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Bretagne-Pays de la Loire
École Mines-Télécom

Introduction in Internet of Things

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OUTLINE

1. Introduction in Internet of Things
2. IoT-based Applications
3. Technical Overview
4. IEEE Std 802.15.4-2015 PHY
5. Characteristics & Challenges

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1. What is *IoT* ?

Check the relevant video
"*Introduction to Media Layers of IoT Protocol Stack*"
on YouTube!

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Things are using the Internet

The Internet of Things

Internet des objets (IoT) est un nouveau paradigme dans lequel les objets intelligents, connectés et identifiables de manière unique avec une adresse IPv6, construisent un réseau d'objets.

Ces éléments peuvent communiquer entre eux ou à travers l'infrastructure dans réseau existantant comme Internet.

Ils peuvent être déployés presque partout, dans les maisons, les hôpitaux, les villes, les champs agricoles, même sur les corps humains.

1. What is our *thing* ?

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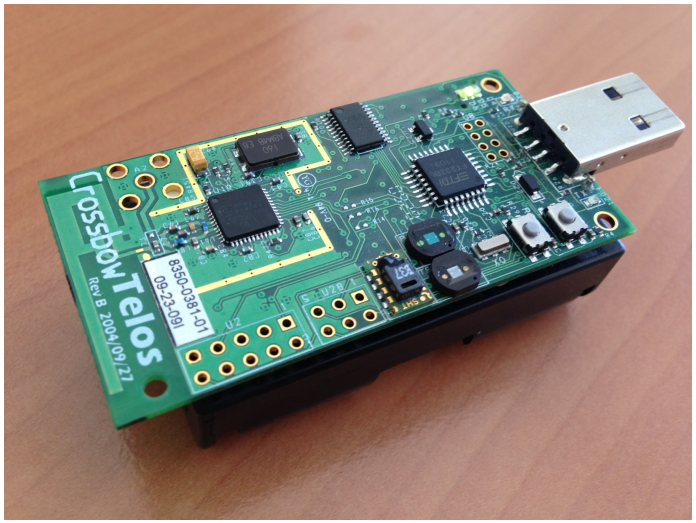
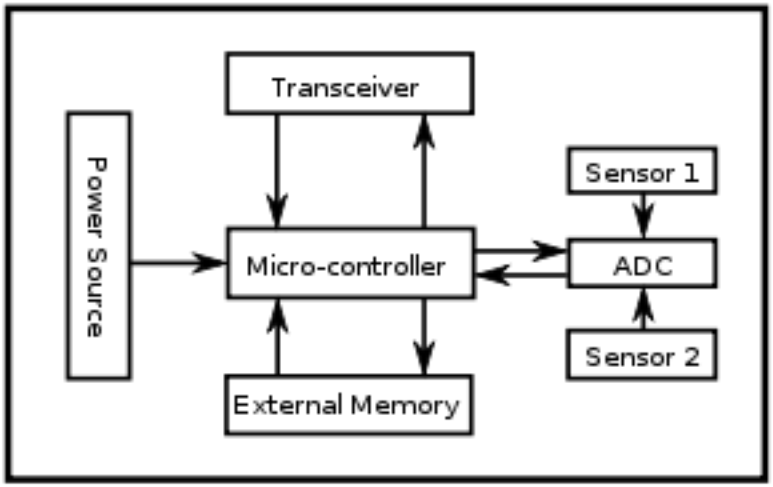
Sensor node architecture





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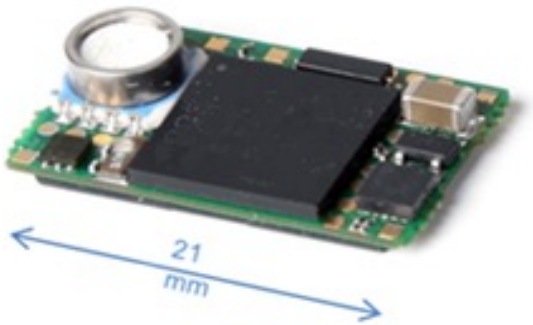
Sensor node



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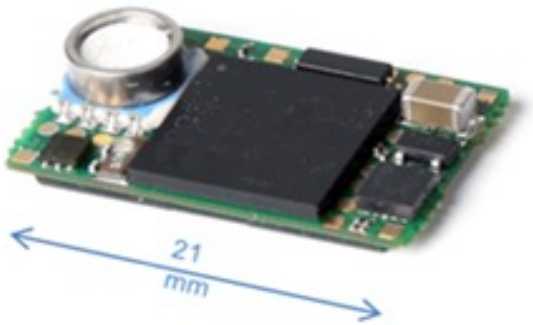
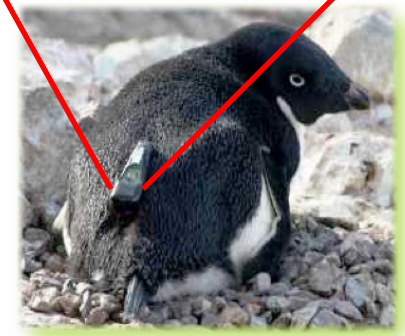


Battery lifetime: some years

Bio-logger



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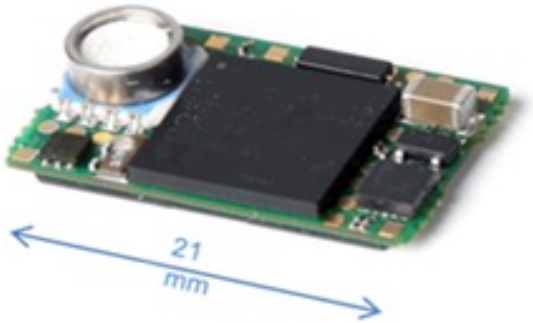

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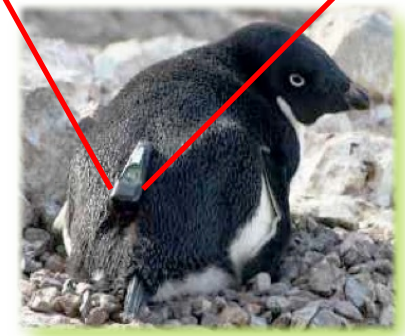


Battery lifetime: some years

3 4G

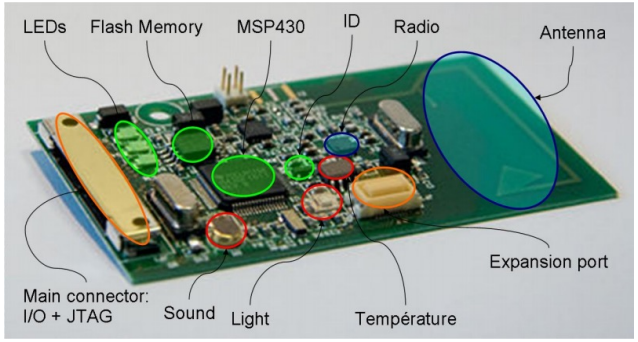
LoRa™

WiFi

Bluetooth®

ZigBee®

Wireless sensor node



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What is our *thing* ?

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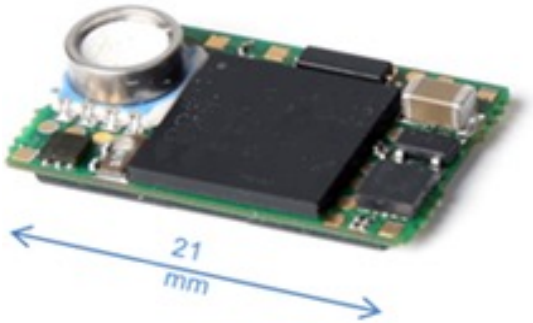

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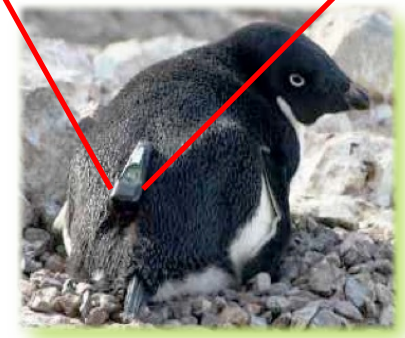


Battery lifetime: some years

Battery lifetime: < months

3 4G

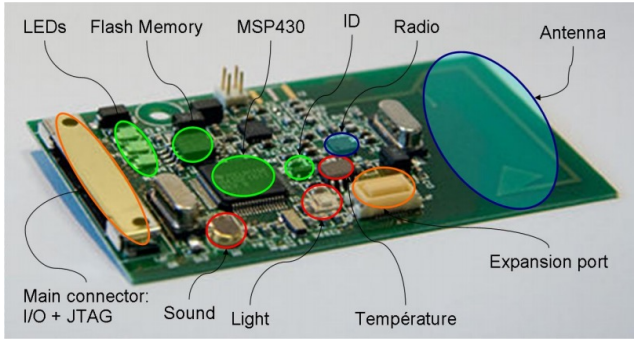
LoRa™

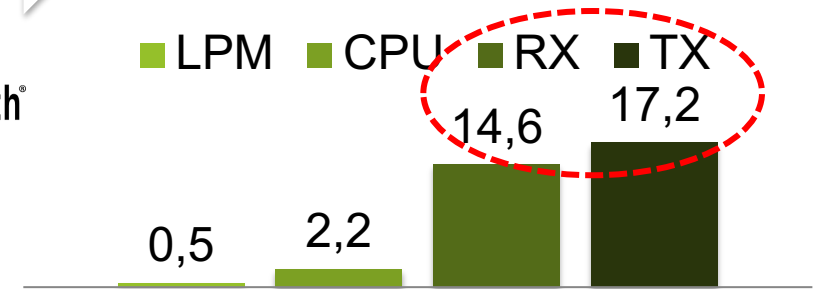
Wi Fi

Bluetooth®

ZigBee®

Wireless sensor node





Energy consumption (mA)
of electronic components [1]

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[1] DATA SHEET : 2.4 GHz IEEE 802.15.4 / ZigBee-ready RF Transceiver

2. IoT-Based Applications

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WHY would Homes connect *things*?

http://www.postscapes.com/internet-of-things-examples/

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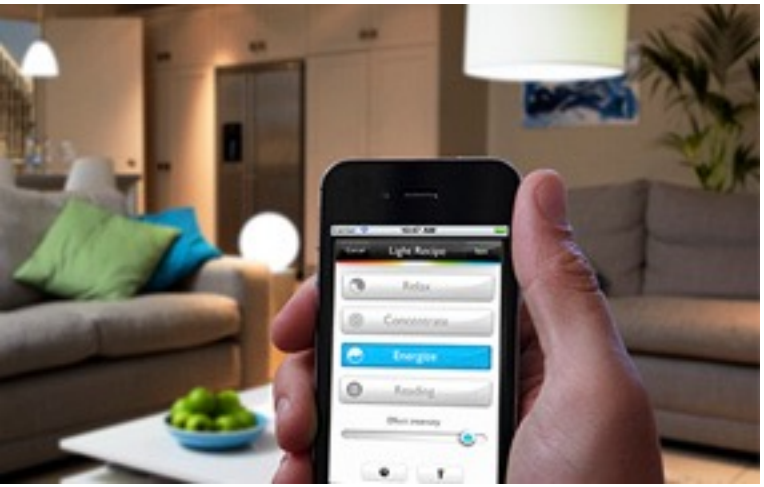

LIGHT YOUR HOME IN NEW WAYS

http://www.postscapes.com/internet-of-things-examples/

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AVOID DISASTERS

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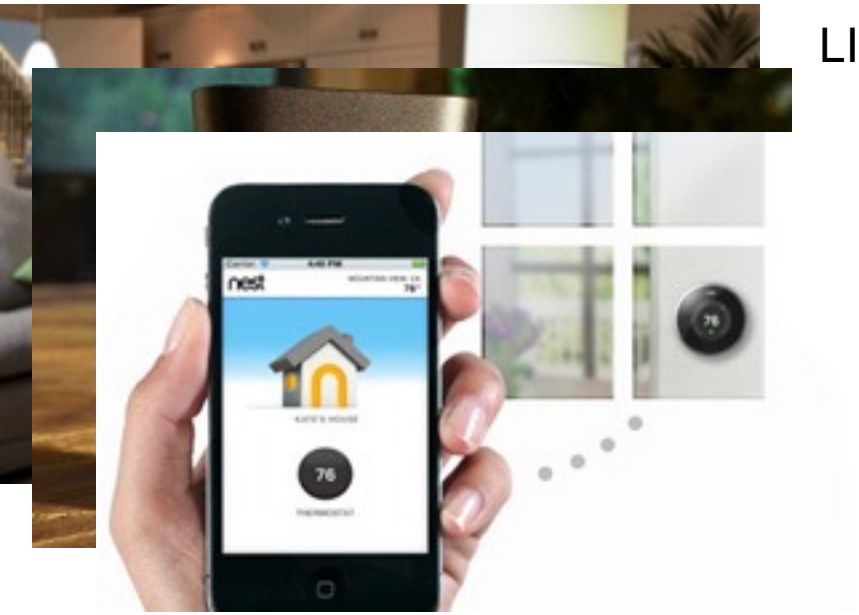

LIGHT YOUR HOME IN NEW WAYS

AVOID DISASTERS

HEAT YOUR HOME EFFICIENTLY (thermostat)

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MAKE SURE THE OVEN IS OFF

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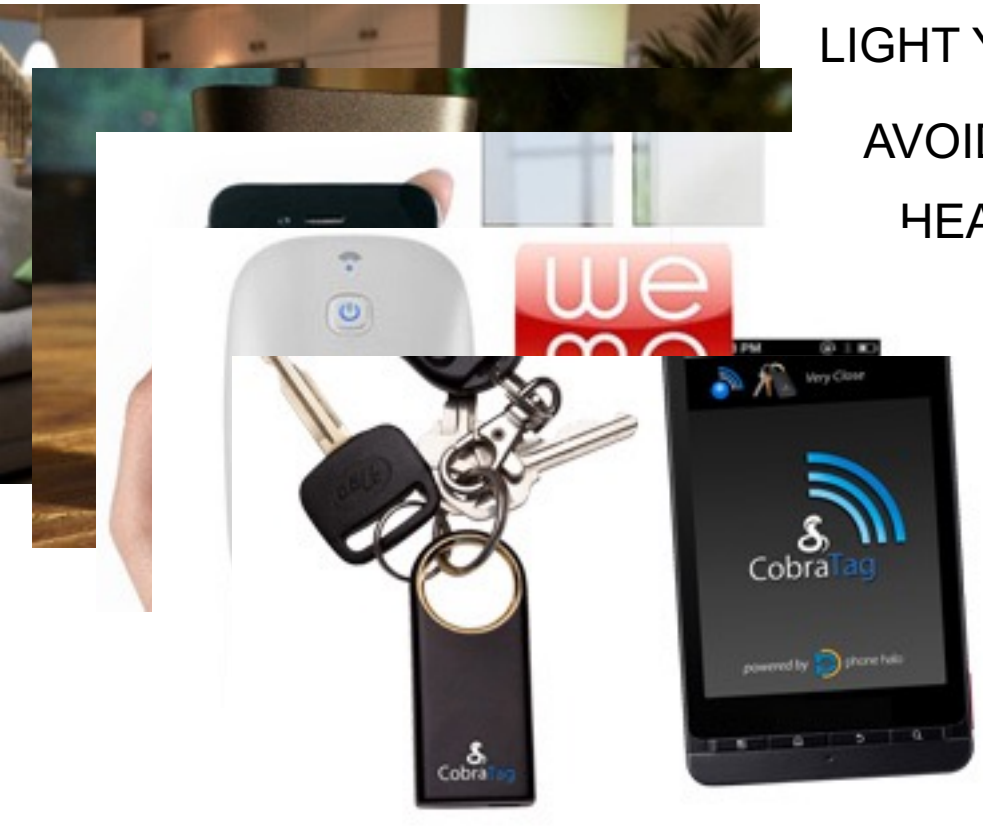

LIGHT YOUR HOME IN NEW WAYS

AVOID DISASTERS

HEAT YOUR HOME EFFICIENTLY (thermostat)

MAKE SURE THE OVEN IS OFF

TRACK DOWN THOSE LOST KEYS

http://www.postscapes.com/internet-of-things-examples/

WHY would Homes connect *things*?

LIGHT YOUR HOME IN NEW WAYS

AVOID DISASTERS

HEAT YOUR HOME EFFICIENTLY (thermostat)

MAKE SURE THE OVEN IS OFF

TRACK DOWN THOSE LOST KEYS

KEEP YOUR PLANTS ALIVE

http://www.postscapes.com/internet-of-things-examples/

https://www.youtube.com/watch?v=5Jxo7AGZmMw

WHY would Cities connect *things* ?

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http://www.postscapes.com/internet-of-things-examples/

WHY would Cities connect *things* ?

KEEP STREETS CLEAN

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STOP DRIVING IN CIRCLES

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WHY would Cities connect *things* ?

KEEP STREETS CLEAN

STOP DRIVING IN CIRCLES

RECEIVE POLLUTION WARNINGS

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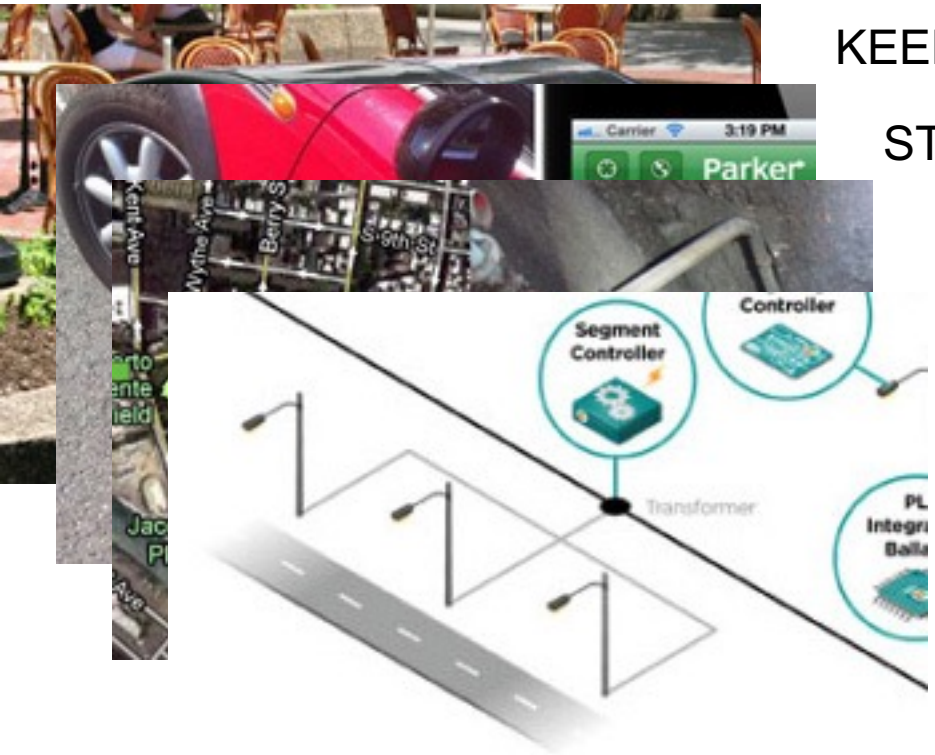

KEEP STREETS CLEAN

STOP DRIVING IN CIRCLES

RECEIVE POLLUTION WARNINGS

LIGHT STREETS MORE EFFECTIVELY

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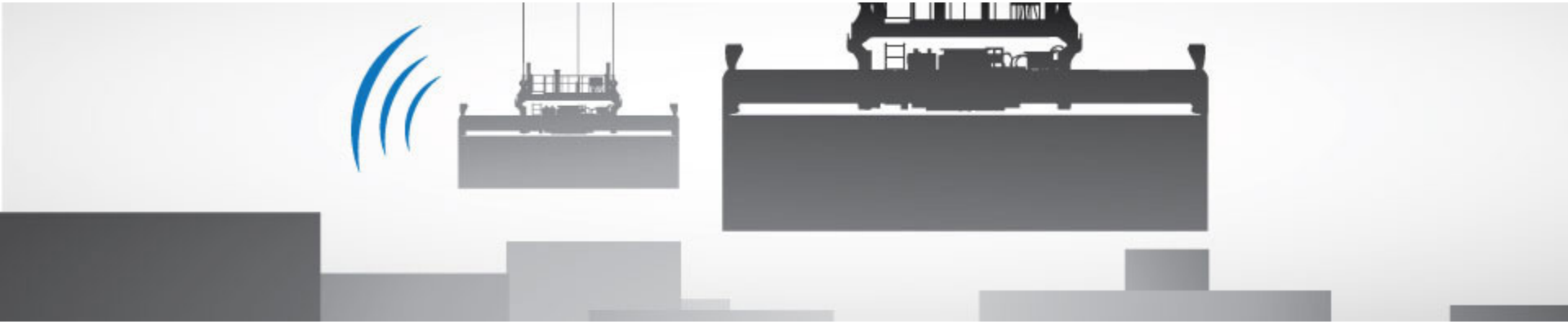
WHY would Industries connect *things* ?



http://www.postscapes.com/internet-of-things-examples/

WHY would Industries connect *things* ?

MAINTAIN QUALITY & REPAIR

http://www.postscapes.com/internet-of-things-examples/

WHY would Industries connect *things* ?

MAINTAIN QUALITY & REPAIR

MONITOR

http://www.postscapes.com/internet-of-things-examples/

WHY would Industries connect *things* ?

MAINTAIN QUALITY & REPAIR

MONITOR

KEEP TRACK OF YOUR ASSETS

http://www.postscapes.com/internet-of-things-examples/

WHY would Industries connect *things* ?

MAINTAIN QUALITY & REPAIR

MONITOR

KEEP TRACK OF YOUR ASSETS

SAFETY FIRST

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WHY would Environment connect *things* ?

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http://www.postscapes.com/internet-of-things-examples/

WHY would Environment connect *things* ?

MONITOR POLLUTION LEVELS

http://www.postscapes.com/internet-of-things-examples/

WHY would Environment connect *things* ?

MONITOR POLLUTION LEVELS

HELP PROTECT WILDLIFE

http://www.postscapes.com/internet-of-things-examples/

WHY would Environment connect *things* ?

MONITOR POLLUTION LEVELS

HELP PROTECT WILDLIFE

GET AN ADVANCED WARNING

http://www.postscapes.com/internet-of-things-examples/

WHY would Environment connect *things* ?

MONITOR POLLUTION LEVELS

HELP PROTECT WILDLIFE

GET AN ADVANCED WARNING

STOP THE BLEEDING

http://www.postscapes.com/internet-of-things-examples/

The Internet of Things

https://www.youtube.com/watch?v=wL34vK-On3o

3. Technical Overview

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IoT Technology Features

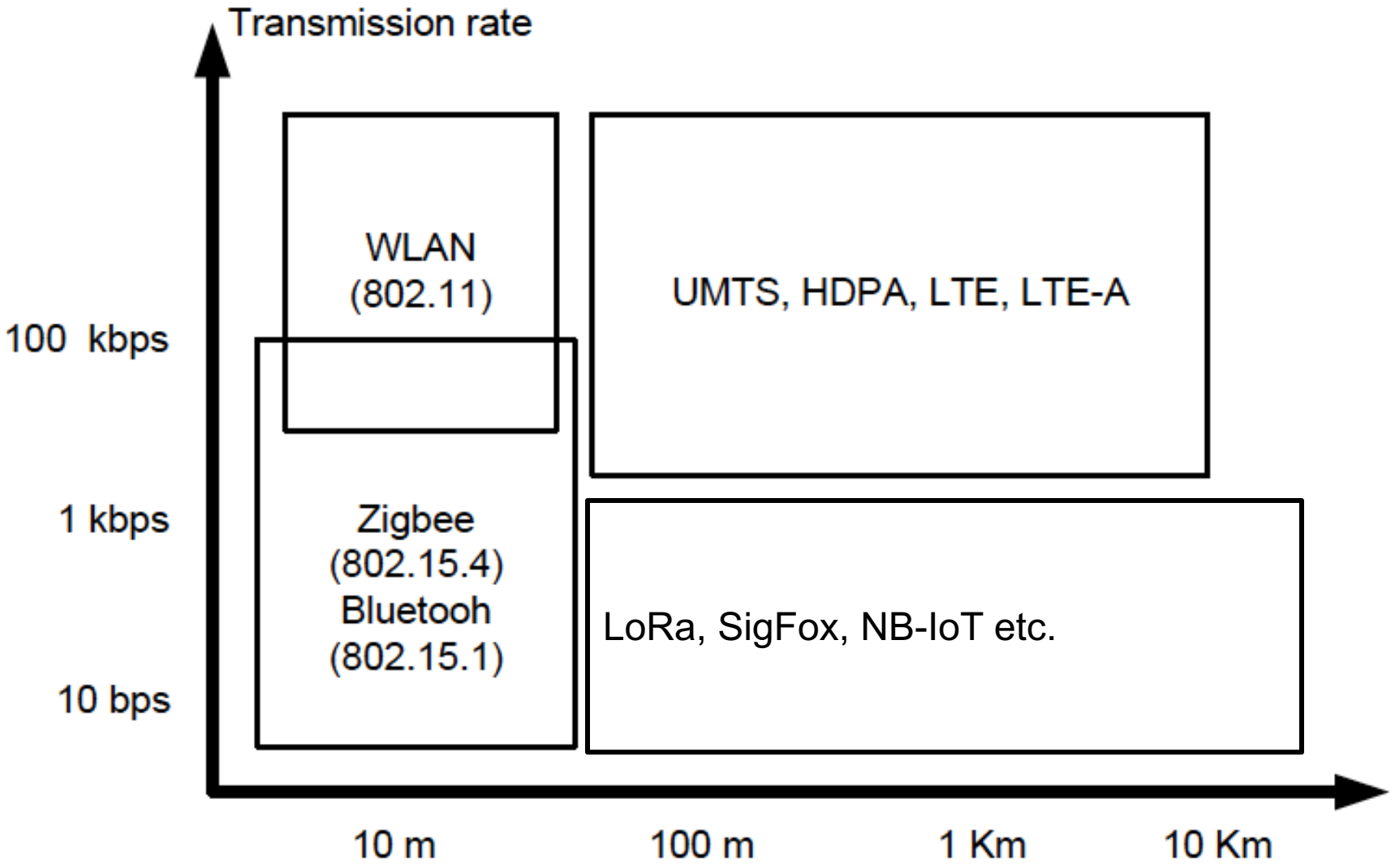
- Long-range

	range	bitrate	frequency
SigFox	13km	100bps	900MHz
LTE-M	15km	150kbps – 1 Mbps	licensed 900MHz
LoRa	11km	10kbps	900MHz

- Short-range

	range	bitrate	frequency
IEEE 802.15.4 / ZigBee	10-100m	250Kbps	2.4GHz
BLE	10-100m	125Kbps – 2Mbps	2.4GHz

Technology Criteria



4. IEEE Std 802.15.4-2015 PHY

Check the relevant video
"*IEEE 802.15.4 TSCH MAC protocol*" on YouTube!

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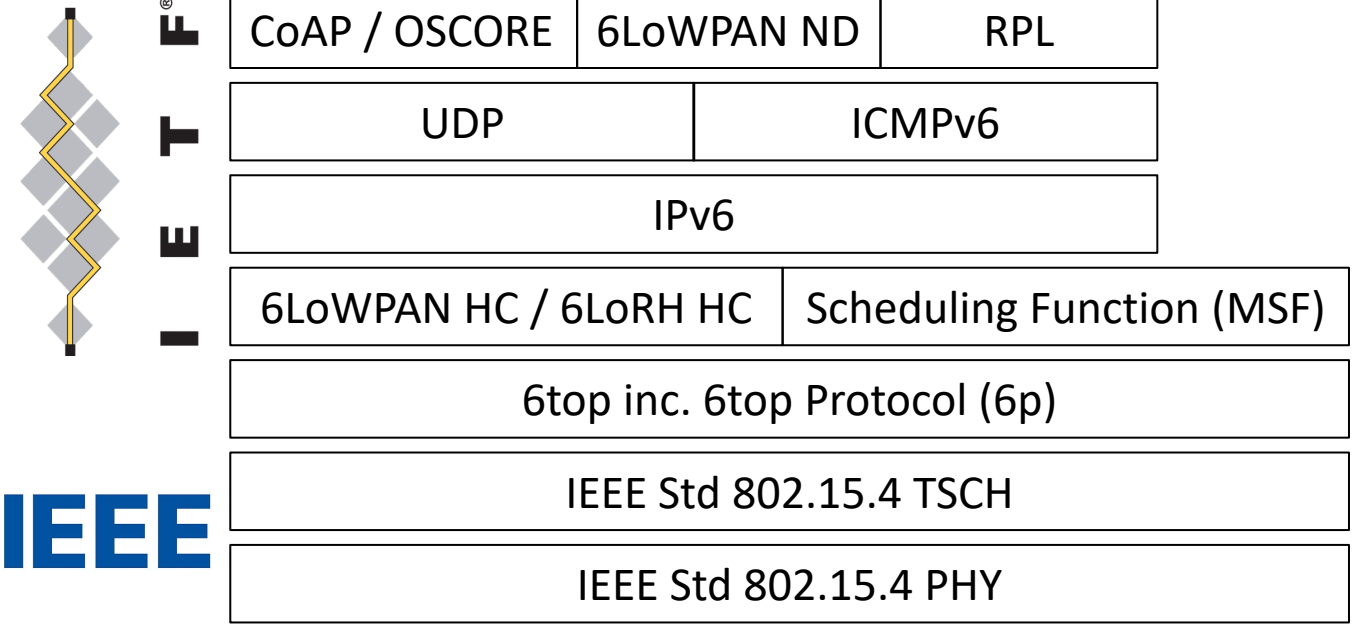
The 6TiSCH Protocol Stack



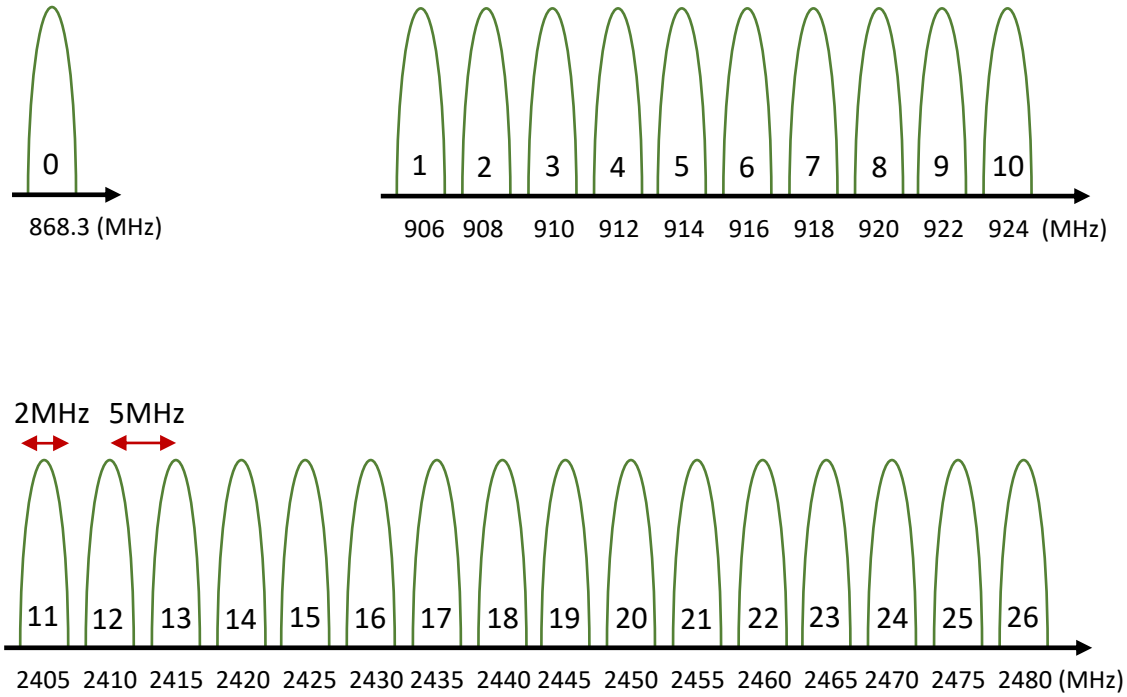
IEEE Std 802.15.4-2015 PHY

MAC and PHY layer specifications for
Low-Rate and Wireless Personal Area Networks (LR-WPANs) [1]

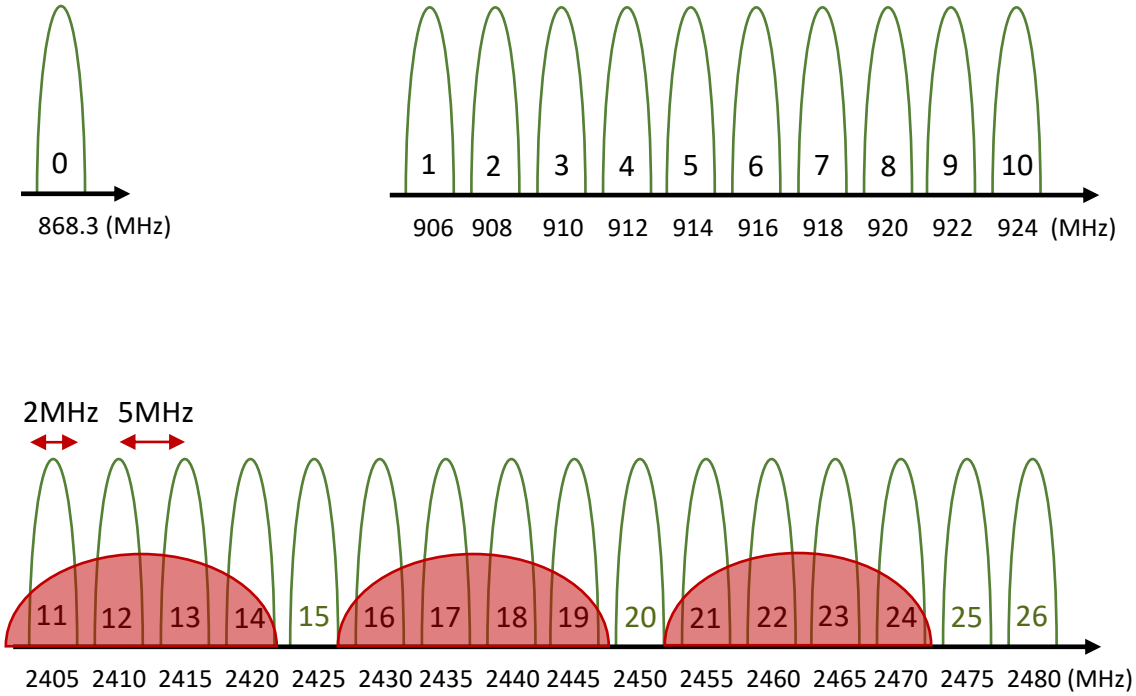
Frequency (MHz)	Channels	Debits (kb/s)	Area	Modulation
868-868.6	1 channel	20	Europe	BPSK
		250		ASK
		100		O-QPSK
902-928	10 channels Bandwidth: 2MHz	40	USA Canada	BPSK
		250		ASK
		250		O-QPSK
2400-2483	16 channels Bandwidth: 2MHz Guard Freq.: 5MHz	250	World	O-QPSK

[1] “IEEE Standard for Low-Rate Wireless Personal Area Networks (LR-WPANs),” IEEE Std 802.15.4-2015, April 2016.

IEEE Std 802.15.4-2015 PHY (Radio Channels)



Overlapping with the Wi-Fi (802.11) Technology



5. Characteristics & Challenges

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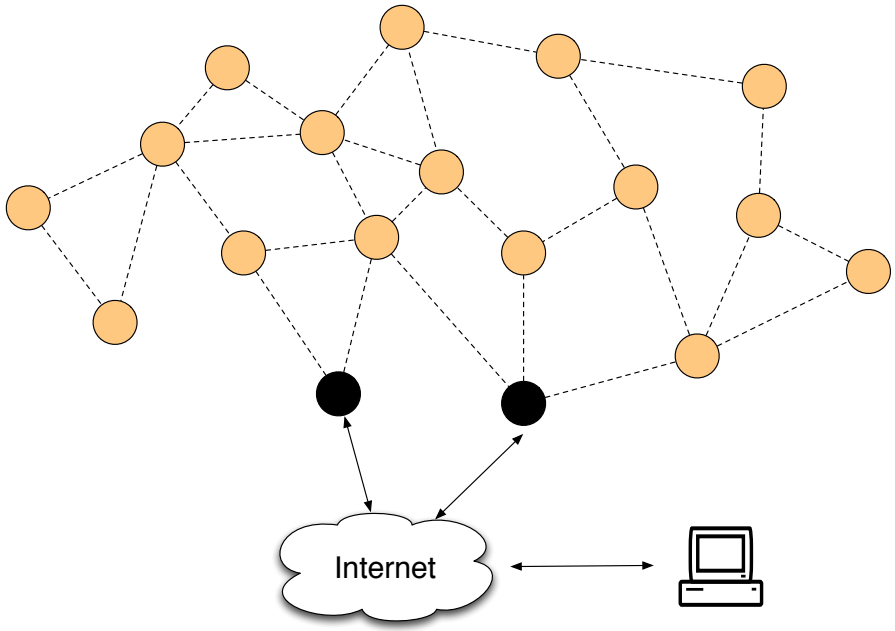
Characteristics and Challenges (1/3)

- Dynamic Topology:
  - New links may establish or break the existing ones.



Characteristics and Challenges (1/3)

- Dynamic Topology:
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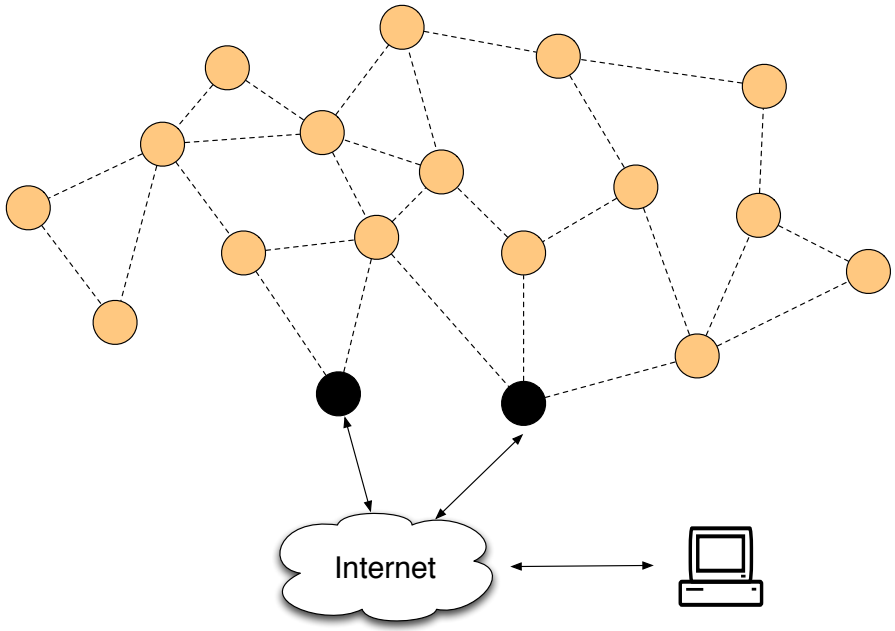
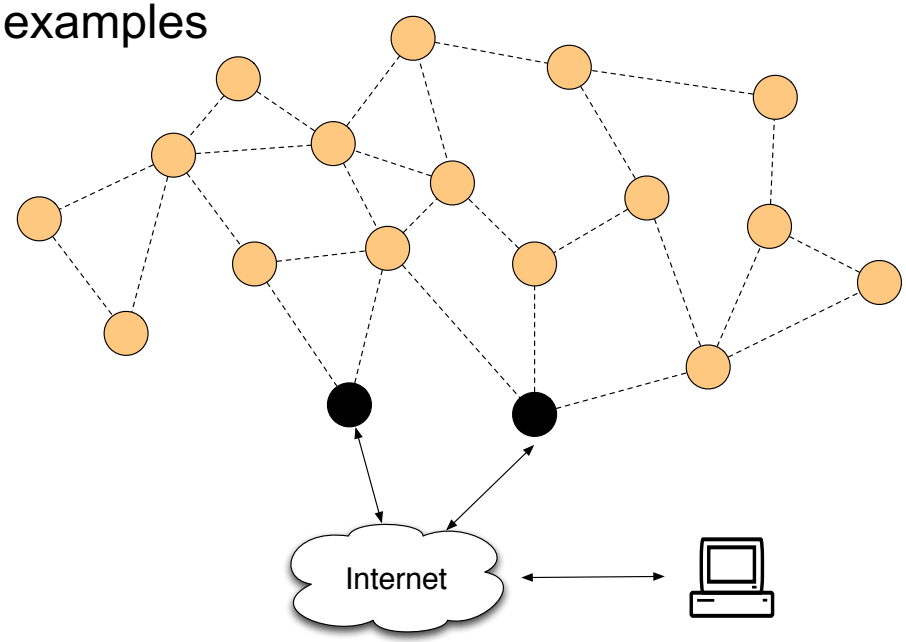


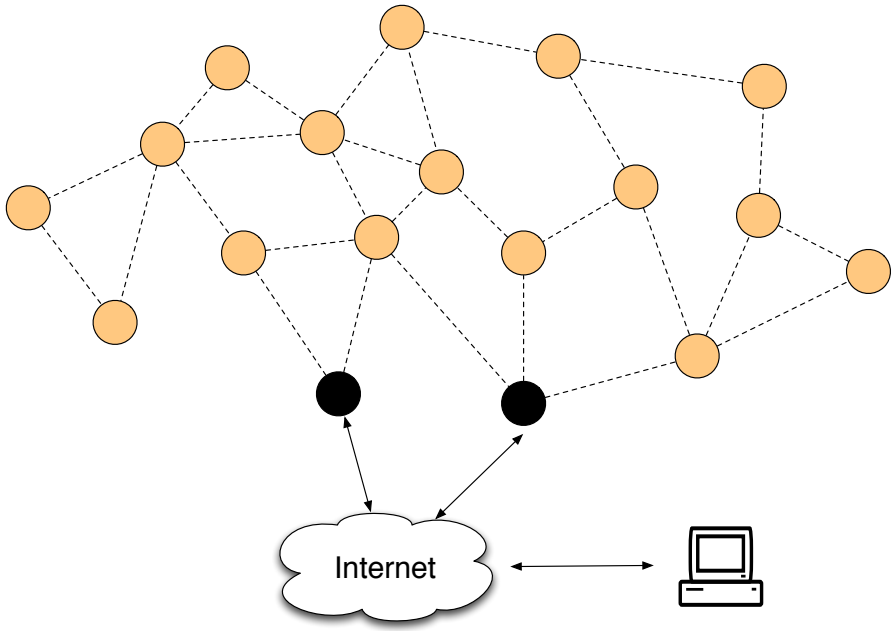
Characteristics and Challenges (1/3)

- Dynamic Topology:
  - New links may establish or break the existing ones.
  - May consists of unidirectional and bidirectional.
  - Nodes are free to move → Mobility level:
    Static: sensor networks
    Mean: pedestrian, battle field
    Rapid: vehicles
    Hybrid: combination of previous examples



Characteristics and Challenges (2/3)

- Bandwidth-constrained & variable link quality:
  - Significantly lower than the wired networks.
  - Sensitive to external interference, multi-path fading, noise etc.
  - Link congestion.



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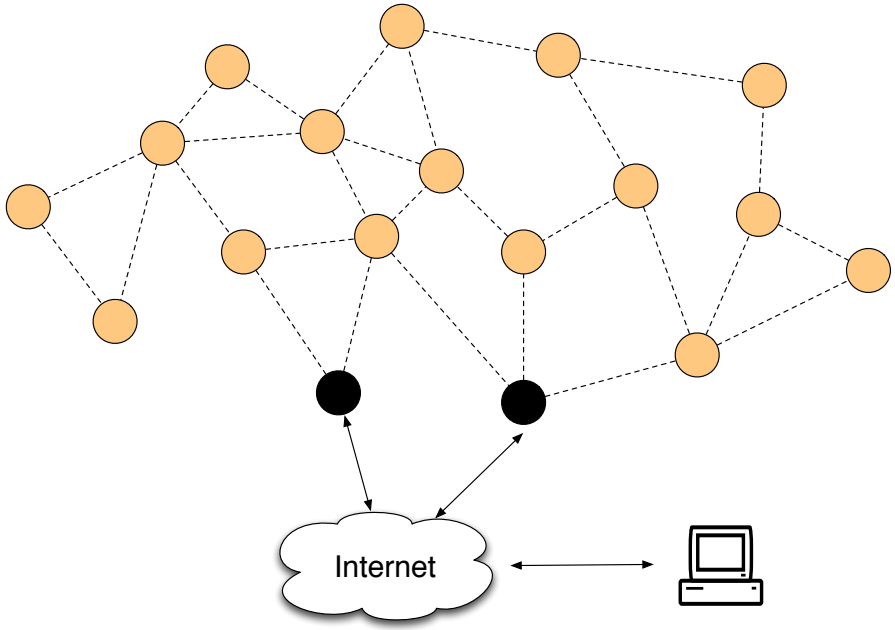

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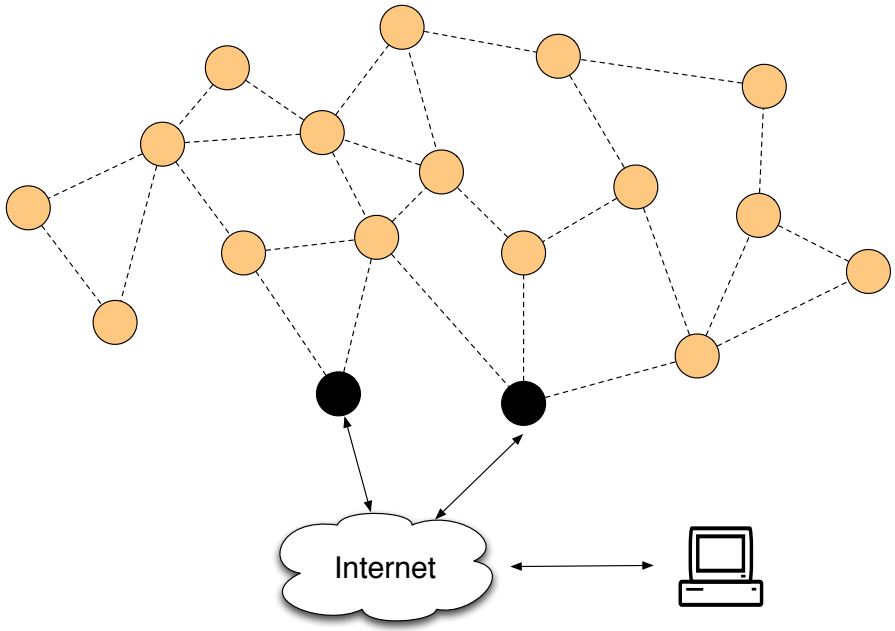
- Limited physical security:
  - Prone to physical security threats.
  - Denial-of-Service attacks.



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- Limited physical security:
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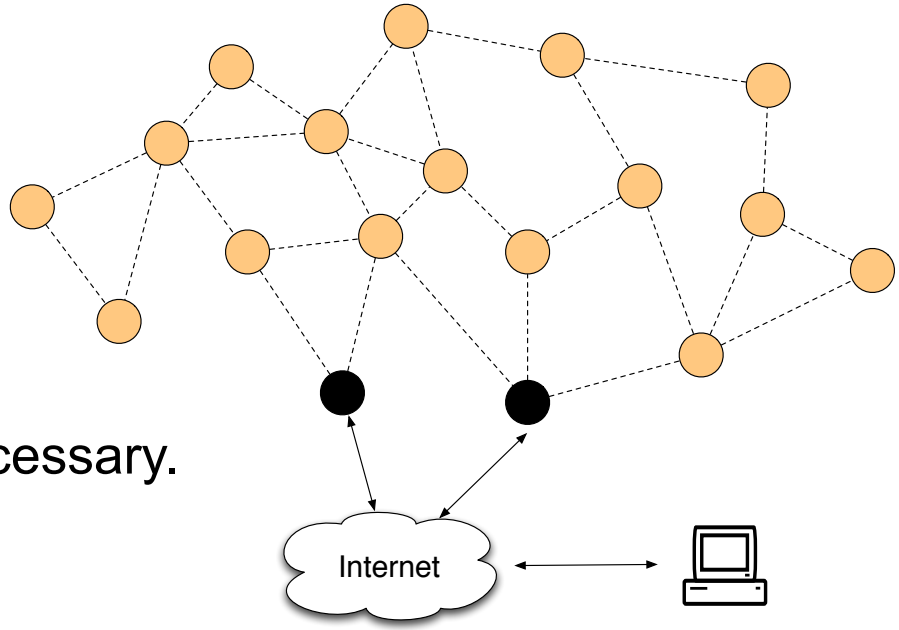
- Fault Tolerance:
  - Nodes can get damaged.
  - → redundant deployments are necessary.



Characteristics and Challenges (3/3)

- Quality of Service:
  - Industrial / multimedia applications : e.g., delay, jitter, availability.

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  - A IoT network can consists of many nodes.
  - → the employed architectures and protocols should be able to scale.

Characteristics and Challenges (3/3)

- Quality of Service:
  - Industrial / multimedia applications : e.g., delay, jitter, availability.
- Scalability:
  - A IoT network can consists of many nodes.
  - → the employed architectures and protocols should be able to scale.
- Maintainability & Programmability:
  - Nodes should be flexible → the tasks or the environment could change.
  - The software should be programmable during the operation.

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