Tech on Health

"I believe, if you zoom out into the future, and you look back, and you ask the question, 'What was Apple's greatest contribution to mankind?', it will be about health." --Tim Cook (Apple CEO)

HOW THE HEART BECAME THE CENTRE OF THE APPLE WATCH, Independent
https://www.independent.co.uk/life-style/gadgets-and-tech/features/apple-watch-health-heart-world-day-jeff-wiliams-interview-features-a9124601.html

"Health care is one of the most important fields that technology will help transform over the next decade, and it's a major area of investment for Google."

-- Sundar Pichai (Google CEO)

How Google and Mayo Clinic will transform the future of healthcare
https://cloud.google.com/blog/topics/customers/how-google-and-mayo-clinic-will-transform-the-future-of-healthcare

Today

- Class updates
  - Updated schedule, reading list, and critique assignments
  - Upcoming proposal presentations and writeup
- Primer on the rest of the IoT stack
  - Devices
  - Wireless
  - Cloud
- Clinical monitoring

Proposal Presentation

- In class on **9/19**
- **6 min** per group
  - 5-min talk + 1-min Q&A
  - 4 slides
  - Rehearse in advance
- Your **elevator pitch!**
- Email TA your slides before class

Written Proposal

- One proposal/team, one page
  - Team members
  - Concise description of project
  - Responsibilities of each member
  - Equipment needed

- Written proposal due: **9/19, 11:59pm**

The IoT Stack

CPSL Cyber-Physical Systems Laboratory

- **Devices**: processor + sensors + radio, embedded OS
- **Wireless**: connect millions of devices to the Internet
- **Cloud**: scalable real-time data processing
- **Analytics**: make sense of sensor data

- This course will focus on analytics (AI) in medicine.

- Next, a primer on the rest of the stack…

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Embedded Hardware Platforms

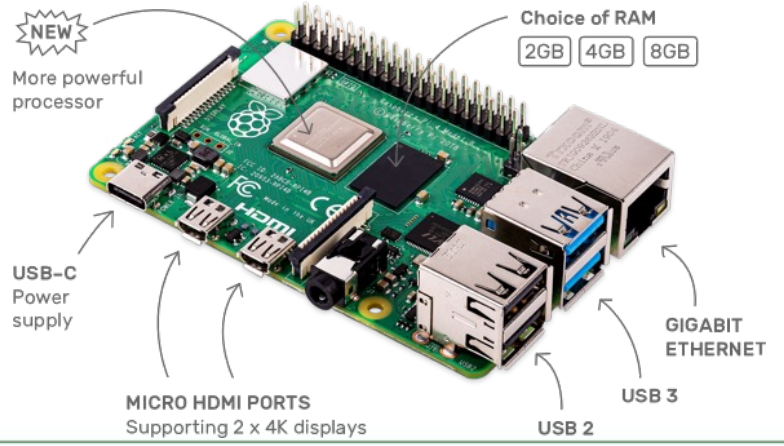
TelosB

- TI MSP430 microcontroller, 4/8 MHz, 8 bit
- Memory: 10KB data, 48 KB program
- IEEE 802.15.4 radio: max 250 Kbps

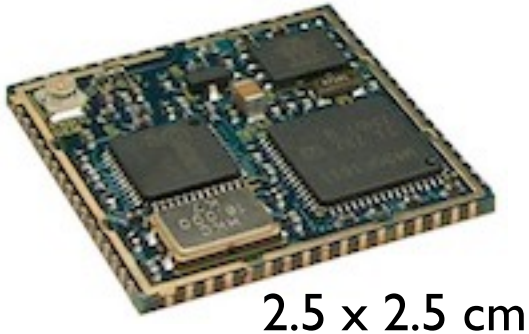


Raspberry Pi 4

- Quad core Cortex-A72 64-bit SoC, 1.5GHz
- 2GB-8GB SDRAM
- IEEE 802.11ac wireless, Bluetooth 5.0, BLE
- Gigabit Ethernet



Epic Core



2.5 x 2.5 cm

RAM 10 KB

Flash 48 KB

TI MSP430

Clock 4/8 MHz

CC2420 radio
802.15.4
6LoWPAN/IPv6

I/O (some shared)
8 ADC (12 bit)
2 DAC (12 bit)
1 I2C
1 JTAG
1 1-Wire
2 SPI
2 UART

8 general, 8 interrupt, and 5 special pin connectors

3 V

Unique hardware ID

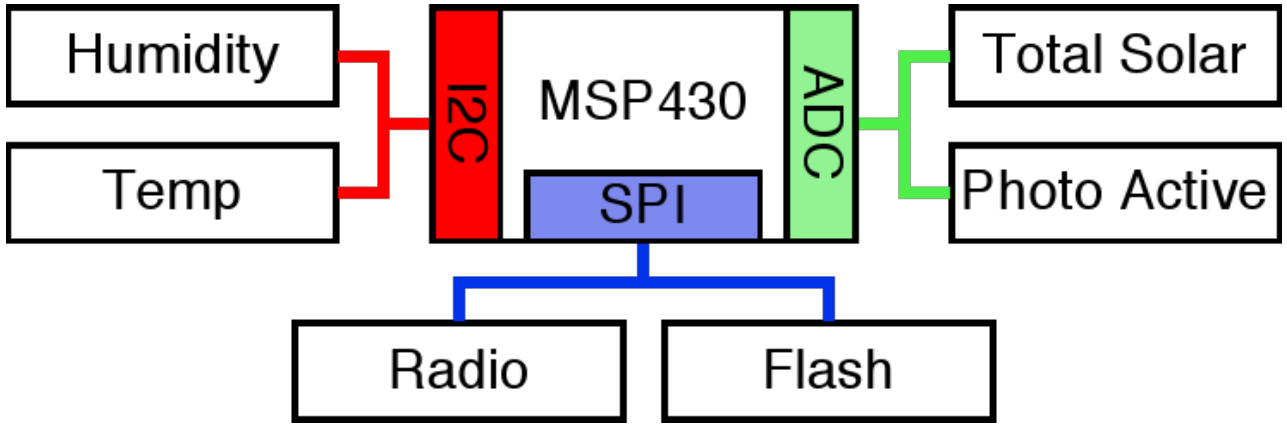
16 MB
Flash memory

Typical sleep current 9µA at 3V, radio active ~20mA

TelosB: Wireless Sensor

- Six major I/O devices
- Possible Concurrency
  - I^2C, SPI, ADC
- Energy Management
  - Turn peripherals on only when needed
  - Turn off otherwise





Power!

	Active	Idle	Sleep
CPU	5 mA	2 mA	5 µA
Radio	7 mA (TX)	4.5 mA (RX)	5 µA
EE-Prom	3 mA	0	0
LED's	4 mA	0	0
Photo Diode	200 µA	0	0
Temperature	200 µA	0	0

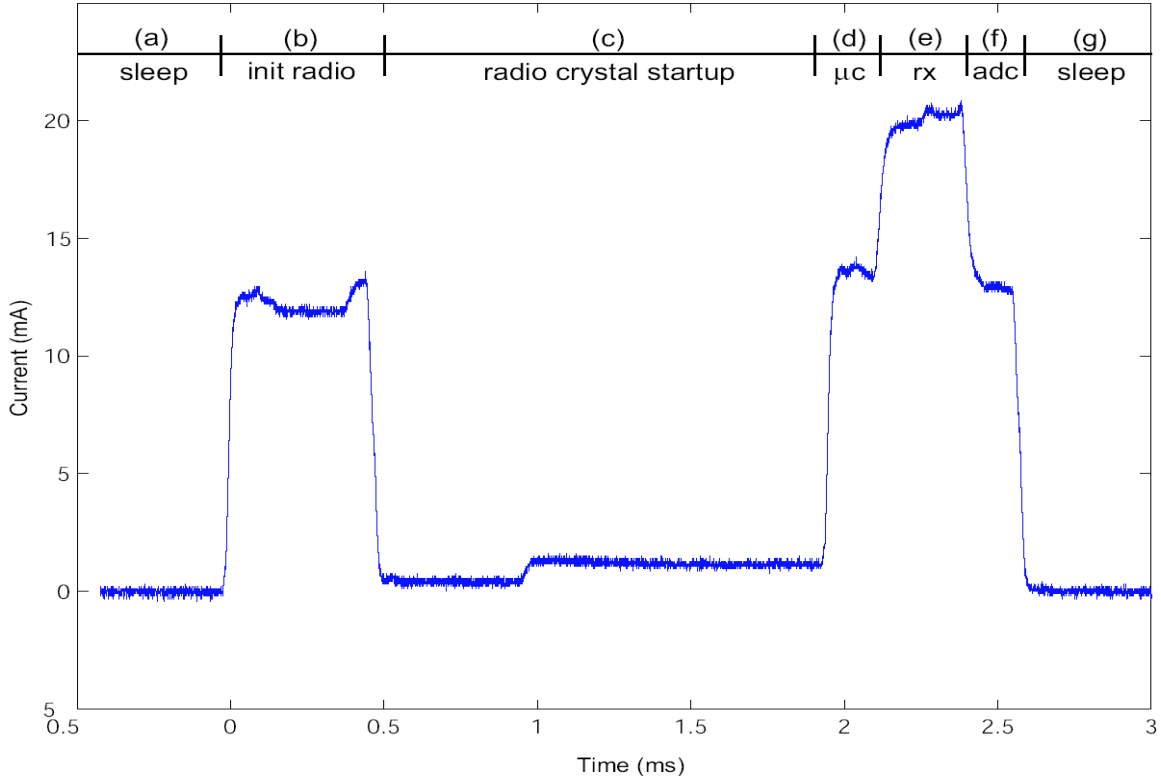


Panasonic
CR2354
560 mAh

- Lithium battery runs for **35 hours** at peak load and **years** at minimum load!
  - That's three orders of magnitude difference!
- A one-byte transmission uses the same energy as approximately 11000 cycles of computation.

Power Management

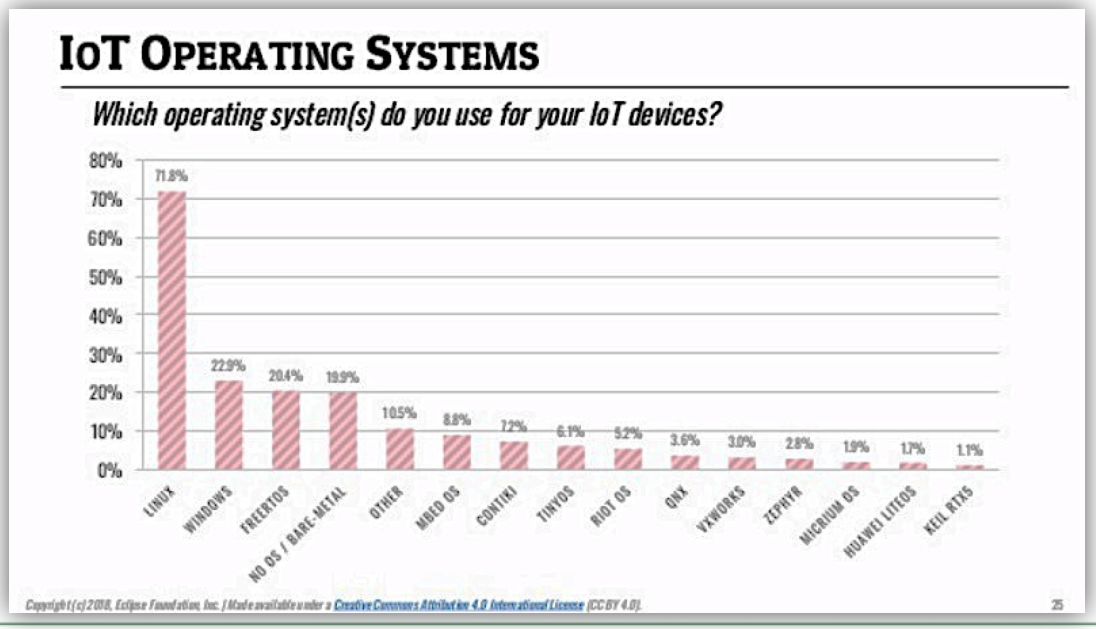
- System view when switching from sleep to active (TinyOS/TelosB)



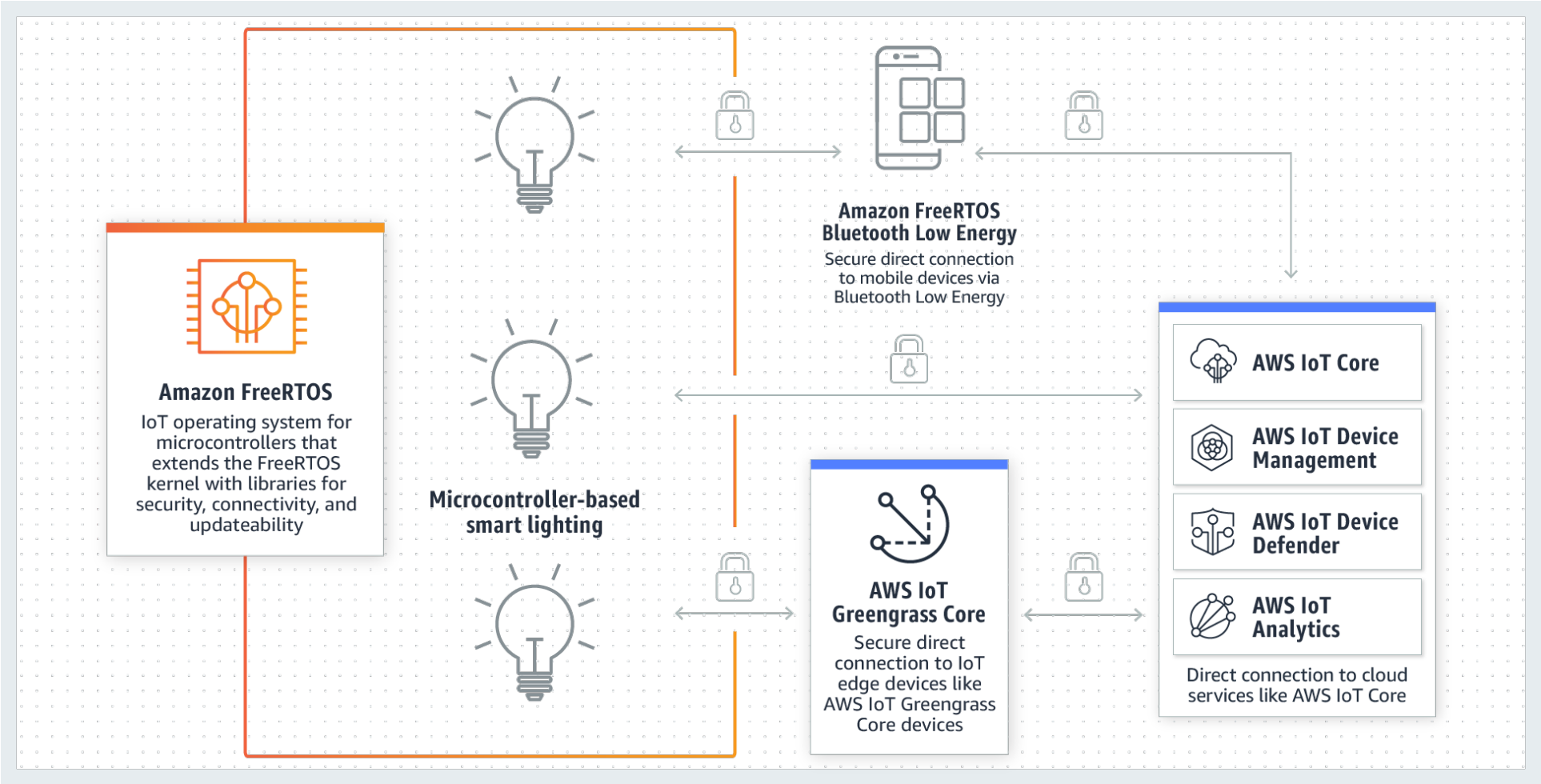
Source: J. Polastre, R. Szewczyk, C. Sharp, D. Culler. The Mote Revolution: Low Power Wireless Sensor Network Devices. In Hot Chips 16, 2004.

IoT OS

- **Linux**
- Windows 10 IoT Core: Windows 10 optimized for ARM and x86/x64.
- Amazon FreeRTOS: open-source FreeRTOS kernel + libraries to securely connect devices to AWS cloud services.
- Arm Mbed: open-source OS for Arm Cortex-M microcontrollers.
- Contiki: open-source, multi-threaded OS.



Amazon FreeRTOS



https://aws.amazon.com/freertos

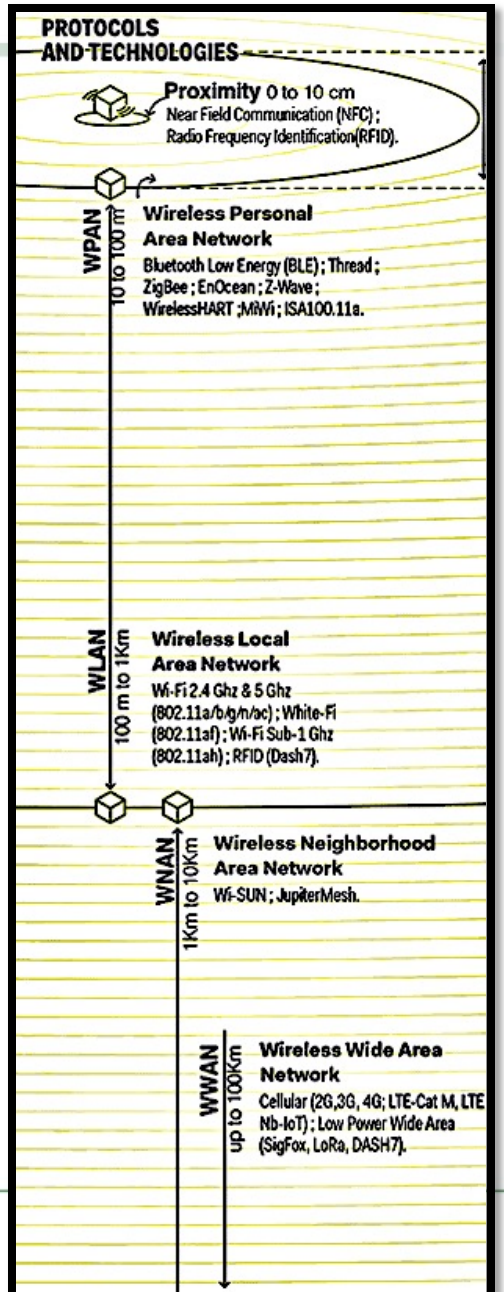
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IoT Wireless Technologies

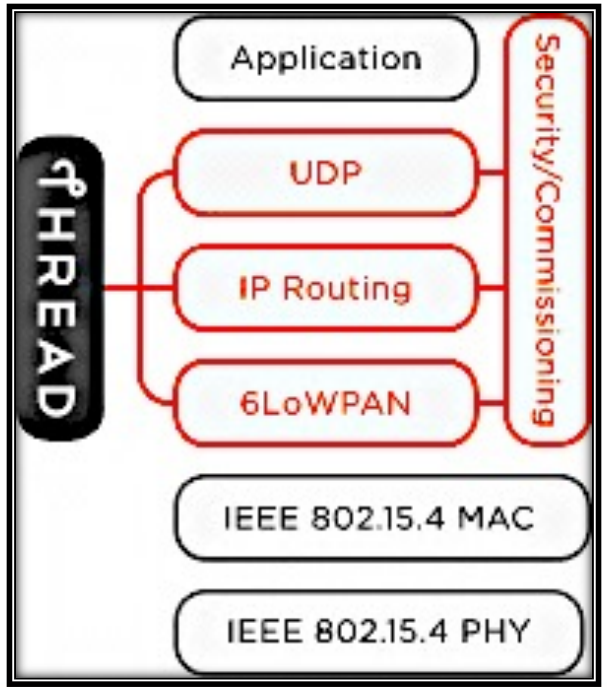
- Wireless Personal Area Networks (WPAN)
  - Bluetooth Low Energy (BLE)
  - IEEE 802.15.4 radio: Thread, Zigbee, WirelessHART
- Wireless Local Area Networks (WLAN)
  - Different versions of WiFi
- Wireless Wide Area Networks (WWAN)
  - Cellular: NB-IoT
  - Low Power Wide Area (LPWA): LoRa, Sidewalk
- Choice of wireless technology depends on range, data rate, latency, power…

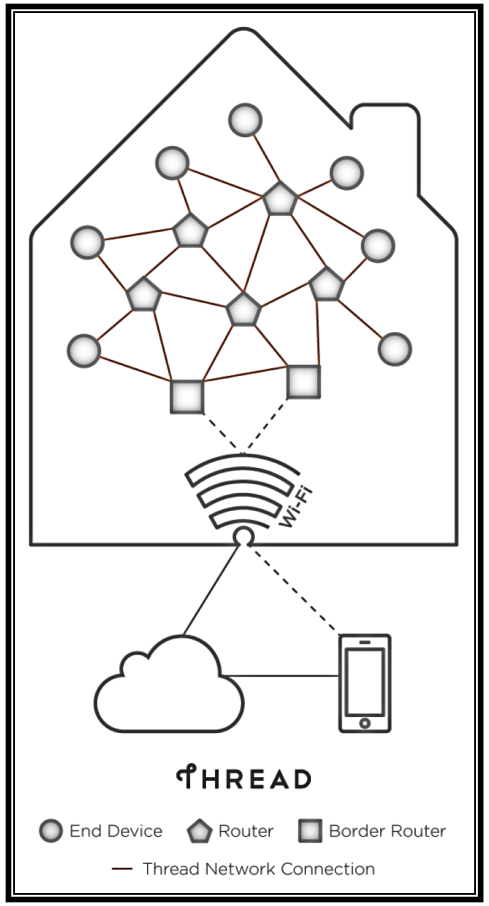


Source & Copyright
Digitize or Die IoT book

Thread: IP-based Mesh Networking

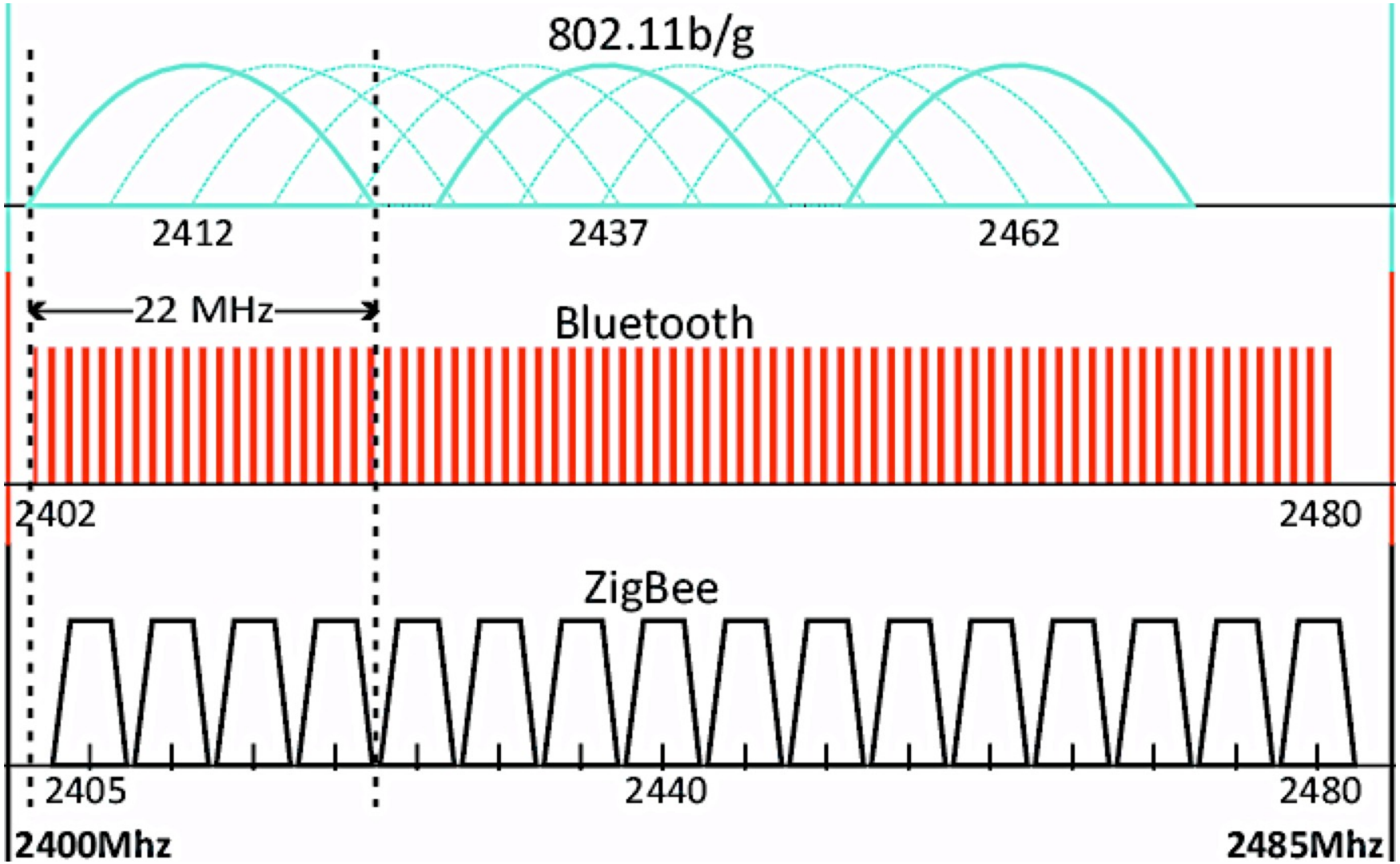
- Interoperability through IPv6
- IP protocol stack based on IEEE 802.15.4 radio
- OpenThread: open-source implementation
  - Released by Google based on Nest technology
  - https://openthread.io





Source: Thread Group
https://www.threadgroup.org

Channels in the 2.4 GHz ISM Band

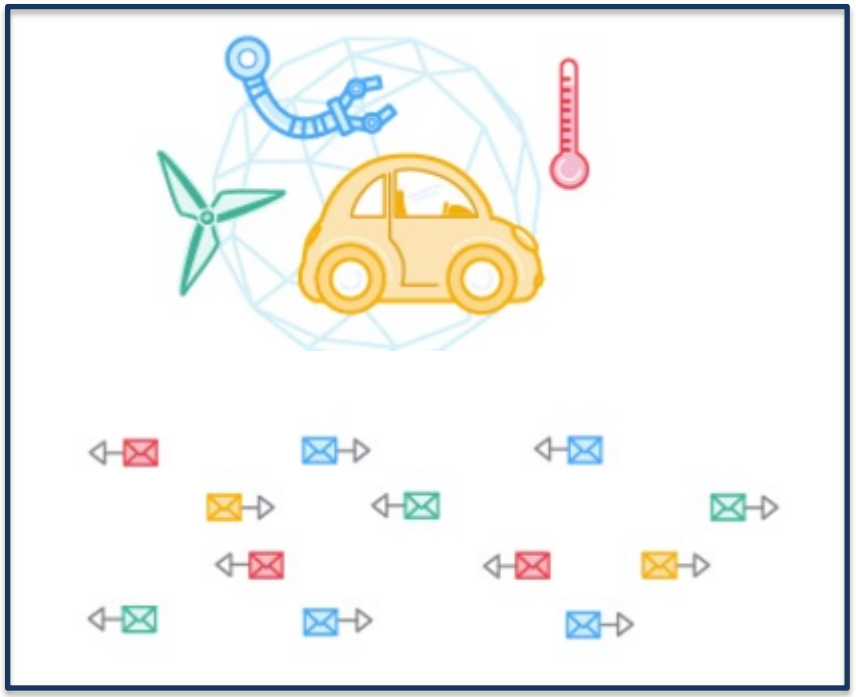


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Why IoT Cloud?

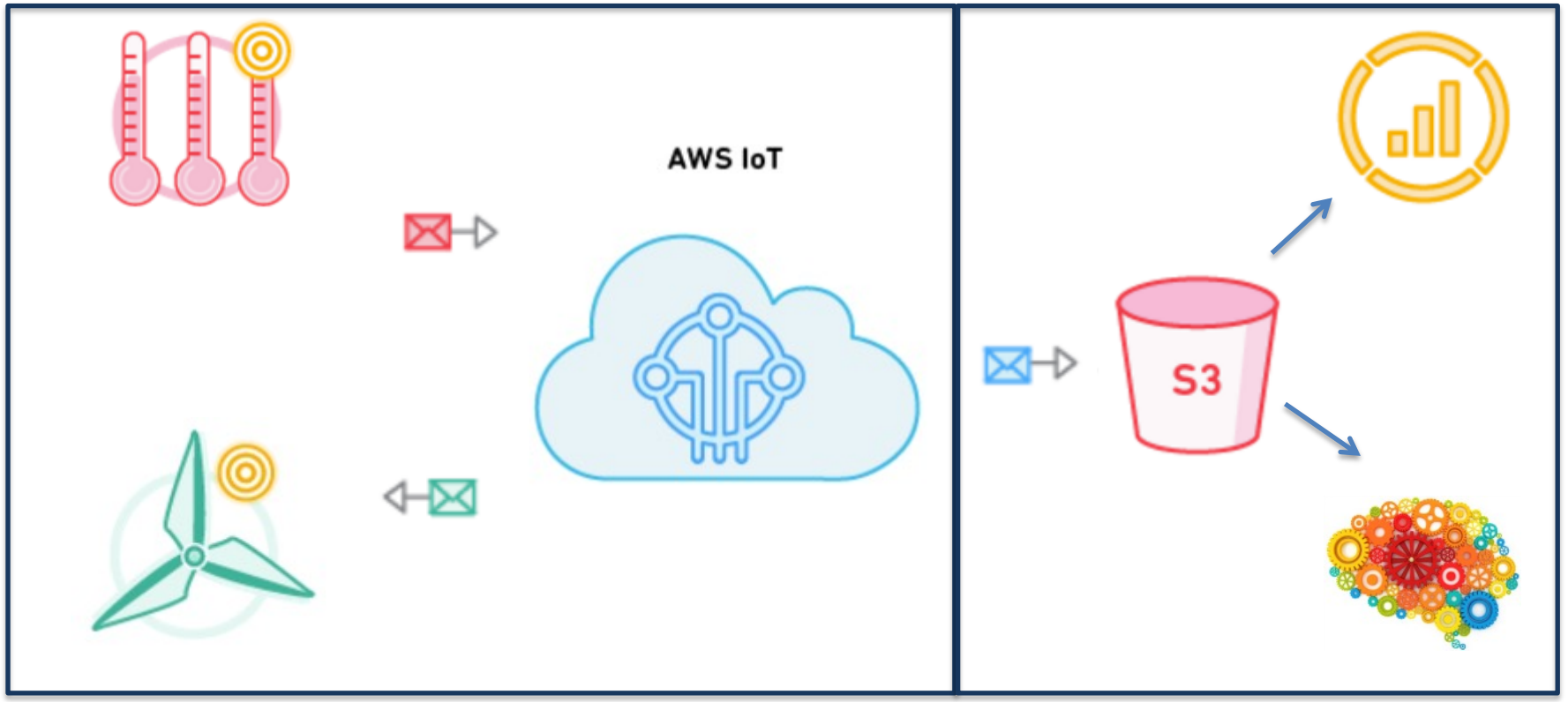
- Devices
  - Sensors, actuators
- Data and Command
  - Sensing the world
  - Give Response
- Challenge
  - United: Connected + Communication
  - Smart: Data Analytics + Strategy





Source: https://aws.amazon.com/iot-platform/
http://www.brain-smart.net/smart-brain-health-blog/page/2/#axzz4W4oSp8a6

AWS for IoT



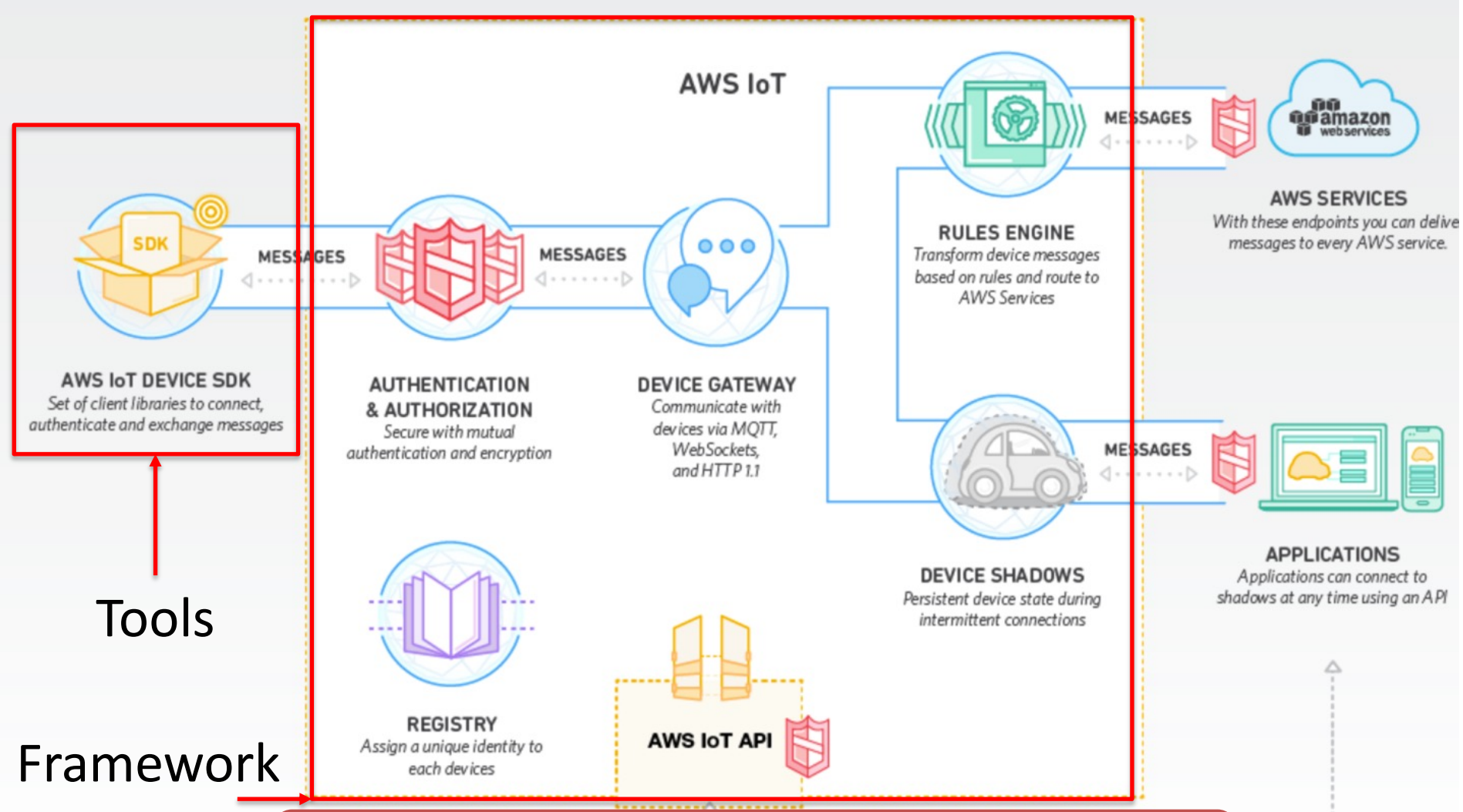
United: Connect + Communication

Stated: “Thing Shadow”

Smart: Data Storage
Machine Learning…

Source: https://aws.amazon.com/iot-platform/

AWS IoT



The essence is **MESSAGING MIDDLEWARE**
Send messages between sensors and servers…