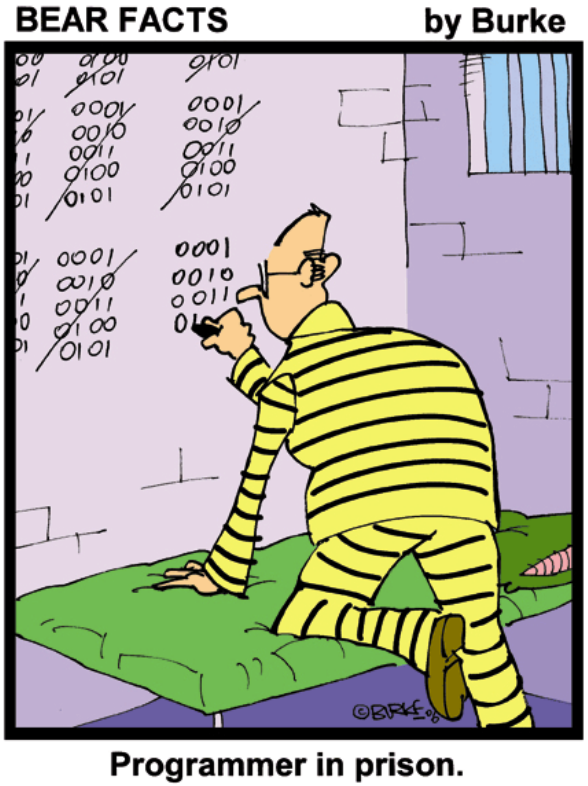
ELC 4438
Embedded Systems Design



"What is more in *Embedded System Design* beyond boring programming?"

“Software (and working with the Internet) is a good starting point.”

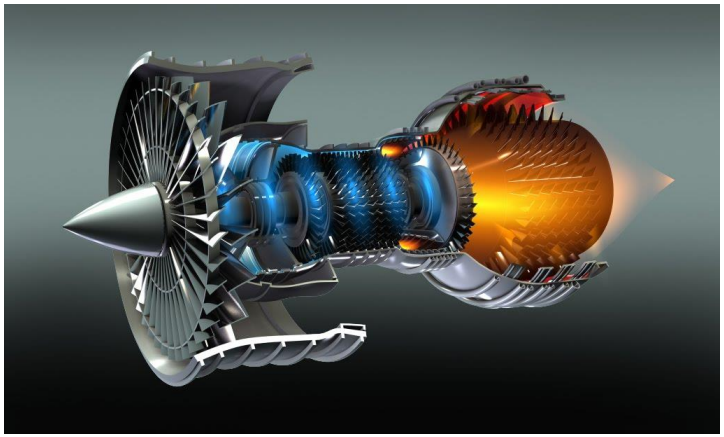
https://www.youtube.com/watch?v=ul1MINoh-z4

Engineers to create value

- Front-end Development
  - Web front-end, Flash, html5, JavaScript, etc.
- Back-end Development
  - Java, Python, PHP (Hypertext Preprocessor), .NET, C/C++/C#, VB, Delphi, Perl, Ruby, etc.
- Mobile Development
  - Android, iOS, etc.
- Hardware Development
  - PCB, Driver development, System Integration, FPGA, DSP, ARM, RF, Automaton, etc.
- Design
- Data Analysis

Try to avoid “low threshold” – Low barriers to entry.

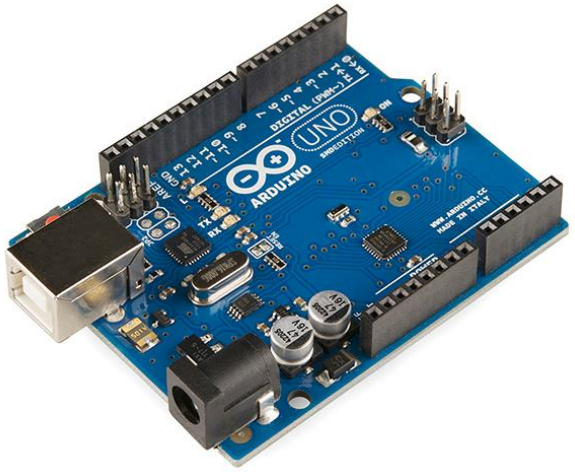
You are an engineer – You are the engine!



Questions that we engineers should ask ourselves in what we do:

- Value and contribution?
- What is needed? How to make it better?
- What is the root of the problem I try to solve?
- The Innovation. What aspects are original, unusual, novel, disruptive, or transformative compared to the current state of the art?
- What are the resources you expect will be needed to implement your approach?

Resource: Open-Source Software and Hardware



open source hardware

TM
open source

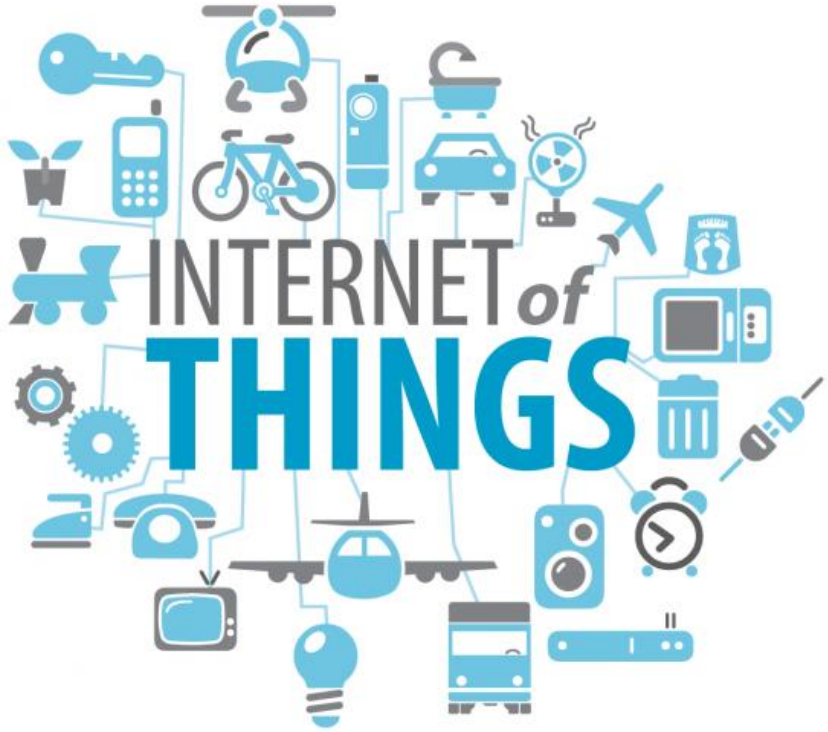
- Sharing creates enormous economic value [1] and can drive a high return on investment for investors [2].

[1] Pearce, J.M. (2015) Quantifying the Value of Open Source Hardware Development. *Modern Economy*, **6**, 1-11.
[2] Joshua M. Pearce. (2015) Return on Investment for Open Source Hardware Development. *Science and Public Policy*.

Industrie 4.0

Industry automation which draws together Cyber-Physical Systems, the Internet of Things, and the Internet of Services.

Internet of Things (IoT)



Experts estimate that the IoT will consist of almost 50 billion objects by 2020[1].

[1] Dave Evans (April 2011). "The Internet of Things: How the Next Evolution of the Internet Is Changing Everything" (PDF).*Cisco*. Retrieved 4 September 2015.

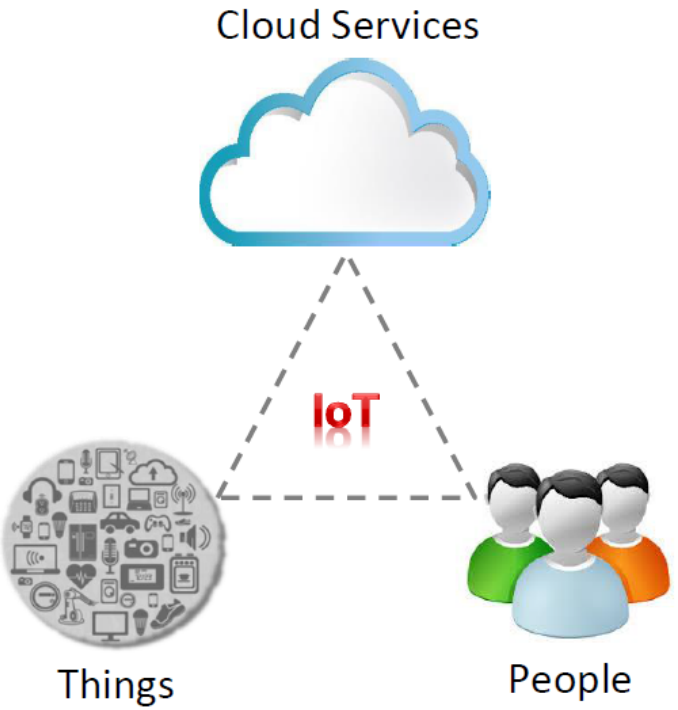
IoT

What is the IoT ?

Things, people and cloud services getting connected via the Internet to enable new use cases and business models

How is IoT different than M2M?

- M2M focused on connecting machines – mainly proprietary closed systems
- IoT is about harmonizing the way humans and machines connect using common public services



IoT - Why now?

- More products are adding intelligence with MCUs to support more sophisticated control
- Adding connectivity is getting easier & cheaper
- Low-power semiconductors allow for more battery-powered applications
- Wi-Fi and internet access broadly available
- Tablets, PCs and Smartphones broadly available – can be leveraged as a gateway
- Connectivity brings control, sensing & ability to update system software over the internet

IoT is an enabling technology

Wearables
- Entertainment
- Fitness
- Smart watch
- Location and tracking

Building & Home Automation
- Access control
- Light & temp control
- Energy optimization
- Predictive maintenance
- Connected appliances

Smart Cities
- Residential E-meters
- Smart street lights
- Pipeline leak detection
- Traffic control
- Surveillance cameras
- Centralized and integrated system control

Smart Manufacturing
- Flow optimization
- Real time inventory
- Asset tracking
- Employee safety
- Predictive maintenance
- Firmware updates

Health Care
- Remote monitoring
- Ambulance telemetry
- Drugs tracking
- Hospital asset tracking
- Access control
- Predictive maintenance

Automotive
- Infotainment
- Wire replacement
- Telemetry
- Predictive maintenance
- C2C and C2I

IoT challenges

Sensing a complex environment

position/motion material composition
proximity gas current/power
temperature **environment** light humidity
chemical
occupancy **biosensing** pressure

Multiple connectivity options

Wi Fi
6LoWPAN
Bluetooth SMART

Power is critical

Security is a must

The IoT is complex

Connecting to the cloud

Sensing

Sensing technologies that address a wide variety of applications


Biosensing


Humidity


Position / motion


Chemical


Light


Pressure


Current / power


Material composition

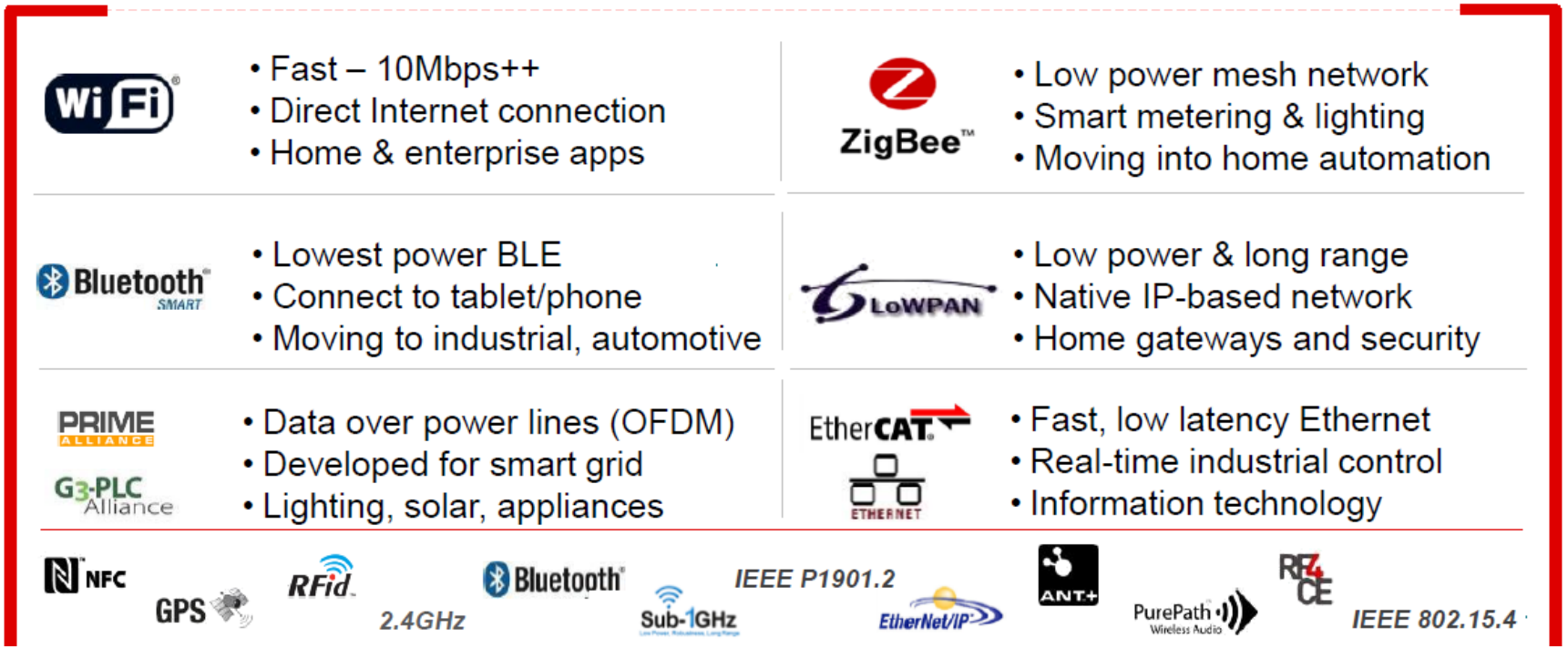

Proximity


Gas

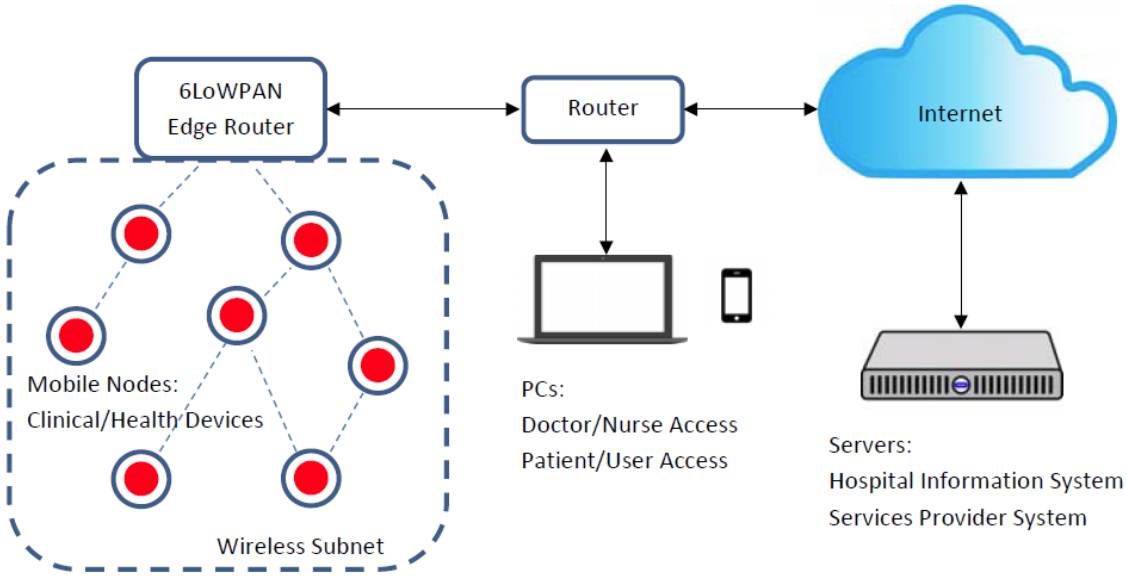

Occupancy

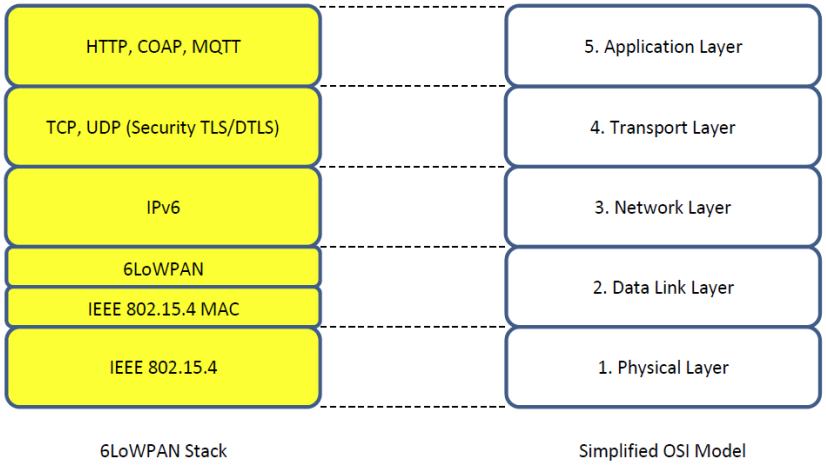

Temperature

Connectivity



6LoWPAN (IPv6 over Low-Power Wireless Personal Area Networks)

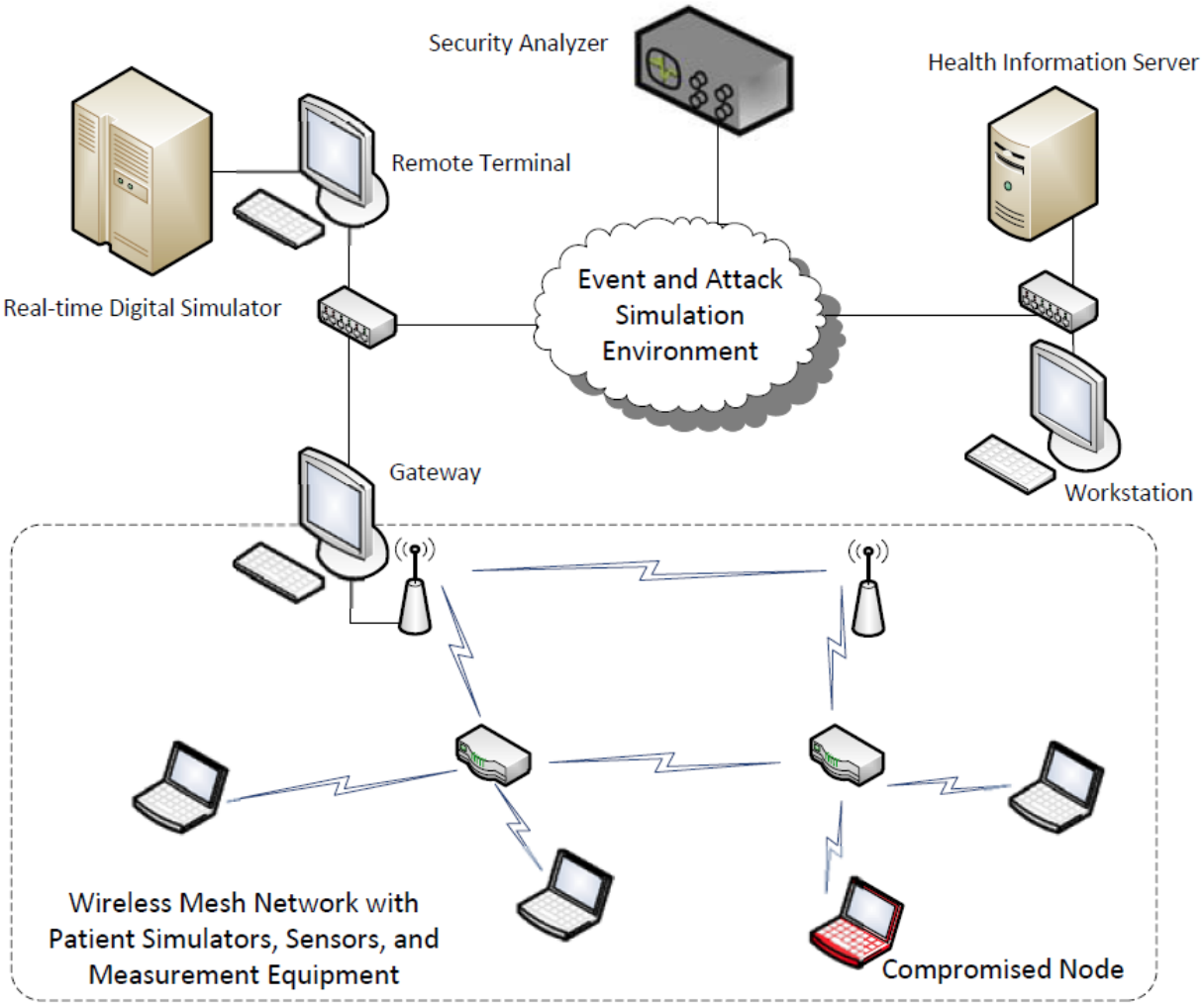




IoT for ubiquitous healthcare

The 6LoWPAN stack and the corresponding OSI model

6LoWPAN Lab Testbed



Low-power

Days to years of battery operation or harvested-powered devices

Power management & precision analog ICs

Low-power microcontrollers

MSP430™ MCU

Tiva™-C MCU

Low-power wireless connectivity

Wi-Fi

Bluetooth

ZigBee

Sub-1 GHz

Wi-Fi-based sensors running on 2xAA batteries over 1 year
ZigBee/6LoWPAN-based light switch running on coin cell battery for 10 years

Harvesting power and stretching battery life

Light  Vibration  Thermal  RF 

Security

Security solutions to prevent, detect and respond to unintended or malicious behavior

Hardware

Symmetric cryptography

Software

Authentication & anti-cloning

Connectivity

IP protection

Tamper protection

Protecting manufacturers' and consumers' devices, solutions and services

Connection to the Cloud

New open ecosystem of IoT cloud service providers

IBM

xively by LogMeIn

ARM

spark

ARRAYENT

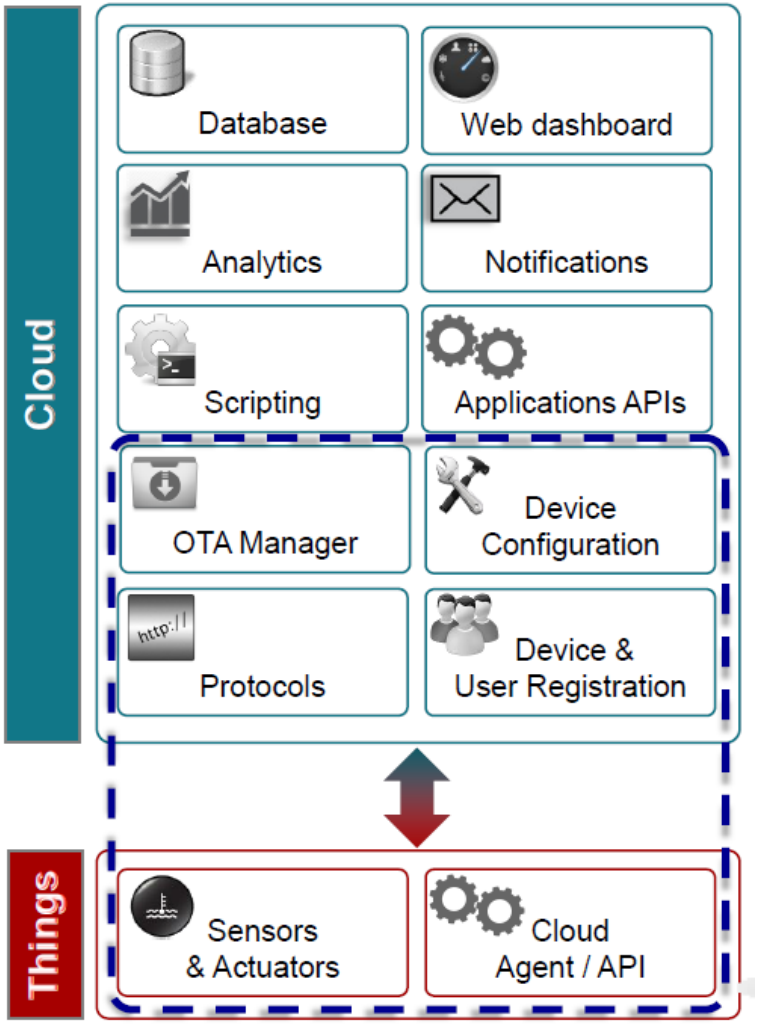
2lemetry

thingsquare

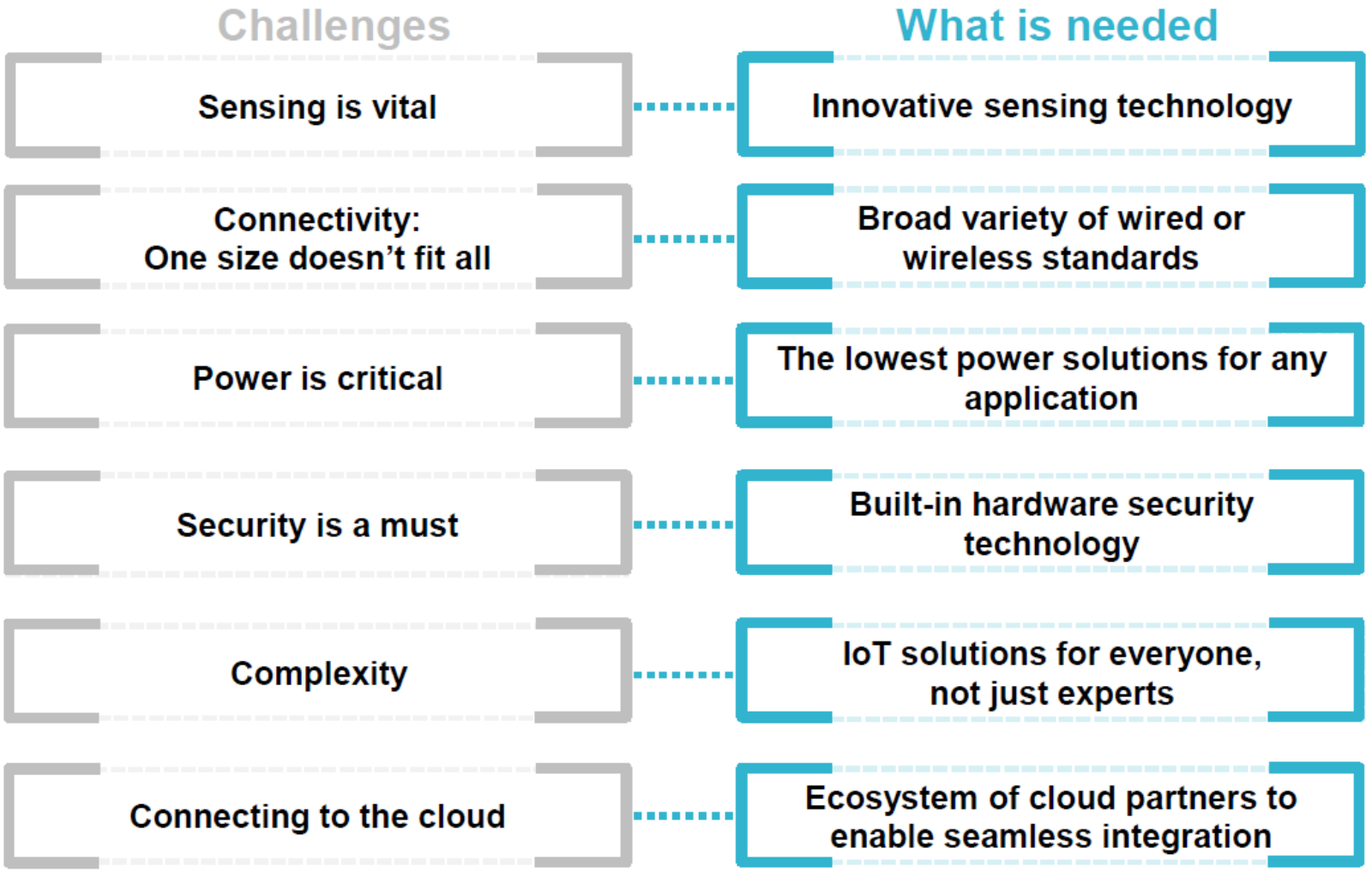
EXOSITE

Faster time to market of new devices and services based on TI's IoT silicon solutions.
Meets individual needs of manufacturers.

Typical IoT cloud services



IoT in 2020?


Challenges
What is needed
Sensing is vital
Innovative sensing technology
Connectivity:
One size doesn't fit all
Broad variety of wired or wireless standards
Power is critical
The lowest power solutions for any application
Security is a must
Built-in hardware security technology
Complexity
IoT solutions for everyone, not just experts
Connecting to the cloud
Ecosystem of cloud partners to enable seamless integration

We engineers need an entrepreneurial spirit

- Does it work? → Does it create value?
- System life-cycle, adaptation to the needs - Gradually modify you designs according to customer needs
- Entrepreneurship is an experiment…that failure is acceptable and learning from failure is important.

"You only have to be right once!"

More questions that we engineers should ask ourselves:

- The Customer. The expected customer for your innovation. What customer needs or market pain points are you addressing?
- The Value Proposition. What are the benefits to the customer of your innovation? What is the key differentiator of your company or technology?
- The Innovation. What aspects are original, unusual, novel, disruptive, or transformative compared to the current state of the art?
- What are the market and addressable market for the innovation? What are the business economics and market drivers in the target industry?
- Market opportunity? Business model? Competition?
- What are the key risks in bringing your innovation to market?
- What is your commercialization approach? Potential economic benefits associated with your innovation?
- What are the resources you expect will be needed to implement your commercialization approach?

Resource

- Crowdfunding?

KICKSTARTER

indiegogo

crowdfunder

ROCKETHUB
The world's crowdfunding machine.

Small Business Innovation Research (SBIR)

https://www.sbir.gov/