Internet of Things 2015/2016

The Things

John Carpenter, 1982

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Guiding questions

- What makes up the IoT?
- IoT versus WSN
- What are examples?

Some definitions of IoT (march 2015)

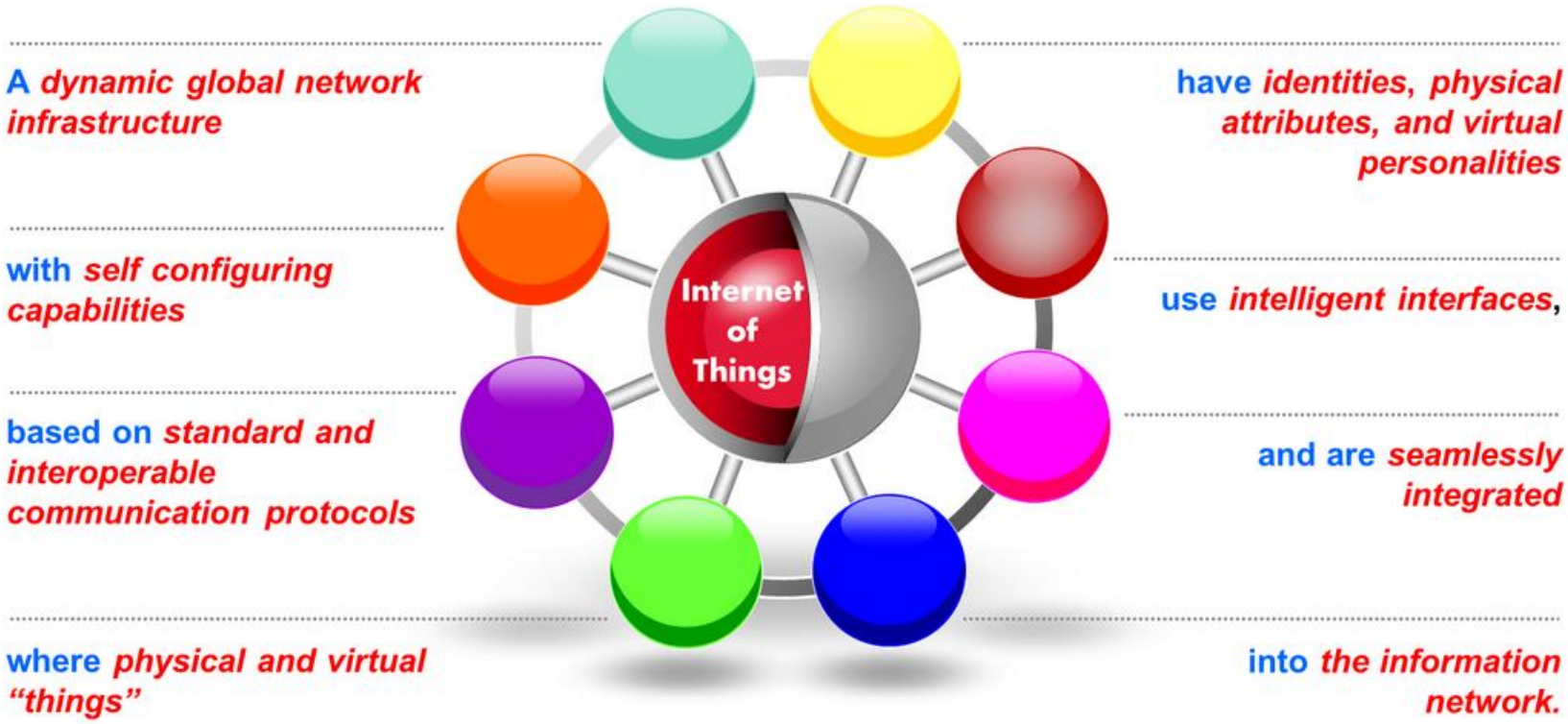
- **Whatis.com:** *a scenario in which objects, animals or people are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. IoT has evolved from the convergence of wireless technologies, micro-electromechanical systems (MEMS) and the Internet.*

- **Wikipedia:** … *is the network of physical objects or "things" embedded with electronics, software, sensors and connectivity to enable it to achieve greater value and service by exchanging data with the manufacturer, operator and/or other connected devices. Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet infrastructure.*

- **Techopedia:** … *is a computing concept that describes a future where everyday physical objects will be connected to the Internet and be able to identify themselves to other devices*.

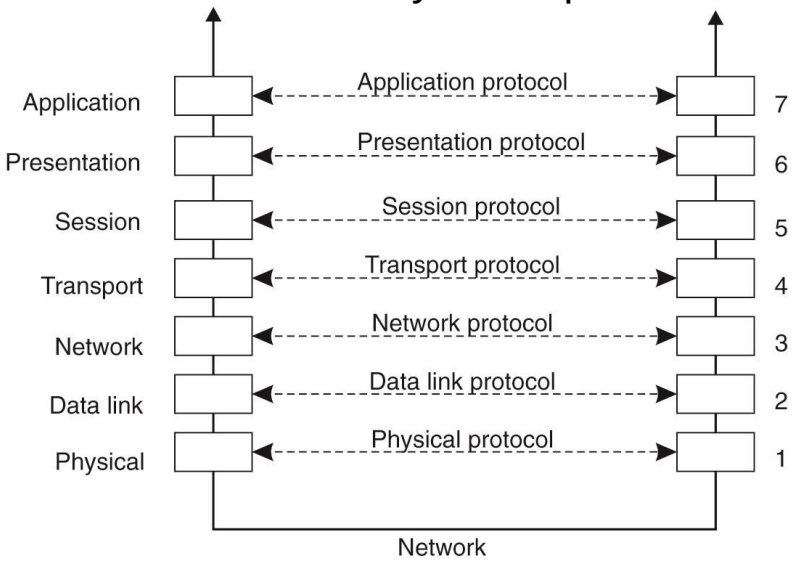
Some definitions of IoT (march 2015)

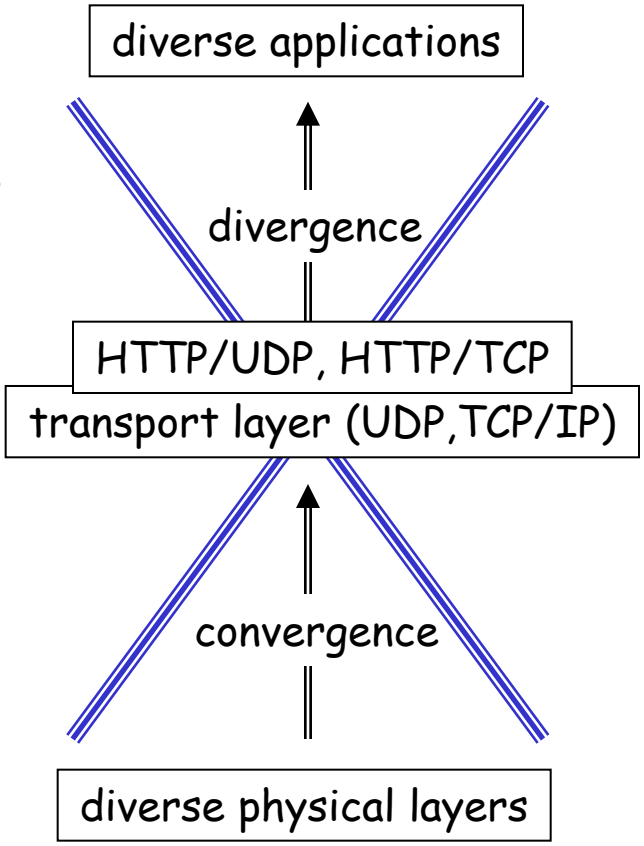
- IERC:



The hour glass of IP

- The essence of IP, and its success
  - *a unified protocol and naming (addressing) scheme to enable communication between any pair of devices*
    - all 'layer breaking' or application knowledge is banned from lower layers until the transport layer
    - semantics only at endpoints





Is IoT so much different?

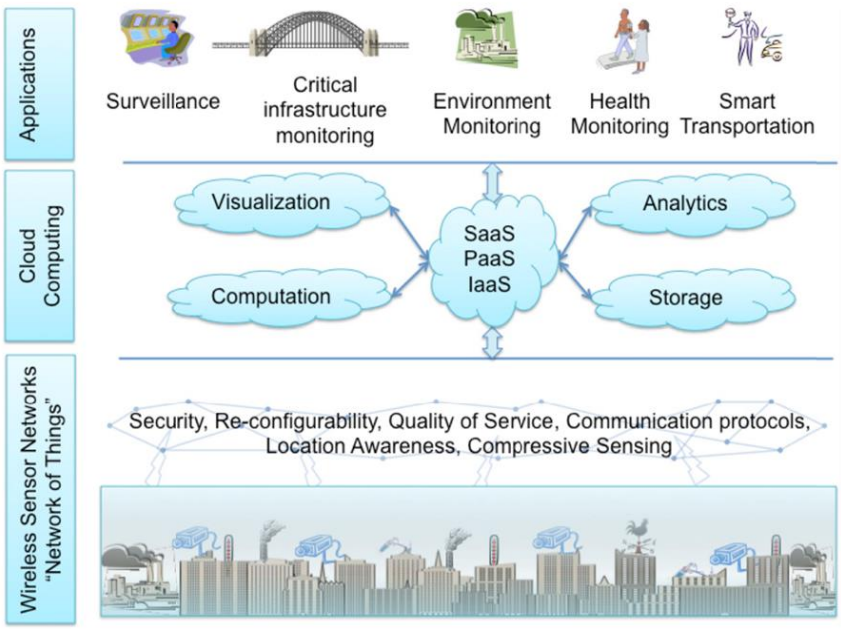
- The essence of IoT
  - *a unified protocol and naming (addressing) scheme to enable communication between any pair of ~~devices~~ things*
    - *… that contain embedded networked electronics, of course*

What's new with IoT?

- There are **many** things
  - #things / person >> 1 (50B in 2020)
  - hence, things need to talk to *each other*
    - about …..
  - self-* properties, autonomy
    - self management, self healing, …
  - scalability, at access networks
    - many things sharing your wireless LAN
- Things have **limitations**
  - low processing power, memory, network capacity
    - size IP packet comparable to available memory
  - sometimes battery operated
- Their numbers and locations enable **entirely new applications**
  - large-scale data collection
  - data-based applications
  - manufacturers probing into the deployed systems
- Their penetration comes with **complex concerns**
  - data handling, ownership
  - security, safety, application reliability
    - at a compelling scale
  - application development, deployment, management

Scope

- Literature mentions converging elements:
  - Internet, IP protocols
  - WSN
    - low resource communication standards
  - Cyber Physical Systems
    - tight integration of communication, computation, physical world
  - Cloud Computing
- Using cloud computing:
  - build power services and applications on top of massive amounts of data
  - … collected through the embedded devices
  - however, there are more operational views



J. Gubbi et al., *Internet of Things (IoT): A vision, architectural elements and future directions*, Future Generation Computer Systems, 29(2013), p1645-1660.

But we had already WSN?

IoT

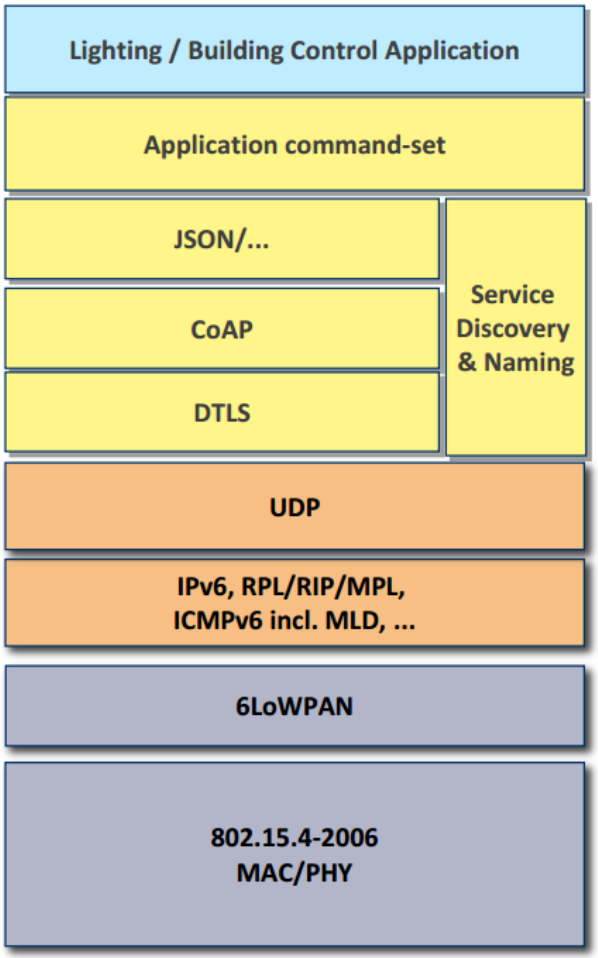
- System
  - is platform: concurrent applications at endpoints
- Protocol
  - IP to endpoints
  - … on top of low resource networks
- Applications
  - use standard IP protocols
  - developed separately
- Management
  - IP management protocols
  - explicit, requires interfaces

WSN

- System
  - … is the application
- Protocol
  - application oriented
  - cross-layer optimization
- Applications
  - developed and optimized along with the entire system
- Management
  - implicit, part of the application

Which (IP) protocols are we talking about?

- Connectivity:
  - uIP, IP/X, with X = Zigbee, 802.15.[14], and others
  - 6lowpan (= IP/802.15.4), UDP, TCP [sometimes]
  - RPL, RIP, MPL: routing
  - DTLS: security
  - Trickle: dissemination
- Application
  - RESTful style (REST plus HTTP methods)
    - CoAP – constrained application protocol
  - DSN-SD using mDNS, CoAP directory: for service discovery
  - M2M protocols, e.g. MQTT



Courtesy of Dee Denteneer

What makes up the IoT?

- ‘Things’ are *constrained* devices…
  - memory: static background (flash) and dynamic (RAM)
  - processing power: #instructions / second
  - available energy
  - accessibility, uptime (duty cycling)
- …connected into *constrained* networks (typically deriving from node constraints)…
  - low bitrate
  - duty cycle limits [may not use network more than x%]
  - high packet loss, and variability
  - asymmetric links
  - small packet size
  - limited group communication primitives
- …but then, united with regular Internet devices

RFC 7228

- Three classes
- C0: dependent on proxies for secure Internet inclusion
- C1: only low resource protocols
- C2: can run most Internet protocols

Name	data size (e.g., RAM)	code size (e.g., Flash)
Class 0, C0	<< 10 KiB	<< 100 KiB
Class 1, C1	~ 10 KiB	~ 100 KiB
Class 2, C2	~ 50 KiB	~ 250 KiB

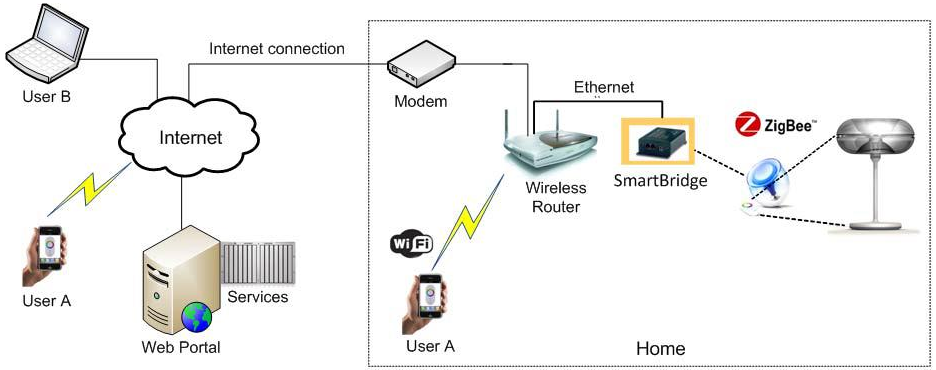
Some taxonomy

	Flash	RAM	Address space	Processor (type)	OS	Energy	Operation	Actively reachable	Example
A	small code memory	several bytes	<= 8bits	~100Hz	no	External, or battery + wakeup	Externally activated, simple read/write	not designed for reachability via multi-hop	RFID tag, ISO 18000-6c
B	<= 32K	Few hundreds	<=16 bits	~1Mhz TMS430	no, or simple executive	mechanical	mechanically activated, just generates some data	no; needs proxy	power switch
C	<=32K	Few hundreds	<=16 bits	~1Mhz TMS430	Contiki, TinyOS	battery	simple, fixed external behavior, needs proxy, simple sensing	duty cycled, needs proxy	simple sensor mote
D	<=32K	~10K	<=16 bits	~1Mhz TMS430	Contiki, TinyOS	battery + recharge	capable of managing most constrained IP protocols, sensing, actuating, processing	self-managed on/off behavior	Crossbow
E	<=256K	~32K	<=32 bits	~1-10Mhz ARM	Contiki, TinyOS	battery + recharge, mains	complete IP endpoint behavior, limited storage	yes	Jennic mote
F	~GB	~500Mb	32 bits	~Ghz ARM	Linux	battery + recharge, mains	full fledged embedded computer system	yes	Rasberry PI
G							phones, laptops, servers		

Every Thing?

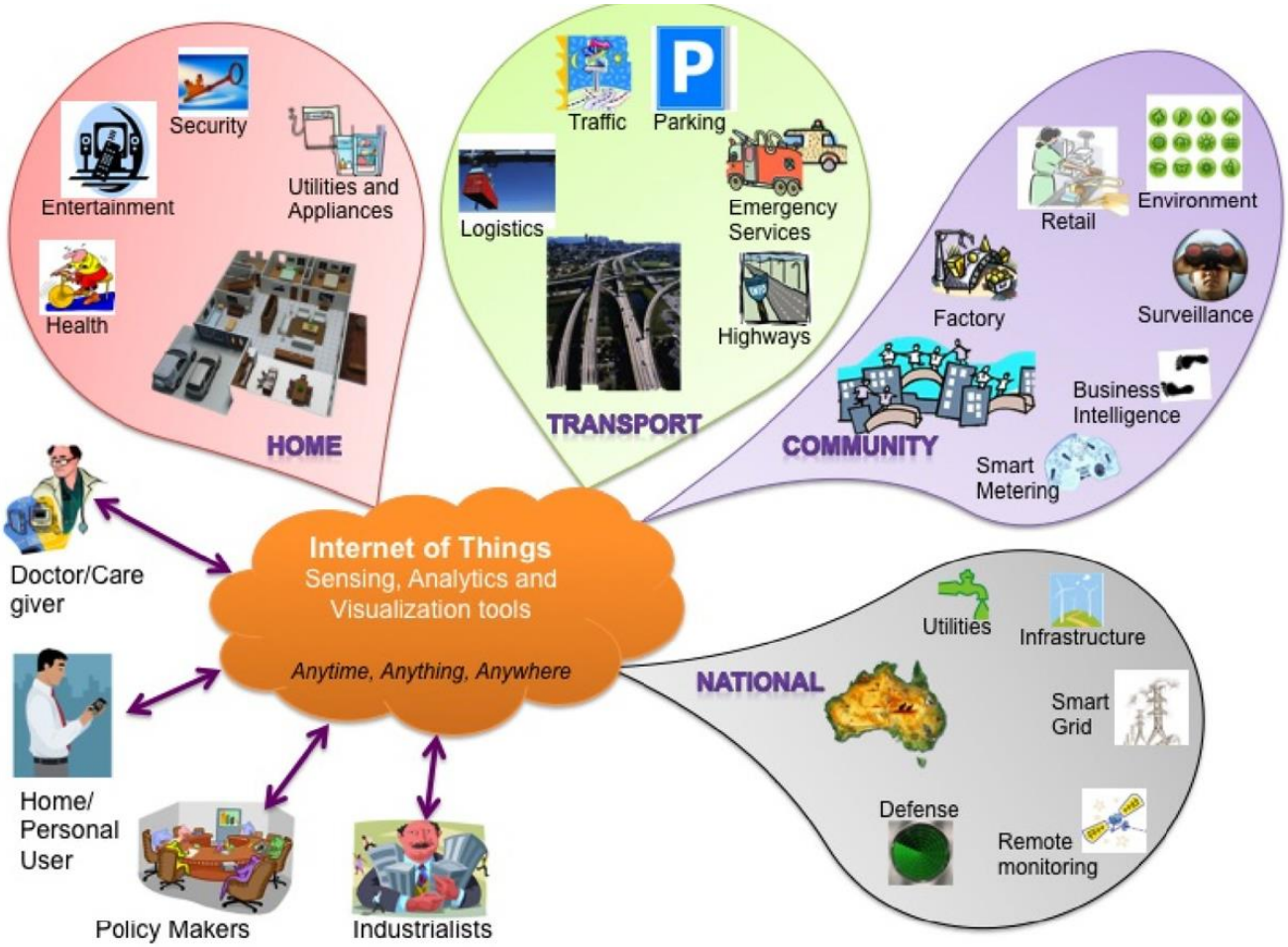
- IP connectivity comes with hidden assumptions
  - endpoints are active, reachable
  - … by IP packets

- Devices cannot always guarantee this
  - passive nodes, when there is no reader
  - battery-less nodes
  - duty cycling, or off-time planning
  - incapability to process IP



- Legacy may prevent IP to endpoints
  - existing networks, without capability to use IP

Example applications



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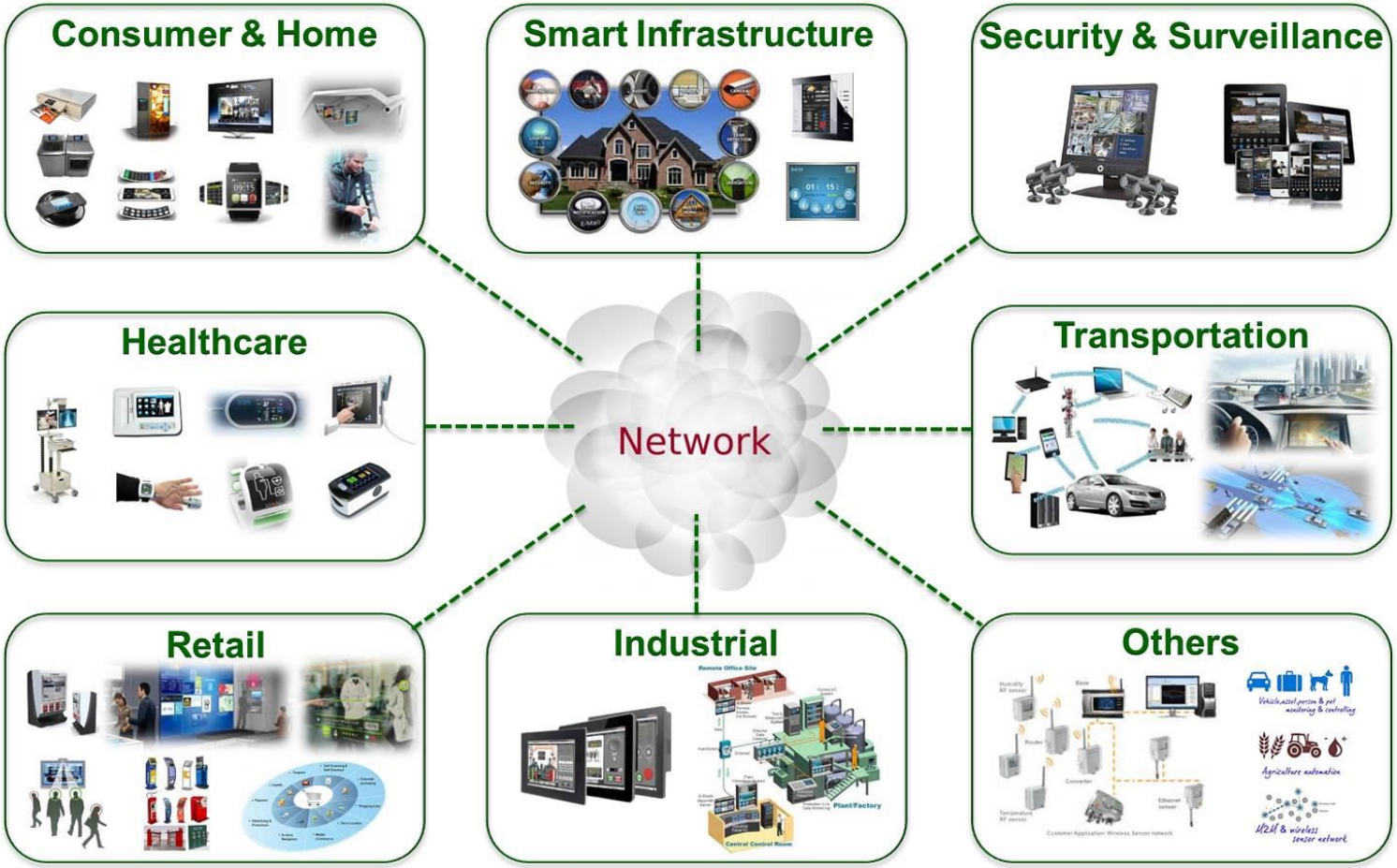
Some Things



retrieved from bensontao.com, March 2015

Conclusion, and concerns

- IoT networks: devices and topology
- IoT protocols: typical operation
- IoT applications: patterns and life cycles
- IoT platform
  - reliability
  - security
  - data management

- IoT trends