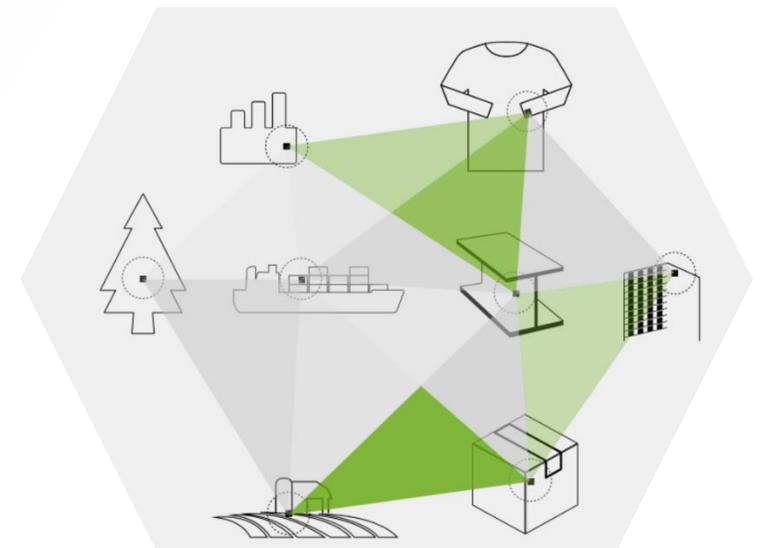




ARPA-e – July 2016

Organizing a Trillion Sensors



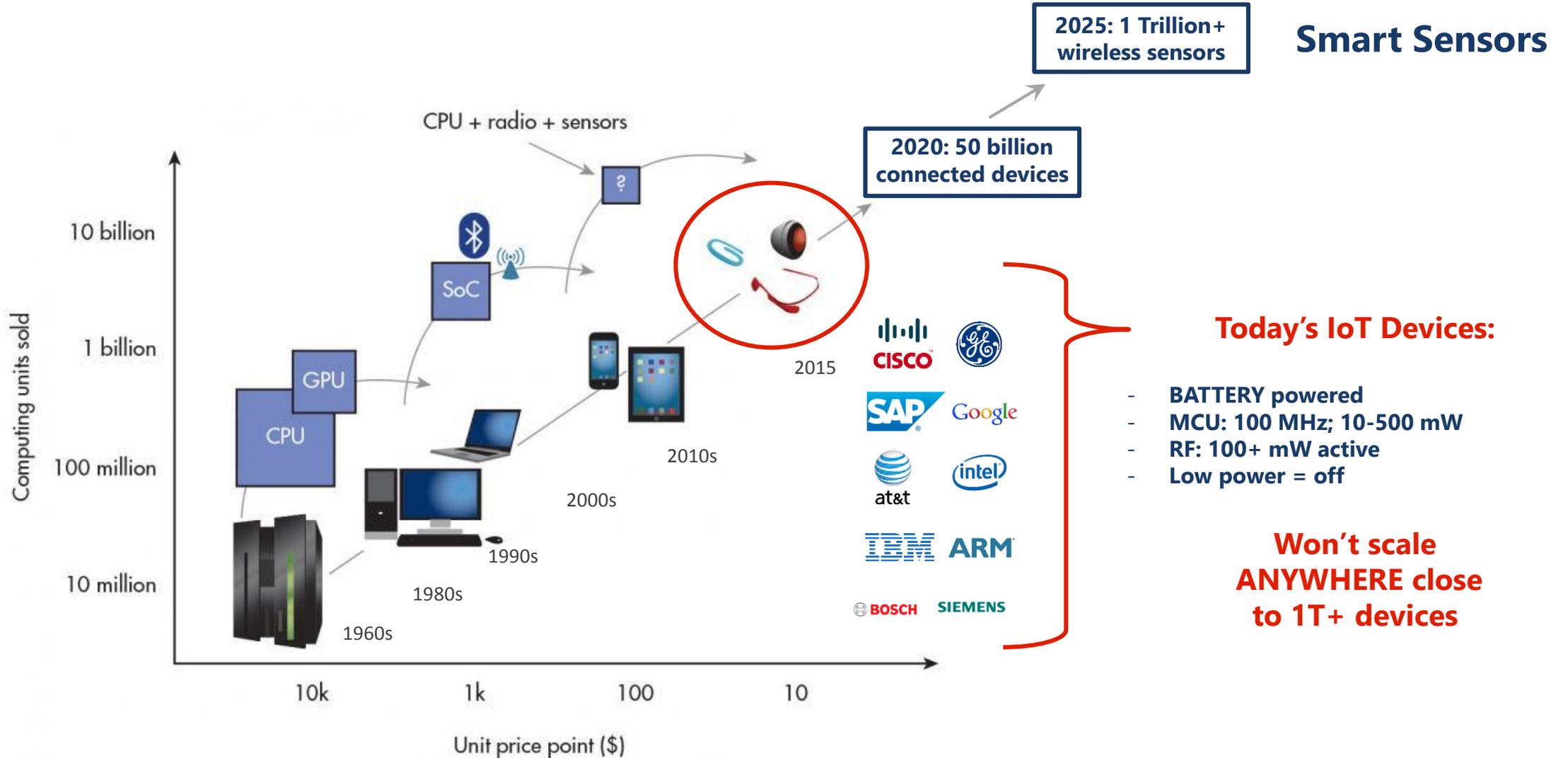
Sense The World Around You



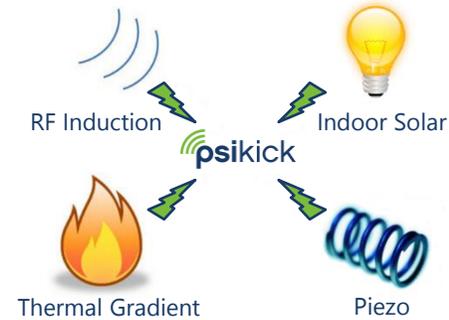
View of the future

- **Trillions of sensors to provide large amounts of sensor data.**
 - Large amounts of data can't all be computed in the cloud. Need local compute capabilities.
 - Everything is SMART
- **Data to deliver real, meaningful insights.**
 - Ignore data overload for the moment.
- **Improve quality of life, streamline processes and increase efficiencies.**
 - Not a connected toaster

The Next Wave = Pervasive Computing



Batteries Just Can't Do It



BATTERIES

- Today's RF IC = tens to hundreds of mW
- With current batteries = hours / days / months
- No "Moore's Law" for energy density
- Batteries can't be the primary power source

ENERGY HARVESTING

- Is "**THE ANSWER,**" but...
- It only delivers tens of μW per cm^2
- Versus tens to hundreds of mW
- Need 2-3 orders of magnitude improvement
- **Need active power budget to be 20-50 μW**

**Need wireless SoCs @
1/1,000th of today's power consumption**

Smart Sensors Require Batteryless Operation

Wireless systems @ 1,000x lower power than current solutions

Operating at a mere tens of μW active system power

Generated entirely from harvested energy



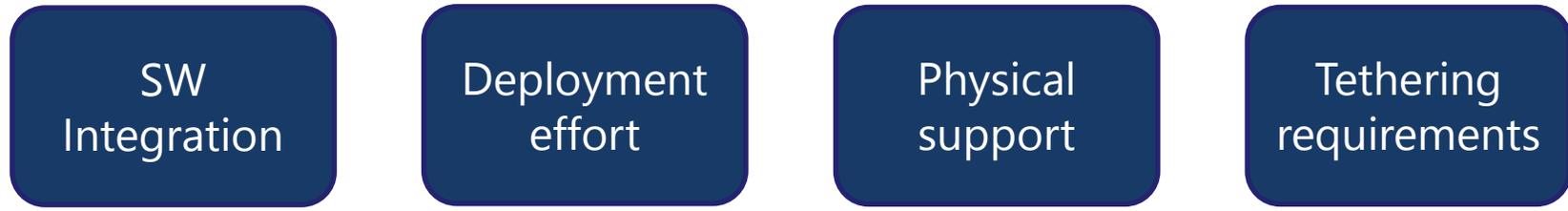
UNLOCK A WORLD OF

BATTERYLESS

SENSING SYSTEMS

Deploying Trillions of Sensors is Hard

Issues

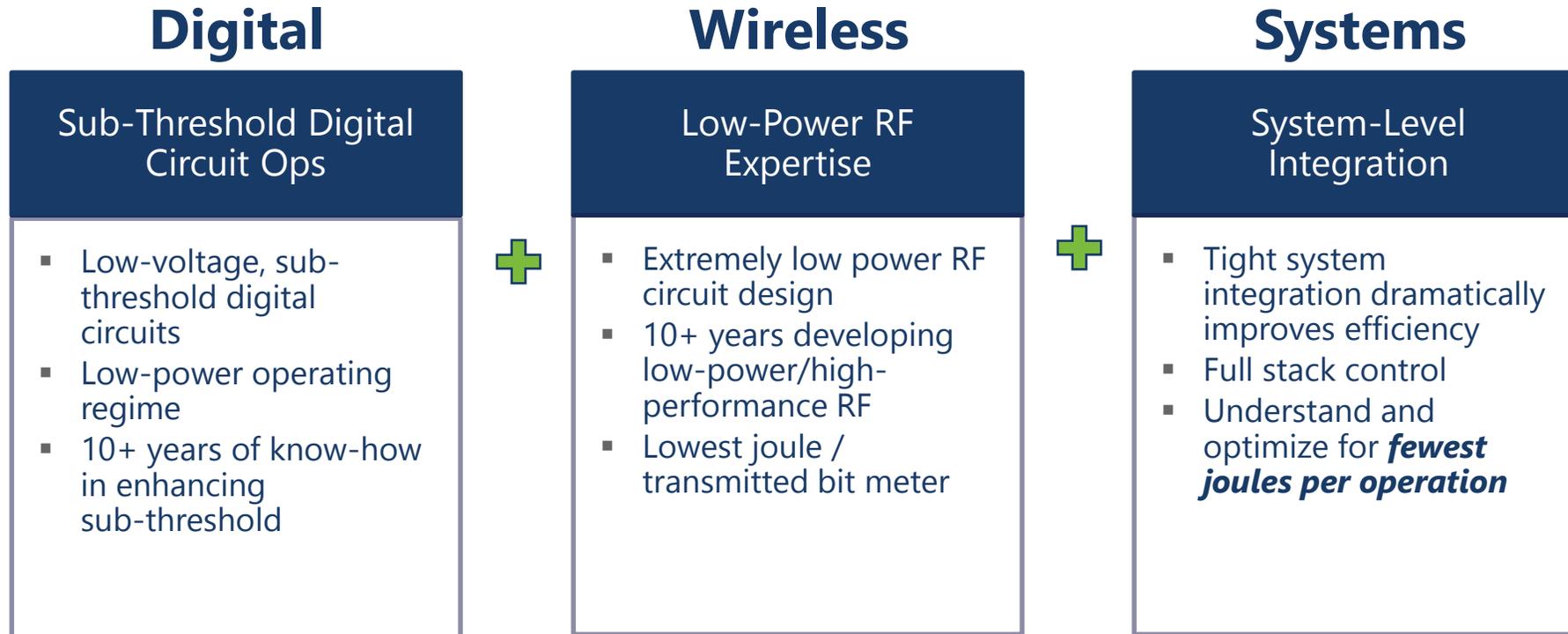


Impossible without a new approach

Solutions



Our “Secret Sauce” is Three Key Domains of Expertise



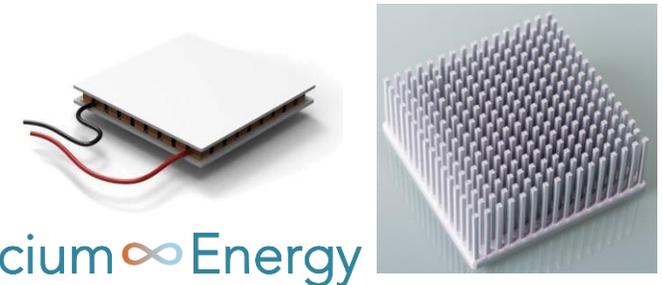
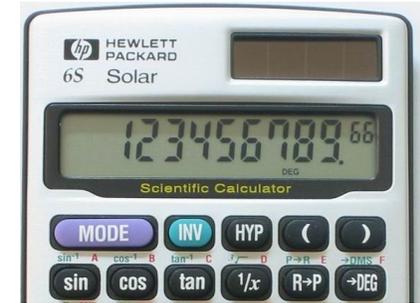
...resulting in a new paradigm of circuit design

Operating Parameters are Ideal for the IoT

- **RF Range and Data Rate** – sweet spot between 10m at 1Mb/s and 4km at 1 kb/s
- **Processor Speed** – sweet spot between hundreds of kHz and tens of MHz

Harvest from any harvesting source

- Applications specific options:
- Solar/ PV
 - Pros: Best understand, silicon is relatively low cost, high power
 - Cons: Light not always available. Highly orientation and light source dependent
- Thermoelectric Generator (TEG)
 - Pros: Harvest from temperature gradients. No light needed/
 - Cons: Lots of mechanical challenges to maintaining temp gradient. Typically higher cost.
- Vibration/ motion (piezo, etc.)
 - Pros: No light needed, simply harvest from vibration if available.
 - Cons: Generally low energy (high peak power). Cost can be higher and lots of mechanical considerations (cantilever arm, etc.)



Silicium ∞ Energy



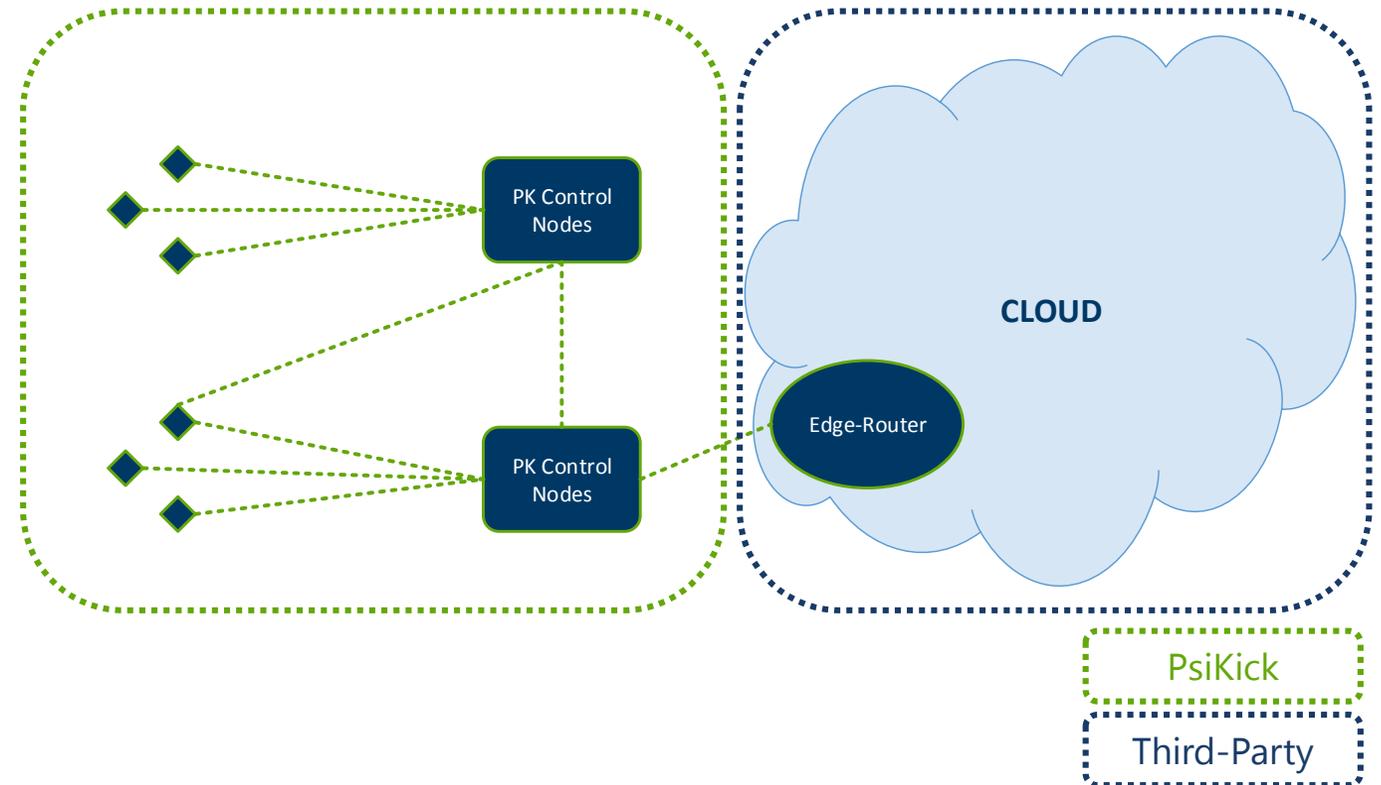
stryde
TECHNOLOGIES

Low Power Sensor Interfacing

- Low power sensors during acquisition and standby
- Completely power gated with fast time to data acquisition
- Standard interface for digital, or analog output.
- Minimal needs for calibration in the SoC.
- Pre-processing at the SoC to reduce size of data sent to the cloud.

Data Acquisition System

- **Advantage:** Easiest way to get sensed data into the cloud without batteries where better informed decisions can be made.
- **Hardware:** Leverage differentiated silicon to build systems platform to connect any sensor to the cloud
- **Smart Nodes:** customized communications
- **Cloud:** funnel data to standard infrastructure



Trillion Sensors + mW Power + Batteries = FAIL

*1 Trillion Sensors with 10-year batteries
translates into 275,000,000 battery
replacements every day*

Thank You!

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