IoT Sensor Devices

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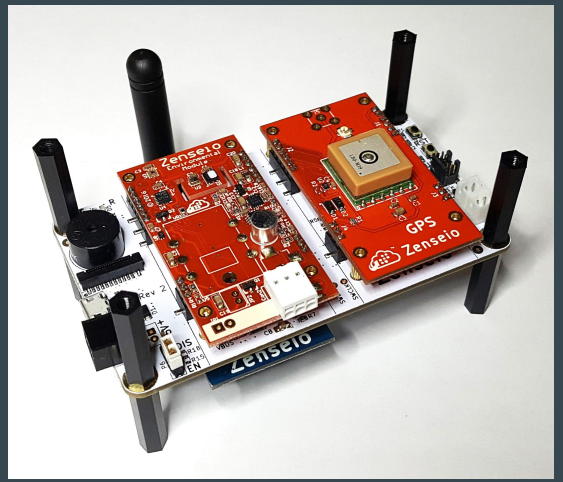
Agenda

- What hardware is needed for IoT systems?
- What are IoT Sensor Devices (“The Things”)?
- What are sensors used for?
- How are sensors connected to internet?
- How are IoT sensors powered?

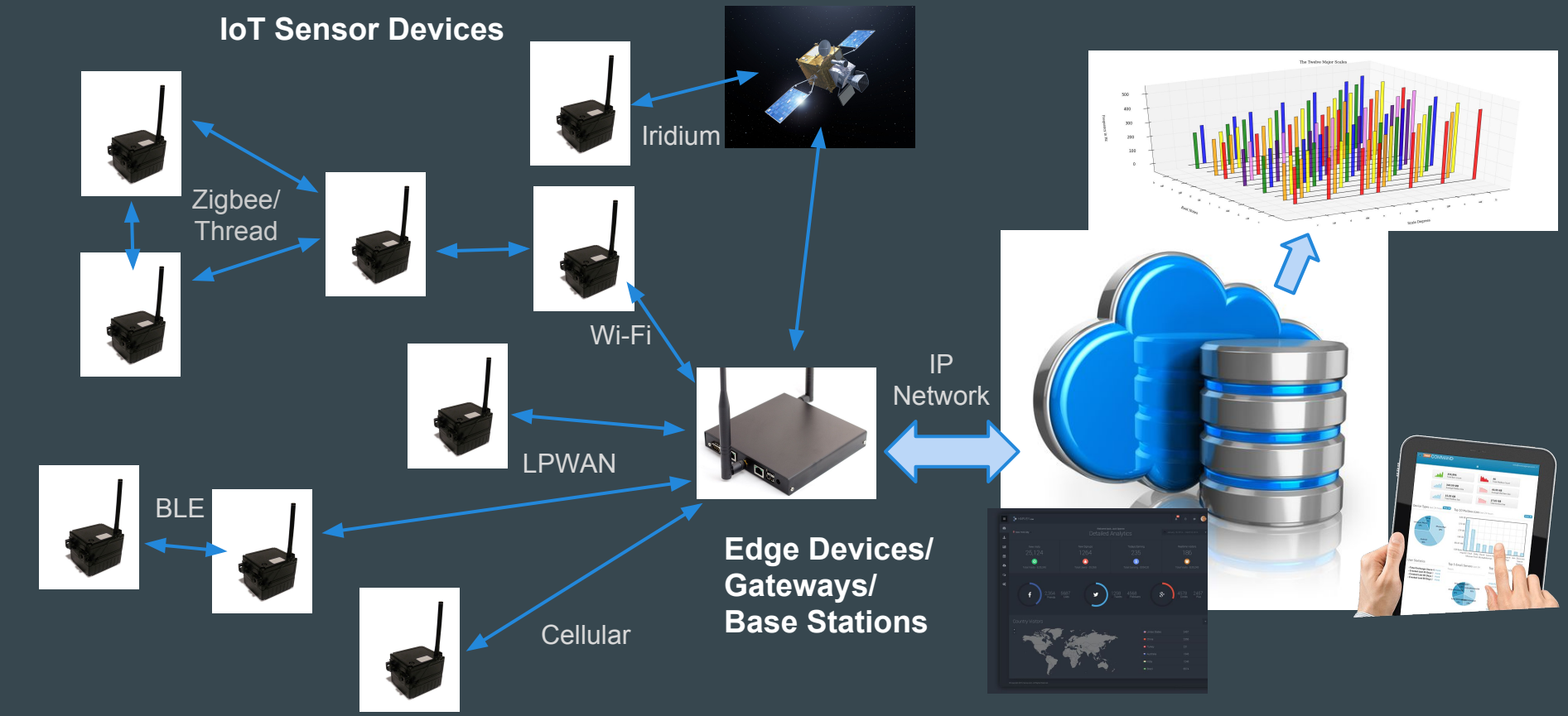
About Roman Staszewski and Zenseio

- The founder and CEO of Zenseio since 2014
- Expertise in embedded hardware and systems
- Previously, Distinguished Member of Technical Staff at Texas Instruments for over 20 years

- Zenseio versatile IoT Sensor Platform for rapid prototyping and industrial deployments
- Consulting and custom engagements

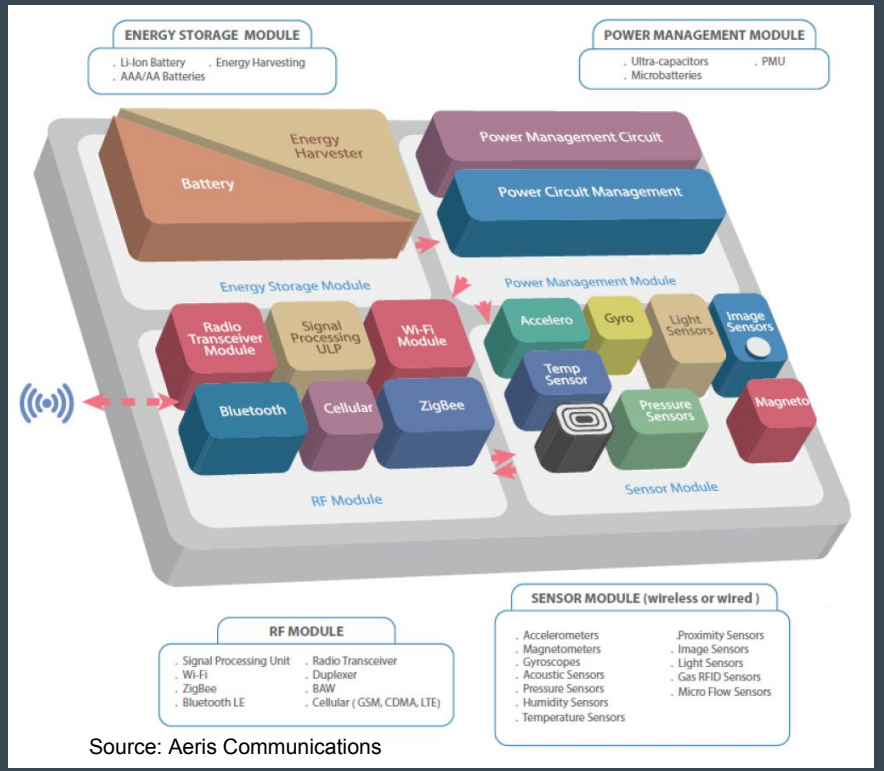


What hardware is needed for IoT systems?



What are IoT Sensor Devices ("The Things")?

- IoT Sensors are sensors that connect to internet
- 3 required functions:
  - Sensors
  - Connectivity
  - Power Supply
  - MCU is a helpful support function
- There are thousands of different sensors
- There are hundreds of different communication methods
- There are hundreds of power supply options
- Diversity, low power, RF, and low cost make IoT Sensors difficult to implement

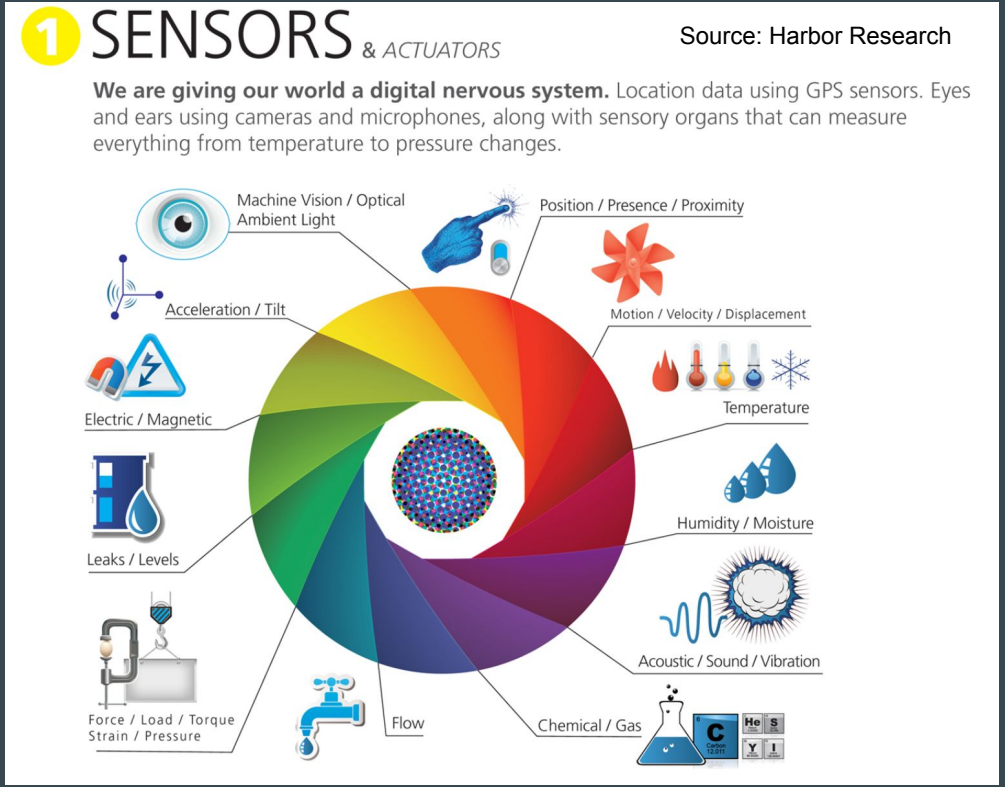


Source: Aeris Communications

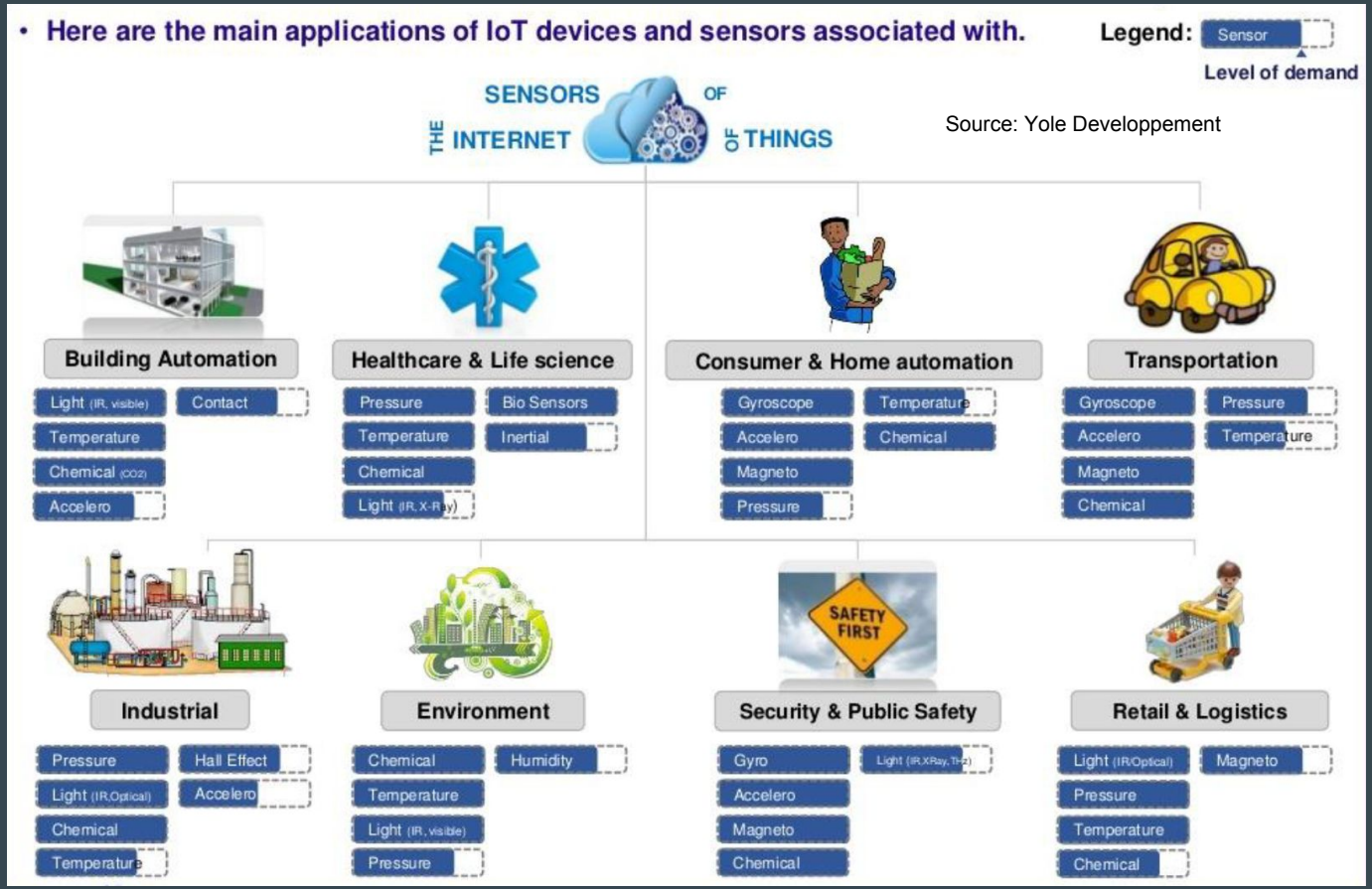
Sensors

What Are Sensors Used For?

- Sense and measure physical quantities, and convert them into digital representation
- Not only (super)human-like senses
- But, everything else worth measuring
- Not only our world's digital nervous system
- But, eventually, digital mirror of our world

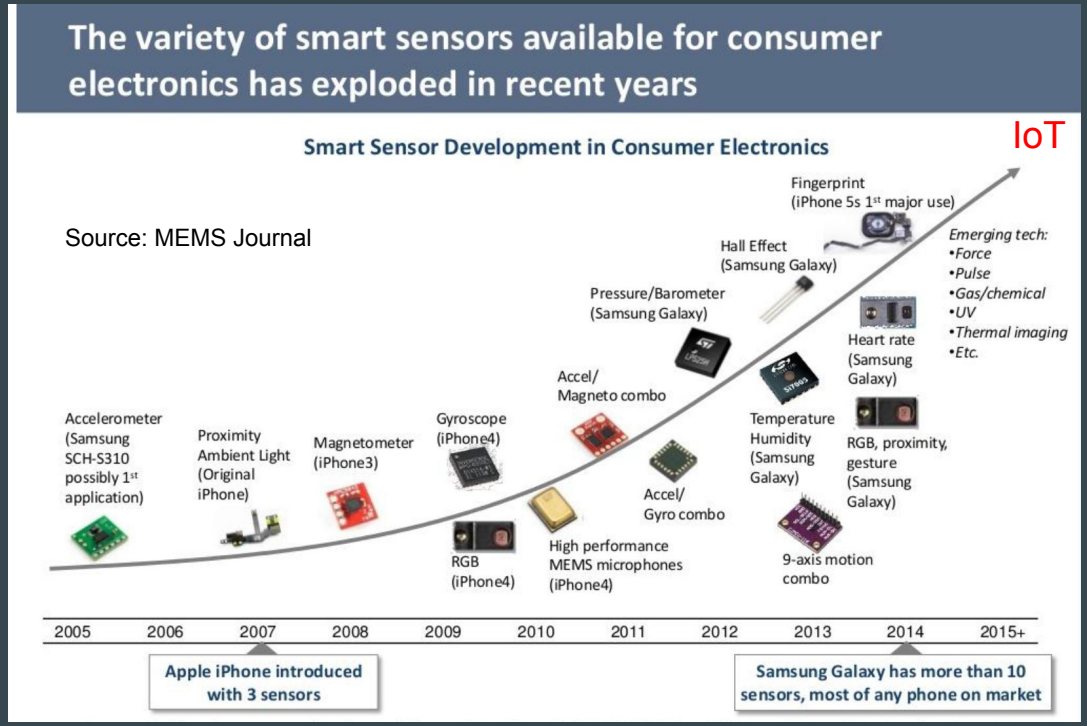


Example - How Sensors are Used … Today



What drives sensors progress?

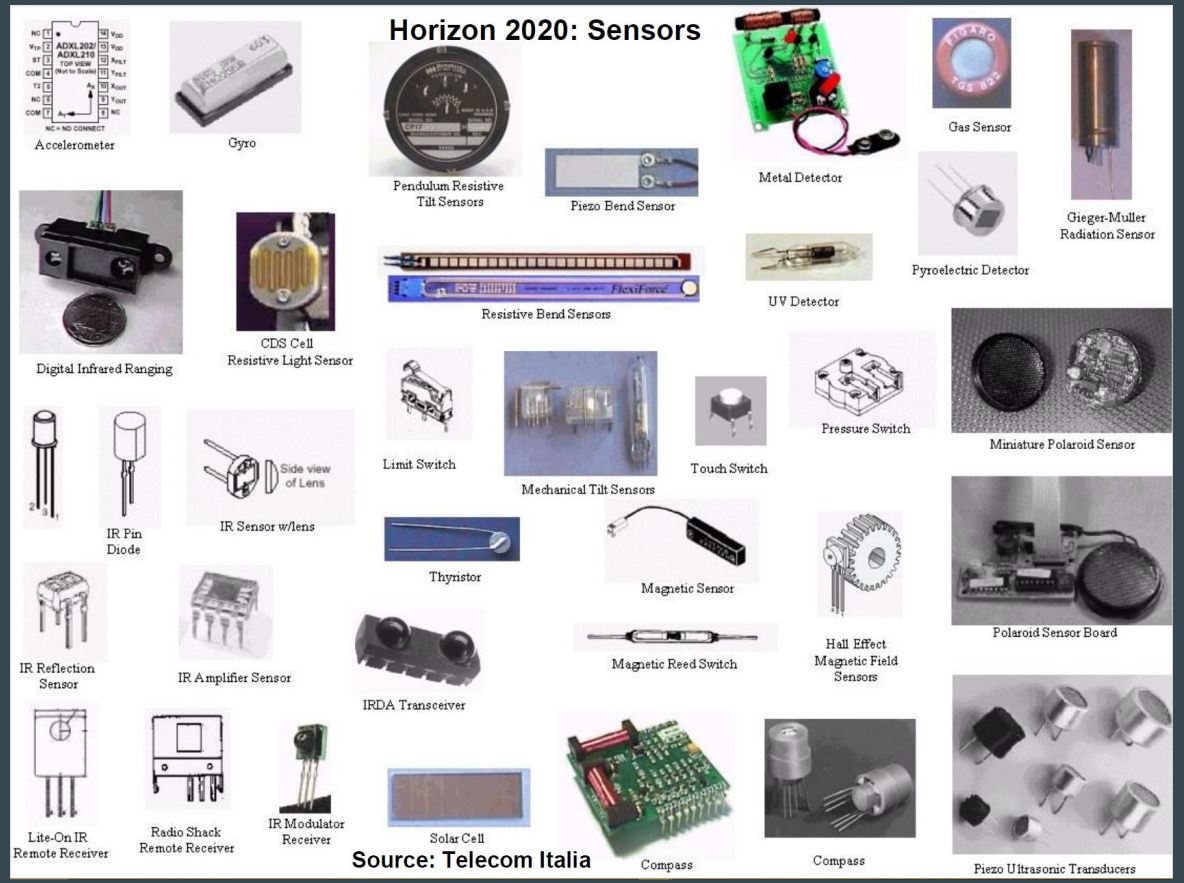
1. MEMS - Micro-Electro-Mechanical Systems
   a. Digital friendly
   b. Versatile
   c. Precise
   d. Small
   e. Low power
2. Consumer electronics created economies of scale to reduce costs
3. IoT benefits from MEMS and economies of scale will further slash costs & increase capability



Future Sensor Trends

- More sensors
  - MEMS
  - Imagers
  - Electro-Magnetic
  - Biochemical
- ... For everything
- Cheaper
- Smaller
- More power efficient
- Easier to use

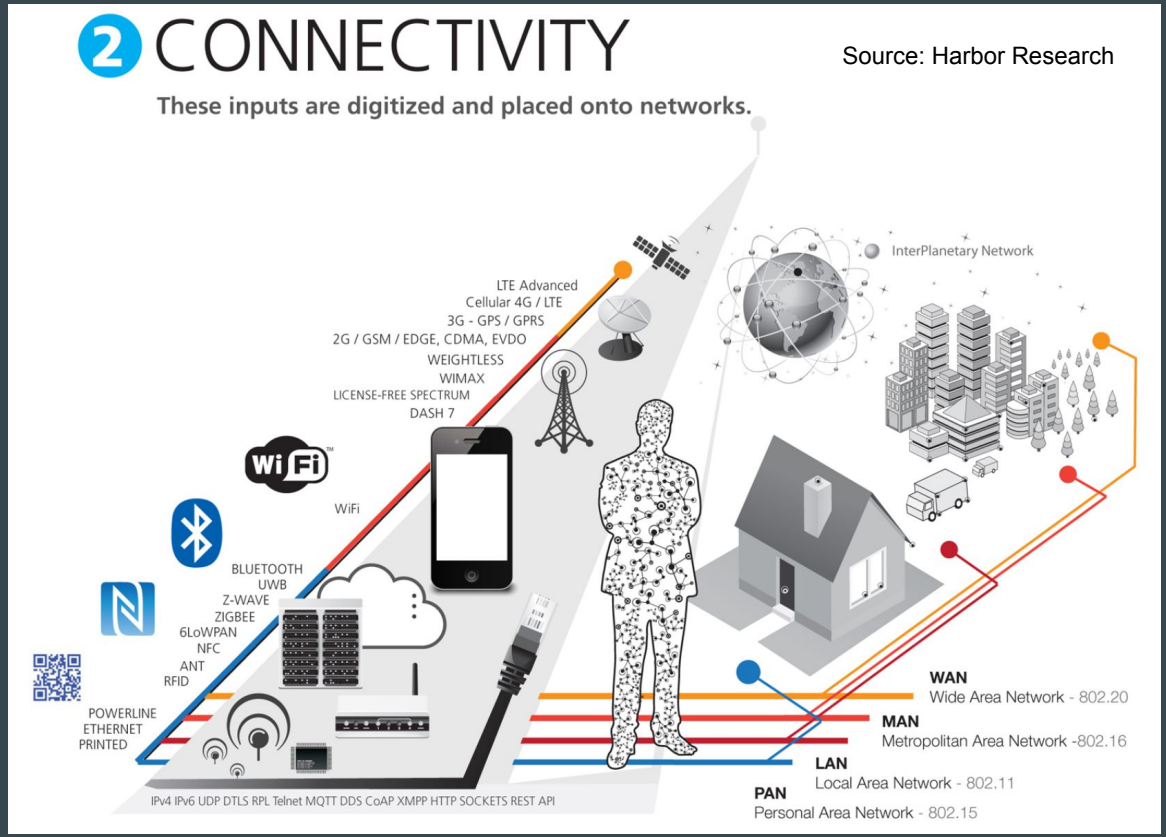
But, know-how about sensor properties is vitally more important :)



Wireless Connectivity

How are sensors connected to internet?

- Plethora of connectivity options with various characteristics
- Wireless is the key enabler
- Pushing power/cost/range capabilities, so always many tradeoffs to consider and to compromise on
- Applications drive the connectivity choice



How to Select Communication Technology

Application Requirements

Technology

- Range & Throughput
- Interoperability
- Power consumption
- Size

Business

Solution cost (Capex+Opex)
Time to market
Ease of use / support model
Risk factors

Short Range High Speed	Short Range Moderate Speed	Long Range High Power	Long Range Low Power
• Ethernet • Wi-Fi	• 802.15.4 • ZigBee • ZWave • Bluetooth • Thread	• Cellular • Satellite • Microwave	SIGFOX One network A billion dreams, INGENU, LoRa™, 3GPP A GLOBAL INITIATIVE

Source: Infiswift

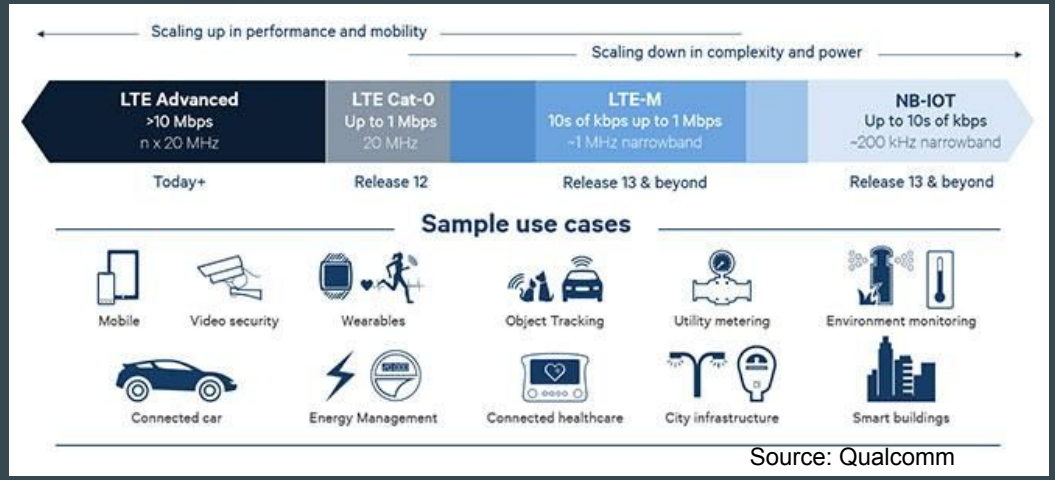
Comparison of Leading (Unlicensed) LPWAN

LoRa™	SIGFOX	W-N	inGENU
Pros	**Pros**	**Pros**	**Pros**
• Private and public networks • MAC & network layers are open • Good hardware availability • Flexible for broad uses • Inexpensive • Excellent battery life	• Easy/quick product development • Well capitalized and good network availability • Inexpensive	• Very similar to SIGFOX – great for sensor networks • Good urban range • Open standard	• Private and public networks • Excellent bi-directional communication • Scalable base stations • Good bandwidth utilization
Cons	**Cons**	**Cons**	**Cons**
• Proprietary PHY layer • Transceivers only available from Semtech (for now)	• Must use public network • Very limited data transfer • Use is limited and caters to sensor networks, status monitoring, etc.	• Upstream data only • Very slow (100bps)	• Works in crowded 2.4 GHz band • Higher frequency less penetrable

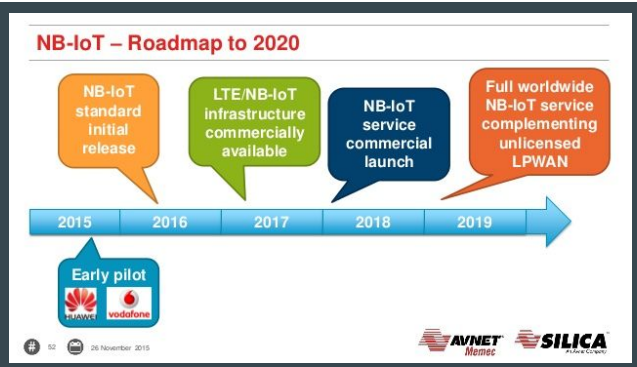
Source: Infiswift

Cellular IoT Strategy (Licensed Spectrum)

- NB-IoT and EC-GSM
- Matching range and low power to unlicensed LPWAN
- Late to market compared to unlicensed LPWAN
- Will be more expensive to operate
  - Need to pay for spectrum license
  - And, for network certifications
- But, will provide better QoS and scalability
- And, possibly better longevity with more big suppliers



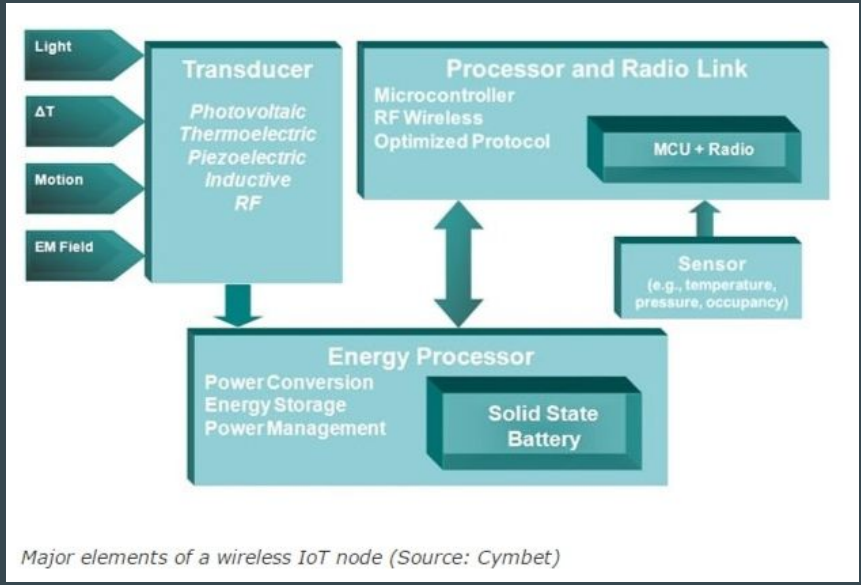
Source: Qualcomm



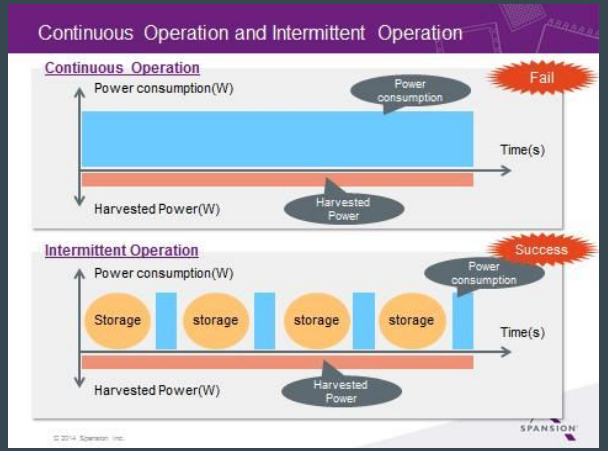
Power Supply

Energy Harvesting

- Sensors, radios, and MCU's are becoming very power efficient
- Low cost power management technology is already here
- Battery technology is improving too
- Powering IoT Sensors from harvested ambient energy sources is feasible in intermittent operation
- Typical ambient energy sources
  - Light
  - Thermal
  - Motion/vibration
  - EM fields



Major elements of a wireless IoT node (Source: Cymbet)



Energy Source	Harvested Power
Vibration/Motion	
Human	4 μW/cm²
Industry	100 μW/cm²
Temperature Difference	
Human	25 μW/cm²
Industry	1–10 mW/cm²
Light	
Indoor	10 μW/cm²
Outdoor	10 mW/cm²
RF	
GSM	0.1 μW/cm²
WiFi	0.001 mW/cm²

Energy-harvesting sources and harvested power. (Source: Texas Instruments)

Conclusions

Exciting Times for IoT !!!

- IoT Sensors & Cloud - fundamental enablers for IoT
- Wireless/sensor/power/compute technologies becoming good enough & improving
- Entering **virtuous circle**
  - Increased capabilities / Cost reduction
  - Business (and not only) benefits
  - Investment
  - Innovation
- Driving the fourth industrial revolution (Industry 4.0)
- Unprecedented, once-in-a-lifetime opportunities
- Still early stages - best time to get in