“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

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

Industrie 4.0

Industry automation which draws together Cyber-Physical Systems, the Internet of Things, and the Internet of Services.
Experts estimate that the IoT will consist of almost 50 billion objects by 2020[1].

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
  - chemical
  - environment
  - light
  - humidity
  - occupancy
  - biosensing
  - pressure

- Multiple connectivity options
  - WiFi
  - Z
  - LoWPAN
  - Bluetooth

- Power is critical

- Security is a must

- The IoT is complex

- Connecting to the cloud
Sensing technologies that address a wide variety of applications

- Biosensing
- Chemical
- Current / power
- Gas
- Humidity
- Light
- Material composition
- Occupancy
- Position / motion
- Pressure
- Proximity
- Temperature
# Connectivity

<table>
<thead>
<tr>
<th>WiFi</th>
<th>ZigBee™</th>
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<tbody>
<tr>
<td>- Fast – 10Mbps++</td>
<td></td>
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<tr>
<td>- Direct Internet connection</td>
<td></td>
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<tr>
<td>- Home &amp; enterprise apps</td>
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<tr>
<td></td>
<td>- Low power mesh network</td>
</tr>
<tr>
<td></td>
<td>- Smart metering &amp; lighting</td>
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<tr>
<td></td>
<td>- Moving into home automation</td>
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<table>
<thead>
<tr>
<th>Bluetooth® SMART</th>
<th>LoWPAN</th>
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<tbody>
<tr>
<td>- Lowest power BLE</td>
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<tr>
<td>- Connect to tablet/phone</td>
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<tr>
<td>- Moving to industrial, automotive</td>
<td></td>
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<tr>
<td></td>
<td>- Low power &amp; long range</td>
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<tr>
<td></td>
<td>- Native IP-based network</td>
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<td></td>
<td>- Home gateways and security</td>
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<thead>
<tr>
<th>PRIME Alliance</th>
<th>EtherCAT.™</th>
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<tbody>
<tr>
<td>- Data over power lines (OFDM)</td>
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<tr>
<td>- Developed for smart grid</td>
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<tr>
<td>- Lighting, solar, appliances</td>
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<td></td>
<td>- Fast, low latency Ethernet</td>
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<td>- Real-time industrial control</td>
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<td>- Information technology</td>
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### Wireless Technologies
- **NFC**
- **GPS**
- **RFid.**
- **2.4GHz**
- **Sub-1GHz**
- **IEEE P1901.2**
- **EtherNet/IP**
- **IEEE 802.15.4**
- **Antenna**
- **PurePath™**
- **RFCE**
6LoWPAN (IPv6 over Low-Power Wireless Personal Area Networks)

The 6LoWPAN stack and the corresponding OSI model

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

Low-power wireless connectivity

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

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

- Sensing is vital
- Connectivity: One size doesn’t fit all
- Power is critical
- Security is a must
- Complexity
- Connecting to the cloud

What is needed

- Innovative sensing technology
- Broad variety of wired or wireless standards
- The lowest power solutions for any application
- Built-in hardware security technology
- IoT solutions for everyone, not just experts
- 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 your 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?
Small Business Innovation Research (SBIR)

https://www.sbir.gov/