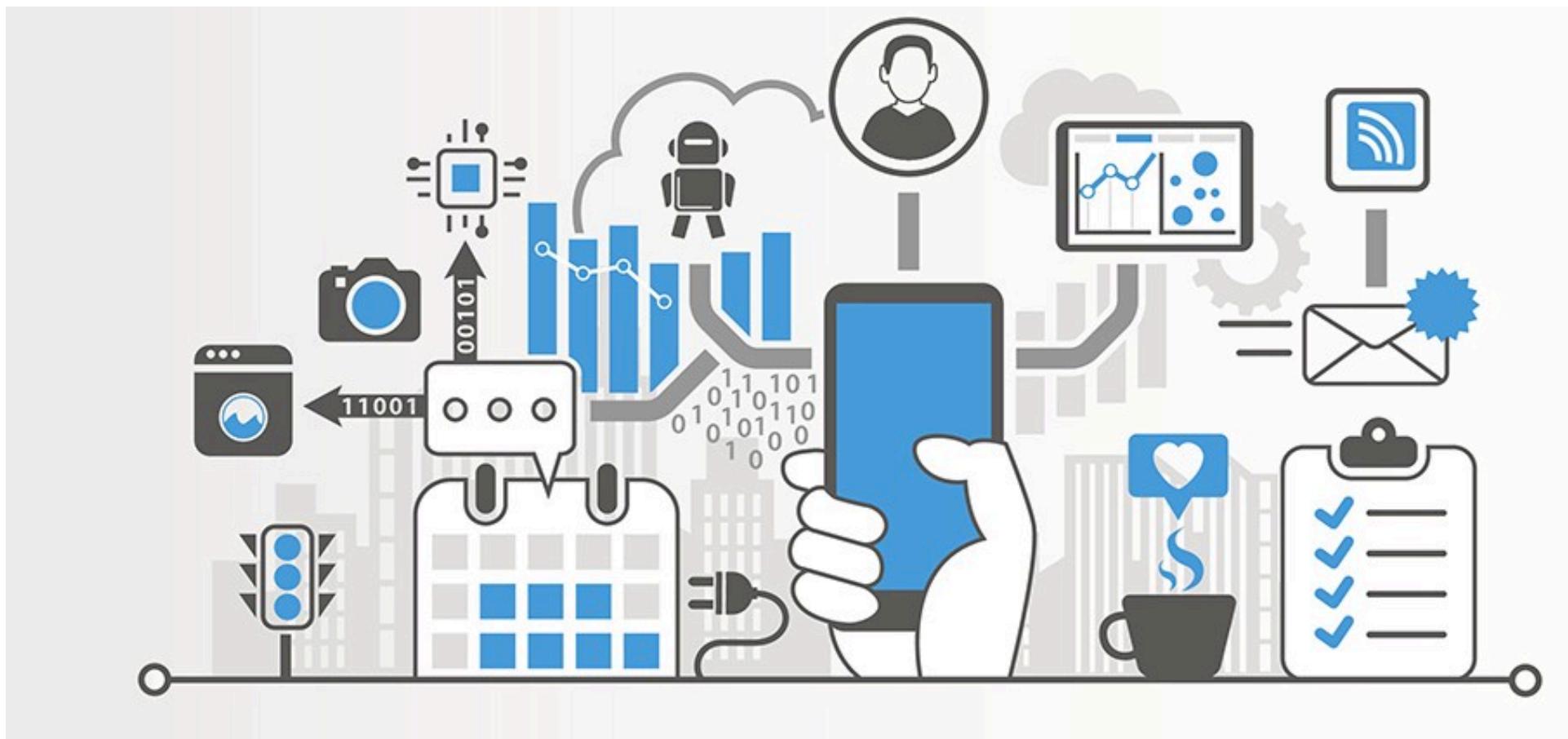




Programming for IoT Applications

Edoardo Patti
Lecture 1





Introduction

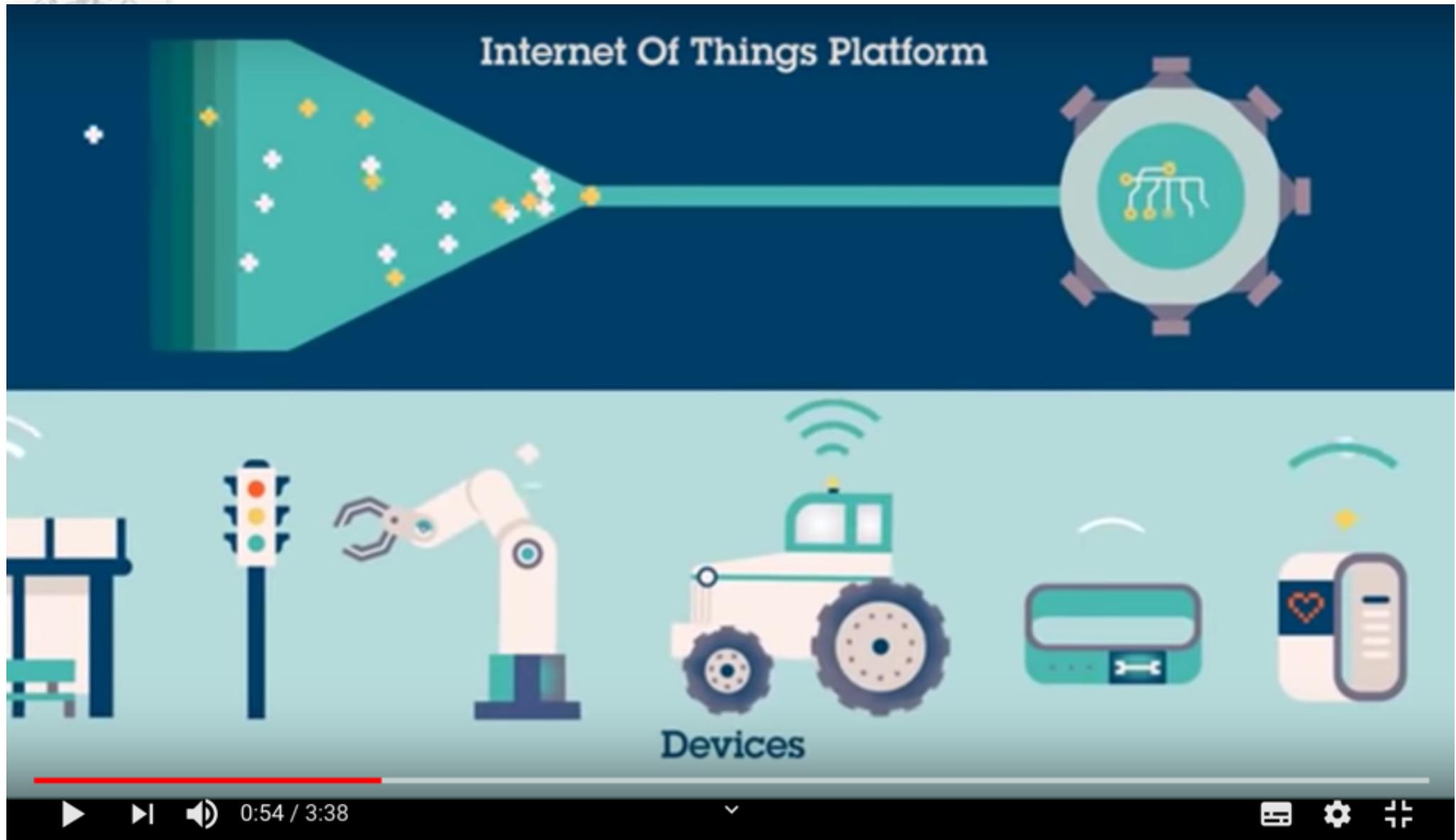
THE INTERNET OF THINGS SCENARIO

What is the Internet of Things?





How the IoT works





How the IoT works



SUBS
CRIBE
e!



Video at: <https://www.youtube.com/watch?v=LlhmzVL5bm8>

Are they IoT devices?





IoT concept

- US National Intelligence Council (NIC) considers Internet of Things as one of the 6 “Disruptive Civil Technologies”
(April 2008)





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- US National Intelligence Council (NIC) considers Internet of Things as one of the 6 “Disruptive Civil Technologies”
(April 2008)
- IEEE ranks IoT #1 in the list of “Top Trends for 2013” (Winter 2012):
 - “...The IoT promises to be the most disruptive technological revolution since the advent of the World Wide Web. Projections indicate that up to 100 billion uniquely identifiable objects will be connected to the Internet by 2020...”





A more practical one...

IoT refers to the interconnection of uniquely identifiable embedded computing-like devices within the existing **Internet** infrastructure.



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Typically, IoT is expected to offer advanced connectivity of devices, systems, and services that goes beyond **machine-to-machine communications** (M2M) and covers a variety of protocols, domains, and applications.



A more practical one...

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Typically, IoT is expected to offer advanced connectivity of devices, systems, and services that goes beyond **machine-to-machine communications** (M2M) and covers a variety of protocols, domains, and applications.

The interconnection of these embedded devices (including **smart objects**), is expected to usher in automation in nearly all fields, while also enabling advanced applications like a **Smart Grid**.



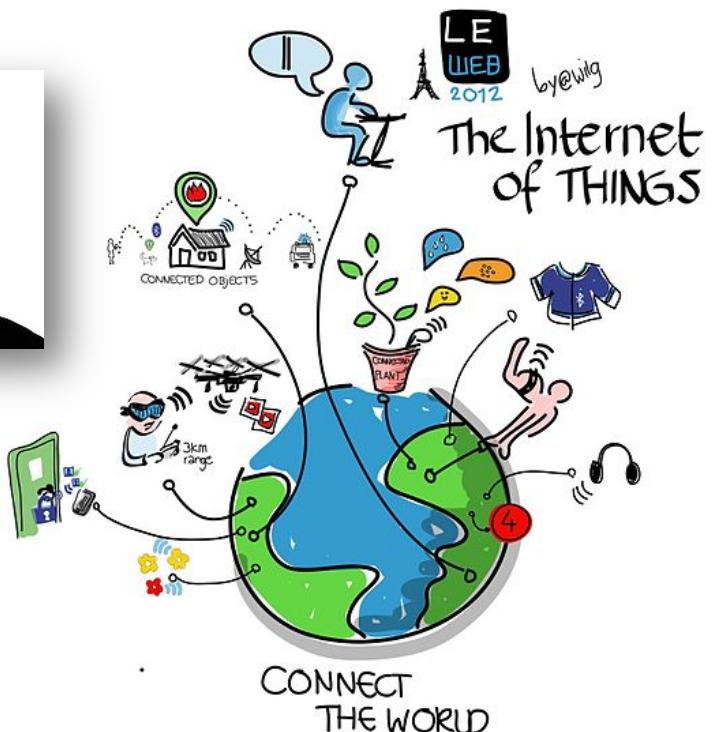
What is IoT then?

The Internet of Things connects everyday consumer objects and industrial equipment onto the network, enabling information gathering and management of these devices via software in order to increase efficiency, enable new services, or achieve other health, safety, or environmental benefits.

@Kevin_Ashton

Kevin Ashton, a British technologist in 1999 was Executive Director at MIT's Auto-ID Center, an RFID research consortium

[Wired talk on youtube](#)

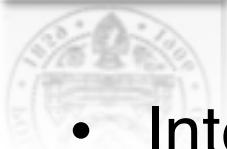




What is IoT then?



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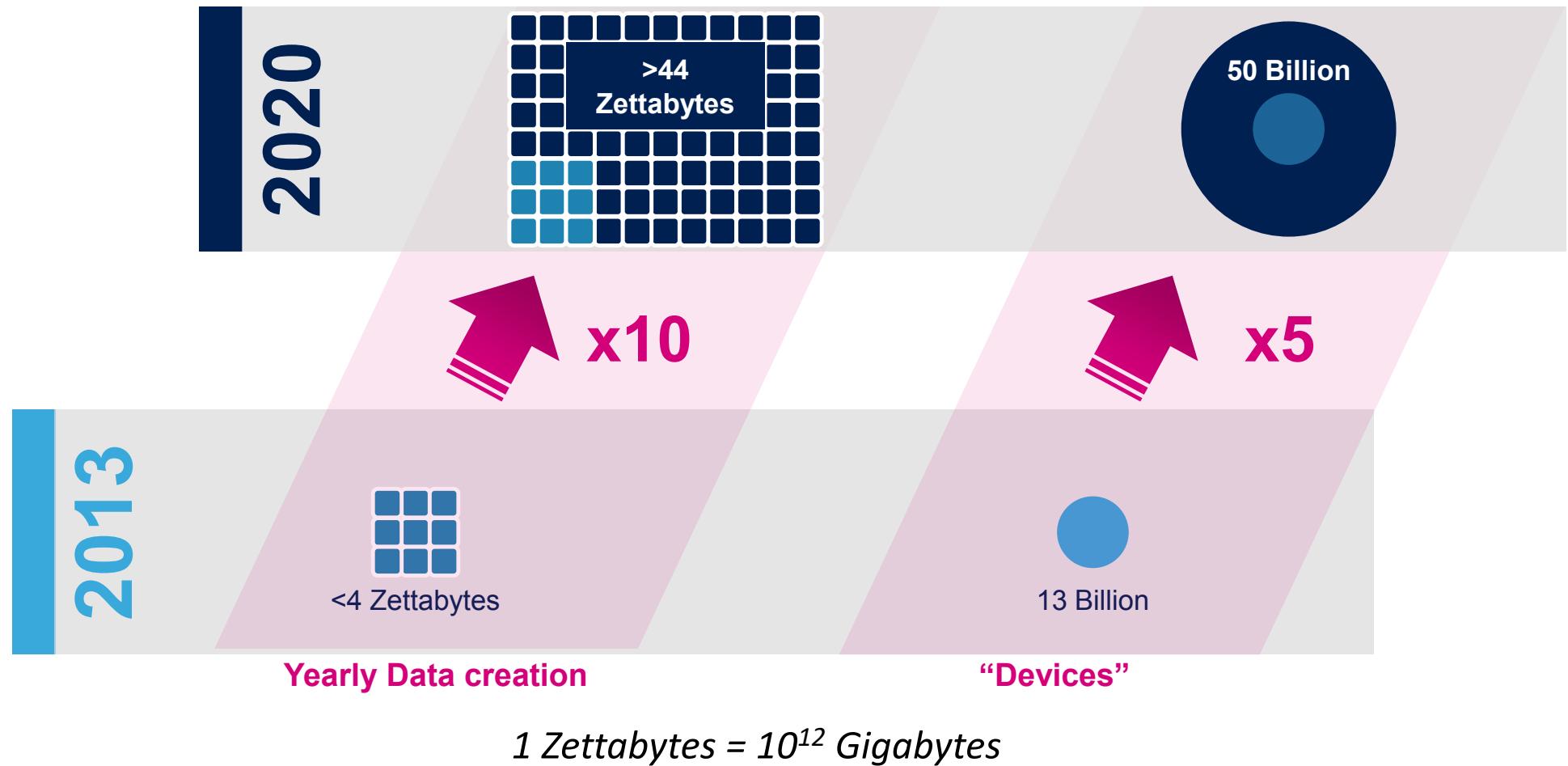


Some other Videos....

- Intel IoT -- What Does The Internet of Things Mean?
 - <http://www.youtube.com/watch?v=Q3ur8wzzhBU>
- Cisco - How the Internet of Things Will Change Everything-- Including Ourselves
 - http://www.youtube.com/watch?v=B_hjAfPJeRA
- Dr. John Barrett at TEDxCIT – The Internet of Things
 - <http://www.youtube.com/watch?v=QaTIt1C5R-M>



The Digital Explosion



[Courtesy: Roberto Zafalon, ST microelectronics]



By 2020 the Internet traffic will shift dramatically!

- Most of the IP traffic will originate from other than personal computers (PCs). Wi-Fi traffic will exceed wired traffic and Full HD video will generate more traffic than standard video.



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- Most of the IP traffic will originate from other than personal computers (PCs). Wi-Fi traffic will exceed wired traffic and Full HD video will generate more traffic than standard video.
- According to a report issued by Cisco, the number of connected devices (i.e. through IPv6 and evolution) will grow to some 50 billion devices by 2020. The internet traffic will get close to 44 Zettabytes (i.e. 10^{21} bytes)!



IoThings on the Market

- Things in the IoT:
 - heart monitoring implants
 - **bio-chip** transponders on farm animals
 - **automobiles** with built-in sensors
 - field operation devices that **assist fire-fighters** in search and rescue
 - **shopfloor** with sensors (i.e. vision sensors for in-process inspection systems)
- Current market examples:
 - Google NEST
 - Washer/dryers with WiFi for remote monitoring





New Things to Augment Life

Smart City

- Reduce traffic congestion
- Better use of resources
- Improve security



Smart Me – Healthcare

- Empower patients
- Help physicians monitor and diagnose remotely



Smart Car

- Reduce emissions
- Increase safety
- Save fuel



Smart Me – Wellness

- Help to lead healthier lives
- Optimize sports performance
- Early warning of illness



Smart Home

- Make entertainment more interactive and immersive
- Increase comfort
- Save energy



Smart Industrial & Smart Services

- Productivity gains
- Efficiency, agility, water and food.



[Courtesy: Roberto Zafalon, ST microelectronics]



Making Things Smarter



[Courtesy: Roberto Zafalon, ST microelectronics]



Making Things Smarter



It used to tell you
the time



Now it tells
you what to do



And how you
are doing



They used to keep
your feet warm



Now they help you keep you
and your feet fit





Making Things Smarter



It used to tell you
the time



Now it tells
you what to do



And how you
are doing



It used to remind
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And exactly
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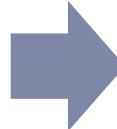
They used to keep
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And exactly
what you
doing



They used to help you
see clearly



Now they help you
to see more



Making Things Smarter

CENSORED



Making Things Smarter



Internet of Shit
@internetofshit

"It's an electronic fork that lights up and vibrates when you are eating too fast." !

[Traduci il Tweet](#)

HAPILABS ★★★★★ 9

HAPILABS 105 Bluetooth-Enabled Smart Fork (Pink)



Heart icon

Currently unavailable
We don't know when or if this item will be back in stock.

About this item

Description

HAPIfork Bluetooth-Enabled Smart Fork. The smart fork that coaches you into healthier eating habits. The HAPIfork is the world's first smart fork. It's an electronic fork that lights up and vibrates when you are eating too fast. As it takes 15-20 minutes to feel satisfied, by simply slowing down your pace while eating, you will consume fewer calories. Pair with your smartphone or tablet over Bluetooth to see your eating stats in real time. Download the HAPIfork app for iOS or Android and connect it to your device via Bluetooth to check: How long it took to eat your meal The number of "fork servings" (each time food is brought to the mouth) per minute A timer to



Making Things Smarter



Internet of Shit
@internetofshit

i can't wait to find out my husband is cheating on me from my toilet's user profiles

[Traduci il Tweet](#)



The Verge



Kohler's smart toilet promises a 'fully immersive experience ...'

- In the dark, as you walk up to Numi 2.0, the integrated nightlight helps to guide you, the lid will open and treat you to a warm seat; when you walk away, it flushes and closes.
- Use the KOHLER Konnect app to program personalized presets for different users, and you can use voice to access the preset/profile. There is probably a difference between you, your spouse, and your children when it comes to your interaction with Numi 2.0; this lets you easily personalize your experience.
- Even when not using Numi 2.0 the lighting and sound features create an ambient



Making Things Smarter



Internet of Shit
@internetofshit

boils from a plane

[Traduci il Tweet](#)

 **Jonah** @jonahbron · 27 dic 2018

@internetofshit "boil from anywhere"





Making Things Smarter



Internet of Shit
@internetofshit

hey so these things called keys are good and fast

[Traduci il Tweet](#)



Alex Barredo @somospstpc · 26 mar

Unlocking your €100,000 car is now easier than ever

[Mostra questa discussione](#)

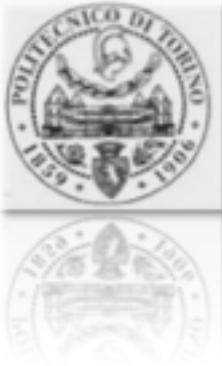


Video at: <https://twitter.com/internetofshit/status/1110625844974813185>

Making Things Smarter

.....without exaggerating



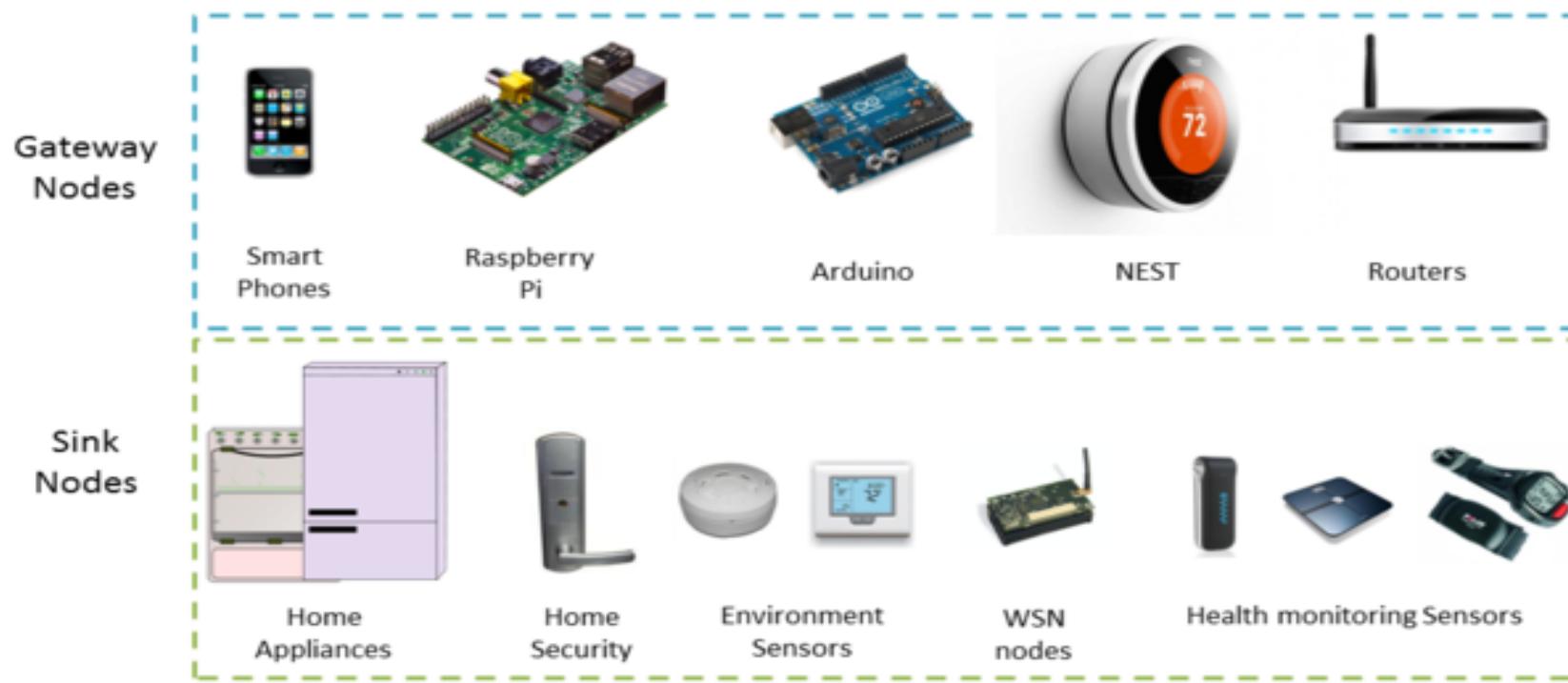


IoT Services



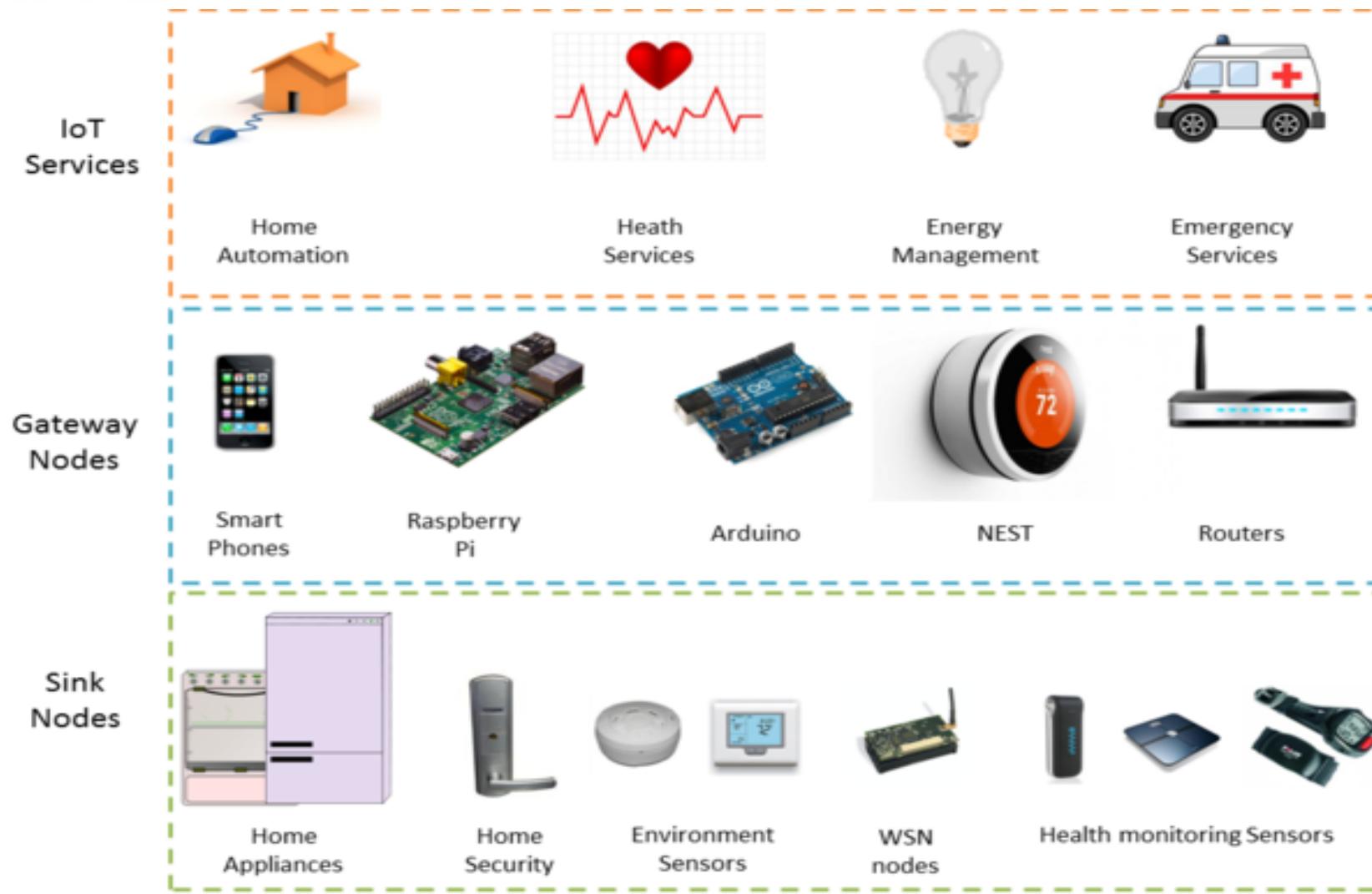


IoT Services





IoT Services





IoT Services

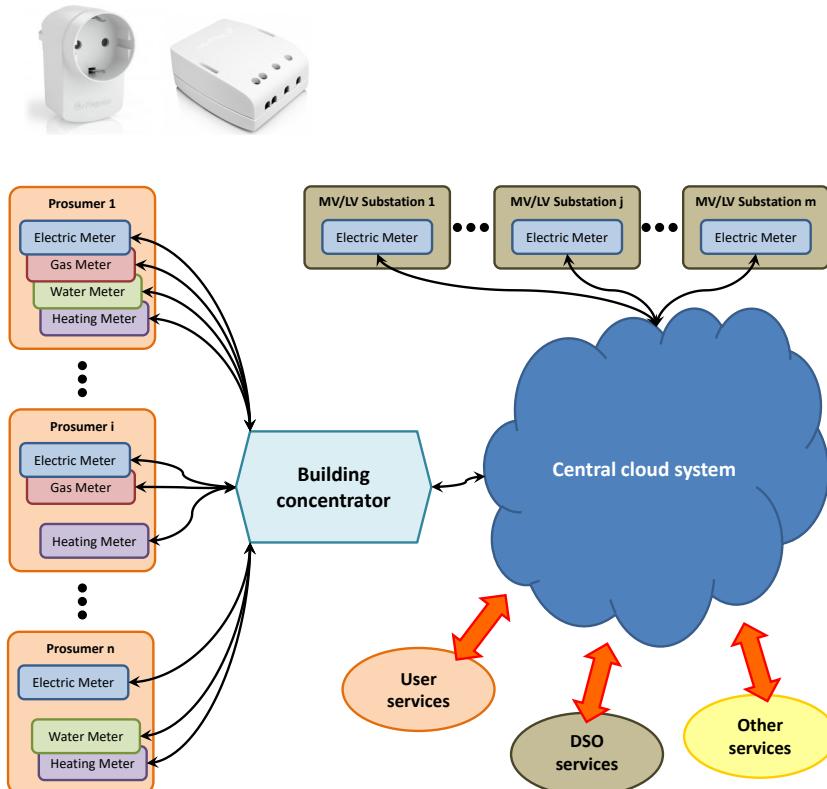




Example Application: Smart Buildings



- The thing here is the power plug that becomes a “smart plug”
- Data are processed in the CLOUD and visualized in A/R or V/R through context aware technologies on a mobile device





IoT as enabling technology for..

- Ambient intelligence and context aware applications
 - User interacting with an interactive environment providing personalized services



Minority Report Scene Gap Store

Video at: <https://www.youtube.com/watch?v=lTjsb22-EwQ>



Enabling Technologies and Issues

- Key technologies:
 - Sensors/Actuators
 - Low power, autonomic, pervasive, ubiquitous computing
 - Communication protocols (REST, MQTT)
 - Microservices and Middleware
 - Data Analytics Engines -> in the CLOUD
 - Apps (iOS, Android, Web)



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- Key issues:
 - Interoperability
 - Security/trust and privacy
 - Low resources (=> revisit protocols and algorithms implemented in Internet and Web)
 - Scalability



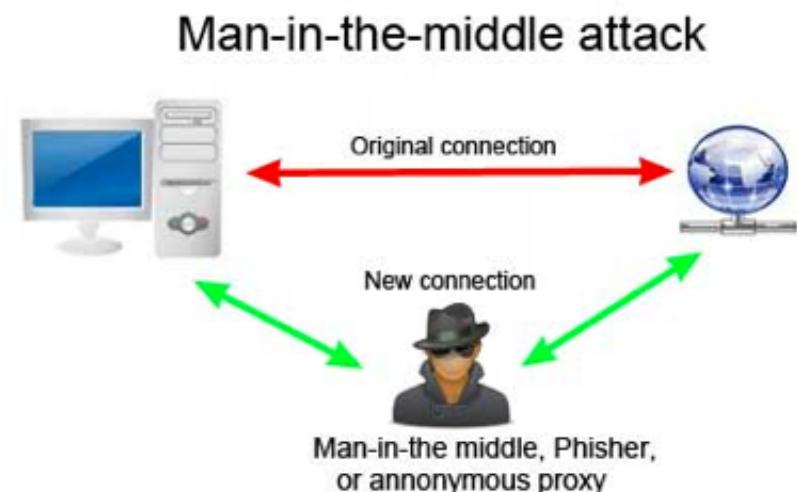
The Network Issue

- Which protocol for communication?
 - TCP is not adapted
 - Designed for long-lasting connections, while objects (like tags or sensors) exchange small pieces of data => handshake + congestion control/retransmit/recovery + flow control + buffering procedures too complex
 - Very heterogeneous networks and traffic
 - Scalability?
 - Quality of service?
 - Naming
 - unique/universal ID for naming and addressing individual objects i.e., to attach an ego to each object, condition to develop ego-centric applications
 - IPv6 comes to the rescue (10^{38} addresses) but still lacks mobility, moreover, imposes overhead limiting payload (e.g. 21-46 bytes for 6LowPAN)



Security and Privacy (1/2)

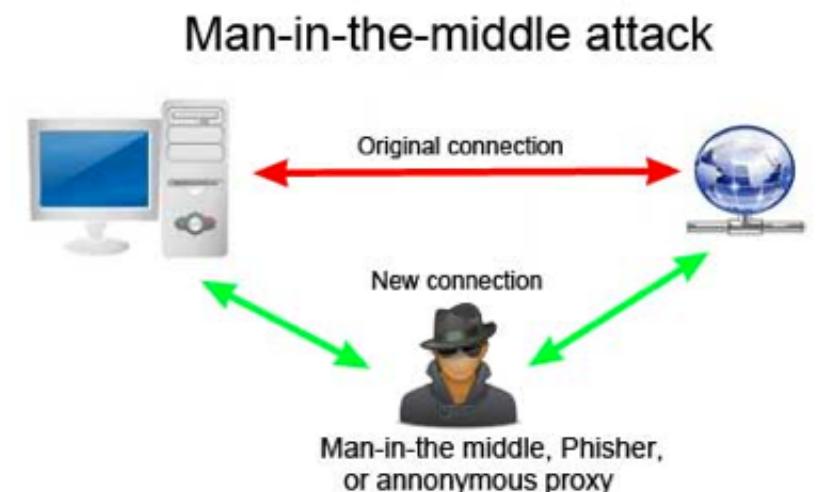
- A definitive threat for privacy!
- A security nightmare!





Security and Privacy (1/2)

- A definitive threat for privacy!
- A security nightmare!
- Security
 - IoT = a kind of unsupervised mobile/pervasive grids whose end-components are resource limited tiny objects = a security nightmare
 - Physical attacks
 - Man in the Middle attacks
 - Cryptographic techniques too CPU-intensive for low energy objects
 - Etc...



<http://www.computerhope.com>



Security and Privacy (2/2)

- Privacy
 - Your life can will be traced => possible monitoring, mining, analysis
 - Open-air connection
 - Not only your digital life but also your “analogical” life
 - You cannot even know what is sensed about you, when it is sensed, etc. Sensors do not ask for permission (cf. video surveillance)
 - No “forget option” -> once data are on the Internet they cannot be (easily) deleted



IoT Challenges

The most natural way for things to talk over Internet is to use web services



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Web browsing is yet a M2M communication between server and client: reuse same stack



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However, things must be instrumented with ultra low-power, small footprint, everlasting electronics to be as transparent as possible



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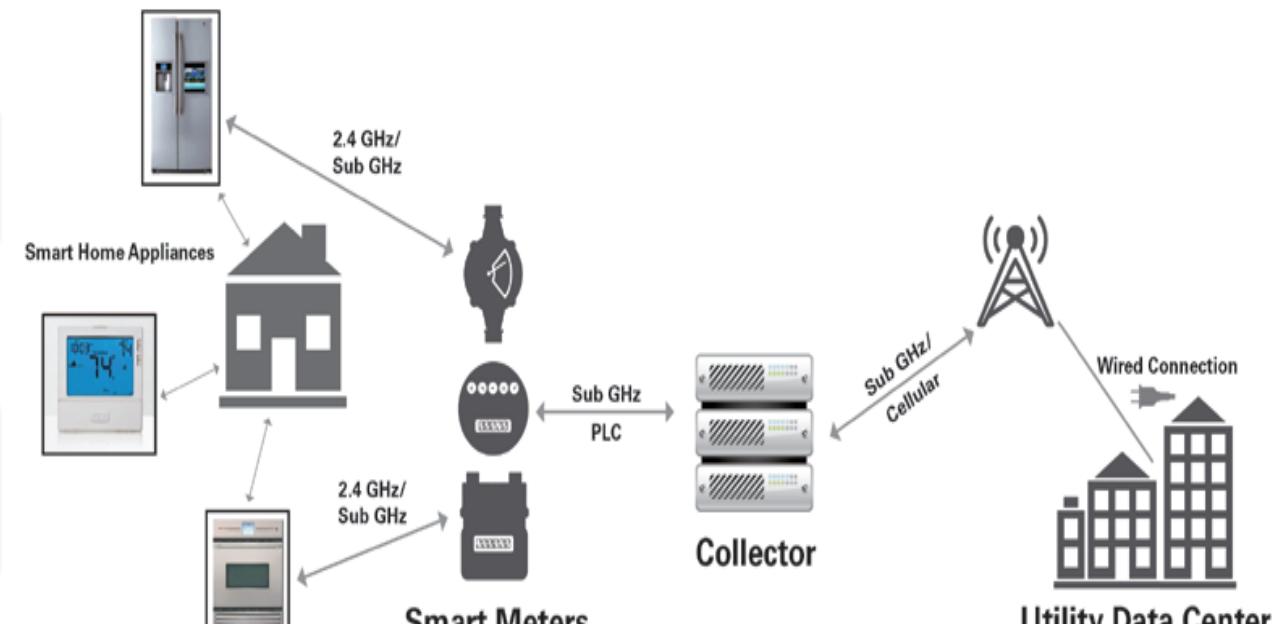
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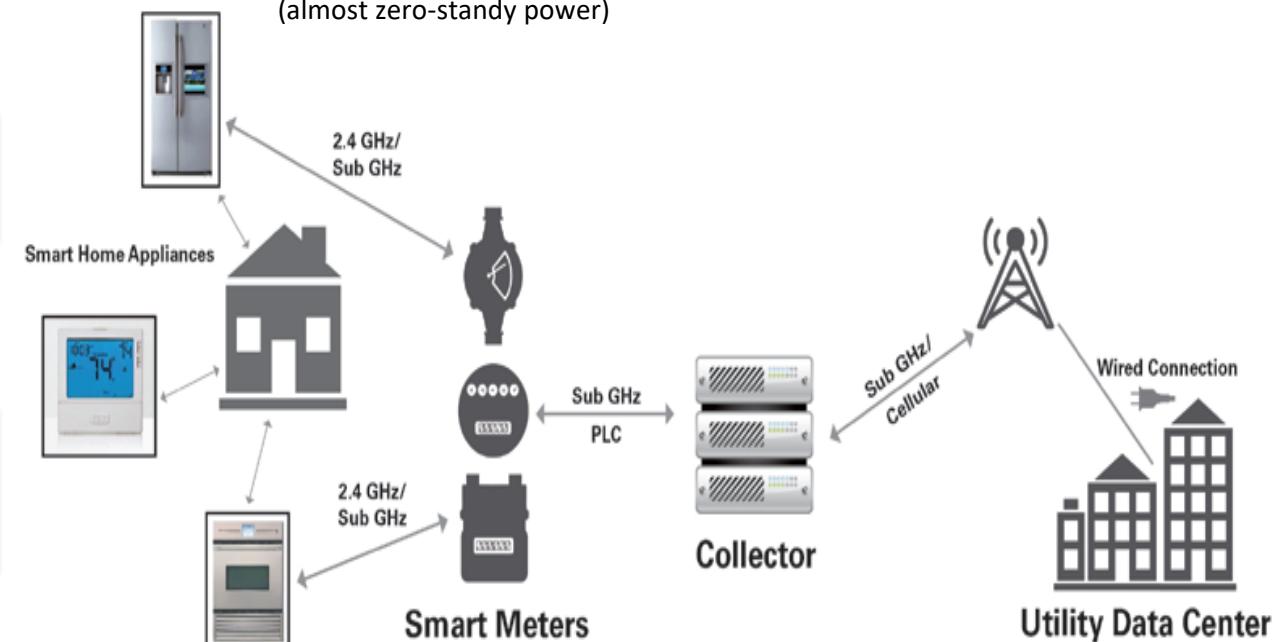
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- Nano sensors
- Very efficient low-duty cycle operations (almost zero-standby power)





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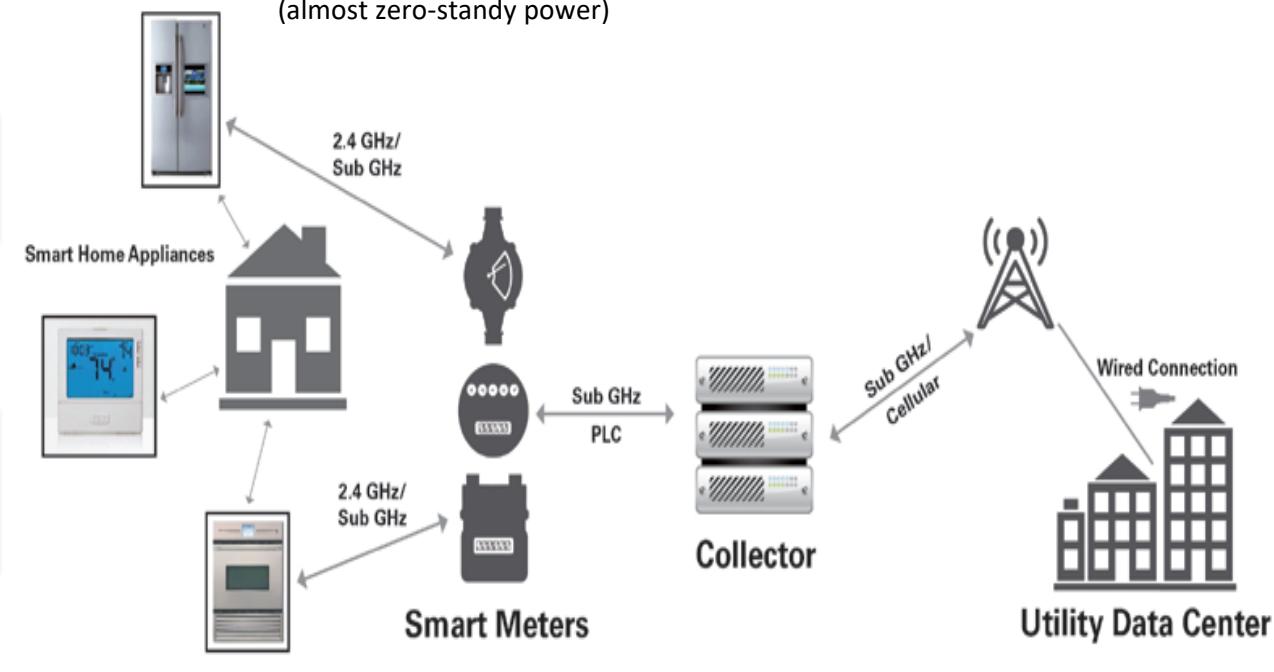
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W-PAN protocols

- IP networking (e.g. 6LoWPAN)
- Low header overhead, low bitrate, mesh networking



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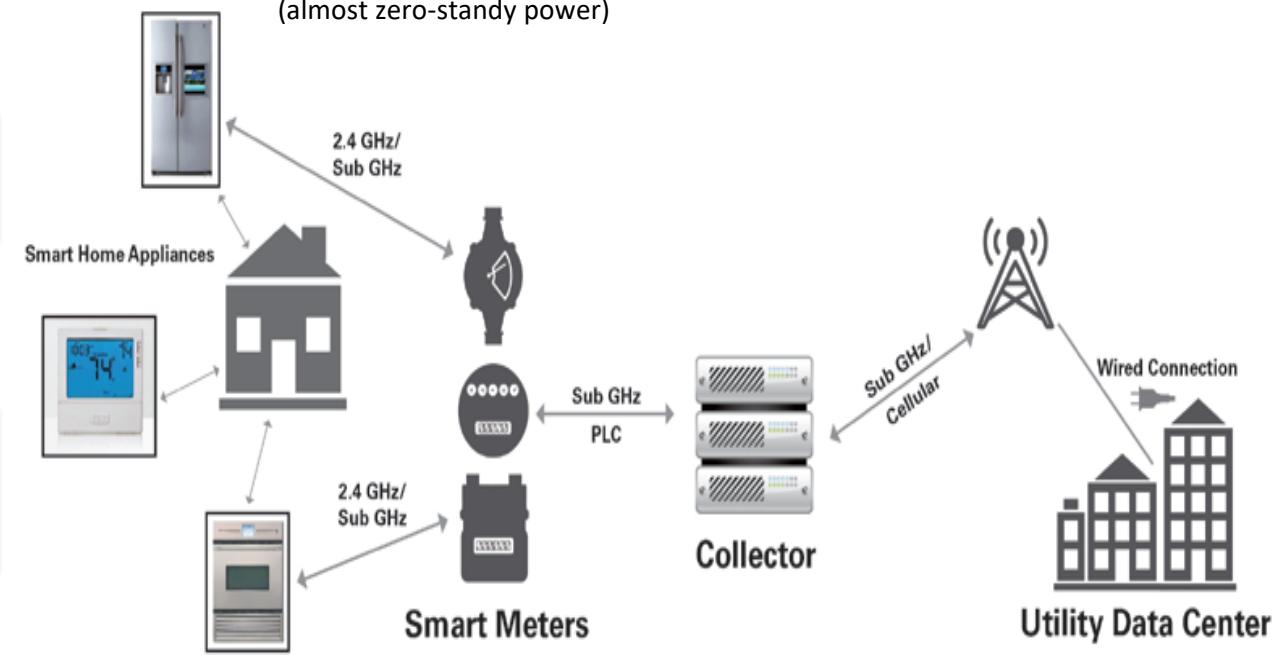
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Middlewares

- Web-service oriented
- Network management
- Role-based access
- Encryption
- Authentication



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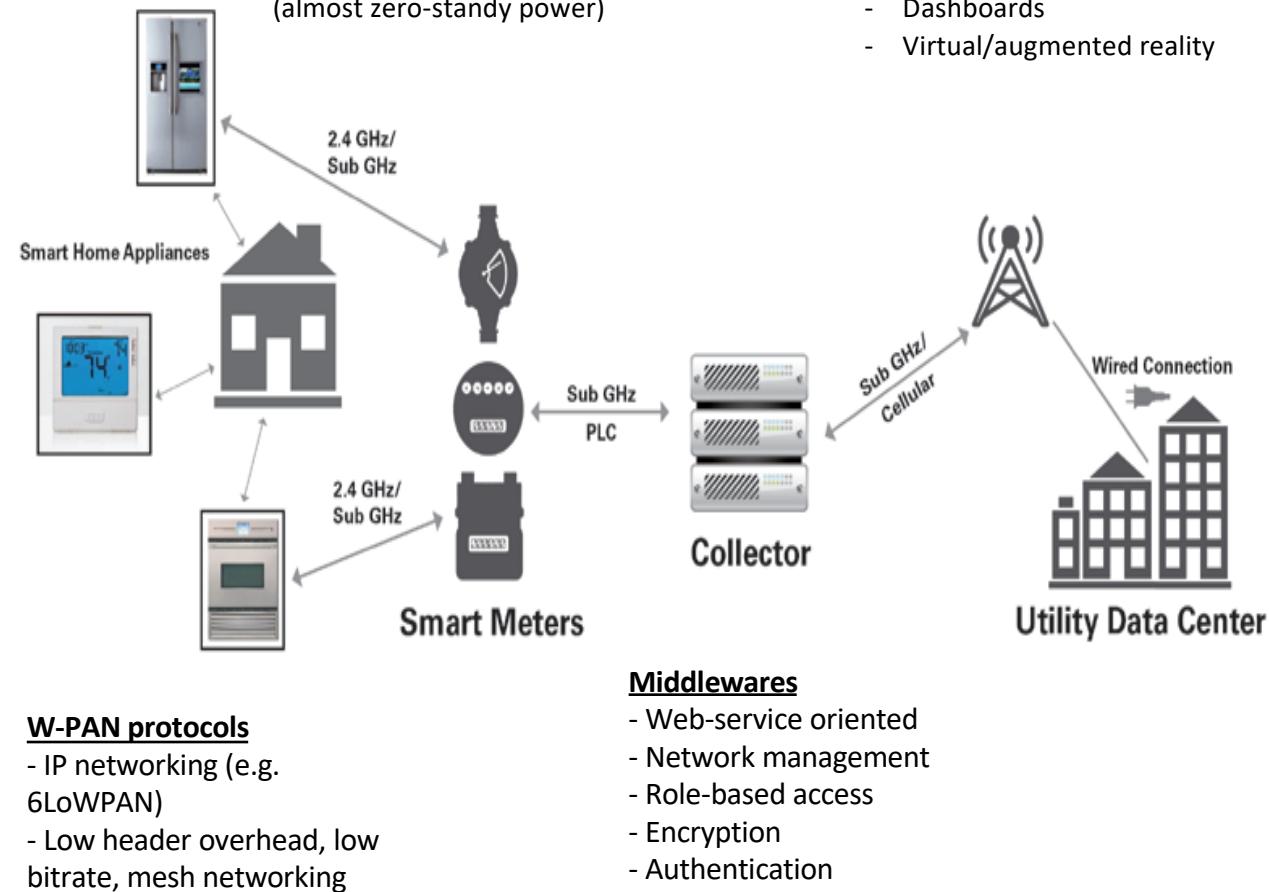
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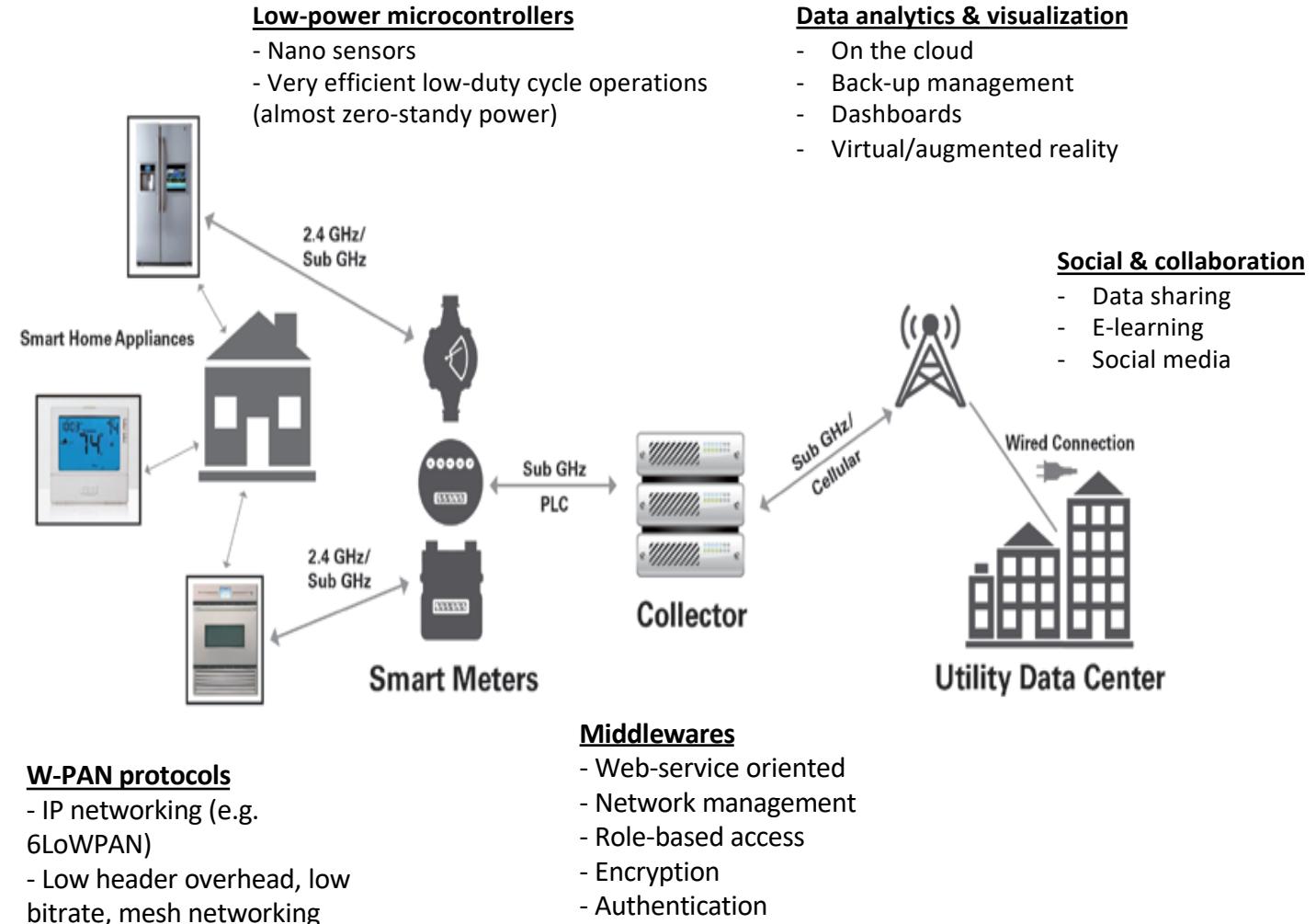
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IoT Challenges

IoT Ecosystem

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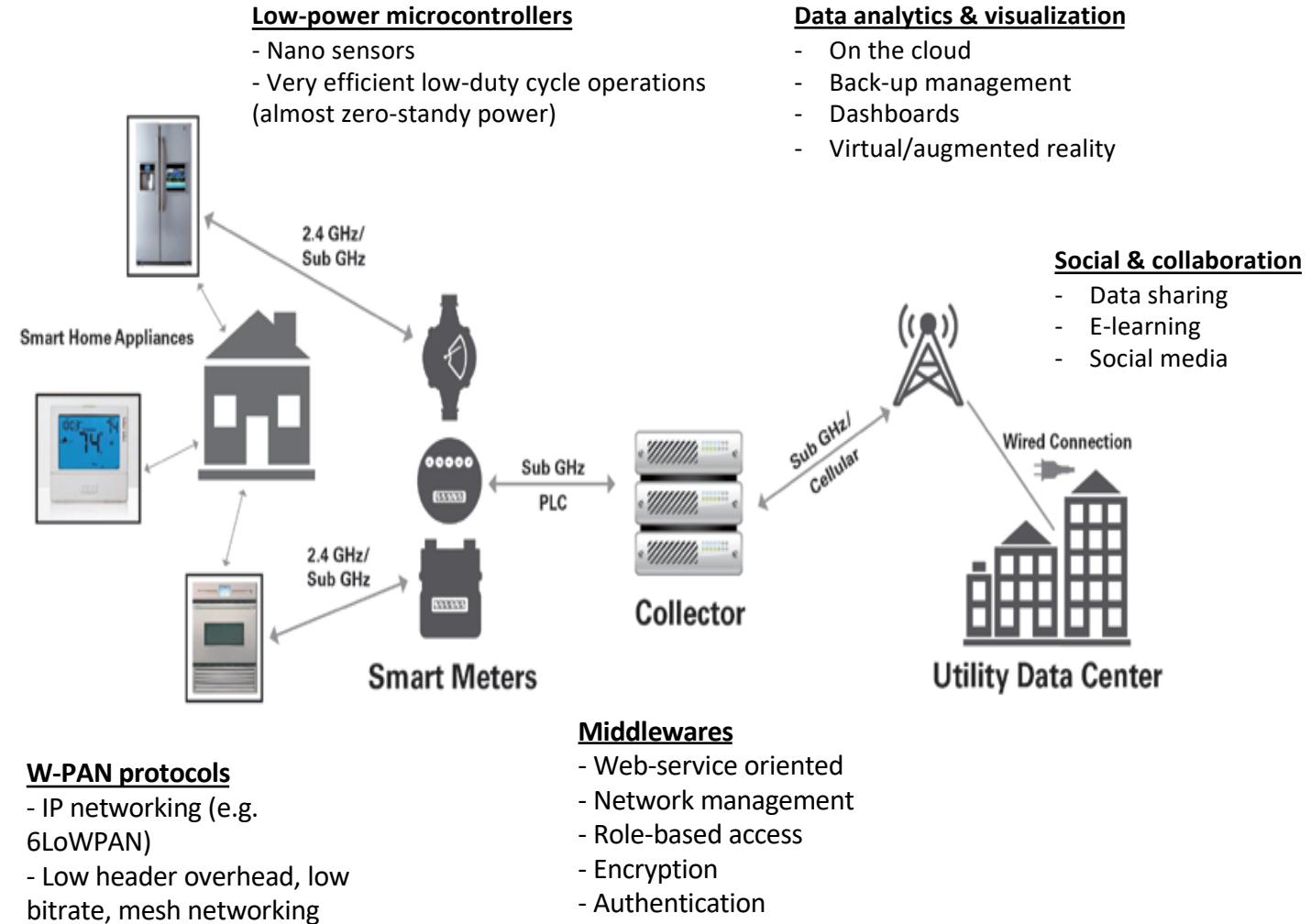
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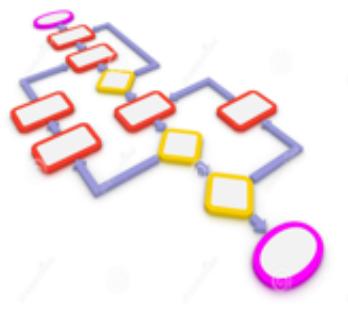
- Just HW?



- Just networks?



- Just computing/algorithms?



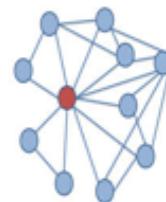


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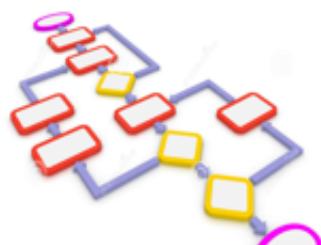
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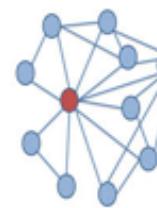
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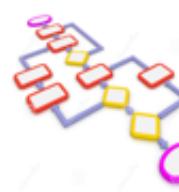
To get low-power/tiny objects running complex network stack as required to talk over Internet and collaborate we need:



Ultra low power wireless nodes with nano sensors with large lifetime (possibly energy harvesting)



Low-power/low-overhead Internet protocols over low bitrate networks and running on tiny objects (e.g. IP over PAN)



Distributed computing and algorithms to implement collaboration (in the CLOUD) but with real-time reaction capabilities



Terminologies similar to IoT

1. USN (Ubiquitous Sensor Networks)
2. M2M (Machine-to-Machine)
3. IoE (Internet of Everything) – Cisco's favorite term
4. Cloud of Things
5. Web of Things



Summary

- IoT is an incoming revolution, enabling a world of new applications
- New communication paradigms are needed (i.e. publish/subscribe)
- Programming IoT requires specific skills (web-network-object oriented, resource constrained programming)
- In this course we will study the main paradigm of IoT programming using Python, similar concepts can be implemented in Java and other scripting languages