# Designing and Building for End-to-End Solutions

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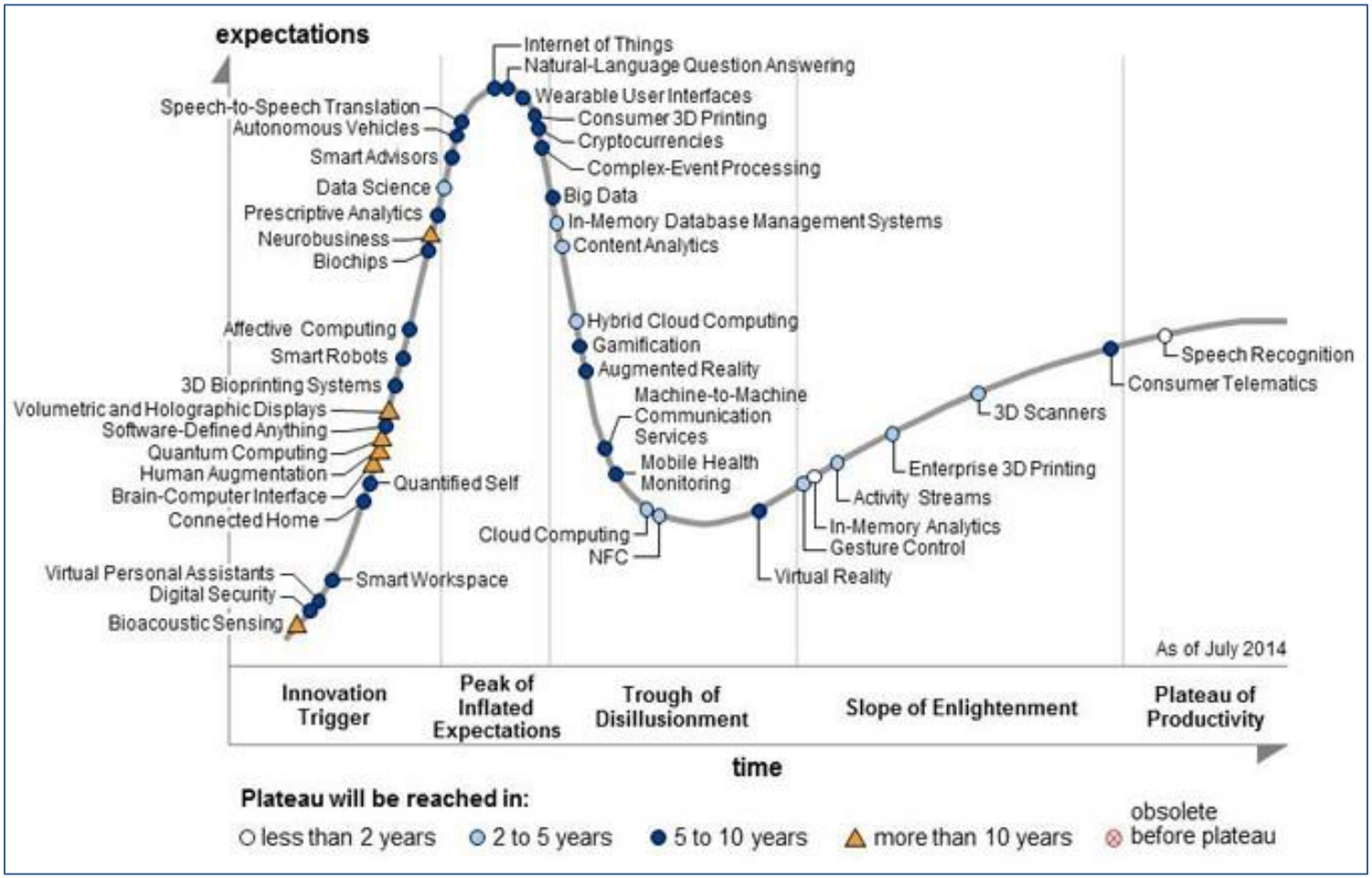
# Introduction
# to
# Internet of Things (IoT)

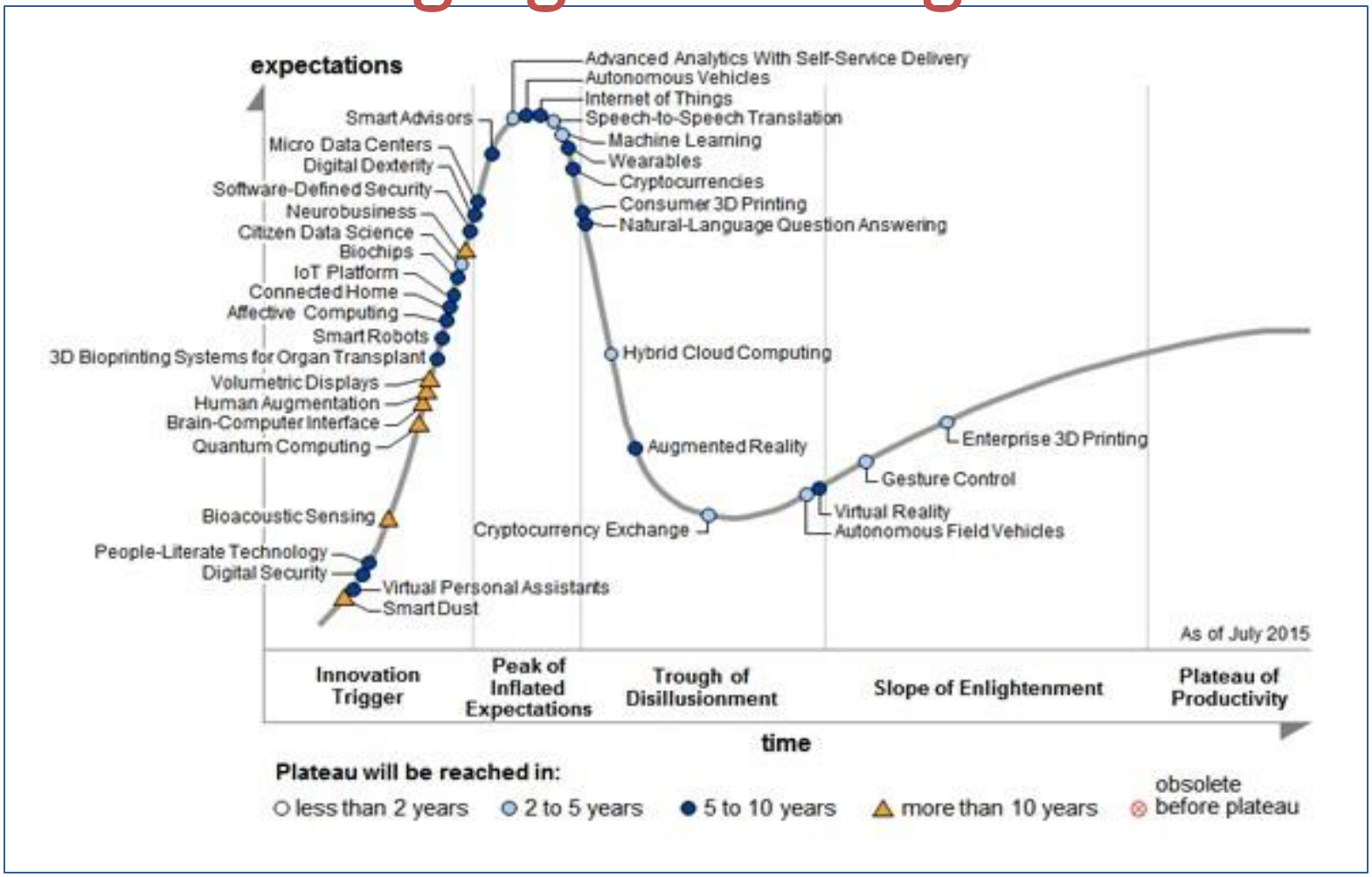
# Definition from IEEE

The Internet of Things (IoT) is a self- configuring and adaptive system consisting of networks of sensors and smart objectswhose purpose is to interconnect “all” things, including everyday and industrial objects, in such a way as to make them intelligent, programmable and more capable of interacting with humans.

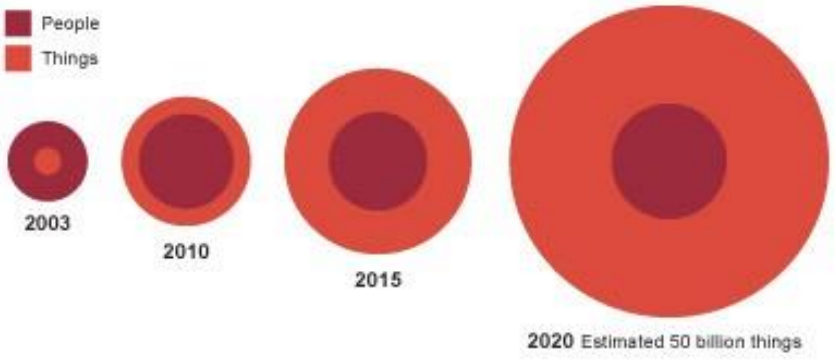
# Gartner Hype Cycle for Emerging Technologies 2014

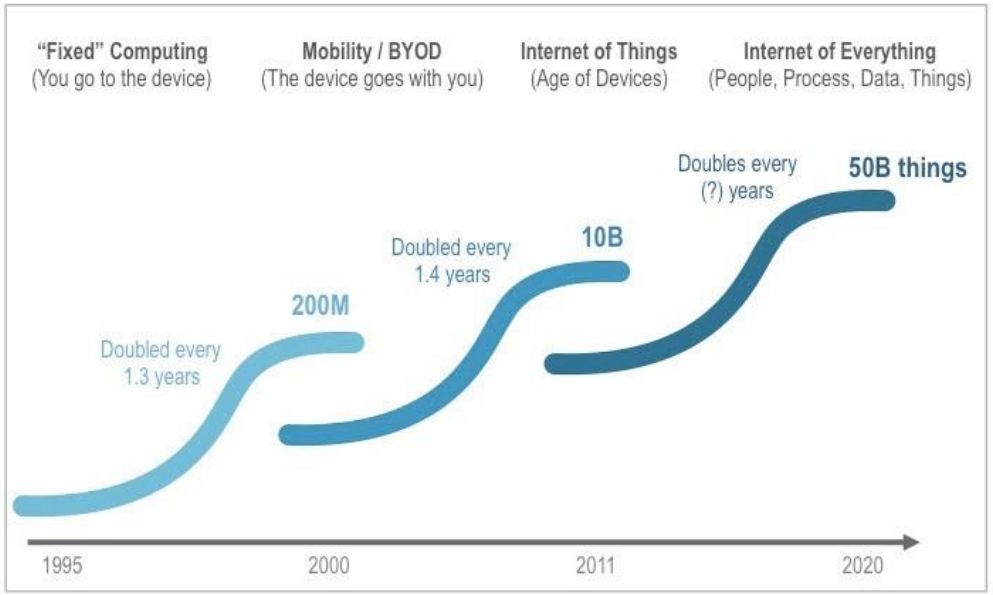


# Gartner Hype Cycle for Emerging Technologies 2015



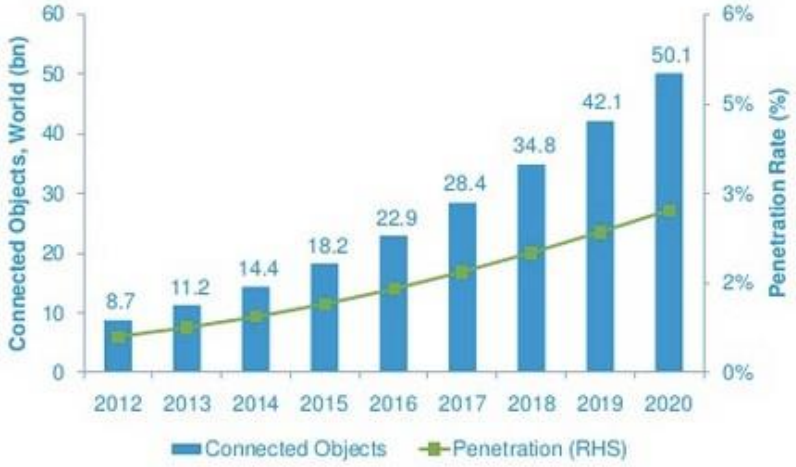
# THE INTERNET OF THINGS



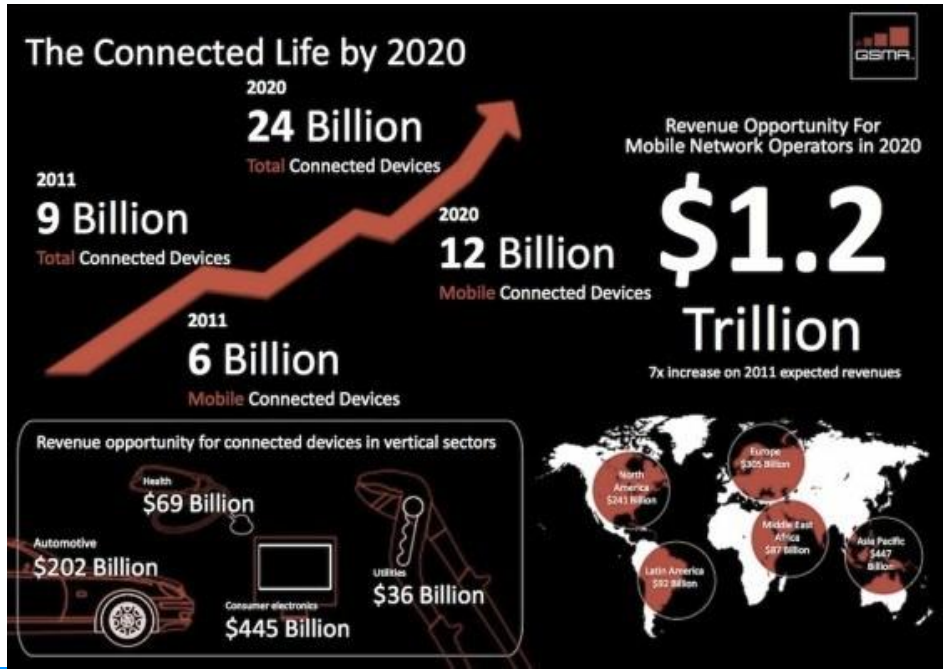

During 2008, the number of things connected to the internet exceeded the number of people on Earth.

# Number of Connected Objects Expected to Reach 50bn by 2020




**Penetration of connected objects in total 'things' expected to reach 2.7% in 2020 from 0.6% in 2012**

Source: CCS, 2013



A BRIEF HISTORY OF THE INTERNET OF THINGS

## 1969
### The Internet Emerges

The first nodes of what would eventually become known as ARPANET, the precursor to today's Internet, are established at UCLA and Stanford universities.

Baseline

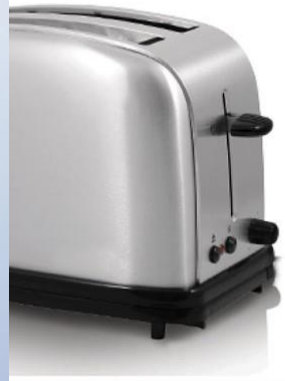
A BRIEF HISTORY OF THE INTERNET OF THINGS

## 1982
### TCP/IP Takes Shape

Internet Protocol (TCP/IP) becomes a standard, ushering in a worldwide network of fully interconnected networks called the Internet.

Baseline

A BRIEF HISTORY OF THE INTERNET OF THINGS



## 1990
### A Thing Is Born

John Romkey and Simon Hackett create the world's first connected device (other than a computer): a toaster powered through the Internet.

Baseline

A BRIEF HISTORY OF THE INTERNET OF THINGS

IoT

## 1999
### The IoT Gets a Name

Kevin Ashton coins the term "Internet of things" and establishes MIT's Auto-ID Center, a global research network of academic laboratories focused on RFID and the IoT.

Baseline

A BRIEF HISTORY OF THE INTERNET OF THINGS

## 2005
### Getting Global Attention

The United Nations first mentions IoT in an International Telecommunications Union report. Three years later, the first international IoT conference takes place in Zurich.

Baseline

A BRIEF HISTORY OF THE INTERNET OF THINGS

IPSO Alliance

## 2008
### Connections Count

The IPSO Alliance is formed to promote IP connections across networks of "smart objects." The alliance now boasts more than 50 member firms.

Baseline

A BRIEF HISTORY OF THE INTERNET OF THINGS

http://www
http://www
http://www
http://www
http://www

## 2011
### IPV6 Launches

The protocol expands the number of objects that can connect to the Internet by introducing 340 undecillion IP addresses (2128).

Baseline

A BRIEF HISTORY OF THE INTERNET OF THINGS

## 2013
### Google Raises the Glass

Google Glass, controlled through voice recognition software and a touchpad built into the device, is released to developers.

Baseline

A BRIEF HISTORY OF THE INTERNET OF THINGS

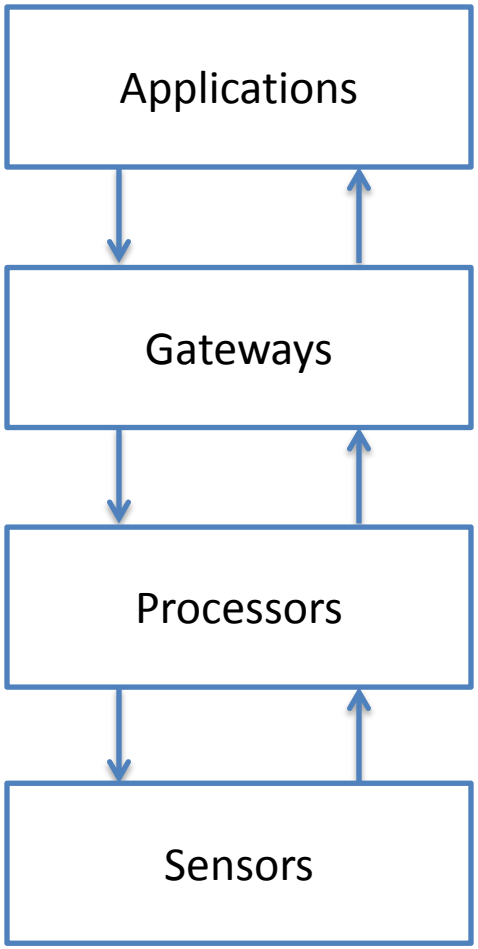
## 2014
### Apple Takes a Bite

Apple announces HealthKit and HomeKit, two health and home automation developments. The firm's iBeacon advances context and geolocation services.

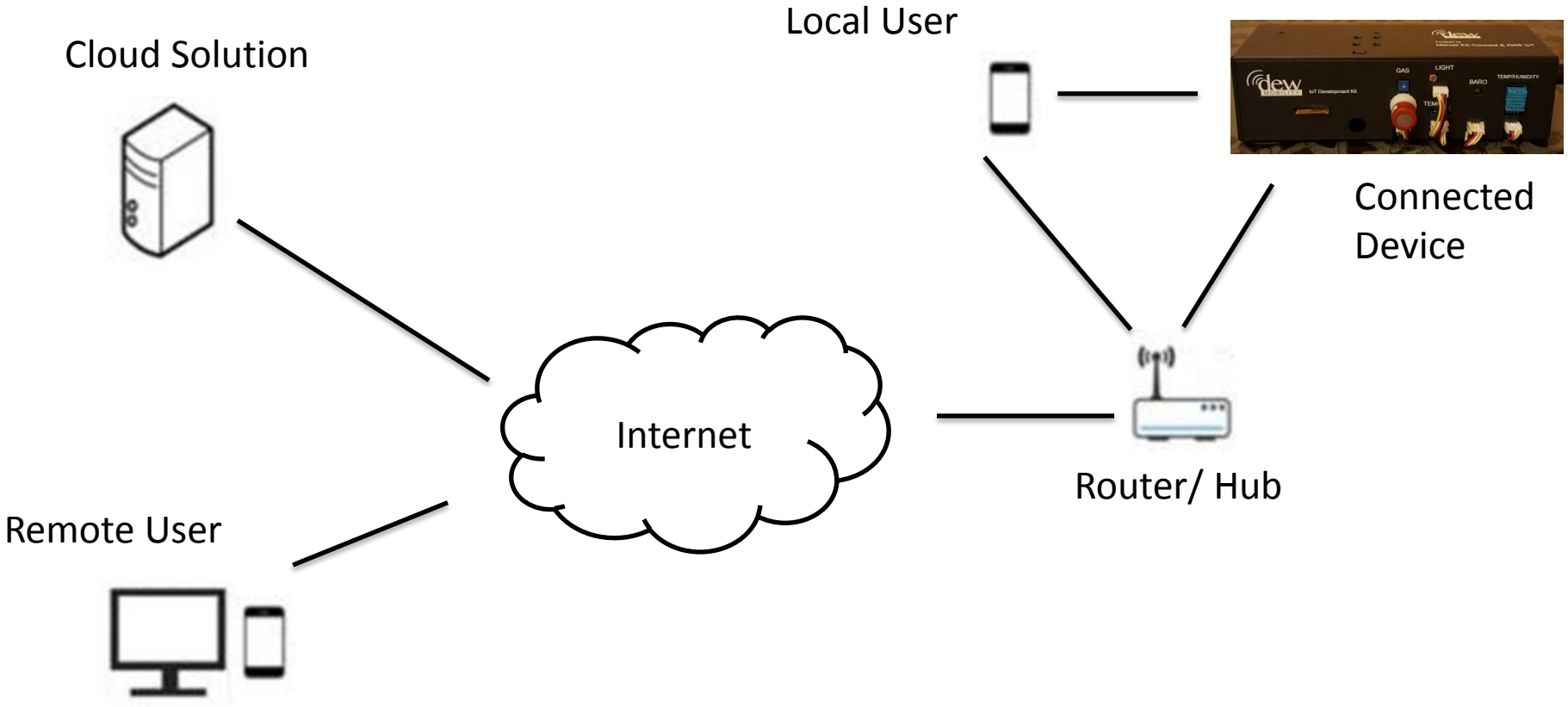
Baseline

# Architecture Block diagram

# Architecture Diagram - IoT



# Architecture Diagram - IoT



# Protocols

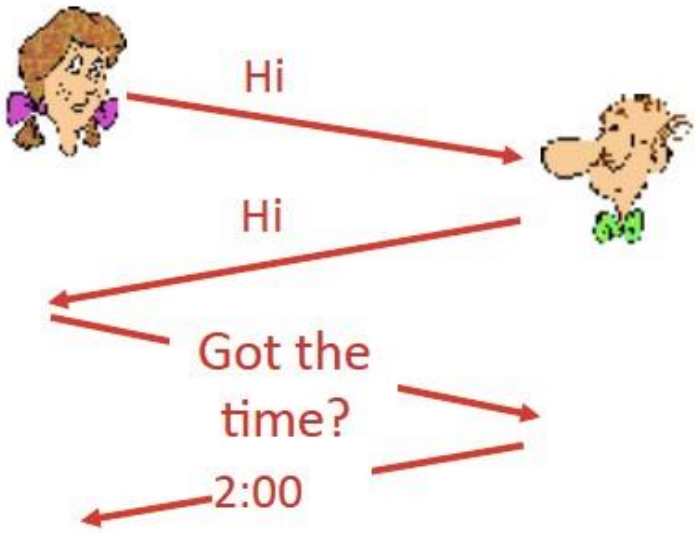
# Protocol

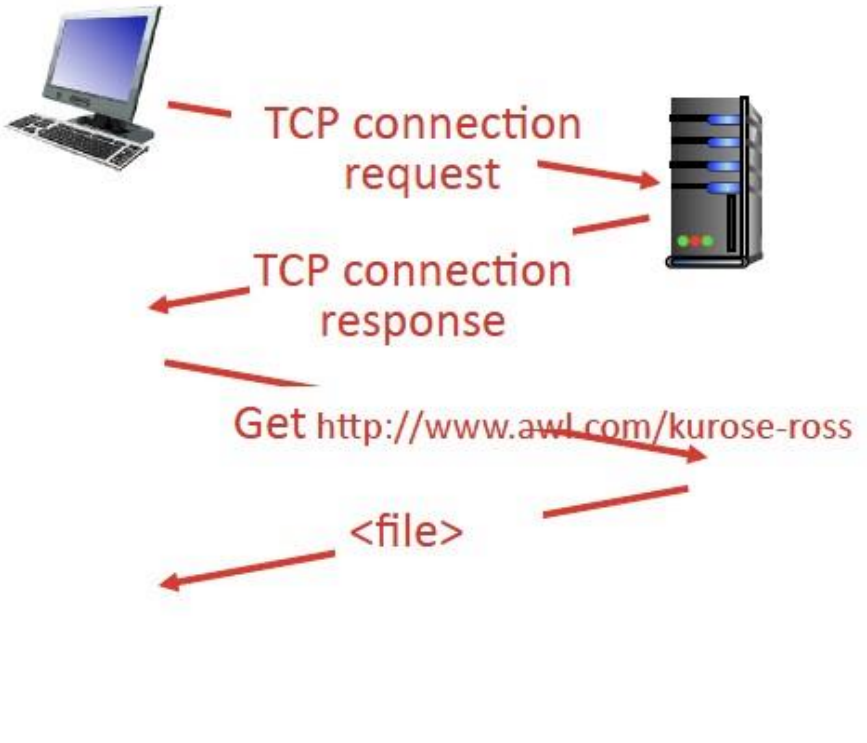
Protocols define format, order of messages sent and received among network entities,
and actions taken on message transmission and/or receipt

# What is a Protocol ?

- Human Protocols:
  - What is the time?
  - I have a question
  - Introductions
- Characterized by:
  - Specific Message sent
  - Specific Actions taken when messages received or on events
- Network Protocols:
  - Machines rather than Humans
  - All Communication Activity between Computers is governed by protocols

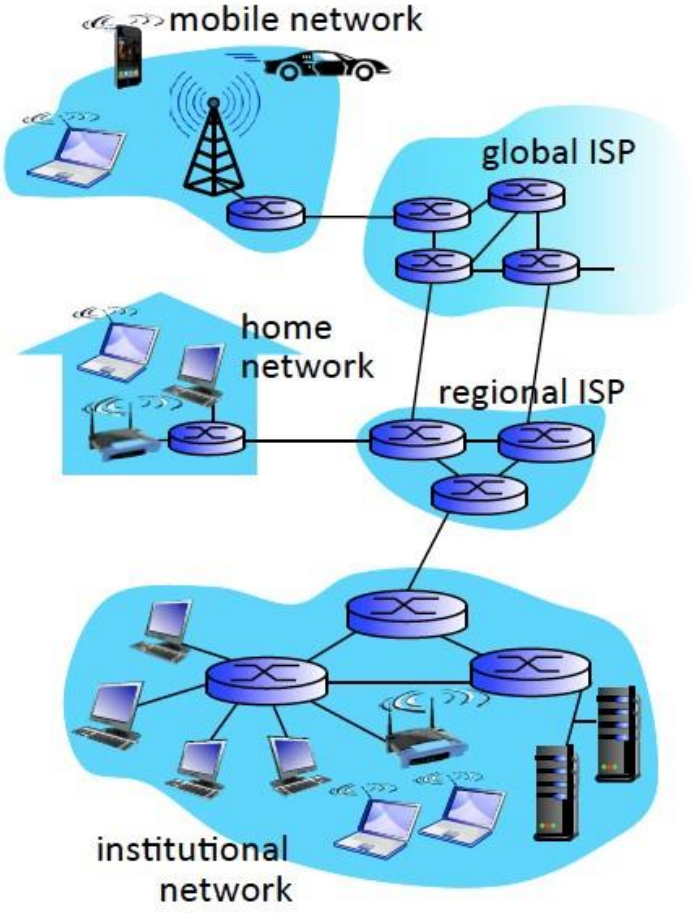
# Human Protocol
# Computer Network Protocol



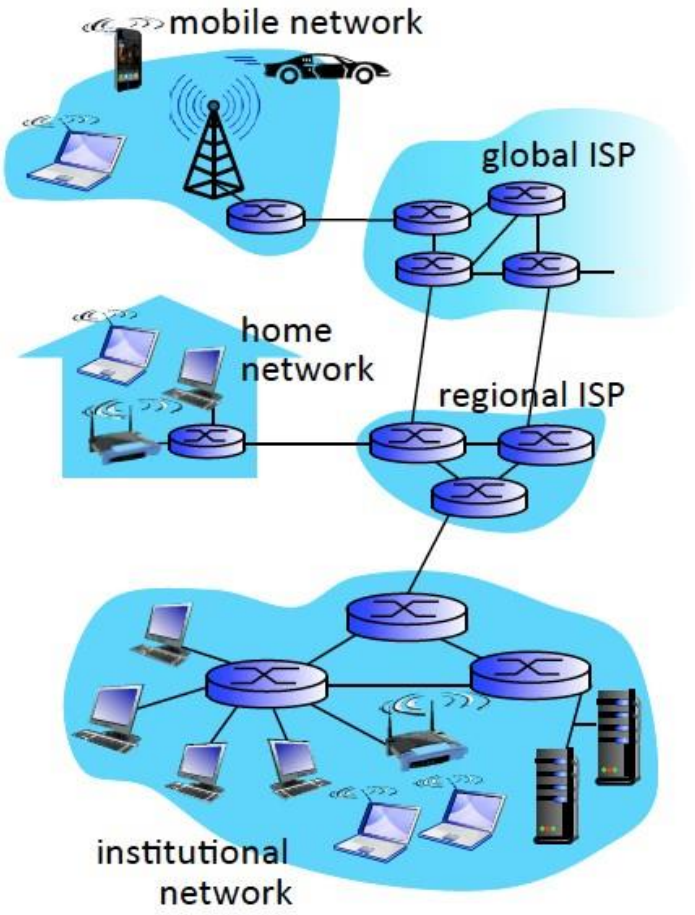
# Internet : Nuts and Bolts View

- Network of Networks
  - Interconnected ISPs
- Protocols Control Sending and Receiving of Data as Messages or Packets
  - E.g. Ethernet, 802.11, TCP, IP, FTP, HTTP, etc..
- Internet Standards
  - RFC: Request for Comment
  - 7736 Documents as of 12/15
  - IETF: Internet Engineering Task Force



# Internet : Service View

- Infrastructure that provides services to applications:
  - Web, VoiP, Email, Games, E-Commmerce, Social Networking, etc..
- Provides Programming Interfaces to Apps
  - Hooks that allow sending and receiving app programs to "connect" to the internet
  - Provides Service Options.
  - Analogous to Postal Service



# Networking technologies for IoT – BLE & 6LoW PAN

# Bluetooth 4.0: Use-cases

**Connecting the things we carry with us:**

- Watches: remote display from other devices
- Tags: locate objects or keep track of them (e.g. warming if you walk away)
- Health & fitness sensors (e.g. pedometer in your shoes)
- Body sensors (e.g. blood pressure, pulse rate, blood glucose, etc)

**Accessing the things around us:**

- Fobs: use proximity as a security/access control means
- Home and office automation

**Low duty cycle M2M communication:**

- Sensors and controls in home, office and factories

**Communication within a system**

- Car to car wheels/tiers

**Connecting anything that has intrinsic data to the internet**

# Bluetooth 4.0: Opportunities

**New classes of gadgets**

- Around a person
- Around a house
- In your car

**New application on PCs and smart phones**

- Use those devices

**New web services**

- Anything can connect to the web

**New Social Applications**

- Your beer glass can talk to your Facebook page

# Bluetooth 4.0: Example of products

Kensington
Proximity tag


Nokia
Precious Tag

Lifesense
Blood Pressure Monitor

Ruwido/Swisscom
Remote Control

UnderArmor
Heart Rate Monitor

Kwikset
Smart door lock


Schneider
Notebook protector

# 6LoWPAN

- 6LoWPAN is an acronym of IPv6 – Low power wireless personal area networks
- Concluded working group in the internet area of the IETF
- To apply for smallest devices and low power devices
- Limited processing capabilities should be able to participate within IoT
- Defined encapsulation and header compression mechanism that allow packets to be sent and received IEEE 802.15.4 based networks
- Desired working connection within local-area networks, metropolitan area networks and wide area networks
- The concept was created because engineers felt like the smallest devices were being left out from the Internet of Things. 6LoWPAN can communicate with 802.15.4 devices as well as other types of devices on an IP network link like Wi-Fi. A bridge device can connect the two.

# 6LoWPAN – Flow

6Lowpan : what does it mean?


**6**
**Low** Power
**Low** Datarate
**Low** Cost

Wireless Personal Area Networks

# Introduction to IPv6

# Internet Protocol, Version 6 (IPv6)

- The Internet Engineering Steering Group approved the IPv6 recommendation and drafted a Proposed Standard on November 17, 1994
  - RFC 1883, "Internet Protocol, Version 6 (IPv6) Specification," was published in 1995
- Core set of IPv6 protocols became an IETF Draft Standard on August 10, 1998
  - This included RFC 2460, which obsoleted RFC 1883

# What's New in IPv6?

- Extended address space
  - The address format is extended from 32 bits to 128 bits
    - This is enough to provide a billion IP addresses for every star in the universe (~ $10^{29}$)
      - http://www.space.com/26078-how--many--stars--are---there.html
  - It also allows for hierarchical structuring of the address space in favor of optimized global routing

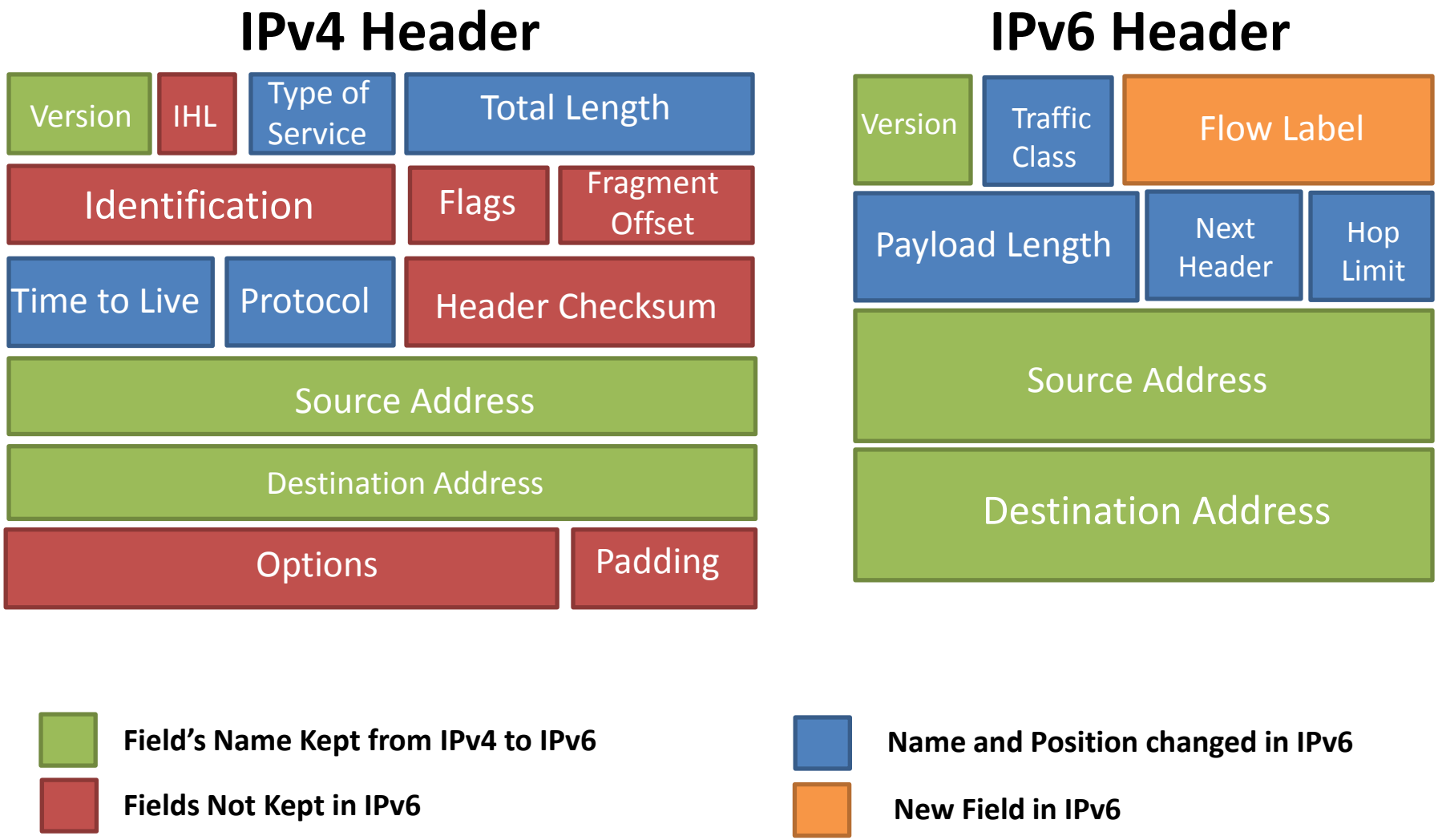
# What's New in IPv6?

*Autoconfiguration*

One of the most intriguing new feature of IPv6 is its Stateless autoconfiguration mechanism

- When a booting device in the IPv6 world comes up and asks for its network prefix, it can get one or more network prefixes from an IPv6 router on its link
- Using this prefix information, it can autoconfigure for one or more valid global IP addresses by using either its MAC identifier or a private random number to build a unique IP address

# General Header Structure



# IoT Hardware platform

# IoT Platform – Hardware and Software

**Hardware :**

- ARM mBed
- Intel - Edison
- Intel - Galileo
- Intel – Arduino 101
- ARC - Bluetooth model

# Hardware communication protocol

# Introduction - Communication

- **Protocol**: A set of rules and regulations is called a protocol.
- **Communication:** Exchange of information from one system to another system with a medium is called a communication.
- **Communication Protocol:** A set of rules and regulations that allow two electronic devices to connect to exchange the data with one and another.

# Inter Integrated Circuit – I2C

- Protocol introduced by Philips Semiconductor in 1982
- Lower speed devices :
  - Standard mode : 100 kbit/s
  - Full speed : 400 kbit/s
  - Fast mode : 1 mbit/s
  - High speed : 3.2 Mbit/s
- Master/Slave communication.
- Slave has unique address bits.
- Master device sends the address of the target, slave device and read/write flag.
- The address is match any slave device that device is ON, remaining slave devices are disable mode.
- Once the address is match communication proceed between master and that slave device and transmitting and receiving the data.

# Universal asynchronous receiver/transmitter -UART

- Translates data in Serial and Parallel.
- Also known as RS 232.
- Transmits bits serially at a mutually agreed speed without providing a clock.
- The speed is known as the baud rate such as : 9600 baud, 115200 baud, or 10 Mbaud.
- Single wire in each direction ( VCC and Ground).
- Asynchronous , as there is no clock signal.

# General Purpose Input and Output SPECS -GPIO

Both input and out puts are controllable by the user at a runtime :

- No pre-defined pins. Go unused by default.
- GPIO Pins can be enabled/disabled.
- May be exposed to the developer for configuring / state set up.

# IoT Cloud Platforms

# CLOUD PLATFORM

**Cloud**

- AWS IoT
- Azure - Microsoft
- Bluemix – IM
- GE – Predix
- Open IoT - National University of Ireland

# Sensor components

Grove - Digital Light Sensor

Grove - Light Sensor

Grove - Temperature and Humidity Sensor

Grove - Barometer Sensor

Grove - Dust Sensor

Grove - Gas Sensor

Grove - Temperature Sensor

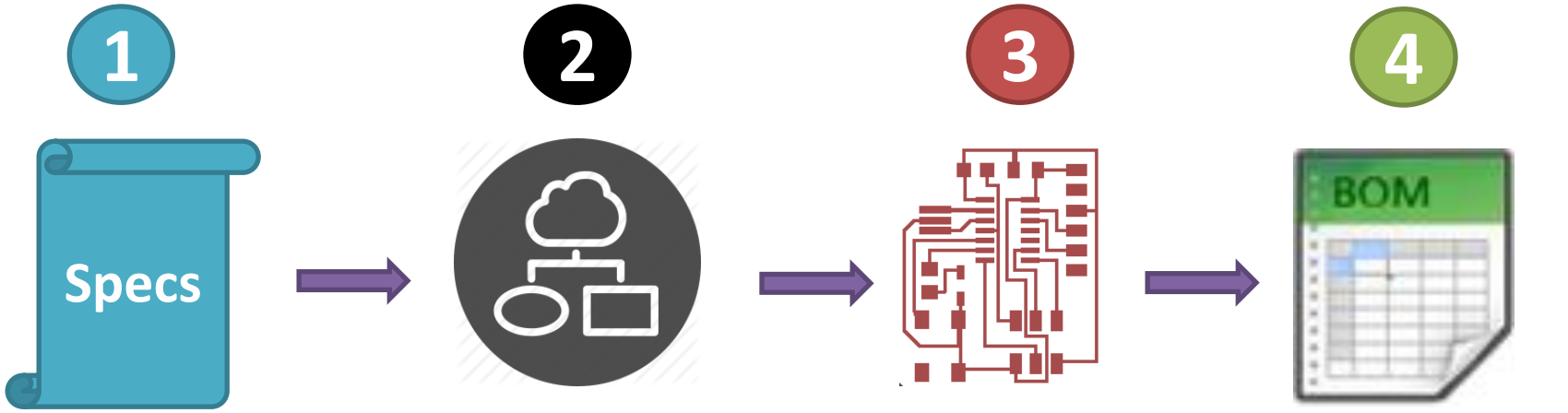
Grove - Air Quality Sensor

Grove - Temperature and Humidity Sensor Pro

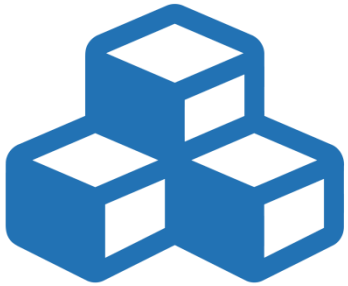
Grove - Gas Sensor($O_2$)

Grove - HCHO Sensor

# How to build end to end IoT solutions

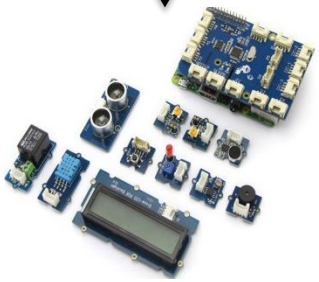

1
2
3
4
Specs
BOM
Concept Paper
Block Diagram
Schematic
Bill of Materials

5



***Build prototype using evaluation board and Open source cloud components***

**Prototype**



***Assembling sensor and electronics***

***Writing device drivers***

***Writing APIs for cloud infrastructure***

***Client integration such as Desktop, Tablet, Mobile, etc.,.***

6

**Field Testing**
**(3-6 months)**

7


**Beta version**
**(1 - 2 months)**

8

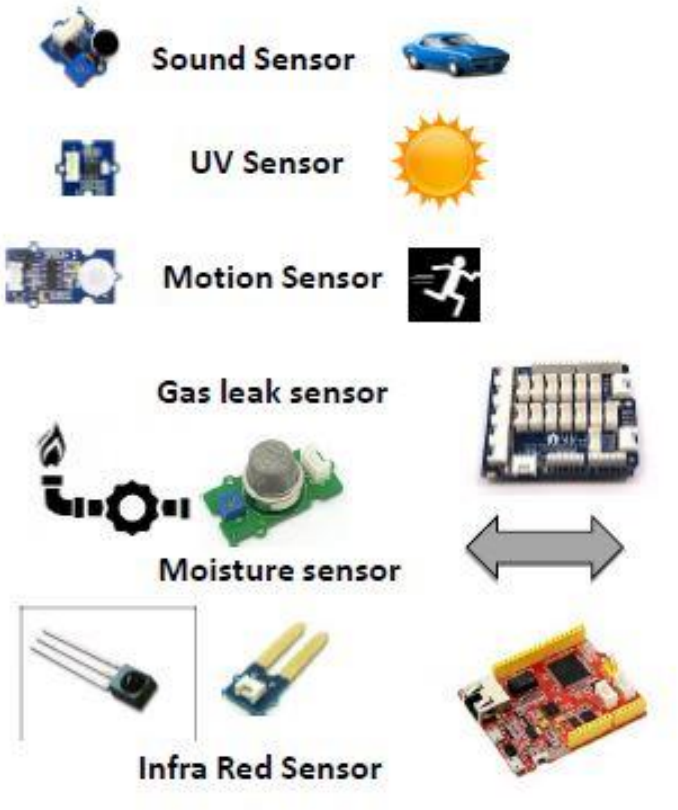
**Production**

9

**Release and**
**Documentation**

# Few IoT Examples

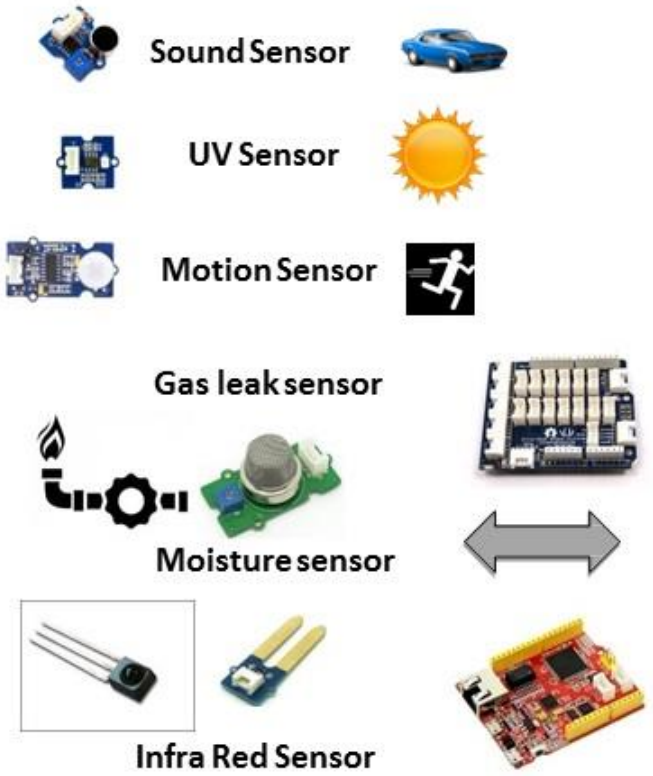
# Project Examples
# Assistance Living and Smart Cities Projects




# Environmental Projects

- Air Pollution Monitoring : Control of CO2 emissions of factories, pollution emitted by cars and toxic gases generated in farms.
- Indoor Air Quality : Monitoring of toxic gas and oxygen levels inside chemical plants to ensure workers and goods safety.
- Earthquake Early Detection : Distributed control in specific places of tremors.
- Forest Fire Detection: Monitoring of combustion gases and preemptive fire conditions to define alert zones.
- Waste Management Detection of rubbish levels in containers to optimize the trash collection routes.

# Project Examples





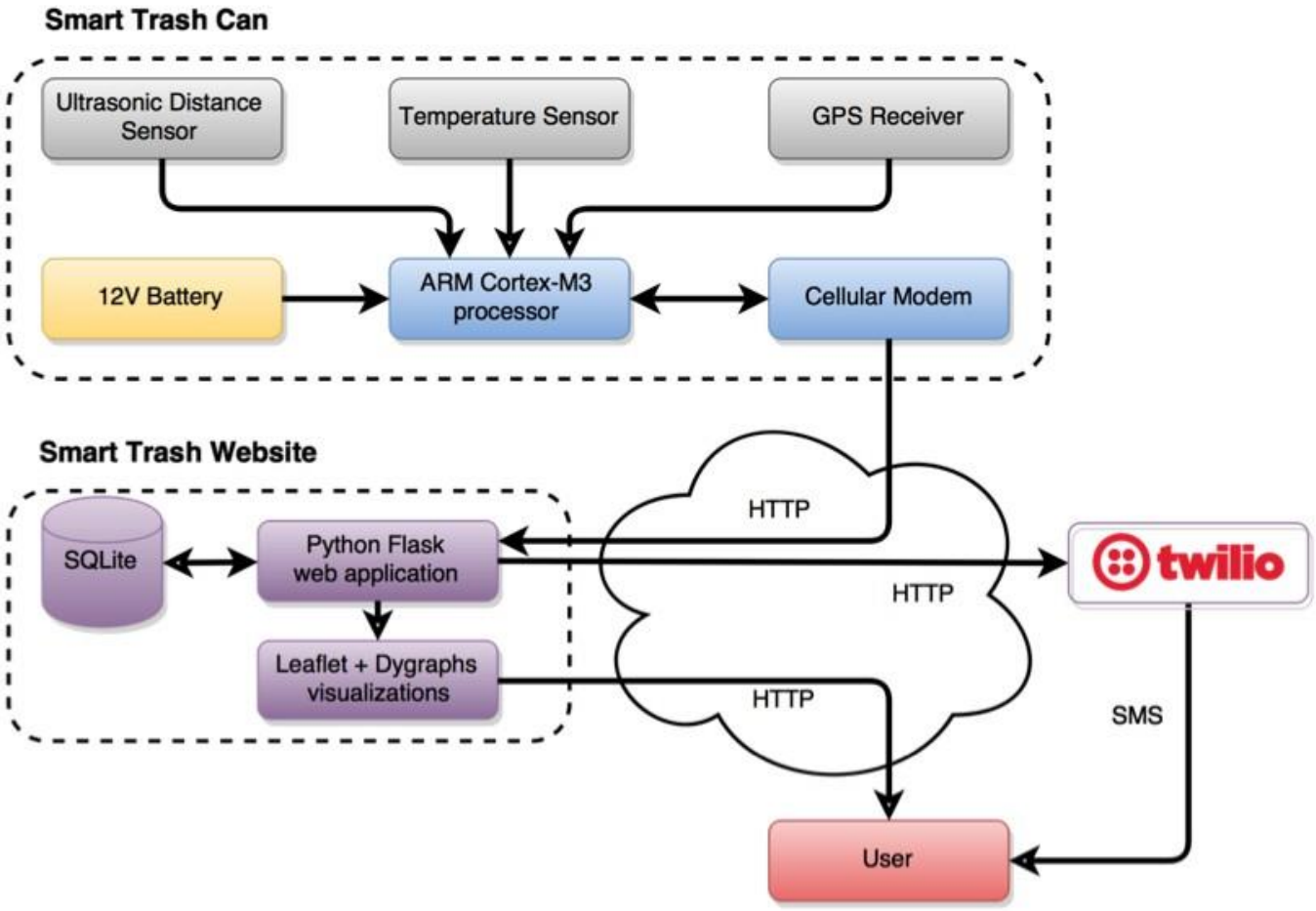
Crowd Sensing Data
Linked Sensors
Sensors Discovery
Super Stream Collider

Vision Band Smart
Help BuzzMe
Smart Helmet
Smart Locking
Smart Glow Lighting

Smart Trials
Smart Bin

# IoT for Smart Garbage Monitoring

# SMART BIN - WASTE MANAGEMENT (DESIGN AND ARCHITECTURE)



# ARMmbed IoT platform(Prototype)

# ASSEMBLY 1 (Field Deployment)

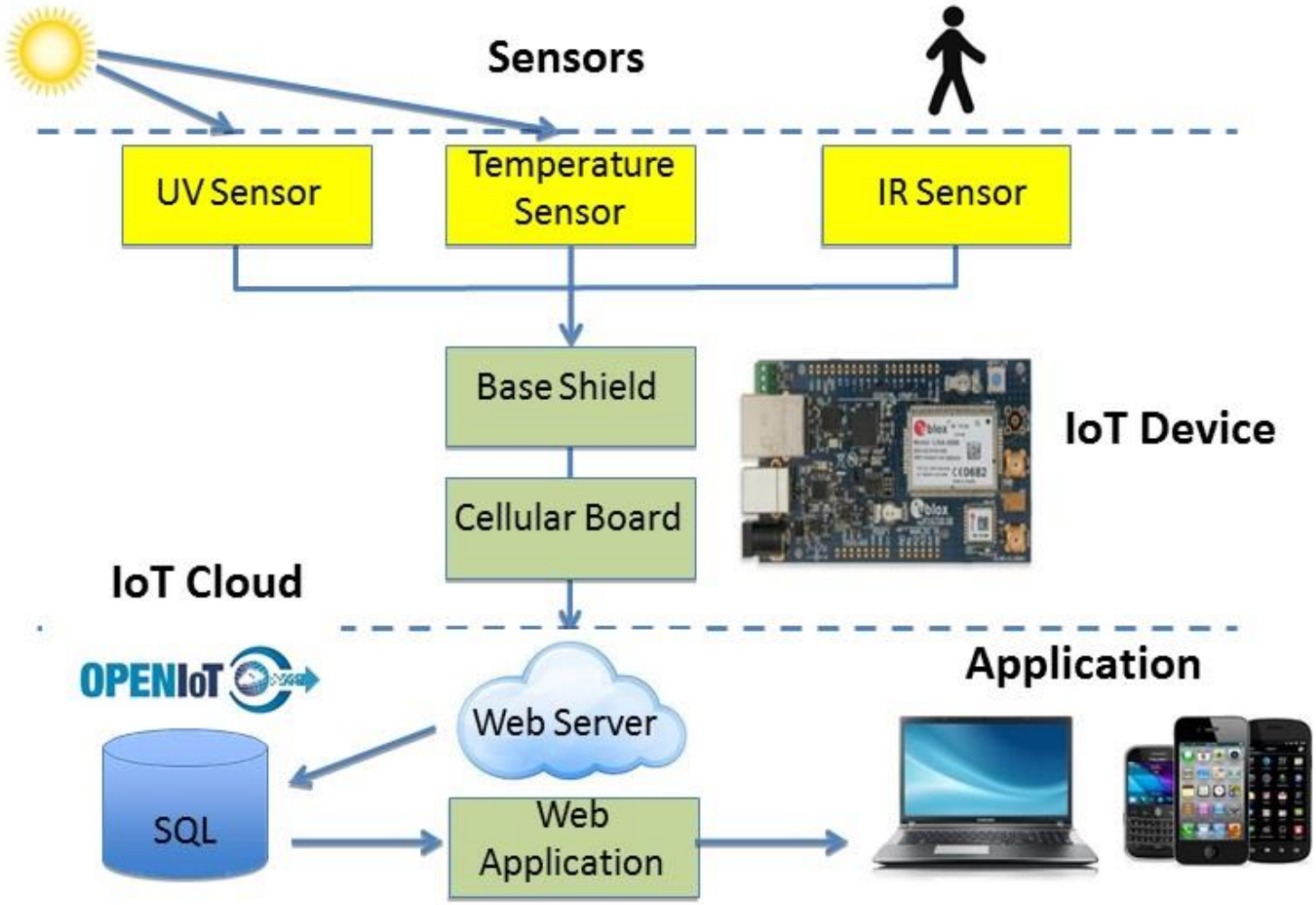
# ASSEMBLY 2 (Field Deployment)

# Battery Connection (Test Run)

# Message Test

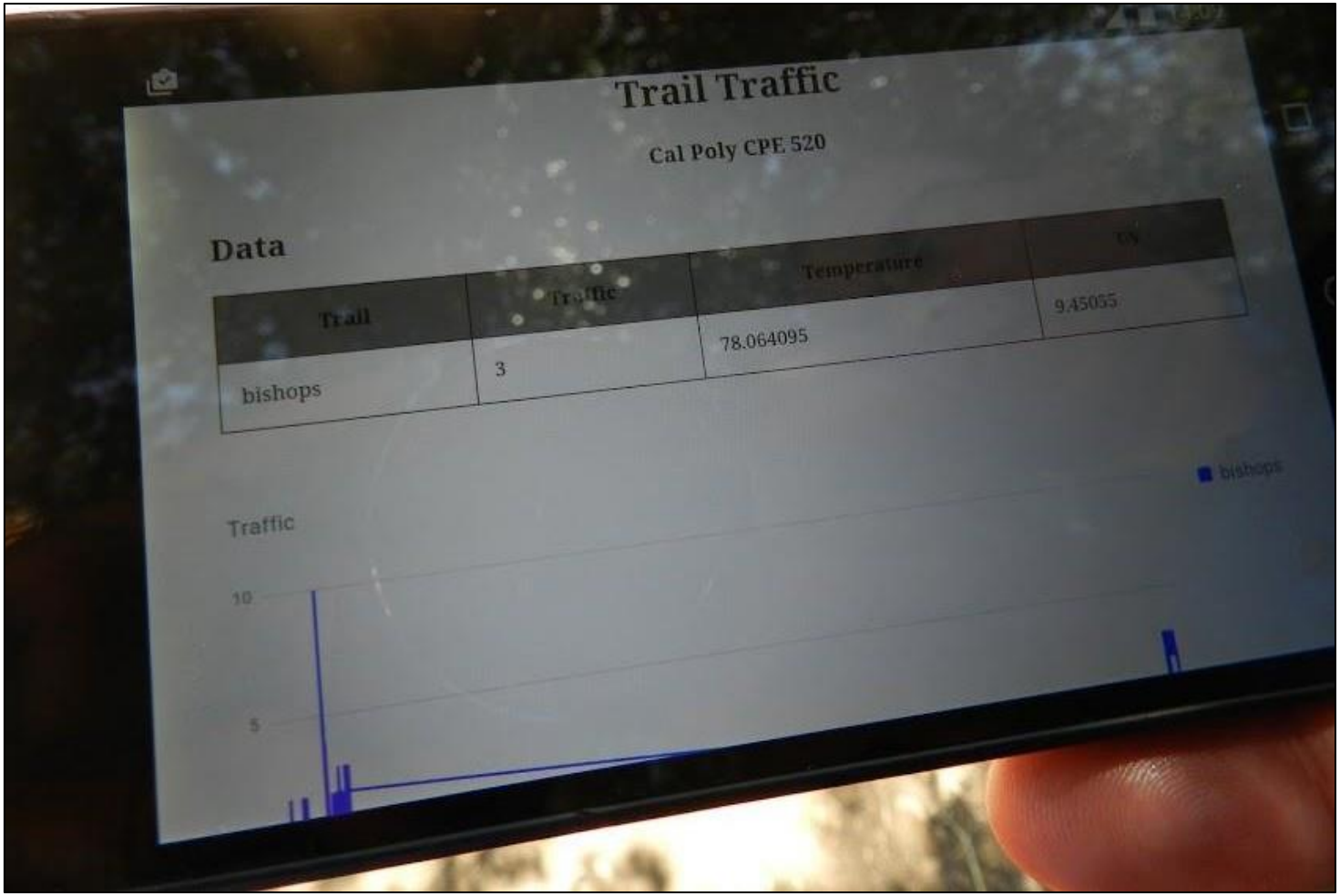
# 24 Hour test result
# (Laptop Application)

# SENSED TRIALS - CITIZENS' MOBILITY (DESIGN AND ARCHITECTURE)

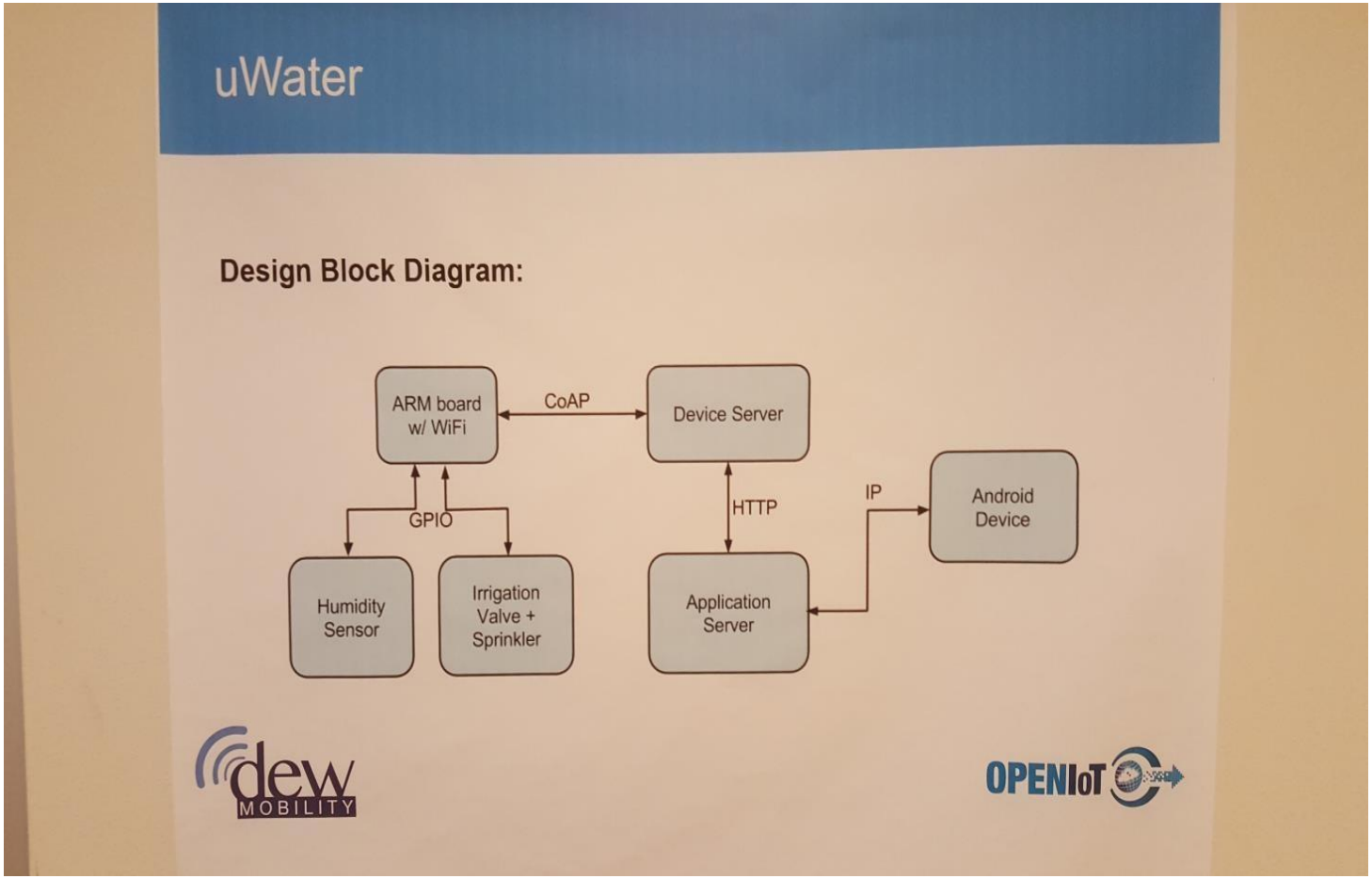


# IoT for Trail (Field Deployment)

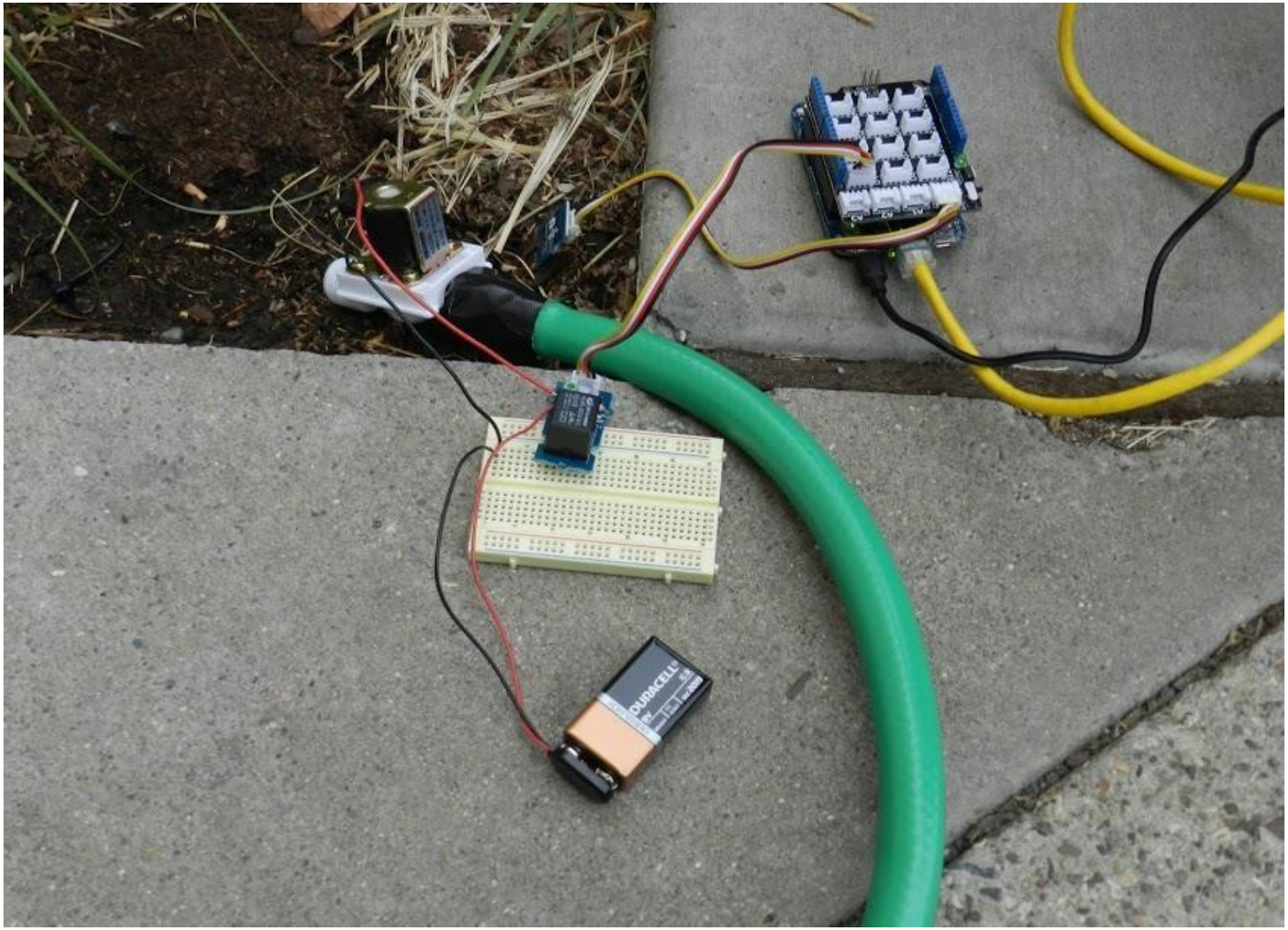
# Test results (Tablet App)



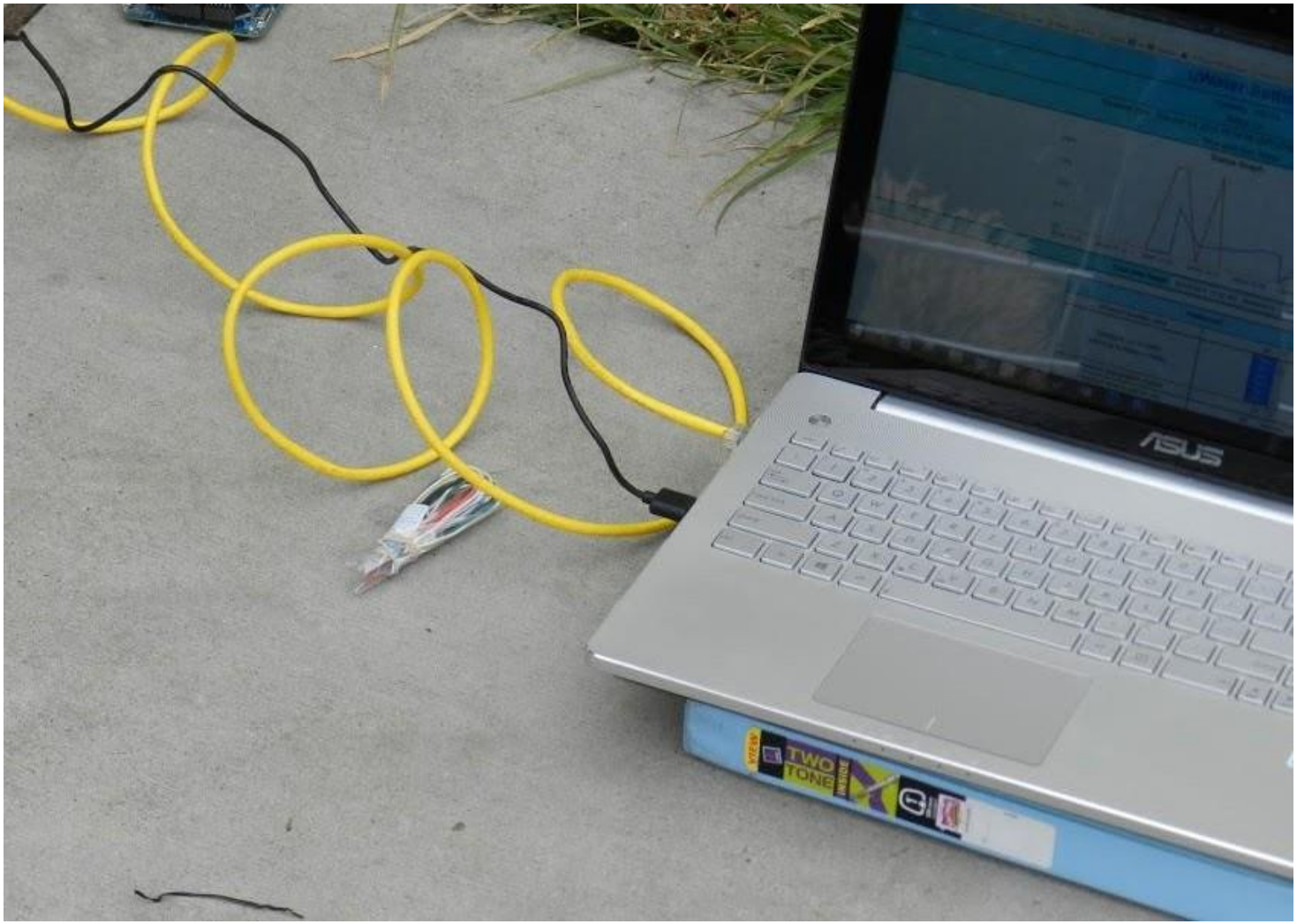
# Irrigation and Sprinkle control (Design and Architecture)



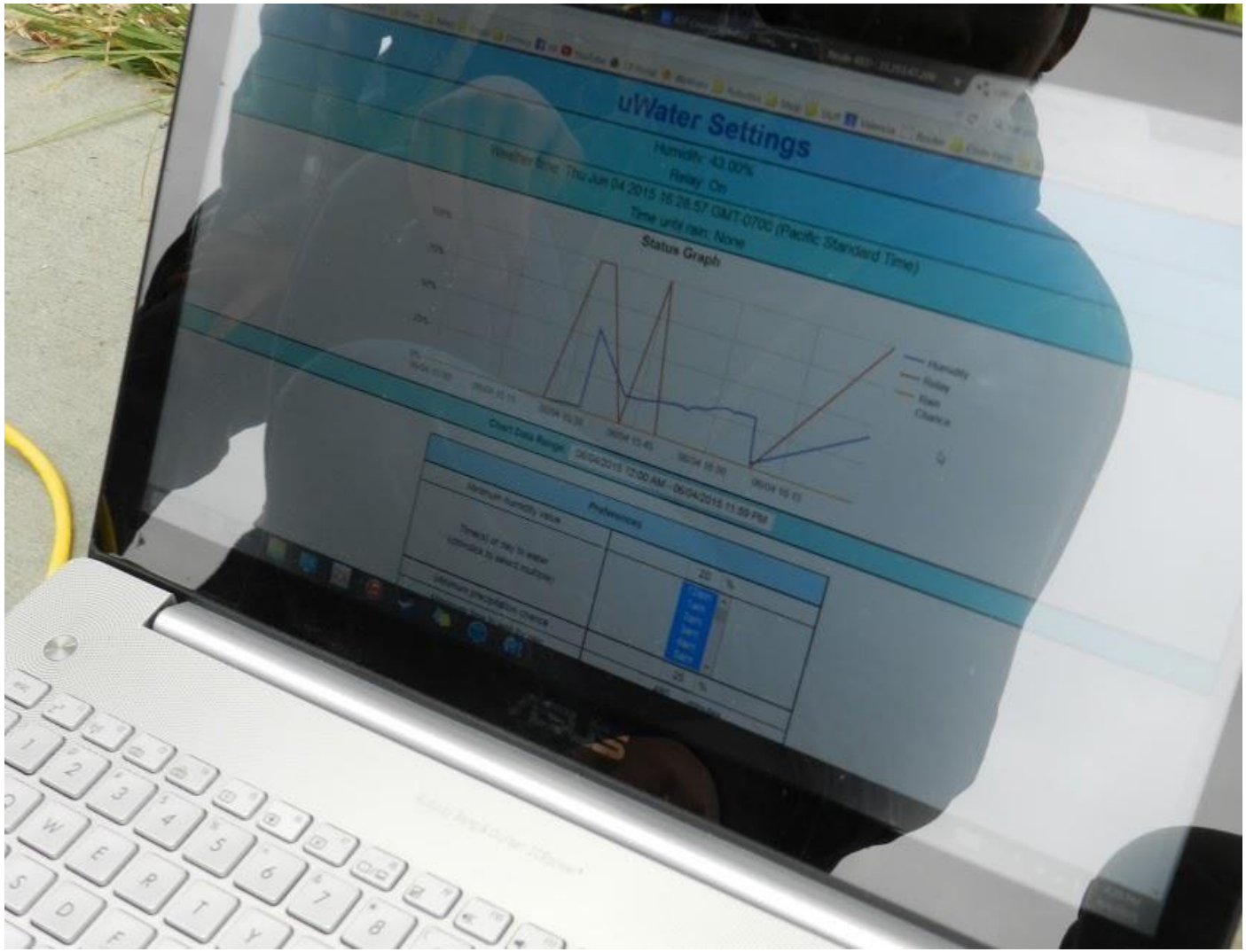
# IoT for Irrigation (Field Deployment)



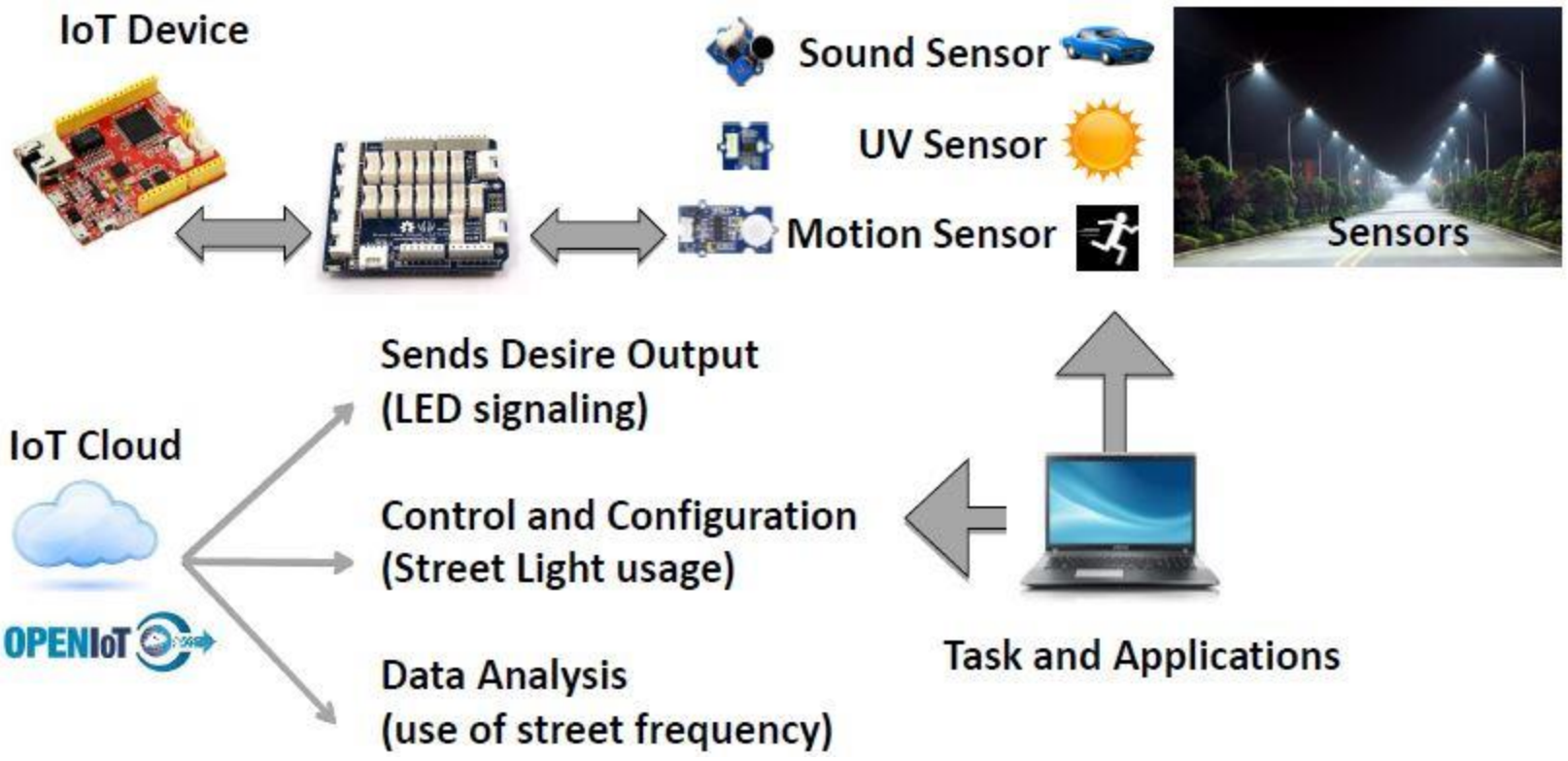
# Integration (Data Collection)



# Test results (Web Services)



# Smart Glow Lighting System



# Thank you

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