

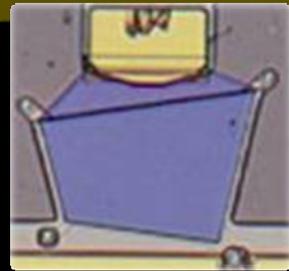
Ultra-Low Power Radios for Sensing and Asset Management

We have developed low power radios that:

- Consume 2 orders of magnitude less power than commercial radios
 - Enable self-powered wireless nodes
 - Are easy to deploy

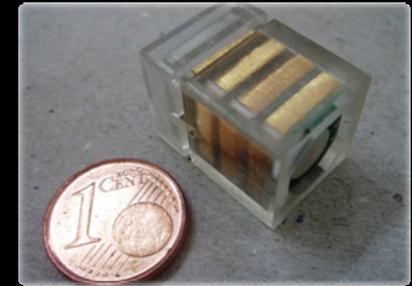
Michael Mark, Louis Alarcón, Mervin John, Wen Li, Tsung-Te Liu, Jesse Richmond,
Wenting Zhou, Jan Rabaey

Innovations in ULP Radios

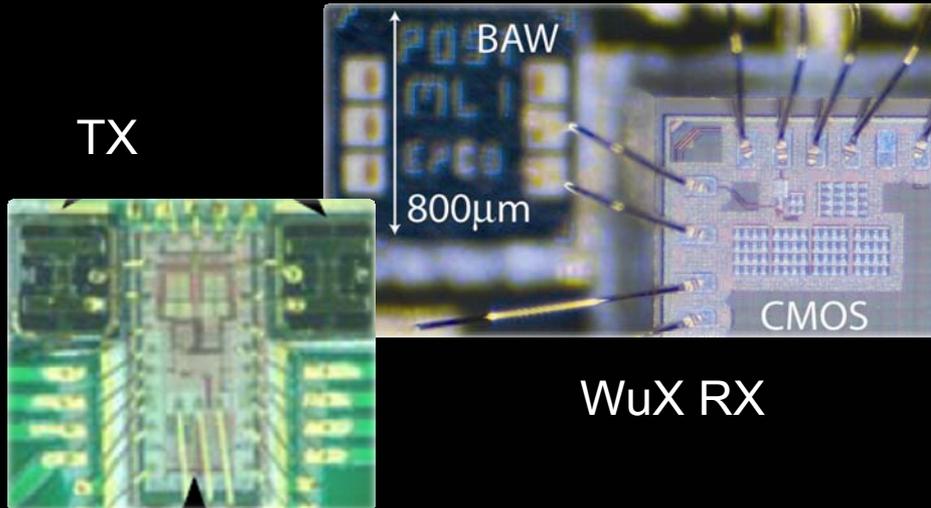


FBAR MEMS Resonator
(Avago Technologies)

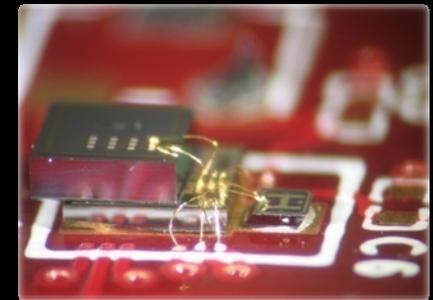
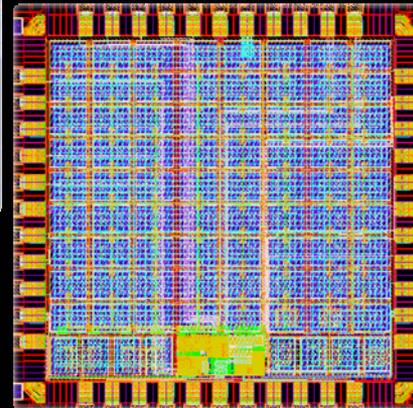
- MEMS-based ultra-low power receiver and highly efficient transmitter
- Low-voltage, low-power logic family
- Integrated, efficient energy conversion and innovative power management



UCB PicoCube

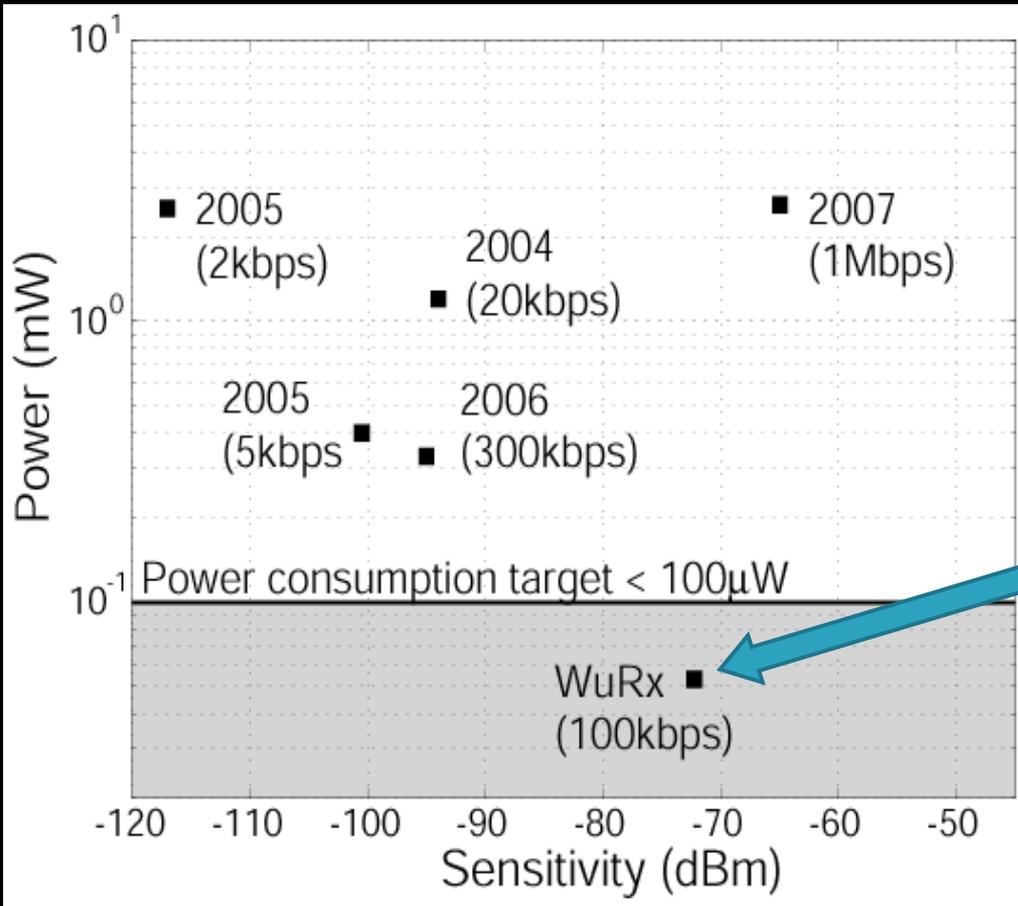


Voltage converter and regulator



UCB mm³ radio

A 50 μW Receiver

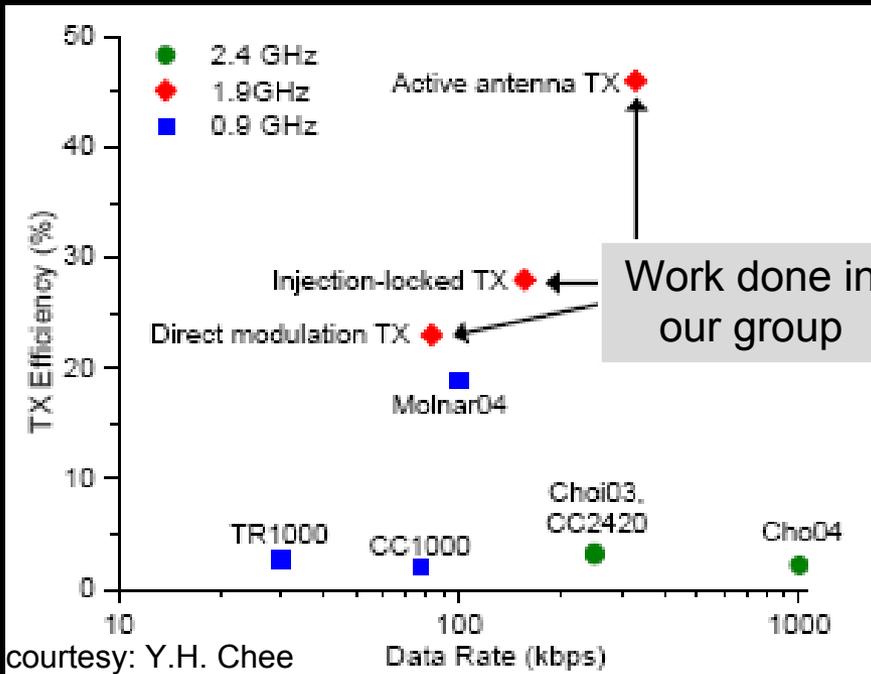


Nominal data rate	100 kbps
Sensitivity	-72 dBm
Total power dissipation	52 μW

Enabled by innovative use of scaled CMOS and MEMS technology

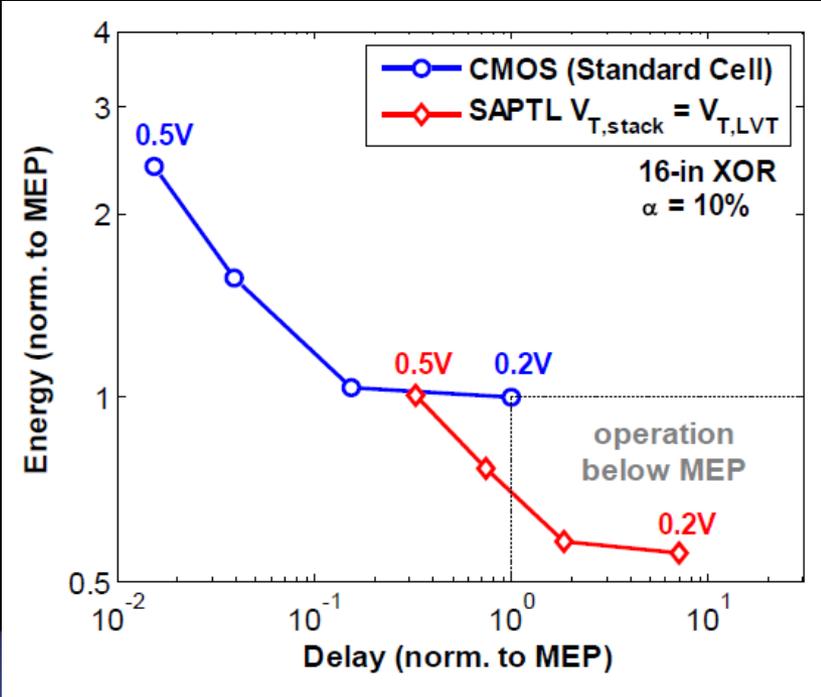
courtesy: N. Pletcher

Transmitter and Baseband Logic



Transmitting 1mW (0 dBm) with an efficiency of close to 50 % utilizing MEMS

Novel logic family to extend region of operation below minimum energy/operation point of conventional CMOS



Our Radios

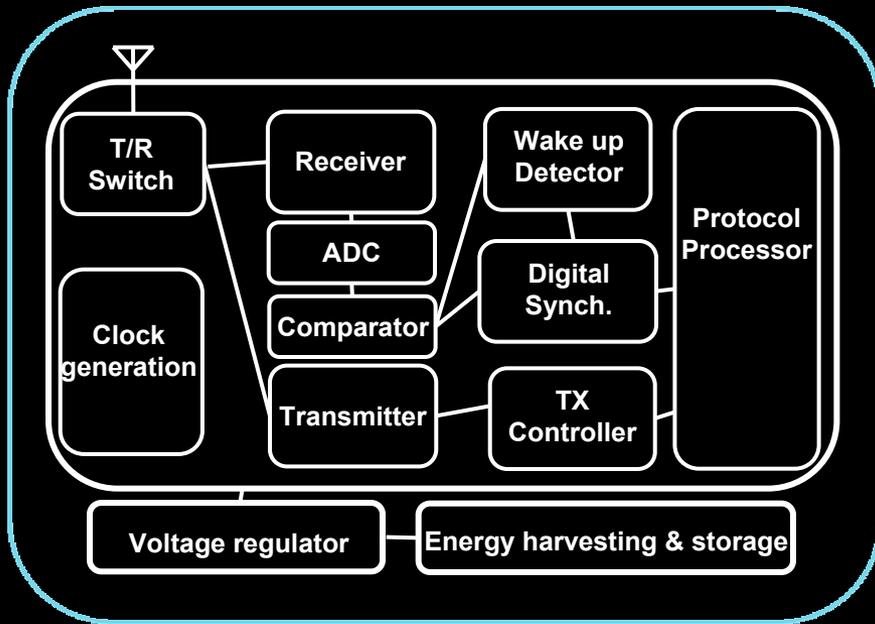
- Enable small wireless sensing nodes powered **purely** by energy scavenging
- Can communicate over more than 10 m indoors at 100 kbps data rates
- Are a perfect match for Wireless Sensor Network (WSN) or active RFID applications

WSN and Active RFID

- WSN and active RFID markets continue to grow rapidly
- By 2019 WSN will be a \$ 1.75 billion market
- Battery powered active RFID will take on a market of more than \$ 6.75 billion

*Source: Wireless Sensor Networks 2009-2019, Nov 2008 IDTechEx
<http://www.rfidsolutionsonline.com/article.mvc/Wireless-Sensor-Networks-2009-2019-0001> (retrieved 09/11/09)*

Our Fully Integrated Self-Powered Active RFID Tag



- Can operate indefinitely (for 24 hours/day) from single solar cell
- Footprint of a postage stamp (while only mm's thick).
- Fully compatible with RFID link and MAC specification

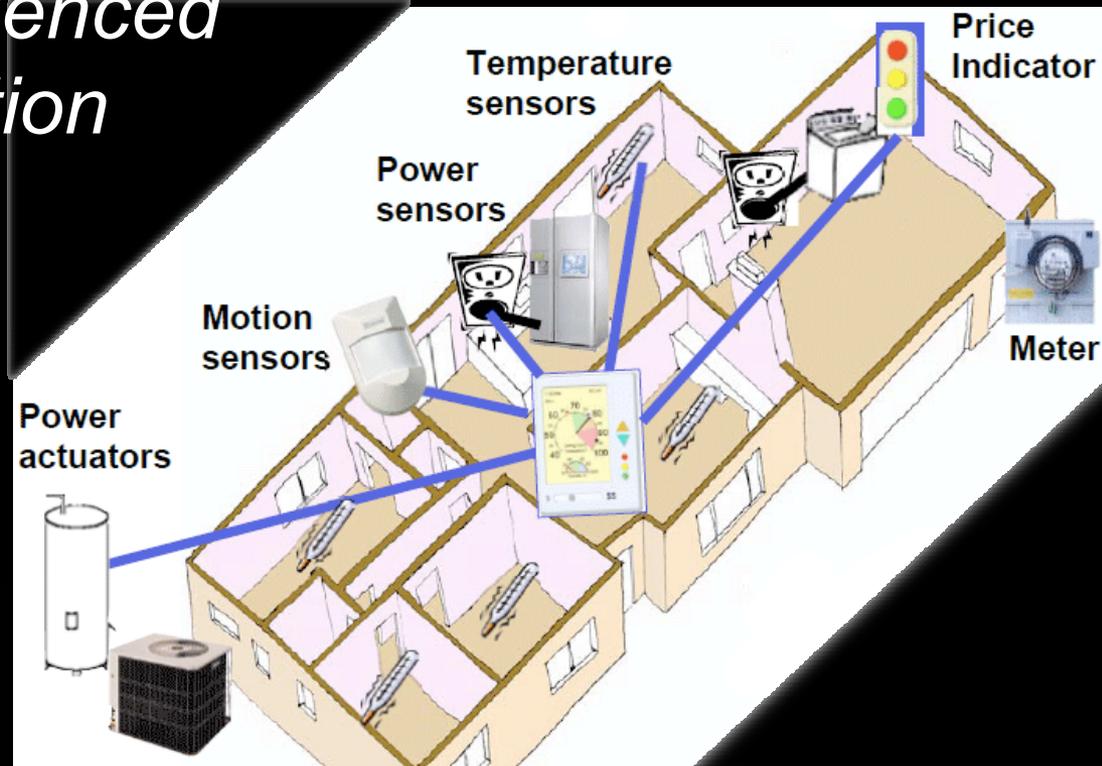
Enables querying from portable mobile devices (e.g. cell phones), or from a deployed network (such as WiFi)

Applications: Smart Buildings

- “Nearly 70% of the average household utility bill could be influenced by WSN application to temperature and lighting”

Wireless Sensor Network
Technology Trends Report
July 2009

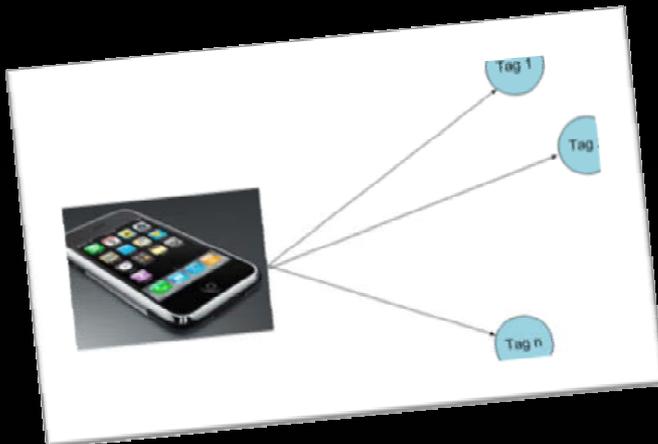
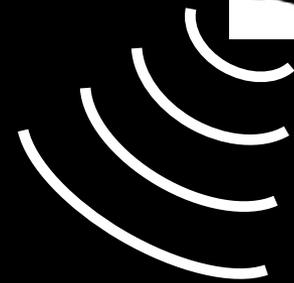
- Huge potential to reduce peak energy demand



courtesy: M. Seeman

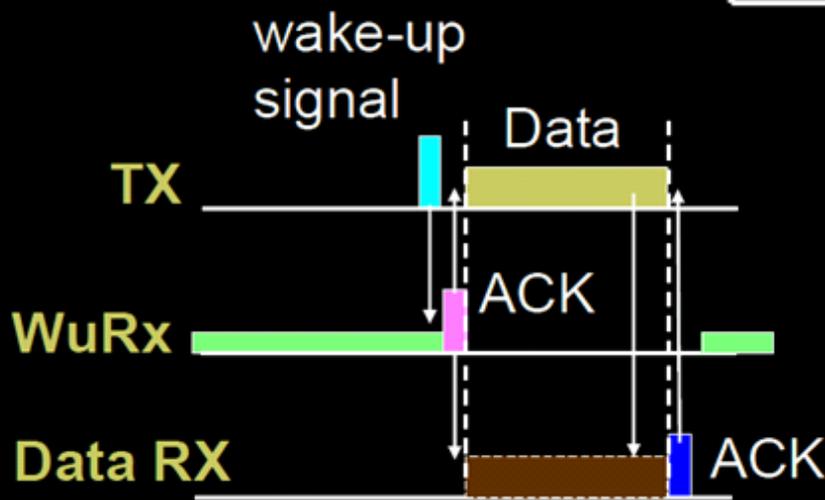
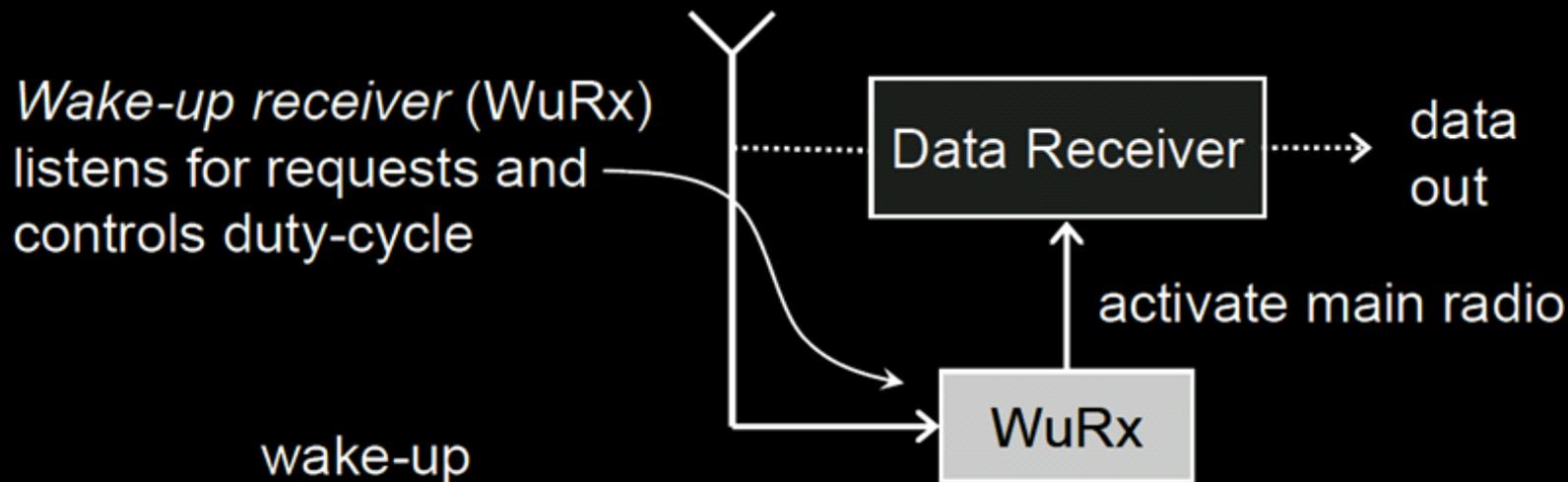
Utilities Asset Management

- Monitor devices and infrastructure
 - fuses, fault indicators, etc.
- Retrofitting existing equipment using self-powered active RFID tags
 - easy to deploy
 - utilize existing infrastructure and / or power handheld devices to poll tags
 - smaller and cheaper than WSN nodes



- Obviously applicable to **asset management in the broad sense** (warehouses, stores, containers, etc).

Wake-up Receiver: Lower Power - Lower Latency



- Significantly reduces power consumption or latency of network

courtesy: N. Pletcher

We have developed Ultra-Low Power Radios that

- Enable small wireless sensing nodes powered purely by energy scavenging
- Are easy to deploy and can use existing infrastructure
- Can communicate over more than 10 m indoors
- Are perfectly suitable for Wireless Sensor Network and active RFID – like applications

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