



Towards an Internet of Things: Android meets NFC

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Outline

Internet of Things: History

Internet of Things: Definition and Components

Internet of Things: *Applications*

NFC technology: *Main Characteristics*

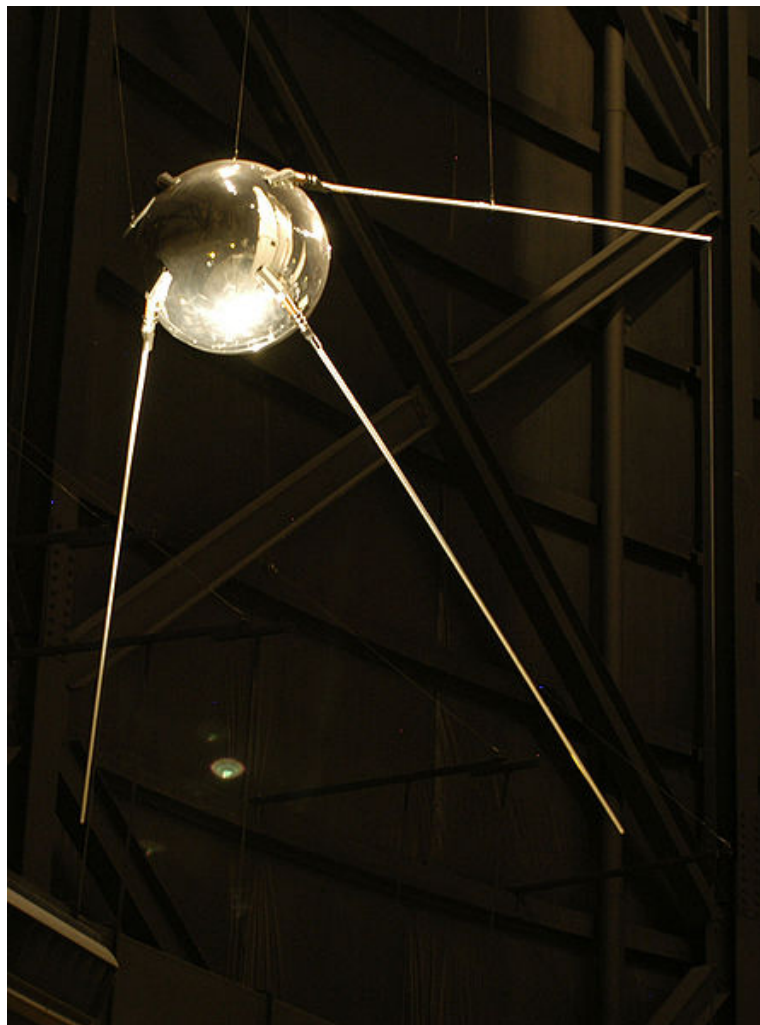
NFC technology: *Message format*

Android and NFC: *TAG Operations (r/w)*

Android and NFC: *P2P communication*



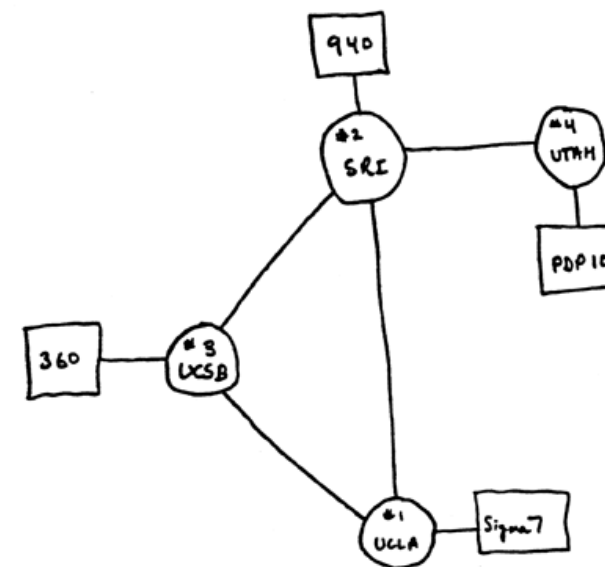
The **Internet of Things**: Main Concepts



Sputnik 1, 1957



Defense Advanced Research
Projects Agency (DARPA), 1958

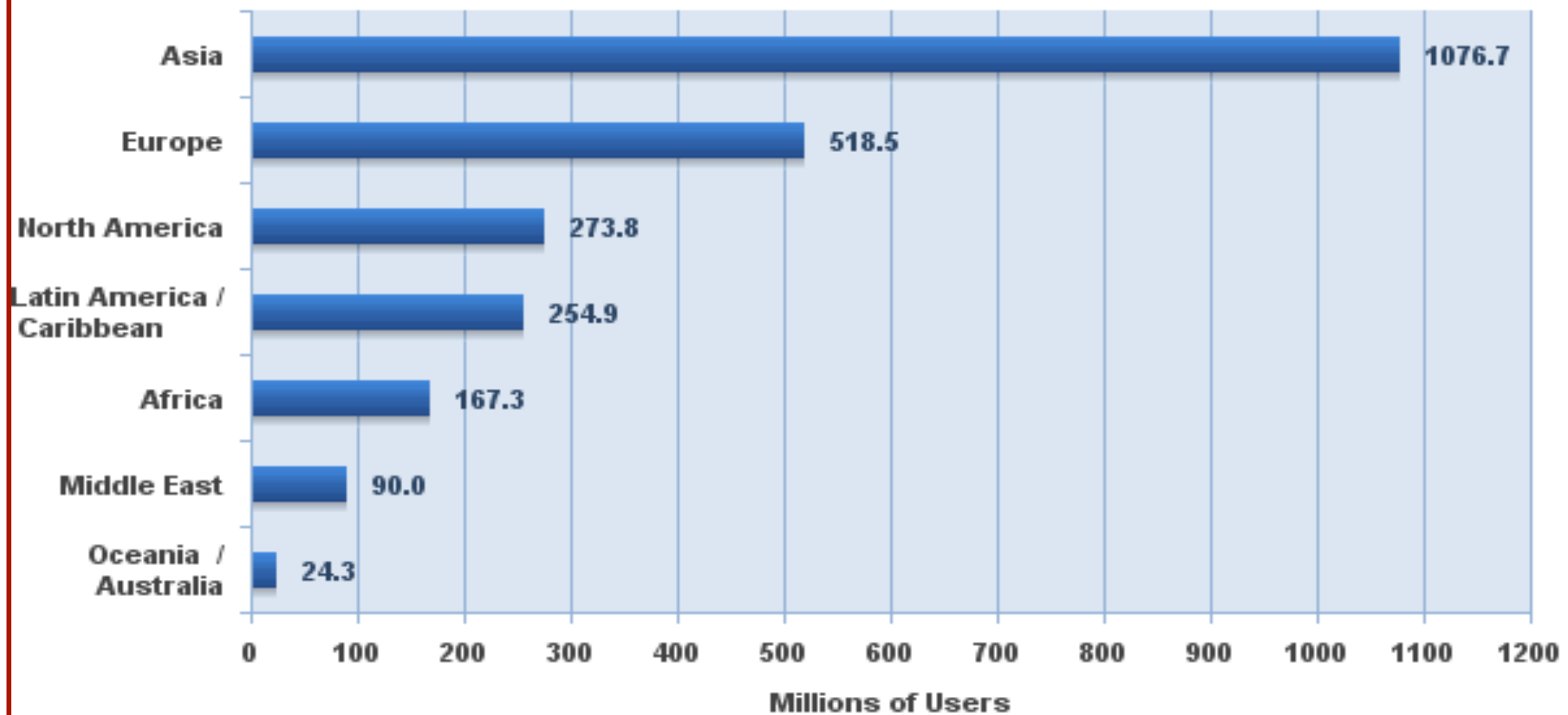


4-node Internet diagram, 1969



The **Internet of Things**: Main Concepts

Internet Users in the World by Geographic Regions - 2012 Q2

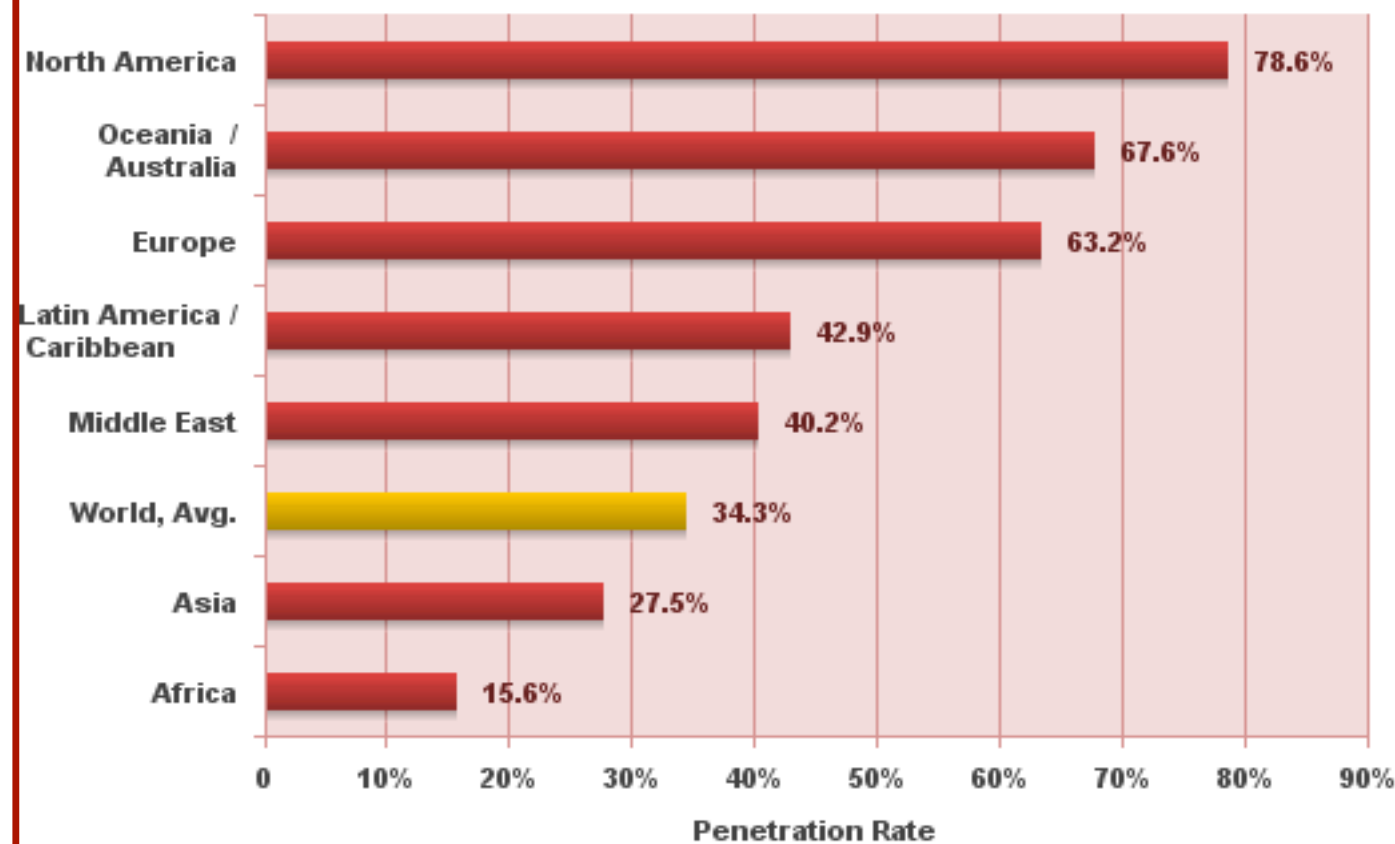


Source: Internet World Stats - www.internetworldstats.com/stats.htm
2,405,518,376 Internet users estimated for June 30, 2012
Copyright © 2012, Miniwatts Marketing Group



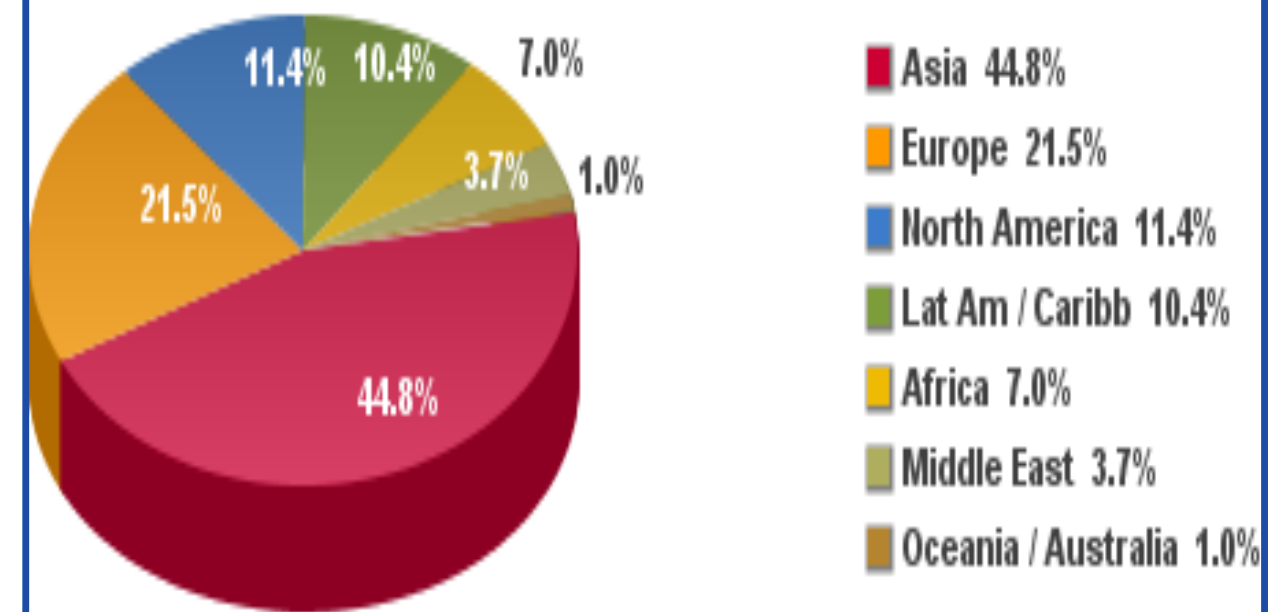
The Internet of Things: Main Concepts

World Internet Penetration Rates by Geographic Regions - 2012 Q2



Source: Internet World Stats - www.internetworldstats.com/stats.htm
Penetration Rates are based on a world population of 7,017,846,922 and 2,405,518,376 estimated Internet users on June 30, 2012.
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Internet Users in the World Distribution by World Regions - 2012 Q2

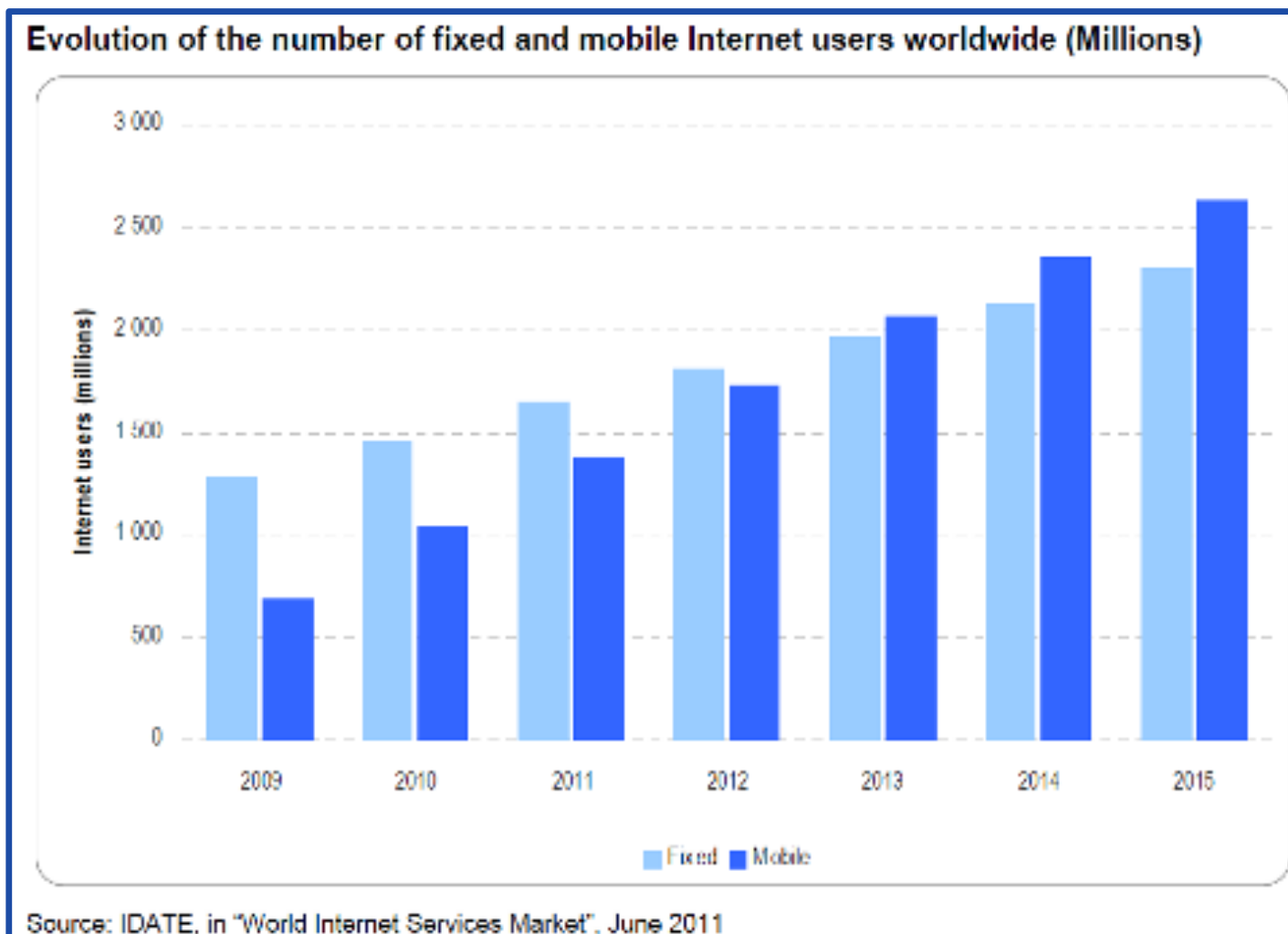


Source: Internet World Stats - www.internetworldstats.com/stats.htm
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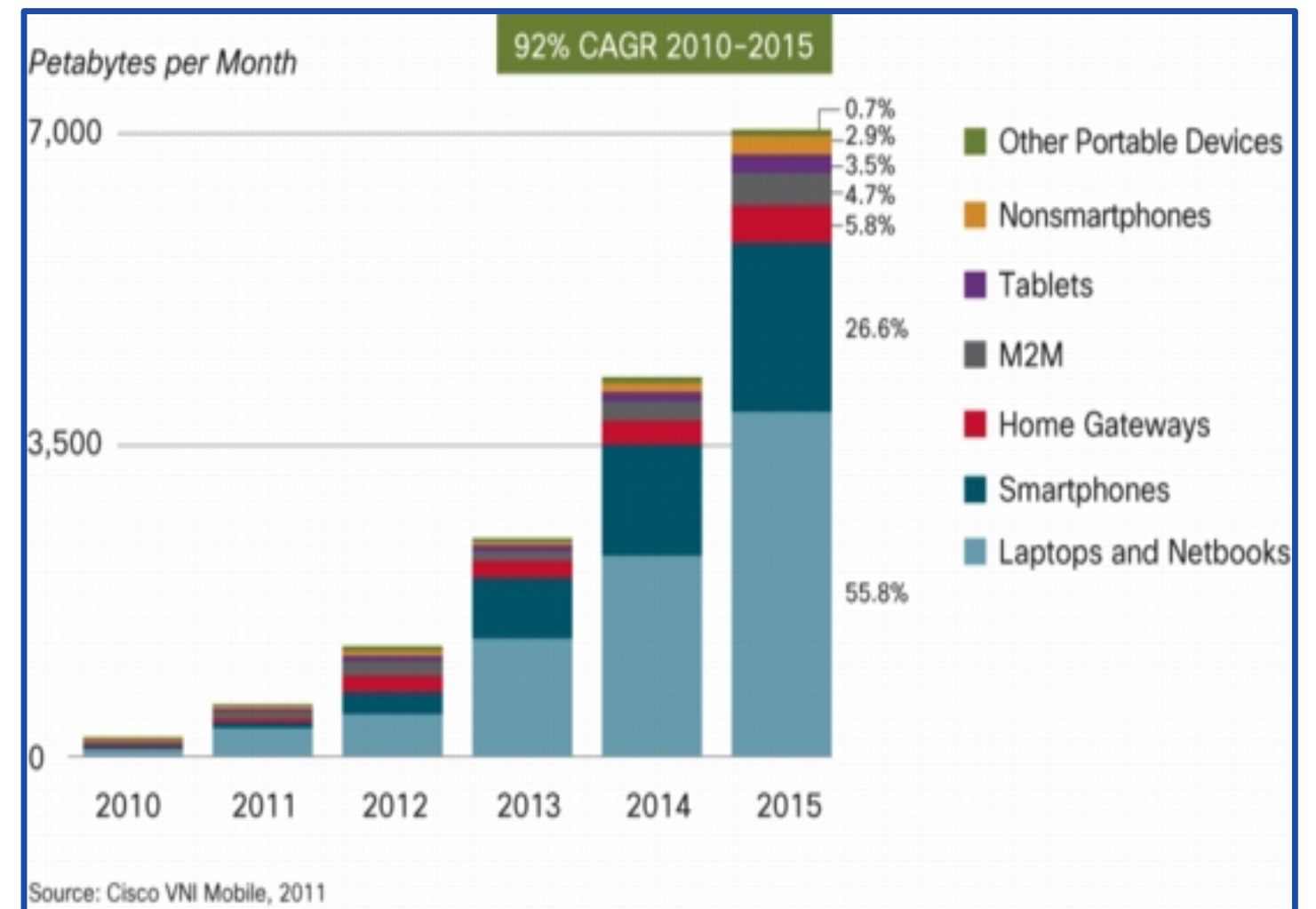


The Internet of Things: Main Concepts

MOBILE INTERNET USERS WORLDWIDE



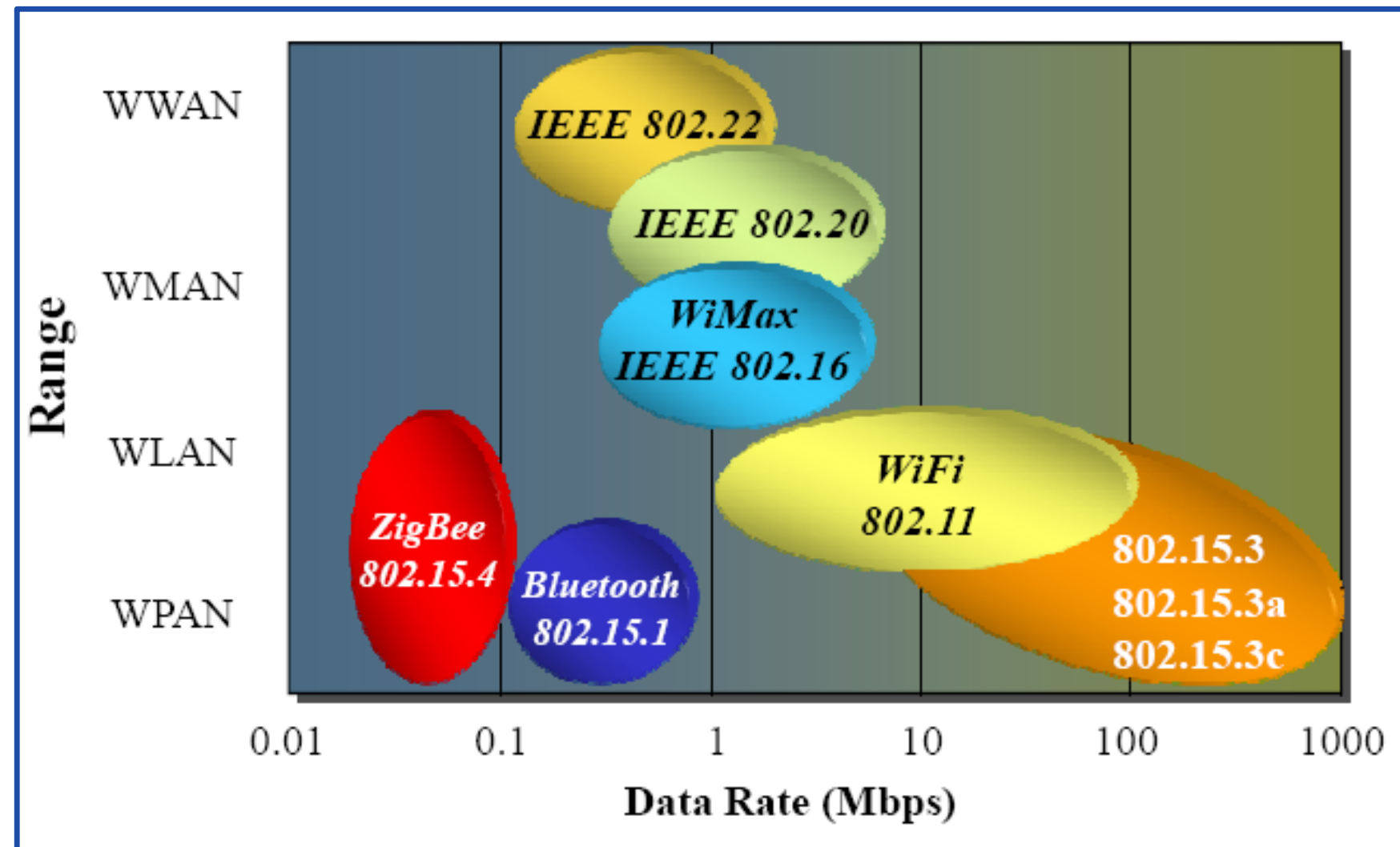
MOBILE DEVICE DIVERSIFICATION





The **Internet of Things**: Main Concepts

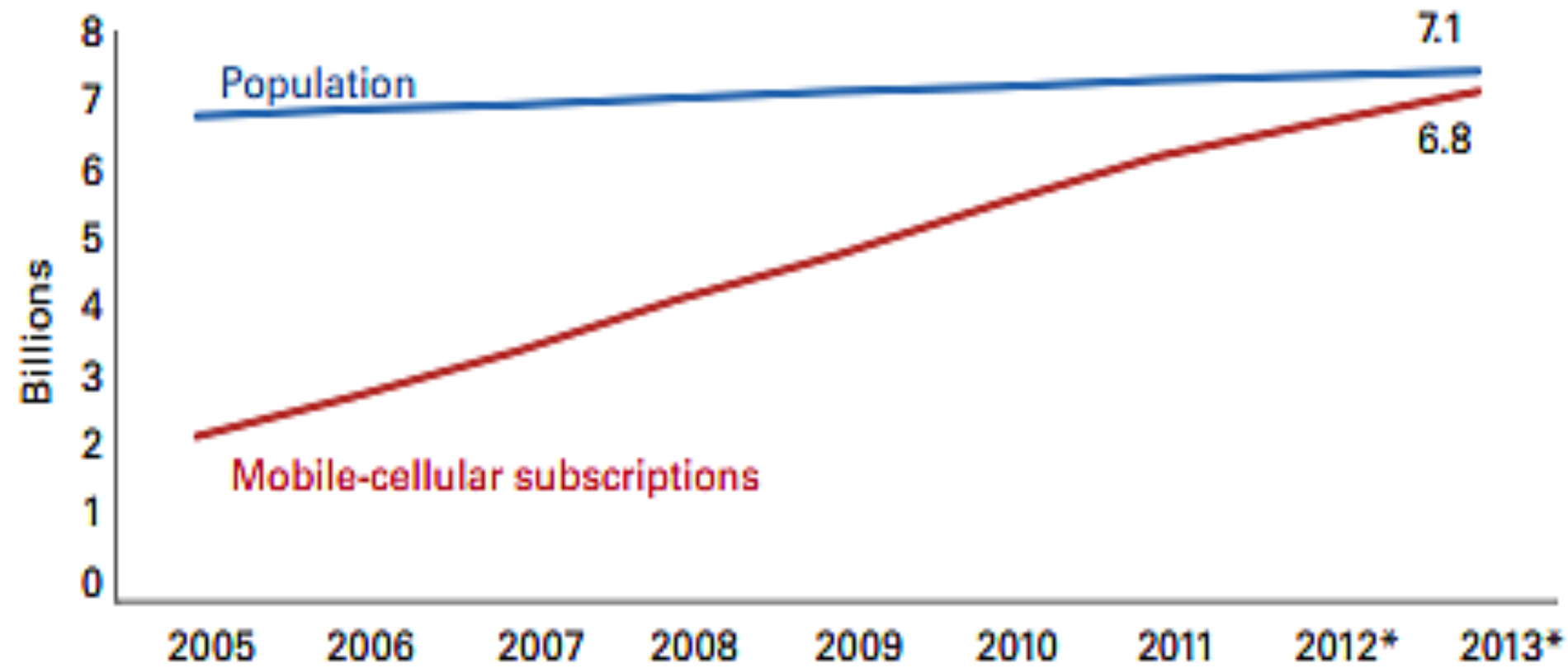
Beyond the cellular technology, the **Wireless Internet** can refer to a multitude of **wireless access standards** ...





The **Internet of Things**: Main Concepts

Cellular subscriptions growth (compared to population growth)



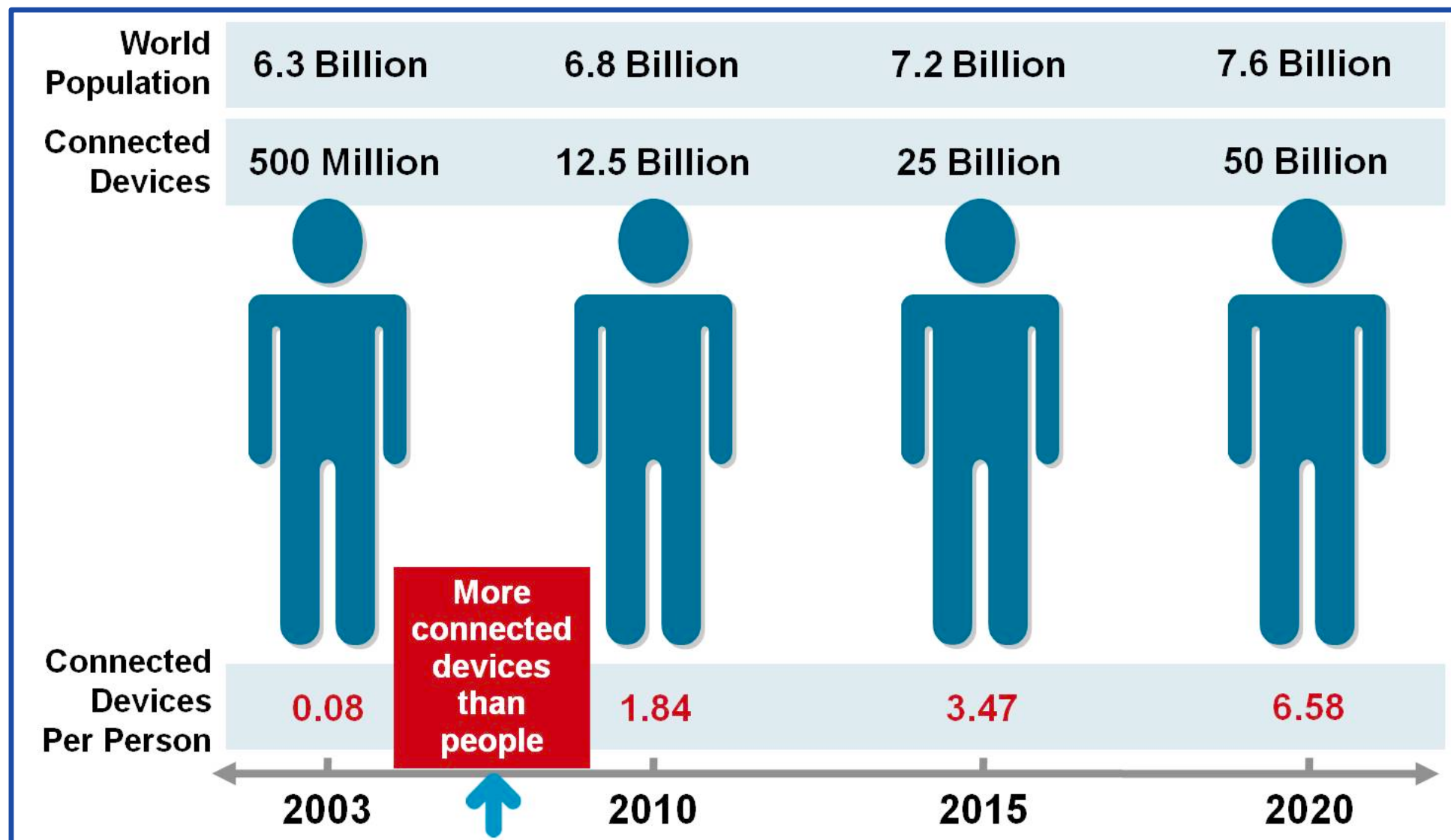
Source: ITU World Telecommunication JICT Indicators database

Note: * Estimate



The **Internet of Things**: Main Concepts

From an Internet of Humans ... to an **Internet of Things** ...



Source: Cisco IBSG, April 2011



The **Internet of Things**: Main Concepts

... What is exactly the **Internet of Things (IoT)** ?

Several definitions, corresponding to different visions ...

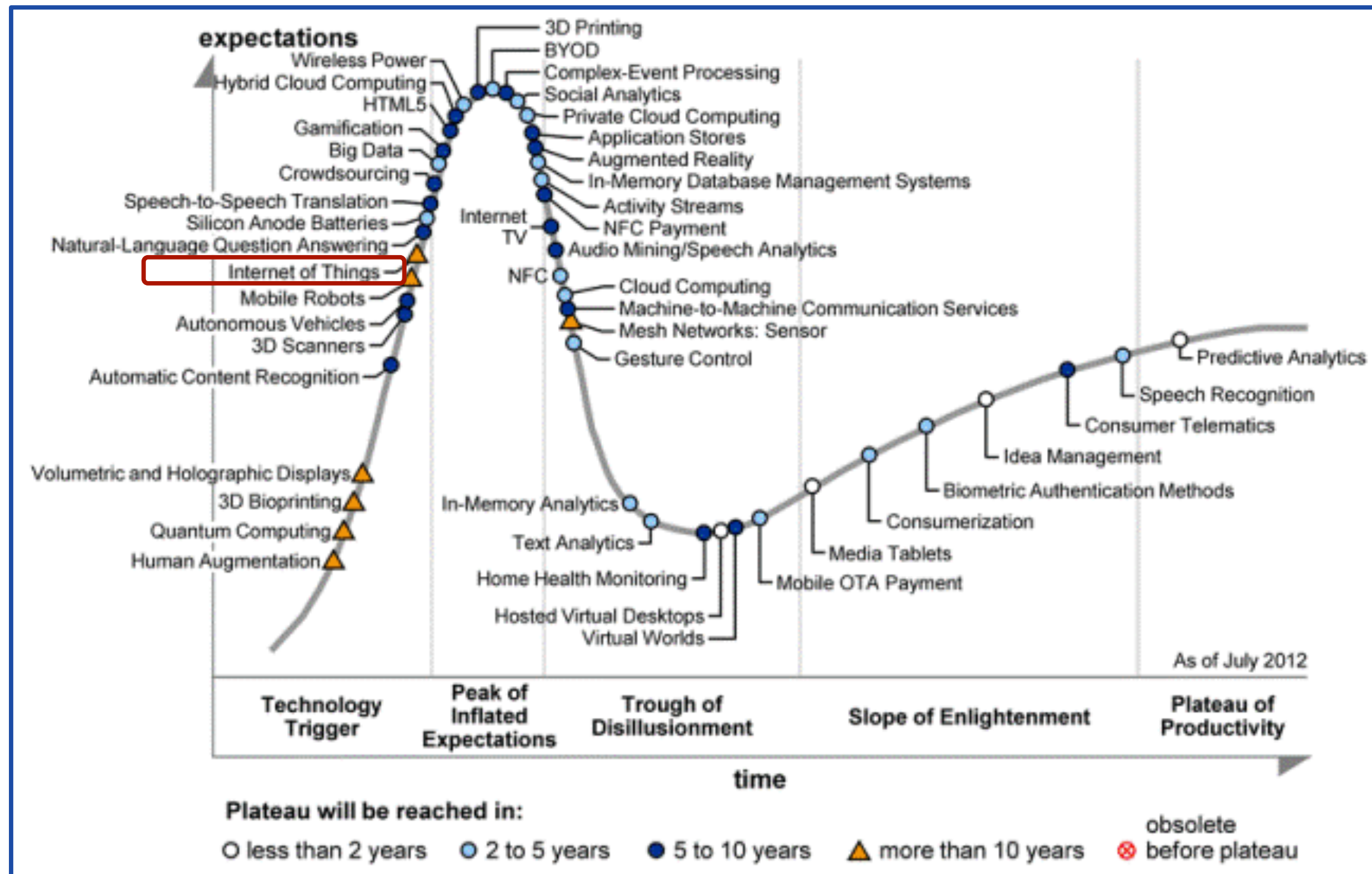
“World where things can automatically communicate to computers and each other providing services to the benefit of the human kind.” (CASAGRAS consortium)

- ~~IoT is a New Wireless Technology~~
- ~~IoT is a New Wireless Standard~~
- IoT is a New Communication Paradigm



The Internet of Things: Main Concepts

Fonte: Gartner, 2012





The **Internet of Things**: Main Concepts

The Internet of Things is composed of **Smart Objects (SO)**.

Smart Objects: *abstract* vision

Objects that are able to **sense** the environment, **interpret** the environment, **self-configure**, **interact** with other objects and exchange information with people.

www.samsung.com



Smart Refrigerator

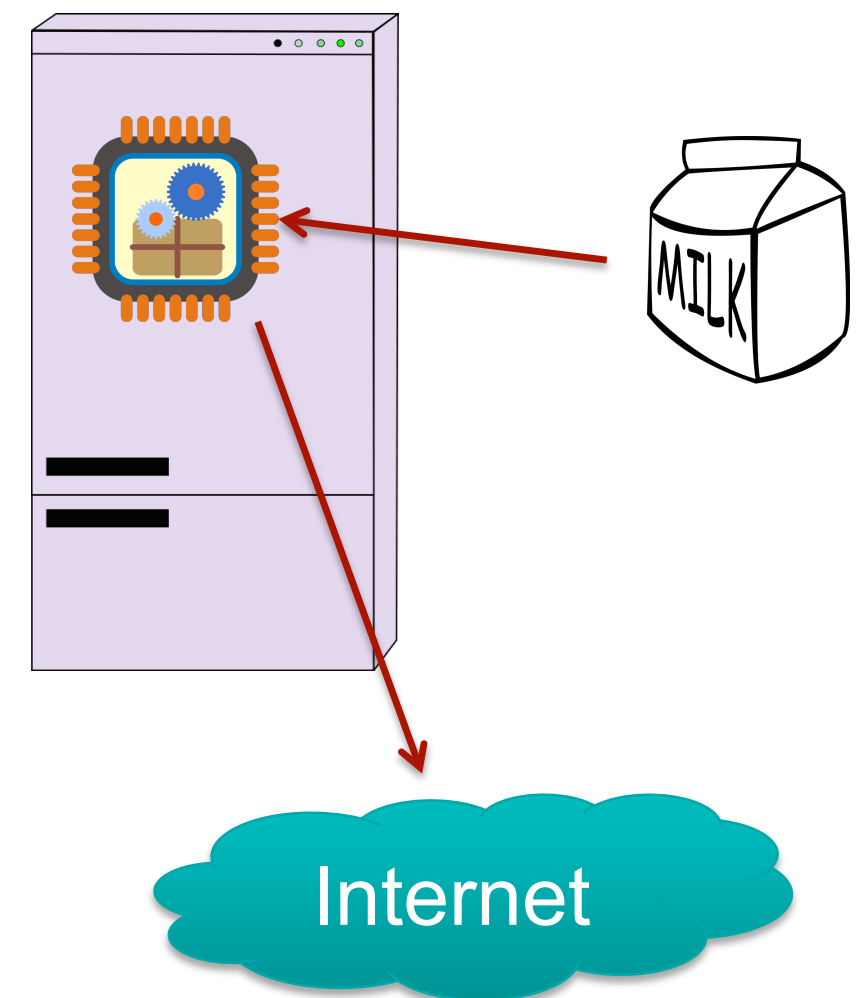


The **Internet of Things**: Main Concepts

The Internet of Things is composed of **Smart Objects (SO)**.

Smart Objects: *implementation* vision

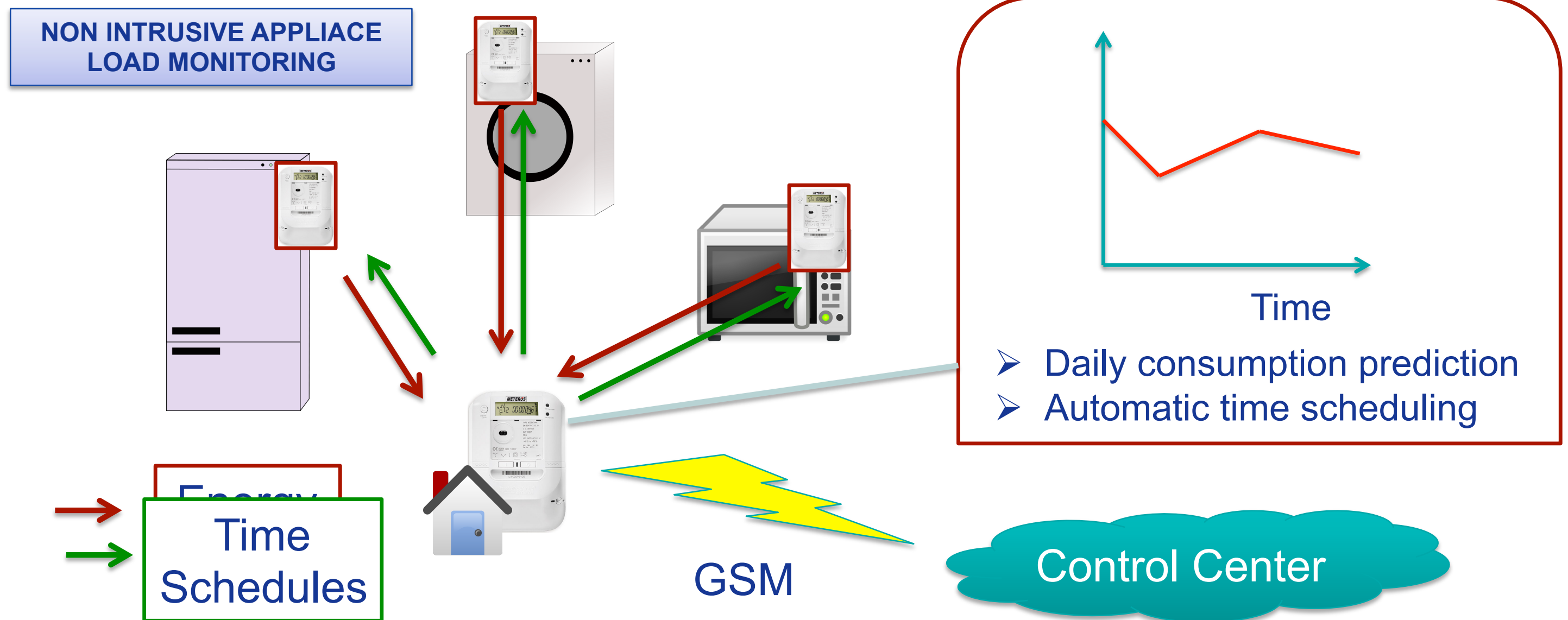
- Objects have **communication** capabilities
- Objects have **storage** capabilities
- Objects have **unique ID**
- Objects can be **addressable** on Internet (URI/IP)





The Internet of Things: Main Concepts

An example of The Internet of Things: Smart meters

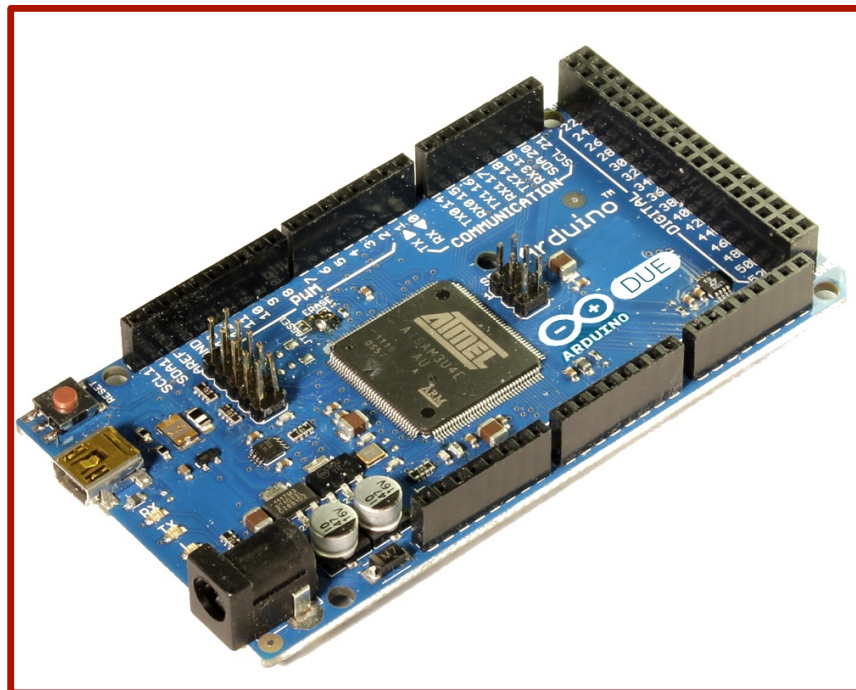




The **Internet of Things**: Main Concepts

Ingredients of the Internet of Things ...

WIRELESS SENSORS



Arduino sensor

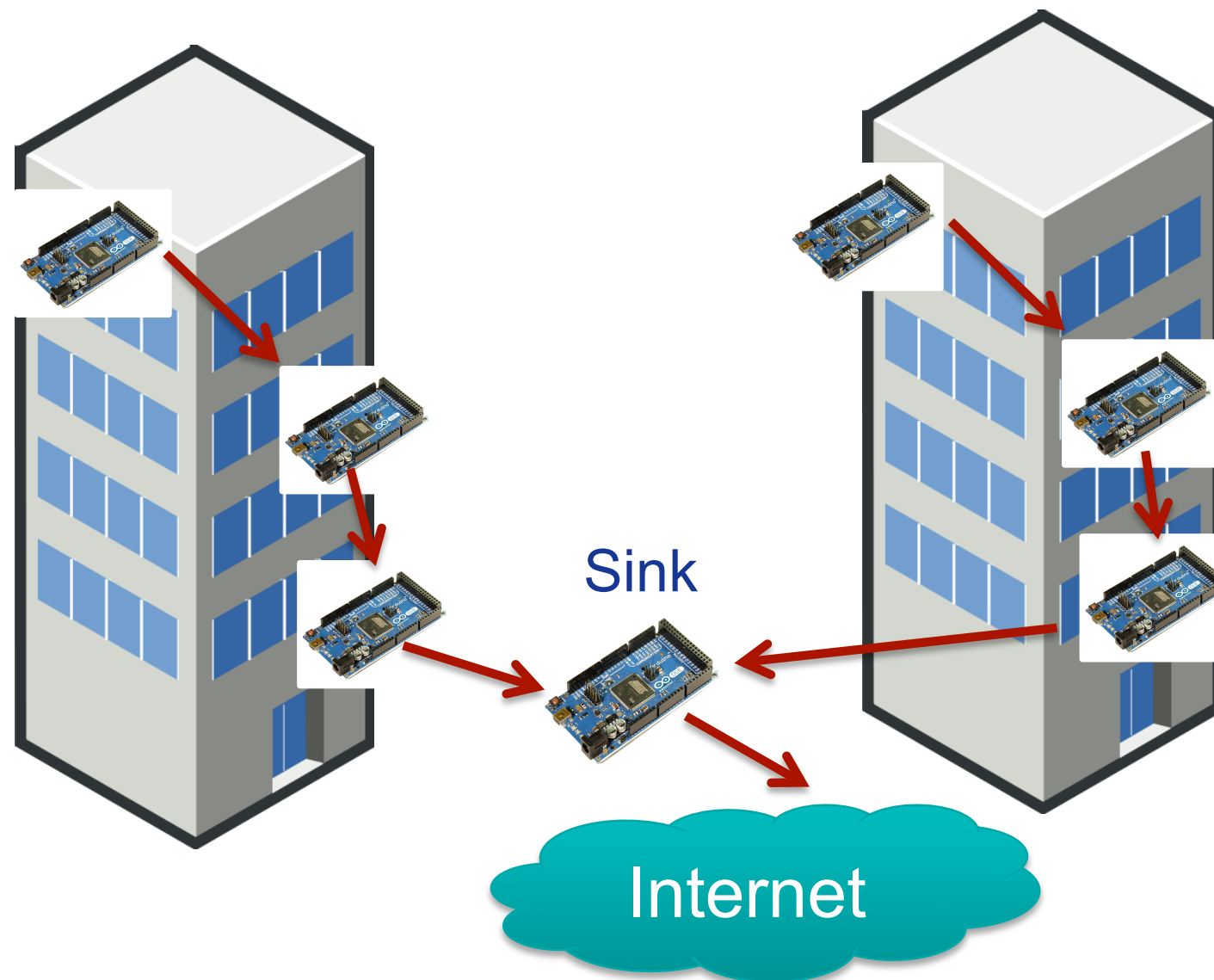
Low-energy computation node, provided with:

- **Computation** unit (CPU)
- **Wireless communication interface** (Zigbee, Bluetooth, WiFi, etc)
- **Environmental Sensing** unit (e.g. CO₂, temperature, humidity, etc)



The **Internet of Things**: Main Concepts

Ingredients of the Internet of Things ...



WIRELESS SENSORS

Sensors can be deployed into multi-hop **networks (WSN)** to cover larger areas.

- **Leaf Nodes**
- **Relay Nodes**
- **Sink Nodes**

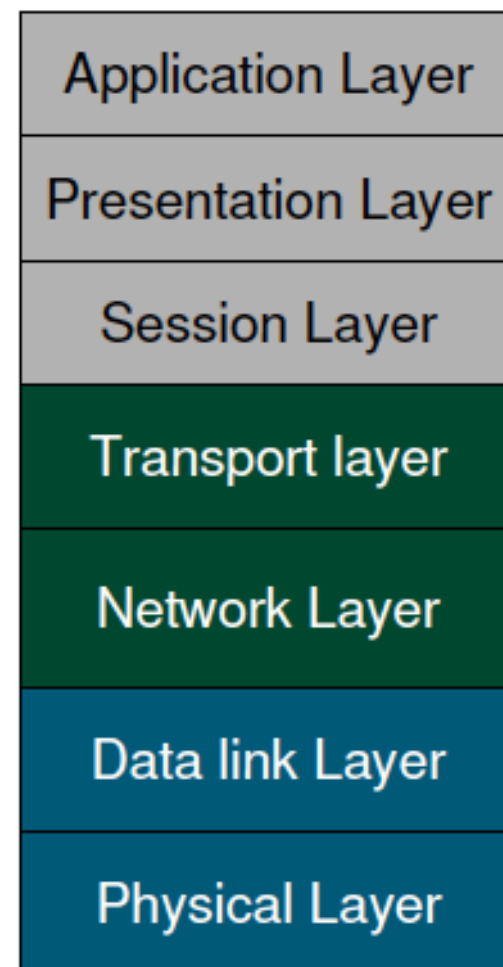


The **Internet of Things**: Main Concepts

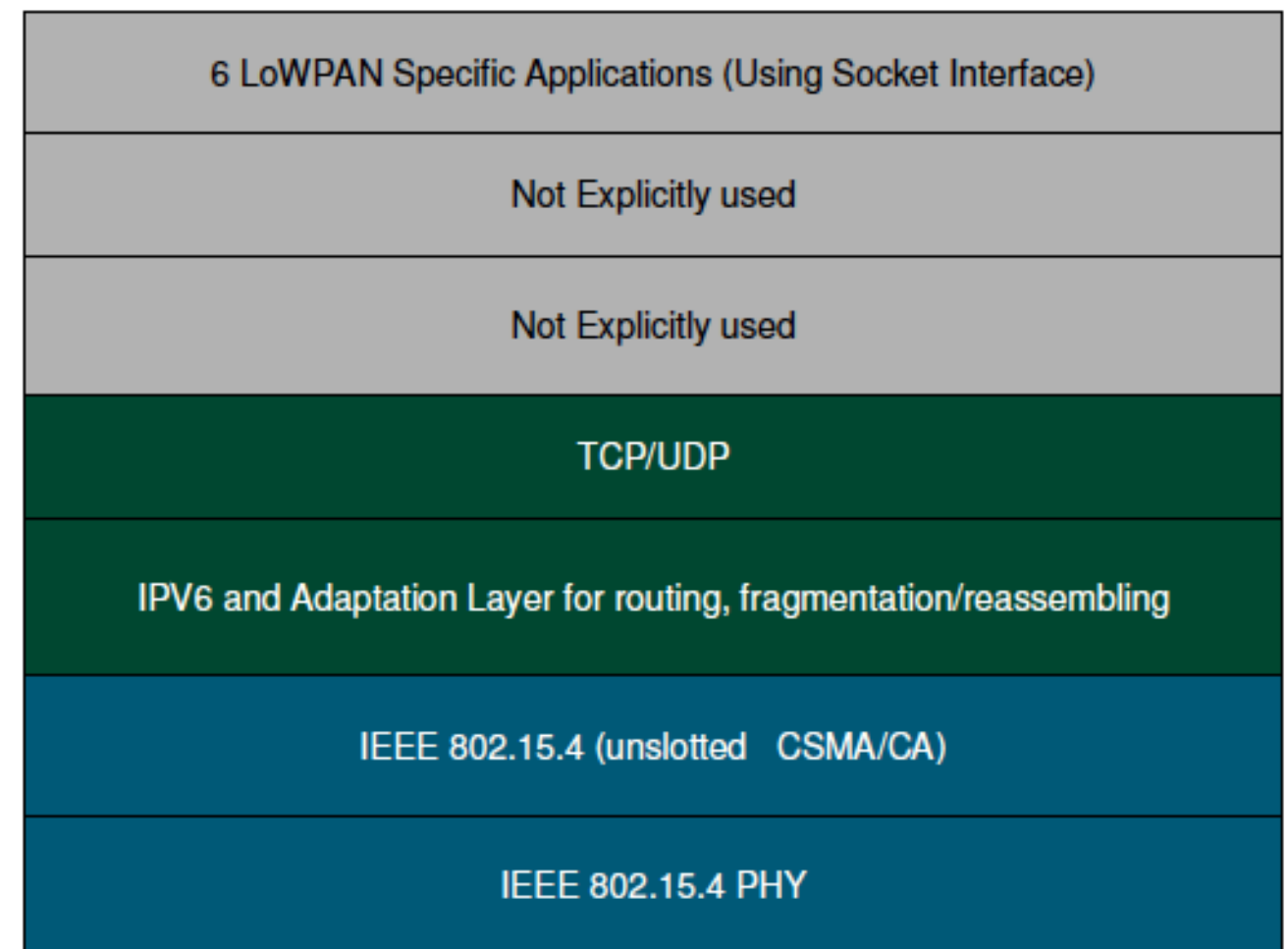
Ingredients of the Internet of Things ...

Network protocol stack for a sensor node ...

ISO/OSI Layer Model



6LoWPAN Stack



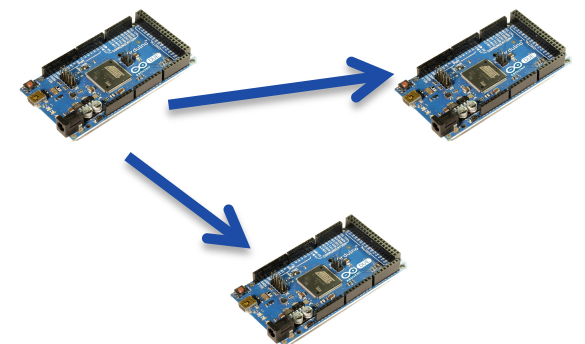


The **Internet of Things**: Main Concepts

Ingredients of the Internet of Things ...

IEEE 802.15.4 Standard

- Defines MAC/PHY functionalities of a sensor node
- Operates in the 2.4 GHz ISM bands, 16 channels available
- Transmission range: up to 75 meter
- Transmission data-rate: up to 250 KB/s
- Optimized for low-energy communication
- Includes duty-cycle mechanisms



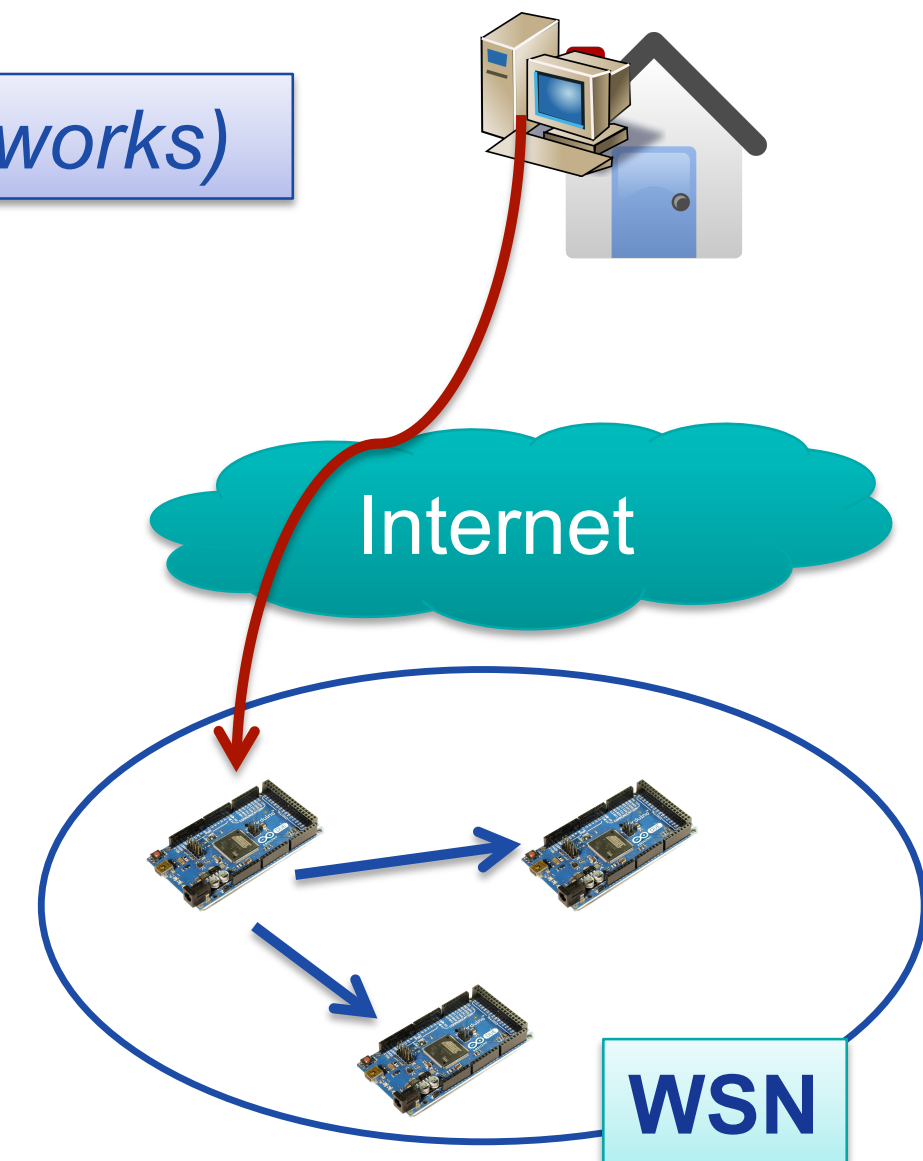


The **Internet of Things**: Main Concepts

Ingredients of the Internet of Things ...

6LoWPAN (*Low power Wireless Personal Area Networks*)

- Network protocol that allows IPv6 packets to be sent to and received from over IEEE 802.15.4 based networks ... In practice, *allows a sensor node to be addressable over the IPv6 Internet.*
- Defines **encapsulation and header compression** mechanisms
- Hides the difference between **IPv6/802.15.4** frame formats.



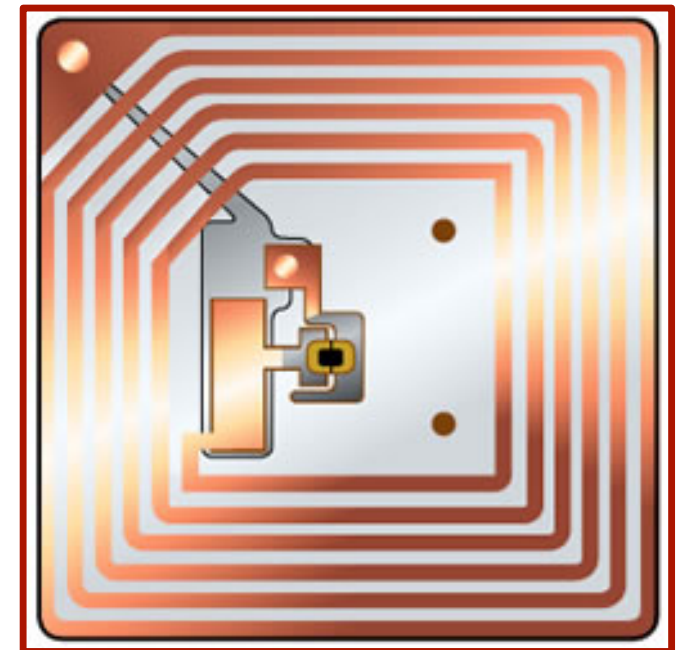


The **Internet of Things**: Main Concepts

Ingredients of the Internet of Things ...

RFID TAGS

- **Contact-less** radio technology
- Tags contain electronically stored information
- Tags can be placed on objects and read by electronic devices
- Short-range communication



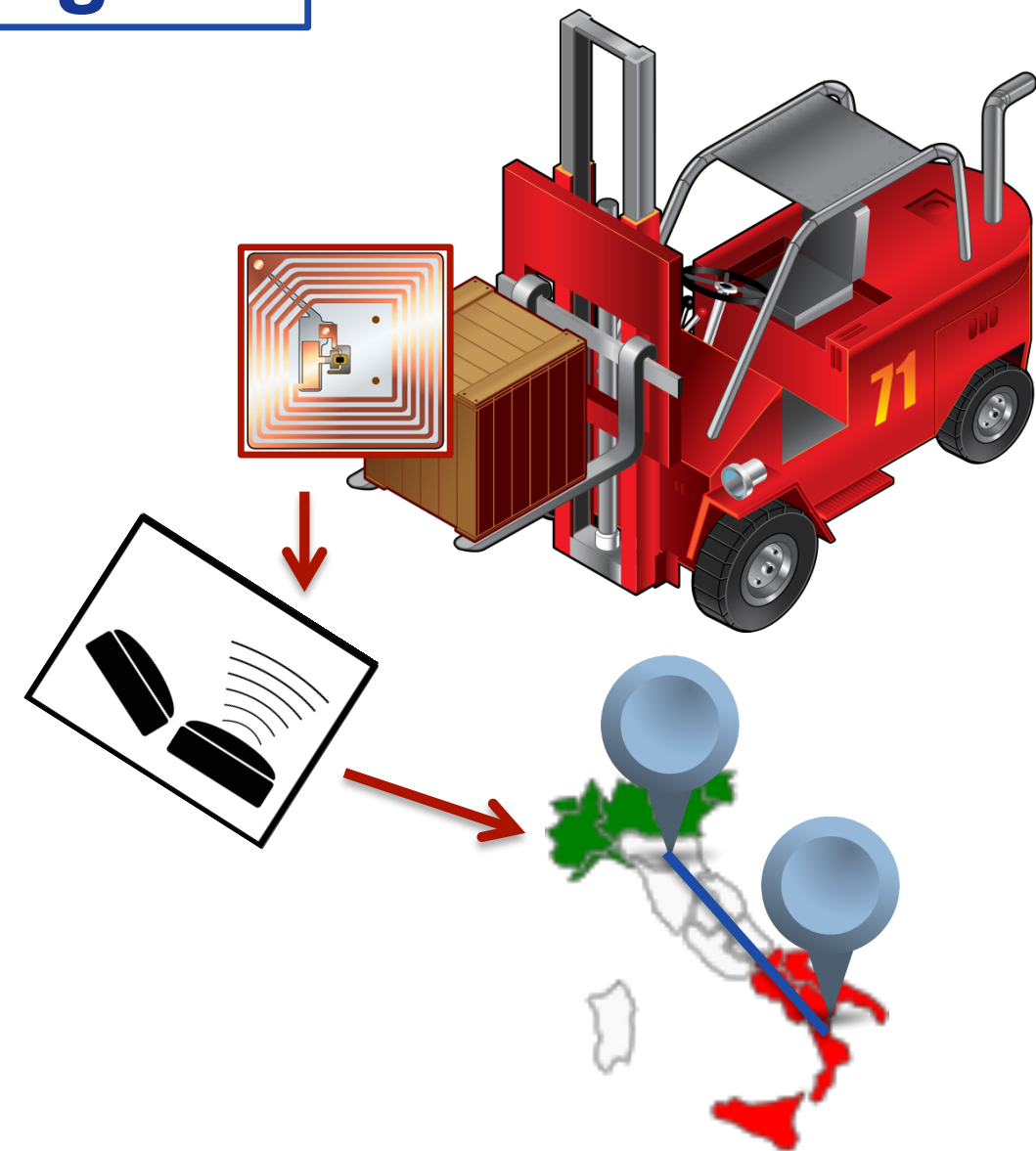


The **Internet of Things**: Main Concepts

Ingredients of the Internet of Things ...

RFID TAGS

- **Track and Locate** Smart objects
- Identify Smart objects
- Tracking of animals
- Smart places implementation
- Indoor navigation
- Transportation systems
- ...





The **Internet of Things**: Main Concepts

- Wireless Sensors exist since 1980 ...
- WSN based on IEEE 802.15.4 exists since 2007 ...
- RFID tags are commonly used since 1973 ...

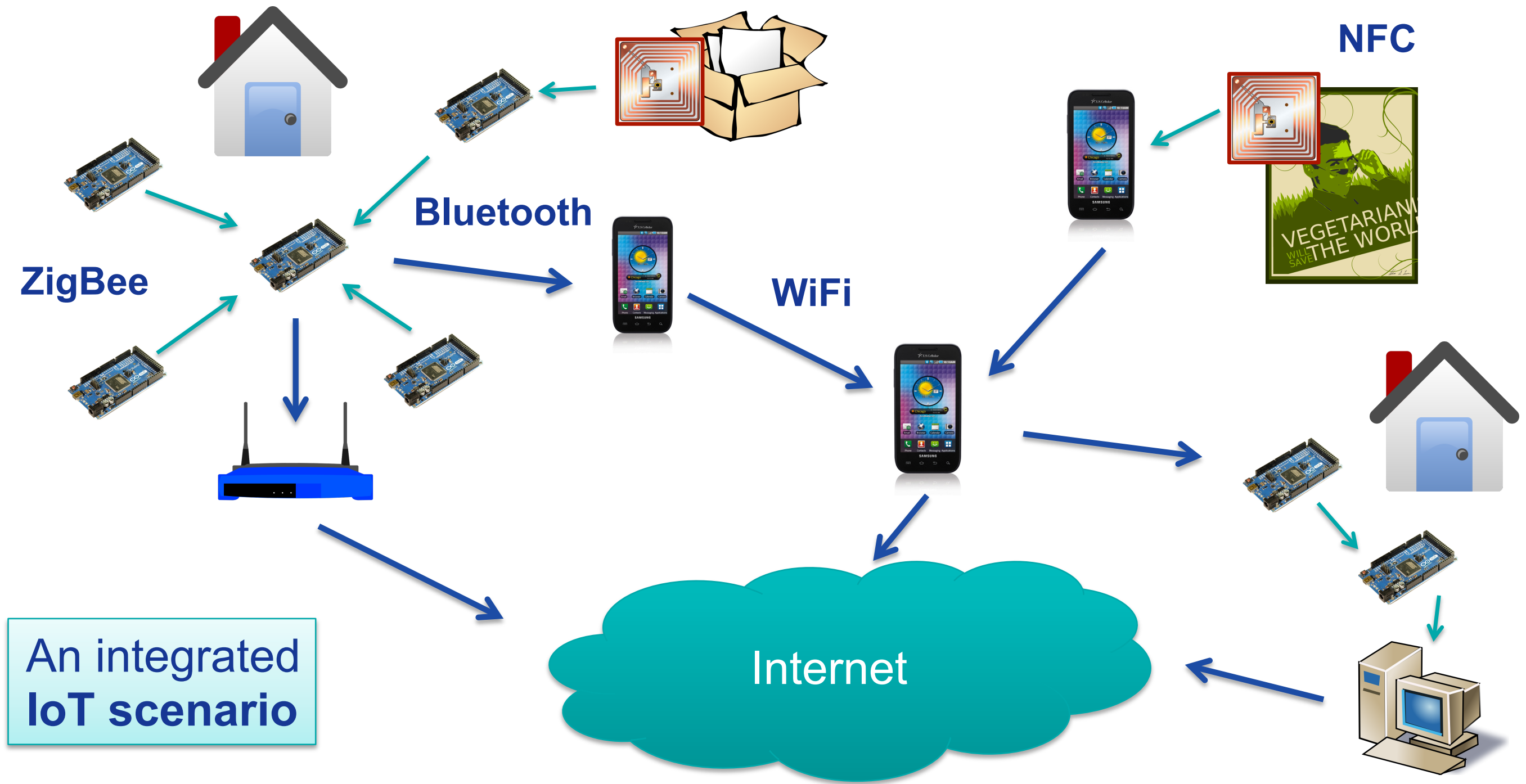
... so **what is new with the Internet of Things paradigm?**

A1. Pervasiveness of Smart Objects

A2. Seamless Integration of Smart Objects with the Internet and with other electronic devices!



The Internet of Things: Main Concepts

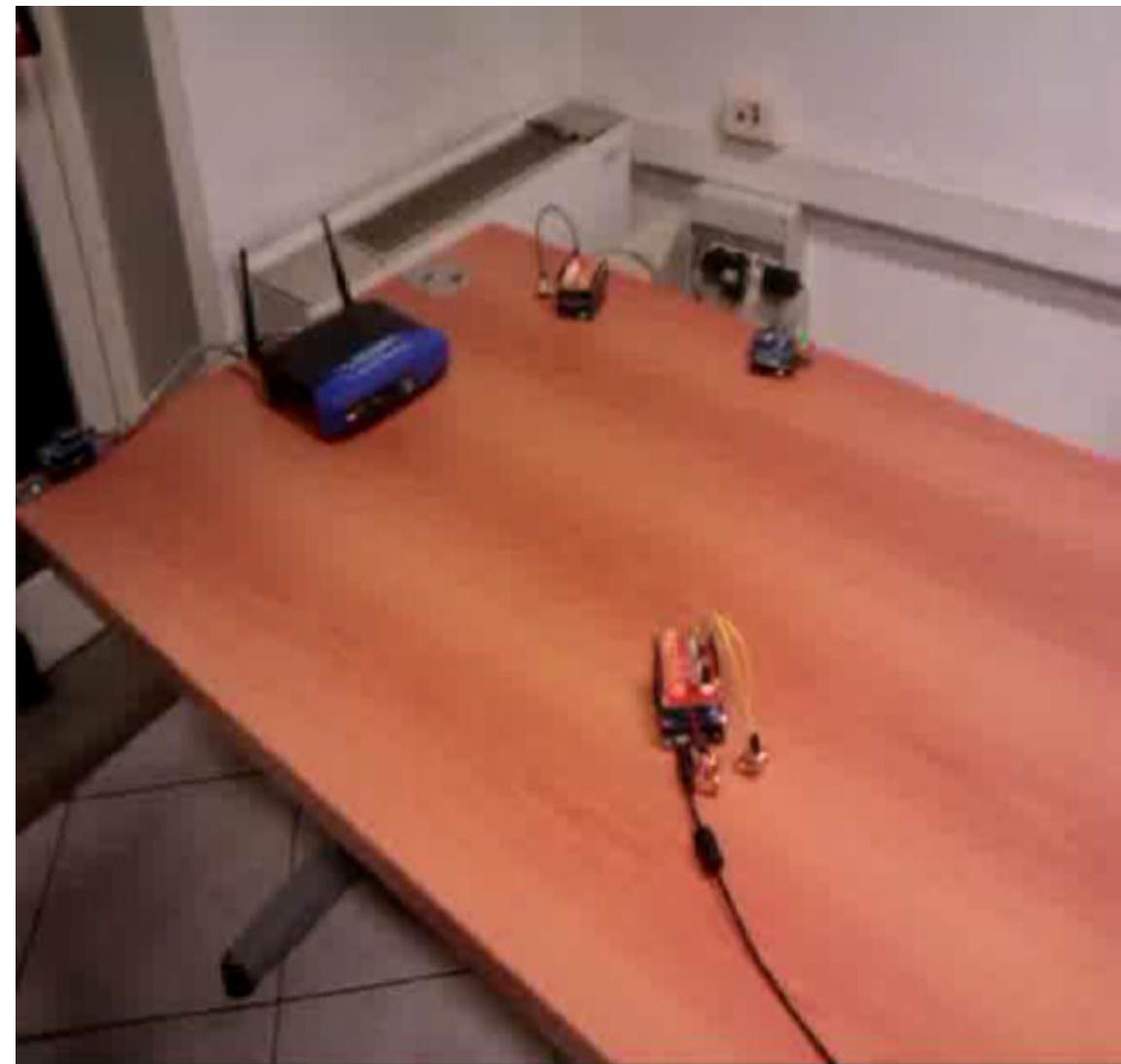




The **Internet of Things**: Main Concepts

Smart Spaces → Ecosystems of Smart Objects

Environments (apartments, offices, museums, hospitals, schools, etc) that are enabled for **co-operation of smart objects** and provide advanced **context-aware functionalities** to the visitors.





The **Internet of Things**: Main Concepts

The Internet of Things: **Application Domains**

http://www.libelium.com/top_50_iot_sensor_applications_ranking/

Waste Management

Eletromagnetic Monitor

Structural Health

Noise Urban Maps



Smart Parking

Smart Roads

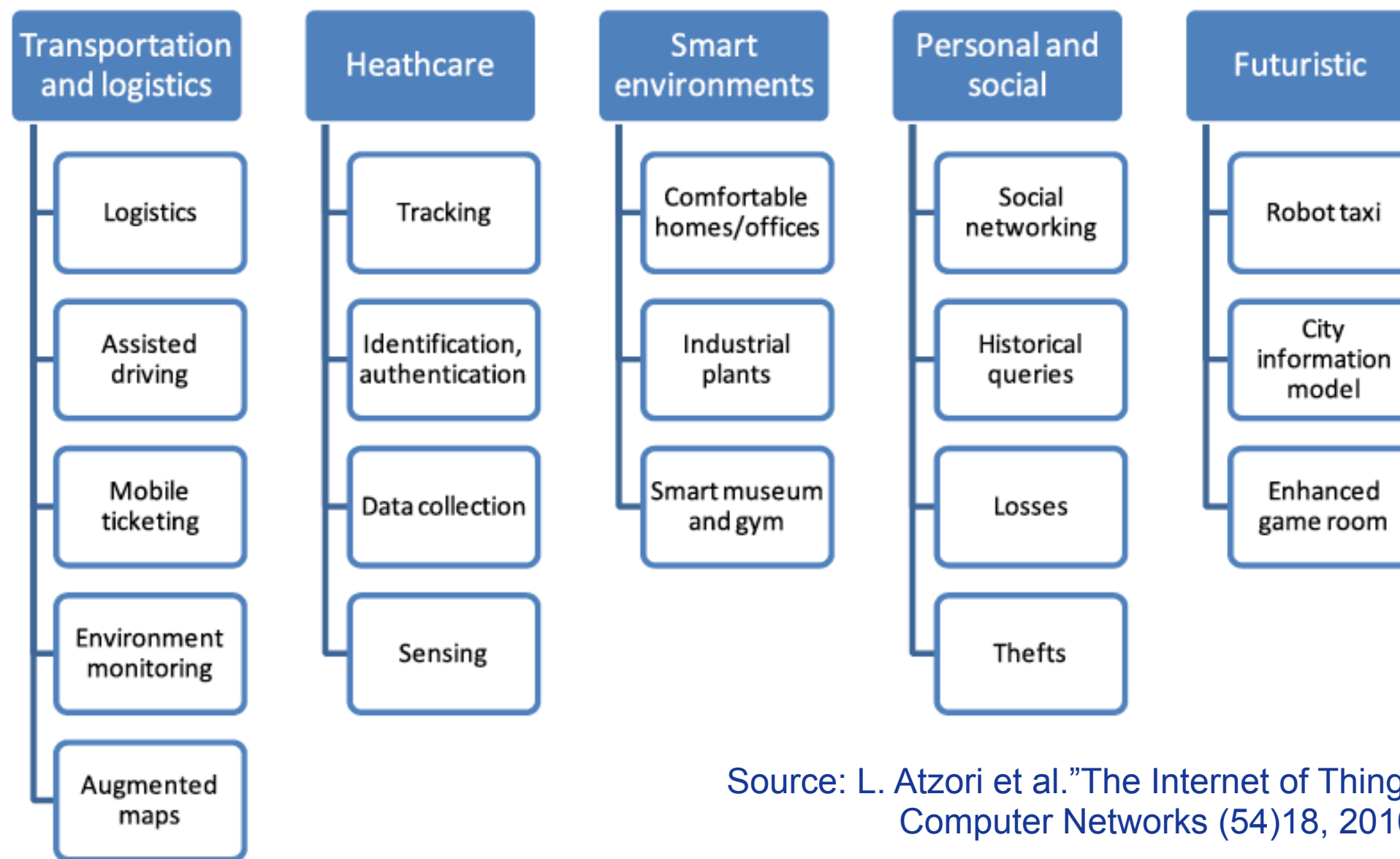
Traffic Congestion

Smart Lightning



The Internet of Things: Main Concepts

The Internet of Things: Application Domains

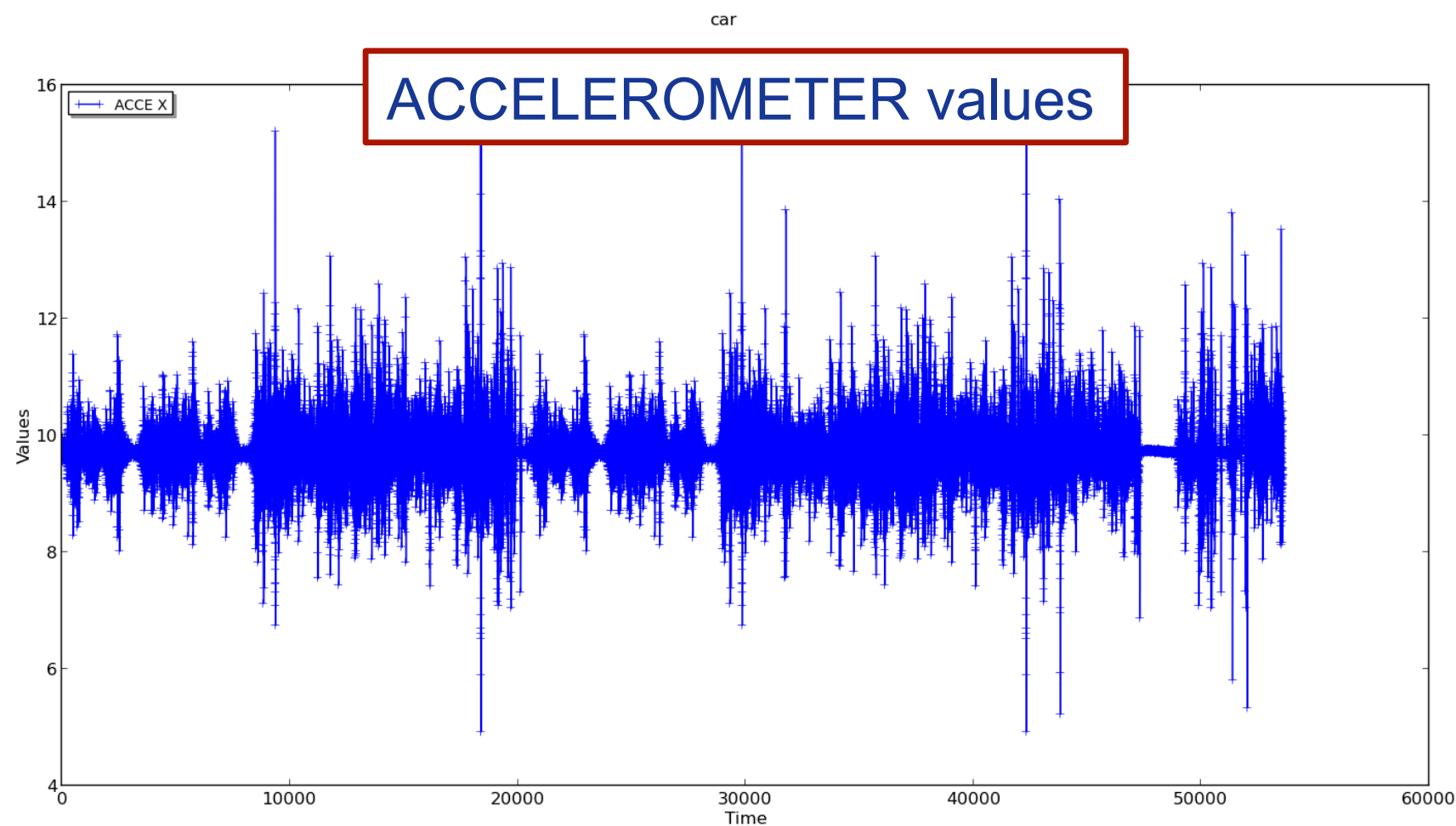


Source: L. Atzori et al. "The Internet of Things: A Survey" Computer Networks (54)18, 2010



The **Internet of Things**: Main Concepts

Smart objects (e.g. sensors, smartphones, etc) can produce **huge amounts of data** that can be shared over the Internet and among devices.



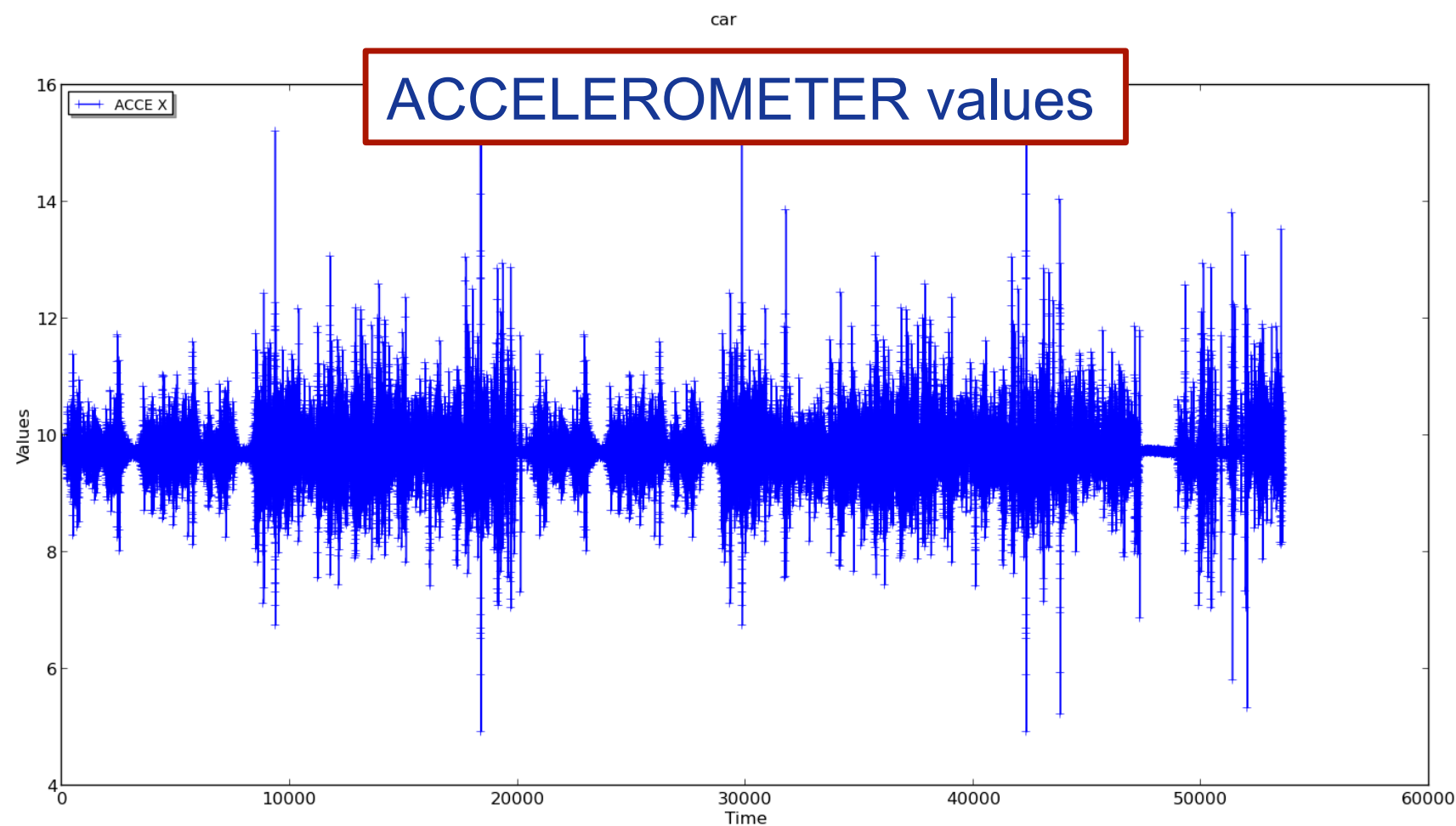
Complex data, but lots of **novel and useful information** can be extracted

L. Bedogni, M. Di Felice, L. Bononi, By Train or By Car? Detecting the User's Motion Type through Smartphone Sensors Data, in Proc. of Wireless Days 2012



The **Internet of Things**: Main Concepts

Smart objects (e.g. sensors, smartphones, etc) can produce huge amounts of data that can be shared over the Internet and among devices.



Good News:
New applications/
services can be
provided over the IoE

Bad News:
How to manage these
BIG DATA?



The **NFC** Technology: an **Overview**

NFC (Near Field Communication)

- 2nd generation of a proximity contact-less technology.
- Designed to *support exchange-data, support peer-to-peer communication and act as a secured smart key.*

1th generation



2nd generation





The **NFC** Technology: an **Overview**

NFC: Wireless characteristics

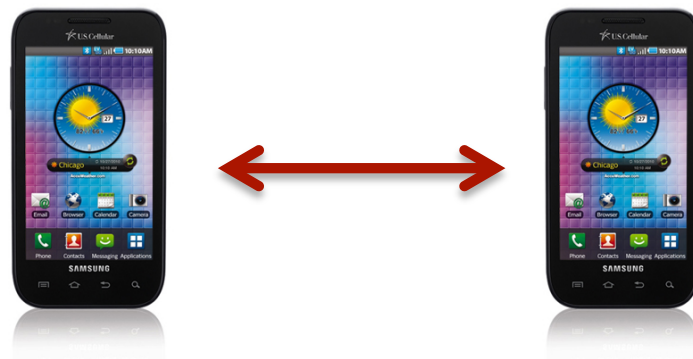
- Based on RFID technology at **13,56 MHz**
- Data rates range between **100 Kb/s** and **424 Kb/s**
- Theoretical working distance: up to **20 cm** (practically 5 cm)
- Full duplex devices: transmit and receive at the same time
- Fast setup time: **< 0.1s**
- Power consumptions: **< 15 mA** (read)
- Standards: ISO18092 and ISO21481



The **NFC** Technology: an **Overview**

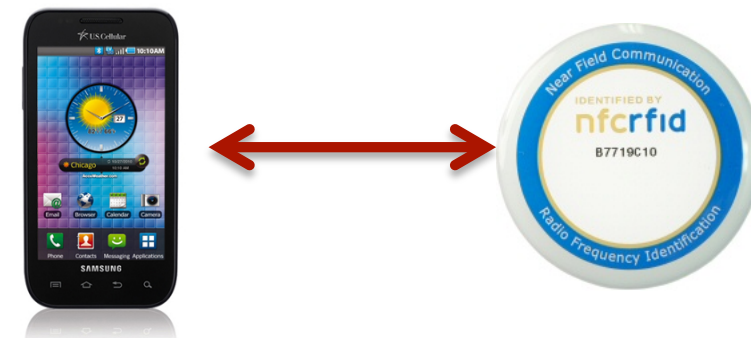
NFC: Two communication modes.

Active Mode



Both devices generate RF.

Passive Mode



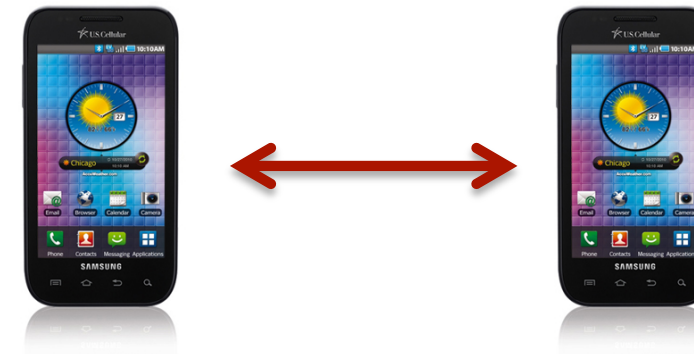
NFC TAG

Only the initiator device generate RF.



The **NFC** Technology: an **Overview**

NFC Active Communication Mode



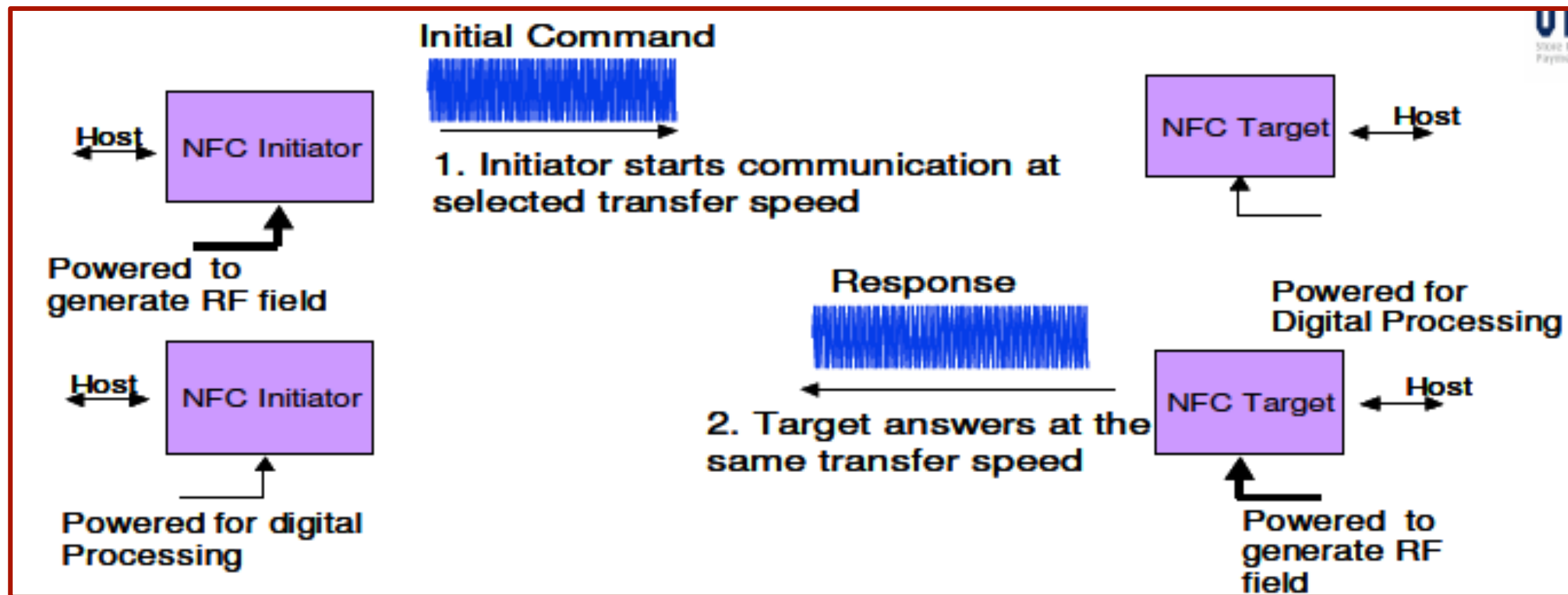
Feature	NFC	Bluetooth
Network Standard	ISO 13157	IEEE 802.15.1
Standardization	ISO/IEC	Bluetooth SIG
Range	< 0.2 meter	< 75 meter
Frequency	13,56 MHz	2.4 GHz
Bit Rate	Up to 424 Kb/s	1 Mb/s
Set-up Time	< 0.1 sec	< 5 sec
Network type	Point-to-point	WLAN
Power consumption	< 15 mA (read)	varying



The **NFC** Technology: an **Overview**

Question: HOW does NFC work?

Answer: Through magnetic induction!





The **NFC** Technology: an **Overview**

Question: HOW does NFC work?

1. The reader emits a *small electric current*, which creates a **magnetic field** that in turn bridges the physical space between the devices.
2. The field is received by a similar coil in the client device, where it is turned back into electrical impulses.
3. 'Passive' NFC tags use the energy from the reader to encode their response.



The **NFC** Technology: an **Overview**

NFC Passive Communication Mode



NFC TAG

- Tag **size**: 96 - 4096 Bytes of memory
- Data transfer speed: 106, 212, 424 or 848Kb/s
- NFC Data Exchange Format (**NDEF**) protocol
- **NDEF record types**:
 - ❑ Smart Poster, Text, URI, Signature, Generic Control, etc



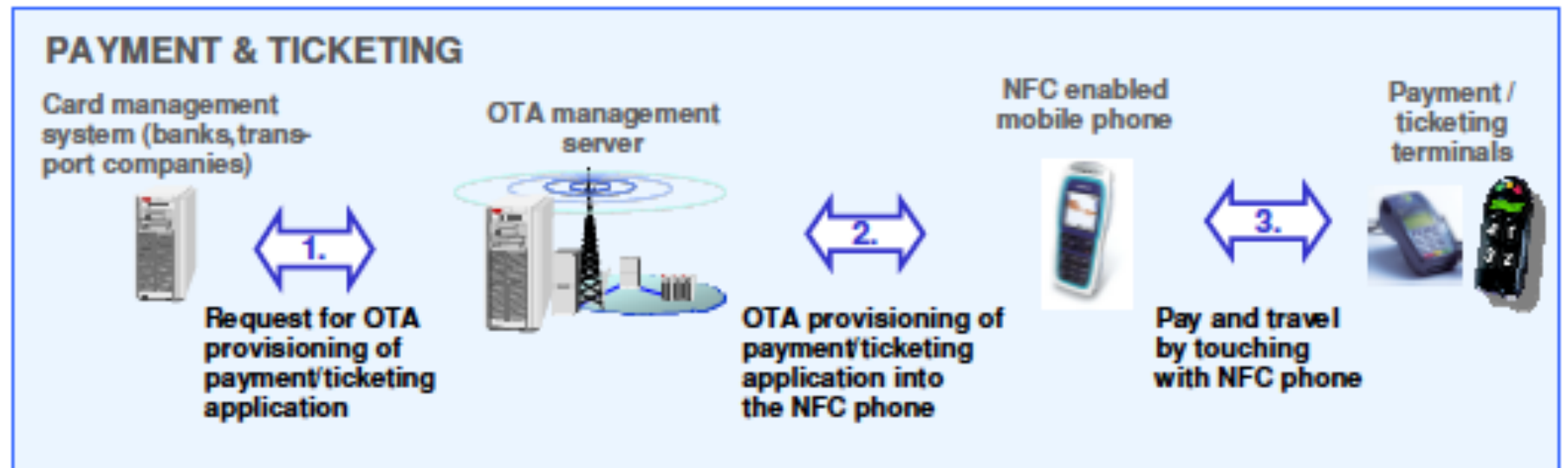
The **NFC** Technology: an **Overview**

NFC: Application Scenarios.



Payment & Ticketing

Payment & Ticketing



PAY TICKET



PAY with CREDIT CARD





The **NFC** Technology: an **Overview**

NFC: Application Scenarios.



NFC Ticketing trails in Europe:

- London (December 2012)
- Malaga (March 2013)
- Strasbourg (April 2013)
- ...

In Italy:

- Mobile wallets trials (2013)



The **NFC** Technology: an **Overview**

NFC: Application Scenarios.



Service Initiation



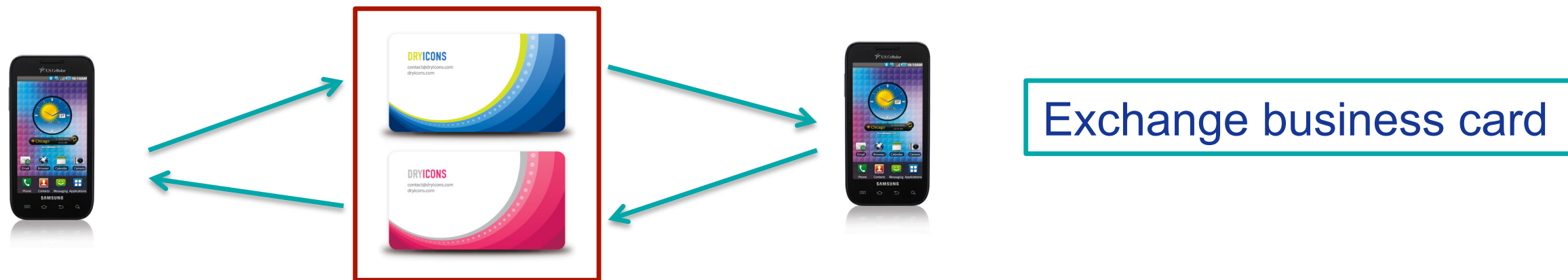
SMART POSTERS

- Contains URL with additional information



The **NFC** Technology: an **Overview**

NFC: Application Scenarios.





The **NFC** Technology: an **Overview**

NFC Data Exchange Format (NDEF)

Standard produced by the NFC Forum which defines:

- *Message format* and types
- *Encapsulation* methods
- *Transmission sequence* procedures
- ...

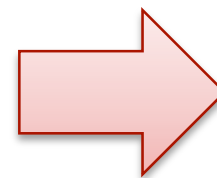


The **NFC** Technology: an **Overview**

NFC Data Exchange Format (NDEF)



Each NFC Tag
Contains 1 or more
NedfMessage



NdefMessage1
NdefMessage2
...
NdefMessageN

NdefMessage is
composed of:
a **header** and of
a **payload**



NdefRecord

PayLoad



The **NFC** Technology: an **Overview**

NFC Data Exchange Format (NDEF)

Each header (called **NdefRecord**) is composed of 3 fields:

TNF (Type Name Format) → described how to interpret the following fields

Variable Length Type → Type of the record

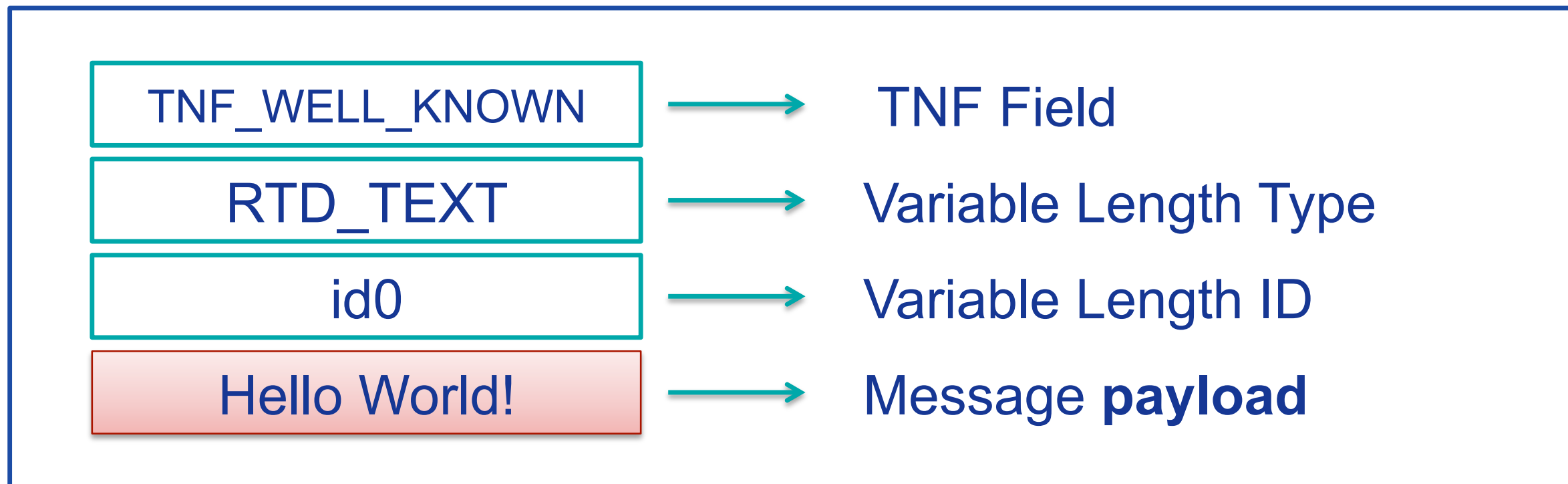
Variable Length ID → Unique identifier of the record



The **NFC** Technology: an **Overview**

NFC Data Exchange Format (NDEF)

NdefMessage example





The **NFC** Technology: an **Overview**

NFC Data Exchange Format (NDEF)

TNF types

- TNF_ABSOLUTE_URI
- TNF_EMPTY
- TNF_EXTERNAL_TYPE
- TNF_MIME_TYPE
- TNF_UNCHANGED
- TNF_UNKNOWN
- **TNF_WELL_KNOWN**

- RTD_SMART_POSTER
- RTD_TEXT
- RTD_URI
- RTD_ALTERNATIVE_CARRIER
- RTD_HANDBOVER_CARRIER
- RTD_HANDBOVER_REQUEST
- RTD_HANDBOVER_SELECT



The **NFC** Technology meets **Android**

Several **Android** smartphones (starting from Nexus-S) includes **NFC** readers ...

NFC APIs available from Android 2.3.3 and allows developers to include **NFC capabilities to their applications:**

- Read/Write NDEF data from and an **NFC tag**
- Send/receive NDEF data to/from another NFC Android device through **the Android Beam technology**



The **NFC** Technology meets **Android**

Problem: devices scan NFC at a very short range, so making the users manually select the Activity to launch might be not practical, since the users might be forced to move the device away from the tag.

Solution: Android provides a **Tag Dispatch System**, that attempts to automatize as much as possible the **tag detection and the activity selection** processes ...



The **NFC** Technology meets **Android**

Action of the Tag Dispatch System

- 1. Parse** the TAG and identify the MIME type of the payload of the tag (e.g. URI? Text?)
- 2. Encapsulate** the MIME and the payload into an Intent object.
- 3. Starts** the most suitable Activity that can match the Intent (through the Intent Filter mechanism defined so far).



The **NFC** Technology meets **Android**

Three **types of Intents**, based on TAG detected:

- **ACTION_NDEF_DISCOVERED**: Tag containing an NDEF payload is detected, and is of a recognized type
- **ACTION_TECH_DISCOVERED**: Tag does not contain an NDEF but it is of a known tag technology
- **ACTION_TAG_DISCOVERED**: default cases if none of the previous ones can be applied.



The **NFC** Technology meets **Android**

Set the NFC permissions on the **Manifest.xml** file

```
<uses-permission  
    android:name="android.permission.NFC">
```

Require the **NFC hardware** for the mobile devices

```
<uses-feature  
    android:name="android.hardware.nfc"  
    android:required="true">
```



The **NFC** Technology meets **Android**

Filter the NFC intents to be notified once the device finds a compatible NFC tag ...

```
<intent-filter>  
  
<action  
android:name="android.nfc.action.NDEF_DISCOVERED />  
<category  
android:name="android.intent.category.DEFAULT />  
<data android:mimeType="text/plain">  
  
</intent-filter/>
```



The **NFC** Technology meets **Android**

Each Intent contains information about the scanned NFC tag:

- **EXTRA_TAG:** A **Tag** object representing the scanned NFC Tag.
- **EXTRA_NDEF_MESSAGE:** An array of NDEF Message parsed from the NFC Tag

Access these fields to read the TAG payload ...



The **NFC** Technology meets **Android**

```
public void onResume() {
    super.onResume();
    ...
    if
(NfcAdapter.ACTION_NDEF_DISCOVERED.equals(getIntent().getAction()
)) {
        Parcelable[] rawMsgs =
intent.getParcelableArrayExtra(NfcAdapter.EXTRA_NDEF_MESSAGES);
        if (rawMsgs != null) {
            msgs = new NdefMessage[rawMsgs.length];
            for (int i = 0; i < rawMsgs.length; i++) {
                msgs[i] = (NdefMessage) rawMsgs[i];
                String s= new String(msgs[i].getRecords()
[0].getPayload());
            }
        }
    }
}
```



The **NFC** Technology meets **Android**

In order to write on a NFC Tag, first **create the NDEF message/record** containing the requested data ...

TNF_ABSOLUTE_URI

```
NdefRecord uriRecord = new NdefRecord(  
    NdefRecord.TNF_ABSOLUTE_URI ,  
    "http://developer.android.com/  
index.html".getBytes(Charset.forName("US-  
ASCII")),  
    new byte[0], new byte[0]);
```



The **NFC** Technology meets **Android**

In order to write on a NFC Tag, first **create the NDEF message/record** containing the requested data ...

TNF_WELL_KNOWN with RTD_TEXT

```
byte[] data;  
// Convert the string into a byte array  
...  
NdefRecord record = new  
NdefRecord(NdefRecord.TNF_WELL_KNOWN,  
           NdefRecord.RTD_TEXT, new byte[0], data);
```



The **NFC** Technology meets **Android**

The **Ndef** class provides access to the operations on the NFC TAG discovered by the device.

```
NdefMessage message;  
// Fill the Ndef Message  
... ..  
Ndef ndef = Ndef.get(tag);  
    ndef.connect();  
    ndef.writeNdefMessage(message);  
    ndef.close();
```




The **NFC** Technology meets **Android**

Android Beam technology allows simple peer-to-peer data exchange among two NFC-equipped devices.

- **setNdefPushMessage(NdefMessage)** → sends a NdefMessage to the other device
- **setNdefPushMessageCallback(callback)** → accepts a callback that is called when a device is in range to beam data to. Create NDEF message only when needed.