IOT TECHNOLOGY OVERVIEW SELECTION CRITERIA

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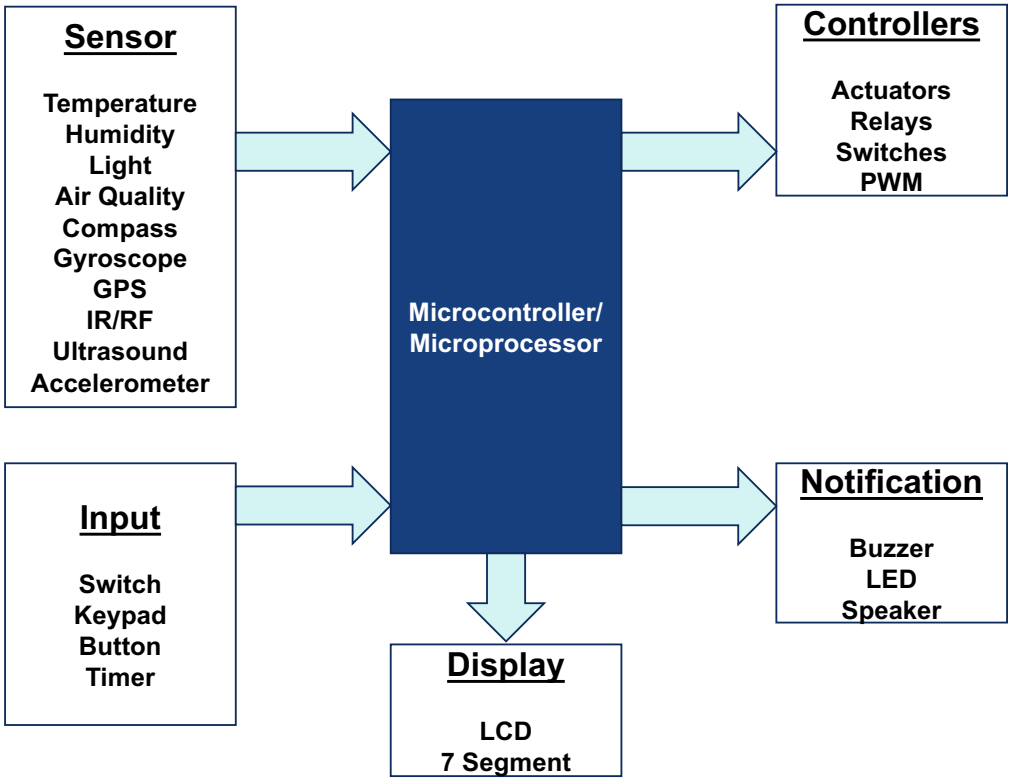
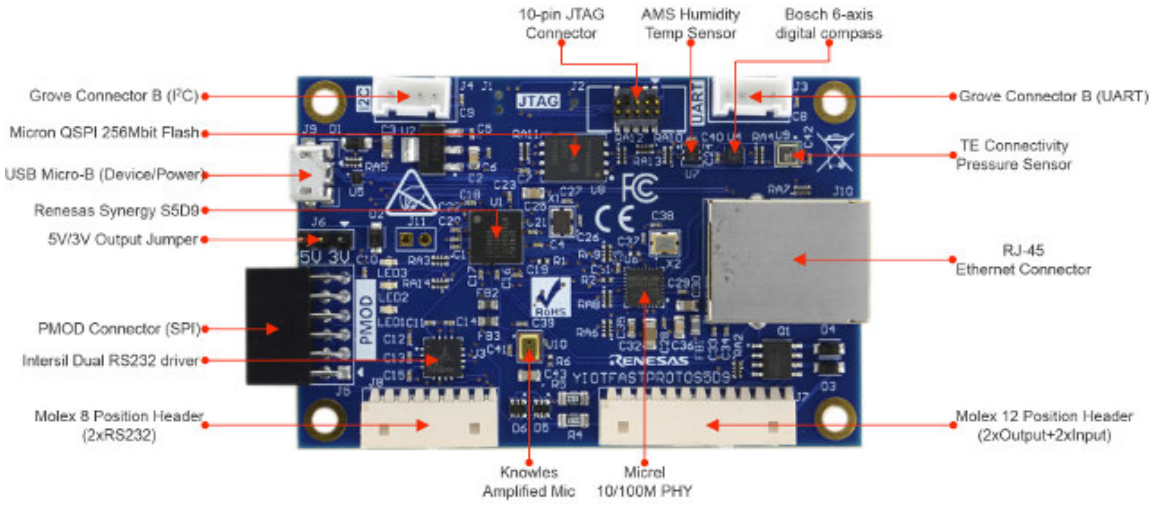
- What is IoT?
  - Industrial Grade Sensor BoardEmbedded System
- Causes of IoT obsolescence & resistance
- Future proof IoT infrastructure
- Stages of IoT
  - Gather, process & deliver
  - Viewpoints
- Reference
  - Architecture
  - Model

- IoT Blueprint
- Architecture approaches
- Technology Grouping
  - Industrial Grade Embedded Board
  - Operating System
  - Sensors & Actuators
  - Gateways
  - Protocols & Network technologies
  - Programming languages
  - Platforms
  - Security
- Summary - Wrapping Up

What is IoT? Embedded System



Industrial Grade Sensor Board



https://www.cnx-software.com/tag/sensor/

Why embedded system?

1.
2.
3.
4.

Ask yourself

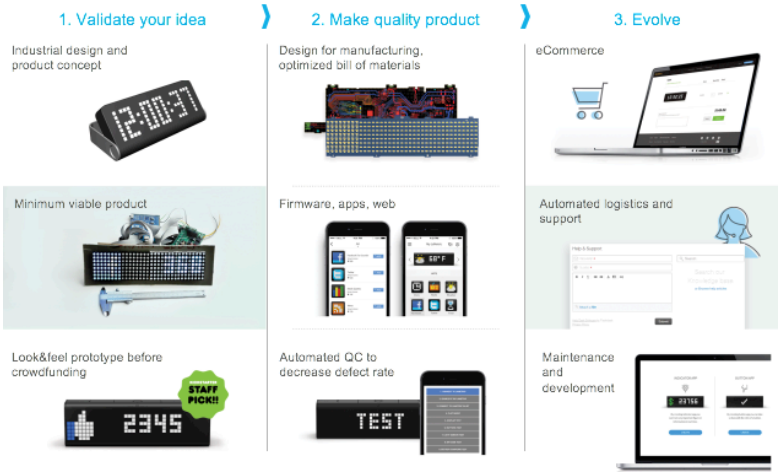
- Are mobile phones IoT devices?
- What are Smart objects?

Causes of IoT solutions – Obsolescence and Resistance

- Disparate/Outdated technology
- Evolving Use Cases
- Supplier Decision
- Regulation and Legal
- Security and Safety
- Market Acceptance
- Poor Economics
- Lack of Support/Expertise

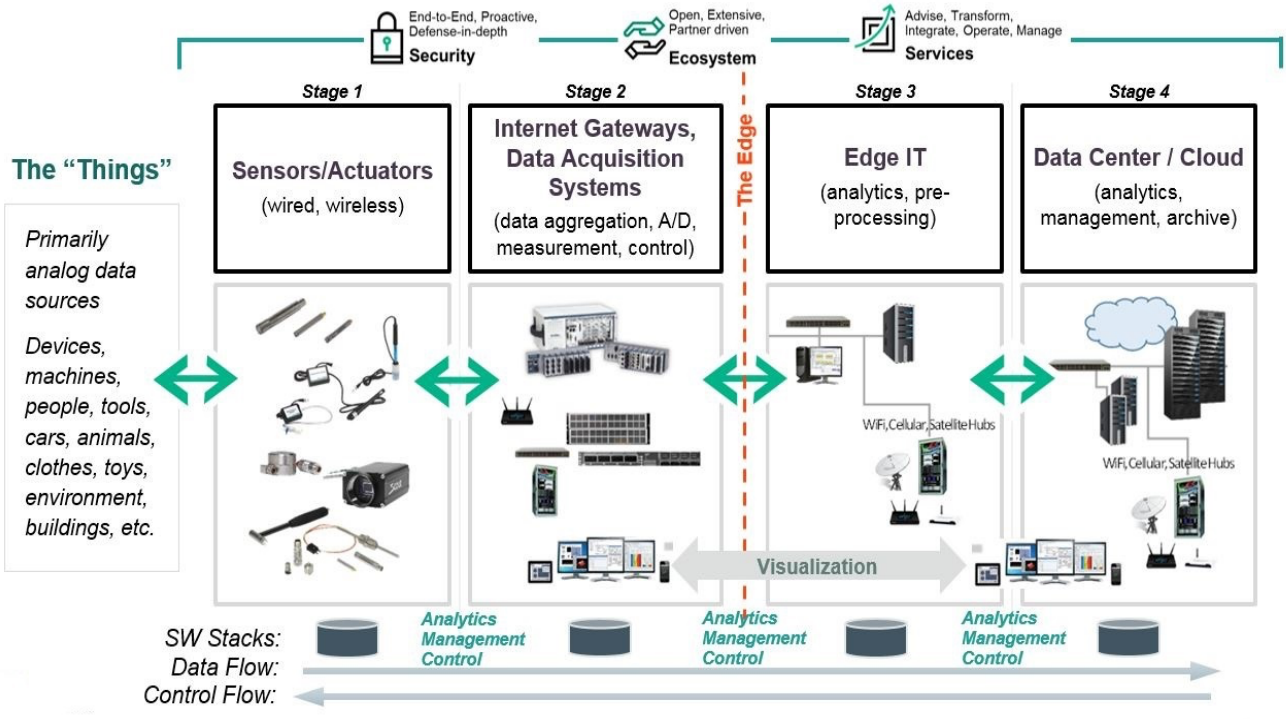
Future Proof Infrastructure

- Usability
- Scalability
- Maintainability
- Changeability
- Economical



https://www.slideshare.net/LembergSolutions/iot-development-services-lemberg-solutions

4 stages of IoT solution



https://techbeacon.com/4-stages-iot-architecture

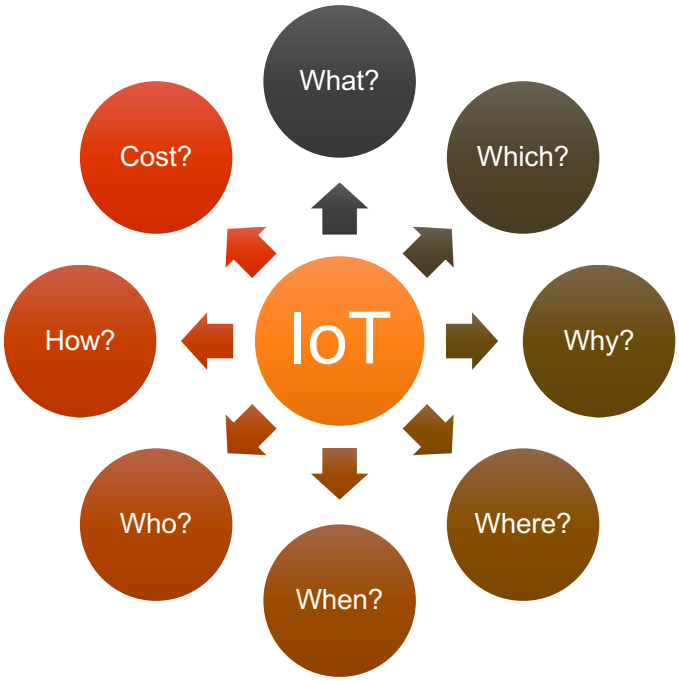
Gather, process and deliver

Sensor Layer	Network Layer	Application Layer
Objective: collect information	Objective: transmit and process information	Objective: deliver information to users

Collection		Connectivity		Processing		Output
Devices	Device Mgmt.	Networking	Security	Analytics	Platform	Applications
➢ RFID ➢ Sensors ➢ Actuators ➢ Power supply	➢ Registration ➢ Provisioning ➢ Asset mgmt. ➢ Identity ➢ Security	➢ M2M ➢ Input network ➢ Node processing ➢ Output network	➢ Authen-tication ➢ Identity mgmt. ➢ Privacy	➢ Aggregation ➢ Integration ➢ Analytics	➢ App development ➢ Storage ➢ App Management ➢ App	➢ Platforms ➢ Visualization ➢ Automation ➢ Event processing ➢ Monitoring ➢ Diagnostics ➢ Logistics ➢ Vertically-focused apps

Openview 2015

Viewpoints



Reference Model

Database
Repository that stores the important data sets

External interfaces
APIs, SDKs and gateways that act as interfaces for 3rd party systems (e.g., ERP, CRM)

Analytics
Algorithms for advanced calculations and machine learning

Additional tools
Further development tools (e.g., app prototyping, access management, reporting)

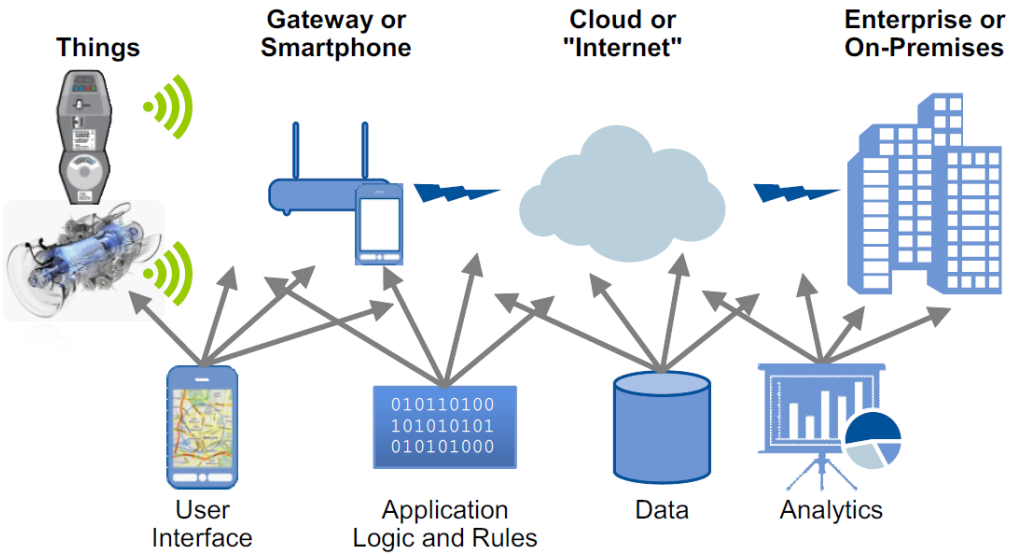
Data visualization
Graphical depiction of (real-time) sensor data

Processing & action management
Rule engine that allows for (real-time) actions based on incoming sensor & device data

Device management
Backend tool for the management of device status, remote software deployment and updates

Connectivity & Normalization
Agents and libraries that ensure constant object connectivity and harmonized data formats

Build A Blueprint



GUI, application logic, data and analytics can be placed anywhere

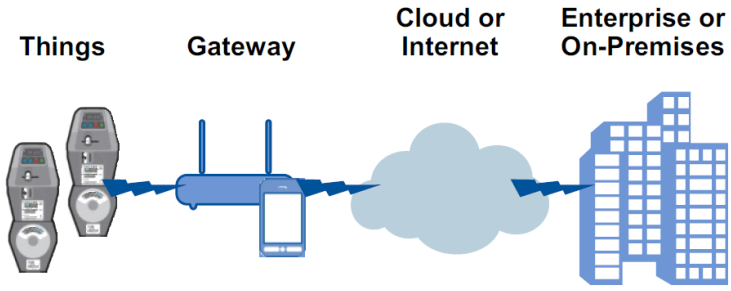
GUI = graphical user interface

Source: Gartner (September 2014)

Architectural Approaches

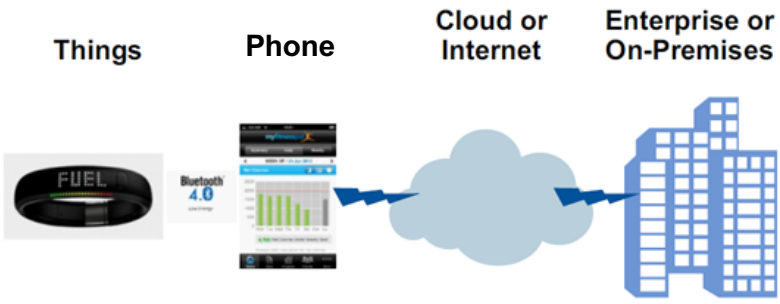
1. *Gateway-Centric architecture*
2. *Smartphone-Centric architecture*
3. *Thing-Centric architecture*
4. *Cloud-Centric architecture*
5. *Enterprise-Centric architecture*

Gateway-Centric Architecture



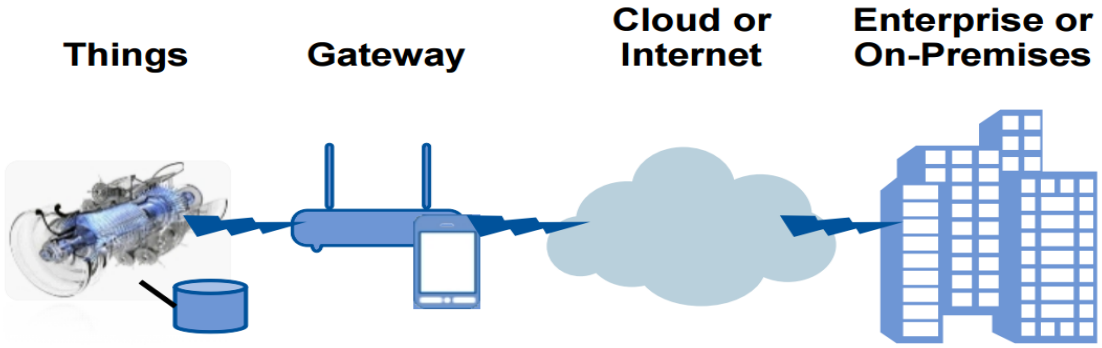
- act as the connector hub for things
  - provide security capability to connected things
  - control what data to be sent to Internet
  - provide an uniform face to the next tier
  - Converge different data standards and wireless protocols
  - link legacy equipment
- reduce the cost and complexity on the edge devices
  - aggregation and processing

Smartphone-Centric architecture



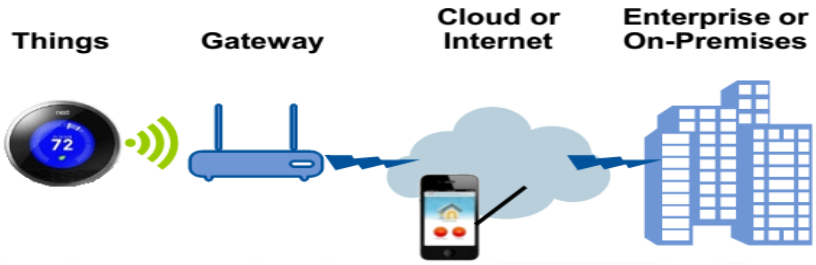
- smartphone acting as a gateway
  - Internet connectivity
  - Mobility
  - Sufficient computing power
- smartphone required for full functionality and connectivity
- security of the things depends on the security of the phone

Thing-Centric Architecture



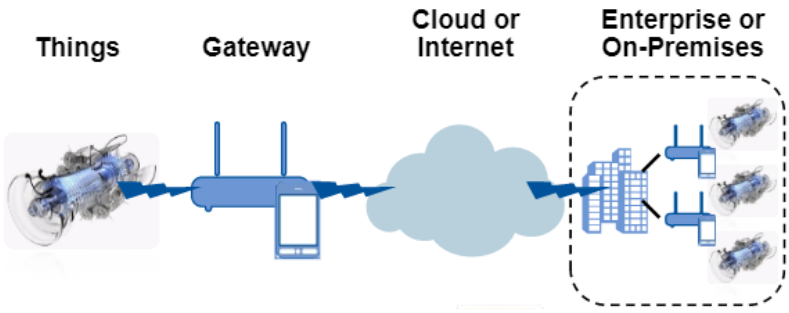
- Real-time functionality and response
  - Local resources and immediate
- connectivity is problematic or not desired
  - not relying on the Internet for resources, trigger or actions (make things independent)
  - more security and privacy
  - saves on communications costs

Cloud-Centric Architecture



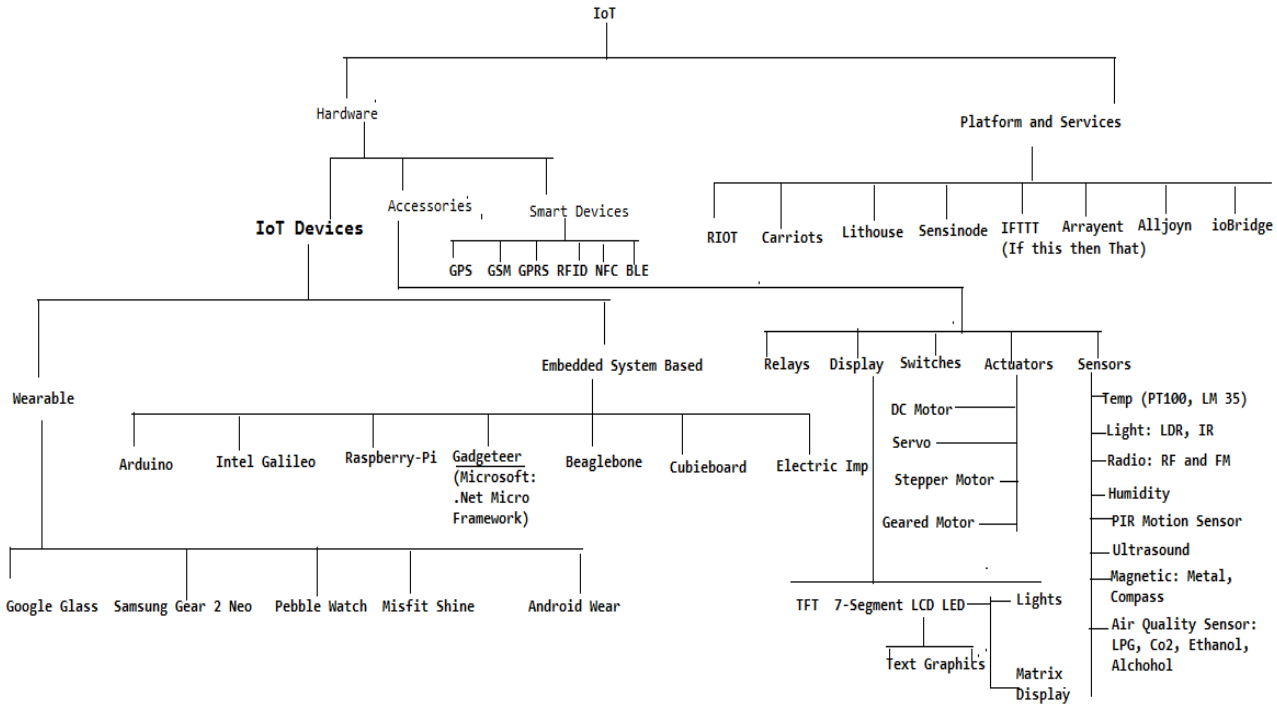
- Benefits of cloud computing
- Minimize cost and complexity of implementation
  - Shift in focus from thing to cloud
- Centralized approach
  - network-level smartness

Enterprise-Centric Architecture



- on-premises and in close proximity
  - enhanced real-time control and monitoring
  - better contained security and privacy
  - restricting Internet and public cloud access

Technology Grouping



Industrial Grade Embedded Board

Catalyst BT
Ultra Low Power CoM based on Intel® Atom™ SoC

CPU-301-16
Rugged, Ultra Low Power i.MX6 SBC/CoM

Catalyst CV
Ultra Low Power and Multicore CPU Module Based on Latest Intel® Atom™ N2x00 Processor

Catalyst TC
Intel® Atom™ E6xx in Small Form Factor

Catalyst LP
Low power high-performance solution based on Intel® Atom N450™ and D510™

Catalyst Module XL
Single board computer based on Intel® Atom processor for rugged applications

Catalyst FX
Flexible solution equipped with Intel® Atom™, multimedia and I/O

PROCESSOR
Core Capability & Multi-Processing

RAM MEMORY
Low Power DDR3L DRAM at 1333 MHz

STORAGE
Onboard SATA SSD & external attachment (8GB to 32GB)

NETWORK
Gigabit Ethernet LAN with manageability features

SERIAL INTERFACES
PCI Express, SPI, 12C, 12S, UART, SD, Optional SDIO

GPIO
Multiple GPIO

VIDEO
eDP/DP/HDMI/LVDS option
Format: VP8, MPEG2, H.264, VC-1, HD 1080p at 30fps, Flash and WMP support

AUDIO
High Definition Audio & low power

TPM
Optional Trusted Platform Module

TEMPERATURE
Operating from: -40° to +85°C

https://www.eurotech.com/en/products/embedded+boards

Operating System

	TinyOS	Contiki OS	RIOT OS
Availability	For older sensors, Mica family, ATMega, Telosb etc	For older and recemt sensors like Mica, Telosb	For all new sensors
Support	Support stoped	Still actively maintained	Actively maintained
Programming	nesC	Partial C	C/C++
Simulator	TOSSIM	Native emulation available	Native method
RAM/ROM	<1kb, <4kb	<2kb, <30kb	~1.5kb, ~5kb
Multithreading	No	No (Protothreads)	Yes
Modularity	No	Partial support	Yes

Sensors

For collecting information

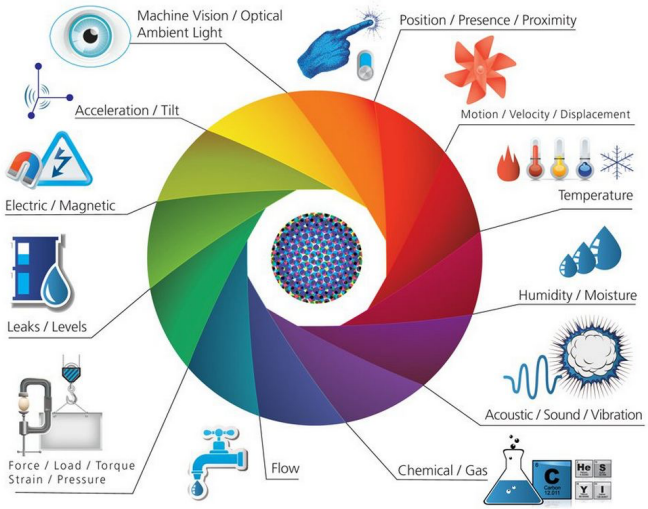
- Humidity sensor
- Level/tilt sensor
- Pressure sensor
- Temperature sensor
- Motion Sensors
- Proximity Sensors
- Optical Sensors
- Acceleration sensors
- Load sensors
- Vibration sensors
- Chemical sensors
- Flow sensors

https://en.wikipedia.org/wiki/List_of_sensors

Actuators

Translate information to action

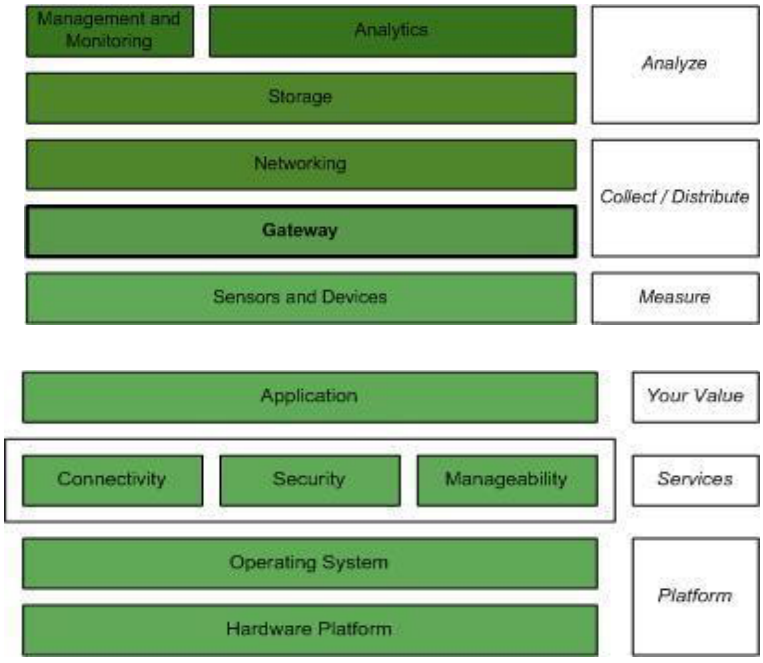
- Light emitting Diodes [LED]
- Relays
- Motors
- Linear actuators
- Lasers
- Solenoids
- Speakers
- LCD or Plasma displays



https://postscapes.com/what-exactly-is-the-internet-of-things-infographic

What is a gateway?

- Handle communication between sensors and devices and the applications that create value from their data and access



Gateways

- Turn Edge Data into Real Value
  - Near Real-Time Analytics, Local Decision-Making, and Tighter Process Controls
- Security
  - Trusted Data from Edge to Cloud
  - Protection against Costly Attacks
- Scalability
  - Varying Levels of Gateway Performance Requirements
- Manageability
  - Remote Upgrades and Services
  - Device configuration, file transfers, data capture, and rules-based data analysis and response

When should you use a gateway?

Collect → Compute → Control

- Fleet monitoring / Freight monitoring
- Environment monitoring / Home monitoring
  - Requisite interfaces and protocols to meet the demands of the application (in a secure and manageable way)
  - Integrated, pre-validated platform with built-in manageability and security features
  - Good support for different communication hardware and drivers to enable connectivity

Questions – Deploy IoT visible solution

- How and when would user know about the status of monitoring?
- How would an user know the current location and its environment?
- What is the critical condition of the monitoring IoT solution?
- How can one detect hazardous conditions?
- What is the immediate actions real-time responses to trigger/react?

Protocols

Protocol	MQTT	CoAP	XMPP	HTTP/RESTful
Transport	TCP/IP	UDP	TCP/IP	TCP/IP
Messaging	Pub/Sub; Req/Res	Req/Res	Pub/Sub; Req/Res	Req/Res
Cellular Suitability (1000s nodes)	Excellent	Excellent	Excellent	Excellent
Low Power and Lossy Network (LLN)	Fair	Excellent	Fair	Fair
Primary Orientation	Message	Web service/ Document	Message	Web service/ Document
Energy/ Power Needs	Low	Low	High	High
Key Scenarios	Lightweight and embedded devices; unreliable connections	Field; state-transfer; platform/network	Mass scale; persistent connections	Home and office

HTTP (request/response)

- One-to-one/one-to-many requests
- Push from client
  - Websocket
- Heavyweight
  - ASCI/text-based headers
  - More bytes on payload
- No Quality of Service
- Security (over SSL/TLS)
  - Basic or digested authentication
- No “messaging middleware”
- REST architecture
  - Resource access by URIs

CoAP

- Binary HTTP-like on UDP (not TCP)
- Observer pattern (avoid long HTTP polling)
- QoS (confirmable and non confirmable messages)
- Security: Datagram TLS
- Resource discovery
- node acts as server
- REST architecture

XMPP

- Text-based, XML-based
- TCP via HTTP using websocket implementation
- Real-time massive scalability
- Asynchronous, long-lived connection
- Extra layering for security

MQTT

- lightweight
  - Smallest packet size header & reduced client footprint
- reliable
  - QoS levels: at most once, at least once, exactly once
- simple
  - TCP based: socket connection oriented
  - Asynchronous
  - Publish/Subscribe
  - Payload agnostic
- Broker oriented

Why MQTT over HTTPS?

	% Battery / Hour			
	3G		Wifi	
Keep Alive (Seconds)	HTTPS	MQTT	HTTPS	MQTT
60	1.11553	**0.72465**	0.15839	**0.01055**
120	0.48697	**0.32041**	0.08774	**0.00478**
240	0.33277	**0.16027**	0.02897	**0.00230**
480	0.08263	**0.07991**	0.00824	**0.00112**

	3G		Wifi	
	HTTPS	MQTT	HTTPS	MQTT
% Battery / Hour	18.43%	**16.13%**	**3.45%**	4.23%
Messages / Hour	1708	**160278**	3628	**263314**
% Battery / Message *	0.01709	**0.00010**	0.00095	**0.00002**
Messages Received	240 / 1024	**1024 / 1024**	524 / 1024	**1024 / 1024**

- Assured delivery
- Retained messages
- Last will & testament
- Multiple subscriptions 'multiplexed' over one connection

http://stephendnicholas.com/posts/power-profiling-mqtt-vs-https

Key aspects for network connectivity

- *Range*
- *Data Rate*
- *Power*
- *Frequency*
- *Security*

Key considerations for connectivity

- Endpoint
  - “thing”, i.e. door lock, washing machine, Philips hue
- Access Point
  - Bluetooth, cellular-based, WiFi, i.e. gateways
- Back End
  - Cloud, i.e. storing data, sending message

Key questions to reviewing connectivity options

- How will identity and provisioning be handled?
- What are the costs of friction points associated with access point technology?
- How will over-the-air security be managed?

LPWAN Technologies

Feature	LORAWAN	SIGFOX	LTE Cat 1	LTE M	NB LTE
Range	45km rural, 2-5 km urban	50km rural, up to 10km urban	OFDMA	35km GSM, 200km 3G/4G	10-15km
Freq Band	Varies, sub GHz	868/902MHz	900/1800/1900/2100MHz	900/1800/1900/2100MHz	700-900 MHz
Data Rate	290bps – 50Kbps	100 bps 12/8 bytes Max	10 Mbit/s	20 kbps – 1Mbps	Avg 20K bps
Max. # msgs/day	Unlimited	UL: 140 msgs / day	Unlimited	Unlimited	Unlimited
Max Output Power	20dBm	20dBm	23 – 46 dBm	23/30 dBm	20 dBm
Deep Indoor Performance	Yes	Yes	Yes	Yes	Yes
Battery lifetime – 2000mAh	105 months	90 months		18 months	
Power efficiency	Very high	Very high	Low	Medium	Medium High
Interference immunity	Very high	Low	Medium	Medium	Low
Coexistence	Yes	No	Yes	Yes	No
Security	Yes	Yes	Yes Oui	Yes	Yes
Mobility/ localization	Yes	Limited mobility, No localization	Mobility	Mobility	Limited mobility, No localization

Short Range Networks Technologies

Feature	BLE	WIFI	Thread	ZigBee	Z-Wave
Range	80m	50m	Mesh	100m/Mesh	30m/Mesh
Freq Band	2.4GHz	2.4/5GHz	2.4GHz	915MHz/ 2.4GHz	900MHz
Data Rate	< 1mbps	600 mpbs	-	250kbps	1- - 100kbps
Max. # msgs/day	-	Unlimited	Unlimited	Unlimited	Unlimited
Max Output Power	20dBm	20dBm	23 – 46 dBm	23/30 dBm	20 dBm
Deep Indoor Performance	No	No	No	-	-
Battery lifetime – 2000mAh	12-18 months	-	-	-	-
Power efficiency	High	High	Low	Low	Low
Interference immunity	Low	Low	Low	Low	Low
Coexistence	Yes	Yes	Yes	Yes	Yes
Security	Trusted Devices problematic	Yes	Yes	Yes	Yes
Mobility/ localization	Yes	Limited mobility, No localization	Mobility	Mobility	Limited mobility, No localization

WiFi

Ideal Use Cases

- Connected machines and factories

Benefits

- Ubiquitous network coverage

Considerations

- 3rd party devices joining WiFi networks
- Provisioning of credentials

Bluetooth

Ideal Use Cases

- Light control, proximity monitors
- Asset Trackers (Active RFID)

Benefits

- Low cost, disposable
- High data rates
- Long Battery life

Considerations

- Short range
- Access point (phone or app specific devices)
- Requires coordination between end point and access point

Mesh Network

Ideal Use Cases

- HVAC controls
- Lighting control (high density)

Benefits

- Resilient physical architecture
- Scalable without system disruption

Considerations

- Short range
- Link performance
- Deployment and manageability
- Interoperability difficulties: configuration differences and key management

Cellular M2M

Ideal Use Cases

- GPS telematic trackers
- Smart meters
- Connected vehicles

Benefits

- Ubiquitous network coverage

Considerations

- Recurring cost
- Expensive chipset
- Short Battery Life

SigFox/LoraWAN

Ideal Use Cases

- GPS tracking devices
- Smart meters
- Connected vehicles

Benefits

- Power efficient
- Inexpensive chipset

Considerations

- Low data throughput
- Network coverage
- QoS, provisioning, and key management

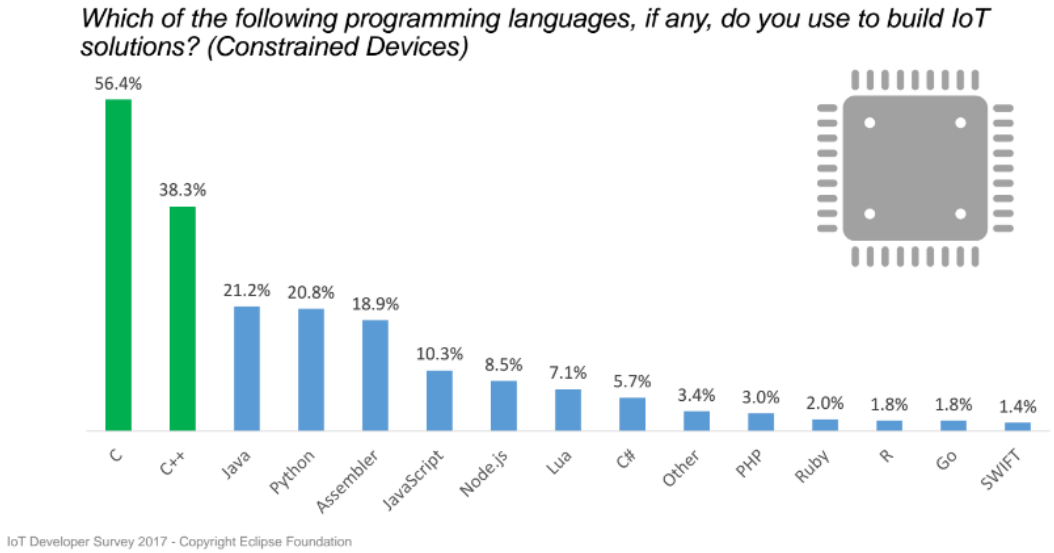
What is your relevant use case?

Ideal Use Cases

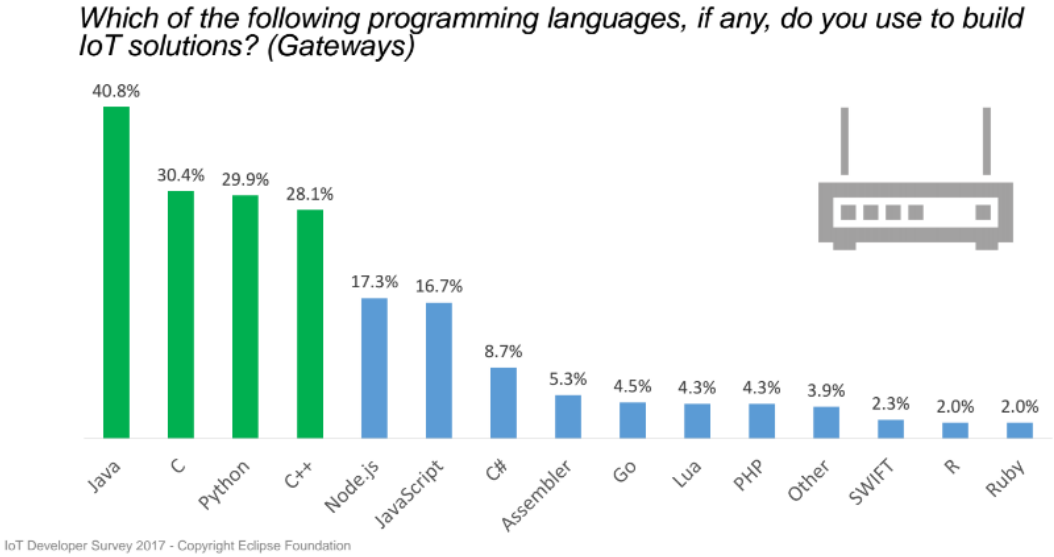
Benefits

Considerations

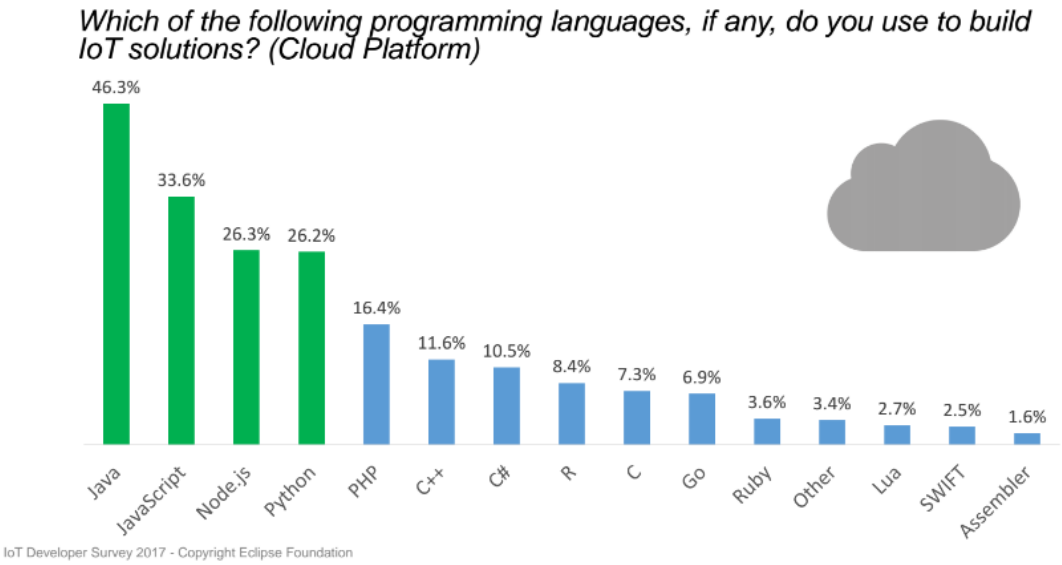
Programming Languages Constrainted Devices



Programming Languages IoT Gateways



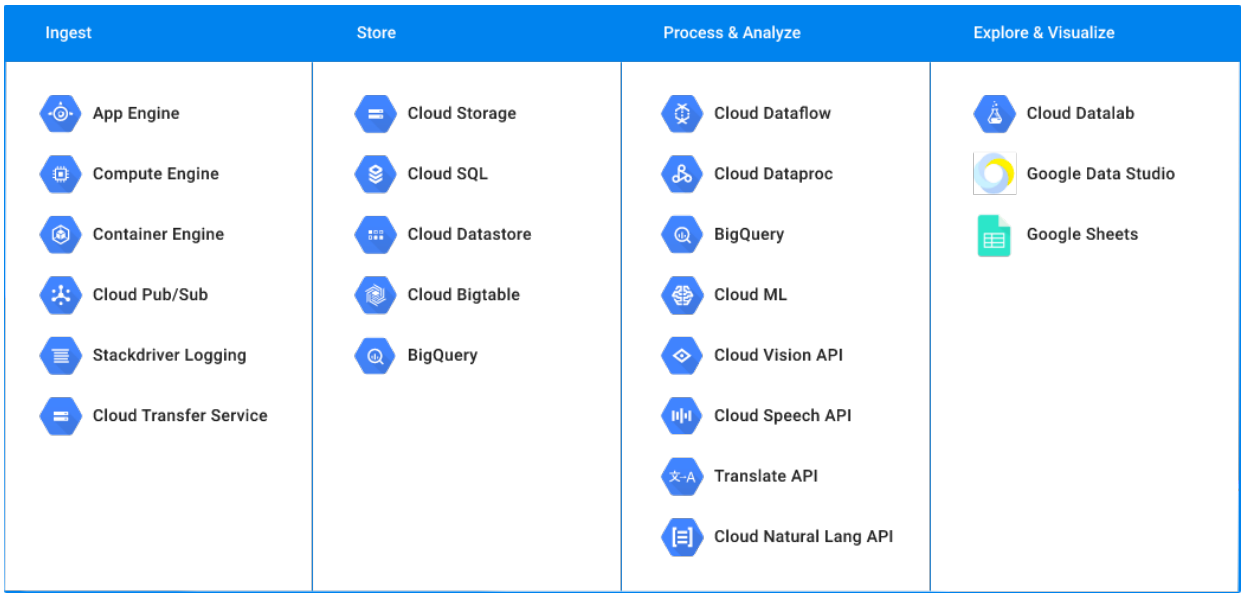
Programming Languages IoT Cloud



Practical Considerations for Platforms

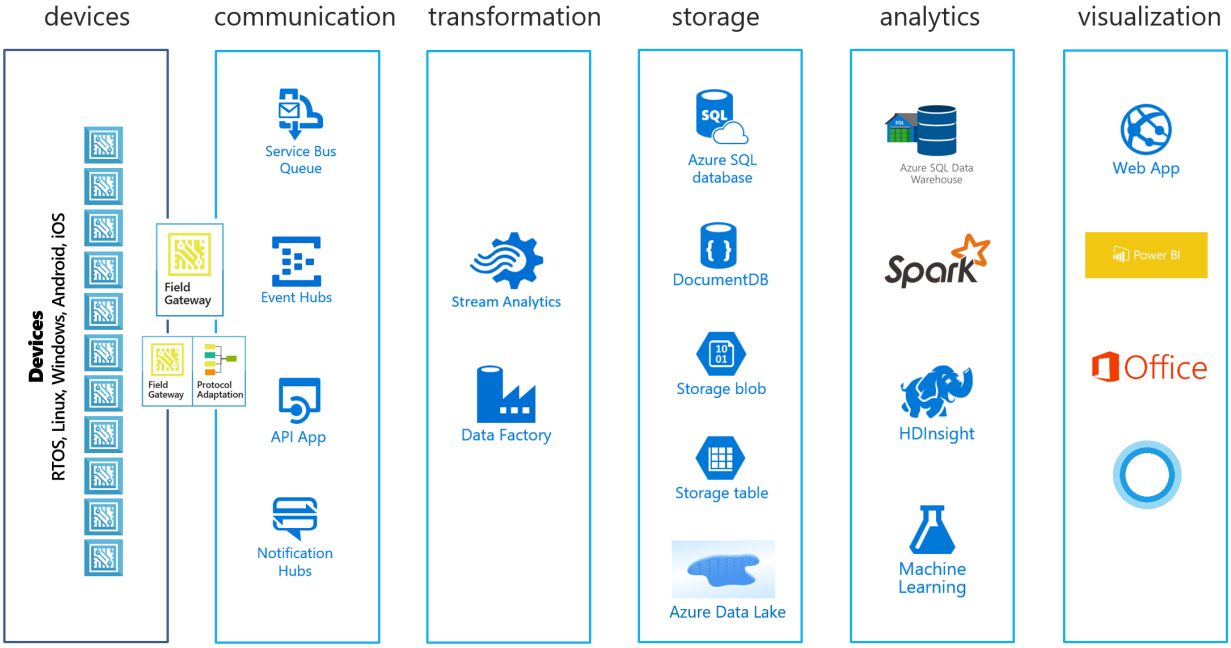
- Connectivity hardware
- Firmware development tools
- Communication protocols
- Message brokers and message queueing
- Security and authentication
- Device administration (aka "fleet management")
- SDKs and documentations for developing complementary mobile apps, web apps, etc.
- Data collection, visualization, and analysis
- Integrations with other web services

Cloud Platform



https://cloud.google.com/solutions/data-lifecycle-cloud-platform

Cloud Platform



http://theundocumentedapi.com/2015/09/24/iot-business-value/

Should we use Cloud Platform?

IBM, January 26

IBM's cloud credibility took a hit at the start of the year when a management portal used by customers to access its Bluemix cloud infrastructure (formerly branded SoftLayer) went down for several hours.

While no underlying infrastructure actually failed, users were frustrated in finding they couldn't manage their applications or add or remove cloud resources powering workloads.

IBM said the problem was intermittent and stemmed from a botched update to the interface.

Microsoft Azure, March 16

Storage availability issues plagued Microsoft's Azure public cloud for more than eight hours, mostly affecting customers in the Eastern U.S.

Some users had trouble provisioning new storage or accessing existing resources in the region. A Microsoft engineering team later identified the culprit as a storage cluster that lost power and became unavailable.

In addition to that problem, Microsoft also listed on the Azure status page a software error affecting storage provisioning across multiple services for longer than an hour.

http://www.crn.com/slide-shows/cloud/300089786/the-10-biggest-cloud-outages-of-2017-so-far.htm/pgno/0/1

When/How should we leverage cloud IoT?

AWS, February 28

This was the outage that shook the industry.

An Amazon Web Services engineer trying to debug an S3 storage system in the provider's Virginia data center accidentally typed a command incorrectly, and much of the Internet – including many enterprise platforms like Slack, Quora and Trello – was down for four hours.

The post-mortem said the employee was using "an established playbook," and intended to pull down a small number of servers that hosted subsystems for the billing process. Instead, the accidental command resulted in a far broader swath of servers being taken offline, including one subsystem necessary to serve specific requests for data storage functions and another allocating new storage.

The outage from a provider that owns roughly a third of the global cloud market reignited debate on the risks of public cloud.

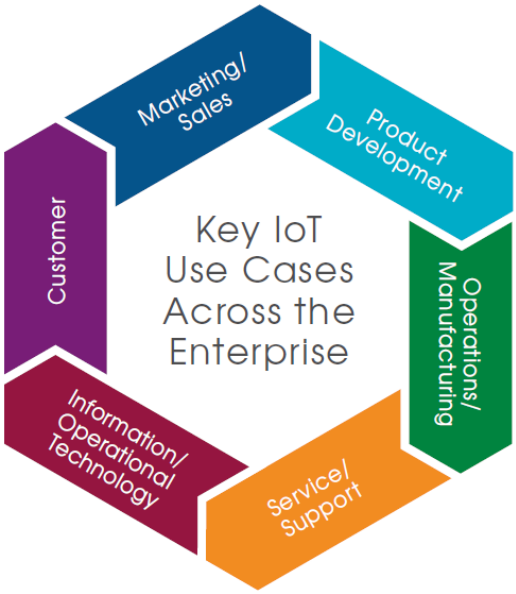
http://www.crn.com/slide-shows/cloud/300089786/the-10-biggest-cloud-outages-of-2017-so-far.htm/pgno/0/1

Security Considerations

- Encryption requirements
- Authentication
- Side-channel attacks
- Hardware OS

IoT Use Case

- **Marketing and Sales**
- Product Development
- Operations and Manufacturing



- **Service and Support**
- **Information and Operational Technology**
- **Customers**

https://www.ptc.com/en/internet-of-things/use-cases

Wrapping Up

Key IoT technologies and enablers

1. Standards & Ecosystem
2. Platforms
3. Event Stream Processing
4. Operating Systems
5. Processors
6. Low-Power, Wide-Area Networks
7. Low-Power, Short-Range IoT Networks
8. Device (Thing) Management
9. Analytics
10. Security

Let's watch…

Transforming In-Store Retail Experience

- https://blogs.windows.com/business/2016/03/16/telstra-transforms-its-retail-stores-with-windows-10/?utm_source=Direct
- https://www.youtube.com/watch?v=Oxs7ub4Eq1M