

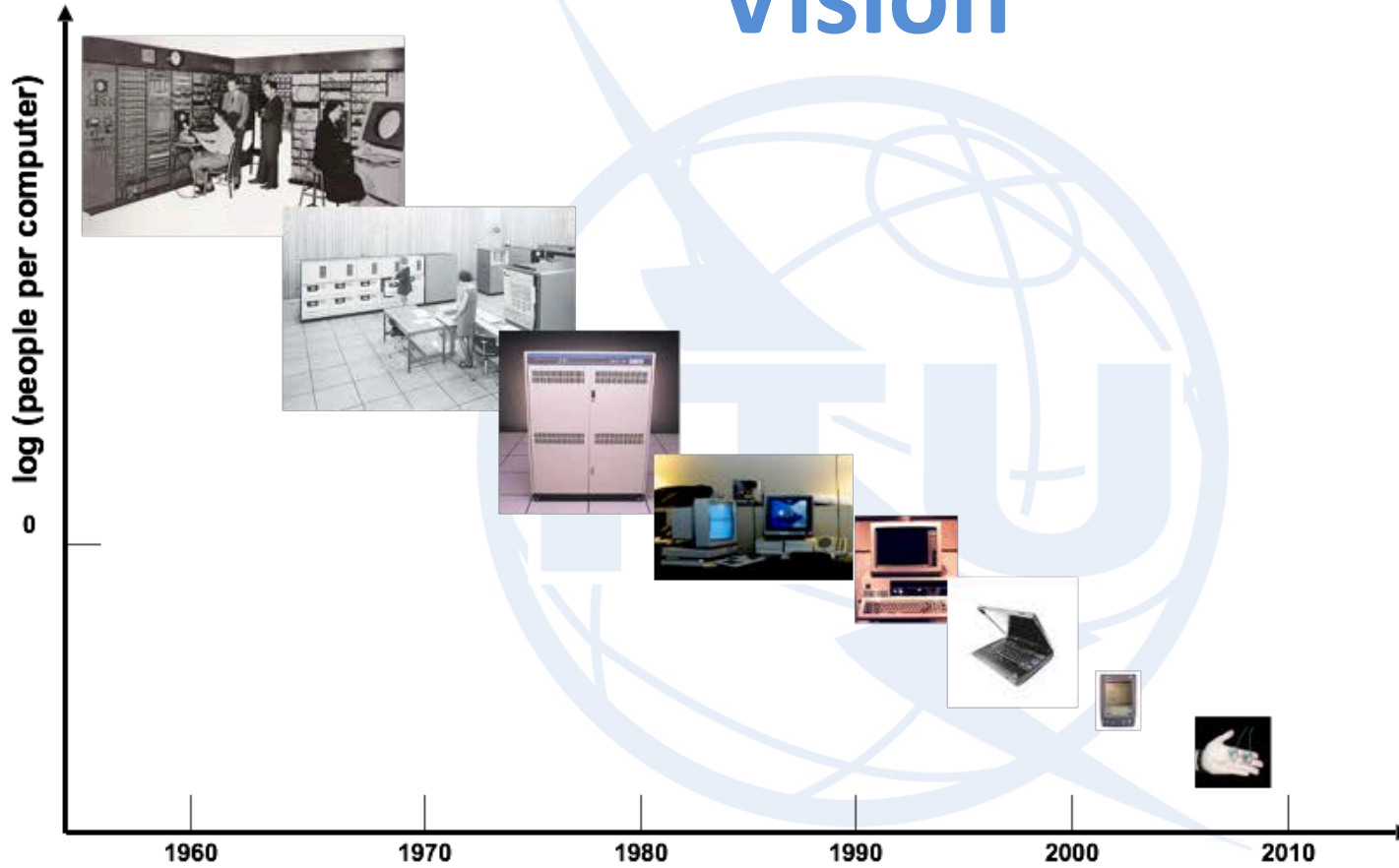


Intro to Internet of Things

ITU ASP COE TRAINING ON
“Developing the ICT ecosystem to harness IoTs”

Marco Zennaro, PhD
13-15 December 2016
Bangkok, Thailand

Vision



[Culler:2004]

History of IoT

- The first **telemetry** system was rolled out in Chicago way back in 1912. It is said to have used telephone lines to monitor data from power plants.
- Telemetry expanded to weather monitoring in the 1930s, when a device known as a **radiosonde** became widely used to monitor weather conditions from balloons.
- In 1957 the Soviet Union launched Sputnik, and with it the Space Race. This has been the entry of **aerospace telemetry** that created the basis of our global satellite communications today.

History of IoT

- Broad adoption of M2M technology began in the 1980s with wired connections for SCADA (supervisory control and data acquisition) on the factory floor and in home and business security systems.
- In the 1990s, M2M began moving toward wireless technologies. ADEMCO built their own private radio network to address intrusion and smoke detection because budding cellular connectivity was too expensive.
- In 1995, Siemens introduced the first cellular module built for M2M.

History of IoT

- A second large wave of adoption and development of cellular M2M solutions became necessary when the Federal Communications Commission mandated a shutdown of analog networks in favor of the more spectrum-efficient digital network technology.
- 75% of M2M and industrial IoT applications use less than one megabyte per month of data.

History of IoT

“Machine to Machine” (M2M)
(~1970s +)



Internet of Things Beginnings



Carnegie Mellon Internet
Coke Machine (1982, 1990)



Internet Toaster
(1990)

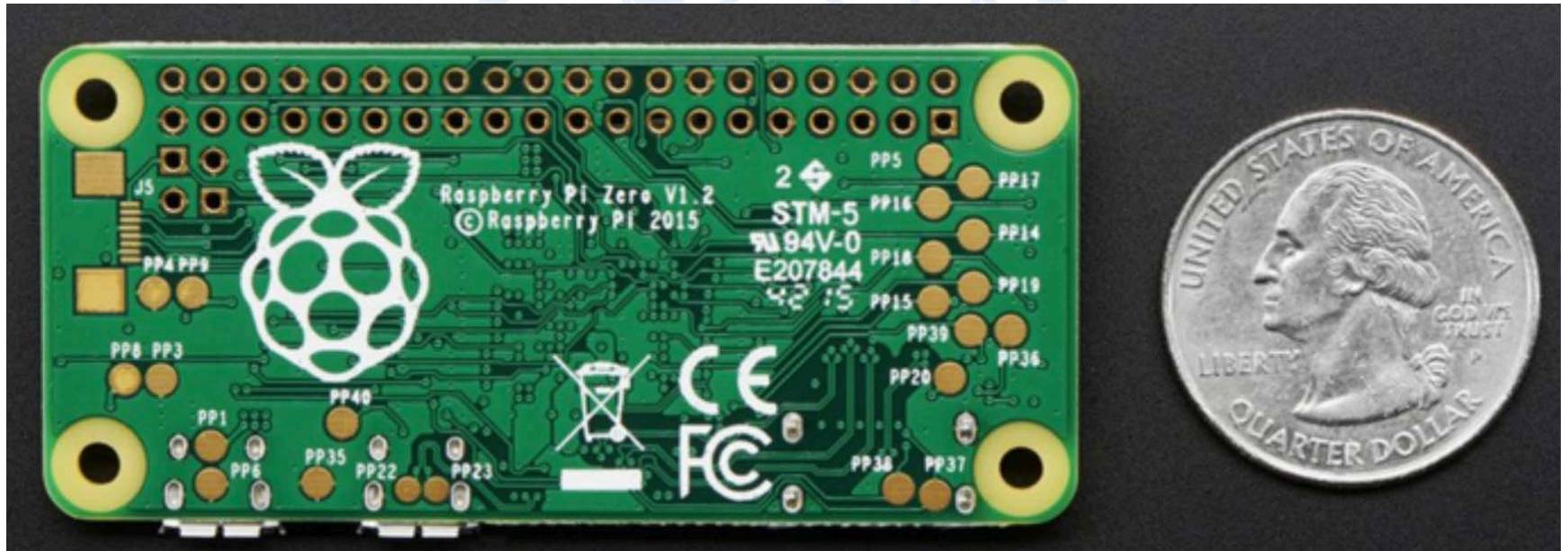


Trojan Room Coffee
Pot
(first webcam)
(1991)

Why IoT now?

- *Ubiquitous Connectivity*
- *Widespread Adoption of IP*
- *Computing Economics*
- *Miniaturization*
- *Advances in Data Analytics*
- *Rise of Cloud Computing*

Rpi zero: \$5



IoT Definition

- **Wikipedia:** The Internet of Things (IoT) refers to **uniquely identifiable objects** and their virtual representations in an **Internet-like structure**.

[http://en.wikipedia.org/wiki/Internet_of_things - 21-Jun-2014]

- **Cisco:** The Internet of Things (IoT) is the network of physical objects accessed through the Internet, as **defined by technology analysts and visionaries**. These objects contain **embedded technology to interact** with internal states or the external environment. In other words, when objects can sense and communicate, it changes how and where decisions are made, and who makes them.

[<http://www.cisco.com/web/solutions/trends/iot/overview.html> - 21-Jun-2014]



ITU Definition

- Recommendation **ITU-T Y.2060** provides an overview of the Internet of Things (IoT). It clarifies the concept and scope of the IoT, identifies the fundamental characteristics and high-level requirements of the IoT and describes the IoT reference model.
- Date: 2012-06-15

ITU Definition

The IoT can be viewed as a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies (ICT).

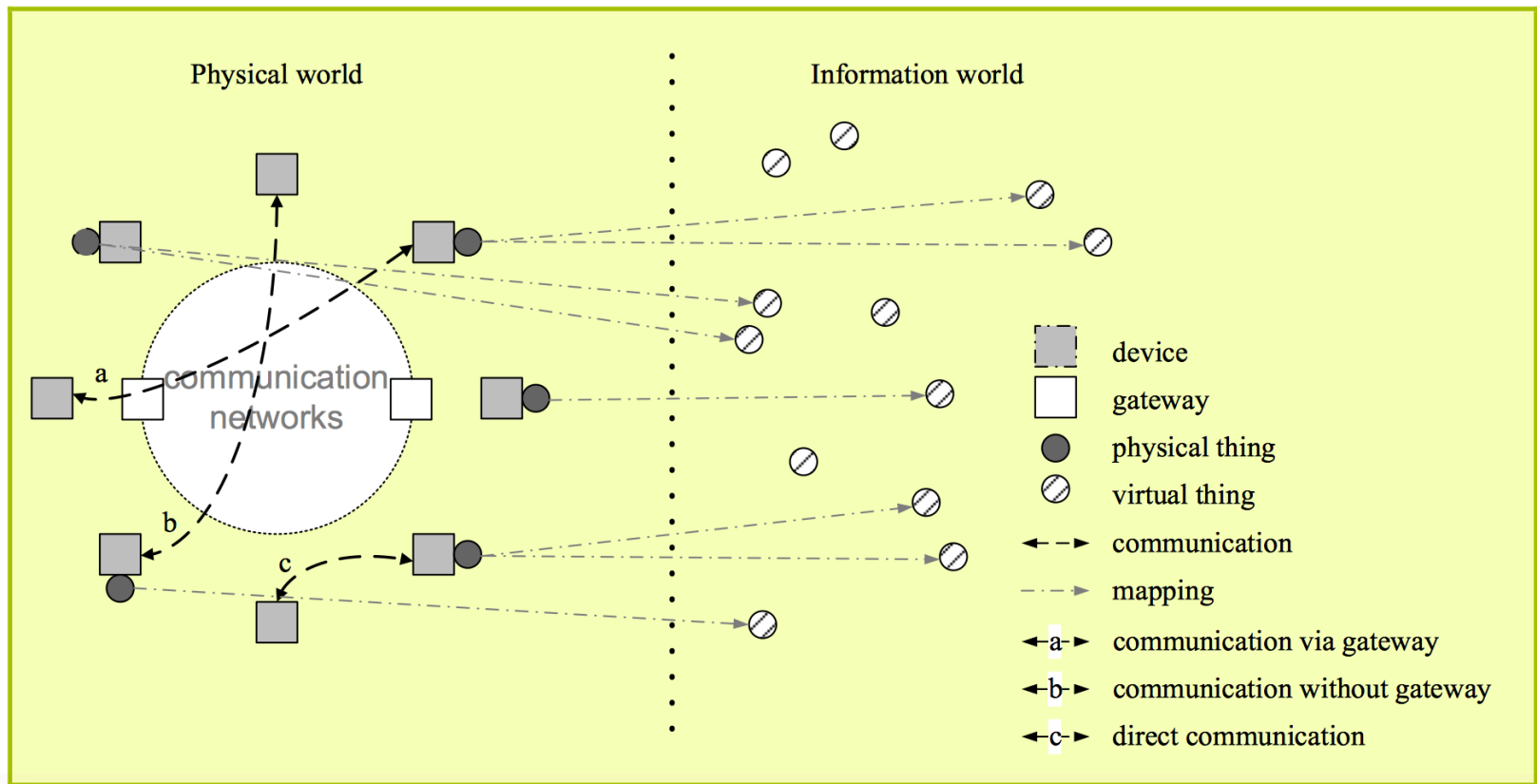
Things

Things are objects of the physical world (physical things) or of the information world (virtual world) which are capable of being identified and integrated into communication networks. Things have associated information, which can be static and dynamic.

Things

- **Physical things** exist in the physical world and are capable of being sensed, actuated and connected. Examples of physical things include the surrounding environment, industrial robots, goods and electrical equipment.
- **Virtual things** exist in the information world and are capable of being stored, processed and accessed. Examples of virtual things include multimedia content and application software.

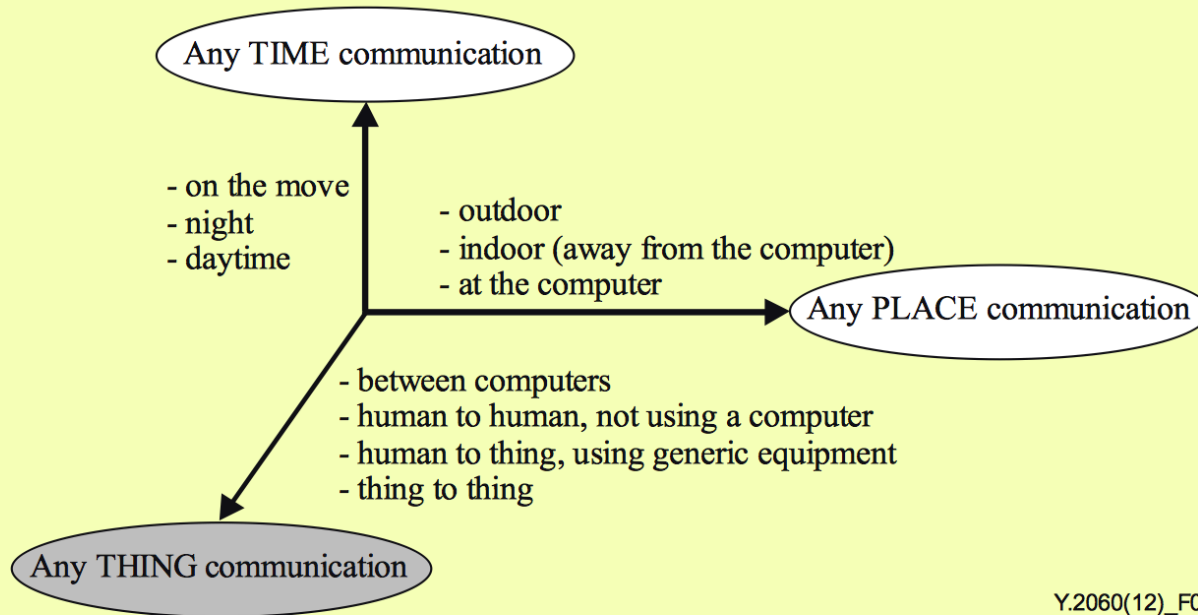
ITU Definition



Source: Recommendation ITU-T Y.2060



Any-Time/Place/Thing



Source: Recommendation ITU-T Y.2060



ITU Definition

A device is a piece of equipment with the mandatory capabilities of communication and optional capabilities of sensing, actuation, data capture, data storage and data processing. The devices collect various kinds of information and provide it to the information and communication networks for further processing.

Some devices also execute operations based on information received from the information and communication networks.

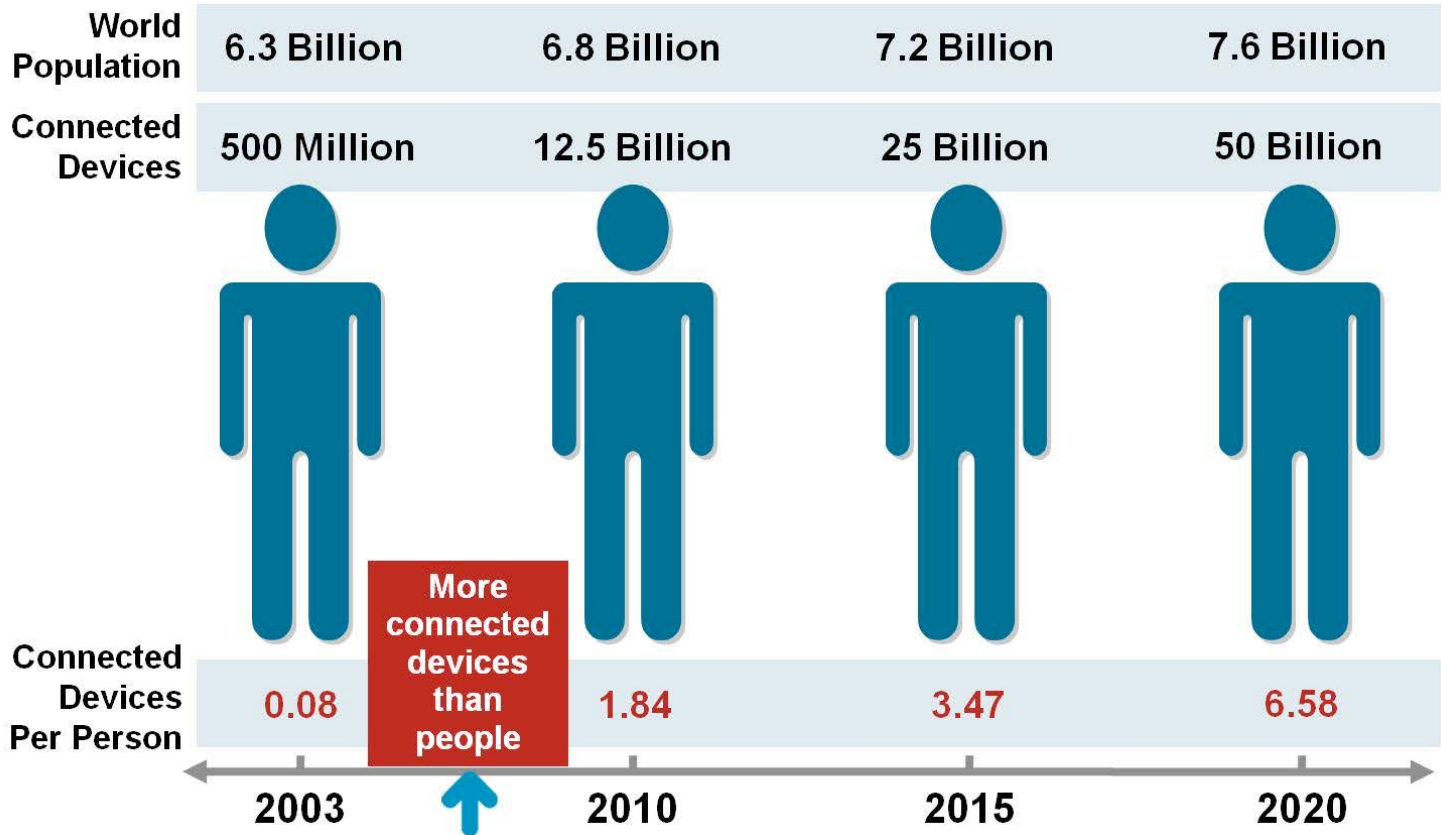
Fundamental characteristics

- **Interconnectivity:** With regard to the IoT, anything can be interconnected with the global information and communication infrastructure.
- **Heterogeneity:** The devices in the IoT are heterogeneous as based on different hardware platforms and networks. They can interact with other devices or service platforms through different networks.
- **Dynamic changes:** The state of devices change dynamically, e.g., sleeping and waking up, connected and/or disconnected as well as the context of devices including location and speed. Moreover, the number of devices can change dynamically.

Fundamental characteristics

- **Enormous scale:** The number of devices that need to be managed and that communicate with each other will be at least an order of magnitude larger than the devices connected to the current Internet. The ratio of communication triggered by devices as compared to communication triggered by humans will noticeably shift towards device-triggered communication.

Predictions



Source: Cisco IBSG, April 2011



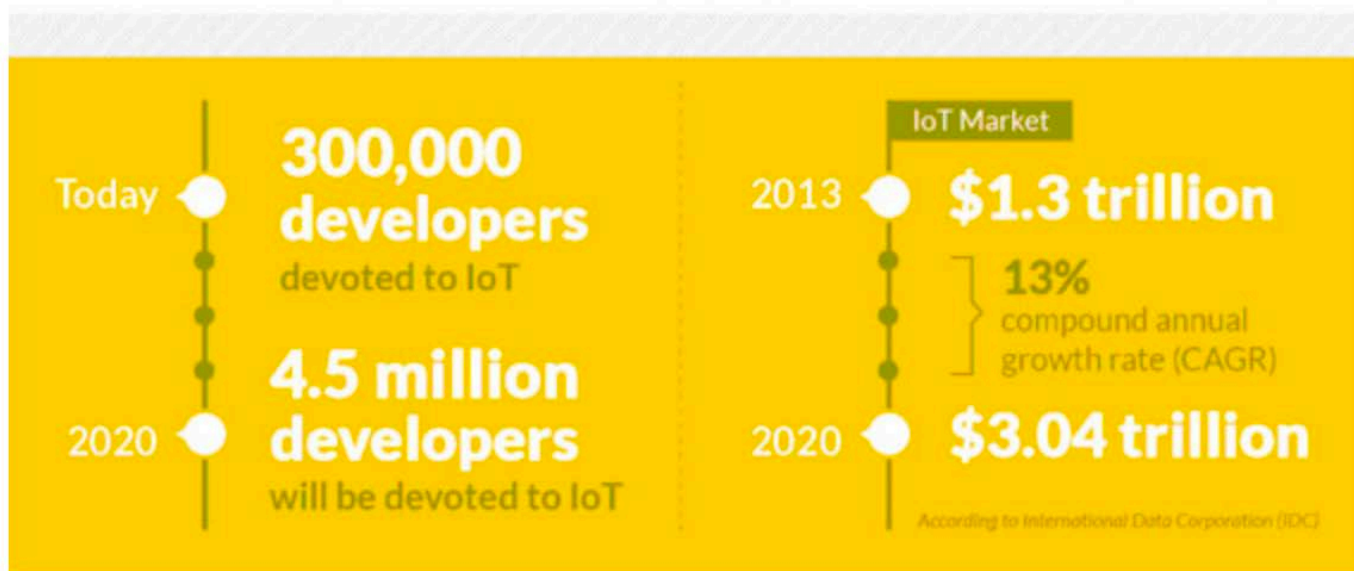
Predictions

IoT is being enabled by advances in

miniaturization

wireless connectivity

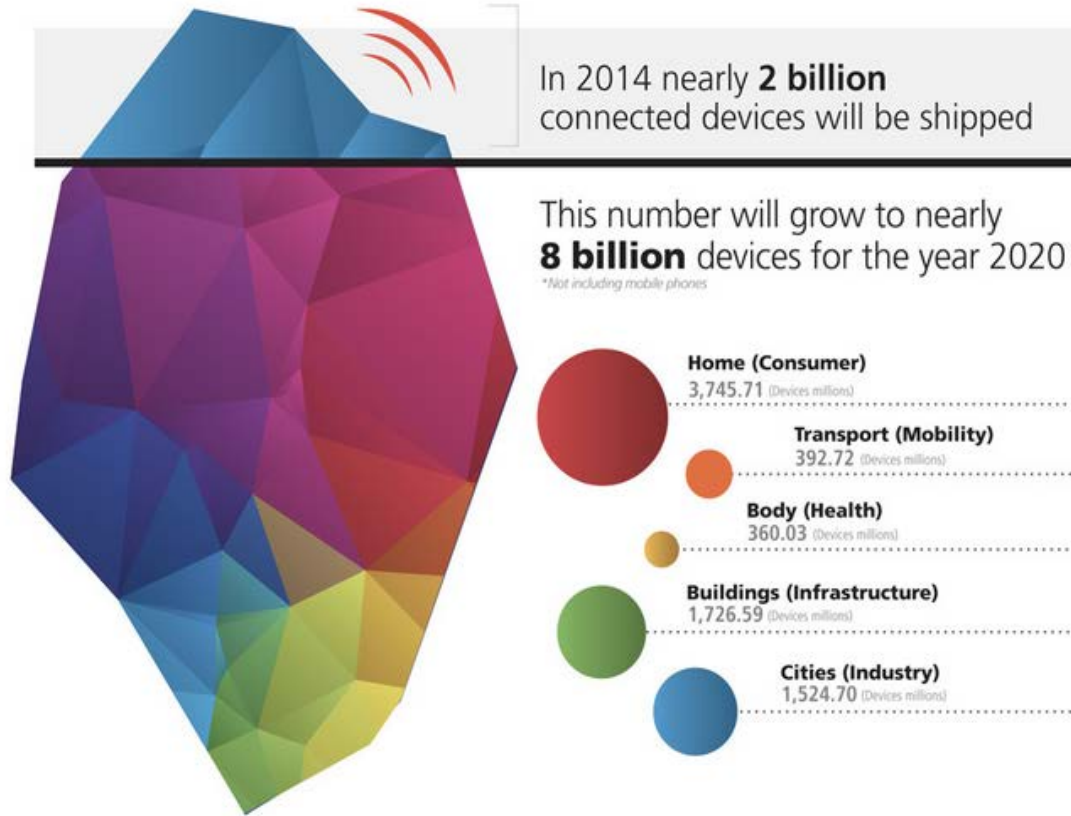
increased data storage capacity



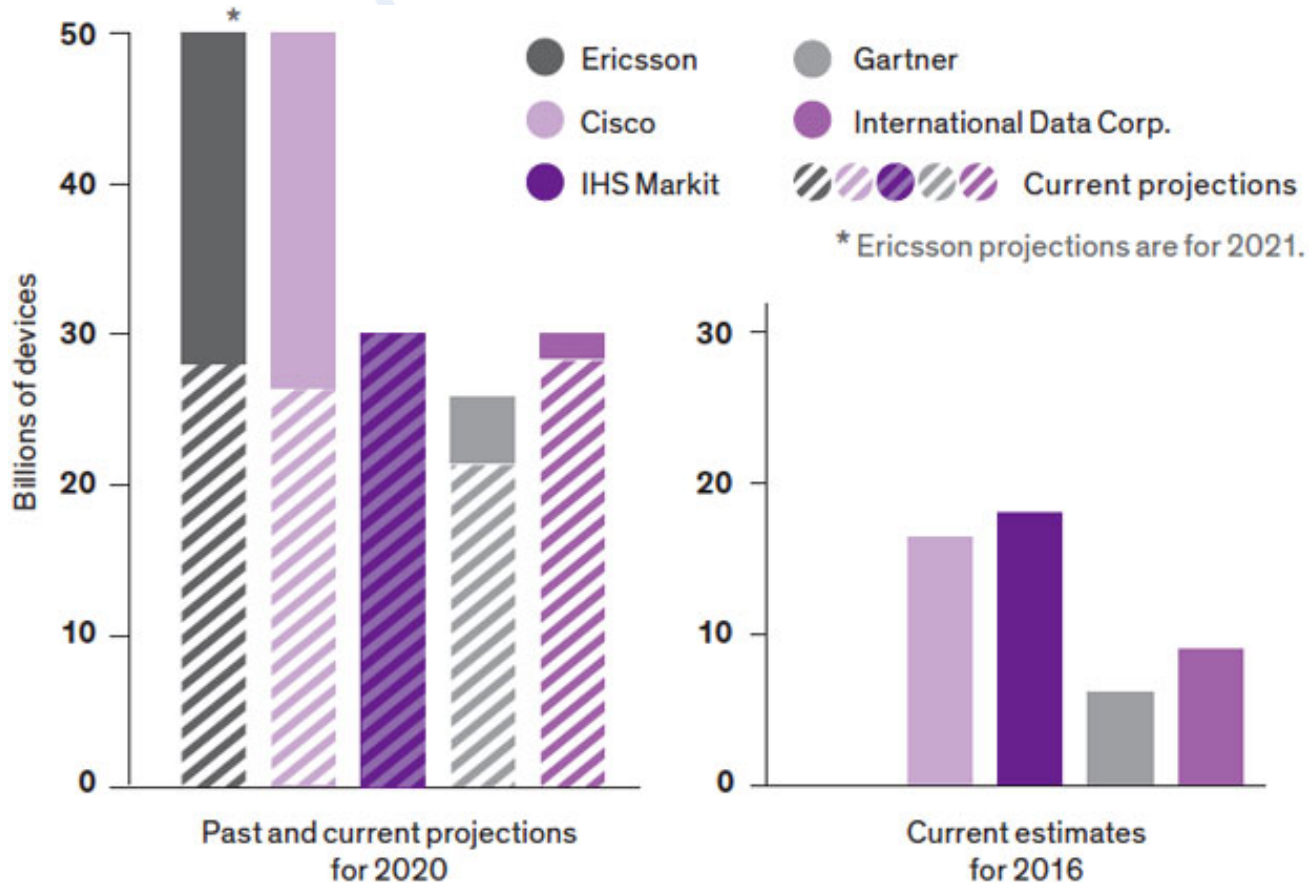
PwC's 6th Annual Digital IQ survey

Predictions

Connected Devices

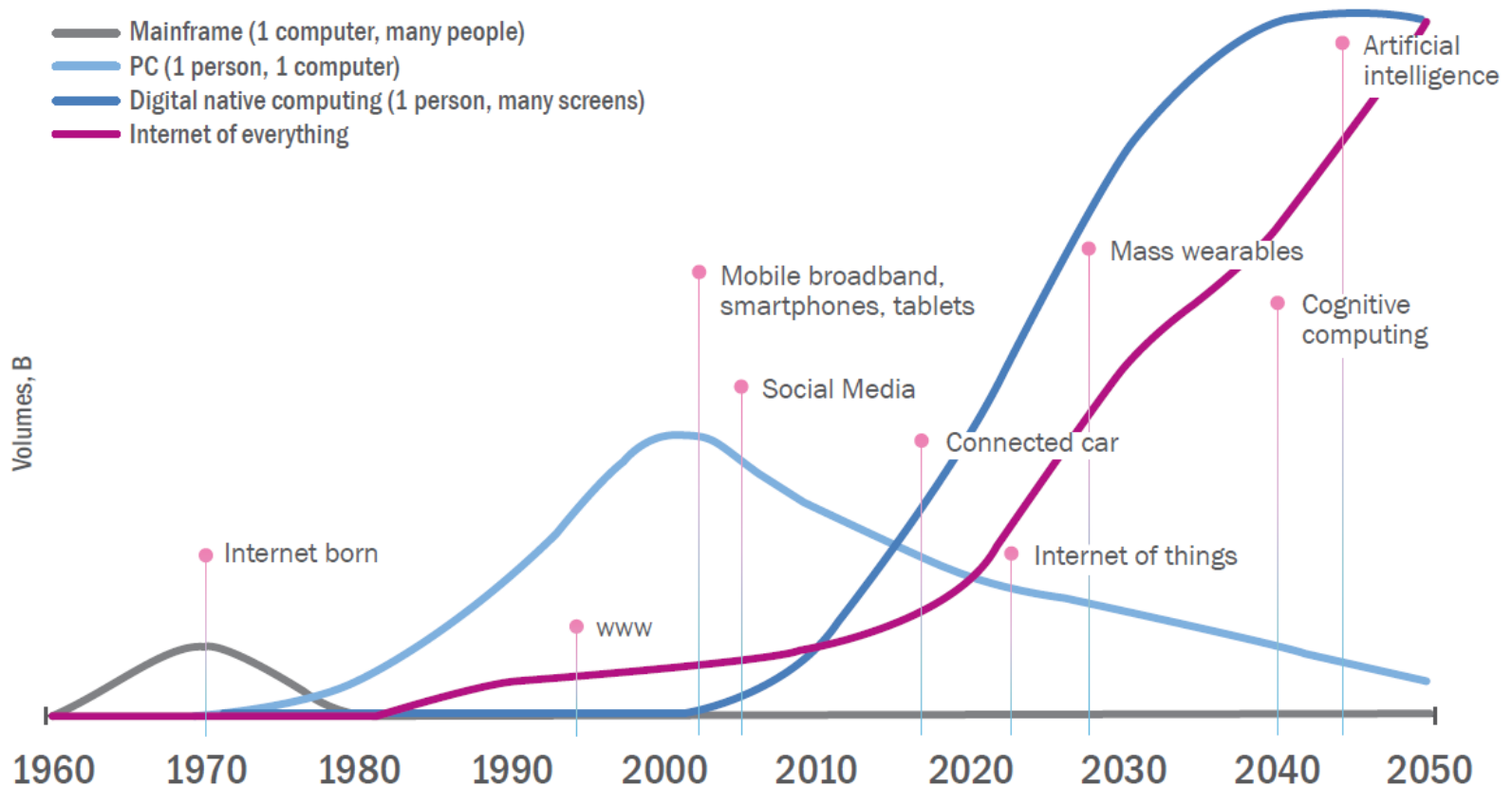


Internet of Fewer Things

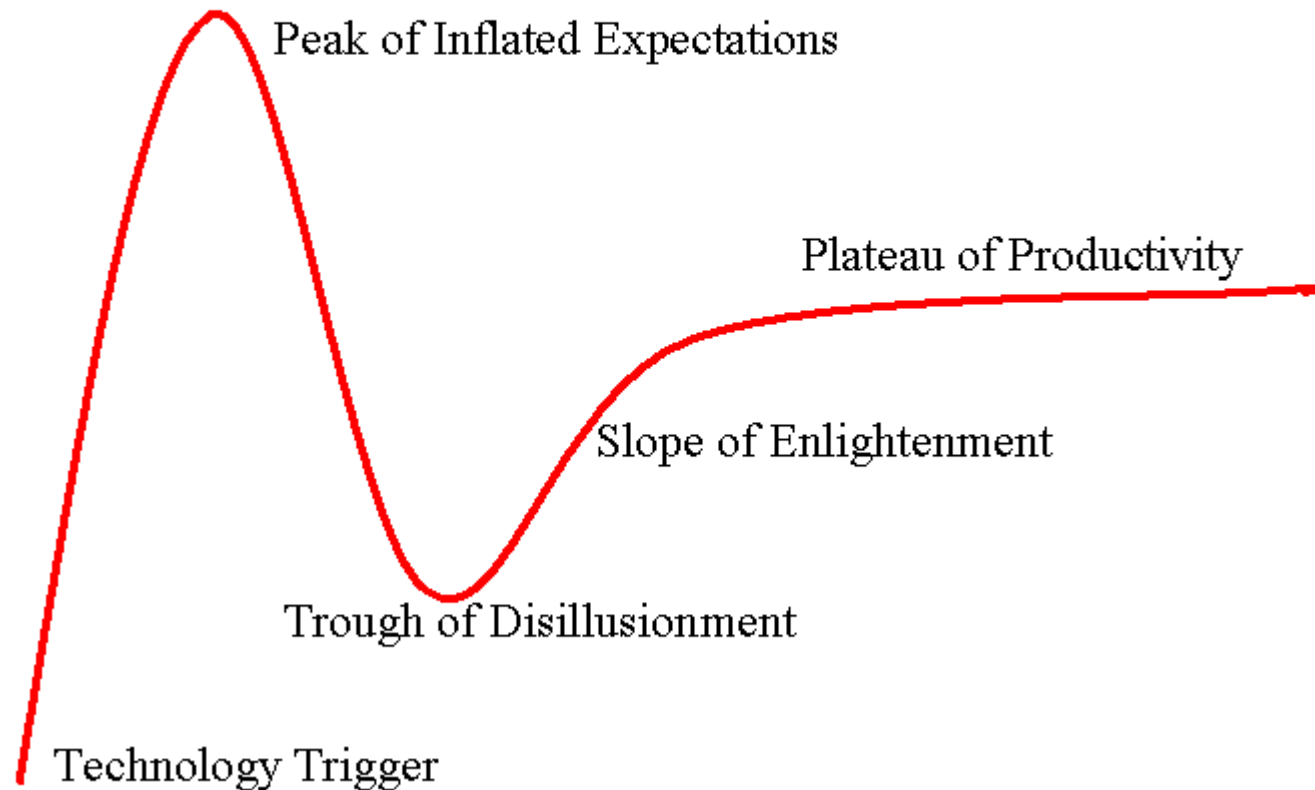


History of the future

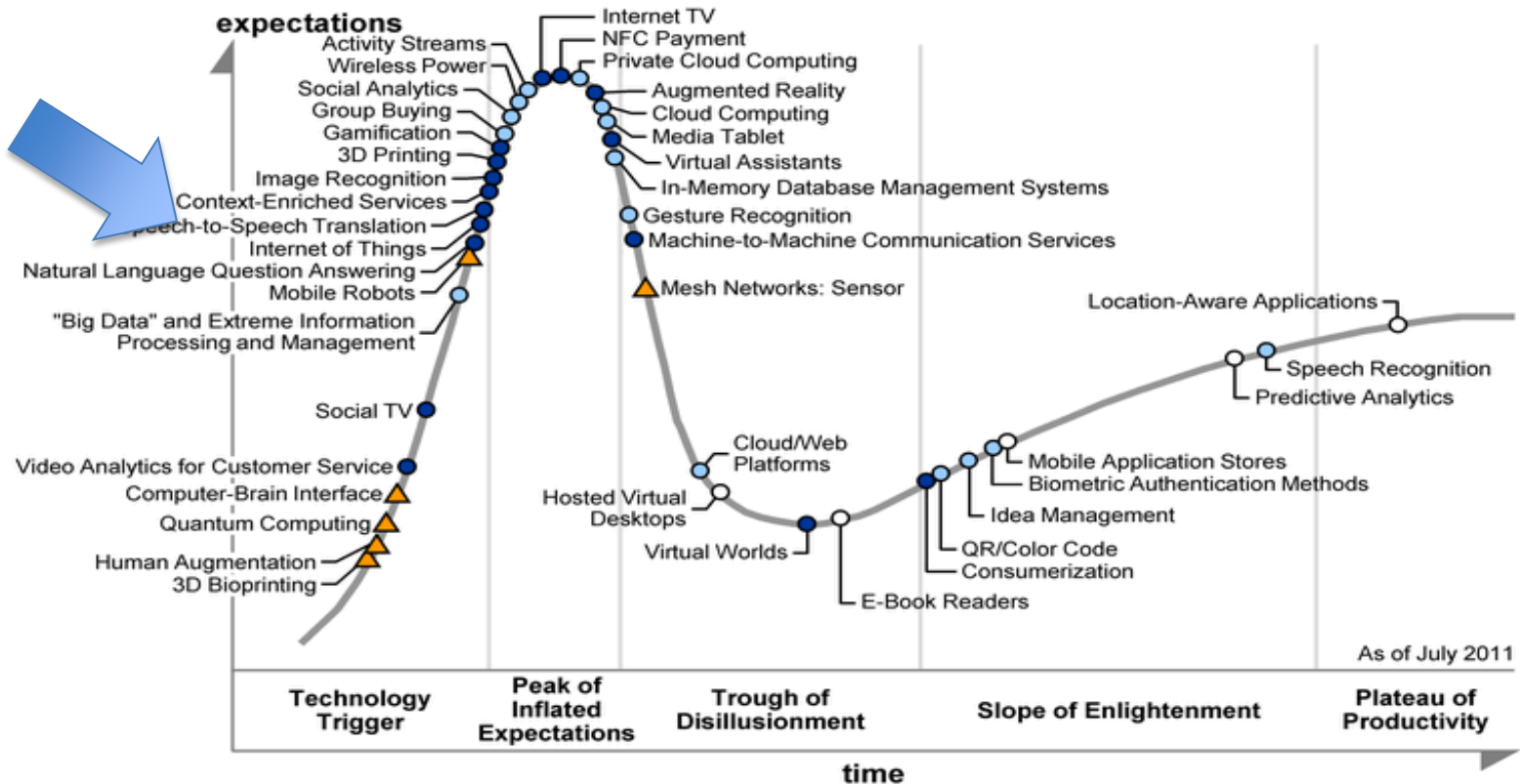
One to many to any: ICTs from happy few to the masses



Gartner Hype Cycle



2011



Years to mainstream adoption:

○ less than 2 years

○ 2 to 5 years

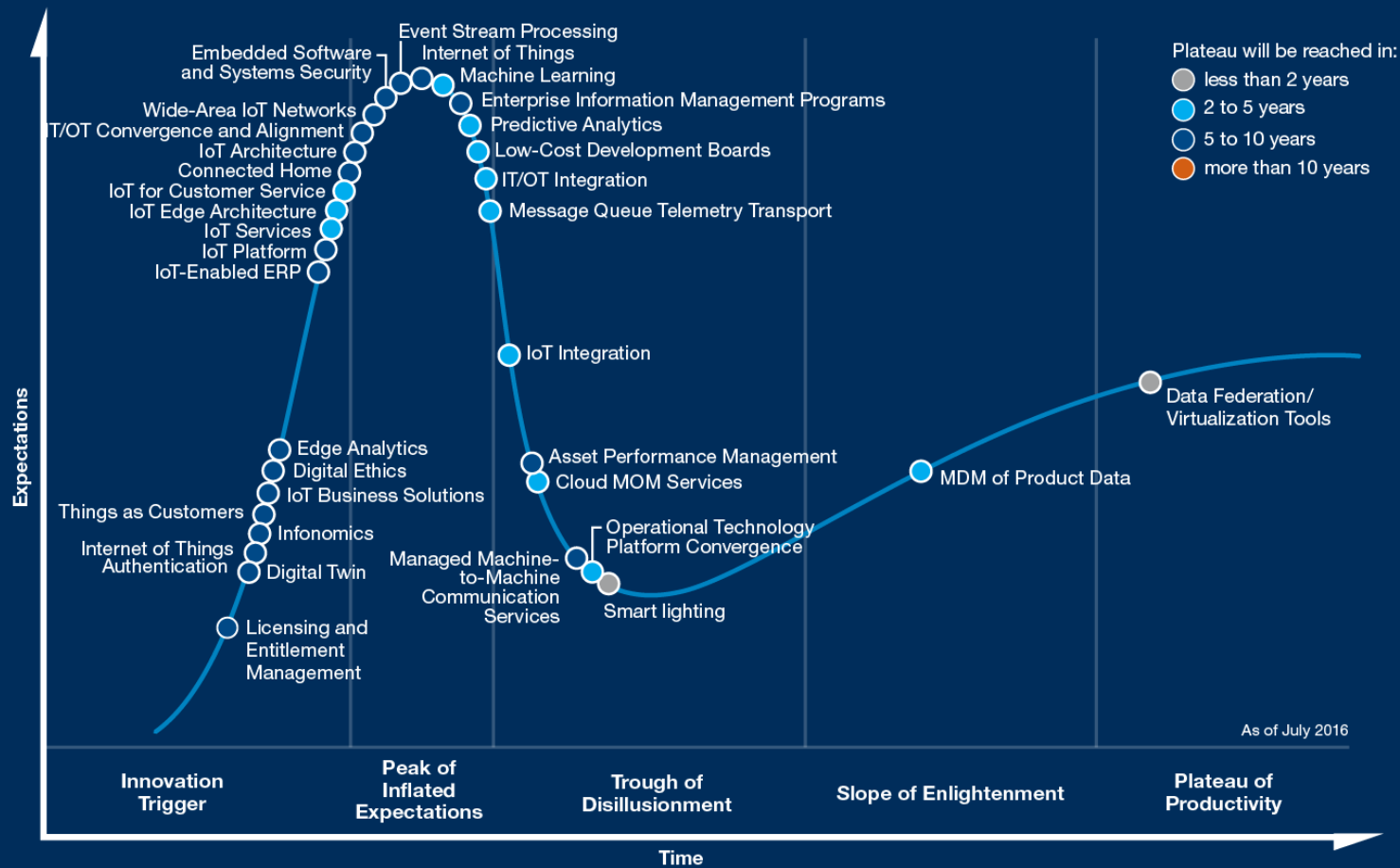
● 5 to 10 years

▲ more than 10 years

⊗ obsolete

⊗ before plateau

Gartner Hype Cycle for the Internet of Things, 2016



gartner.com/SmarterWithGartner

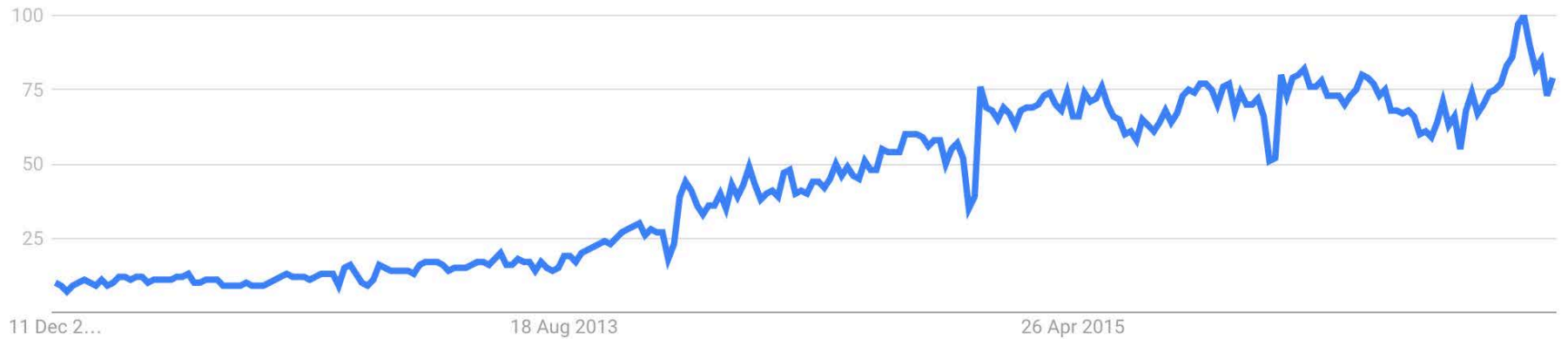
Source: Gartner
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Gartner



Interest: Google Trends

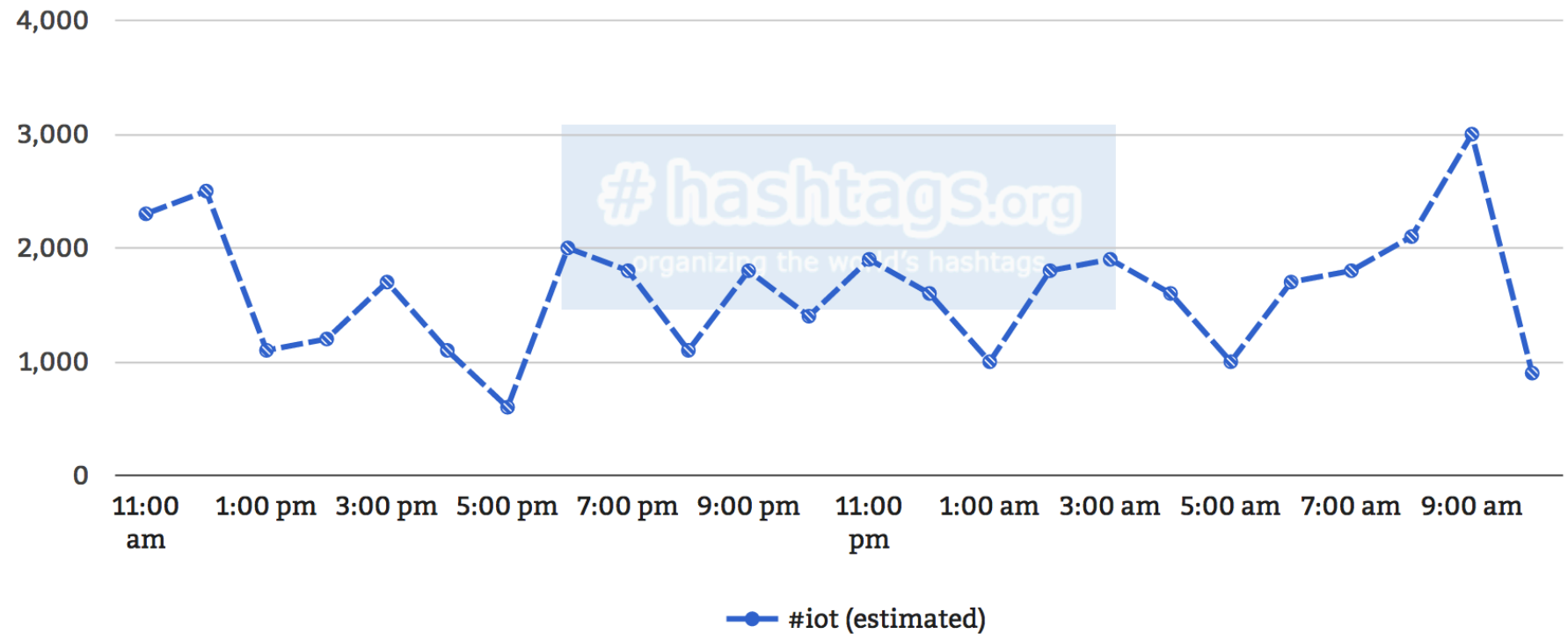
Interest over time ?



Interest: #iot on Twitter

Estimated Tweets per Hour (based on 1% Sample)

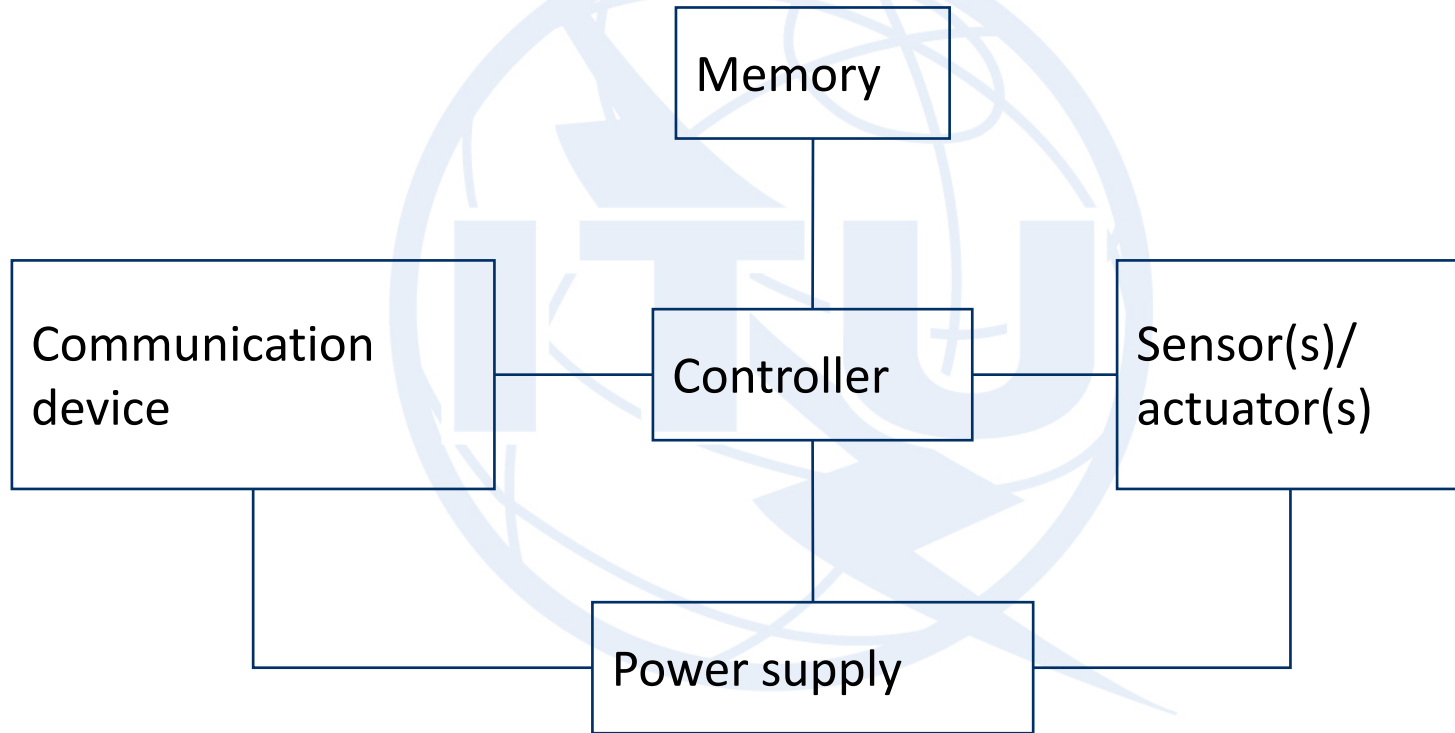
Timezone: America/Chicago



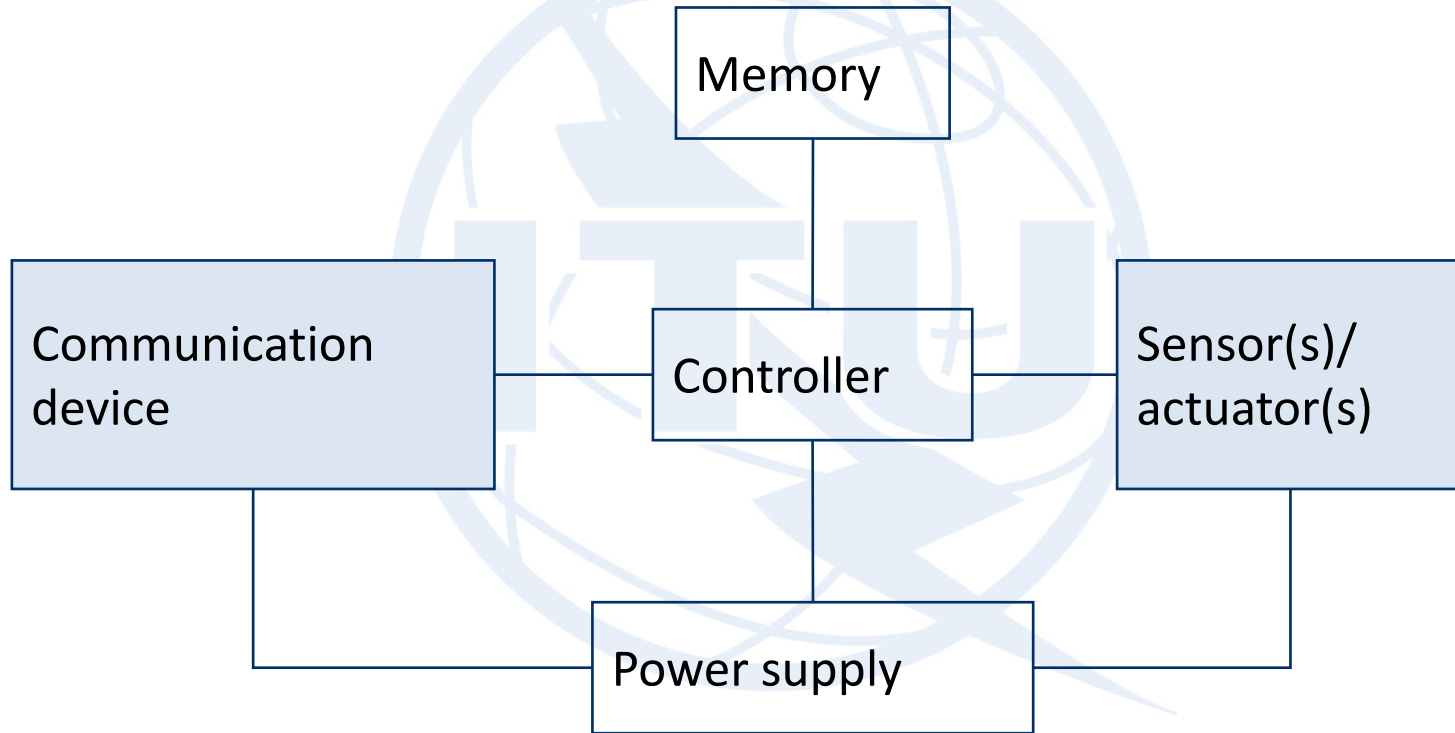
Sensor Nodes

- Main components of a WSN node
 - Controller
 - Communication device(s)
 - Sensors/actuators
 - Memory
 - Power supply

Sensor Nodes



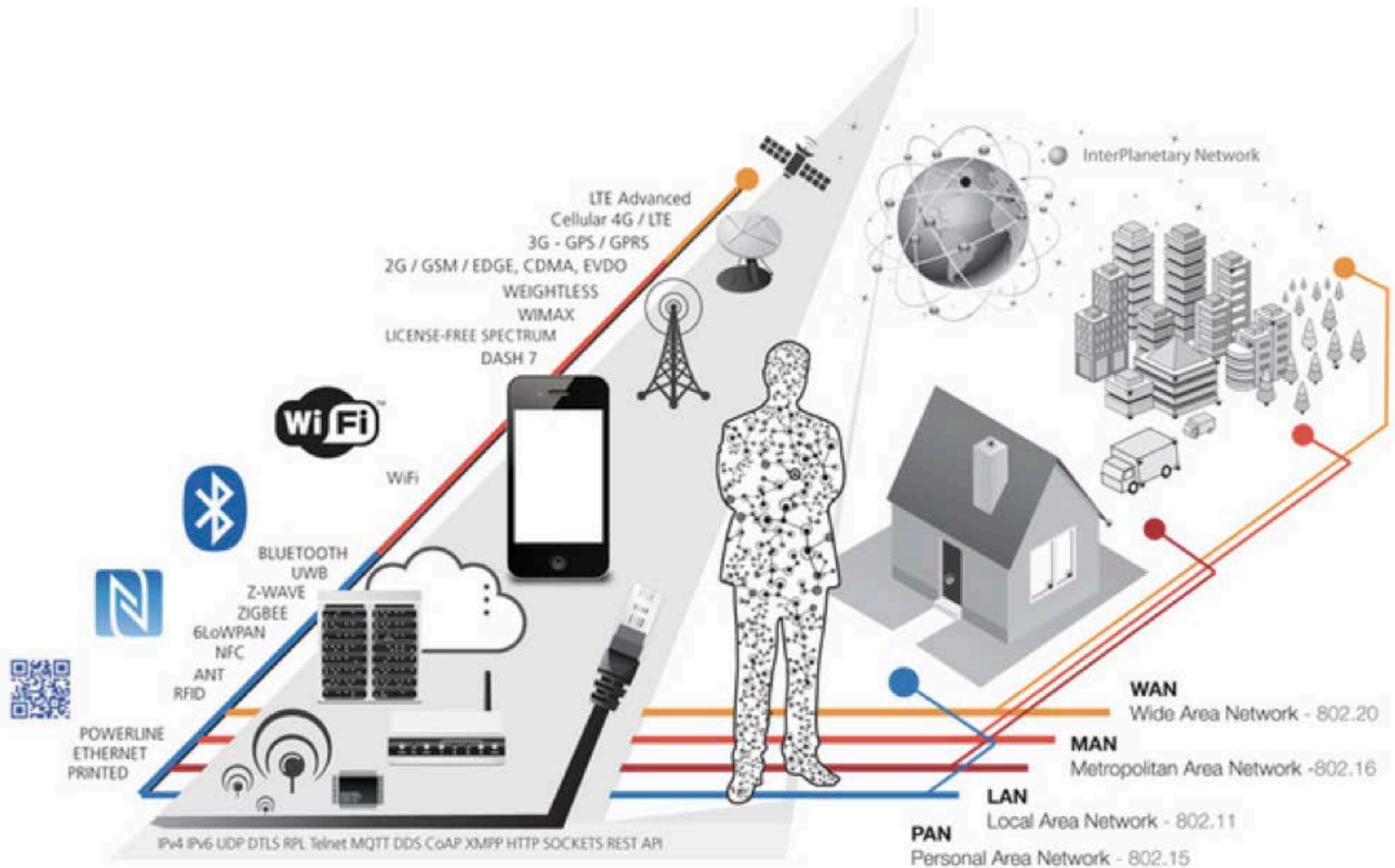
Sensor Nodes



Network Connectivity

Key aspects when considering network connectivity:

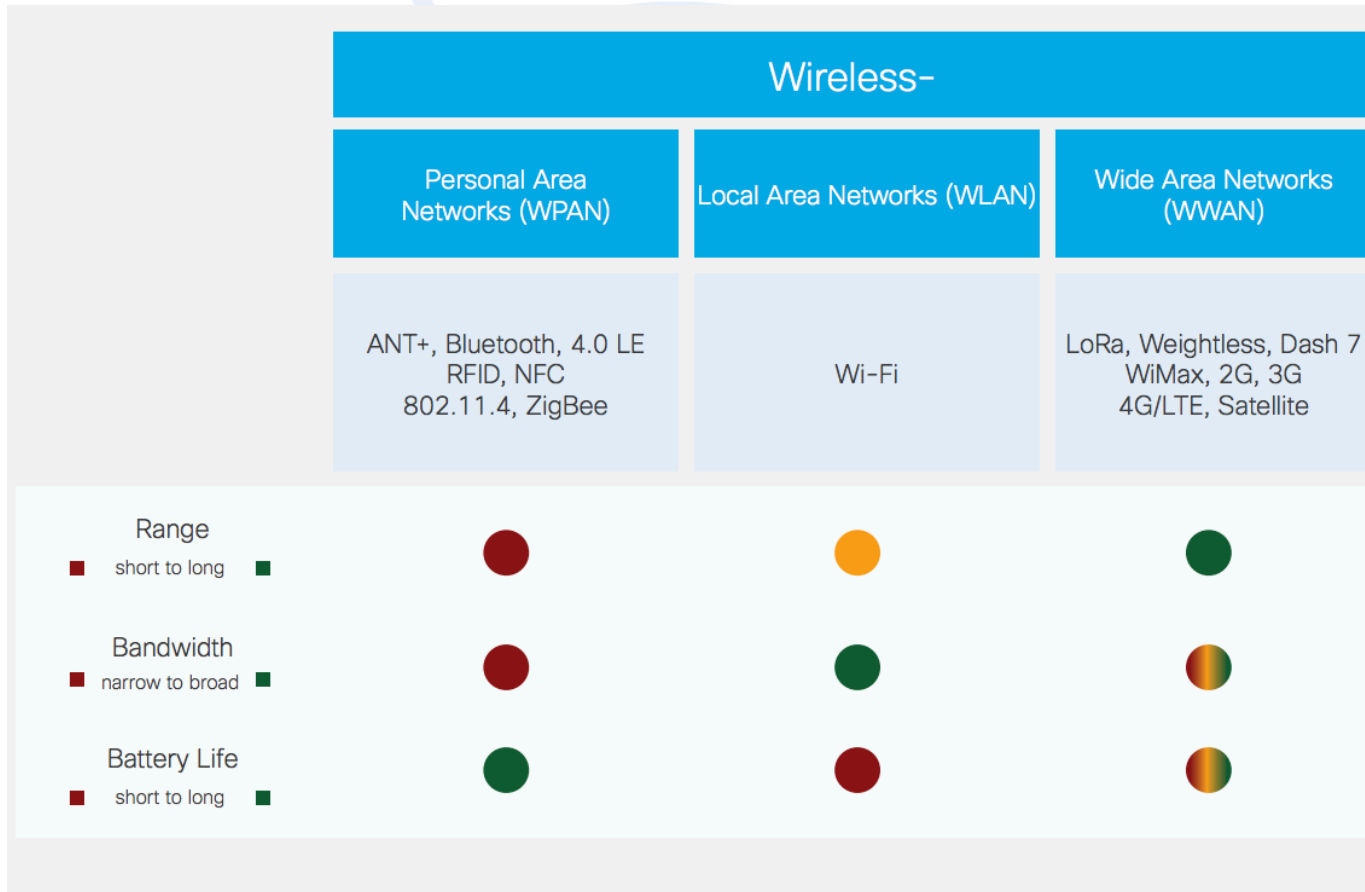
- **Range** - are you deploying to a single office floor or an entire city?
- **Data Rate** - how much bandwidth do you require?
How often does your data change?
- **Power** - is your sensor running on mains or battery?
- **Frequency** - have you considered channel blocking and signal interference?
- **Security** - will your sensors be supporting mission critical applications?

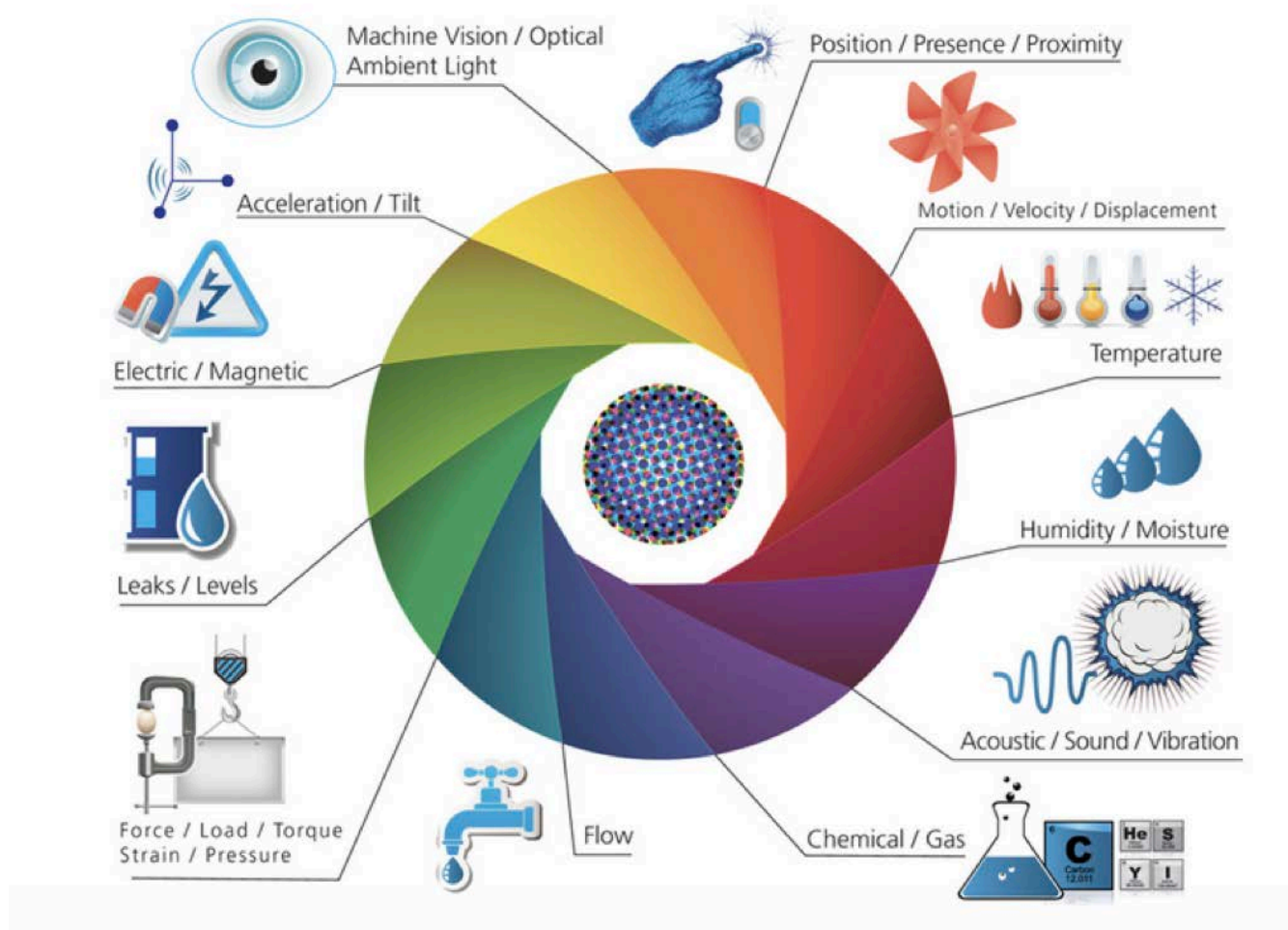


Source: <http://www.postscapes.com/what-exactly-is-the-internet-of-things-infographic/>



Connectivity Landscape





Source: <http://www.postscapes.com/what-exactly-is-the-internet-of-things-infographic/>



Functionality

Sensor Type

\$150-\$1000+

- Long-term install/deployment
- Industrial scale deployment
- Extreme accuracy/precision
- Typically large enterprises
- Ease of solution interoperability

Highest Cost

- Chemical/Gas
- Electrical/Capacitive
- Pressure/Load/Weight
- Proximity/Position

\$50-\$150

- Residential/commercial
- Advanced development kits
- Consumer-based support
- Cloud partnership capability
- Fast deployment
- Medium infrastructure required
- Low-Medium accuracy/Precision

- Water Treatment/Flow
- Weather/Temperature
- Motion/Velocity
- Acoustic/Sound/Vibration
- Light/Imaging
- Proximity/Position
- Flex/Force/Strain

\$0 - \$50

- Single function
- DIY/Prototyping often needed
- Limited without other hardware
- Requires basic equipment
- Geared towards amateurs
- Singular functionality
- No infrastructure required

- Water Treatment/Flow
- Weather/Temperature
- Motion/Velocity
- Acoustic/Sound/Vibration
- Light/Imaging

Lowest Cost

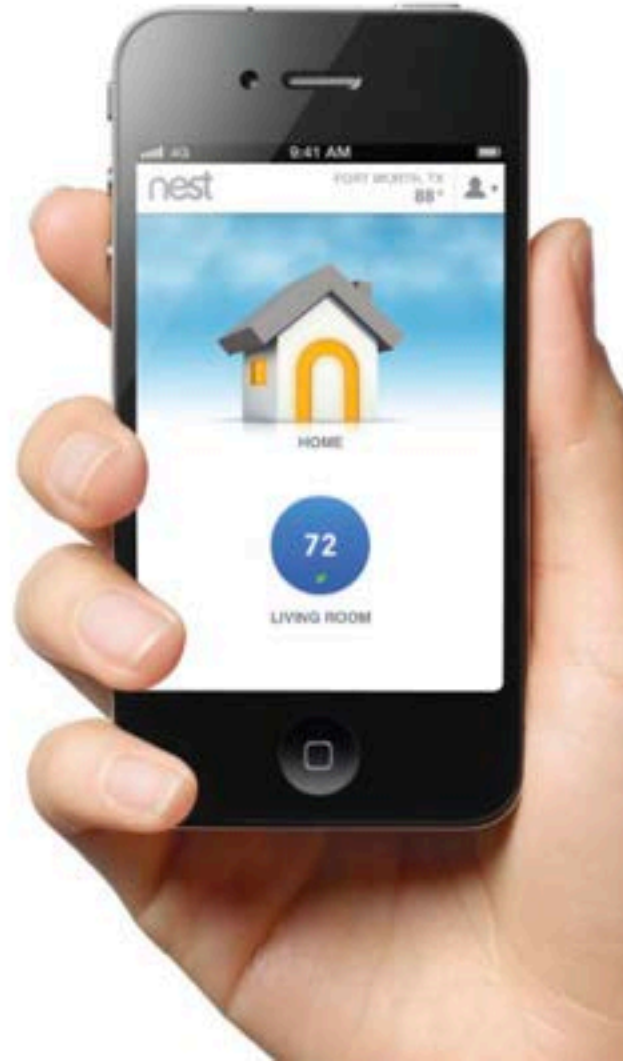
Applications

ambient™

Ambient Umbrella

Glowing intelligence
lets you know that there's
rain in today's forecast.





MyVessyl Cup

It can hold 13 ounces of liquid. The battery takes 60 minutes to fully charge and will last for 5-7 days. Also has wire-free charging.



<https://www.myvessyl.com/>



Egg Minder

THE SMART EGG TRAY

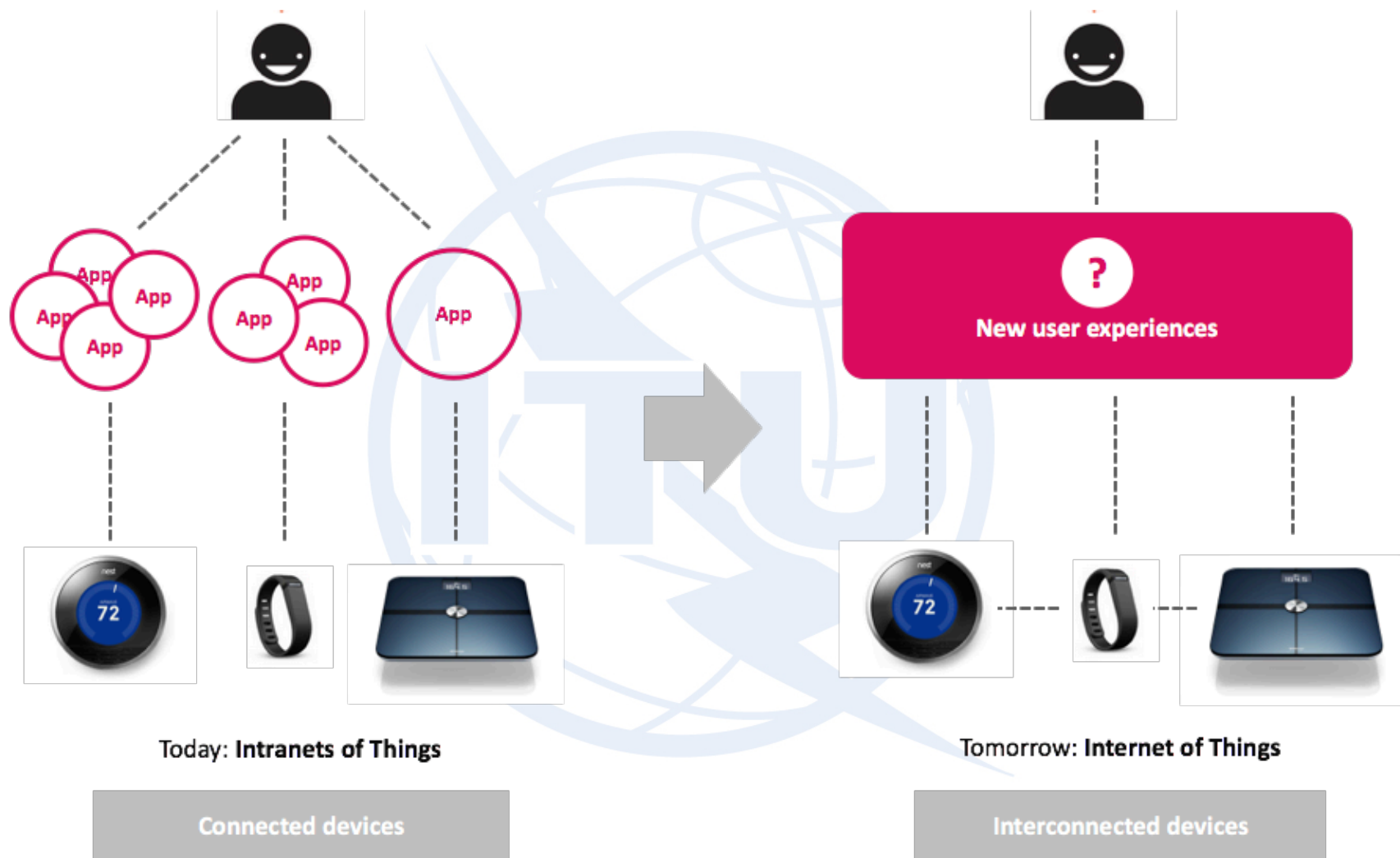






Applications





These **things** are starting to talk to each other and develop their own intelligence. Imagine a scenario where.....



...your **meeting** was pushed back 45 minutes.



...your **car** knows it will need gas to make it to the train station. Fill-ups usually take 5 minutes.



...there was an accident on your **driving route** causing a 15 minute detour.



...your **train** is running 20 minutes behind schedule.

This is communicated to your **alarm clock**, which allows you 5 extra minutes of sleep.



And signals your **car** to start in 5 minutes to melt the ice accumulated in overnight snow storms.



And signals your **coffee maker** to turn on 5 minutes late as well.

IoT Landscape

Internet of Things Landscape 2016

Applications (Verticals)

Personal Wearables Apple WATCH, Samsung Gear2, Pebble, Moto G, LG, Huawei, Fitbit, Jawbone, CAEDEN, MOTIV, textronics, OXION, Jewelbots, nymi, BINGLY	Home Automation nest, LIFX, Honeywell, SAMSUNG, CHAMBERLAIN, Devices, bekin, LG, icontrol, SAVANT, @ecovont, ecobee, SHAWMUT, LIGHT, view, OLUTRON, DRYVIMO, LEVI, somfy, GEM, GEM, roost, tado, AKEEN	Vehicles Automobiles INRIX, waze, AUTOMATIC, STREETLINE, dash, Zobe, navdy, Automile, vinli, Airbiquity, OpenXC	Enterprise Healthcare STANLEY, AUGMEDIX, WERSUS, mc10, vialconnect, Omnim, Senseonics, PIERBRIDGE, vivify, AIRSTRIP, Sotera, Teleflex, Teleflex, PRISTINE	Industrial Internet Machines CATERPILLAR, SIEMENS, BOSCH, Schneider, Irwin, enlightened, SeaCity, Trilliant, Onova, BERNOC, Bentley, DS OutSmart, Genbata, eon, Lucid, Energen, ENERGEN, VIVY, HydroShare
Fitness JAWBONE, fitbit, tomTom, GARMIN, NIKE, MISPIT, BASIS, nuami, Microsoft, ATLAS, mapmyFitness, RunKeeper, amigo, LifeBEAM, ATHOS, lark, senSoria, WHOOP, striv	Hubs nest, INSTEON, BOSCH, Smarthings, connect, iRule, Control, ive, wink, vera, prodea, NINJABLOCKS, Fluent, NEXIA, zonoff	Autonomous Google Self Driving Car Project, TESLA, DAIMLER, UBER, QUANERGY, DELPHI, NOVASANT, Peloton, Volvo	Retail RETAILNEXT, euclid, PRISM SKYLAKE, hiku, cloudtags, GIMBAL, PHUNKARE, NOMI, URRIABLE	Energy Schneider, Irwin, enlightened, SeaCity, Trilliant, Onova, BERNOC, Bentley, DS OutSmart, Genbata, eon, Lucid, Energen, ENERGEN, VIVY, HydroShare
Health QUANTUS, proteus, Gingerio, Health EarlySense, XETHEU, narroweare, vessyl, beddit, sanq, ACHERA, AcheraTech, AliveCor, PROPELLER, HEALTH, GIGACON	Security August, SCHLAGE, Kwikset, dropcam, canary, vivint, ring, XIWI, evercam.io, Locktron, LATCH, cocoon, SEEK, scout	UAVs DJI, Parrot, Airware, LILLY, SKYCAT, SKYDIO, YUNEEC, DroneDeploy, HAKKO, DRL, SKY FUTURE	Payments / Loyalty PayPal, shopify, Square, Verifone, payleven, belly, coin, cantaloupe, SHOPEEK, ciright, LevelUp, AS, ELITE	Supply Chain Fleetmatics, Inspira, VILCO, Omega, Skybitz, SMARTORIVE, Telogis, assetpulse, WEST, TEGO, SERRA, PRECISE, REF, CONTROLLA
Entertainment SONOS, RAZER, doppler labs, ROLI, Narrative, soundhaic, Electric, Narrative, normal	Family nucleus, ily, Glow, Good Night Lamp, FILIP, menboby, ovuline, lilyscribe, WUDY	Kitchen JURA, nomiku, drop, SUPERMECHANICAL, BREWBOT, innit, Sereniti	Smart Office LogiMein, CRESTRON, KISI, Robin, BUILDING, XORA, EB eventboard	Robotics amazon robotics, ABB, CLEARPATH, HARVEST, KUKA, EMPIRE LIQUID ROBOTICS, tempo automation, OPENRV
Sports STRAVA, WILSON X, Peloton, ZEPPE, ARCCOS INFORMATION, COCON, Garmin, XERO, GOLF, XERO	Toys HighGo, ANI, Sifteo, MAKERS, URODLY	Garden EDYN, PLANETIC, BITPONICS, Athenitek, Rachio	Infrastructure World, TACHYON, ELTAV, SMARTSTRUCTURES, LEMASENSE, SENIOR LOGIC, GROUNDINTICS	Industrial Wearables OLISS, DAGRI, parable, BISTEWE, SUBARANA, APX
Consumer Robotics IRobot, RoboT, HACHIKO, Petcube	Pets Whistle, Petriot, HACHIKO, Petcube	Trackers iotera, iotera, TrackR	Bicycles / Motorbikes SOLO, HAMMERHEAD, SKULLY, SKYLOCK	3D Printing / Scanning Project Tango, Intel, REALSENSE, Matterport, strataysis, occipital, formlabs, desktop metal, Carbon, shapeways, sculpteo, voodoo

Platforms & Enablement (Horizontals)

Software xively, Axeda, Jasper, Lemery, Ayla Networks, ThingWorx, wot.io, data networks, PubNub, chingsquare, BSQUARE, greenwave, M2M, Wsilica, InnoPath, machinehop, Gto, arrayent	Platforms Full Stack: SOFONOS, EUROTECH, Predix, HELIUM, Telit Developer: TESSEL, resin.io, Particle, theThings.io, KONEKT, SensorCloud, NewAer Analytics: splunk, sumologic, jobe.com, KAazing, TempoQ, UPTAKE, glassbeam Sensor Networks: placemeter, SAFECAST, SST, MobonIoT	Connectivity SIGFOX, SIERRA, FILAMENT, aeris, JGENU, VENIAM, KORE, intamac, skyroam, ARKESDA, senet, octility Security: Symantec, gemalto, Bastille, inside, MOCANA, NEURA, SHODAN, escrypt Open Source: KPA, ThingSpeak, iot, webinos, openHAB, nimbits	Interfaces Virtual Reality Oculus, VIVE, PlayStation VR, Samsung Gear VR, OSVR	3D Printing / Scanning Project Tango, Intel, REALSENSE, Matterport, strataysis, occipital, formlabs, desktop metal, Carbon, shapeways, sculpteo, voodoo
Augmented Reality Microsoft HoloLens, zSpace, VUZIX, EPSON, SONY, BLIPPAR, PARACOSM	Other amazon alexa, THALMIC, nod, EMOTIV, LEAP, SIXSENSE, ivee, RYTHM, api.ai	Content / Design Sketchfab, Thingiverse, GRABCAD, AUTODESK, BODY LABS, FLOORDD, DISSEUIL SYSTEMS		

Building Blocks

Hardware Processors / Chips intel, QUALCOMM, TOSHIBA, ARM, NVIDIA, LG, SIEMENS, NP, MOVIDIOUS	Software Cloud Google Cloud Platform, CISCO, IBM Watson IoT Platform, Microsoft Azure, amazon web services	Connectivity Protocols WiFi, Bluetooth, ZigBee, LoRa Alliance, MQTT, NFC, AMQP, M-Bus, OMA, MIWI, THREAD, HART, BITX, DDS, RFID, CoAP, RuBee, 2G, 3G, 4G, LTE, 6LoWPAN, LWM2M, DDS, LIDAR	Telecom verizon, AT&T, Sprint, T-Mobile, Telefonica, orange, Vodafone	Consultants / Services ID EO, Dragon Innovation, MESH SYSTEMS, PTC, R/GA, makeXYZ, aifix 8	Partners Retail amazon, Walmart, Target, LOU'S	Incubators HighWay1, HAX, LEMONS LABS, BOLT
Sensors NATIONAL INSTRUMENTS, libelium, psிக்க, Quatre, MEMS, VALEN, CELL Petrasense, XERFFY, skyetek, mCube, MOOG, Thanglong	Mobile OS ios, android, Brillo, BlackBerry	M2M intel, QUALCOMM, SIEMENS, ATMET, LAIRD, CISCO, FIBOCOM, goteno, GainSpan, altair, Weaved	WiFi eero, STARRY, BRCK	Alliances ALLSEEN ALLIANCE, OMA, OPEN CONNECTIVITY FOUNDATION	Manufacturing FOXCONN, flex, JABIL, PEGATRON, Benchmark, Celestica	Funding KICKSTARTER, AngelList



Thank You