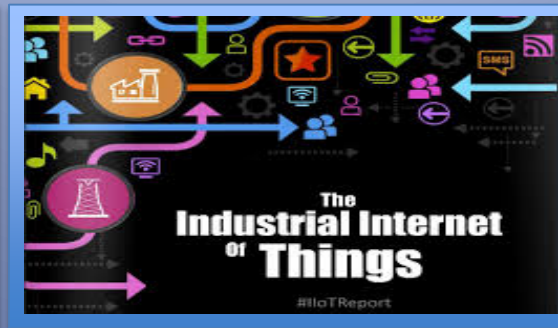


The Key to the Internet-of-Things: Conquering Complexity One Step at a Time



IoT Workshop at IEEE PHM2017
June 19, 2017

Adam T. Drobot
Wayne, PA 19087



IoT Workshop
June 19, 2017

The Key to the Internet of Things
The Evolution of the Connected World

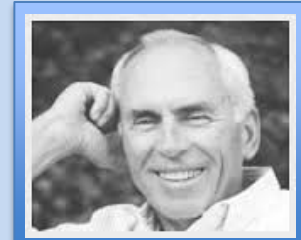


Outline

- *What is IoT?*
- *Where is IoT in its evolution?*
 - *A life Cycle View*
 - *Key ingredients*
 - *Dealing with Complexity*
- *What are the basic ingredients for IoT?*
- *Why are there so many Organizations working on IoT?*
 - *Many many verticals and many differing requirements*
 - *Likely outcomes*
 - *The element of time*
- *A few examples from the IoT front*

Where to Start?

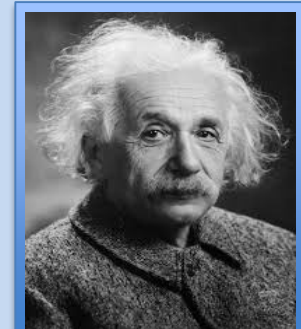
Amara's Law: We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run.



Law of Parsimony (Occam's razor): "Entities must not be multiplied beyond necessity", "The simplest explanation is the best", "It is superfluous to suppose that what may be accounted for by a few principles has been produced by many."



A Corollary (Einstein's observation):
"Everything should be made as simple as possible, but no simpler than necessary!"



What is IoT?

- The catch phrase “The Internet of Things” is a general term that evokes aspects of many ideas, made real in a multitude of forms, and that can bring value to a broad range of products, services, processes, and end use applications.
- What these have in common is:
 - Deep digitization – from analog to digital, mechanical to electronic,..
 - Use of an increasingly pervasive and globally accessible infrastructure
 - Connectivity ranging from local to global – approaching ubiquity
 - Long lived protocols and standards – preserving investment
 - Generation and gathering of “data” – from many sources in many forms
 - Exploitation of computing - analysis methods, algorithms, techniques
 - Progress in closing the “control loop” - automation by design

What is IoT?

When talking about the “Internet of Things” you will often come across:

- Cyber-Physical Systems
- M2M – Machine to Machine Communications
- The Internet of Everything
- The Internet of Things
- The Industrial Internet
- Industry 4.0
- The Network of Things
- The Connected World
- The Networked World

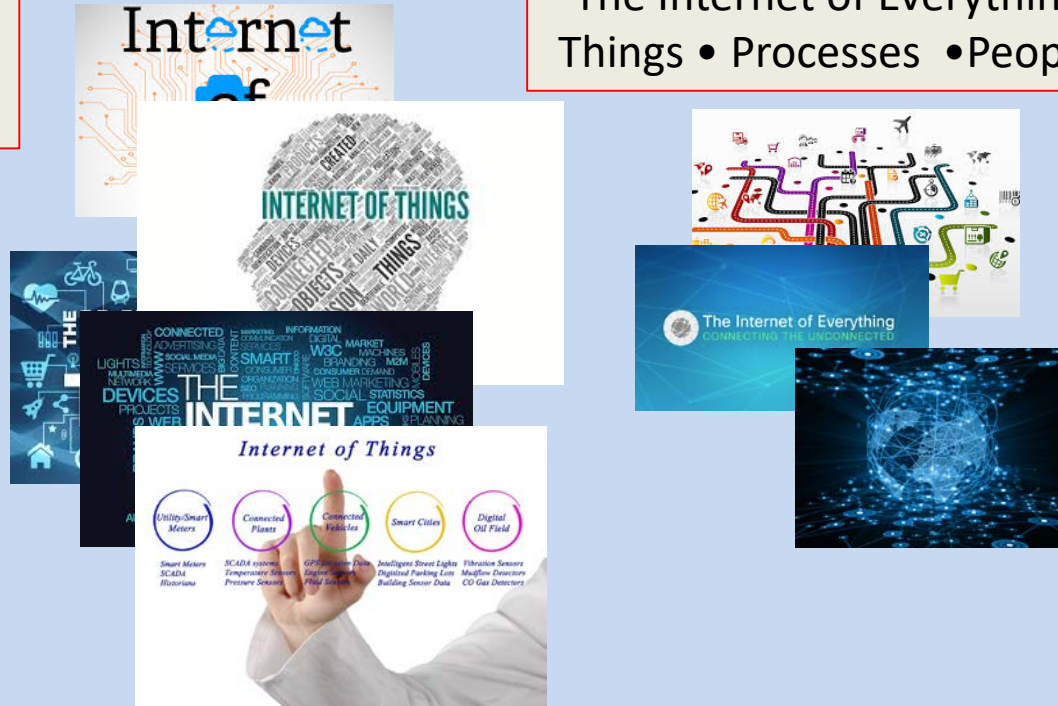
And many similar “terms” that describe how applications and solutions, can be constructed to deliver specific functionality from common components, processes, techniques, and infrastructure and that rely on digitization, connectivity, computation, and decisions to create an outcome.

What is IoT?

M2M Communications Common Carrier Network Protocols for “Things”

The Internet of Everything

Things • Processes • People



The Internet of Things

The Catchall – Applications at the Core

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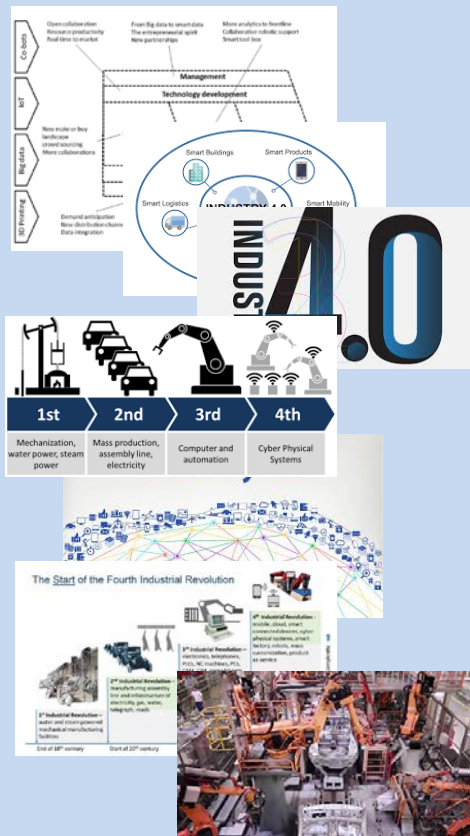
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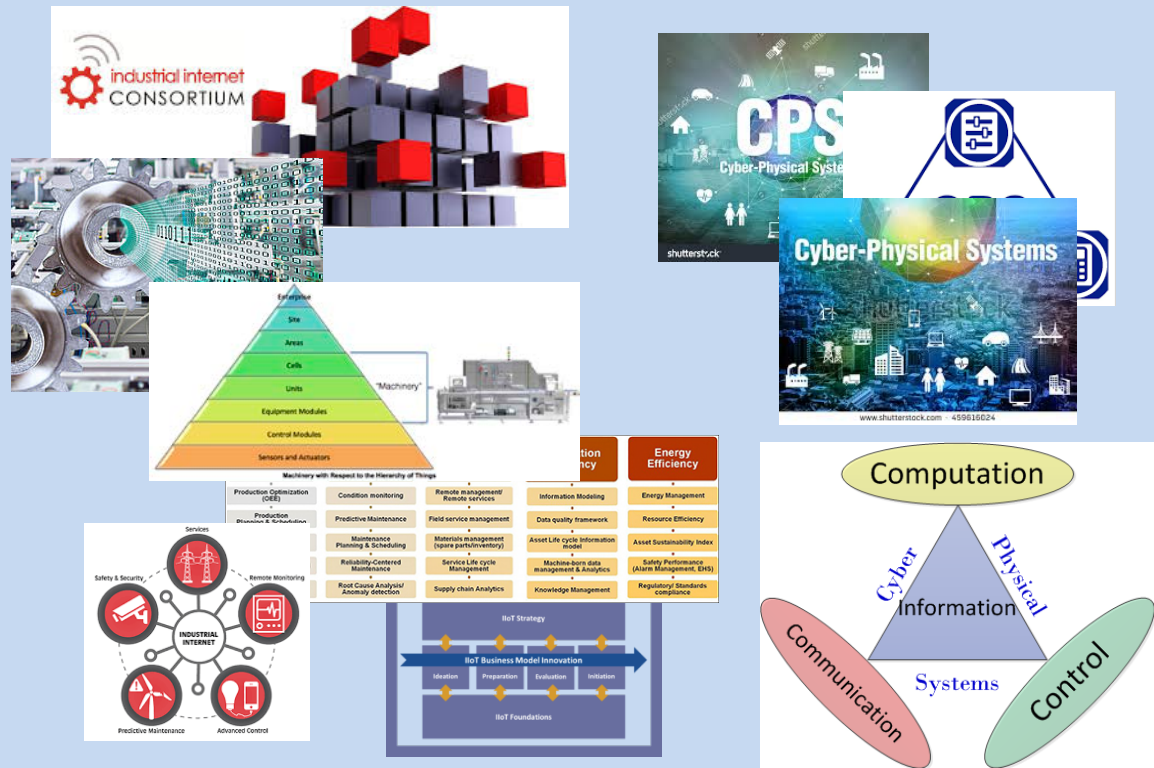


What is IoT?

Industry 4.0 –Life Cycle Framework



Cyber Physical Systems – Digitized Design



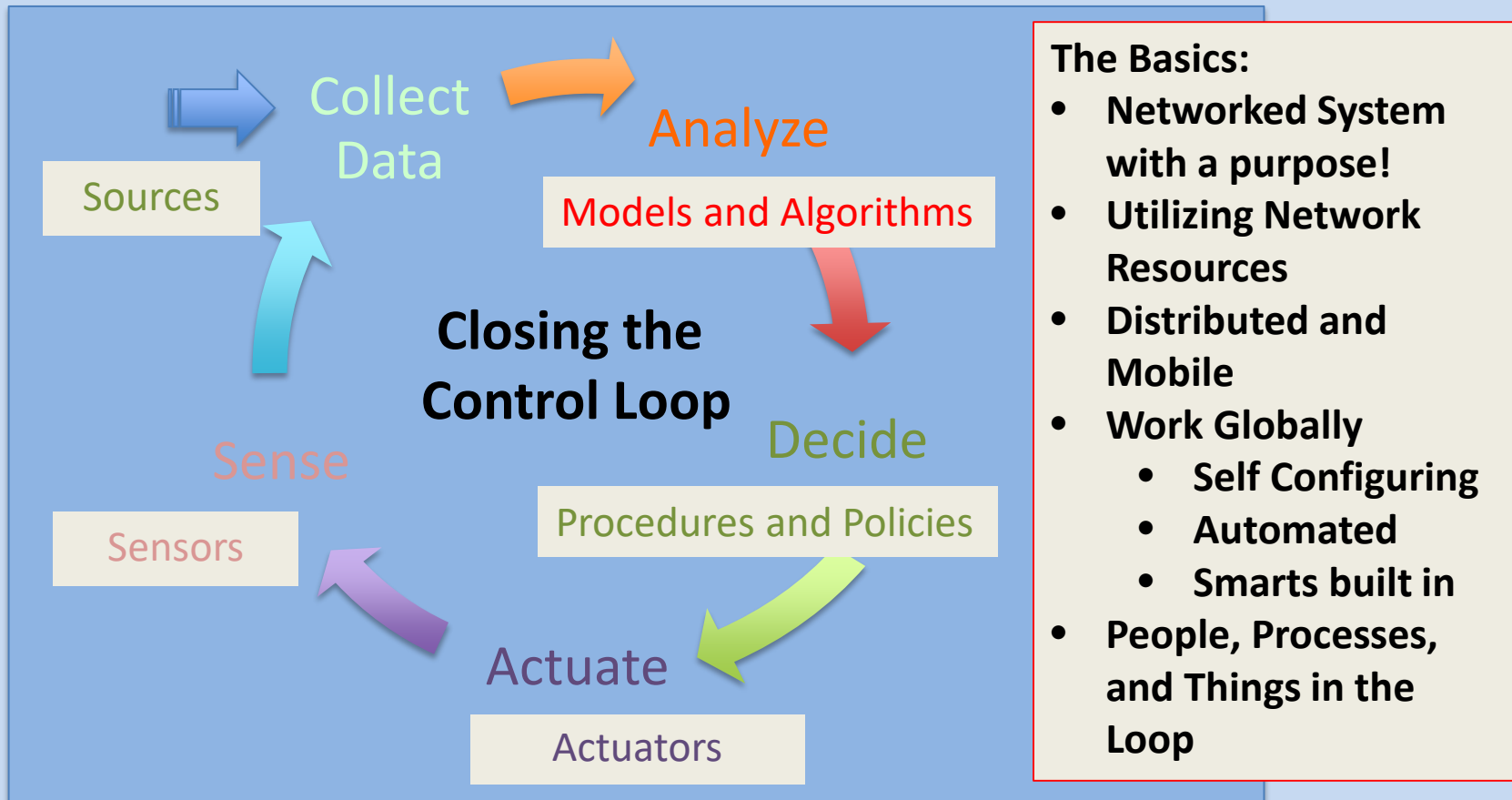
Industrial Internet – Operational Efficiency

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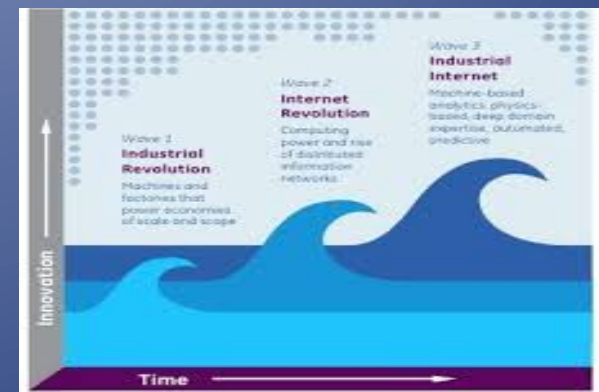
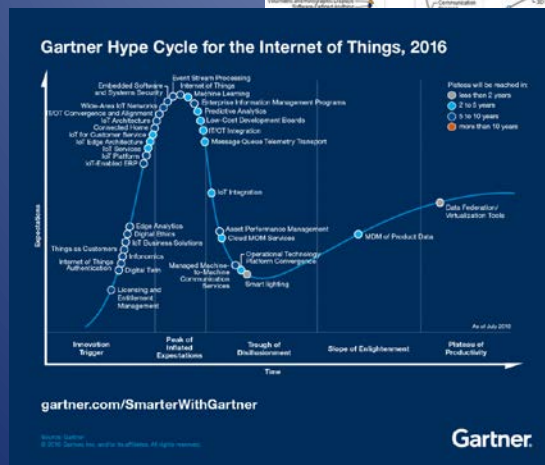
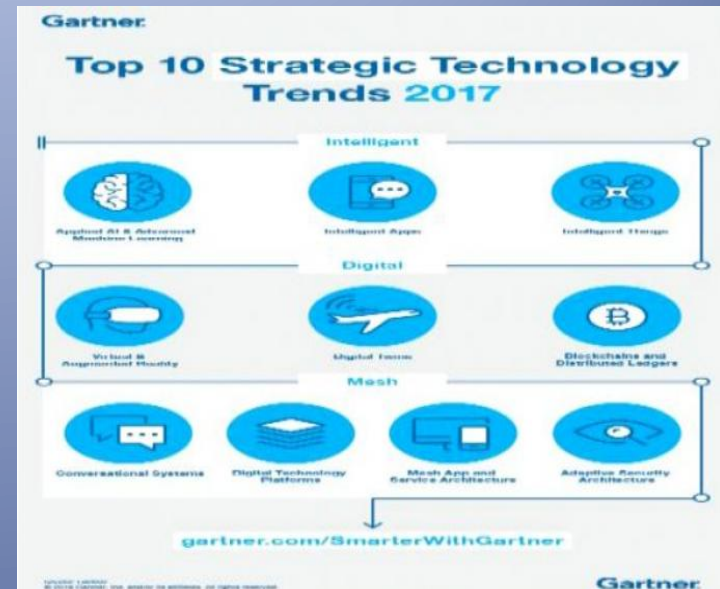
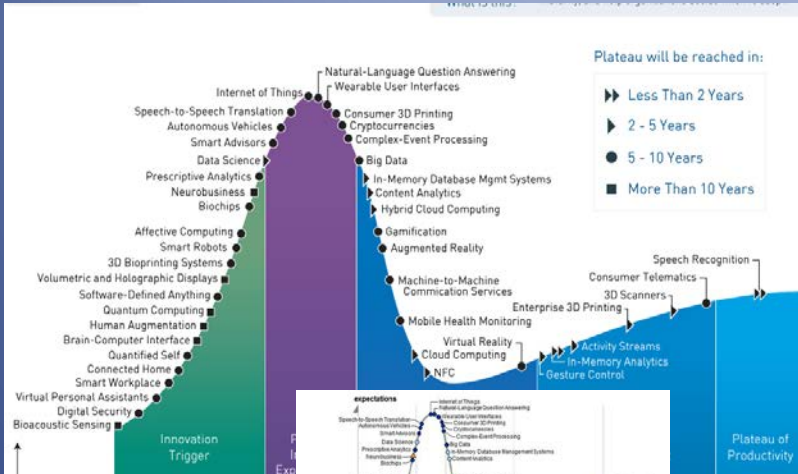
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What is IoT?



Where is IoT in its evolution?



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Where is IoT in its evolution?

Vertical Specific Applications



Core Multi-Vertical Platform

Common Components

Computing	Storage
Connectivity	Interfaces (APIs)
Actuators	Sensors
Software, Data Management	

Core Services

Directory, Naming	Billing
Provisioning, Activation	Deployment
Monitoring, Optimization	Maintenance
Application Enablement	Intellectual Property

End-End Attributes

Security/Privacy	Availability	Reliability	Scaling	Distribution
------------------	--------------	-------------	---------	--------------

Performance

Latency
Jitter
Bandwidth
Capacity

Vertical Specific End-System Implementations



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Where is IoT in its evolution?

Vertical Specific Applications



Enumerating the Space that IoT Spans

Common Components	1,000,000s	Across Building Blocks
Core Services	100,000s	For Application Types
Performance Parameters	100,000s	Over all Verticals
Attributes	10,000s	For Range of Use Cases

Multiple (Hopefully few) Architectures Needed to Span the Space

Vertical Specific End-System Implementations



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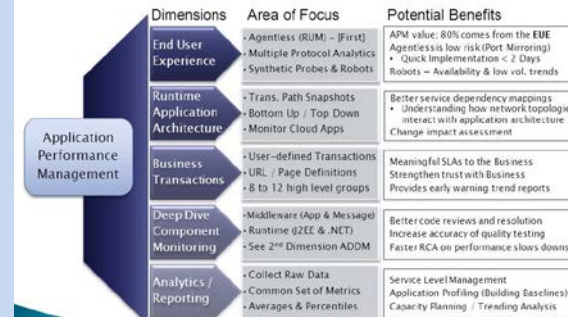


Where is IoT in its evolution?

• Frameworks

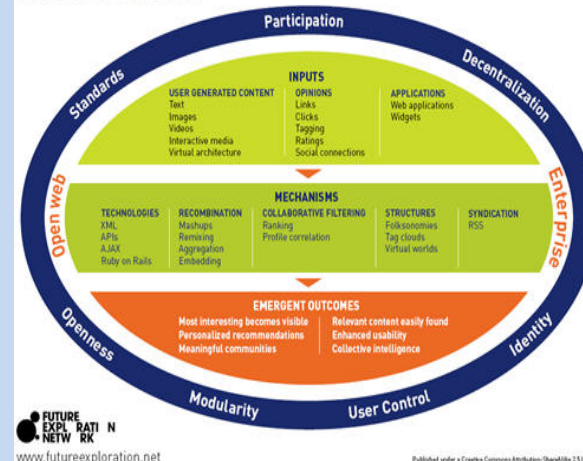
	WHAT	HOW	WHERE	WHO	WHEN	WHY
	DATA	FUNCTION	NETWORK	PEOPLE	TIME	MOTIVATION
SCOPE (Contextual)	List of things important to the business	List of processes the business performs	List of locations in which the business operates	List of organizations important to the business	List of event cycles significant to the business	List of business goals/strategies
Planner	Entity = Class of business things	Process = Class of business processes	Node = Major business locations	People = Major business units	Time = Major business event cycle	End/Mean = Major business goal/strategy
BUSINESS MODEL (Conceptual)	e.g. Semantic Model	e.g. Business Process Model	e.g. Business Logistics System	e.g. Workflow Model	e.g. Master Schedule	Business Plan
Owner	Entity = Business Entity Relationship = Business	Process = Business ID = Business Resource	Node = Business Location Link = Business Linkage	People = Organisation unit Work = Work Product	Time = Business Event Cycle = Business Cycle	End = Business Objective Means = Business Strategy
SYSTEM MODEL (Logical)	e.g. Logical Data Model	e.g. Application Architecture	e.g. Distributed System Model	e.g. Human Interface Architecture	e.g. Processing Structure	e.g. Business Rule Model
Designer	Entity = Data Entity Relationship = Data Relationship	Process = Application Function ID = User Interface	Node = ID Function Relationship = Link Characteristics	People = User Work = Generation	Time = System Event Cycle = Processing Cycle	End = Structural Assertion Means = Action Assertion
TECHNOLOGY MODEL (Physical)	e.g. Physical Data Model	e.g. System Design	e.g. Technology Architecture	e.g. Presentation Architecture	e.g. Control Structure	e.g. Rule Design
Builder	Entity = Segment/Table Relationship = Pointer/Key	Process = Computer Function ID = Data Element/Attribute	Node = HW System/Link Relationship = Link Specification	People = User Work = Screen Format	Time = Logical Cycle = Component Cycle	End = Condition Means = Action
DETAILED REPRESENTATIONS (Out-of-context)	e.g. Data Definition	e.g. Program	e.g. Network Architecture	e.g. Security Architecture	e.g. Timing Definition	e.g. Rule Specification
Subcontractor	Entity = Field Relationship = Address	Process = Language Statement ID = Control Block	Node = Address Link = Protocol	People = Identity Work = Job	Time = Interrupt Cycle = Machine Cycle	End = Sub-condition Means = step
FUNCTIONING ENTERPRISE	e.g. DATA	e.g. FUNCTION	e.g. NETWORK	e.g. ORGANISATION	e.g. SCHEDULE	e.g. STRATEGY

APM Conceptual Framework Prioritizing Gartner's APM Model



Larry Gragich, Director EAS, The Auto Club Group - March 2012

WEB 2.0 Framework



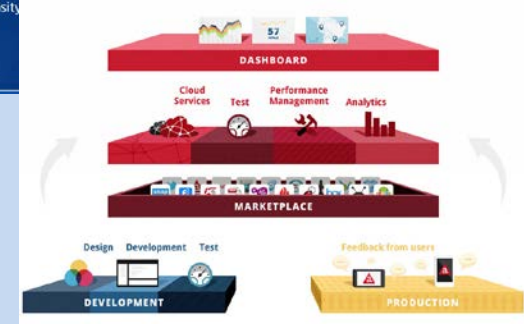
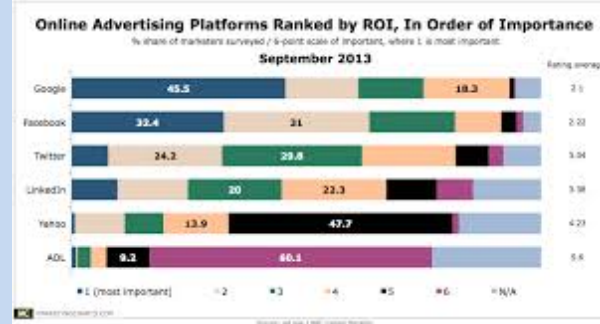
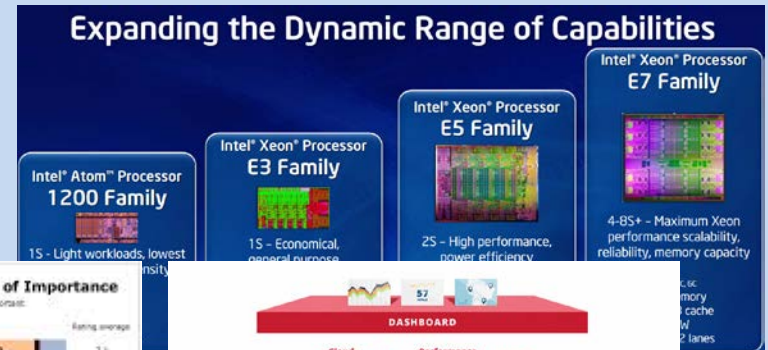
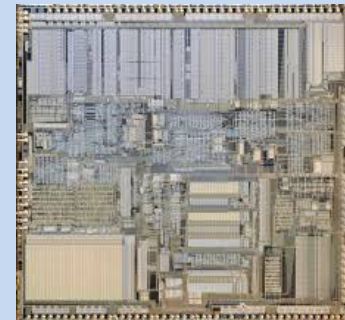
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Where is IoT in its evolution?

- Platforms



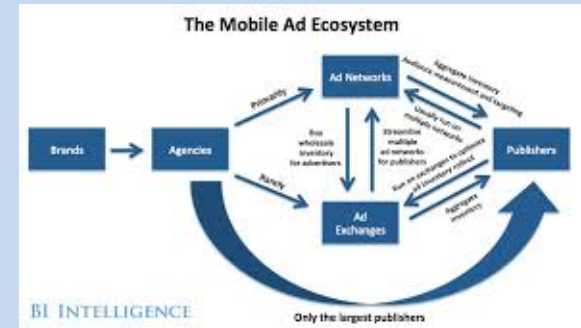
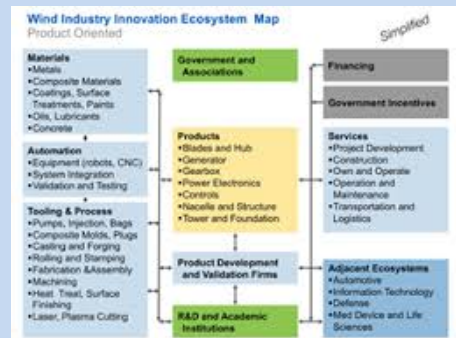
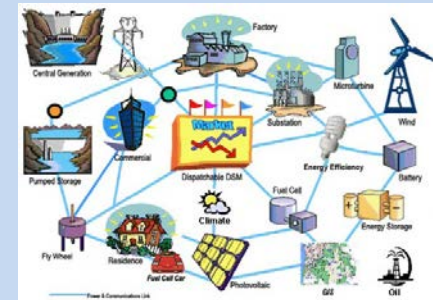
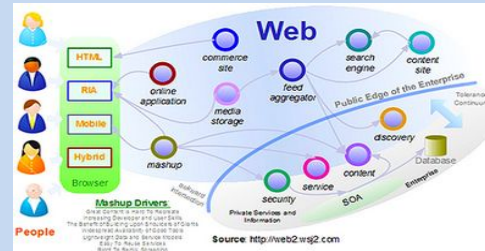
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Where is IoT in its evolution?

• Ecosystems



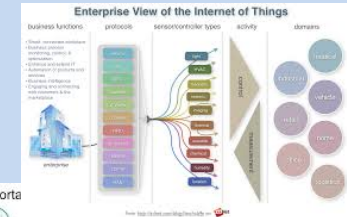
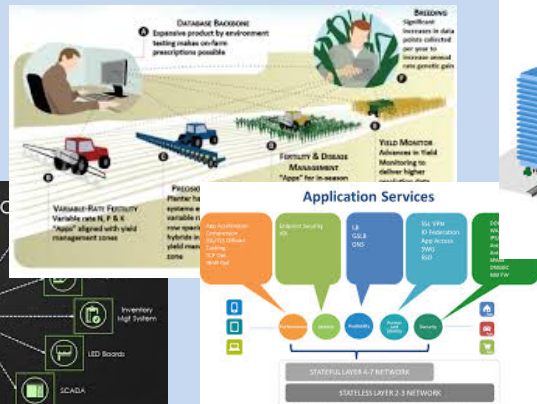
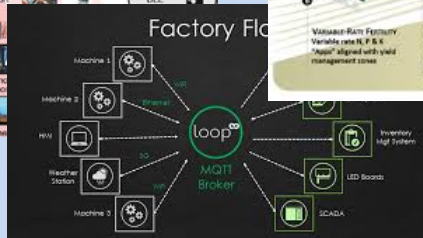
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Where is IoT in its evolution?

- *Almost Every “Vertical” will be impacted by IoT*
 - *The existing stock of “solutions” has crossed a thresh-hold where the ROI from current deployments is positive – it’s all about economics!*
 - *Most solutions are vertical specific, being developed within verticals, and have very different requirements.*
 - *We are learning what is common and what is not and that takes time and experimentation.*



Where is IoT in its evolution?

- *Influence of major trends*
 - *Big data and analytics*
 - *Cloud based computing and storage (including edge/fog)*
 - *Mobility - LTE and precursors for 5G*
 - *Universal access with high bandwidth – copper, coax, and fiber.*

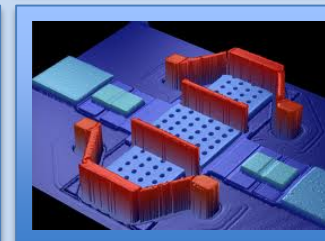


What are the basic ingredients of IoT?

- *Building Blocks and essential Ingredients*

- *Computing*
- *Storage*
- *Connectivity*
- *Sensors*
- *Actuators*
- *Interfaces – Humans in the Loop*
- *Software and Algorithms*

- *Power and Energy*
- *Design and Integration Methods*
- *Operational Technologies*



What are the basic ingredients of IoT?

- *Computing*
- *For IoT the intelligence is everywhere!!*
 - *Cloud*
 - *Fog/Edge*
 - *Embedded*



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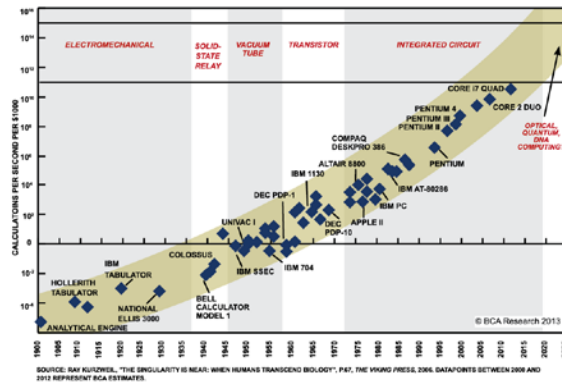
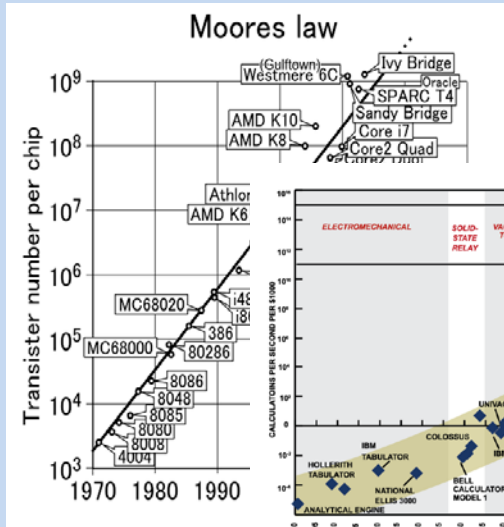
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What are the basic ingredients of IoT?

- Computing – Continue Advances!*



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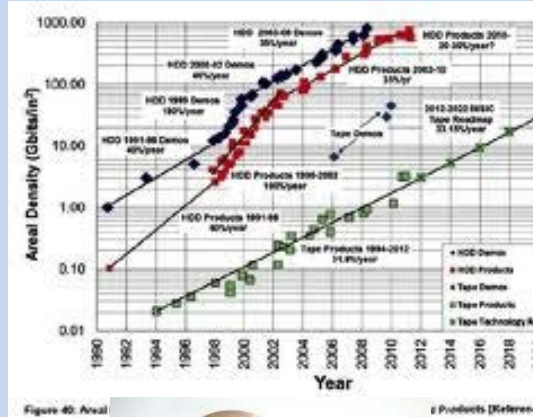


What are the basic ingredients of IoT?

- *Storage*

Kryder's Law

Distributed!!!



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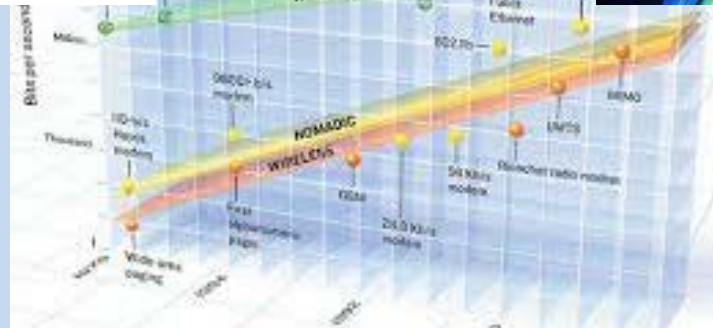
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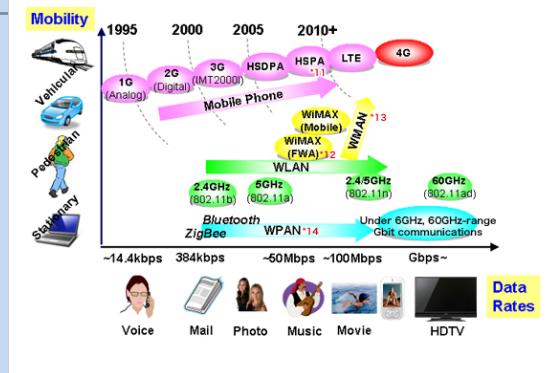
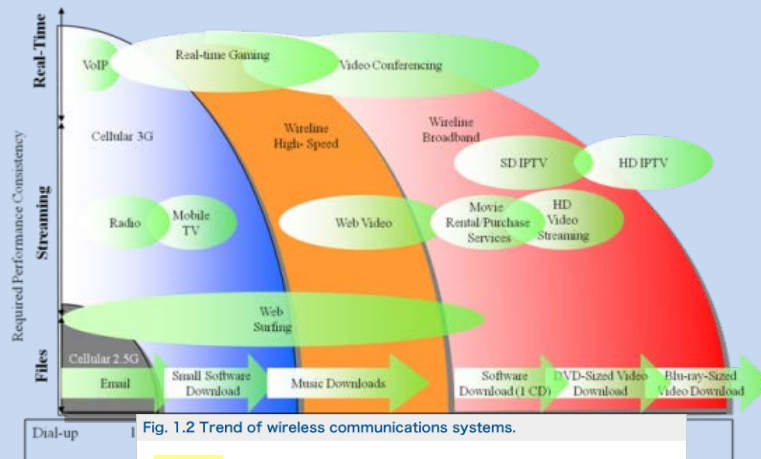


- *Connectivity*



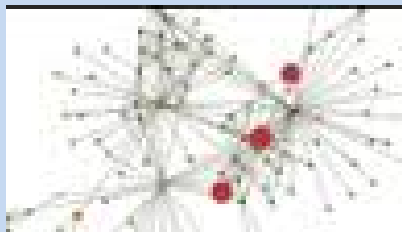
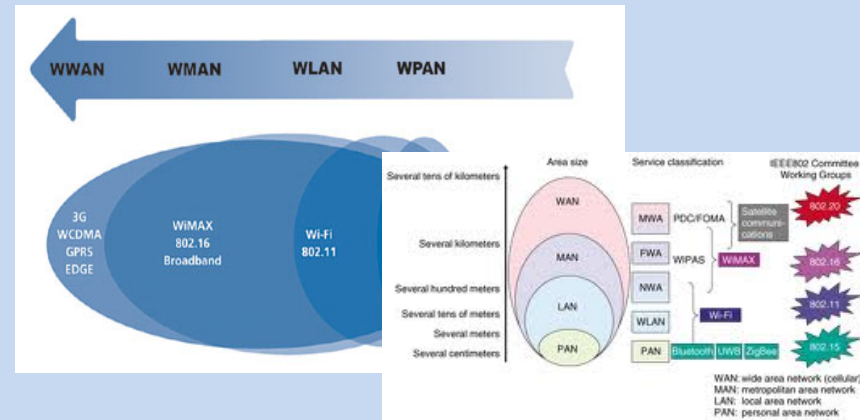
What are the basic ingredients of IoT?

- Communications



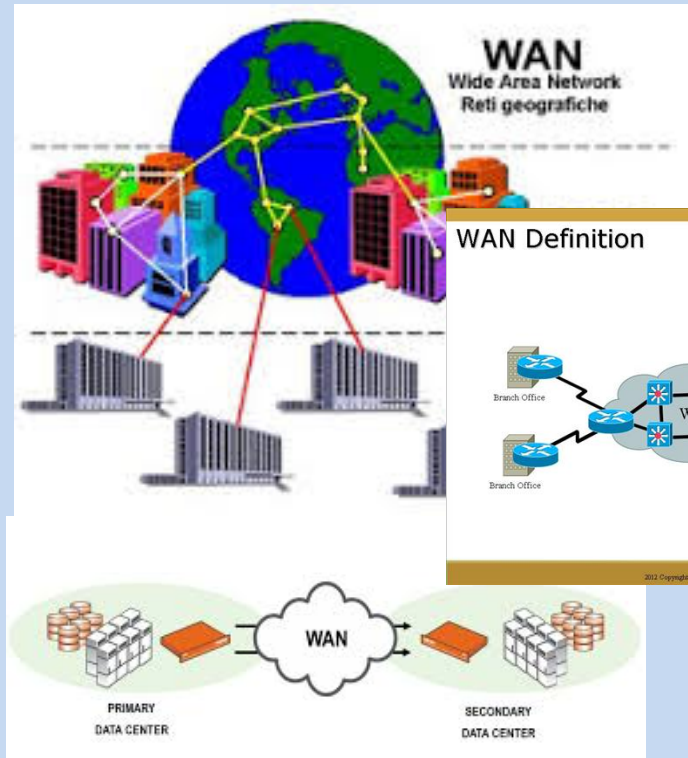
What are the basic ingredients of IoT?

- Communications - Hierarchy and Heterogeneity*

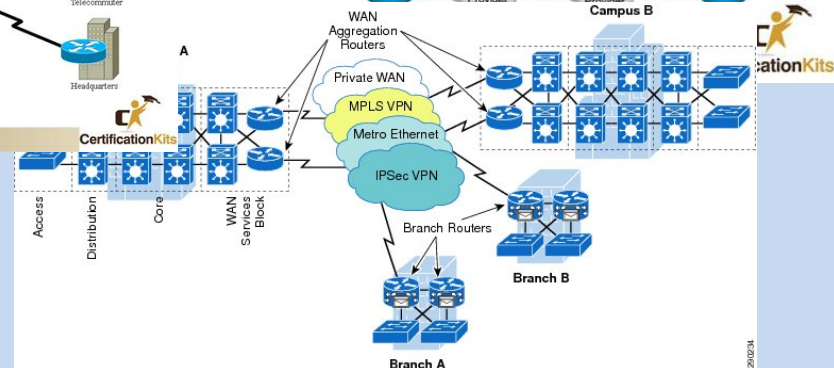
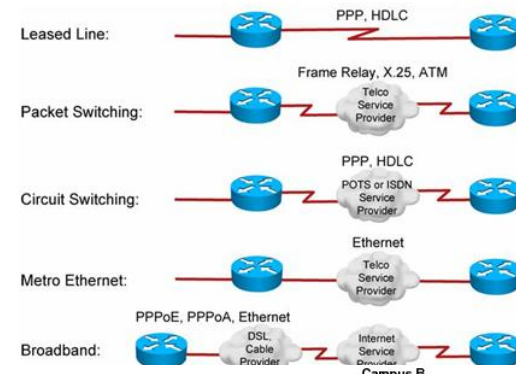


What are the basic ingredients of IoT?

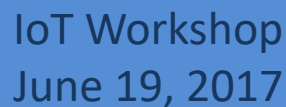
- *Connectivity - Hierarchy and Heterogeneity - WAN*



Typical WAN Encapsulation Protocols

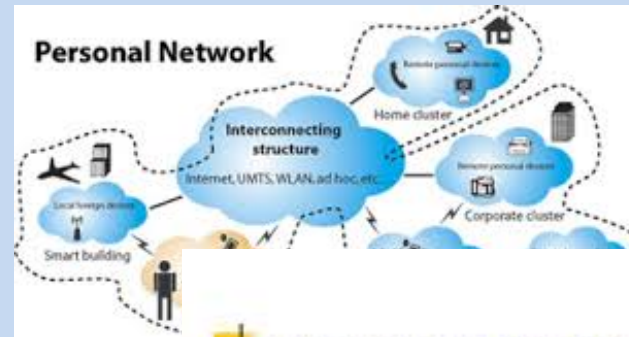


- *Connectivity - Hierarchy and Heterogeneity - LAN*

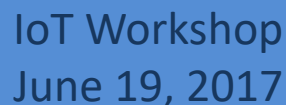


What are the basic ingredients of IoT?

- *Connectivity - Hierarchy and Heterogeneity - PAN*

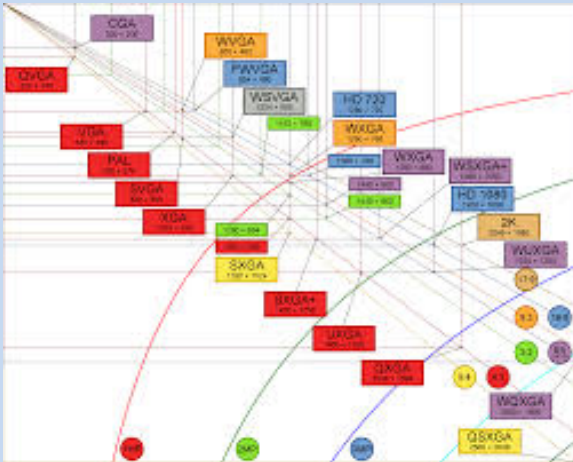


- *Connectivity - Hierarchy and Heterogeneity - Automotive*



What are the basic ingredients of IoT?

- *Interfaces – Humans in the loop*



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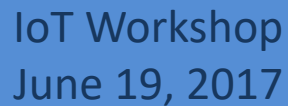
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- *Sensors*



What are the basic ingredients of IoT?

- *Actuators*



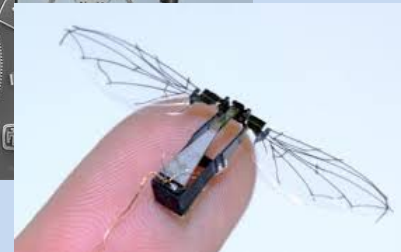
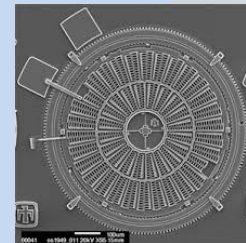
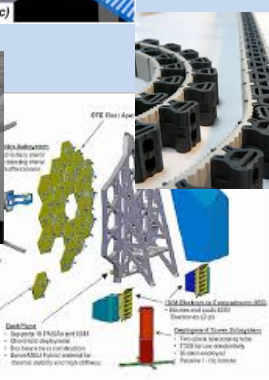
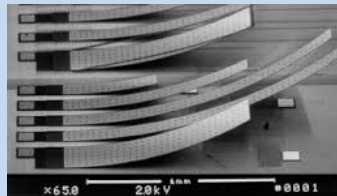
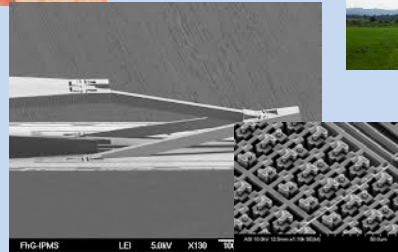
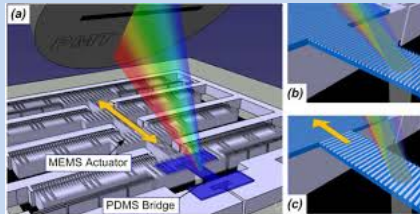
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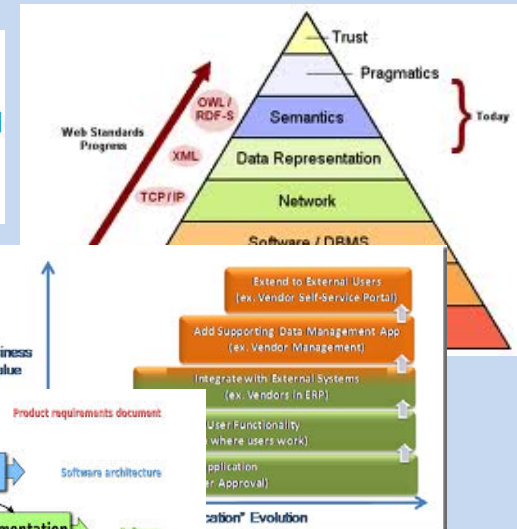
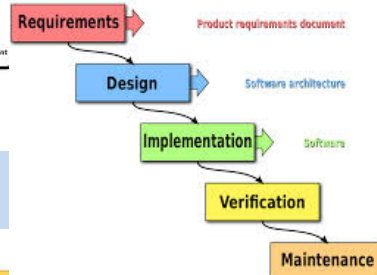
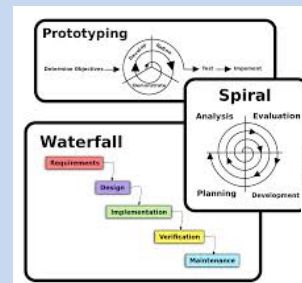
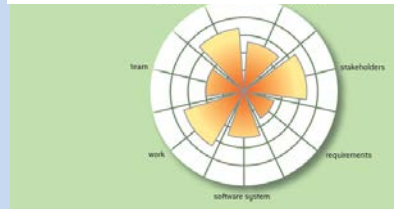
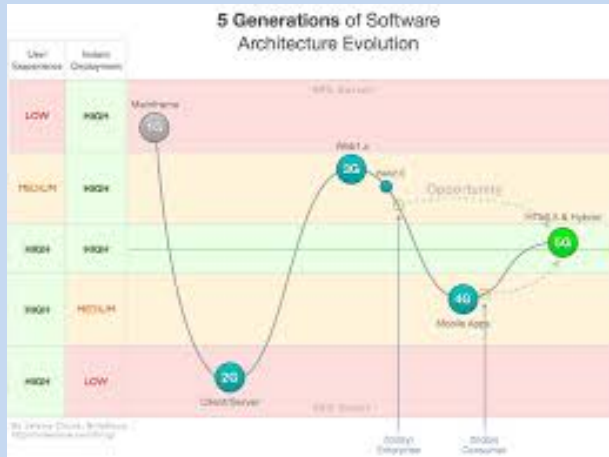
What are the basic ingredients of IoT?

• *Actuators*



What are the basic ingredients of IoT?

- Software and Algorithms



What are the basic ingredients of IoT?

- Software and Algorithms

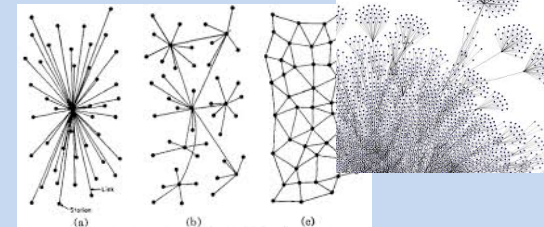
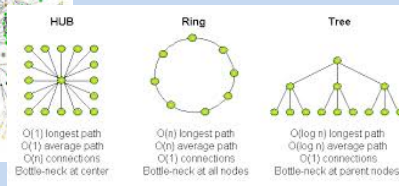
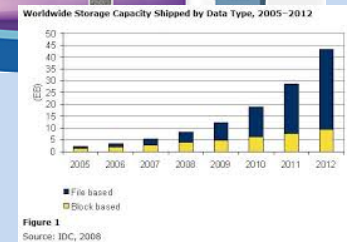
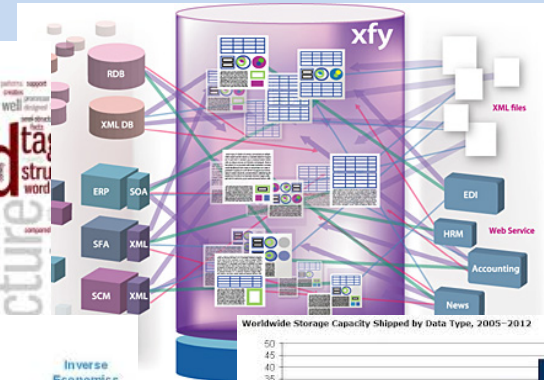
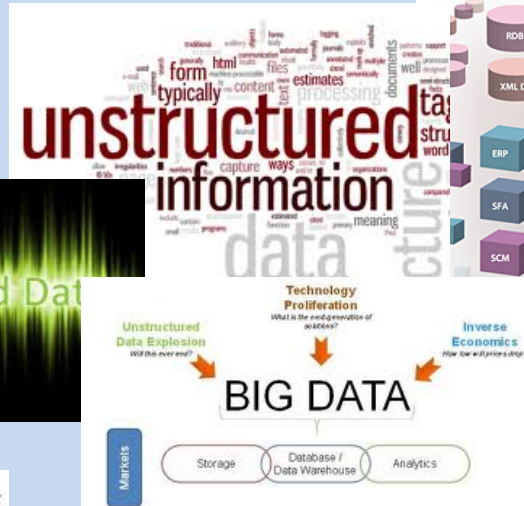
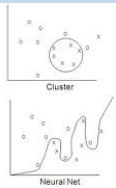
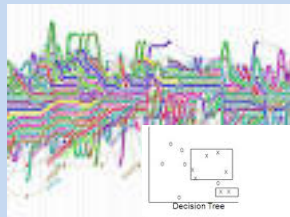
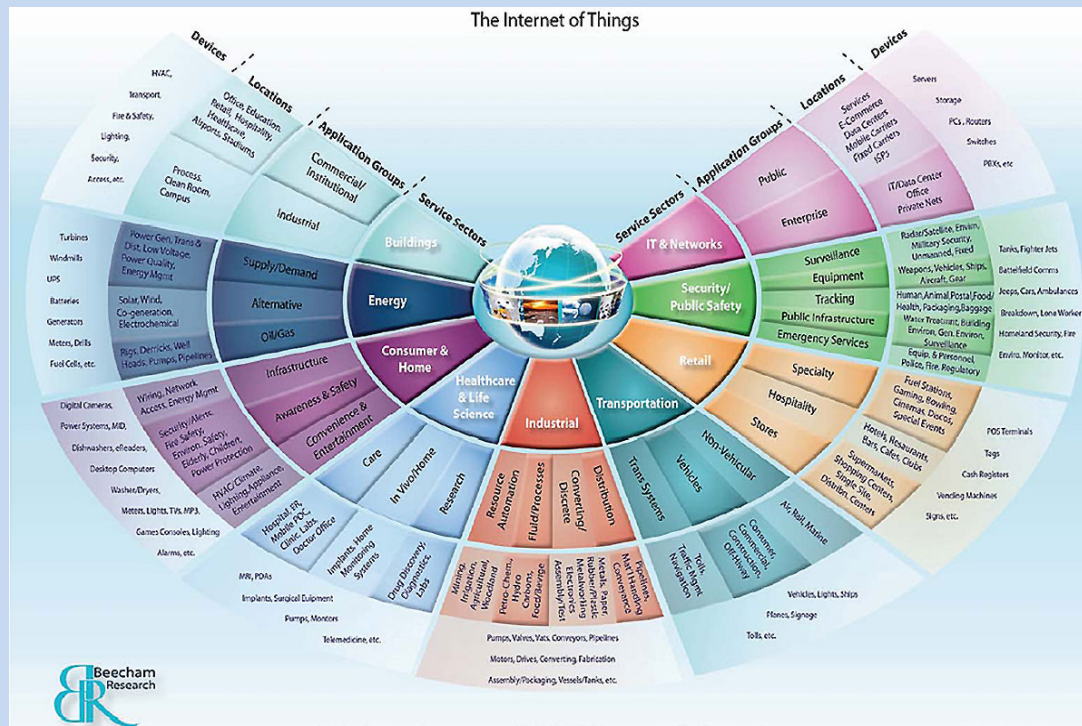


Fig. 1—(a) Centralized. (b) Decentralized. (c) Distributed networks.

Why are so many organizations working on IoT?

- *Its about Economics!!!!*



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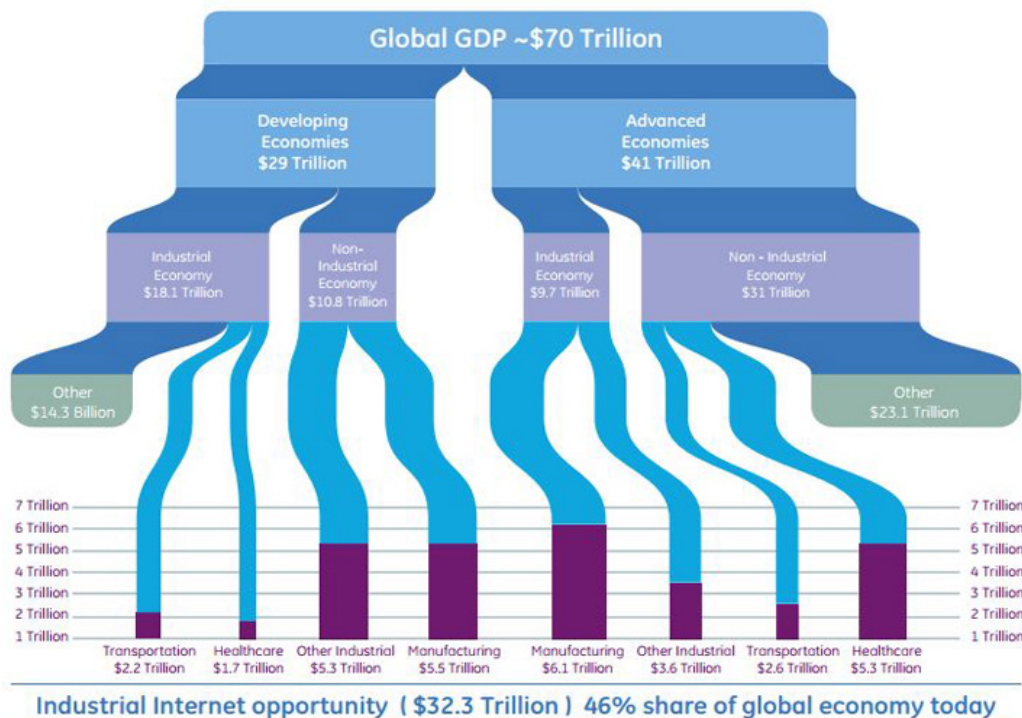
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Why are so many organizations working on IoT?

- *Its about Economics!!!!*

From GE 2015 Annual Report



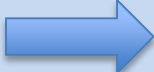
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Why are so many organizations working on IoT?

- *Element of Time*

- *We are on a learning curve*
 - *Low thresh-hold solutions first*
 - *High value solutions next*
- *Greater use of AI*  *Autonomy and Automation*
- *Consolidation of Vertical Solutions and Emergence of a limited number of Dominant of IoT Architectures – hopefully a small number!*
- *A trend that will roll out for the next 20-30 years.*

 *The Biggest Gains Will Come From Refactoring*

A Few Examples

- *Many of the ideas behind IoT applications are not new*
- *The difference between then and now is:*

In the past

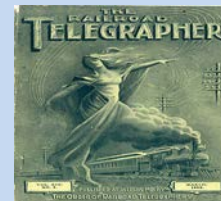
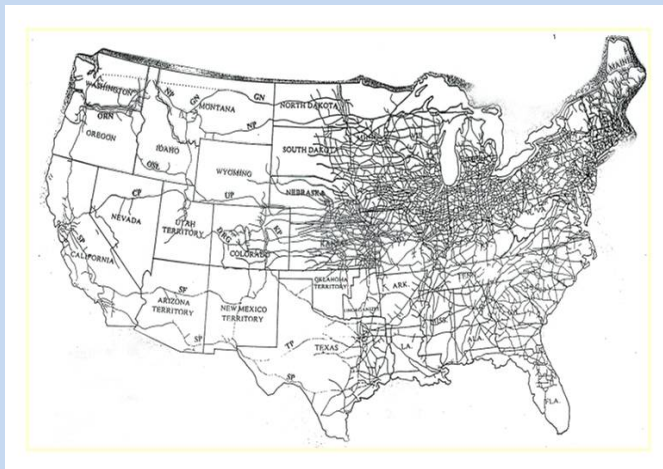
- *Each Application was built in isolation and for a limited number of uses*
- *Often the cost required National means and was linked to an National goal or imperative*

Today

- *The economics that drive IoT are driven by wide availability of IT, Communication, and Operational Technologies, that have benefited from the scale of global markets, and investments to continue improvements in performance (in many different ways)*
- *The deployment of the infrastructure building blocks for IoT is deep and greatly drops the threshold for achieving an ROI.*

A Few Examples – From the Past

- *Impact from the introduction of the Telegraph an early implementation of IoT!!!*



A Few Examples – From the Past

- Space Exploration a high value IoT implementation!*



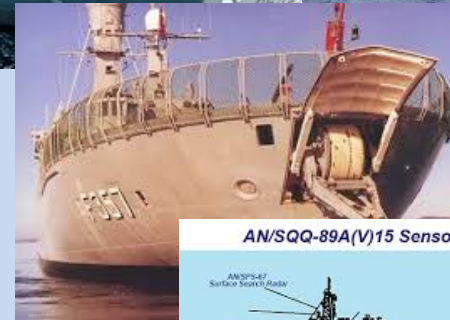
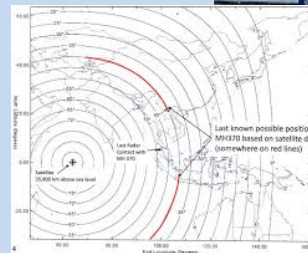
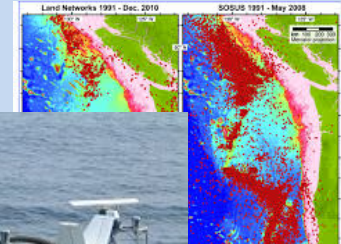
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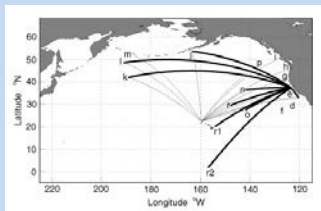
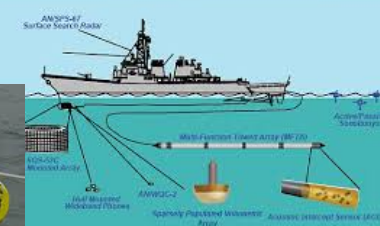


A Few Examples – From the Past

- *Cold War Submarine Tracking*
- *The SOSUS Array*



AN/SQQ-89A(V)15 Sensor Suite



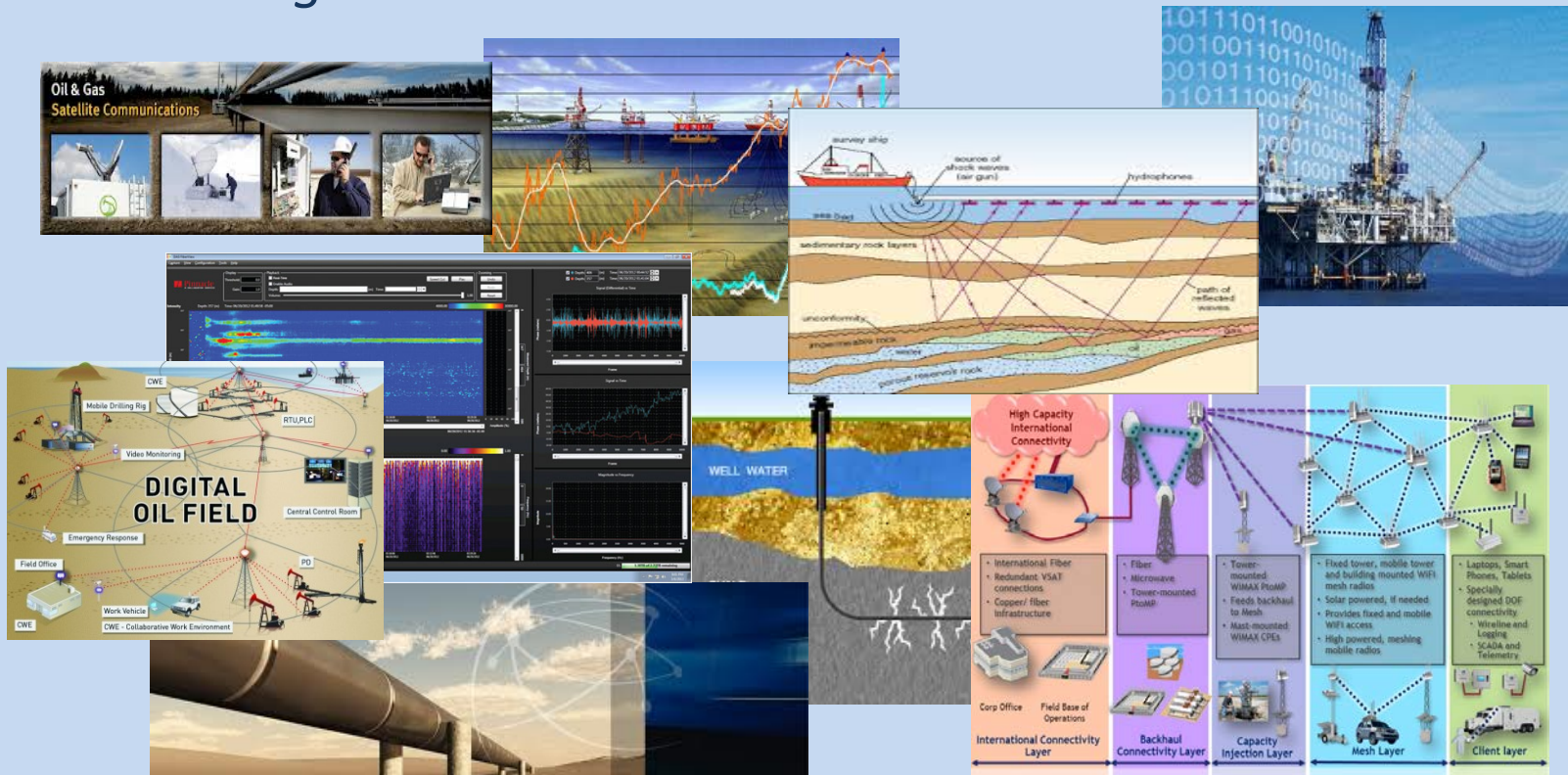
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A Few Examples - Today

- *IoT Oil & Gas Exploration and Production*
- *The Digital Oil Field*



- Smart Grid and Smart Utilities

- Healthcare

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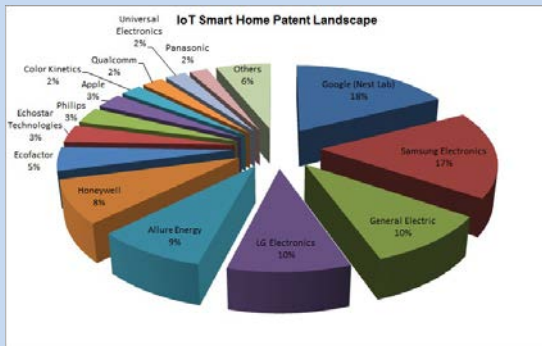
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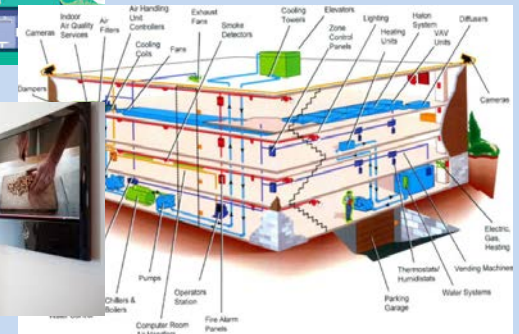
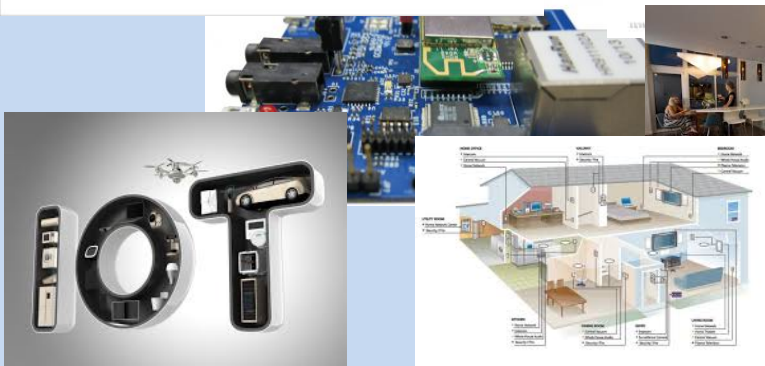


- *Smart Home*
- *Intelligent Home*
- *Home Automation*



What is the Smart Home

- Network interconnected
 - Internet with high speed broadband
 - Highly Automated
 - Light control
 - Climate control
 - Improve comfort
 - Ensure security
- 



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A Few Examples - Today

- Mining and Natural Resources*



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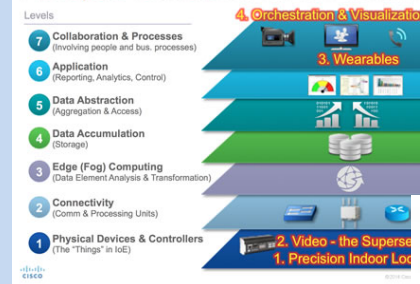


A Few Examples - Today

• Retailing



Hot Spots for Retail in the IoT Techno



A Few Examples - Standards



Initiated by Qualcomm with over 100 members: APIs, interoperability and consumer electronics

IEEE Standard P2431

IoT Architectures



Cross Industry Telecommunication Standards: Led by seven SDOs



Founded by GE, Intel, IBM, Cisco, and AT&T: IoT for the Industrial World

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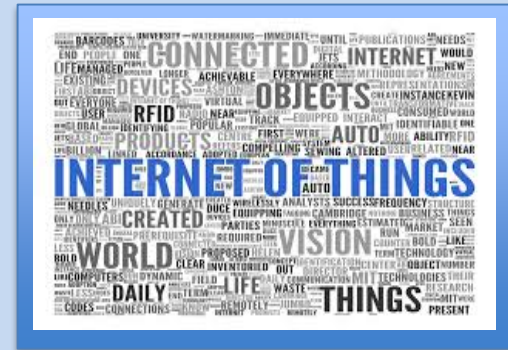
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Summary

- *The Internet of Things is complex and today involves many different IoT implementation.*
- *Standards play a key role in consolidating our knowledge and extending the reach of solutions. This in turn allow us to do new things and at the same time drive down the costs to accelerate adoption.*
- *The greatest gains will come from how we refactor the design of personal and infrastructure systems that are pervasive and affect us all.*

Thank you!



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