UC San Diego

Capttery:

Scalable Battery-like Room-level Wireless power

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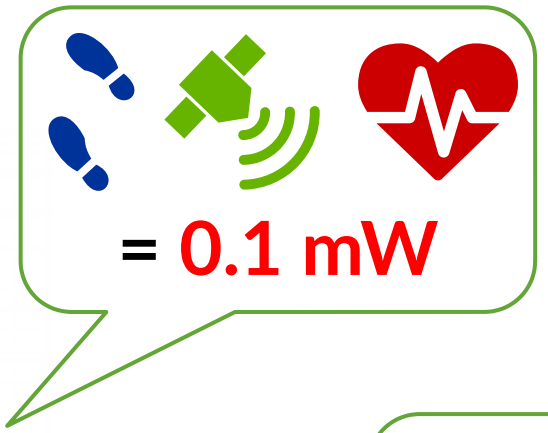
MobiSys 2019

*CO-PRIMARY AUTHORS

Mobile Computing: Era of Low-Power



Still……

Have to charge every now and then!

We Need Ubiquitous Wireless Power!

- Room-level coverage (4-5 meters)
- Battery-like
  - Uninterrupted
  - milliwatt-level
- Scalable

Don’t We Have Wireless Charging?

[2 Pack] Wireless Charger
MAX/XR/XS/X/8Plus,10W for Gala

1,015

Limited time deal

$20.99

prime FREE Delivery **Mon, Jun 10**

Caveats of Inductive Power Transfer

- Limited range (<0.5 meter)
- Metal heating
- Interrupted by surroundings
- Few devices at a time

Caveats of Inductive Power Transfer

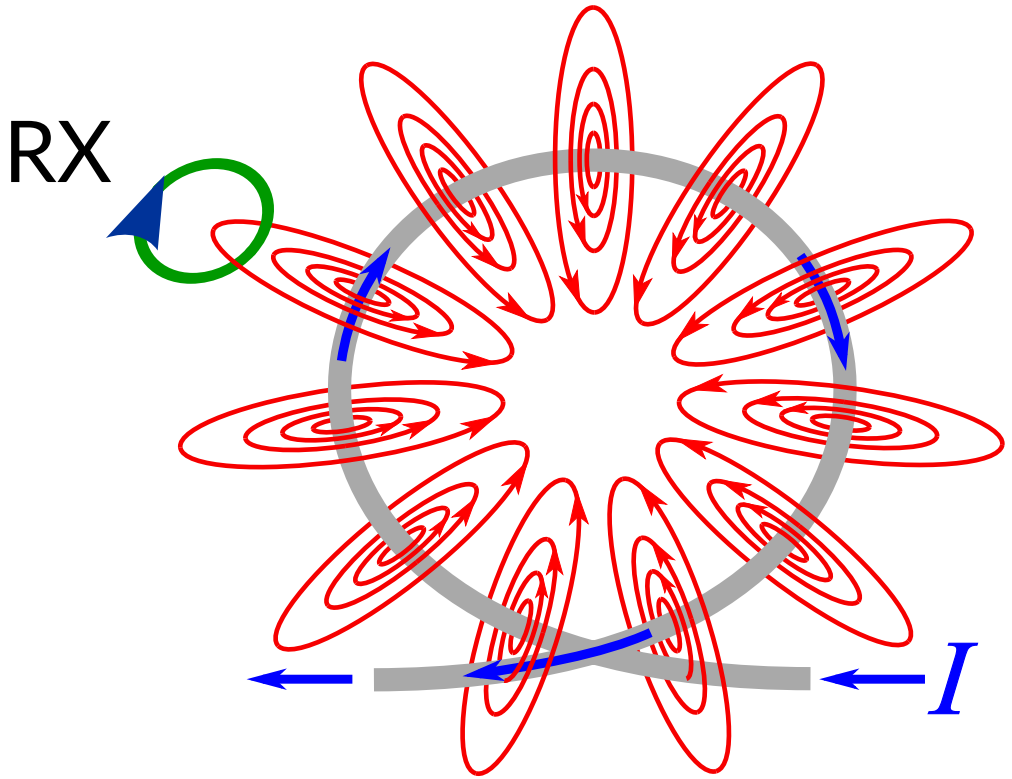
- Limited range (<0.5 meter)
- Metal heating
- Interrupted by surroundings
- Few devices at a time
- Latest: QSCR*

Aluminium Walls

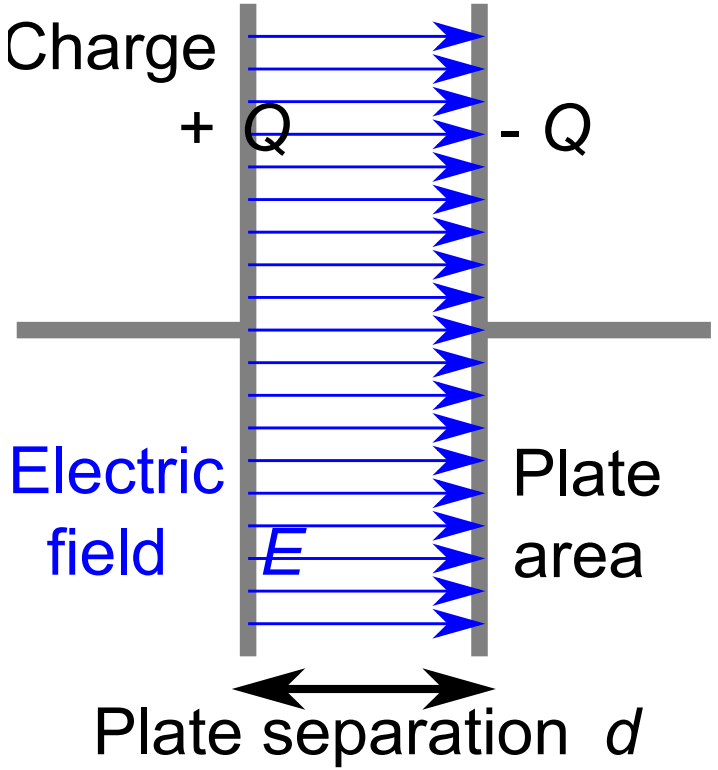
* Chabalko, Matthew *et al.*, "Quasistatic cavity resonance for ubiquitous wireless power transfer."

Fundamental Shift

Magnetic fields



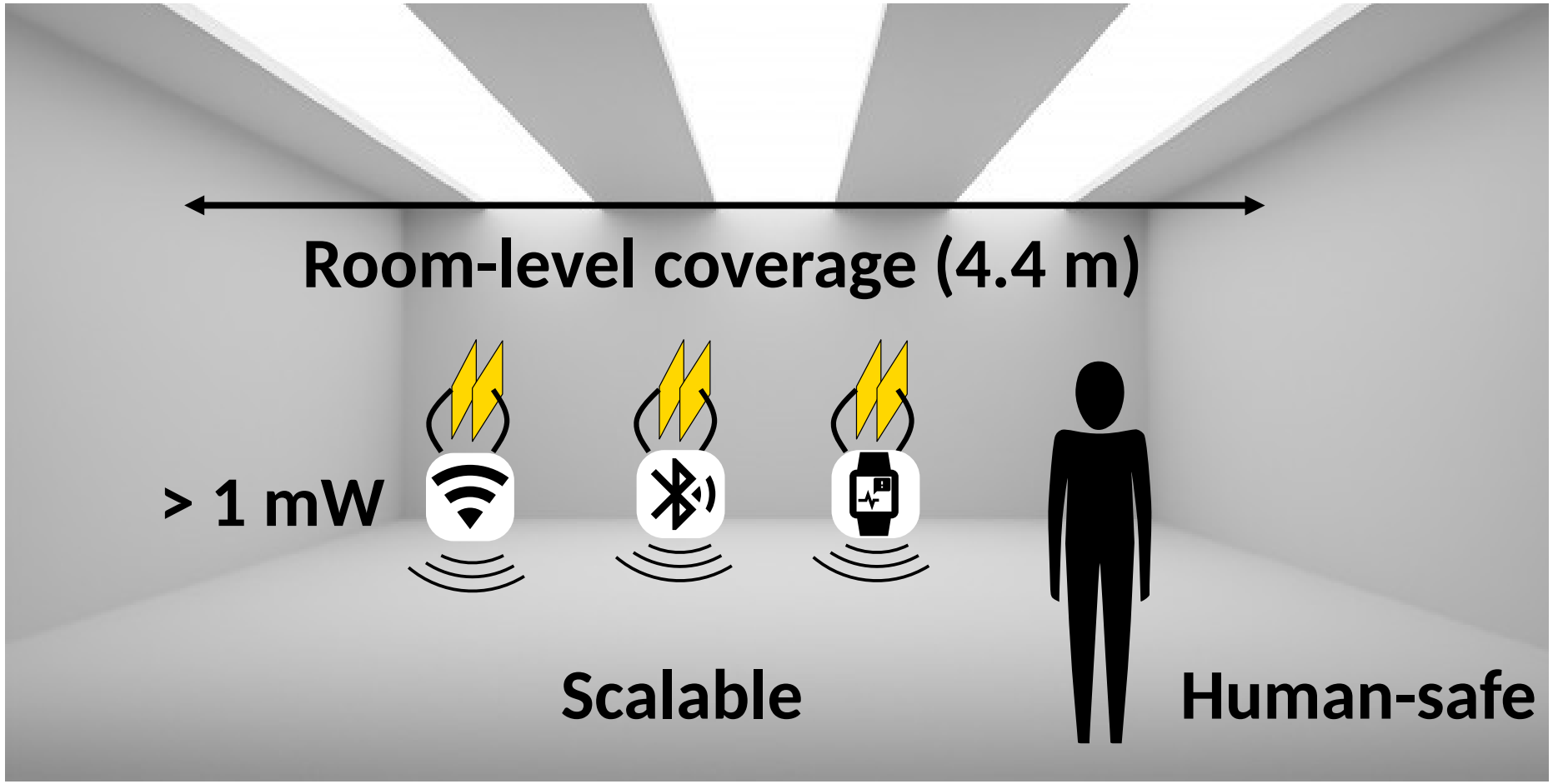
Electric fields



Contributions

- Room-level coverage (4-5 meters)
- Continuous milli-watt level power at IoT form-factor
- Uninterrupted by surrounding and safe for Humans
- Scalable to multiple IoT devices

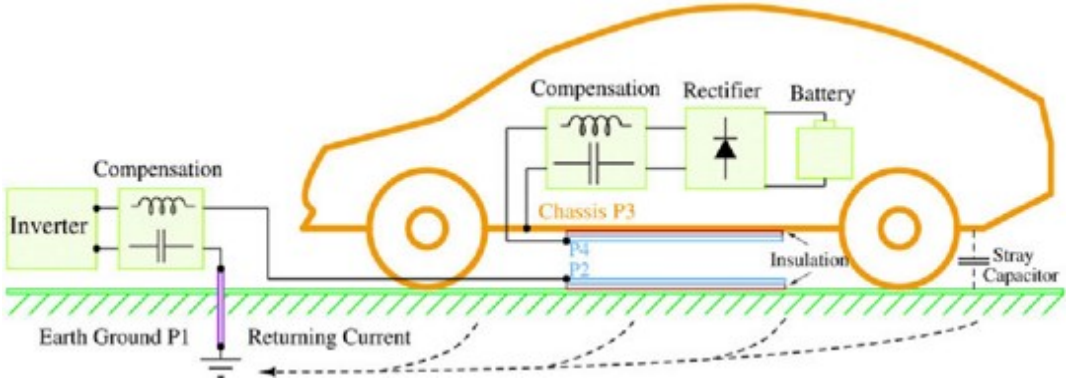
Capttery in One Slide



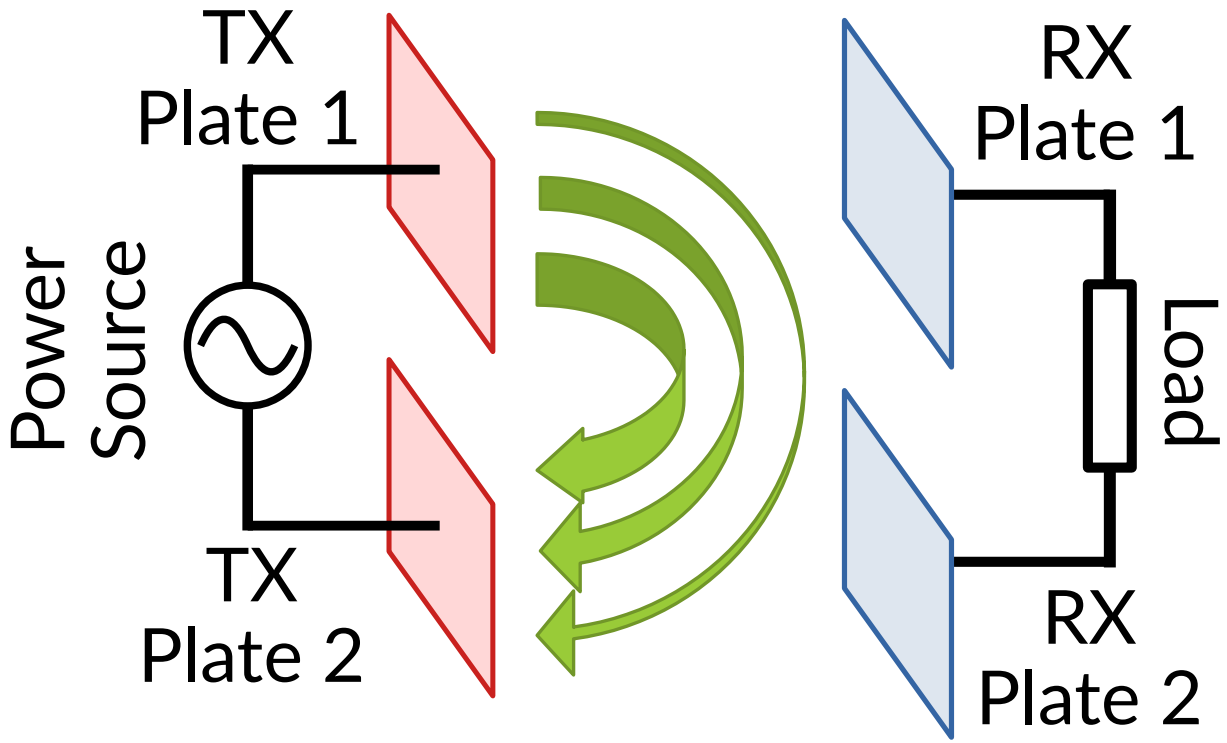
Capttery: Overview

1. Room level range: New architecture
2. Safe and uninterrupted: Novel Tx design
3. IoT size form-factor: Optimized Rx design
4. Scalable to multiple devices: Reducing mutual interference

Conventional Capacitive Power Transfer

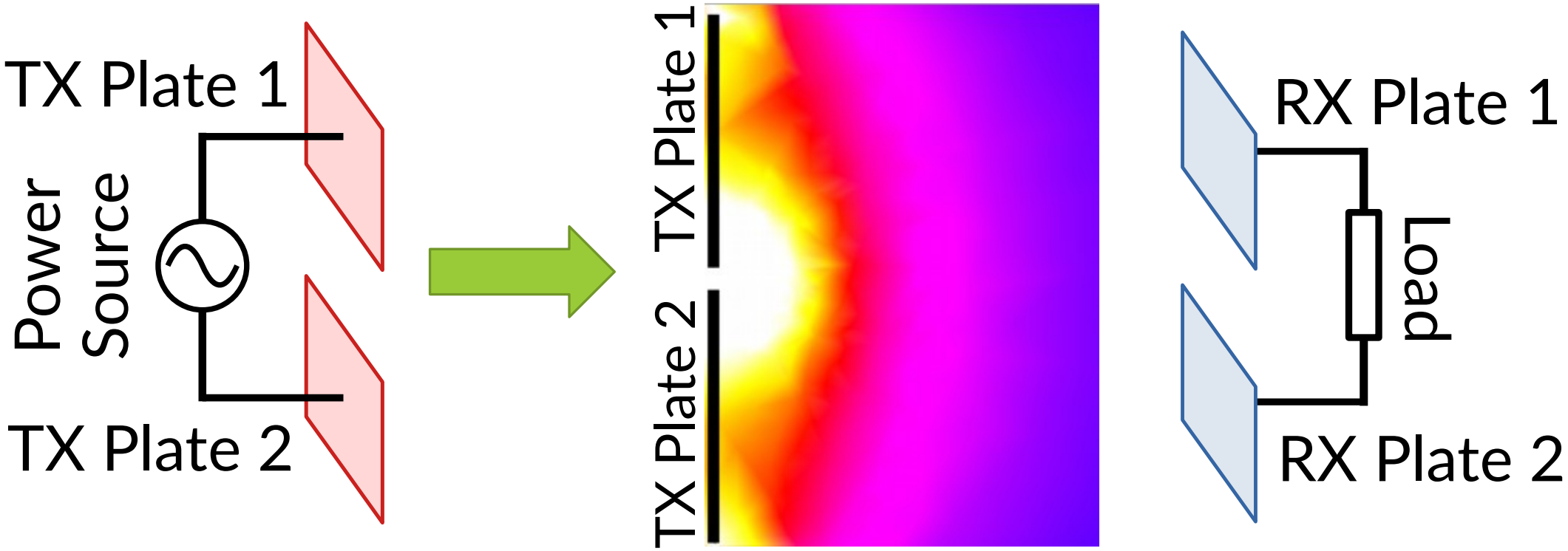


Lu, Fei *et al.*, "A Two-Plate Capacitive Wireless Power Transfer System for Electric Vehicle Charging Applications."



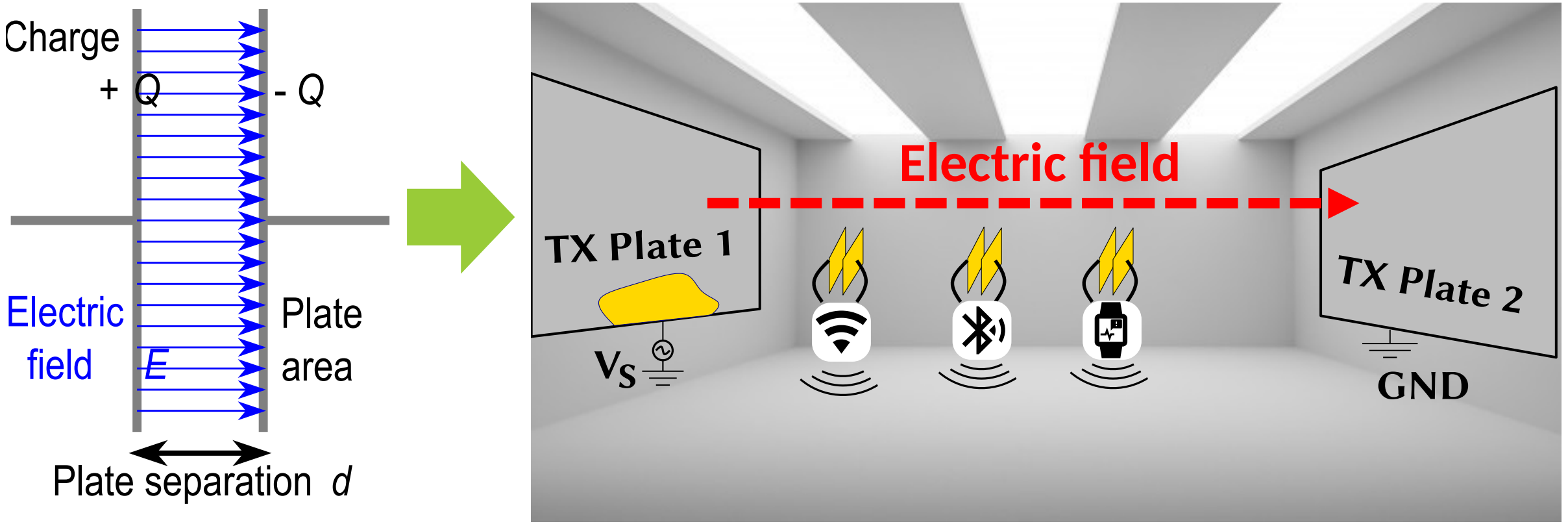
To tap more electric field, RX have to move closer to the TX plates

Why is Conventional CPT Short-range?

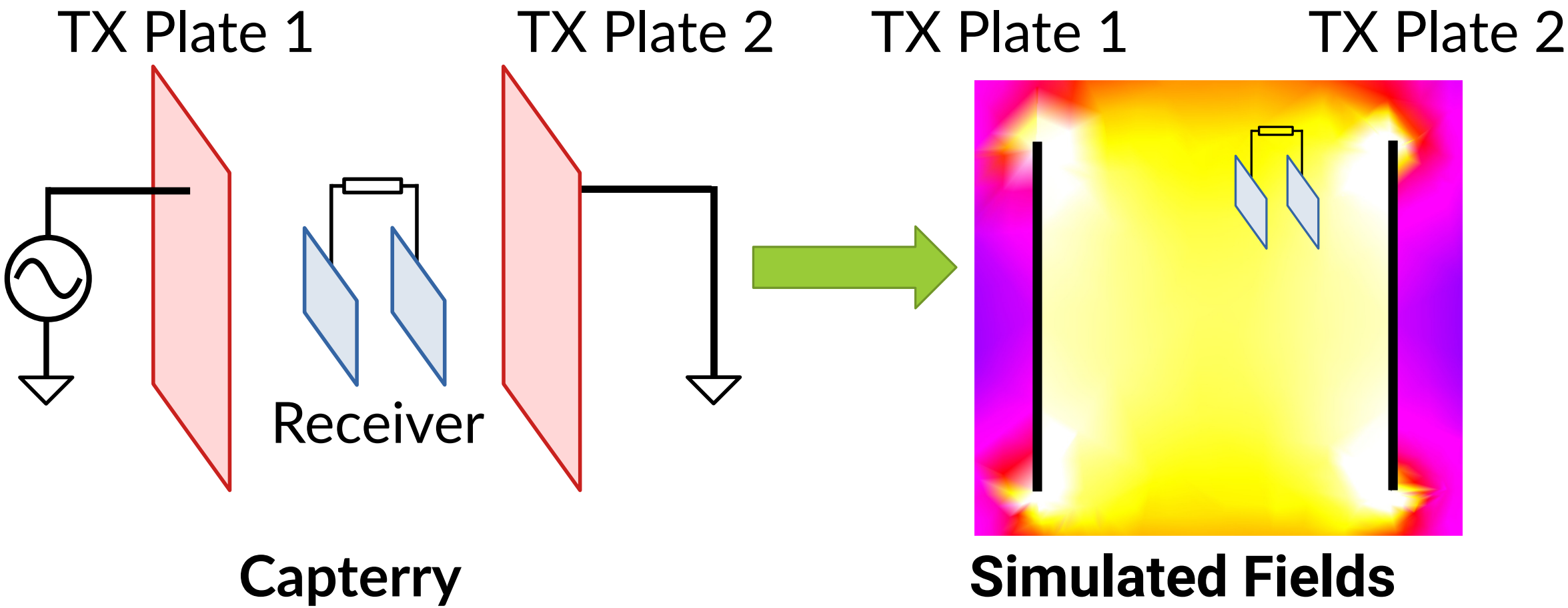


Conventional CPT doesn't leverage openness of electric fields

All-new Architecture



Capttery Leverages Open Electric Field



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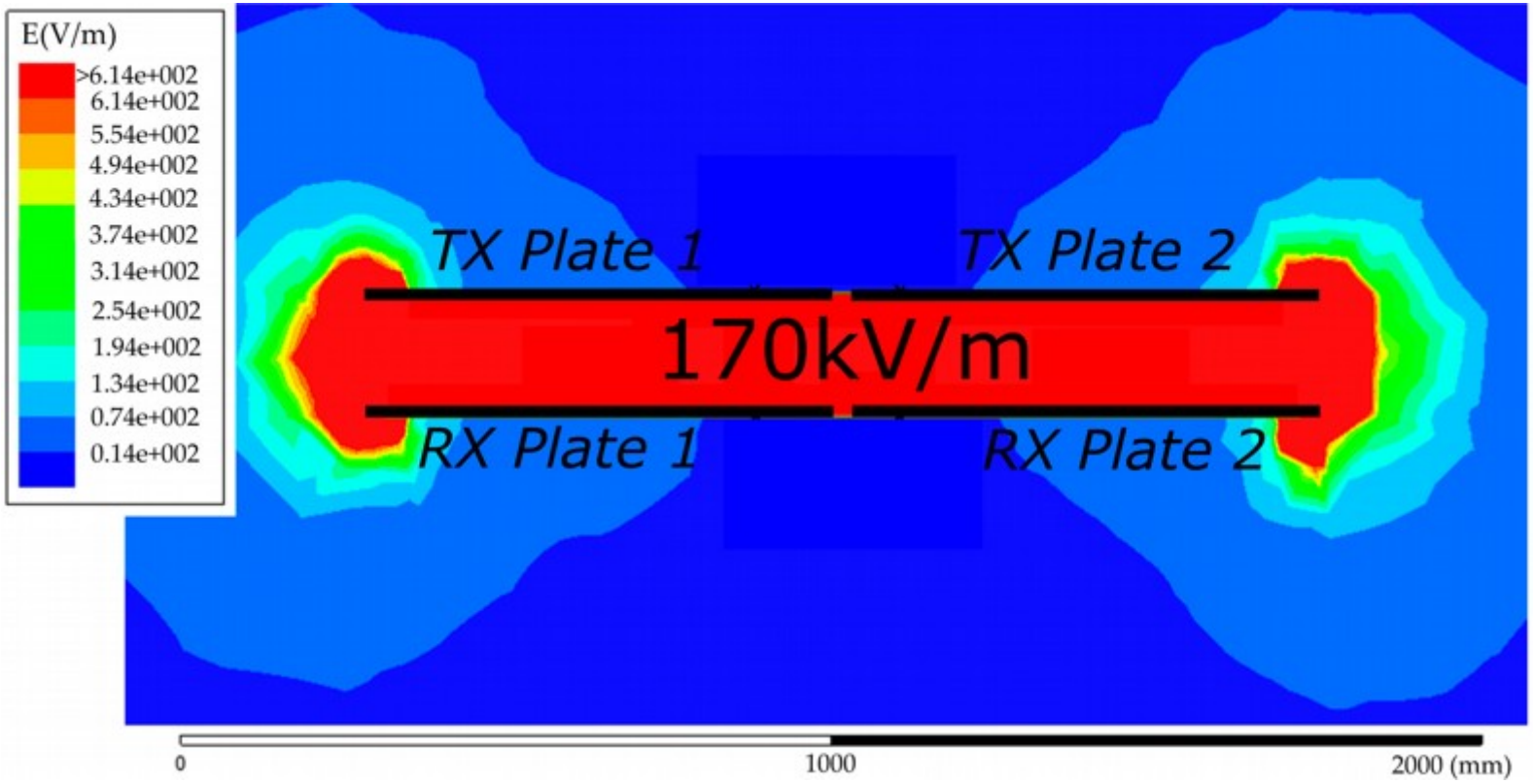
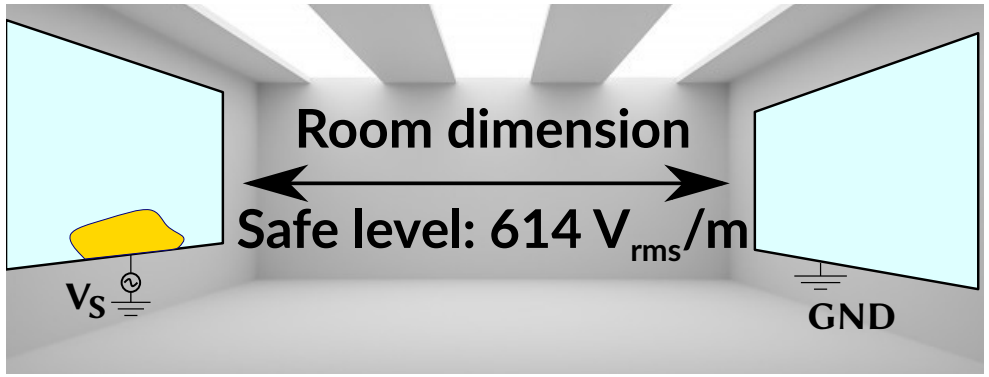
E-fields in Conventional CPT



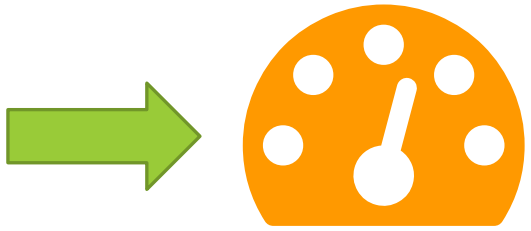
Lu Fei, *et al*., "A Review on the Recent Development of Capacitive Wireless Power Transfer Technology"

Electric field strengths over 40 times the safety limits

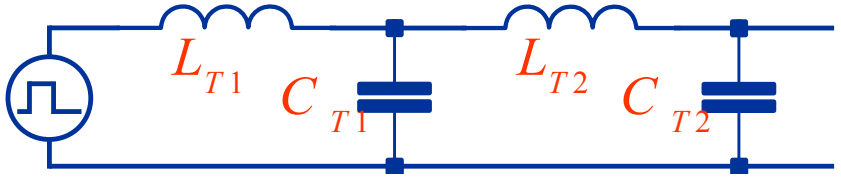
Making Capttery Safe & Robust



Safe voltage limit



Circuit parameters



- Human-safe
- Environment-invariant

Capttery field strengths are within human-safe limits

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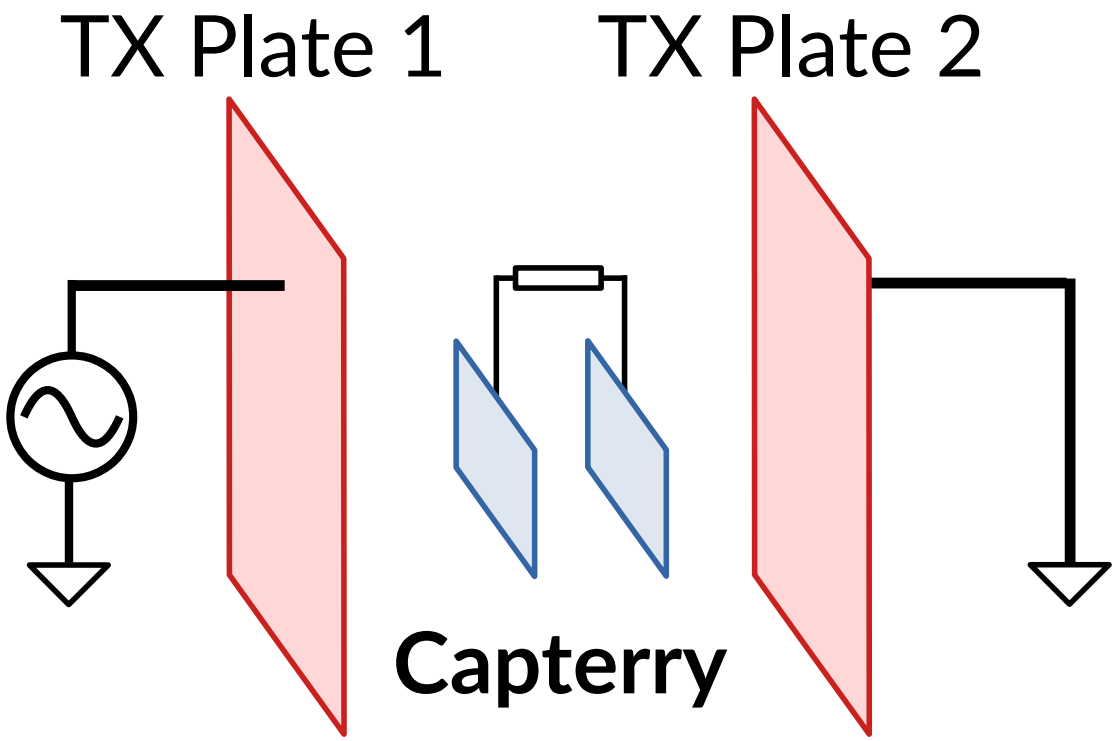
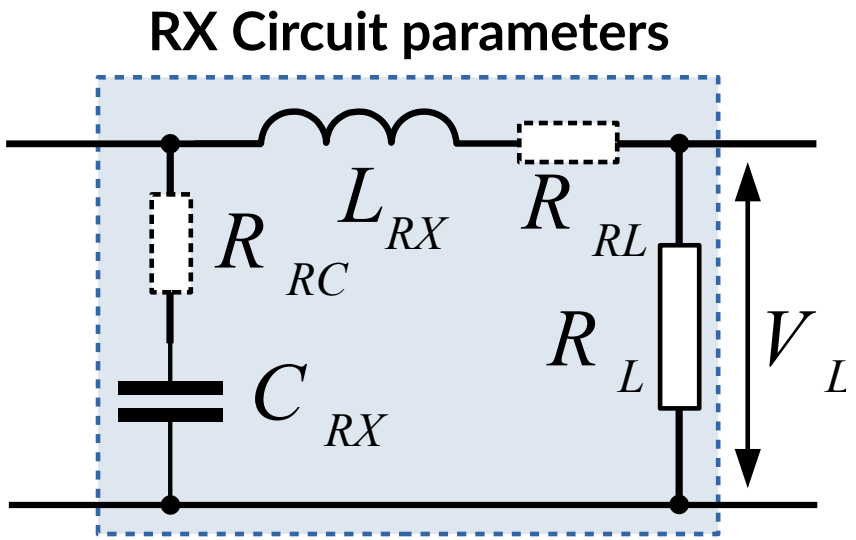
Enabling Smaller Receiver Form-factor





- **Agnostic to other receivers**

Optimized receiver circuit to extract maximum power

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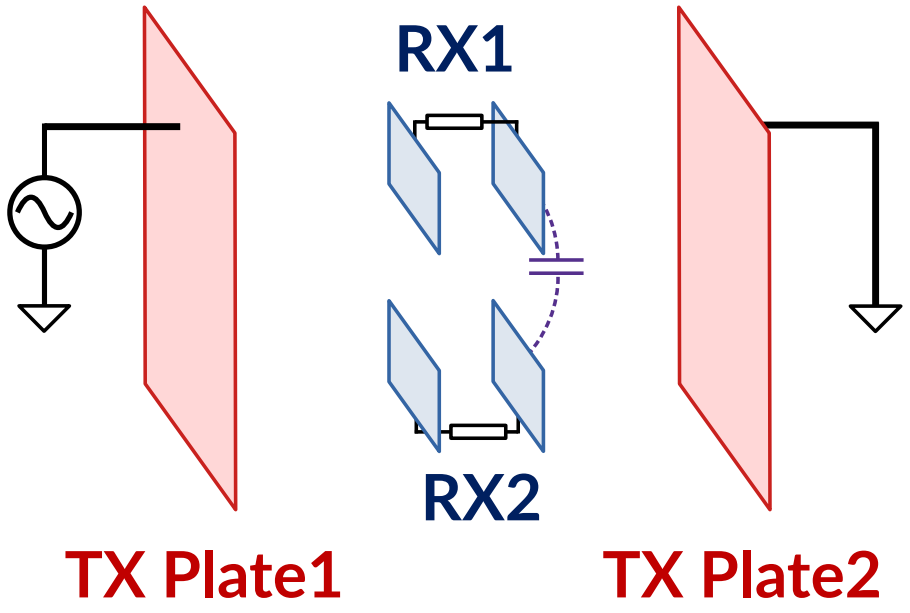
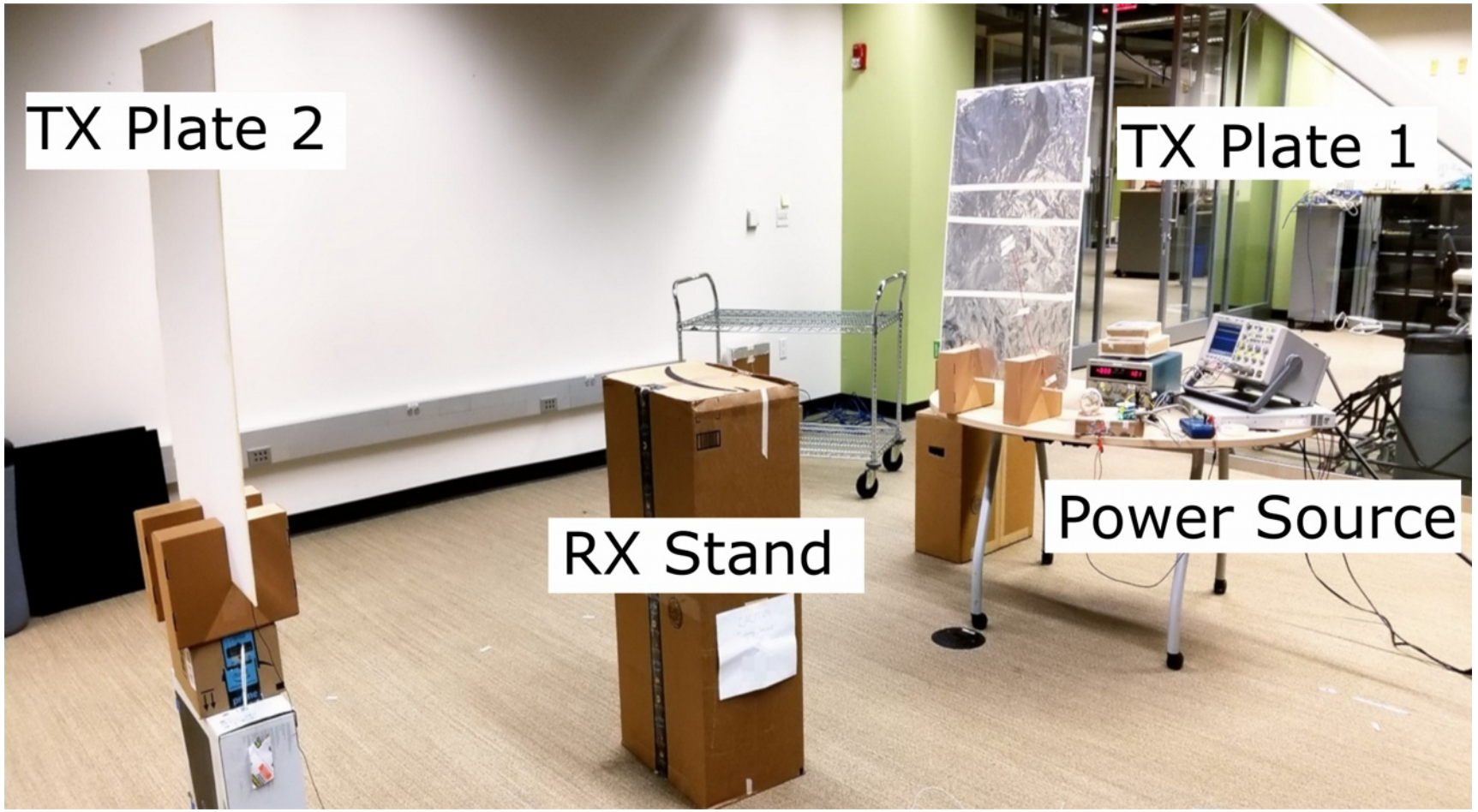
Multi-receiver Operation

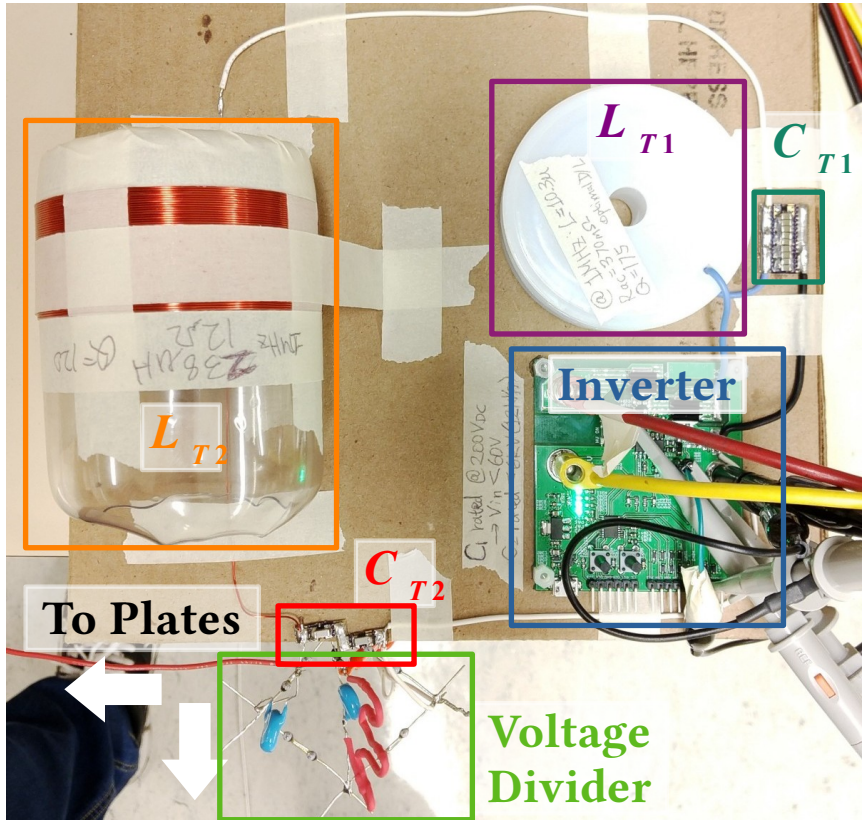
- Receivers interfere with each other
- RX design ensures low voltage on RX
- Low voltage minimizes interference
- Except for closely placed receivers



Implementation

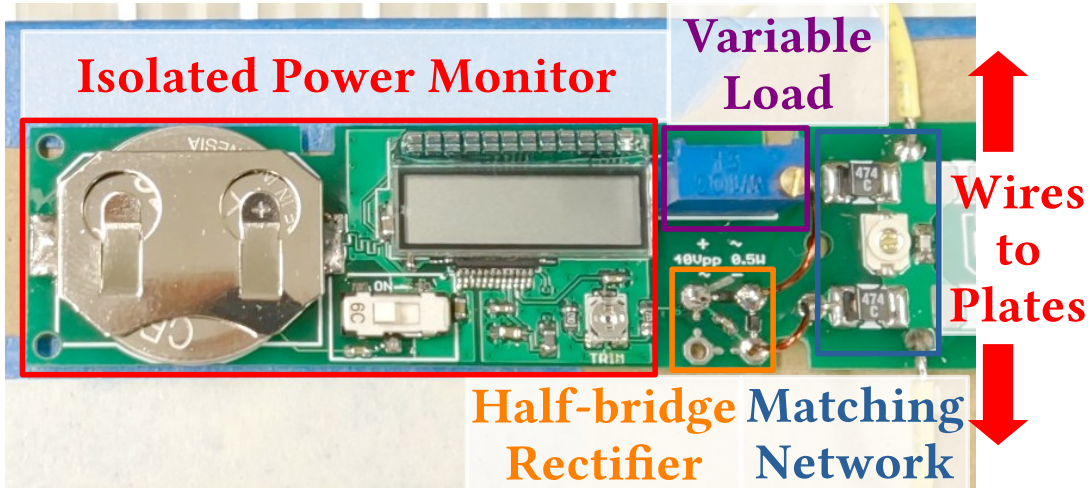


Implementation



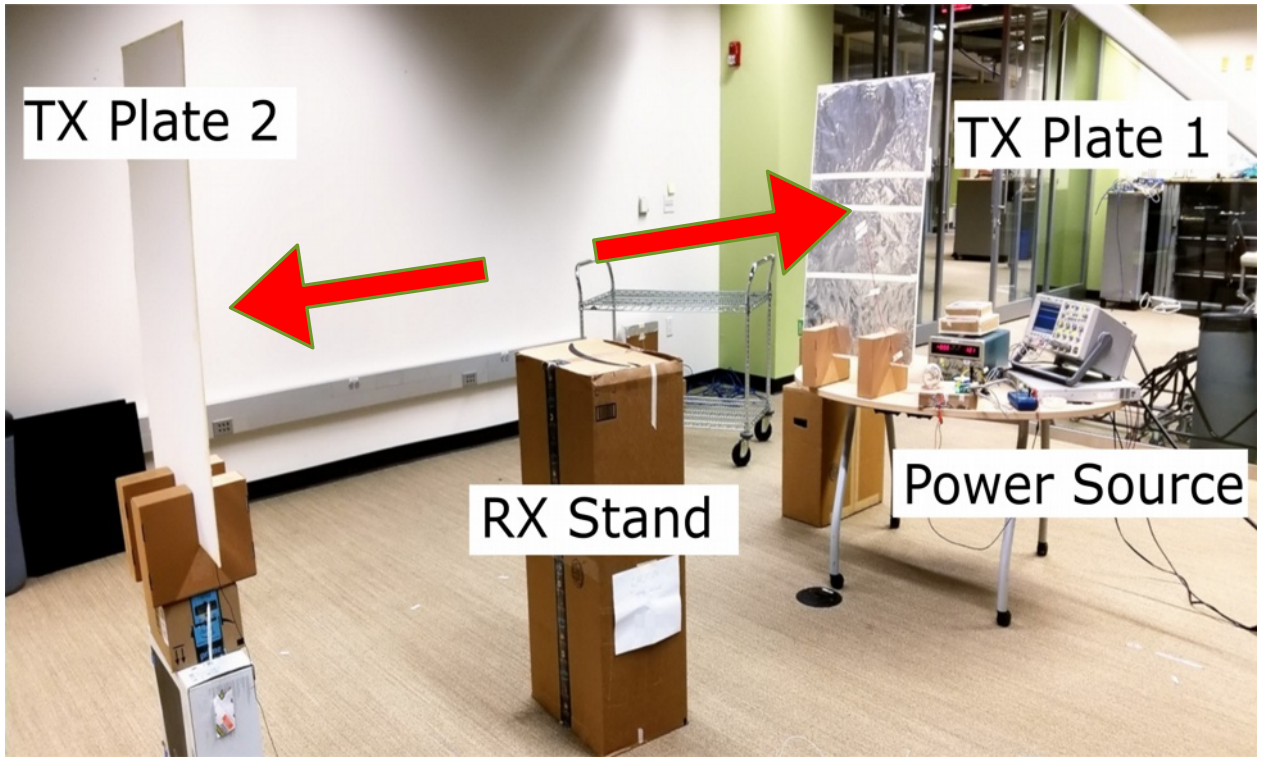
Transmitter

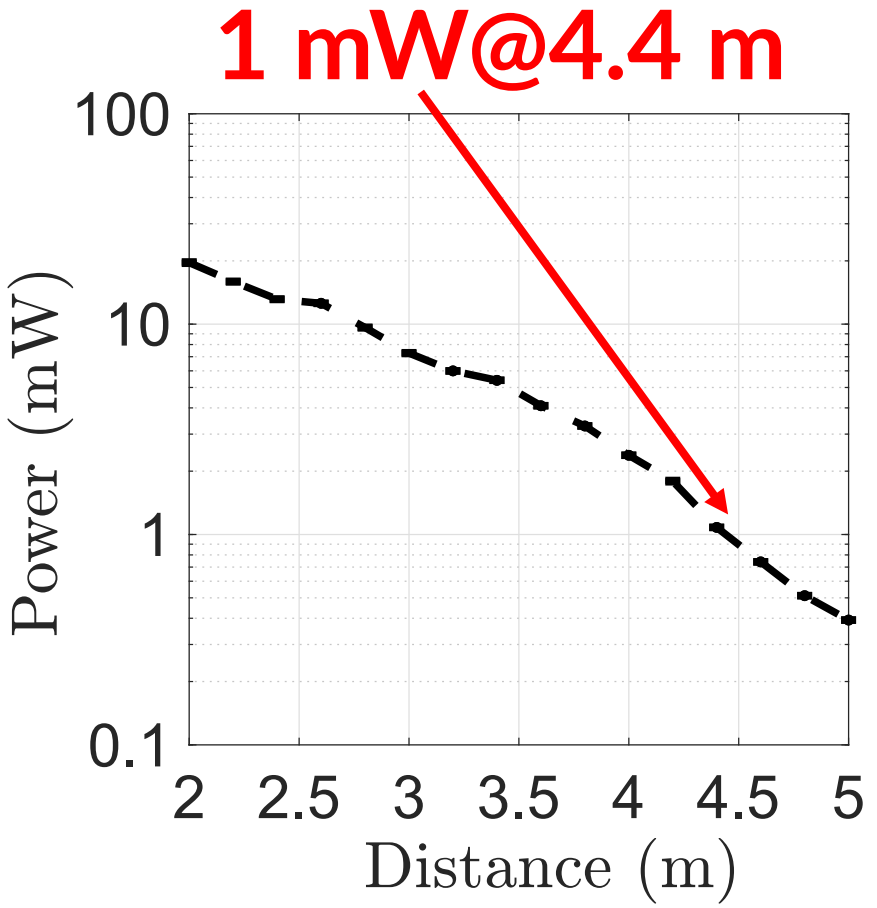
Quarter, Size to Scale



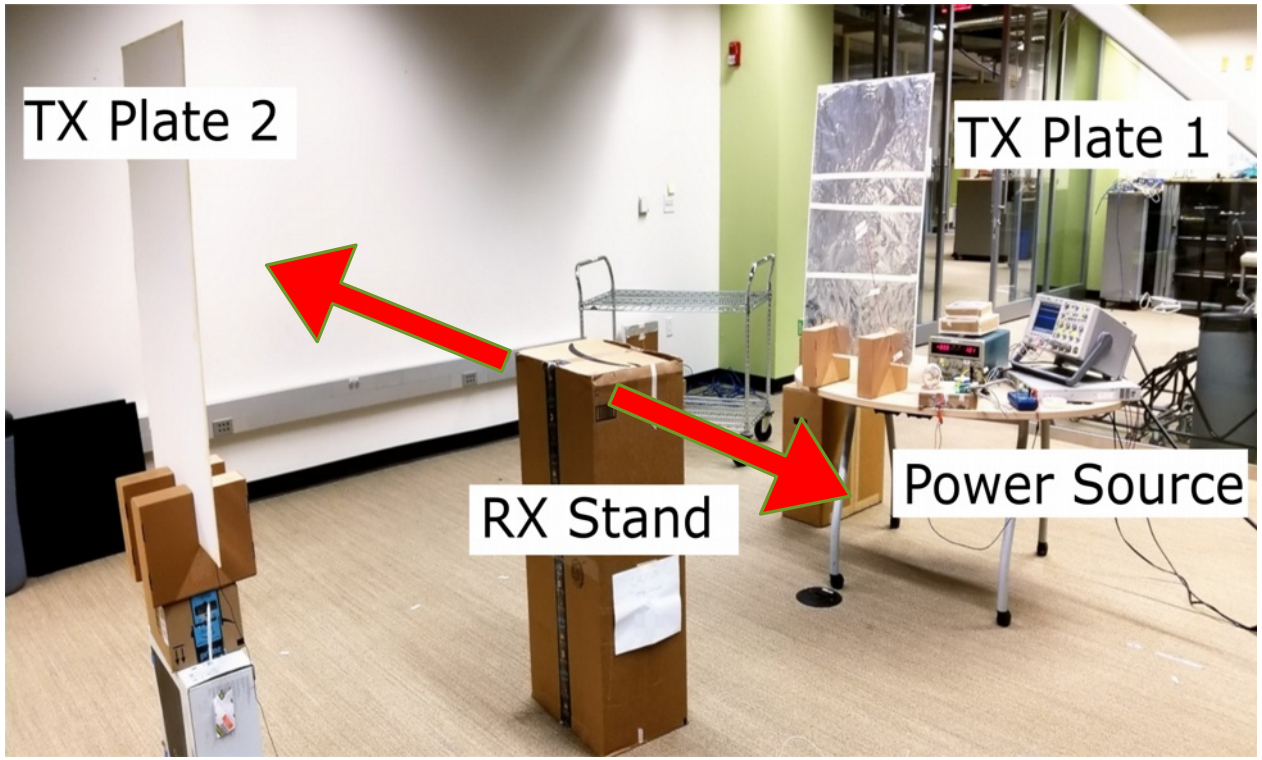
Receiver

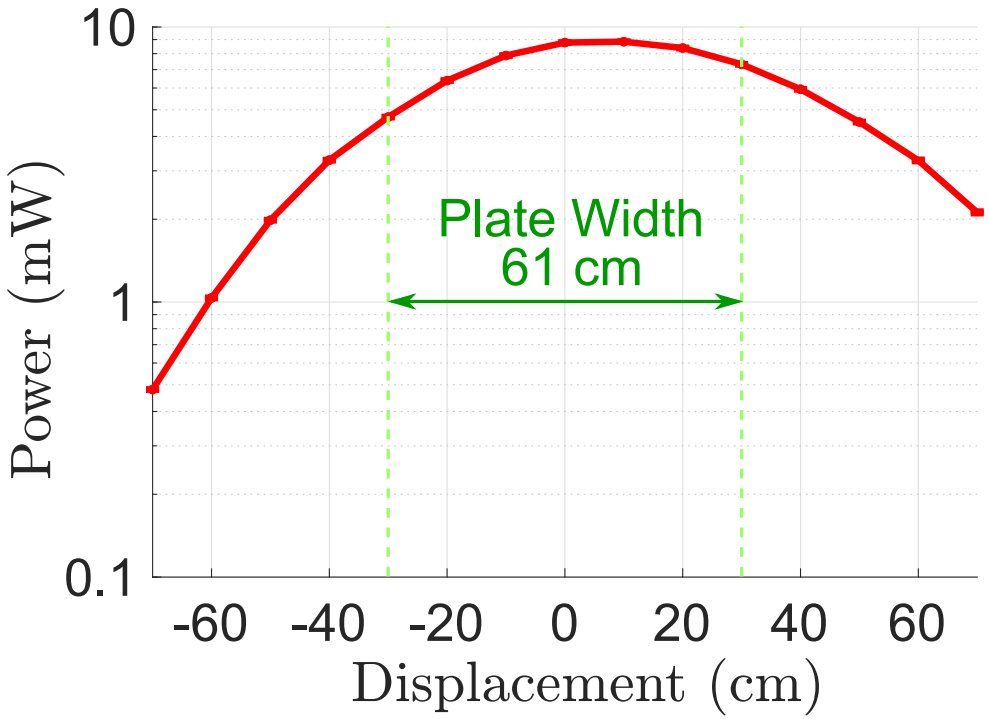
Range for mW-level Power





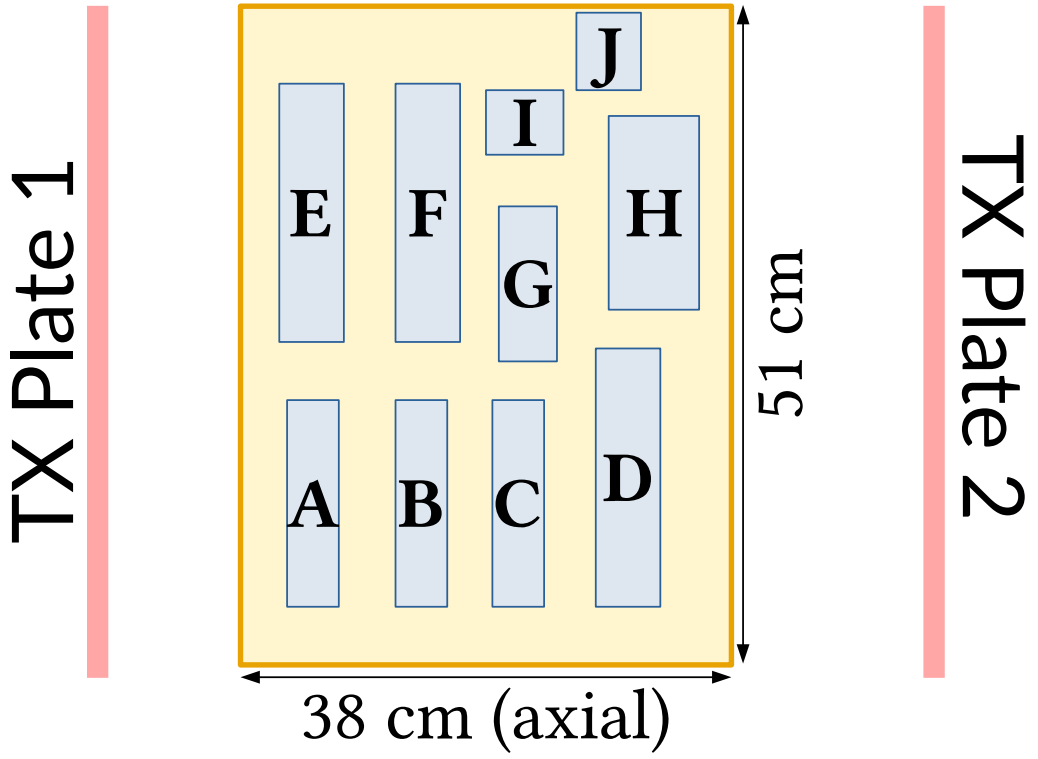
Coverage vs. Plate Size

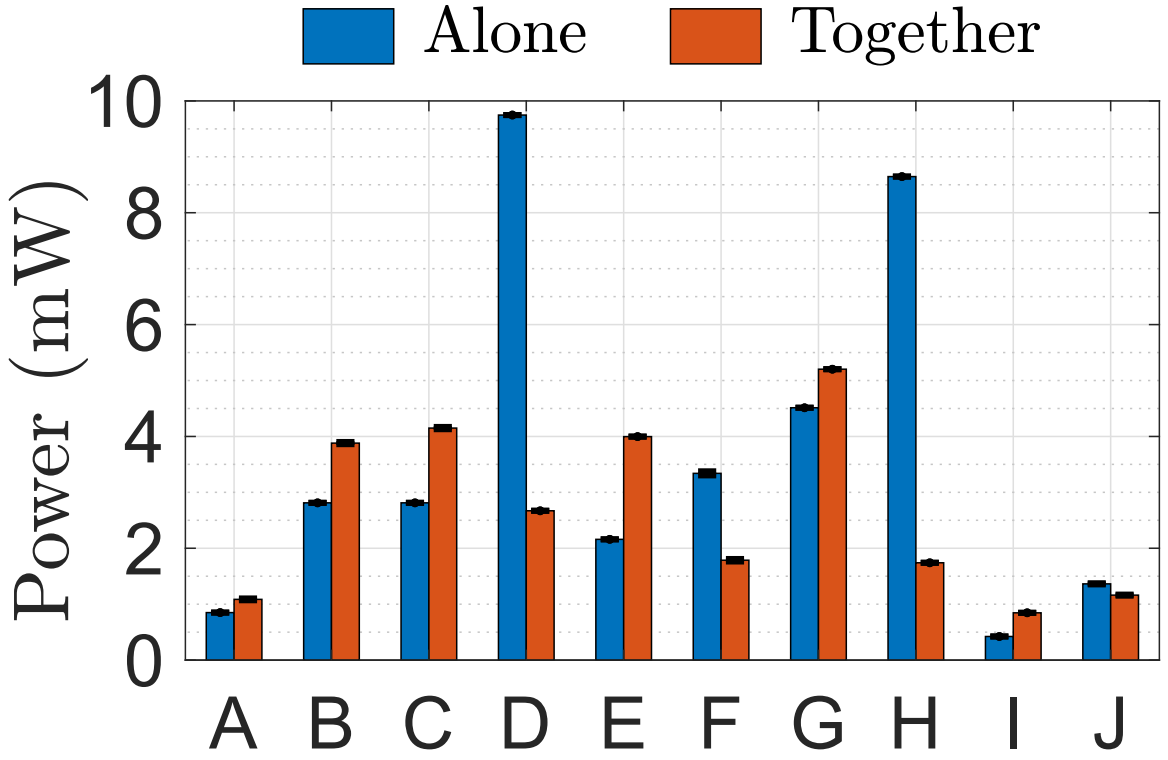




60 cm plate covers 1.2 m space providing 1 mW power

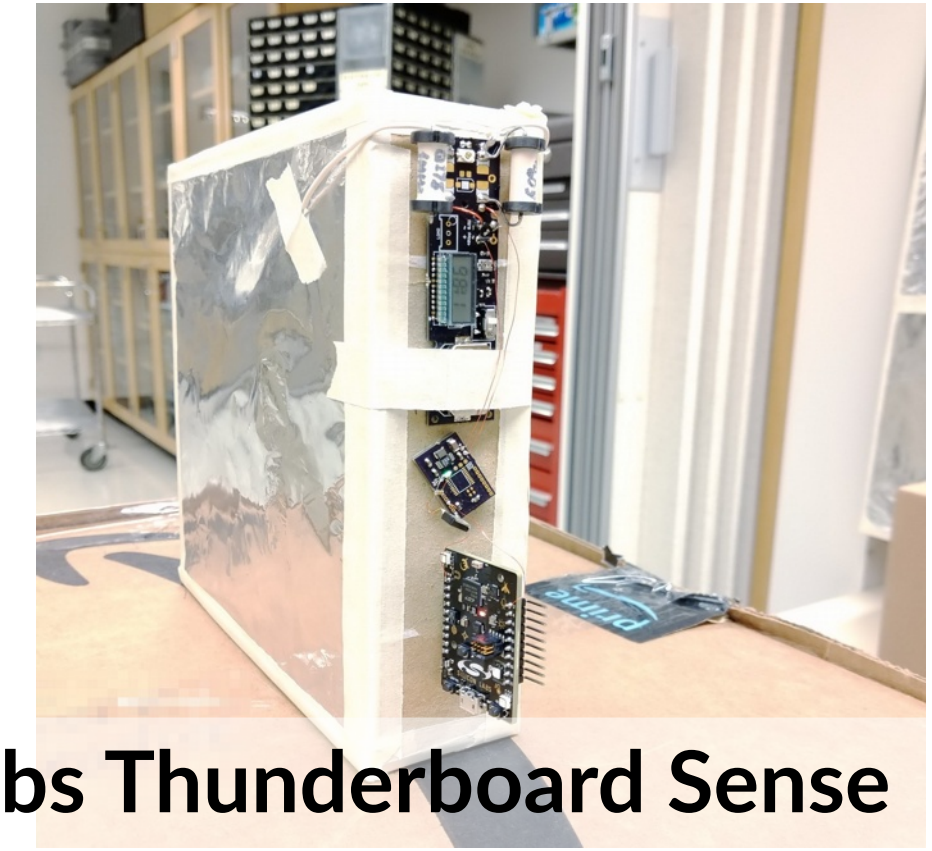
Scaling to Multiple Devices

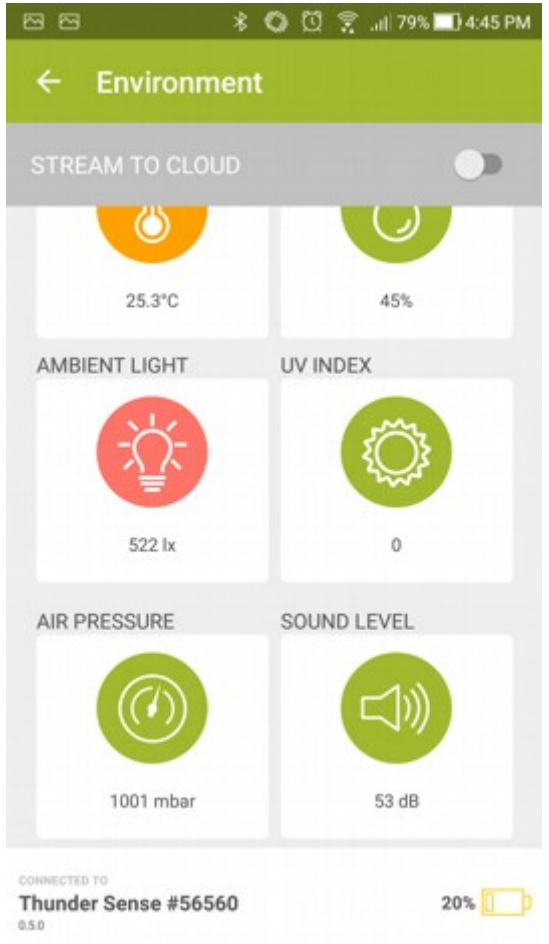




Capttery can provide mW level power to 10 RXs concurrently

Showcase Applications (BLE)

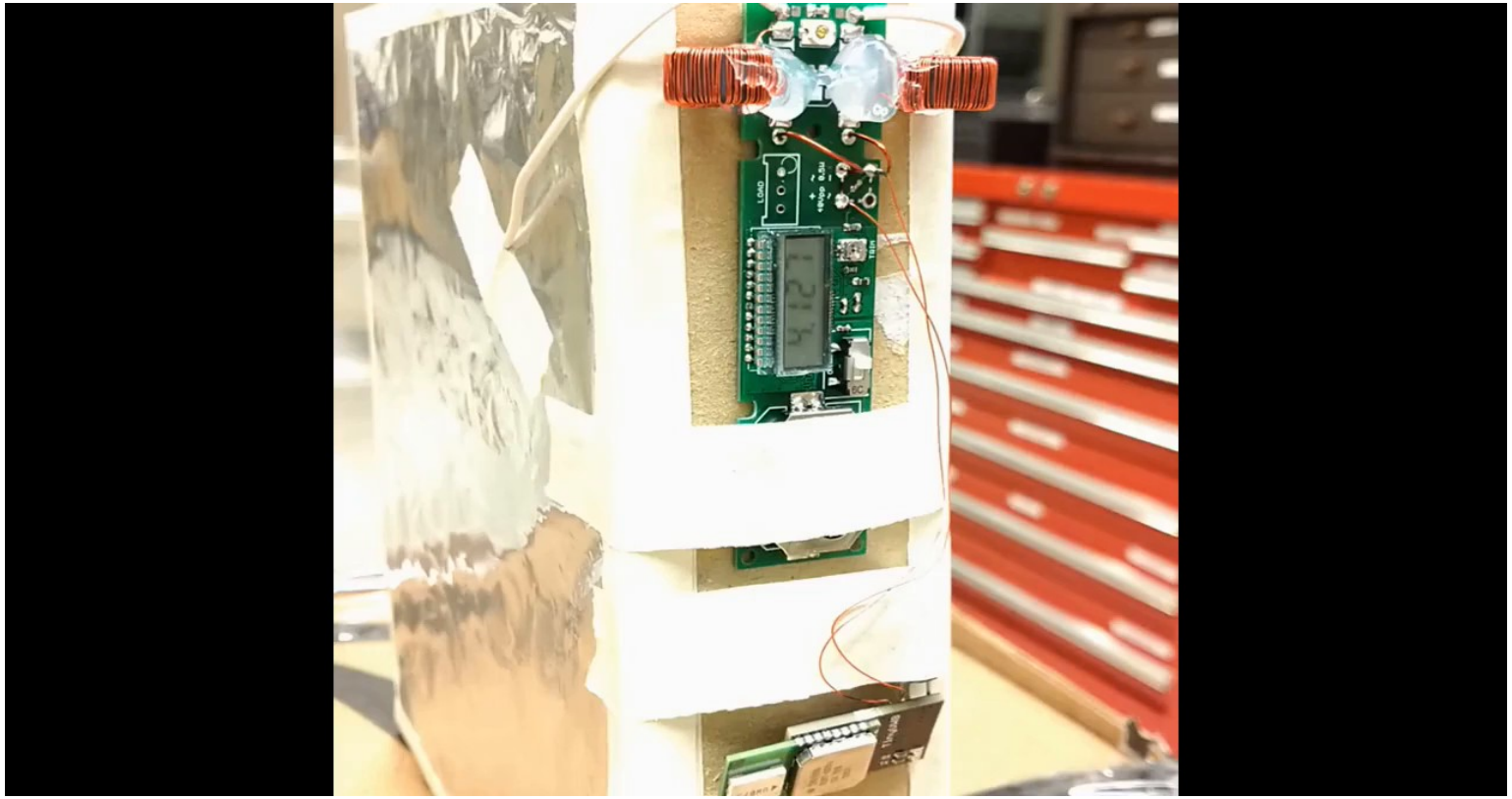




SiLabs Thunderboard Sense
ARM Cortex-M4F & BLE, ~ 2 mW

Showcase Applications (UWB)

UWB Ranging
ARM Cortex-M0+ &
DWM1000
~ 5 mW @ 10 loc/s
Peak Power > 440 mW



Conclusion

- Capttery can deliver **continuous**, **milliwatt-level** power to multiple devices, across a room in a **human-safe** & **scalable** way
- Only infrastructure overhead is to paint a part of the walls with metallic paint
- Capttery was demonstrated to power 2 applications: **BLE sensing station** and **UWB localization**
- Future work include **higher power delivery**, **enhanced efficiency** and **phone level charging**

CODE RELEASE: Simulation files, firmware source code, & PCB designs available at https://github.com/dword1511/capttery

Thanks!

Email: sidharthpunia10500@gmail.com, czhang296@wisc.edu, and dineshb@ucsd.edu

(NOTE: Chi's UCSD email is no longer accessible)

Apple Cancels Product Based on IPT

APPLE \ TECH \ GADGETS

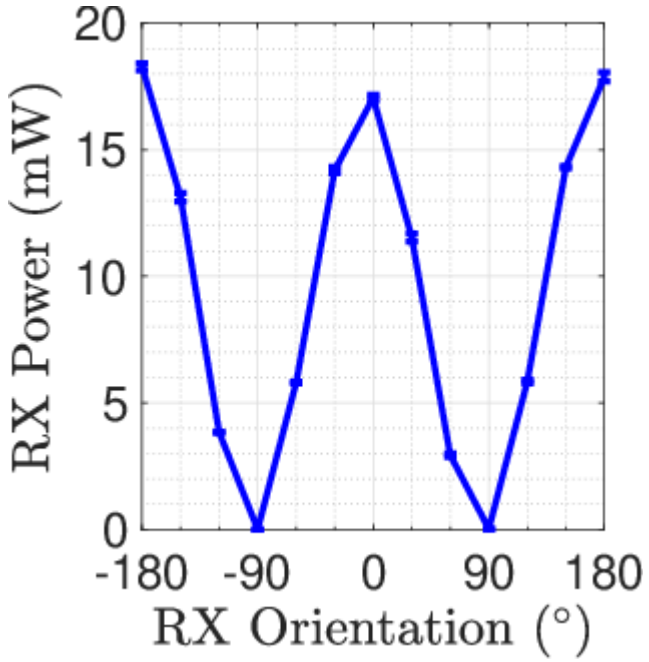
circuit breaker

Apple cancels AirPower wireless charger

'AirPower will not achieve our high standards and we have cancelled the project'

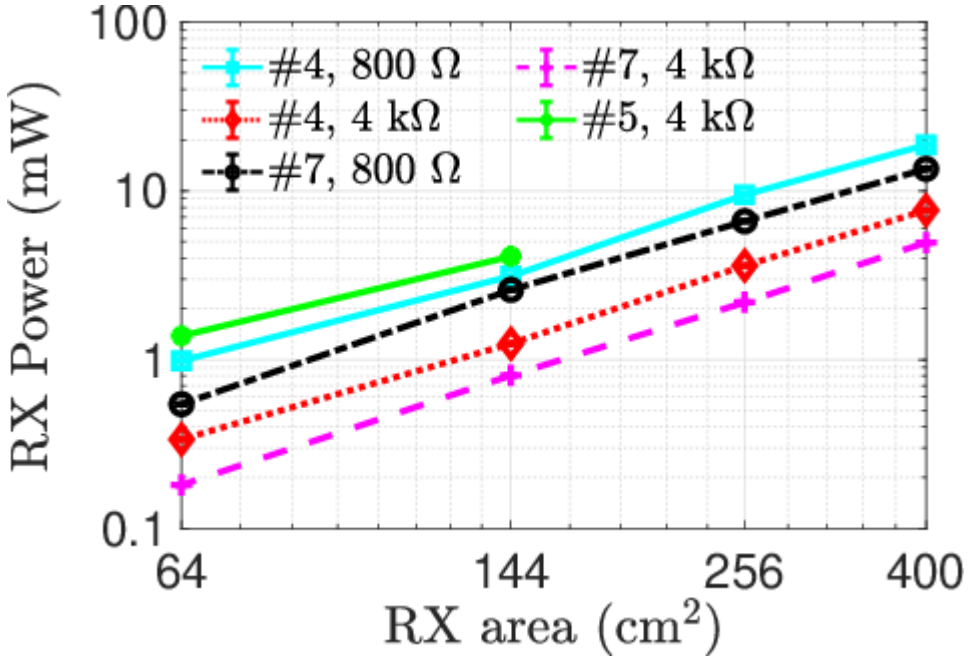
By Chaim Gartenberg, Chris Welch, and Tom Warren | Mar 29, 2019, 3:22pm EDT

Orientation



Power vs. RX Area

Smaller area allows larger L, partly mitigates area reduction



Related Work on Power Transfer

Table 3: Comparison between various wireless power transfer (WPT) systems.

Underlying Tech	Continuous Power Delivery	# Devices	End-to-end Efficiency	Other Inherent Limitations	Special Infrastructure	Showcase Scenario
IPT [30, 34, 48, 57]	1 W total at 0.5 m	6	$<$ 40% at 0.5 m	Metal blockage, eddy current loss	Multiple coils, detectors	Smartphone Charging
RF & RFID [39, 54]	6.3 μW at 6.41 m	Scalable	$<$ 0.001% at 0.5 m	Interference to data communication	High-power RF, high gain antennas	Battery & supercapacitor charging, Camera, and Temp sensor
Laser [28]	2 W at 4.3 m	1-to-1	10% – 20%	LoS requirement	Laser TX, cooling, intrusion detection	Mobile phone charging
Ultrasonic[19, 44]	1 mW at 0.03 m	Scalable	~0.2% at 0.1 m	Low range and blockage	Ultrasound TX	Oscilloscope reading
Cavity Resonance [16–18, 47]	5 W at 2.5 m	Scalable	20% – 50%	Block outside wireless signal, eddy current loss	Fully-covered metal room, pole	Mobile charging and 5W table fan
CPT (this work)	1 mW at 4.4 m	Scalable	up to 0.74% at 1.9 m	High E-field near grounded metal objects Blocked by shunting	Metal plates, matching networks	BLE sensing station and UWB ranging tag