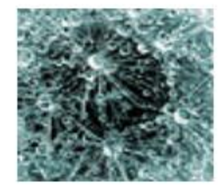
by

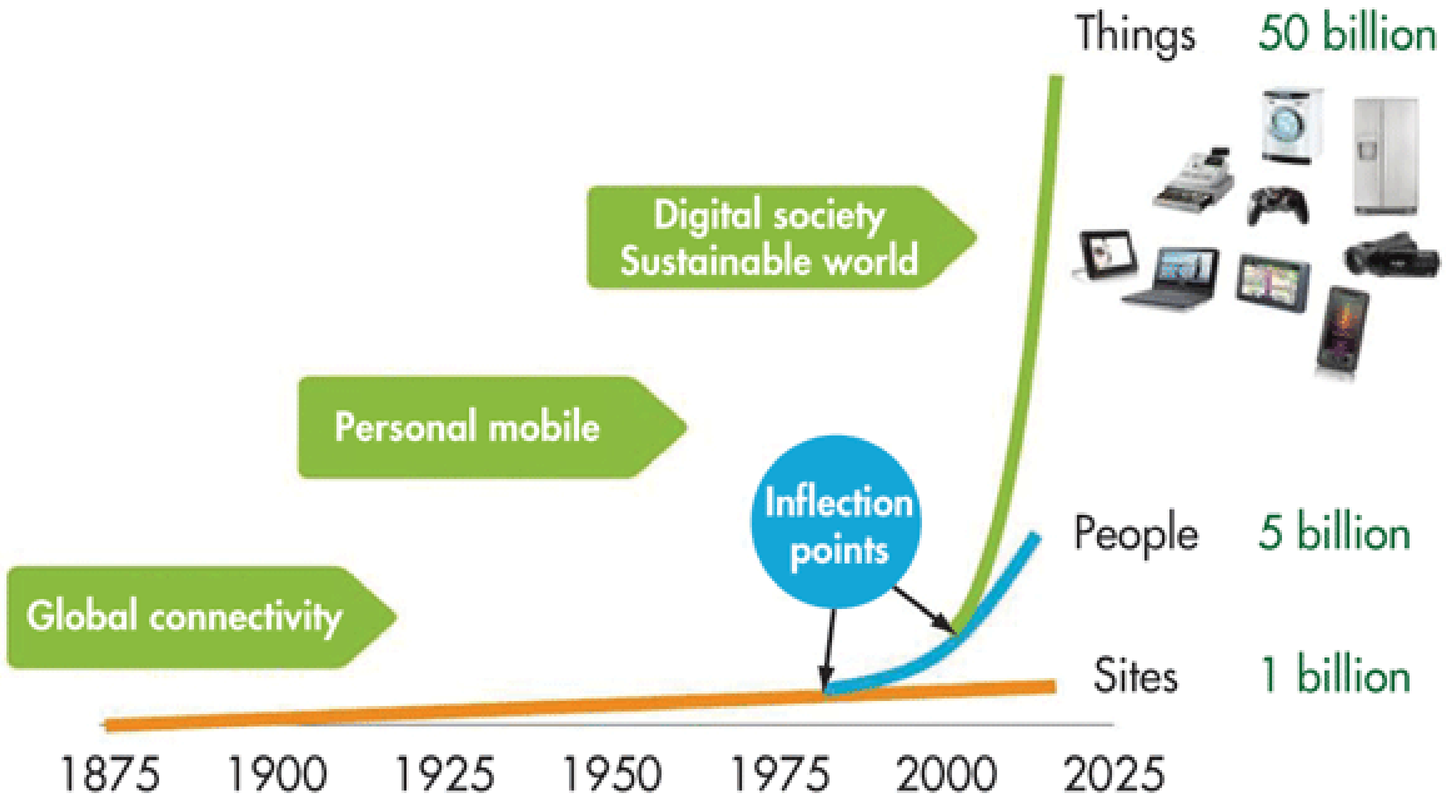
Dr. S.V.Srikanth
Joint Director
C-DAC

The Internet Evolution

Internet Evolution

Internet of boffins	Internet of geeks	Internet of masses	Mobile Internet	Internet of things
				
1969 - 1995	**1995 - 2000**	**2000 - 2010**	**2010 - 2020**	**2020 - beyond**

Evolution of Connected Computing



Things

- We can turn almost every object into a “thing”.
- A “thing” still looks much like an embedded system currently.
- A “thing” has the following properties:
  - A thing is a constraint device
  - It’s usually powered by battery. This implies limited source of energy.
  - It’s generally small in size and low in cost. This limits their computing capability.
  - It doesn’t usually perform complicated tasks.
- Power consumption is the main design issue.

Agenda

- IoT History
- IoT Definition
- IoT Infographic
- IoT Examples
- Smart City Concept and Architecture
- Smart City Case Studies
- Smart City Technology: Hardware/Software/Protocols
- Smart City: Idea to Prototype to Product

Internet of Things: History

“The more you know about the past, the better prepared you are for the future…..”

- Theodore Roosevelt

History of IoT

1832: An electromagnetic telegraph was created by Baron Schilling in Russia, and in 1833 Carl Friedrich Gauss and Wilhelm Weber invented their own code to communicate over a distance of 1200m within Gottingen, Germany.

1844: Samuel Morse sends the first Morse code public telegraph message "What hath God wrought?" from Washington, D.C. to Baltimore.

1926: Nikola Tesla in an interview with Colliers magazine:

"*When wireless* is perfectly applied the whole earth will be converted into a huge brain, which in fact it is, all things being particles of a real and rhythmic whole.........and the instruments through which we shall be able to do this will be amazingly simple compared with our present telephone. A man will be able to carry one in his vest pocket.*“

1966: Karl Steinbach a German computer science pioneer said "***In a few decades time, computers will be interwoven into almost every industrial product***"

1969: Arpanet

1974: Beginnings of TCP/IP

1984: Domain Name System is introduced

1989: Tim Berners-Lee proposes the World Wide Web

History of IoT

1990: John Romkey created the **'First Internet Device'**, a toaster that could be turned on and off over the Internet. At the October '89 INTEROP conference, Dan Lynch, President of Interop promised Romkey that, if Romkey was able to "bring up his toaster on the Net," the appliance would be given star placement in the floor-wide exhibitors at the conference.

1991: The first web page was created by Tim Berners-Lee

1991: Mark Weiser's Scientific American article on ubiquitous computing called 'The Computer for the 21st Century' is written.
"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it".

1995: The Internet goes commercial with Amazon and Echobay (Ebay)

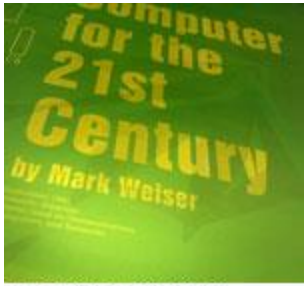
1997: Paul Saffo's prescient article "Sensors: The Next Wave of Infotech Innovation" (Via: Geoffrey Barrows)

1998: Google is incorporated

1999 - A big year for the IoT and MIT

The Internet of Things term is coined by Kevin Ashton executive director of the Auto-ID Center:

"*I could be wrong, but I'm fairly sure the phrase "Internet of Things" started life as the title of a presentation I made at Procter & Gamble (P&G) in 1999. Linking the new idea of RFID in P&G's supply chain to the then-red-hot topic of the Internet was more than just a good way to get executive attention. It summed up an important insight which is still often misunderstood.*"



Credit: CC Flickr - GARNET

Mark Weiser

Kevin Ashton

AUTO-ID LABS

History of IoT

1999: Auto-ID Labs opens which is the research-oriented successor to the MIT Auto-ID Center, originally founded by Kevin Ashton, David Brock and Sanjay Sarma. They helped develop the Electronic Product Code or EPC, a global RFID-based item identification system intended to replace the UPC bar code.

2000: Starting off what is now becoming a meme, LG announces it's first Internet refrigerator plans.

2003-2004: The term is mentioned in main-stream publications like The Guardian, Scientific American and the Boston Globe.
- Projects like Cooltown, Internet0, and the Disappearing Computer initiative seek to implement some of the ideas, and the Internet of Things term starts to appear in book titles for the first time.
- RFID is deployed on a massive scale by the US Department of Defense in their Savi program and Walmart in the commercial world.

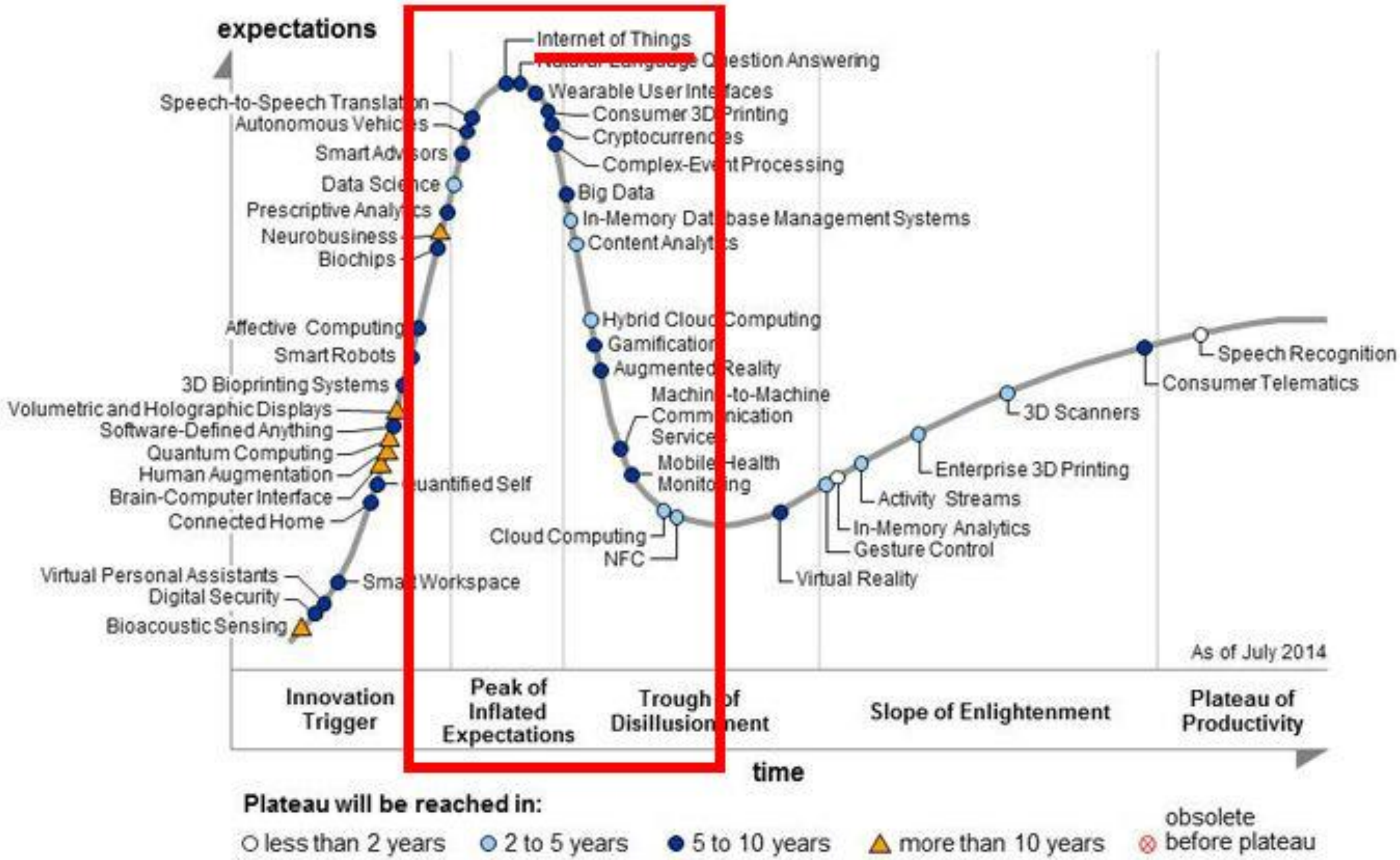
2005: The IoT hit another level when the UN's International Telecommunications Union ITU published its first report on the topic.
2006-2008: Recognition by the EU, and the First European IOT conference is held

2008-2009: The Internet of Things was "Born"

History of IoT

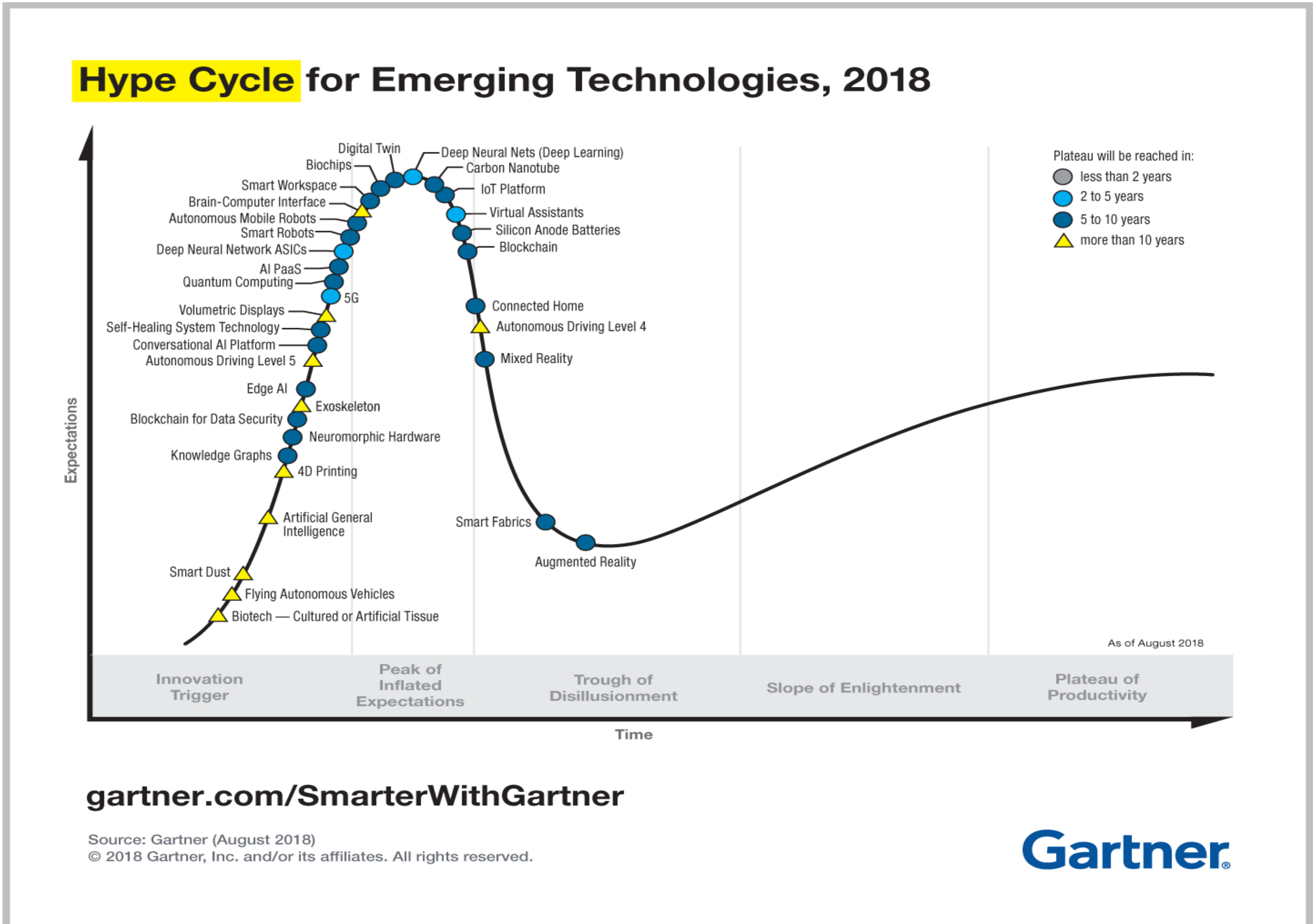
- **2011:** **IPV6 public launch** - The new protocol allows for 2^{128} (approximately 340 undecillion or 340,282,366,920,938,463,463,374,607,431,768,211,456) addresses or as Steven Leibson put it, "we could assign an IPV6 address to every atom on the surface of the earth, and still have enough addresses left to do another 100+ earths."

Finally IoT……



expectations
Internet of Things
Question Answering
Wearable User Interfaces
Consumer 3D Printing
Cryptocurrencies
Complex-Event Processing
Big Data
In-Memory Database Management Systems
Content Analytics
Hybrid Cloud Computing
Gamification
Augmented Reality
Machine-to-Machine Communication Services
Mobile Health Monitoring
Cloud Computing
NFC
Speech-to-Speech Translation
Autonomous Vehicles
Smart Advisors
Data Science
Prescriptive Analytics
Neurobusiness
Biochips
Affective Computing
Smart Robots
3D Bioprinting Systems
Volumetric and Holographic Displays
Software-Defined Anything
Quantum Computing
Human Augmentation
Brain-Computer Interface
Connected Home
Quantified Self
Virtual Personal Assistants
Digital Security
Bioacoustic Sensing
Smart Workspace
Virtual Reality
In-Memory Analytics
Gesture Control
Activity Streams
Enterprise 3D Printing
3D Scanners
Consumer Telematics
Speech Recognition
As of July 2014
Innovation Trigger
Peak of Inflated Expectations
Trough of Disillusionment
Slope of Enlightenment
Plateau of Productivity
time
Plateau will be reached in:
less than 2 years
2 to 5 years
5 to 10 years
more than 10 years
obsolete before plateau

@Present


Hype Cycle for Emerging Technologies, 2018
Expectations
Digital Twin
Biochips
Smart Workspace
Brain-Computer Interface
Autonomous Mobile Robots
Smart Robots
Deep Neural Network ASICs
AI PaaS
Quantum Computing
5G
Volumetric Displays
Self-Healing System Technology
Conversational AI Platform
Autonomous Driving Level 5
Edge AI
Exoskeleton
Blockchain for Data Security
Neuromorphic Hardware
Knowledge Graphs
4D Printing
Artificial General Intelligence
Smart Dust
Flying Autonomous Vehicles
Biotech — Cultured or Artificial Tissue
Deep Neural Nets (Deep Learning)
Carbon Nanotube
IoT Platform
Virtual Assistants
Silicon Anode Batteries
Blockchain
Connected Home
Autonomous Driving Level 4
Mixed Reality
Smart Fabrics
Augmented Reality
Plateau will be reached in:
less than 2 years
2 to 5 years
5 to 10 years
more than 10 years
As of August 2018
Innovation Trigger
Peak of Inflated Expectations
Trough of Disillusionment
Slope of Enlightenment
Plateau of Productivity
Time
gartner.com/SmarterWithGartner
Source: Gartner (August 2018)
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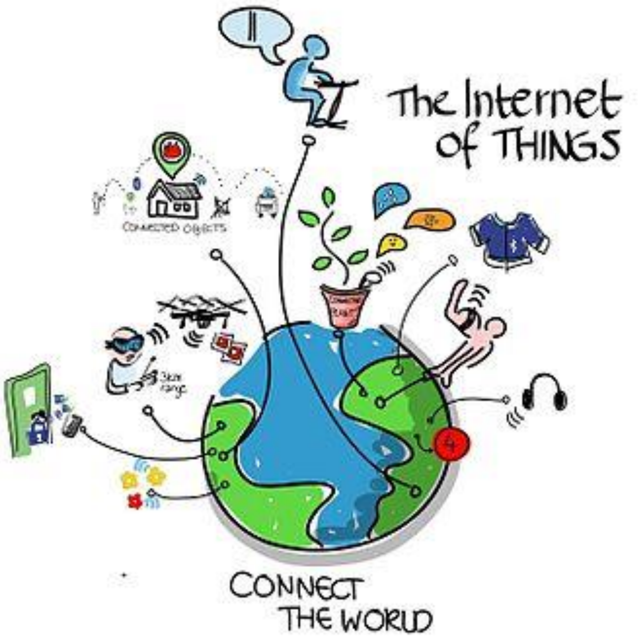
Gartner

Internet of Things (IoT)

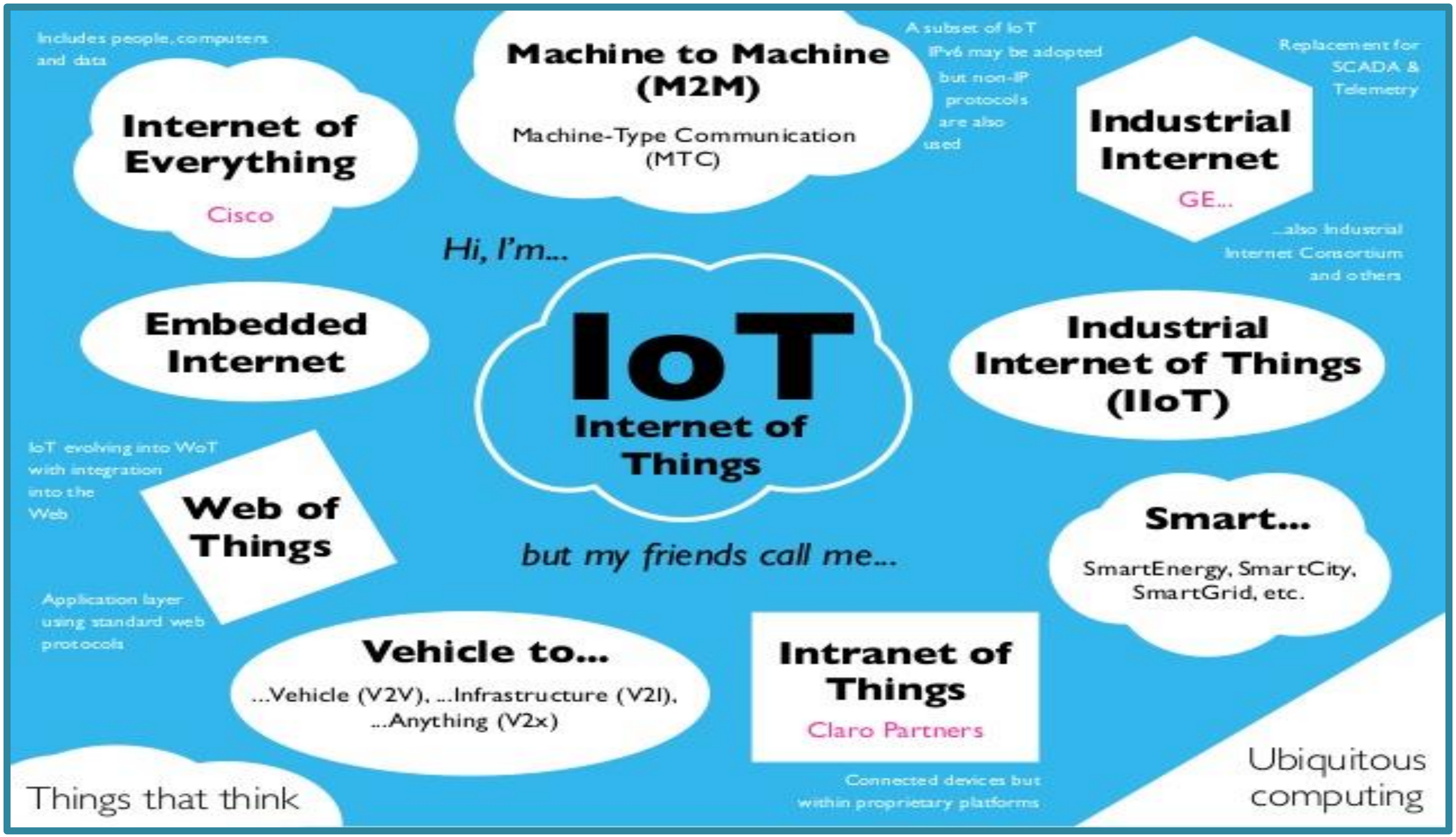
Definition

Internet of Things (IoT)

- Coined by Kevin Ashton in 1999
- Refers to **uniquely identifiable objects** and their **virtual representations** in an Internet like structure



Some IoT Concepts…..



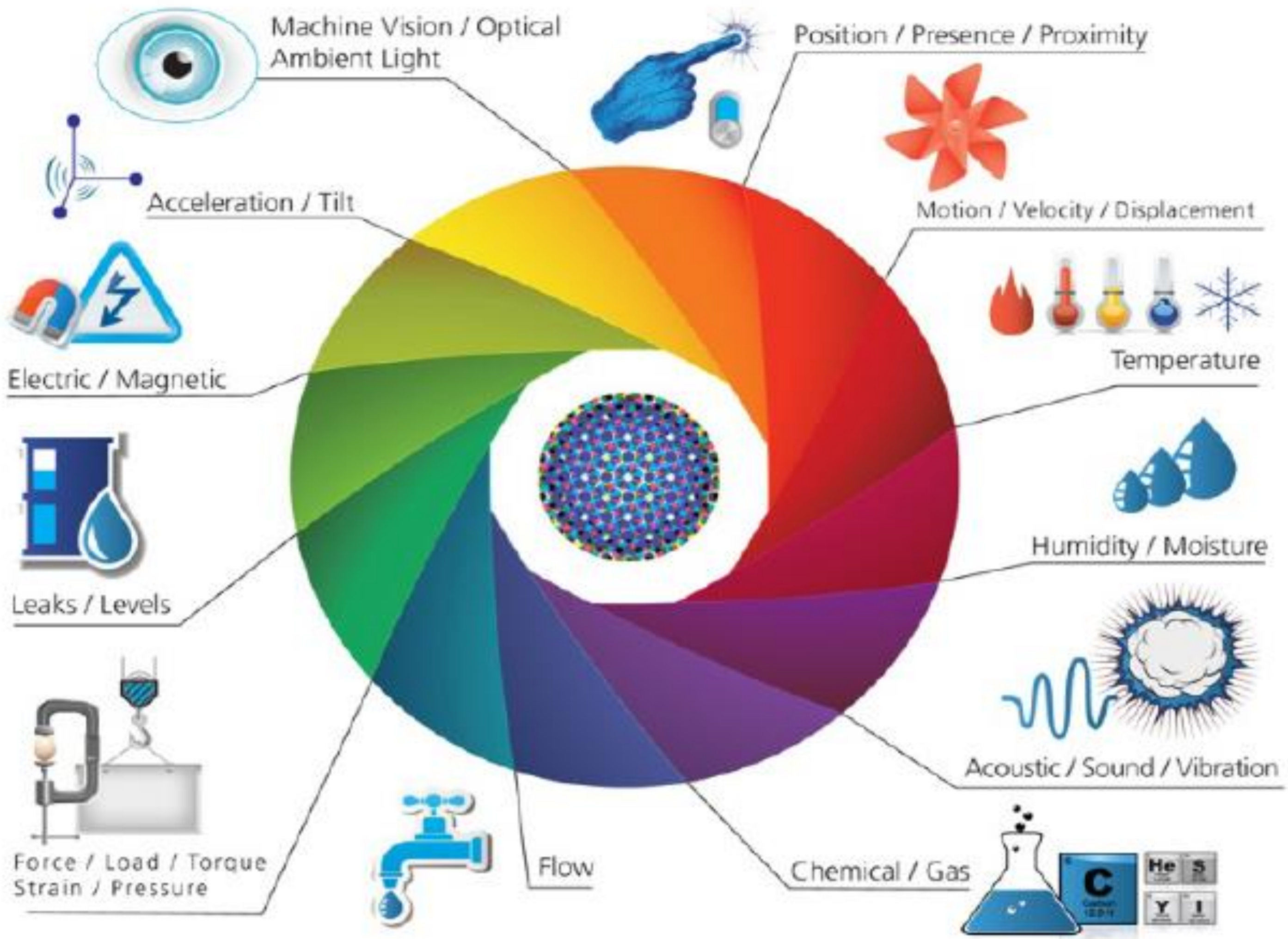
What exactly is the "INTERNET of THINGS"?

Smart Systems and the Internet of Things are driven by a combination of:

1. **SENSORS** & ACTUATORS
2. **CONNECTIVITY**
3. **PEOPLE** & **PROCESSES**

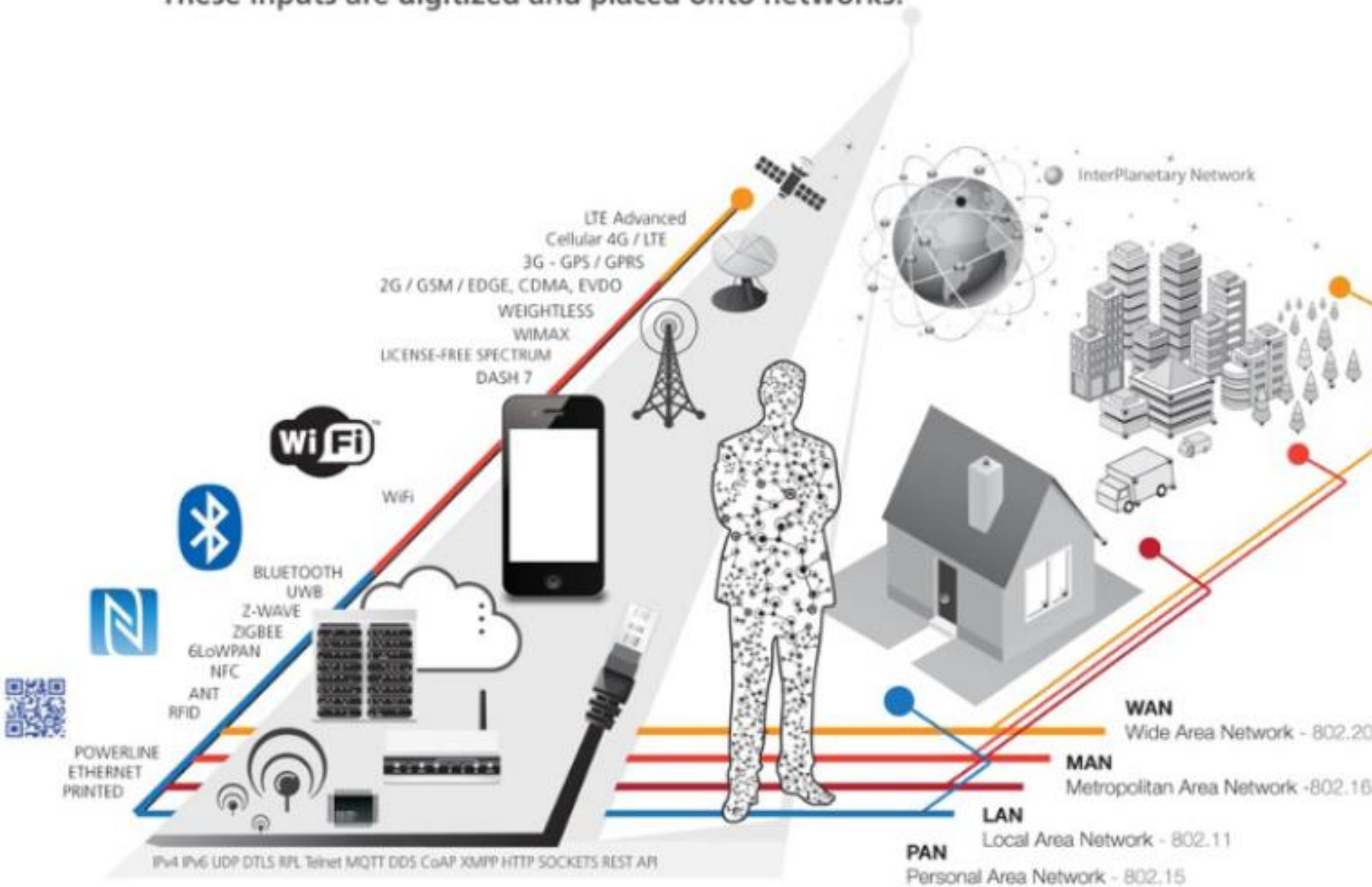
1 SENSORS & ACTUATORS

We are giving our world a digital nervous system. Location data using GPS sensors. Eyes and ears using cameras and microphones, along with sensory organs that can measure everything from temperature to pressure changes.



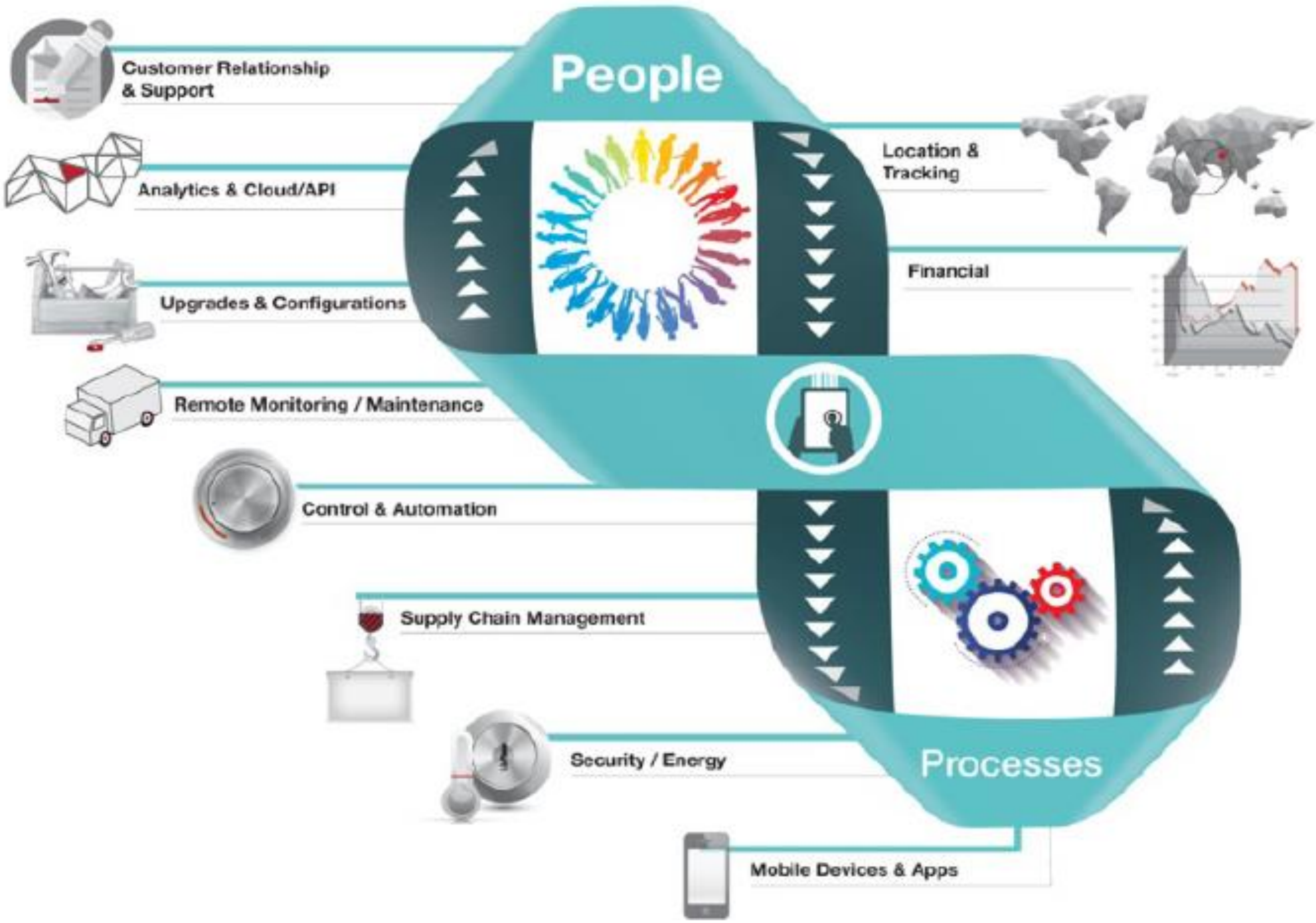
2 CONNECTIVITY

These inputs are digitized and placed onto networks.



3 PEOPLE & *PROCESSES*

These networked inputs can then be combined into bi-directional systems that integrate data, people, processes and systems for better decision making.

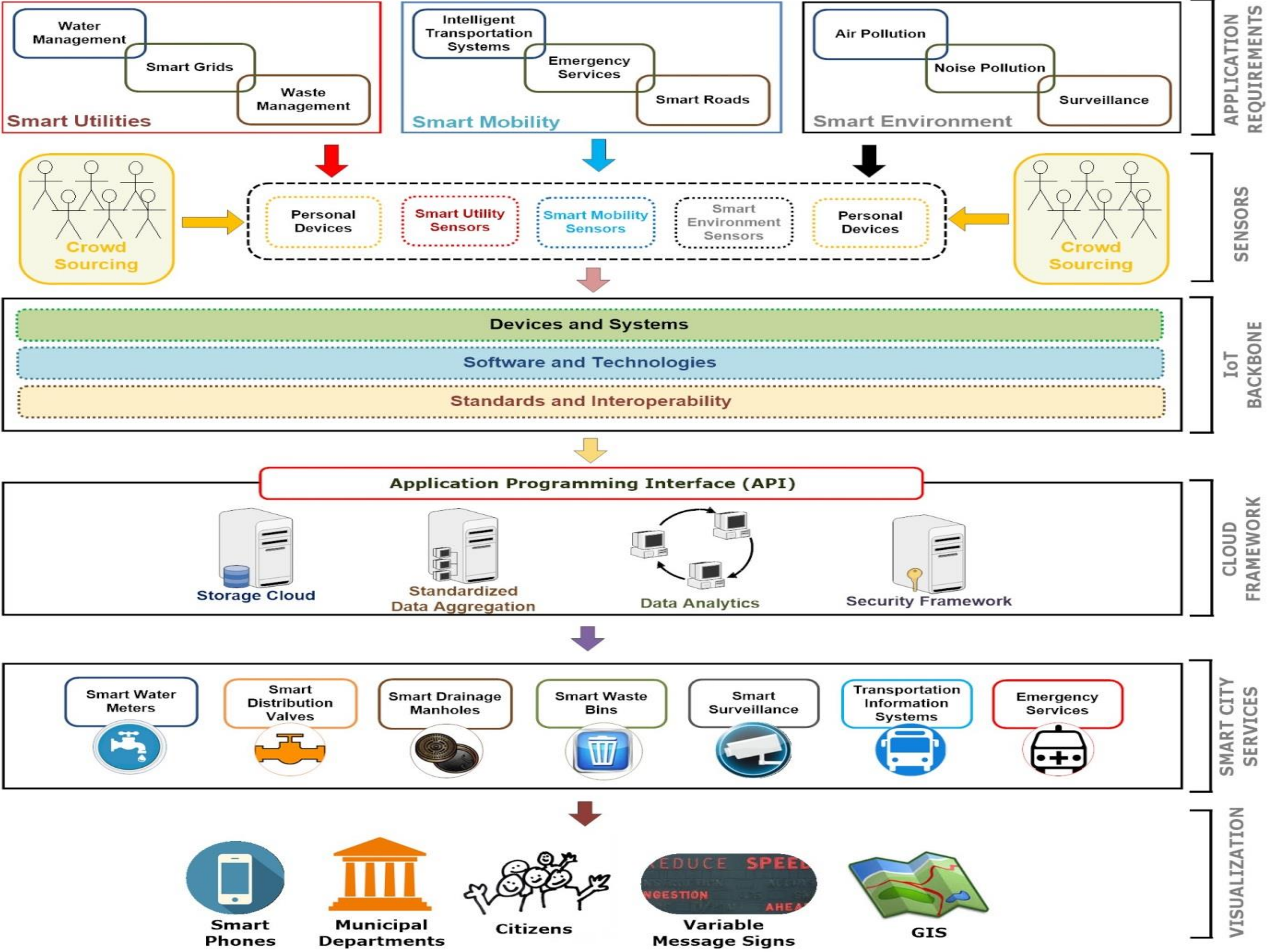


IoT Components: Decrypt Further

Sensors/Actuators (End devices)	Connectivity to INTERNET	Data, People & Processes (Decision making) DATA ANALYTICS

Decrypt further...

Sensors	Controller	Comm. Interface	Gateway	Cloud	Mobile	VUI	Data Analytics
Accelerometer Temperature Ultrasonic .	Apples S1 Qualcomm-wear 2100 Mediatek MT2502	Bluetooth Zigbee	Wi-Fi GSM/GPRS Ethernet	Web interface, Dashboard as in Ubidots Mediatek CS	Apps for Android, iOS...	Alexa, Google's Home Asst,	



Water Management
Smart Grids
Waste Management
Smart Utilities
Intelligent Transportation Systems
Emergency Services
Smart Roads
Smart Mobility
Air Pollution
Noise Pollution
Surveillance
Smart Environment
APPLICATION REQUIREMENTS
Crowd Sourcing
Personal Devices
Smart Utility Sensors
Smart Mobility Sensors
Smart Environment Sensors
Personal Devices
Crowd Sourcing
SENSORS
Devices and Systems
Software and Technologies
Standards and Interoperability
IoT BACKBONE
Application Programming Interface (API)
Storage Cloud
Standardized Data Aggregation
Data Analytics
Security Framework
CLOUD FRAMEWORK
Smart Water Meters
Smart Distribution Valves
Smart Drainage Manholes
Smart Waste Bins
Smart Surveillance
Transportation Information Systems
Emergency Services
SMART CITY SERVICES
Smart Phones
Municipal Departments
Citizens
Variable Message Signs
GIS
VISUALIZATION

The interactions between these entities are creating new types of smart applications and services.

SENSORS + CONNECTIVITY + PEOPLE + PROCESSES

Starting with popular connected devices already on the market

SMART THERMOSTATS

nest

Save resources and money on your heating bills by adapting to your usage patterns and turning the temperature down when you're away from home.

CONNECTED CARS

CAR2GO

Tracked and rented using a smartphone. Car2Go also handles billing, parking and insurance automatically.

ACTIVITY TRACKERS

BASIS

Continuously capture heart rate patterns, activity levels, calorie expenditure and skin temperature on your wrist 24/7.

SMART OUTLETS

belkin

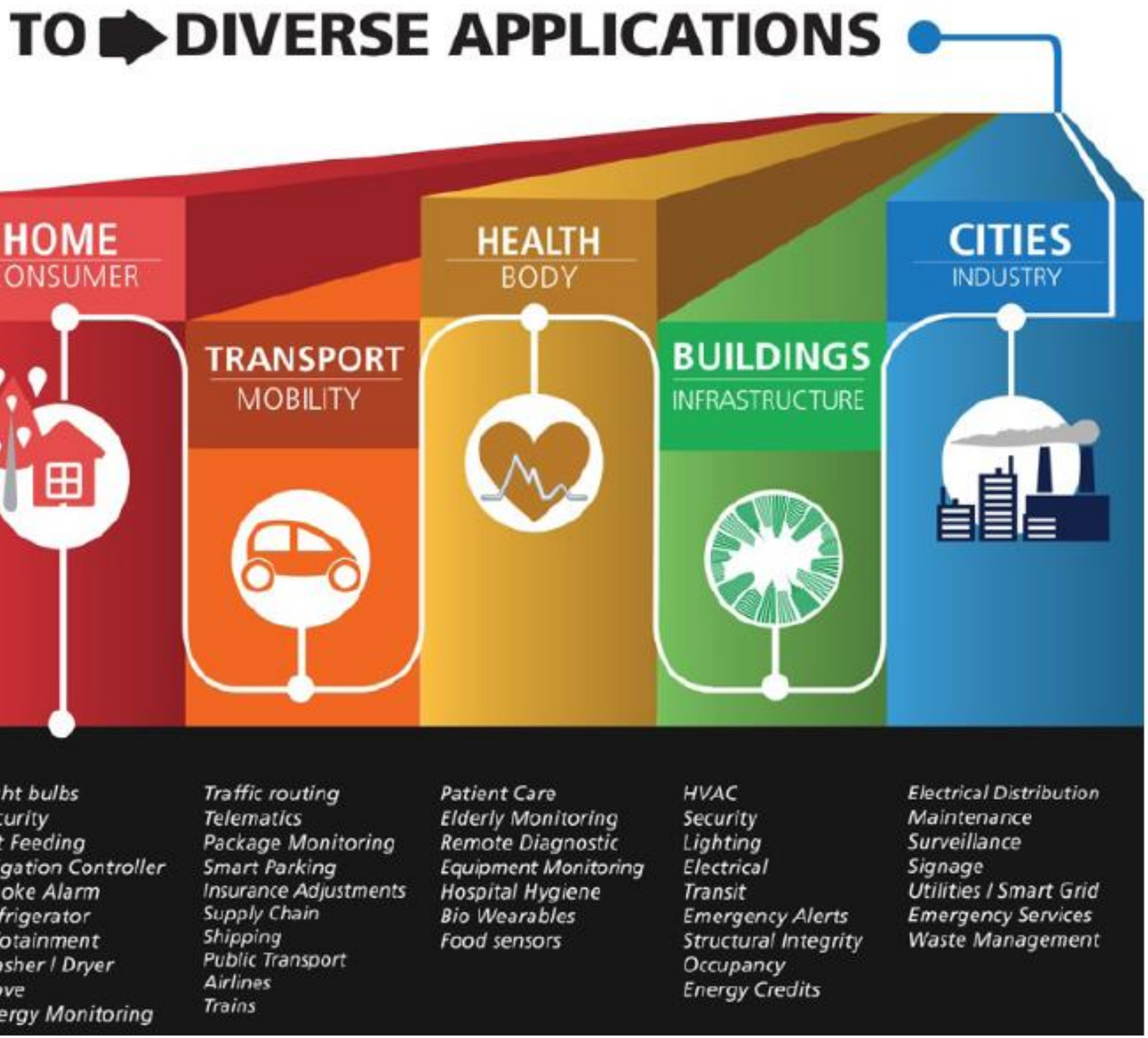
Remotely turn any device or appliance on or off. Track a device's energy usage and receive personalized notifications from your smartphone.

PARKING SENSORS

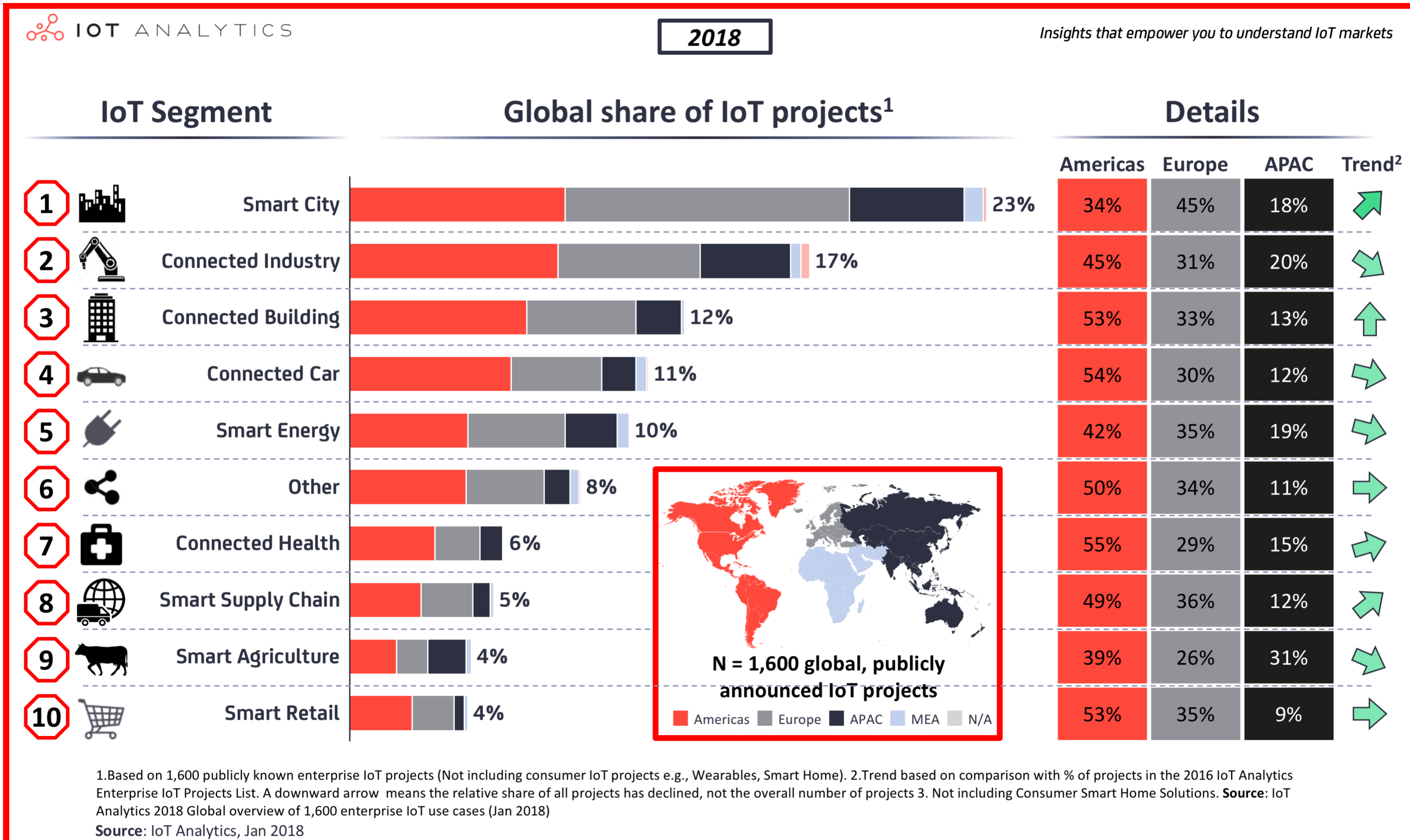
STREETLINE
CONNECTING THE REAL WORLD

Using embedded street sensors, users can identify real-time availability of parking spaces on their phone. City officials can manage and price their resources based on actual use.

AND QUICKLY ADVANCING



IoT Segment Popularity: 2018



#	IoT Segment	Global share of IoT projects[1]	Americas	Europe	APAC	Trend[2]
1	Smart City	23%	34%	45%	18%	↗
2	Connected Industry	17%	45%	31%	20%	↘
3	Connected Building	12%	53%	33%	13%	↑
4	Connected Car	11%	54%	30%	12%	→
5	Smart Energy	10%	42%	35%	19%	→
6	Other	8%	50%	34%	11%	→
7	Connected Health	6%	55%	29%	15%	→
8	Smart Supply Chain	5%	49%	36%	12%	↗
9	Smart Agriculture	4%	39%	26%	31%	↘
10	Smart Retail	4%	53%	35%	9%	→

1.Based on 1,600 publicly known enterprise IoT projects (Not including consumer IoT projects e.g., Wearables, Smart Home). 2.Trend based on comparison with % of projects in the 2016 IoT Analytics Enterprise IoT Projects List. A downward arrow means the relative share of all projects has declined, not the overall number of projects 3. Not including Consumer Smart Home Solutions. **Source**: IoT Analytics 2018 Global overview of 1,600 enterprise IoT use cases (Jan 2018)

Source: IoT Analytics, Jan 2018

The Periodic Table of IoT

An overview of key private companies, investors and strategic acquirers in the Internet of Things

Symbol --> Jw
Firm Name --> Jawbone

created by CB INSIGHTS

- Wearable Tech
- Connected Home
- Building blocks/platforms
- Industrial Internet
- Healthcare
- In-store Retail Tech
- Connected Car
- VC Firms
- Corporate Investors
- Angel Investors
- Accelerators/Incubators
- Crowdfunding
- Acquirers
- Notable Acquisitions and IPOs

Jw Jawbone																	
Ft Fitbit	Wt WiThings	Ri Recon Instruments															
Mc MC10	Mf Misfit Wearables	Vc Valencell															
Qt Quanttus	Pb Pebble Technology	Fl FiLIP Technologies	Ic iControl Networks	Al Alarm.com	Sa Savant Systems	Ss Simplisafe	Jt Jasper Technologies	If IFTTT	Ph Phunware	Lb LittleBits Electronics	Th 3D Robotics	Aw Airware	Pr Proteus Digital Health	St Sotera Wireless	Rn RetailNext	Pl Placemeter	In Inrix
Zp Zepp Labs	Lu LUMO BodyTech	Sh Soundhawk	Vi Vivint	Le Leeo	Am AlertMe	Cn Canary	Im Impinj	Mu mCube	Sf SigFox	Sp Spark OS	Cy CyPhy Works	En Enlighted	Ac AliveCor	Tc Telcare	Eu Euclid	By Bytelight	Ar Airbiquity
Om OM Signal	At Athos Works	Na Narrative	Ps Prodea Systems	Gw GreenWave Reality	Td Tado	Lx Lifx	An Ayla Networks	Is Ineda Systems	Ei Electric Imp	Id iDevices	Rt ReThink Robotics	Lr Liquid Robotics	Ir iRhythm Technologies	Os Orthosensor	Nm Nomi	Ps Prism Skylabs	Nv Navdy
Tl Thalmic Labs	Se Sensoria	Wi Wearable Intelligence	Ag August	Zn Zonoff	Bt BOT Home Automation	Nj Ninja Blocks	Gs GainSpan Corporation	Ay Arrayent	Ev EVRYTHNG	Qr Quirky	Ha Harvest Automation	Rx Robotex	Sc Scanadu	Sn Senseonics	Es Estimote	Sw Swirl Networks	Zb Zubie

Tr True Ventures	Kp Kleiner Perkins	Bg Box Group	It Intel Capital	Qv Qualcomm Ventures	Mm Matt Mullenweg	Rg R/GA Techstars
Fr First Round Capital	Sq Sequoia Capital	Sv SV Angel	Ci Cisco Investments	Gv Google Ventures	Kv Kal Vepuri	Lm Lemnos Labs
Kh Khosla Ventures	Fd Foundry Group	Sc Social+Capital Partnership	Ms Motorola Solutions VC	Ge General Electric	Sb Scott Belsky	Yc Y Combinator
Lhv Lerer-Hippeau Ventures	Nea New Enterprise Associates	Hv Horizons Ventures	Vz Verizon Ventures	Tv T-Venture	Tc Tech Coast Angels	Rh Rock Health
Fe Felicis Ventures	Nw Norwest VP	Fm Formation 8	Fx Foxconn Tech Group	Sv Samsung Ventures	Lp Launchpad Venture Group	Ks Kickstarter
Dcm Doll Capital Management	Ah Andreessen Horowitz	Gp Greylock Partners	Gr Grishin Robotics	Cv Comcast Ventures	Br Bertelsmann Digital Media	Ig Indiegogo

To receive updates to the Periodic Table, visit:

www.cbinsights.com/blog/internet-of-things-periodic-table

Go Google	Pt PTC	Cs Cisco	In Intel	Sm Samsung	Hw Huawei	Md Medtronic	Hn Honeywell	Ar ARM	Ts Toshiba
Nl Nest Labs	Wz Waze	St Smart Things	Ba Basis Science	Cf Control4	Jx Joulex	Dc Dropcam	Ax Axeda	Tw ThingWorx	Rv Revolv

IoT Case Studies

YOUR BODY

Sensors + Connectivity

CHECK ON THE BABY

Aimed at helping to prevent SIDS, the Mimo monitor is a new kind of infant monitor that provides parents with real-time information about their baby's breathing, skin temperature, body position, and activity level on their smartphones.

VITALITY™

REMEMBER TO TAKE YOUR MEDS

GlowCaps fit prescription bottles and via a wireless chip provide services that help people stick with their prescription regimen; from reminder messages, all the way to refill and doctor coordination.

YOUR HOME

Remotely monitor and manage your home and cut down on your monthly bills and resource usage

works with nest

HEAT YOUR HOME EFFICIENTLY

Smart thermostats like the Nest use sensors, real-time weather forecasts, and the actual activity in your home during the day to reduce your monthly energy usage by up to 30%, keeping you more comfortable, and offering to save you money on your utility bills.

MAKE SURE THE OVEN IS OFF

Smart outlets like the WeMo allow you to instantly turn on and off any plugged in device from across the world or just your living room. Save money and conserve energy over time by eliminating standby power, measure and record the power usage of any device, and increase its operating lifespan through more efficient use and scheduling.

amazon echo

Always ready, connected, and fast. **Just ask.**

"Alexa, find me a Chinese restaurant."

"Alexa, re-order paper towels."

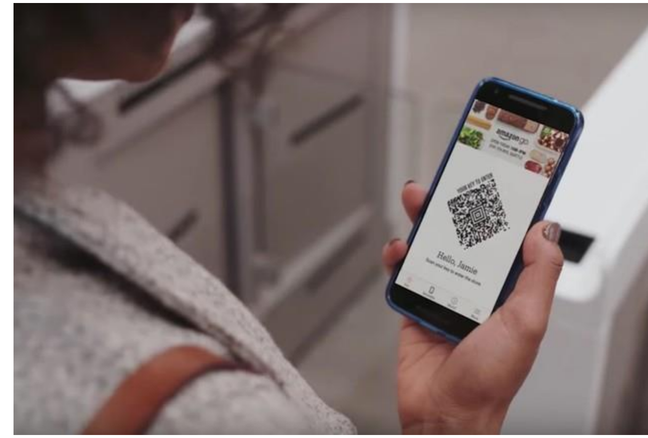
"Alexa, what's on my calendar today?"

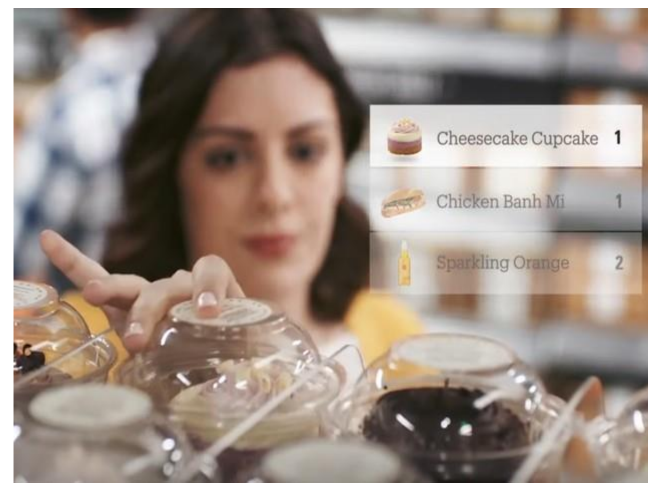
"Alexa, set a timer for 20 minutes."

"Alexa, play Adele from Prime Music."

"Alexa, what's my commute?"

amazon go





No lines. No checkouts. … No cashier jobs?

YOUR CITY

Engage with the data exhaust produced from your city and neighborhood

Bigbelly

CHANGE YOUR SPACE

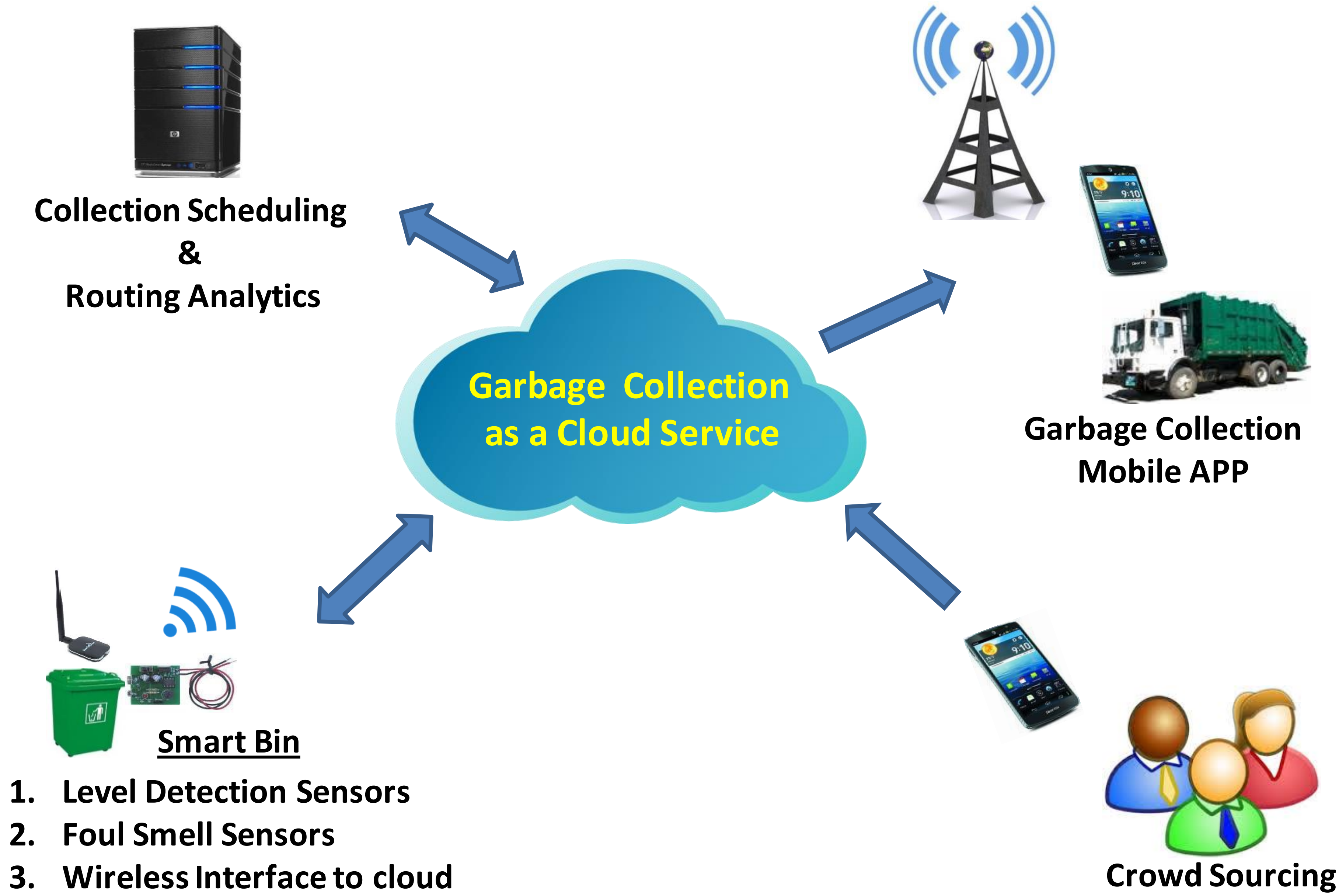
KEEP STREETS CLEAN

Products like the cellular communication enabled Smart Belly trash use real-time data collection and alerts to let municipal services know when a bin needs to be emptied. This information can drastically reduce the number of pick-ups required, and translates into fuel and financial savings for communities service departments.

garbo

Smart Garbage Bins

System Architecture



Proposed Solutions

- Solution 1: Independent Module
  - Retrofitting into the existing Garbage Bins
  - Pros:
    - No need to change the infrastructure
  - Cons:
    - Will our sensor work for both metal & plastic bins
    - Placement of sensors because of different variety of bins
    - Damages are anticipated

- Solution 2: Indigenous bin along with module
  - Design & development of completely new bin
  - Pros:
    - Anywhere, Anyplace can be installed
    - System will be customized for upcoming IOT environment
  - Cons:
    - Infrastructure cost

PUBLIC AWARENESS

Hardware Specifications

Sensors
Ultrasonic Sensors
Foul Smell Sensors (NH_3, H_2S, CH_3SH)
Temperature Sensor

Processor
ARM 7TDMI or Cortex M0+/M3/M4

Wireless Connectivity
GSM (900/1800/2100)
LoRa (868 Mhz)

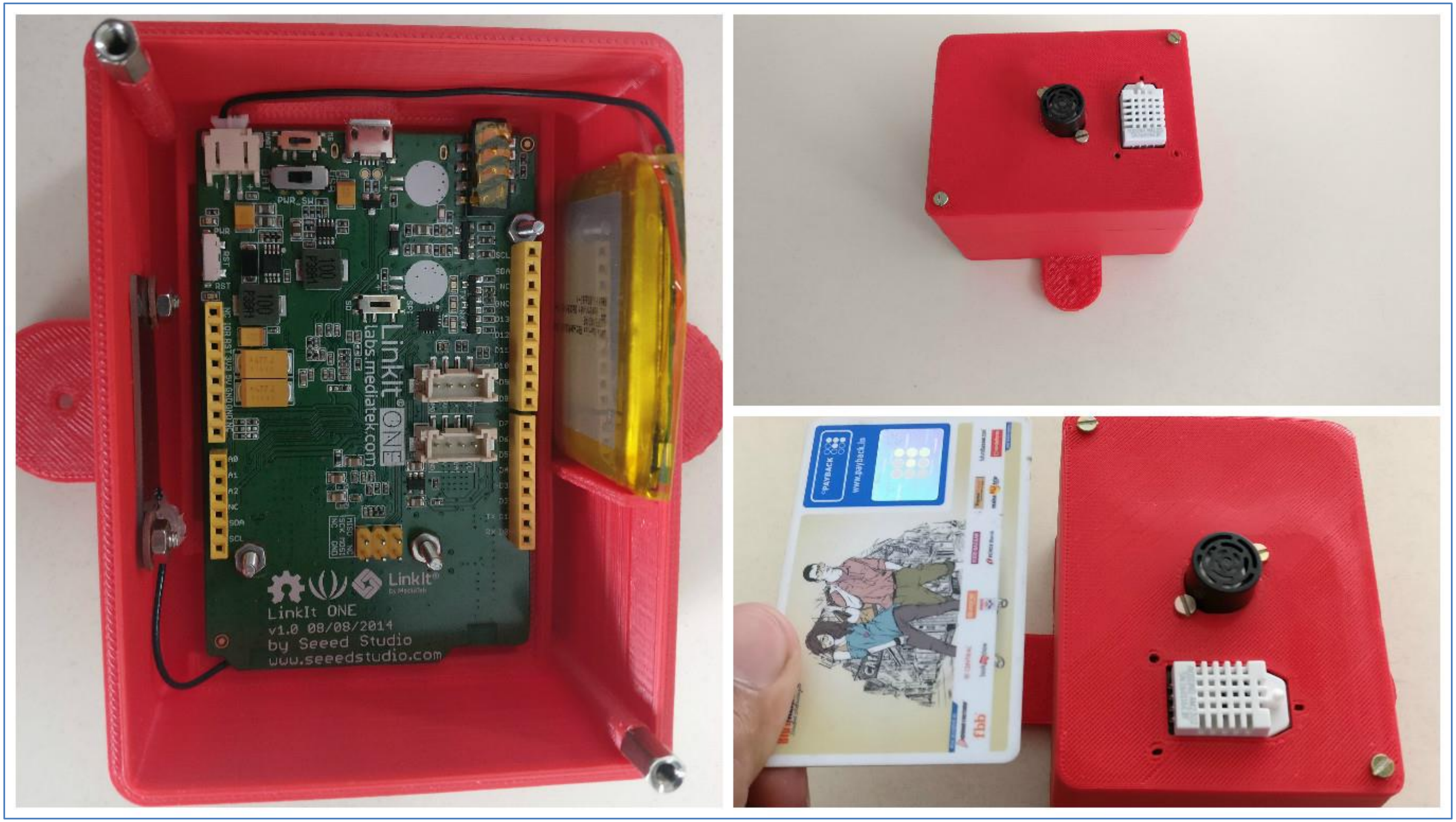
Environmental Protection
IP 66

Power
Lithium Battery
Solar

Others
QR code

Proposed Hardware for PoC

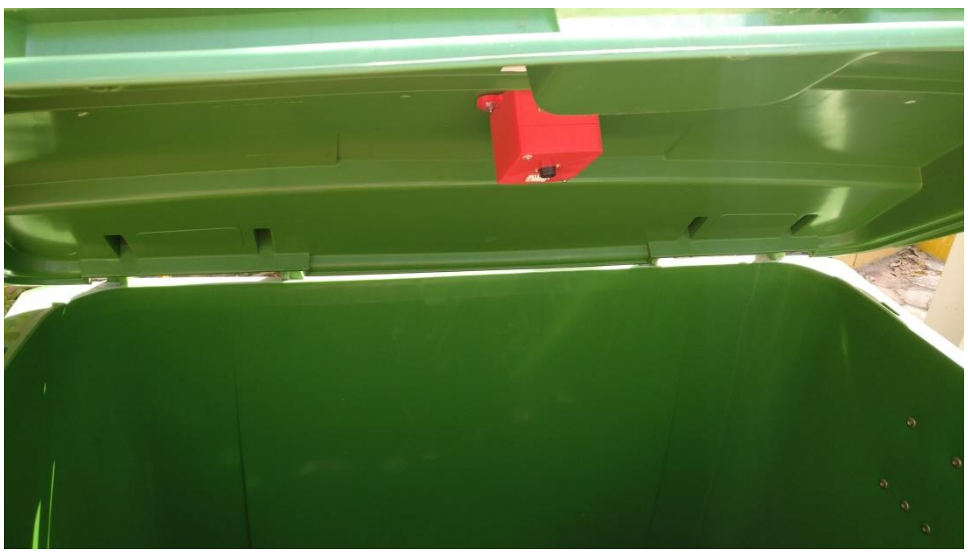
Garb0 Module: Prototype



9.76 x 7.45 cm

Testing

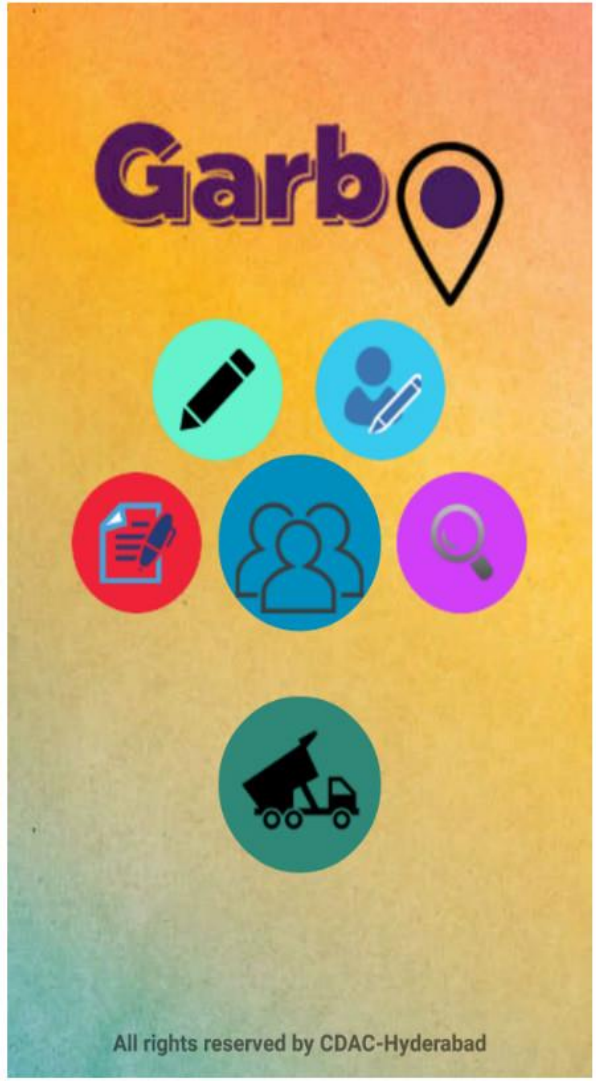
Deployment (PoC)

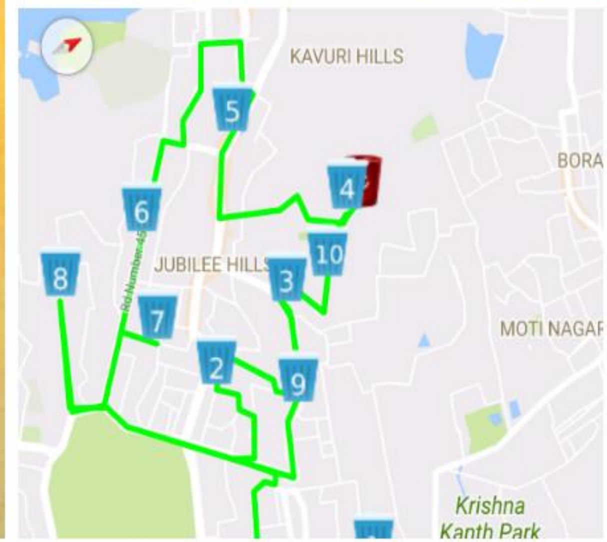


Garb0 v1.0

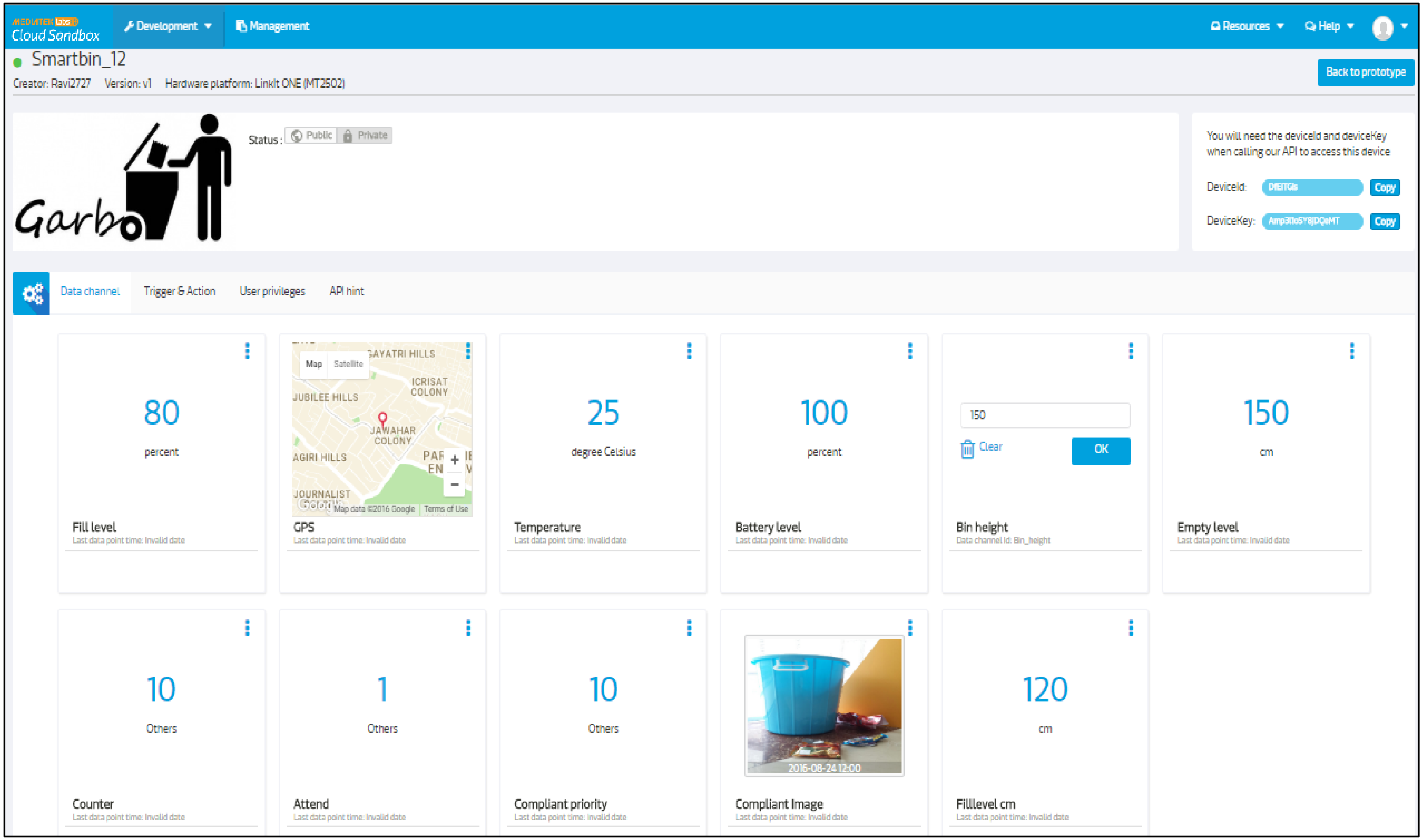
Garb0 v2.0

Garb0 Mobile APP (Android)

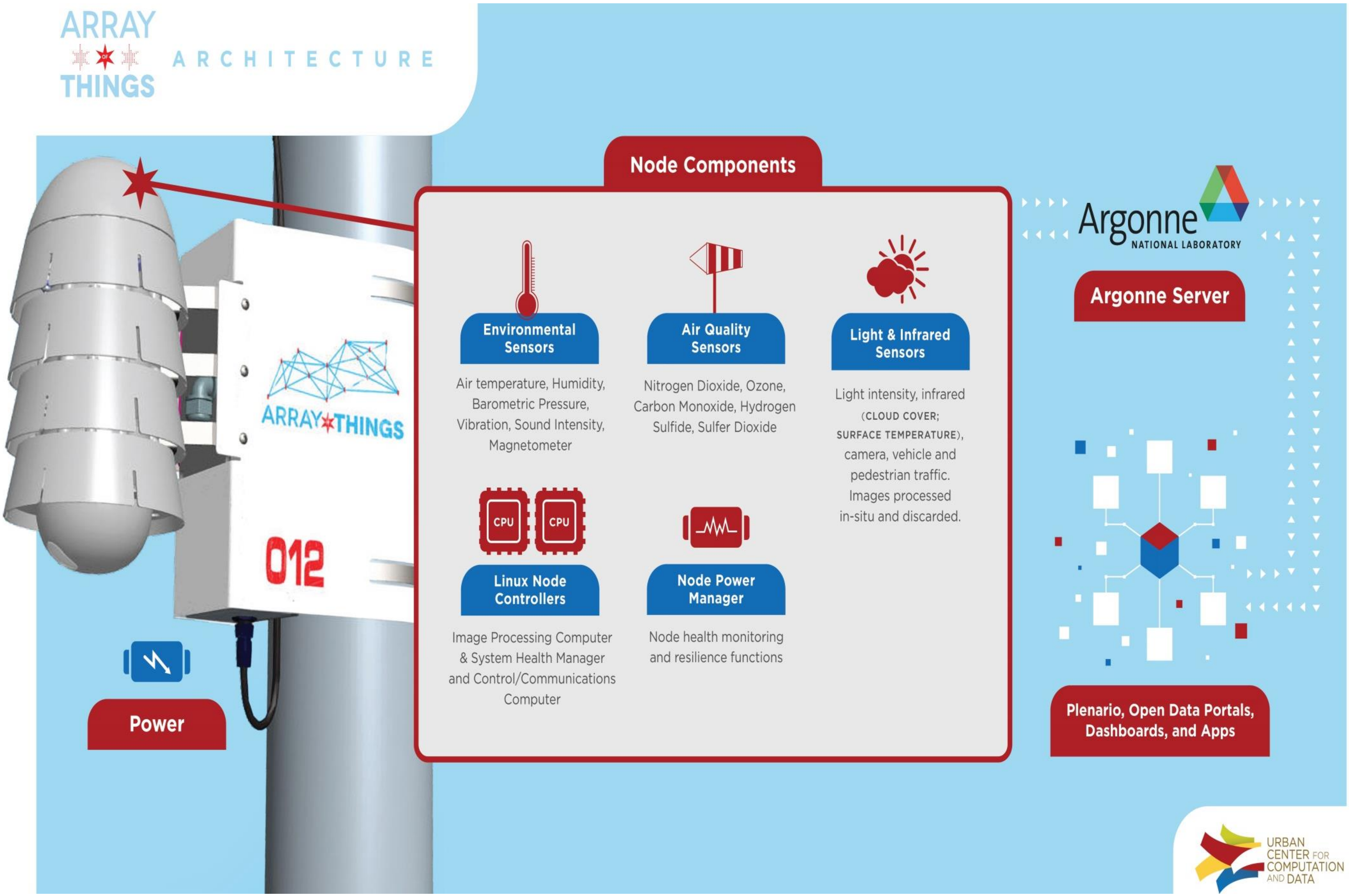


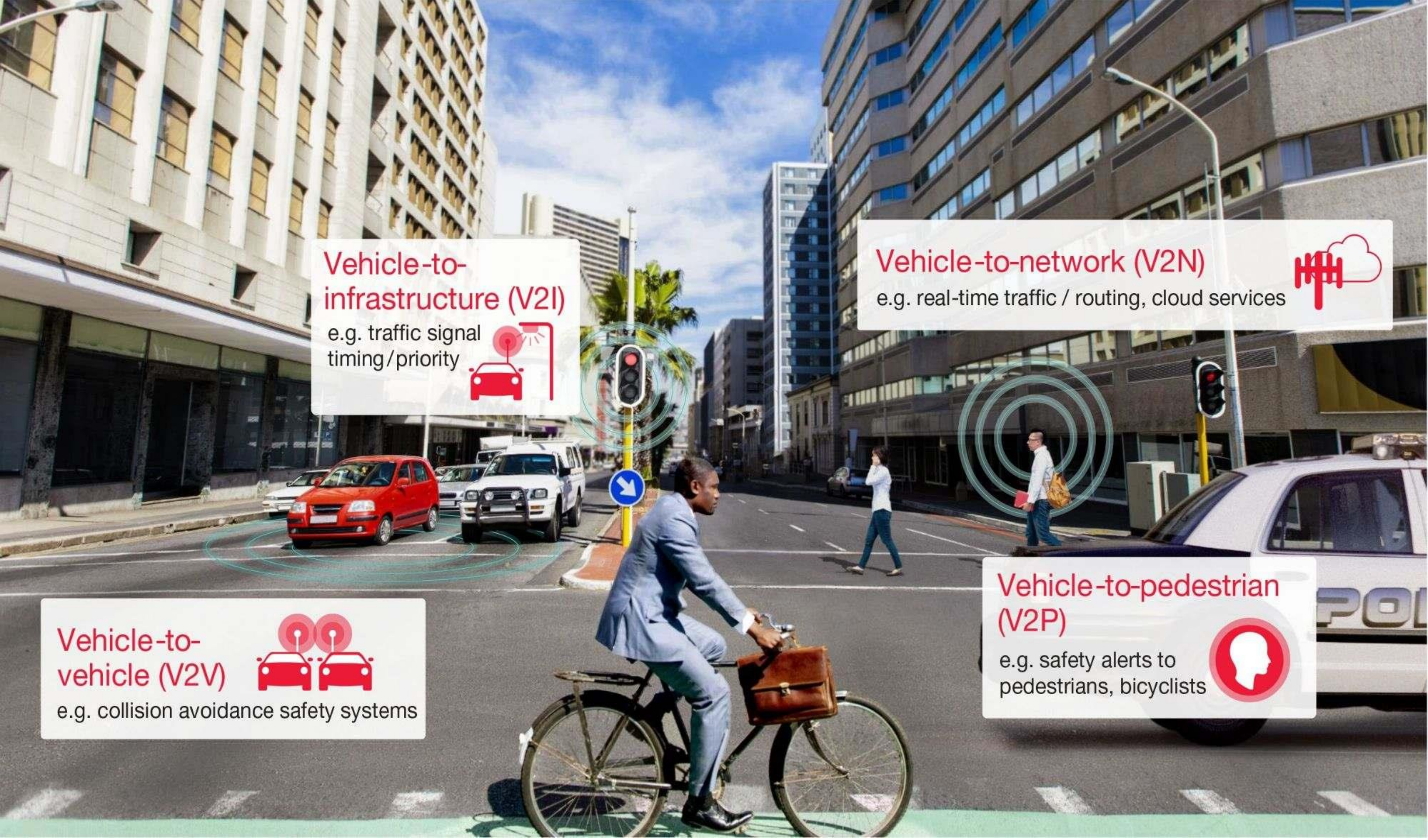


Garb0 Cloud

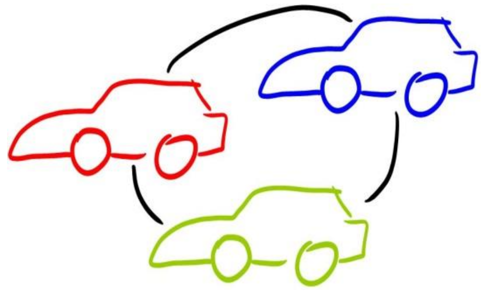


Cloud Sandbox
Development
Management
Resources
Help
Smartbin_12
Creator: Ravi2727 Version: v1 Hardware platform: LinkIt ONE (MT2502)
Back to prototype
Garbo
Status : Public Private
You will need the deviceId and deviceKey when calling our API to access this device
DeviceId:
Copy
DeviceKey:
Copy
Data channel
Trigger & Action
User privileges
API hint
80
percent
Fill level
Last data point time: Invalid date
GPS
Last data point time: Invalid date
25
degree Celsius
Temperature
Last data point time: Invalid date
100
percent
Battery level
Last data point time: Invalid date
150
Clear
OK
Bin height
Data channel Id: Bin_height
150
cm
Empty level
Last data point time: Invalid date
10
Others
Counter
Last data point time: Invalid date
1
Others
Attend
Last data point time: Invalid date
10
Others
Compliant priority
Last data point time: Invalid date
2016-08-24 12:00
Compliant Image
Last data point time: Invalid date
120
cm
Filllevel cm
Last data point time: Invalid date


ARRAY OF THINGS ARCHITECTURE
Node Components
Environmental Sensors
Air temperature, Humidity, Barometric Pressure, Vibration, Sound Intensity, Magnetometer
Air Quality Sensors
Nitrogen Dioxide, Ozone, Carbon Monoxide, Hydrogen Sulfide, Sulfer Dioxide
Light & Infrared Sensors
Light intensity, infrared (CLOUD COVER; SURFACE TEMPERATURE), camera, vehicle and pedestrian traffic. Images processed in-situ and discarded.
CPU
CPU
Linux Node Controllers
Image Processing Computer & System Health Manager and Control/Communications Computer
Node Power Manager
Node health monitoring and resilience functions
Power
ARRAY OF THINGS
012
Argonne NATIONAL LABORATORY
Argonne Server
Plenario, Open Data Portals, Dashboards, and Apps
URBAN CENTER FOR COMPUTATION AND DATA


Vehicle-to-infrastructure (V2I)
e.g. traffic signal timing/priority
Vehicle-to-network (V2N)
e.g. real-time traffic / routing, cloud services
Vehicle-to-vehicle (V2V)
e.g. collision avoidance safety systems
Vehicle-to-pedestrian (V2P)
e.g. safety alerts to pedestrians, bicyclists

SAFETY ALERT SYSTEMS USING DEDICATED SHORT RANGE COMMUNICATION FOR ON ROAD VEHICLES (SAFEDRIVE)



Centre for Development of Advanced Computing
A Scientific Society of Ministry of Electronics and Information Technology (MeitY)
Government of India

Problem Statement

India has the highest number of road accidents in the world

Road accidents have earned India a dubious distinction. The country has overtaken China and now has the worst road traffic accident rate worldwide.

Indian roads witness one accident every minute and one death in road mishaps every four and a half minutes

In India alone, the death toll rose to 14 per hour



Source: WHO

Accidents: Status

Accidents reported in India

Year	2001	2002	2003	2004	2005	2006	2007
Total Nos.	99516	99772	102951	111794	118265	131652	140560

Year	2008	2009	2010	2011	2012	2013	2014	2015
Total Nos.	144587	152689	161736	165072	168301	166506	169107	177423

Source: ACCIDENT - Statistical Year Book India 2017

Fault of driver	78.5%
Fault of pedestrian	2.2%
Fault of cyclist	1.2%
Defect in road conditions	1.3%
Defect in condition of motor vehicle	1.8%
Weather condition	0.8%
All other causes	14.2%

Need of the Hour

Need for Vehicular Communication Systems

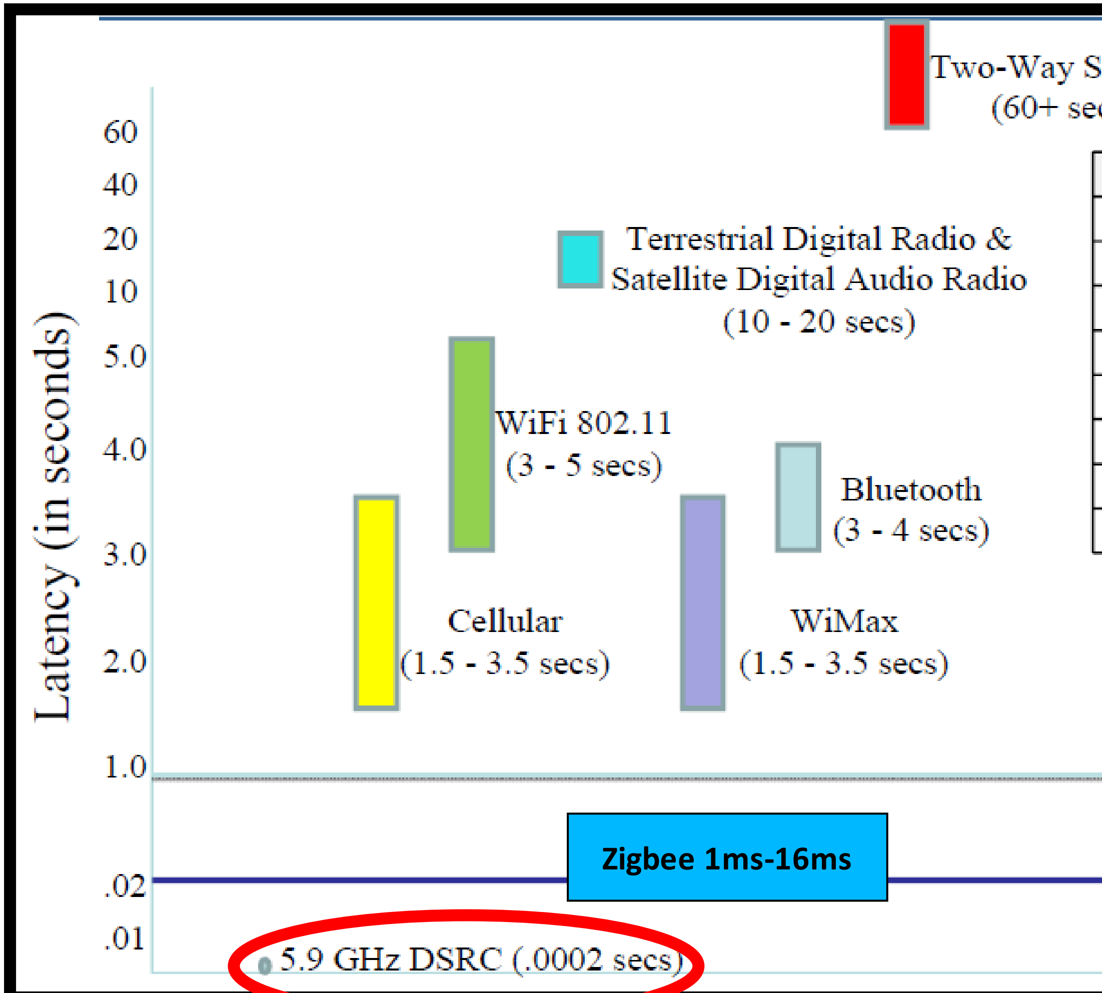
Inform drivers

- Vehicles suddenly changing lanes
- Potholes and slippery patches of roadway ahead
- Blind spots ahead

Inform traffic managers

- Location of Emergency Vehicles
- Diversion of Traffic

Safety Communication Requirements



Active Safety Latency Requirements (secs)	
Traffic Signal Violation Warning	0.1
Curve Speed Warning	1.0
Emergency Electronic Brake Lights	0.1
Pre-Crash Sensing	0.02
Cooperative Forward Collision Warning	0.1
Left Turn Assistant	0.1
Lane Change Warning	0.1
Stop Sign Movement Assistance	0.1

Source:- DOT, USA

Dedicated Short Range Communication (DSRC)

Emerging **Wireless Communication** Standard for **Vehicular Communication** featuring

- ❑ **Vehicle to Vehicle communications (V2V)**
- ❑ **Vehicle to Infrastructure communications (V2I)**

Medium range wireless communication channels specifically designed for automotive use

The cars in front of you could send you information about dangerous road conditions ahead, such as icy roads, fog, heavy rain, and snow

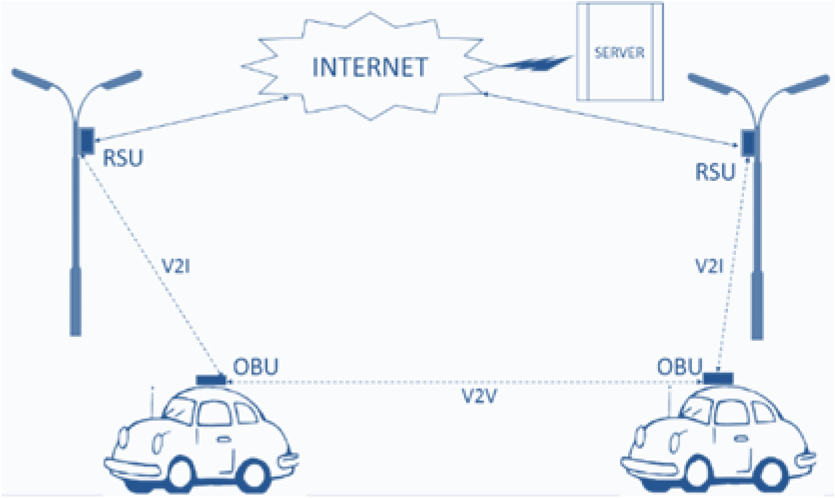
Provide drivers with warnings to help them avoid incidents such as:

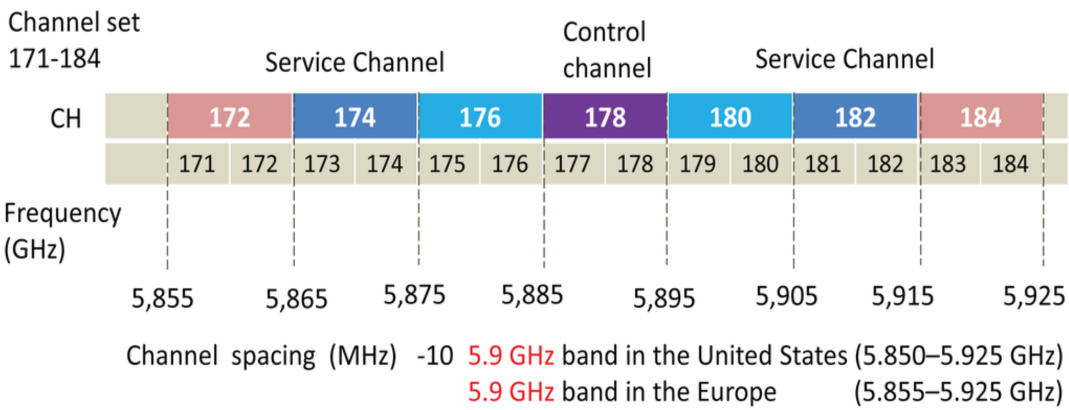
- Veering close to the edge of the road
- Vehicles suddenly stopped ahead
- Collision paths during merging
- Sharp curves or slippery patches of roadway ahead

DSRC Elements & Architecture

The System consist of a network of

- **On Board units (OBUs)**
  - mounted in vehicles
- **Road-side units (RSUs)**
  - typically mounted at intersections on traffic lights or at lamp posts
- **Server**





Seven 10 MHz Channels
1 Control Channel (CCH)
6 Service Channels (SCH)

- 5.9GHz frequency band with a bandwidth of 75MHz
- Transmitter power ranges from 0dBm to 28.8dBm
- Range vary from 10 m to 1Km

On Board Unit (OBU)

OBU is the device installed in a vehicle

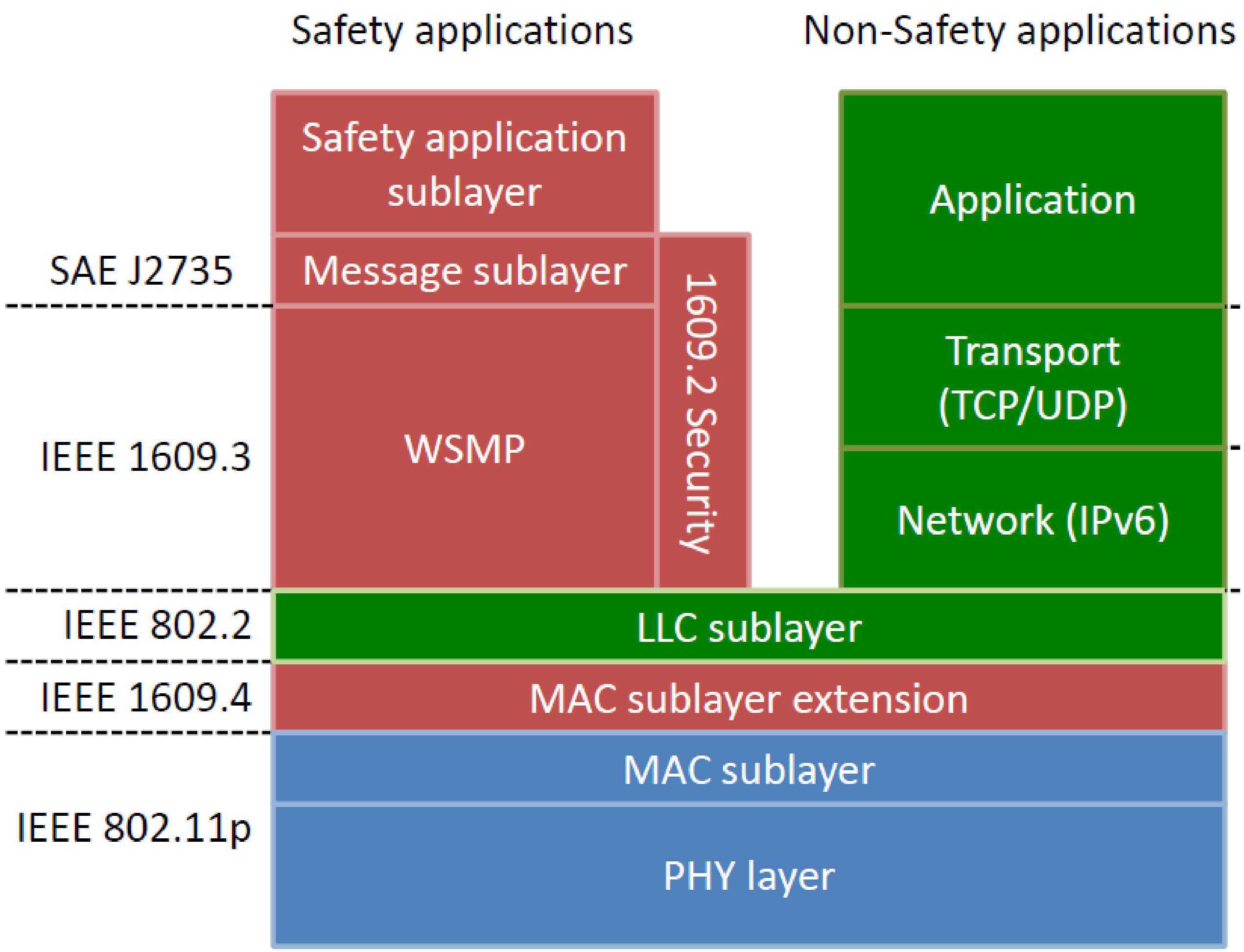
- Connected to DSRC network and to in-vehicle network
- Provide direct V2V wireless communication
- Collect the vehicle diagnostic message via CAN interface

Road Side Unit (RSU)

- **RSU are devices, which are installed near the roadside junctions on traffic lights or lampposts on the roads**

- **It gathers information such as road information, weather information, event information, and other service information and communicates the information to the OBU**

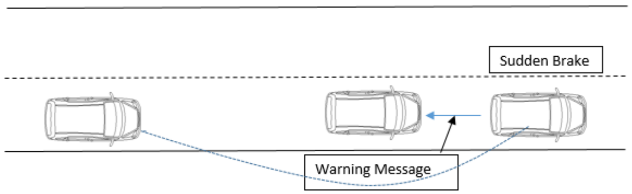
DSRC – Communication Stack

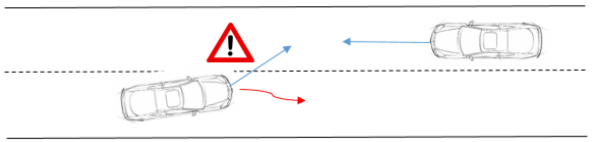


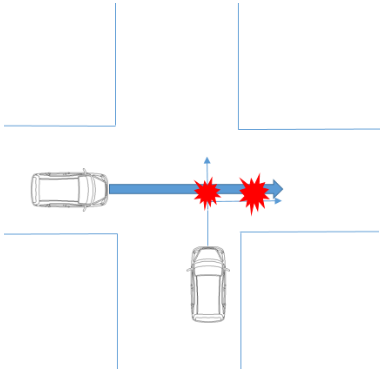
DSRC Applications

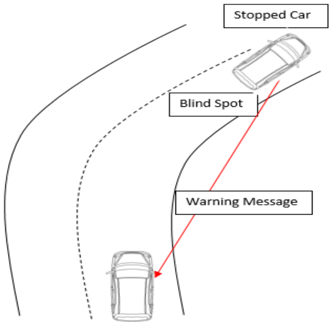
Potential Applications

- Emergency Electronic Brake Lights
- Lane Change Assistance
- Intersection Collision Warning
- Blind Spot Warning
- Electronic Parking Management
- Electronic Toll Collection
- Electronic Road Pricing
- Vehicle Safety Inspection
- Transit or Emergency Vehicle Signal priority









DSRC Applications

V2V Applications

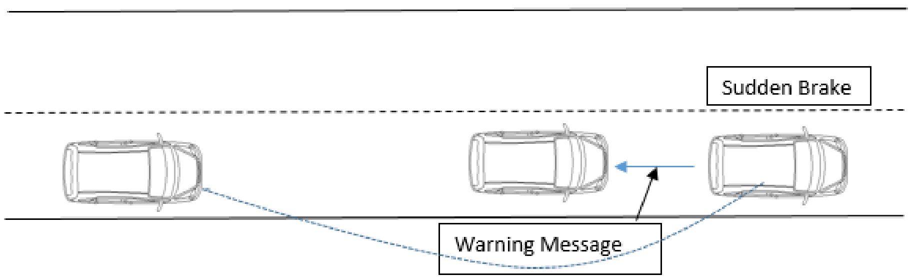
Forward Collision Warning

V2I Applications

Speed Limit Warning

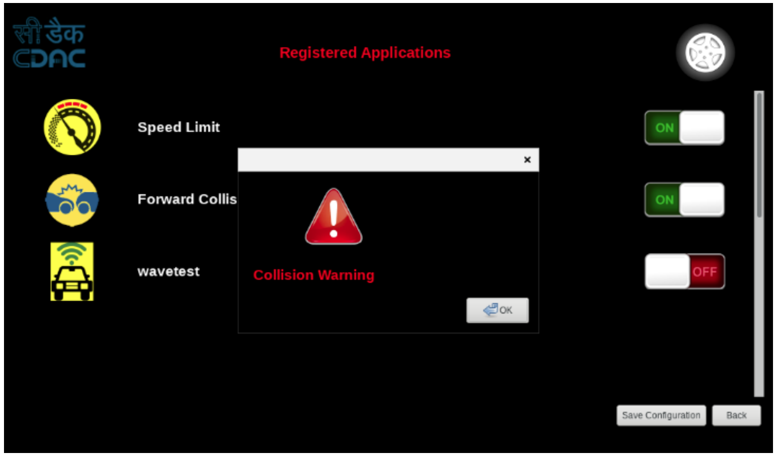
Forward Collision Warning

Alerts driver about the stopped or low speed rear end vehicles in the forward path of travel



The OBU's broadcasted the Basic Safety Messages (BSM) every 100ms, which contains its position, velocity, heading, and acceleration

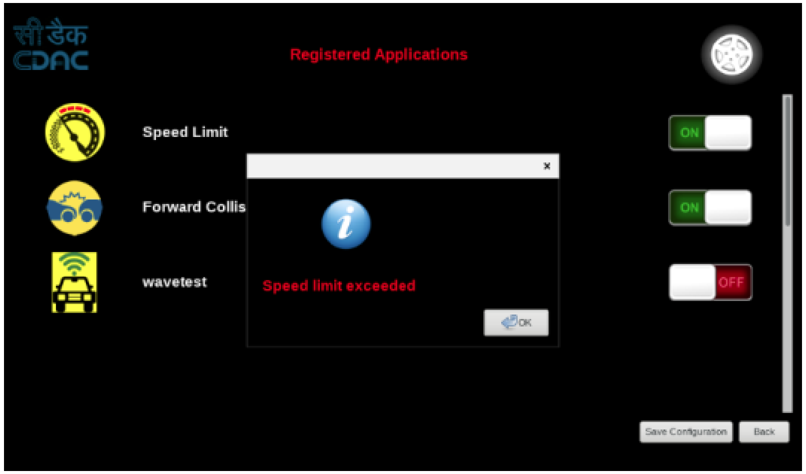
- The algorithm running in OBU will mark its position relative to other vehicle (front, back and sides)
- Computes the relative velocity of the vehicle
- OBU will issue a warning message, if the computed time to collide is lesser than the threshold value



Speed Limit Warning

Notify driver once the vehicle exceeds the permitted speed in a geographical area.

- RSU module broadcasts the maximum speed in an area
- OBU's in the vicinity of the RSU will receive this message
- Algorithm running in the OBU will calculate whether its current position is within the polygon or not



Field Trial

Installation & Commissioning

- Field trial of the system has been successfully carried out at **Srisailam Highway**, **Hyderabad**

Originality of Approach and Thinking

- The OBU and RSU along with the DSRC software stack developed provides an **indigenous system for Indian markets** for addressing the V2V and V2I applications, employing DSRC standard.

- Came with up with a **DSRC Development Kit** targeting academic and research Institute for developing DSRC applications

Potential Societal Impact of Work

The SAFEDRIVE system, with its OBU and RSU architecture is poised to become the go-to technology to provide number of benefits like Road Safety, Realtime Road Information and Seamless Infotainment Services

- **Road safety:** Collision Avoidance, Blind Curve Warnings, Stranded Vehicle Alerts, Alerts in low visibility like Fog or Rainy Conditions
- **Road Side Alerts:** Traffic Status, Alternate Route, Road Repairs, Speed Limits, School or Hospital Zone information
- **Automated Toll Collection:** Eases congestion for Toll Zones by providing a prepaid and drive through feature
- **Advertisements:** Can be used for advertising on Highways, alerting commuters on close proximity of Fuel Stations, Food Stations, Rest Rooms
- **Priority Vehicle Pass:** Allows Ambulances and VIP vehicles a priority pass at busy intersections and junctions
- **Seamless Infotainment Services**

सी डैक
CDAC
www.cdac.in

SAFEDRIVE

Safety Alert Systems using Dedicated Short Range Communication for on Road Vehicles

An indigenous Dedicated Short Range Communication (DSRC) System for vehicles comprising of On Board Unit and Road Side Unit with DSRC Software Stack. The system would enable two-way communication that can contribute to safer driving and also provide various applications that use the secure Vehicle to Vehicle (V2V) communications and Vehicle to roadside Infrastructure (V2I) communications.

ON BOARD UNIT (OBU)

- Dual DSRC Radio
- Range up to 400 meters (LoS)
- Integrated with Bluetooth and GPS
- USB Interface for external devices
- Audio/Display alerts for drivers
- CAN Interface
- 7'' touch screen display (optional)
- Vehicle Battery powered
- Internal Battery backup
- Supports WAVE Standard
- Multi-channel synchronization
- Supports switching between control and service channels
- SDK for application development

ROAD SIDE UNIT (RSU)

- Dual DSRC Radio
- Supports WAVE standard
- Ethernet with POE
- Wi-Fi Interface
- Ingress Protection: IP65
- Pole / Wall mounting
- 4G LTE Backbone connectivity
- Power Source : 12V DC/Solar
- External sensor Interface : Fog / Rainfall

DSRC Software Stack

- IEEE 802.11p compliant MAC
- IEEE 1609.4 compliant Multichannel operation
- IEEE 1609.3 compliant Network services (WAVE Short Message Protocol)
- IEEE 1609.2 compliant Wireless Security

Applications

Extended Signage & Road Alerts using V2I communications | Low visibility alerts during foggy, rainy & low light conditions | Stranded/Stationery vehicle alerts | Upcoming road intersections, cross roads, curved roads , speed limit regions, blind spots & weather conditions | Road diversion alerts due to repairs & work in progress | Toll road ahead alerts & fare information

Learn More About How IoT is Changing the Game

SPECULUR®
SMART WEARABLES

A computer of the size of button! 32 bit microprocessor, 384 KB of Flash, 80KB of SRAM + 6 axis combo sensor with accelerometer and gyroscope, Bluetooth Low energy (BLE), PMIC... all integrated as a module!!

Processor Architecture: x86 !!!

Technology

TCP/IP Model	IoT Model
Application Layer	HTTPS, XMPP, CoAP, MQTT, AMQP
Transport Layer	TCP, UDP
Internet Layer	IPv6, LoWPAN, RPL
Network Access and Physical Layer	IEEE 802.15.4, WiFi(802.11 a/b/g/n), Ethernet(802.3), CDMA, GSM, LTE

- Communication
- Backbone
- Hardware
- Protocols
- Software
- Cloud Platforms

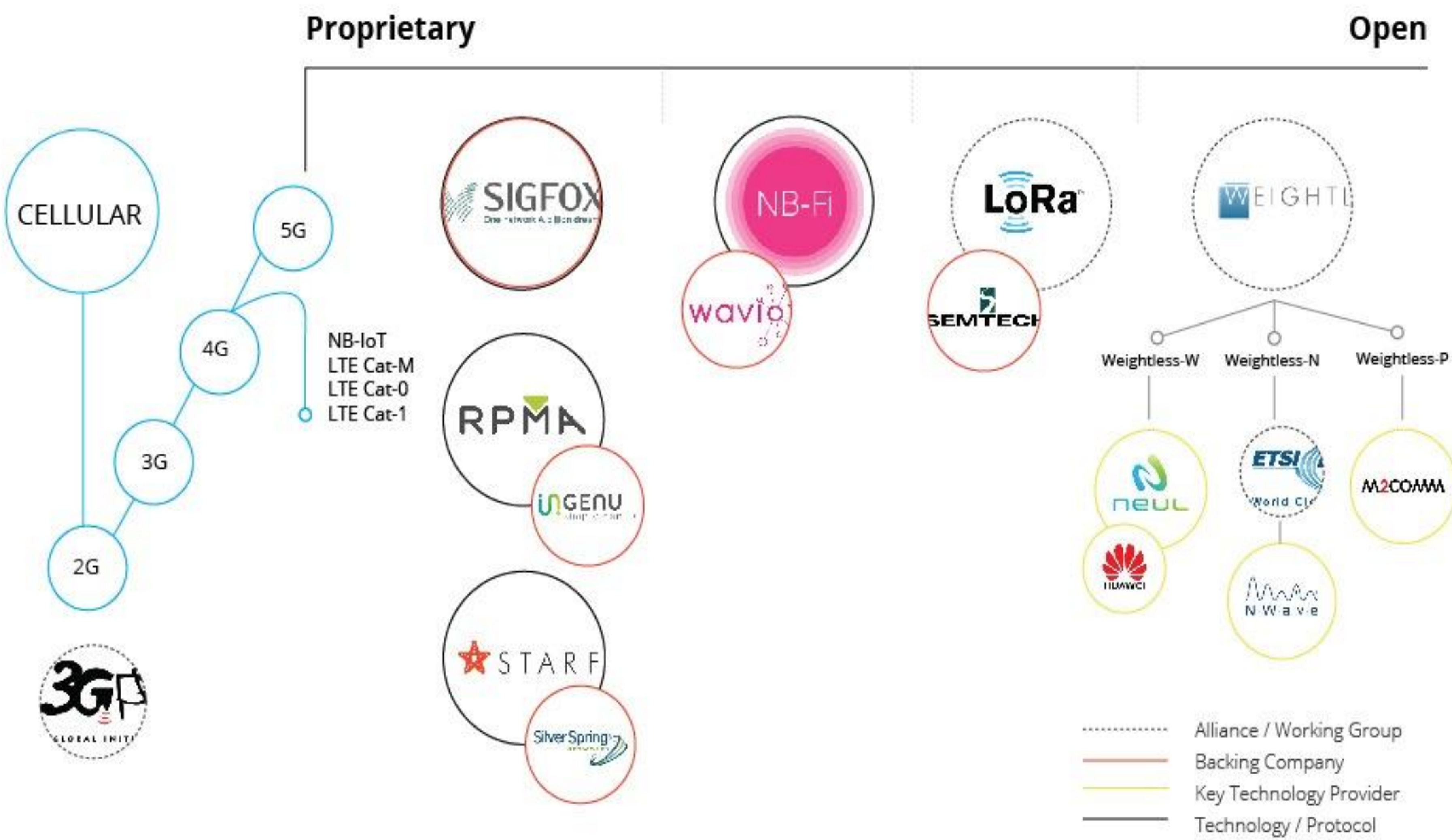
IoT communications are or should be.....

- **Low cost,**
- **Low power,**
- **Long battery duration,**
- **High number of connections,**
- **Low bitrate,**
- **Long range,**
- **Low processing capacity,**
- **Low storage capacity,**
- **Small size devices,**
- **Relaxed latency,**
- **Simple network architecture and protocols**

A few Communication technologies…..

LPWAN Requirements

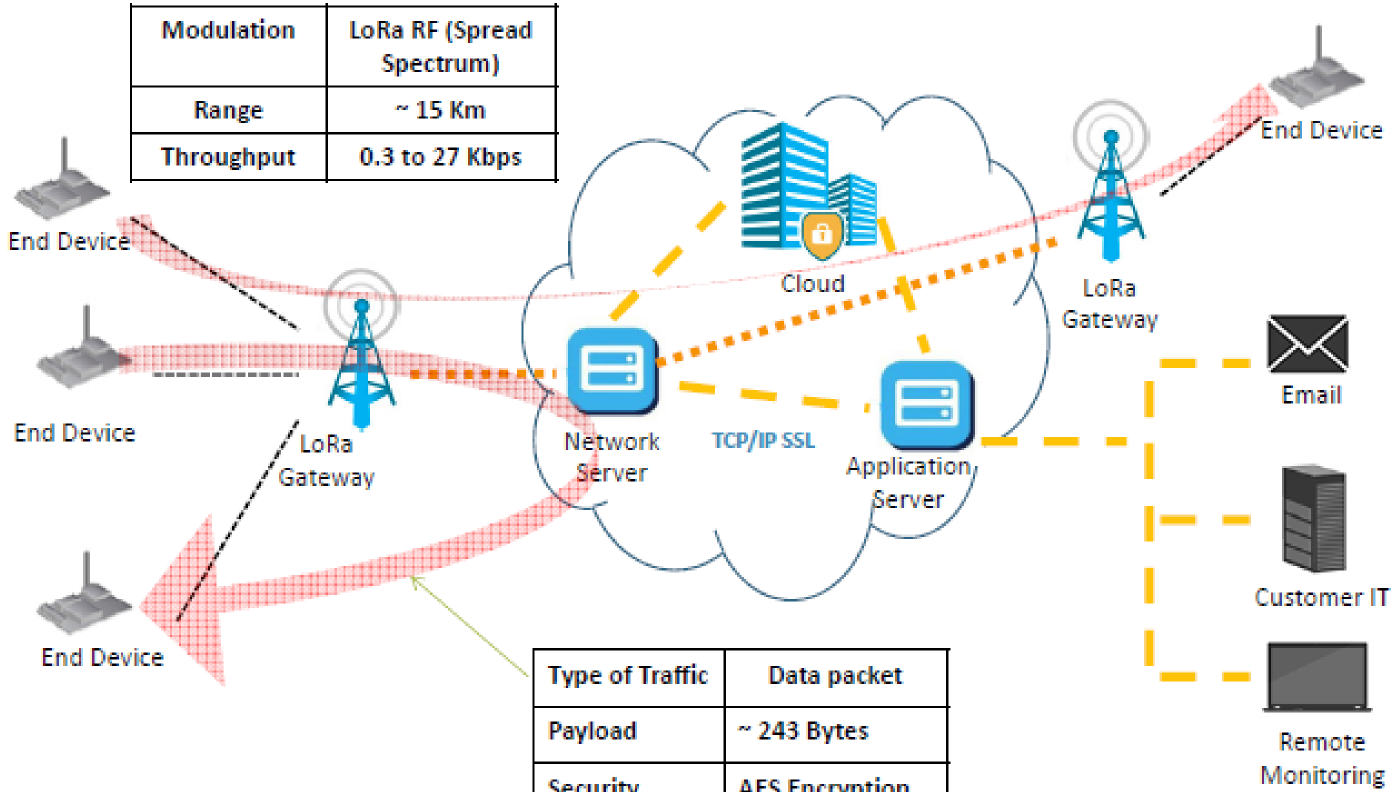
LPWAN IoT Market
(Low-Power Wide Area Network)



LoRaWAN Architecture

Architecture

Modulation	LoRa RF (Spread Spectrum)
Range	~ 15 Km
Throughput	0.3 to 27 Kbps



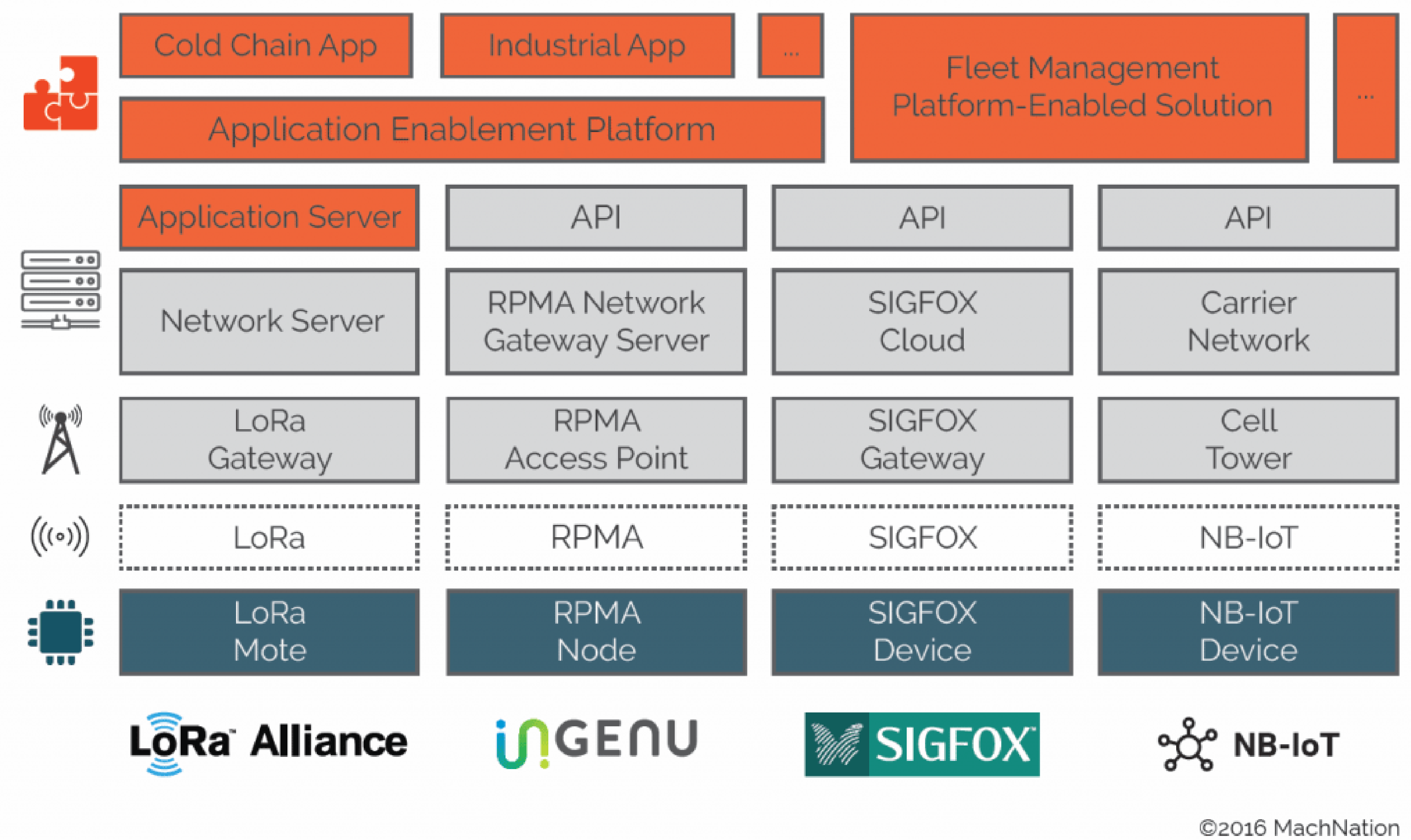
Type of Traffic	Data packet
Payload	~ 243 Bytes
Security	AES Encryption

LoRaWAN: Class of Devices

Classes	Description	Intended Use	Consumption	Examples of Services
A (« all »)	Listens only after end device transmission	Modules with no latency constraint	The most economic communication Class energetically.. Supported by all modules. Adapted to battery powered modules	• Fire Detection • Earthquake Early Detection
B (« beacon »)	The module listens at a regularly adjustable frequency	Modules with latency constraints for the reception of messages of a few seconds	Consumption optimized. Adapted to battery powered modules	• Smart metering • Temperature rise
C (« continuous »)	Module always listening	Modules with a ***strong reception latency constraint*** (less than one second)	Adapted to modules on the grid or with no power constraints	• Fleet management • Real Time Traffic Management

➔ Any LoRa object can transmit and receive data

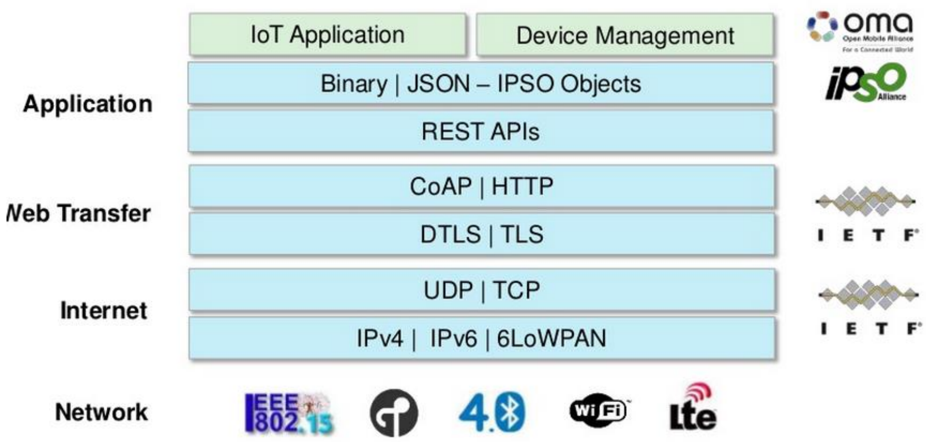
LPWAN: LoRaWAN, RPMA, SIGFOX and NB-IoT

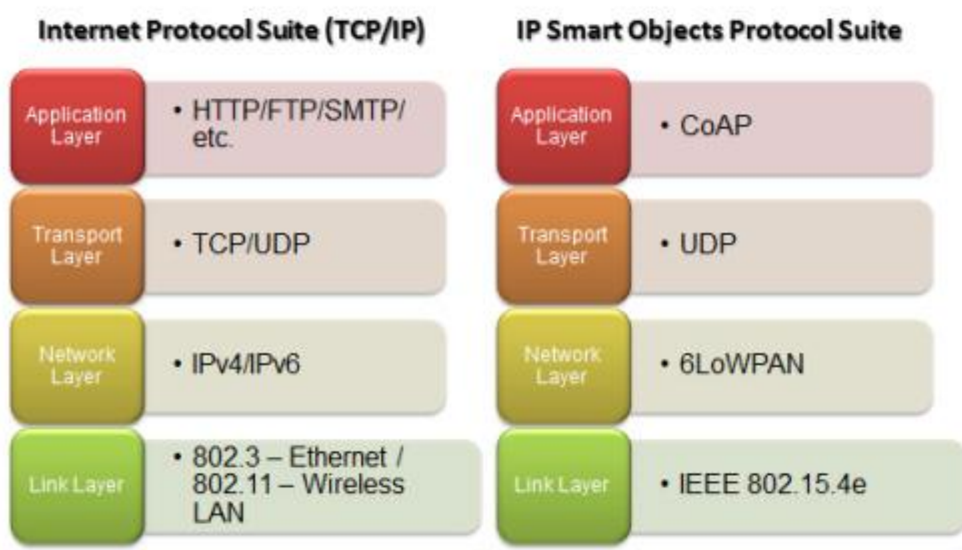


IoT: Blend of Standards

	Short Range	Local Area	Wide Area
Range (typical)	<10m/30ft	<100m/300ft	Outdoor (km/miles)
Content distribution Focus on high data rates	Bluetooth	DIRECT WiFi, WiFi, 6	GSM, Lte
		.11ah: HaLow	5G
Sense and control Low/energy long battery life	Bluetooth SMART	zigbee, THREAD	NB-IoT, GPRS
		ULE	
Proprietary solutions	ANT+	Sub GHz Z WAVE, enocean	LoRa, sigfox, INGENU, WEIGHTLESS
Typical applications	Personal appliances (wristband, smart watch, step counter, keyboard, mouse, pointer, etc.)	Indoor networks (internet, email, phone, security, energy management, home monitoring, etc.)	Outdoor networks (phone, chat, internet, smart city, industry 4.0, agriculture, smart logistics, etc.)

IoT Backbone





IoT Hardware

Prototyping boards and platforms

- Arduino
- Rasberry Pi
- Beaglebone Black
- Linkit One
- ESP32

so on…………………………….

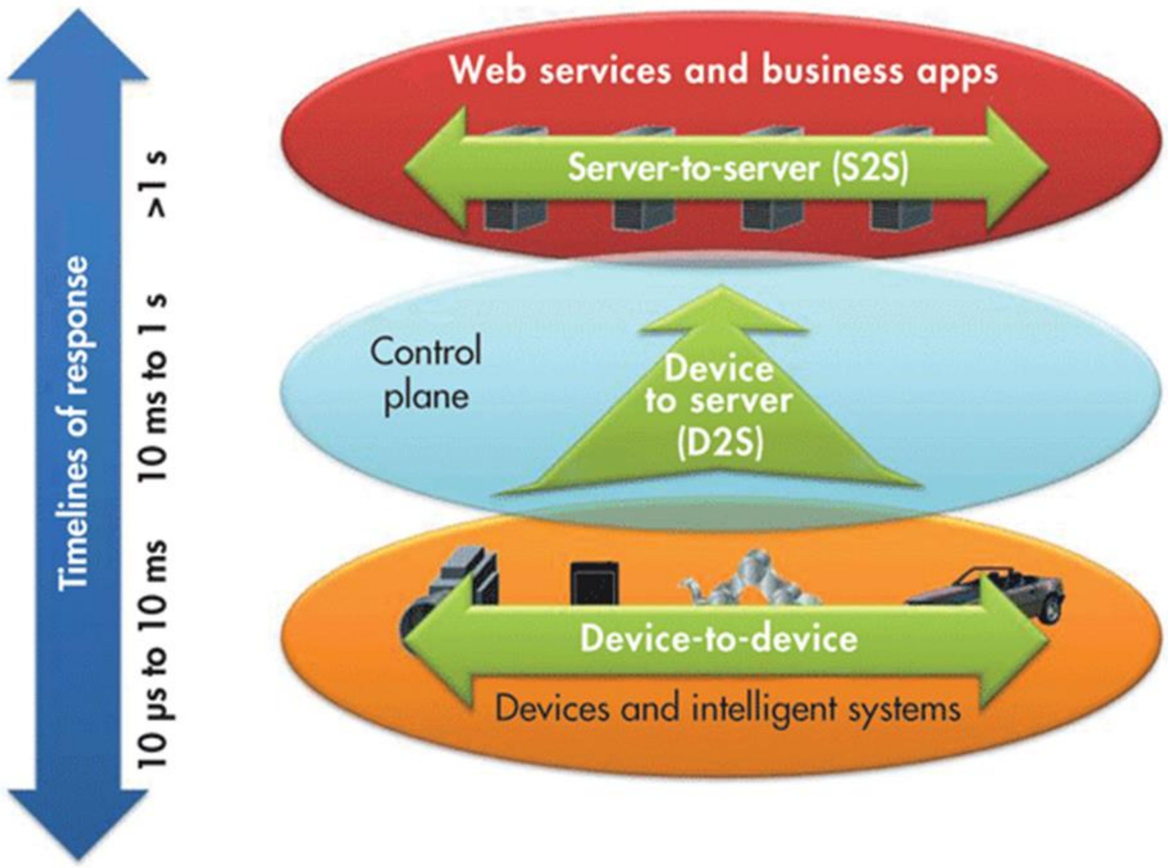
IoT Software

- RIOT
- Contiki
- TinyOS
- Thingsquare Mist

so on……………………

OS	Min RAM	Min ROM
Contiki	< 2kB	< 30kB
Tiny OS	< 1kB	< 4KB
Linux	~ 1MB	~ 1MB
RIOT	~ 1.5kB	~ 5kB

IoT Protocols



IoT protocols war !

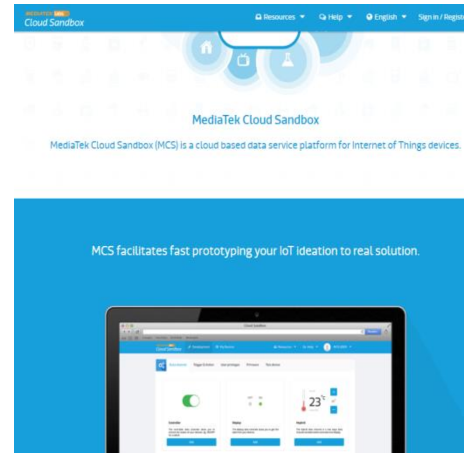
- MQTT
- CoAP
- XMPP
- DDS
- AMQP

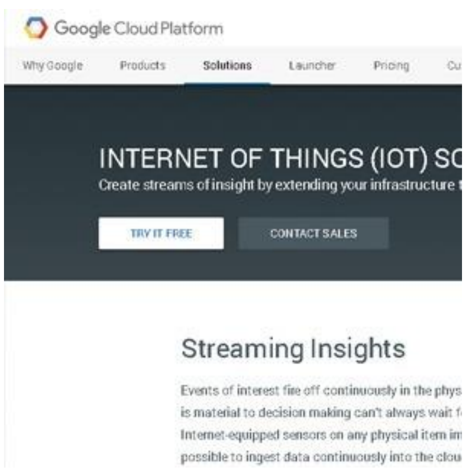
and many more…..

IoT Cloud


IBM
Analytics
Cloud
Commerce
IT Infrastructure
Watson Internet of Things
Watson Internet of Things > IBM Watson IoT Platform trial >
Start developing with IBM Watson IoT Platform
Create your Internet of Things applica
no charge
Start my trial


Chat with AWS Sales
Products
Solutions
Pricing
More
AWS IoT
Easily and securely connect devices
eliably scale to billions of devices and tril
Get started with AWS IoT

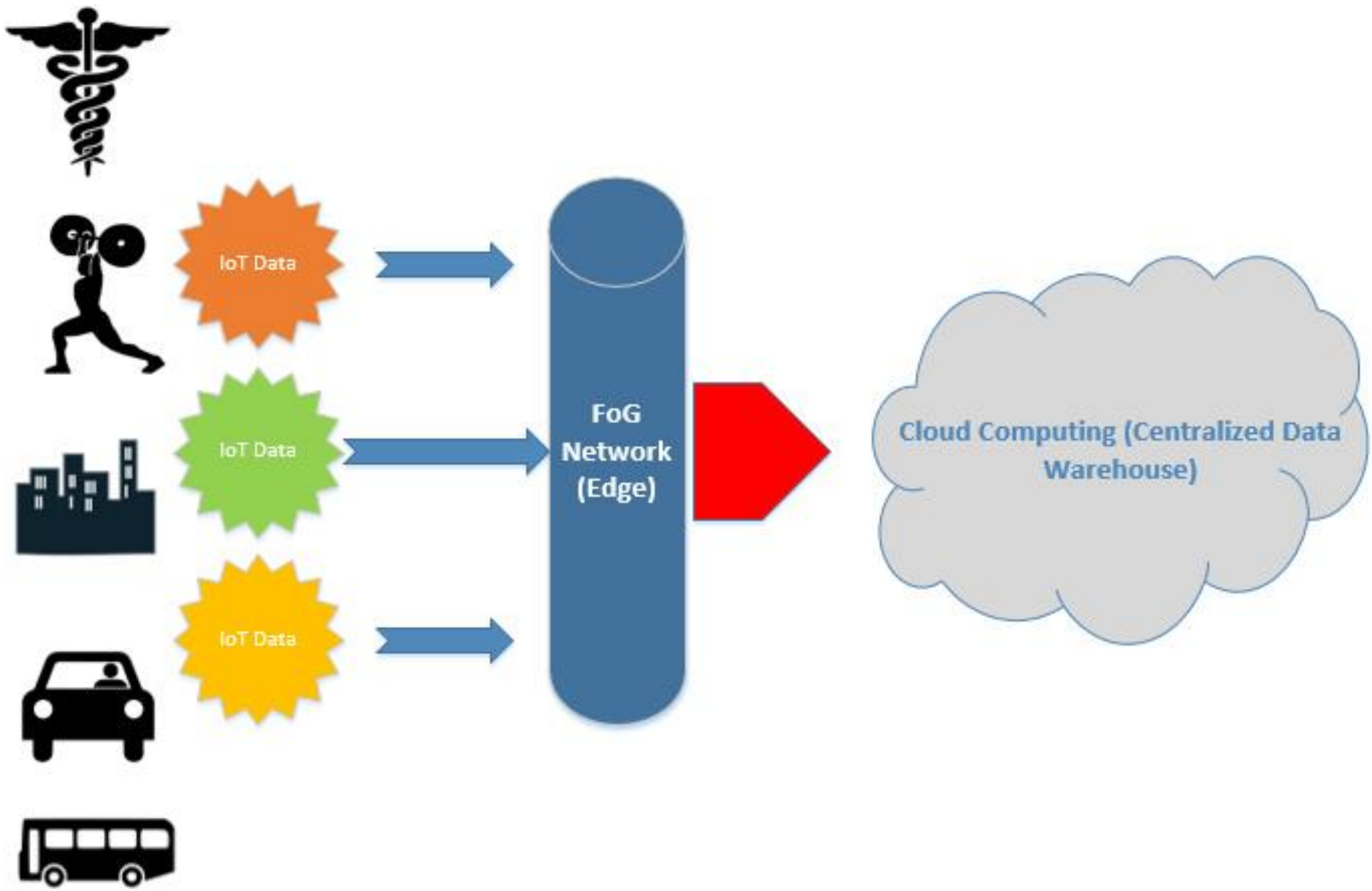

Cloud Sandbox
MediaTek Cloud Sandbox
MediaTek Cloud Sandbox (MCS) is a cloud based data service platform for Internet of Things devices.
MCS facilitates fast prototyping your IoT ideation to real solution.


Google Cloud Platform
Why Google
Products
Solutions
Launcher
Pricing
INTERNET OF THINGS (IOT) SO
Create streams of insight by extending your infrastructure
TRY IT FREE
CONTACT SALES
Streaming Insights
Events of interest fire off continuously in the phys
is material to decision making can't always wait f
Internet-equipped sensors on any physical item im
possible to ingest data continuously into the clou

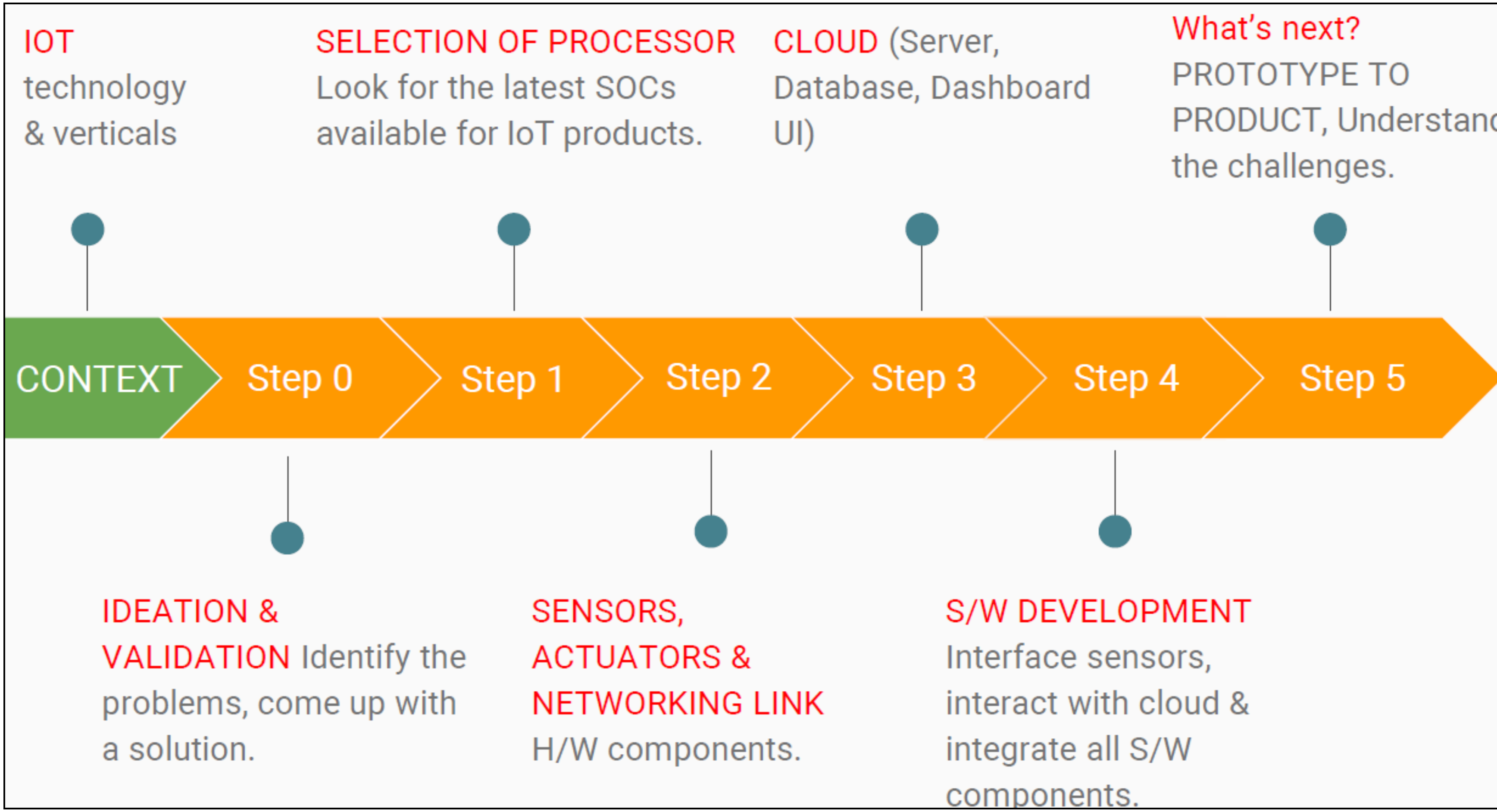

Microsoft Azure
Why Azure
Products
Documentation
Pricing
Azure IoT Suite
Capture and analyze untapped d
Get started quickly with preconfigured soluti
Tailor preconfigured solutions to meet your r
Enhance the security of your IoT solutions
Support a broad set of operating systems an


ubidots
FEATURES
DOCS
PARTNERS
A cloud service to capture and r
sense of sensor data
Start Now
See how it works

Fog Computing



IoT: Idea-Prototype-Product



If you think the Internet has changed your life, think again. The IoT is going to change it all over again!!!!!

Thank You