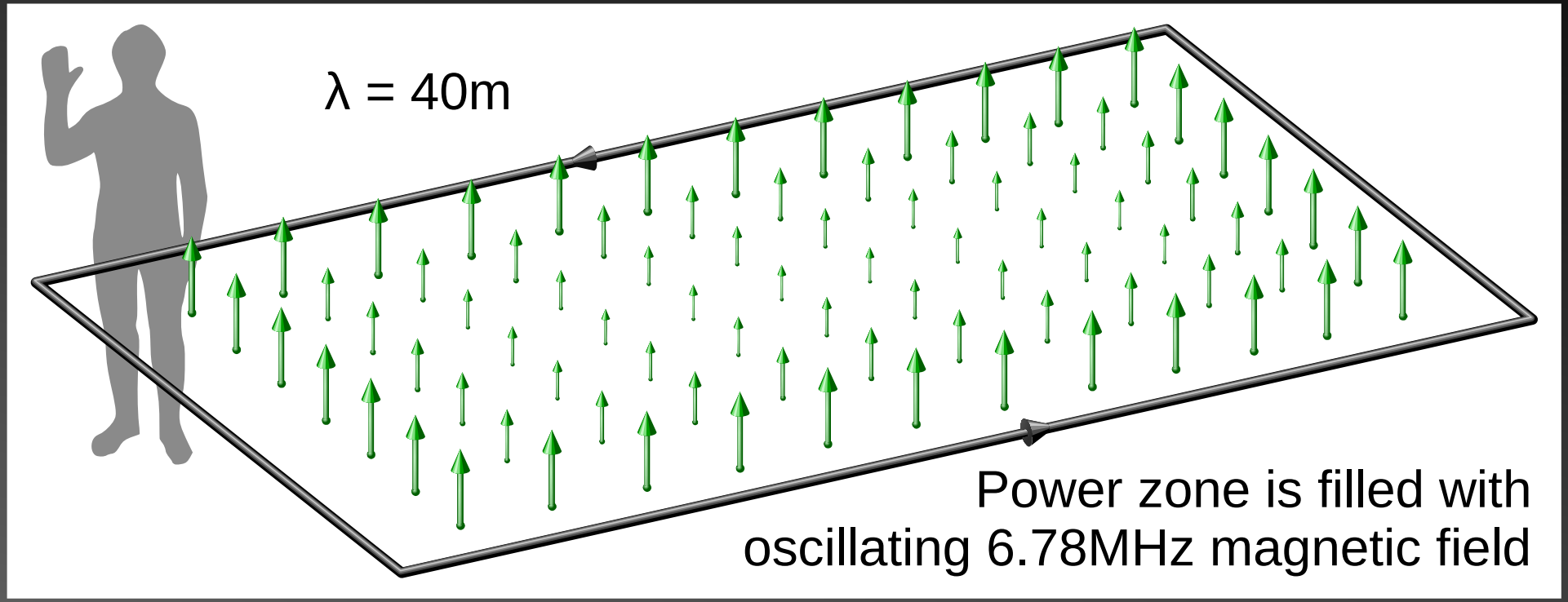


Large-Area Magnetic Resonance

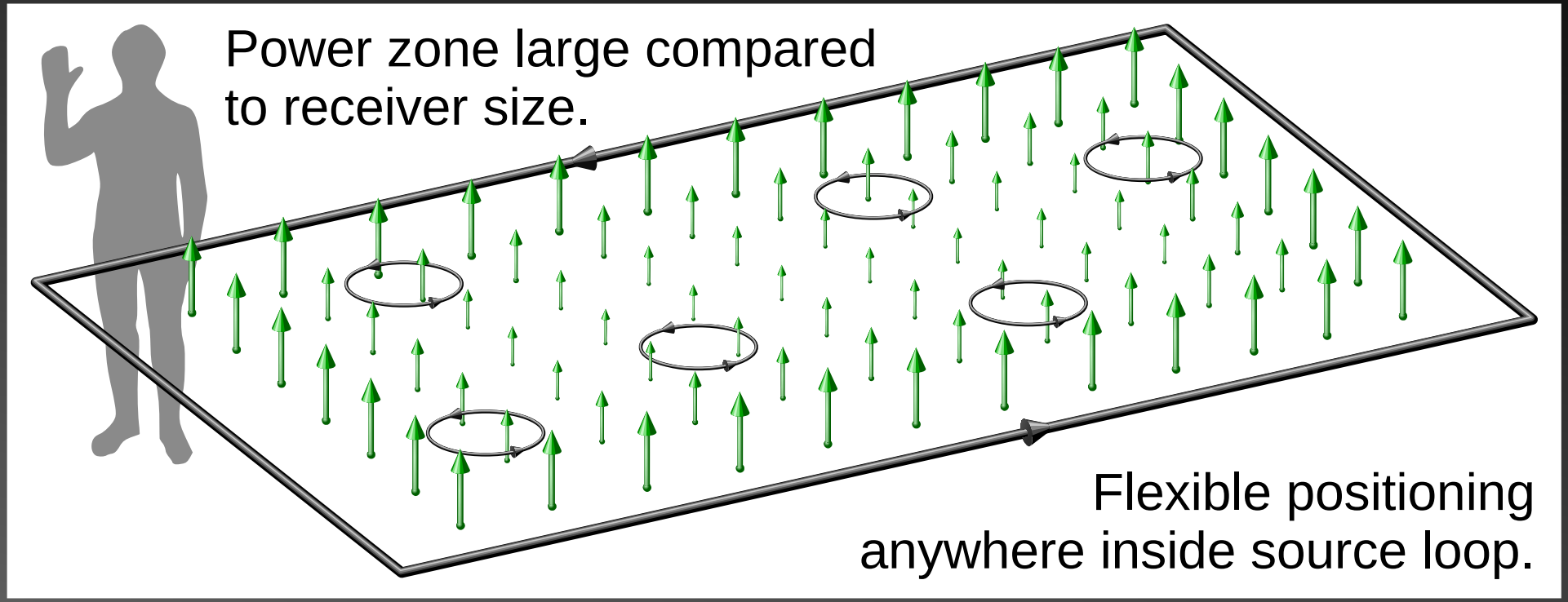


Human outline from https://commons.wikimedia.org/wiki/File:Human_outline.svg

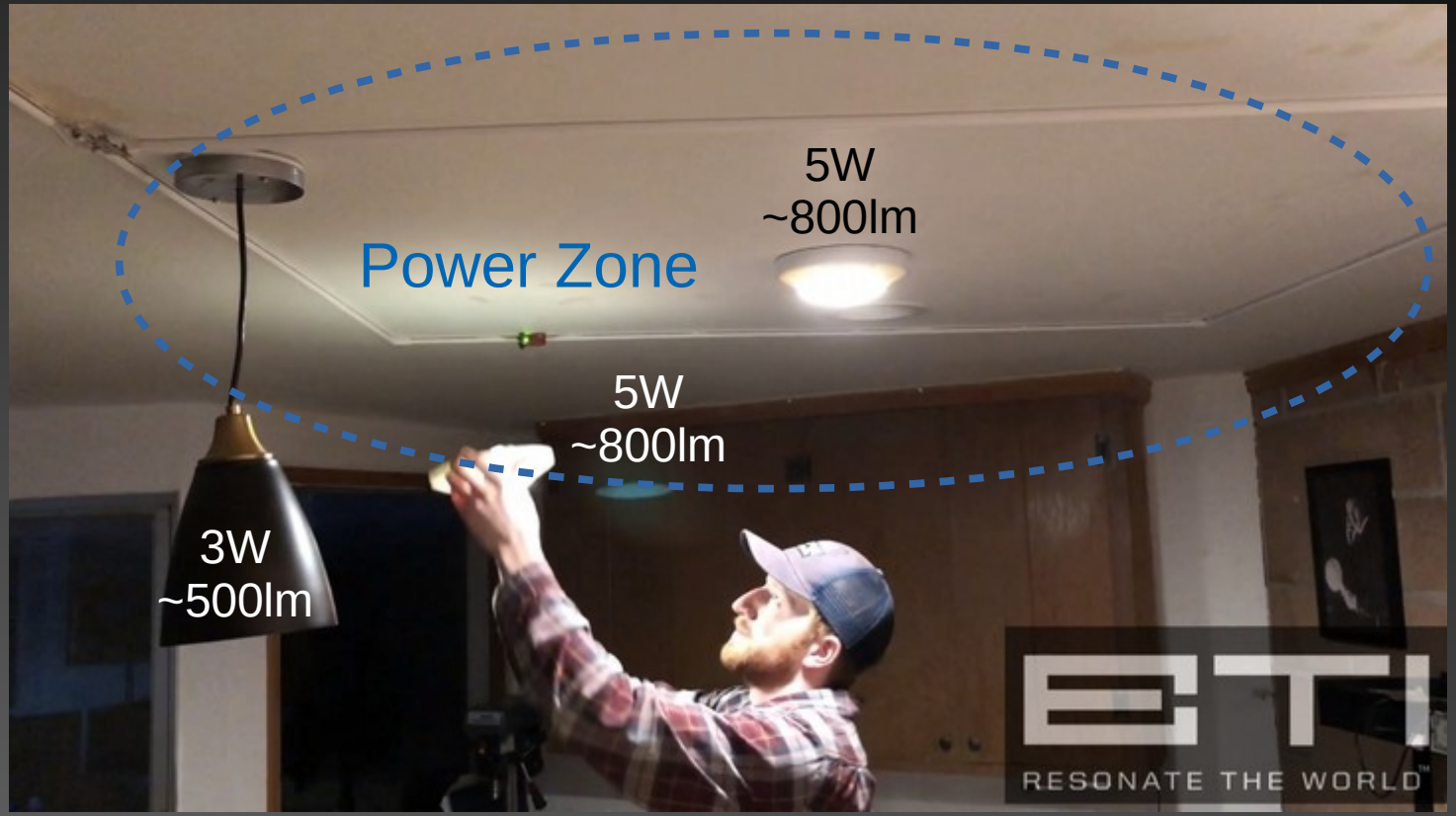
Large-Area Magnetic Resonance



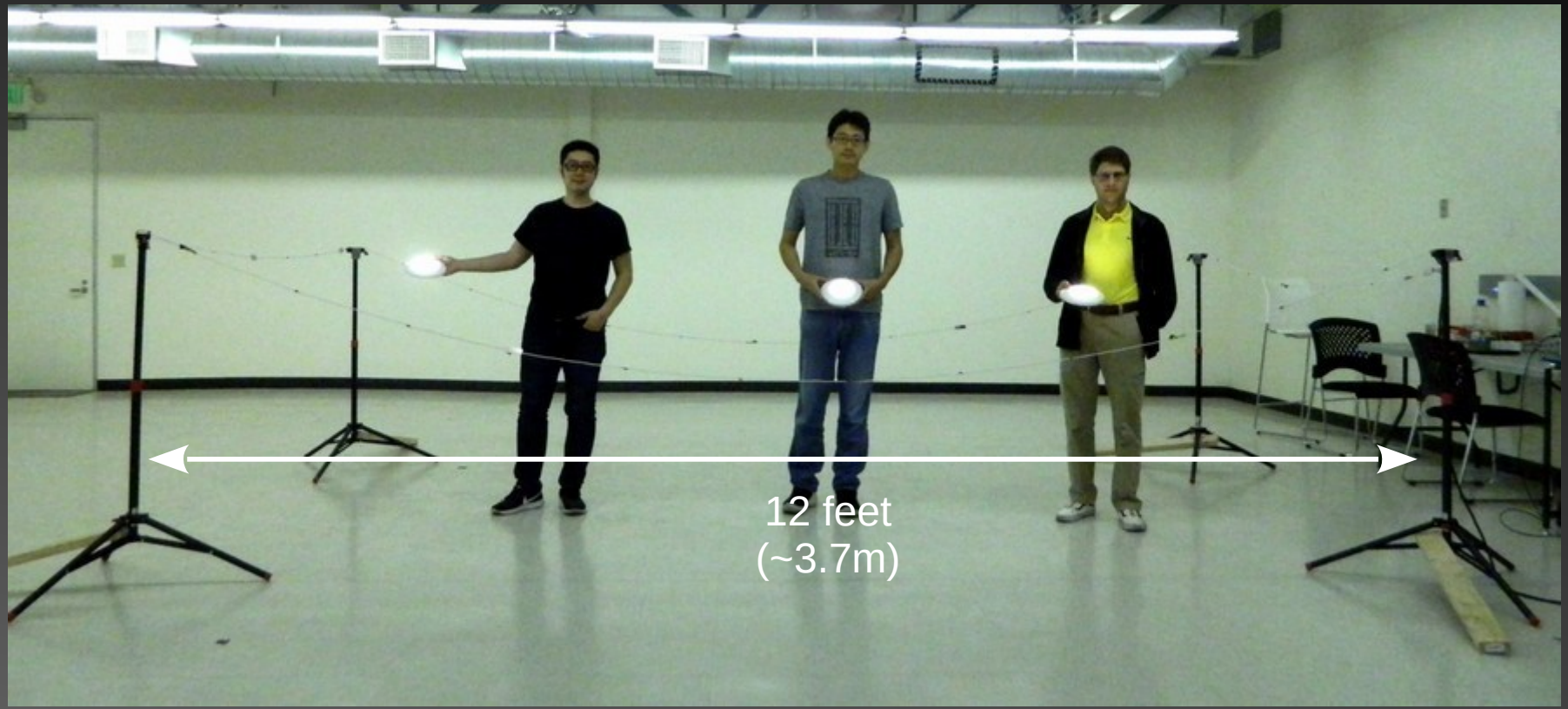
Large-Area Magnetic Resonance



Large-Area Magnetic Resonance



15m Perimeter, 12-Generator Loop



Wireless Ceiling Lights

Wireless Ceiling Lights

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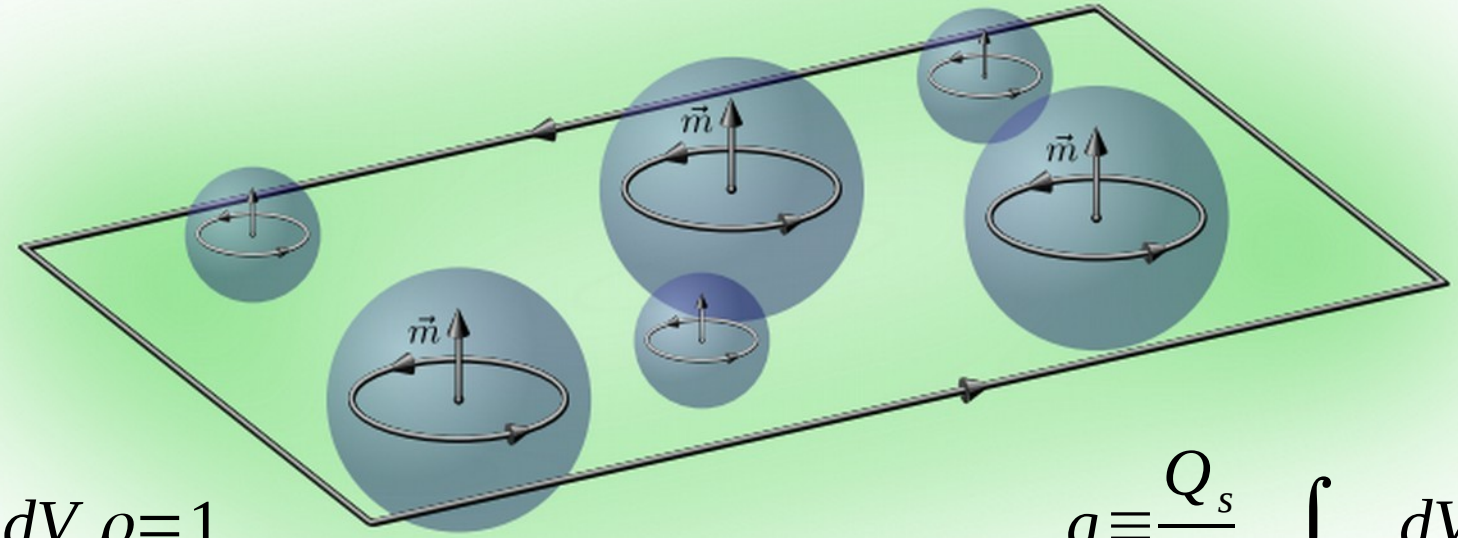
Extra Slides

System Efficiency

Green Cloud = Normalized Energy Density

Blue Spheres = Capture Volumes



$$\int_{\substack{All\\Space}} dV\,\rho = 1$$

$$g \equiv \frac{Q_s}{2} \int_{\substack{Capture\\Volumes}} dV\,\rho$$