# KARPAGAM ACADEMY OF HIGHER EDUCATION
**COIMBATORE-21.**
**Faculty of Engineering**
**Department of Electronics and Communication Engineering**

## LECTURE PLAN

**NAME OF THE STAFF: G.R. MAHENDRA BABU**

**DESIGNATION : ASSISTANT PROFESSOR**

**CLASS : B.E-III YEAR ECE**

**SUBJECT : INTERNET OF THINGS**

**SUBJECT CODE : 17BEEC6E08**

| S.No. | TOPICS TO BE COVERED | TIME DURATION | TEACHING AIDS |
|---|---|---|---|
| **UNIT-I INTRODUCTION** | | | |
| 1 | Introduction | 2 | |
| 2 | Definitions and Functional requirements – motivation | 1 | T1 – Pg.No: 14-21 |
| 3 | Architecture – web 3.0 view of IoT | 1 | T1 – Pg.No: 22 - 26 |
| 4 | Ubiquitous IoT Applications | 1 | T1 – Pg.No: 27 – 33 |
| 5 | Four pillars of IoT | 1 | T1 – Pg.No: 22 – 26 |
| 6 | DNA of IoT | 1 | T1 – Pg.No: 95 – 104 |
| 7 | Tutorial | 1 | |
| 8 | The toolkit approach for end user | 1 | T1 – Pg.No: 95 – 104 |
| 9 | User participation in the internet of things | 1 | |
| 10 | Middleware – overview – communication middleware for IoT | 1 | T1 – Pg.No: 137 – 158 |
| 11 | IoT information security | 1 | |
| | **Total (Theory + Tutorial)** | **12 Hrs (11+1)** | |
| **UNIT II IOT PROTOCOLS** | | | |
| 1 | Protocol standardization for ioT – efforts | 1 | T1 – Pg.No: 169 - 213 |
| 2 | M2M – WSN protocols | 1 | |
| 3 | SCADA and RFID protocols | 1 | |
| 4 | Issues with IoT standardization – unified data standards – protocols | 1 | |
| 5 | IEEE 802.15.1 – BACnet protocols | 1 | |
| 6 | Modbus – KNX | 1 | |
| 7 | KNX – zigbee architecture | 1 | |
| 8 | Network layer | 1 | |
| 9 | APS layer - security | 1 | |
| 10 | Tutorial | 1 | |
| | **Total (Theory + Tutorial)** | **10 Hrs (9+1)** | |
| **UNIT III WEB OF THINGS** | | | |
| 1 | Web of Things vs Internet of Things – Two pillars of the web | 1 | T1 – Pg.No: 217 - 227 |
| 2 | Architecture standardization for WoT – Platform middleware for WoT | 1 | |
| 3 | Unified multitier WoT architecture – WoT portals and Business intelligence | 1 | |
| 4 | Cloud of Things – Grid / SoA and cloud | 1 | |

| | | | |
|---|---|---|---|
| | computing | | T1 – Pg.No: 257 - 272 |
| 5 | Cloud middleware – cloud standards | 1 | |
| 6 | Cloud providers and systems | 1 | |
| 7 | Mobile cloud computing | 1 | T1 – Pg.No: 279 - 288 |
| 8 | The cloud of Things | 2 | |
| 9 | Tutorial | 1 | |
| | **Total (Theory + Tutorial)** | **10 Hrs (9+1)** | |
| **UNIT IV INTEGRATED** | | | |
| 1 | Integrated billing solutions in the internet of things | 1 | R1 – Pg.No – 262 - 271 |
| 2 | Business models for the in the internet of things | 1 | R1 – Pg.No – 253 - 259 |
| 3 | Network dynamics: Population models | 2 | R2 – Pg.No: 483 - 533 |
| 4 | Information cascades | 1 | |
| 5 | Network effects | 1 | |
| 6 | Structural models | 1 | R2 – Pg.No: 561 - 641 |
| 7 | Cascading behavior in networks | 1 | |
| 8 | The small world phenomenon | 1 | |
| 9 | Tutorial | 1 | |
| | **Total (Theory + Tutorial)** | **10 Hrs (9+1)** | |
| | | | |
| **UNIT V APPLICATIONS** | | | |
| 1 | The role of the internet of things for increased autonomy | 2 | R2 – Pg.No: 228 - 259 |
| 2 | The role of the internet of things for agility in collaborative production environments | 2 | |
| 3 | Resource management in the internet of things | 1 | R2 – Pg.No: 192 - 201 |
| 4 | Clustering | 1 | |
| 5 | Synchronization and software agents | 1 | R2 – Pg.No: 350 - 385 |
| 6 | Smart Grid | 1 | |
| 7 | Electric vehicle charging | 1 | |
| 8 | Tutorial | 1 | |
| | **Total (Theory + Tutorial)** | **10 Hrs (9+1)** | |

**Total Lecture: 58 Hours (48+10)**

**TEXTBOOK:**

| S.NO. | Author(s) Name | Title of the book | Publisher | Year of Publication |
|---|---|---|---|---|
| 1. | Honbo Zhou | The Internet of Things in the Cloud: A Middleware Perspective | CRC Press | 2012 |

**REFERENCES:**

| S.NO. | Author(s) Name | Title of the book | Publisher | Year of Publication |
|---|---|---|---|---|
| 1. | Dieter Uckelmann; Mark Harrison; Florian Michahelles | Architecting the Internet of Things | Springer | 2011 |
| 2. | David Easley and Jon Kleinberg | Networks, Crowds, and Markets: Reasoning About a Highly Connected World | Cambridge University Press | 2010 |
| 3 | Olivier Hersent, Omar Elloumi and David Boswarthick | The Internet of Things: Applications to the Smart Grid and Building Automation | Wiley | 2012 |

**FACULTY IN-CHARGE** **HOD/ECE**

**17BEEC6E08 INTERNET OF THINGS L T P C**

**3 0 0 3**

**OBJECTIVES:**

- To understand the basics of Internet of Things.
- To get an idea of some of the application areas where Internet of Things can be applied
- To understand the middleware for Internet of Things.
- To understand the concepts of Web of Things.
- To understand the concepts of Cloud of Things with emphasis on Mobile cloud computing.
- To understand the IOT protocols.

**INTENDED OUTCOMES:**

- To Identify and design the new models for market strategic interaction Design business intelligence and information security for WoB.
- Analyze various protocols for IoT Design a middleware for IoT.
- Analyze and design different models for network dynamics.

**UNIT I INTRODUCTION (10)**

Definitions and Functional Requirements –Motivation – Architecture - Web 3.0 View of IoT– Ubiquitous IoT Applications – Four Pillars of IoT – DNA of IoT - The Toolkit Approach for End-user Participation in the Internet of Things. Middleware for IoT: Overview – Communication middleware for IoT –IoT Information Security

**UNIT II IOT PROTOCOLS (8)**

Protocol Standardization for IoT – Efforts – M2M and WSN Protocols – SCADA and RFID Protocols –
Issues with IoT Standardization – Unified Data Standards – Protocols – IEEE 802.15.4 – BACNet Protocol – Modbus – KNX – Zigbee Architecture – Network layer – APS layer – Security

**UNIT III WEB OF THINGS (10)**

Web of Things versus Internet of Things – Two Pillars of the Web – Architecture Standardization for WoT– Platform Middleware for WoT – Unified Multitier WoT Architecture – WoT Portals and Business Intelligence. Cloud of Things: Grid/SOA and Cloud Computing – Cloud Middleware – Cloud Standards
– Cloud Providers and Systems – Mobile Cloud Computing – The Cloud of Things Architecture

**UNIT IV INTEGRATED (9)**

Integrated Billing Solutions in the Internet of Things Business Models for the Internet of Things - Network Dynamics: Population Models – Information Cascades - Network Effects - Network Dynamics: Structural Models - Cascading Behavior in Networks - The Small-World

Phenomenon

**UNIT V APPLICATIONS (8)**

The Role of the Internet of Things for Increased Autonomy and Agility in Collaborative Production Environments - Resource Management in the Internet of Things: Clustering, Synchronisation and Software Agents. Applications - Smart Grid – Electrical Vehicle Charging

**Total Hours: 45**

**TEXTBOOK:**

| S.NO. | Author(s) Name | Title of the book | Publisher | Year of Publication |
|---|---|---|---|---|
| 1. | Honbo Zhou | The Internet of Things in the Cloud: A Middleware Perspective | CRC Press | 2012 |

**REFERENCES:**

| S.NO. | Author(s) Name | Title of the book | Publisher | Year of Publication |
|---|---|---|---|---|
| 1. | Dieter Uckelmann; Mark Harrison; Florian Michahelles | Architecting the Internet of Things | Springer | 2011 |
| 2. | David Easley and Jon Kleinberg | Networks, Crowds, and Markets: Reasoning About a Highly Connected World | Cambridge University Press | 2010 |
| 3 | Olivier Hersent, Omar Elloumi and David Boswarthick | The Internet of Things: Applications to the Smart Grid and Building Automation | Wiley | 2012 |

# INTERNET OF THINGS
# UNIT-I

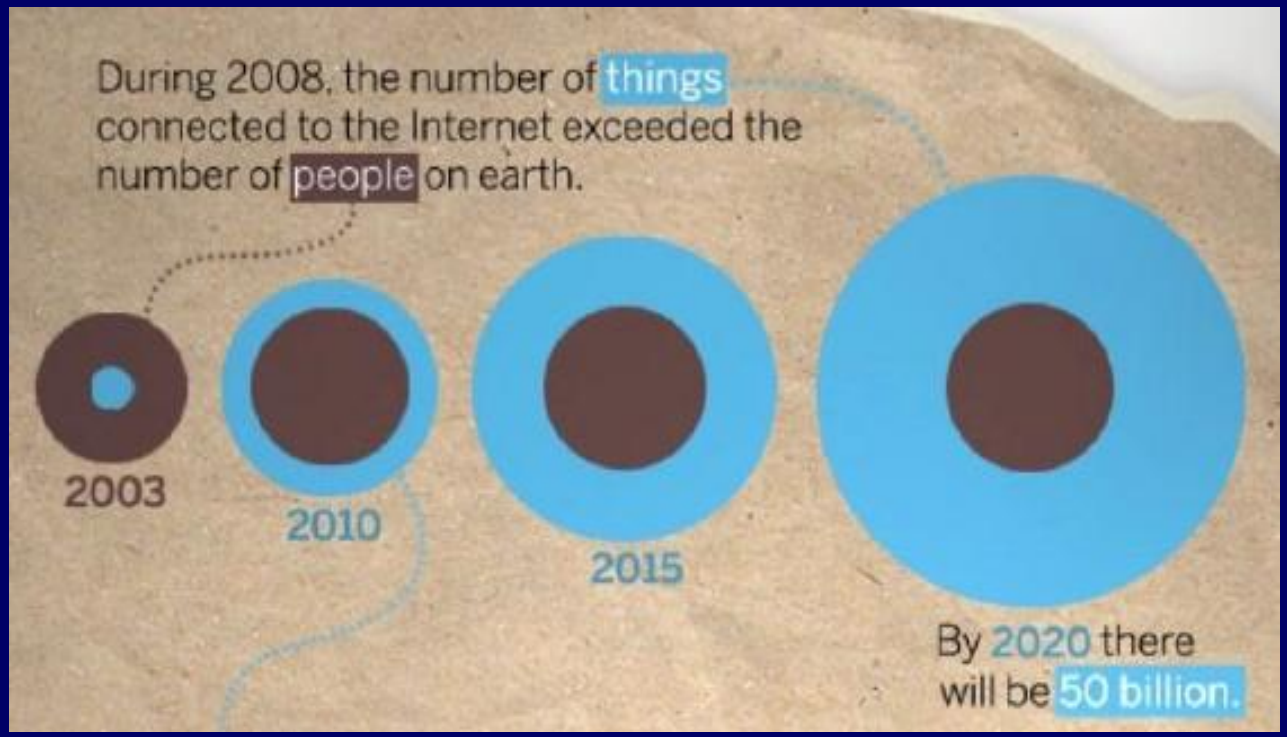
**Presented By,**
**G.R.Mahendra Babu,**
**Assistant Professor,**
**Dept of ECE/ FoE / KAHE.**

# What is the Internet of Things?

Internet connects all peopl → "Internet of People"
Io connects a things à "Interne of Things"

Interconnection of Things or Objects or Machine ,
e.g., sensors, actuators, mobile phones, electronic devices, home applianc , any existin items
and interact with each other vi Internet.

# INTERNET OF THINGS GROWTH



## MAJOR SUBJECT OF 5G WIRELESS SYSTEMS (2020-2030)

Connection of
7 Billion of People and
7 Trillion Things

# MAJOR CHARACTERISTICS

- Very Large Scale
- Heterogeneity
- Pervasivity

  Computing and communication technologies will be embedded in our environments

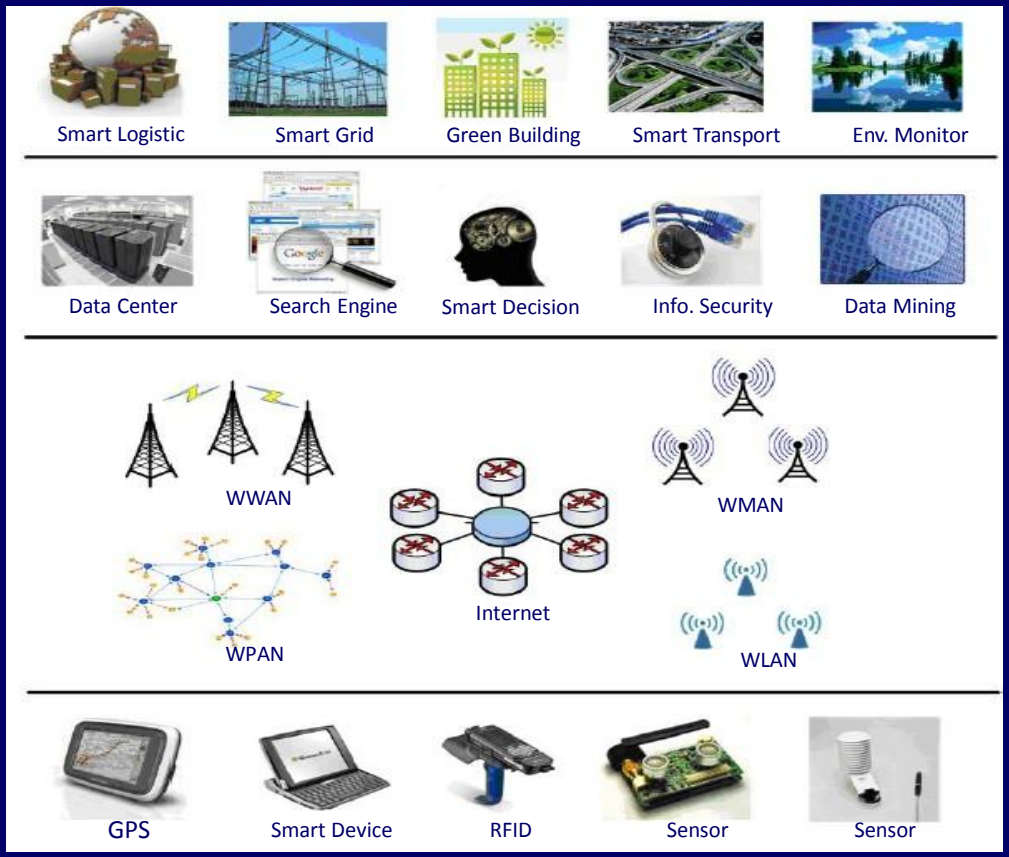
# 4 Layers Model of IoT

**Integrated Application**

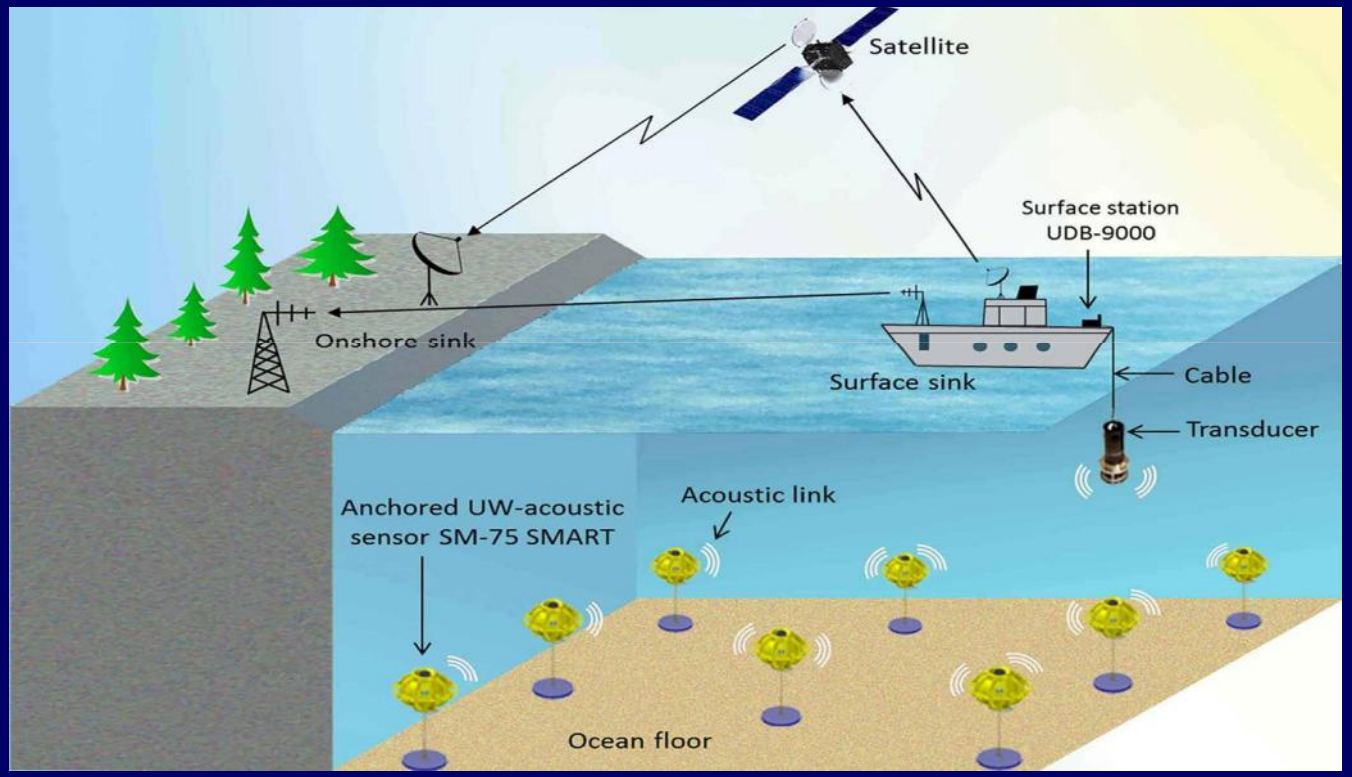
**Information Processing**

**Network Construction**

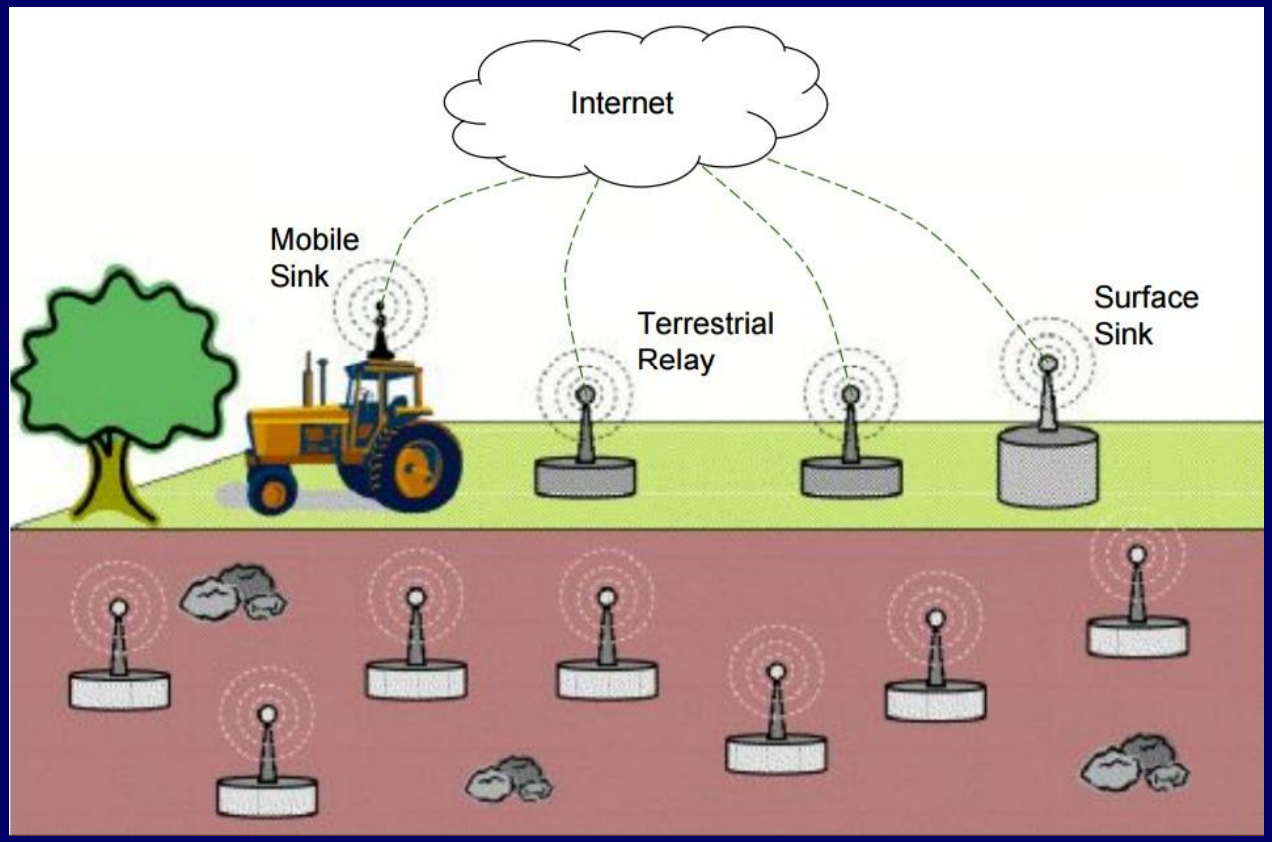
**Sensing and Identification**



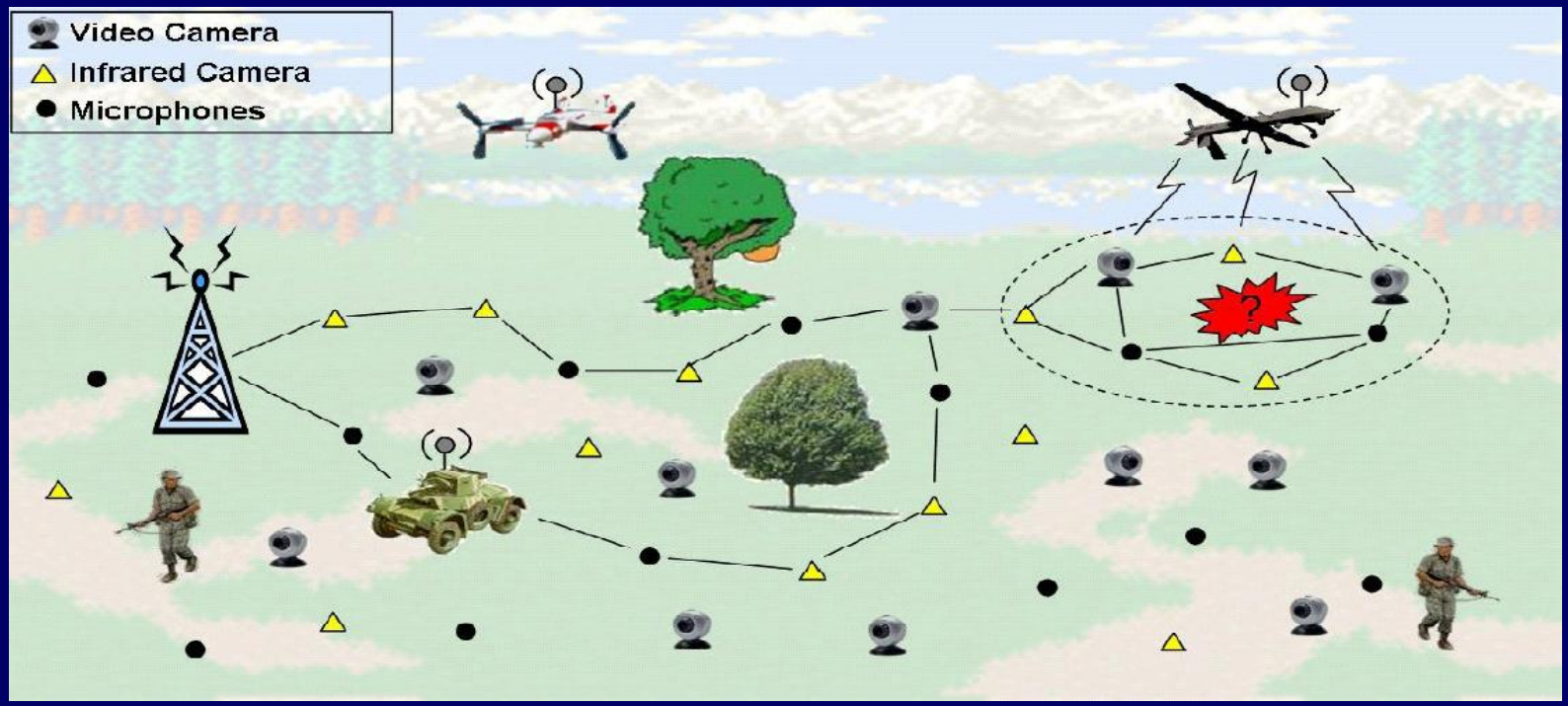
# INTERNET OF UNDERWATER THINGS



## INTERNET OF UNDERGROUND THINGS



# Internet of Battlefield Things



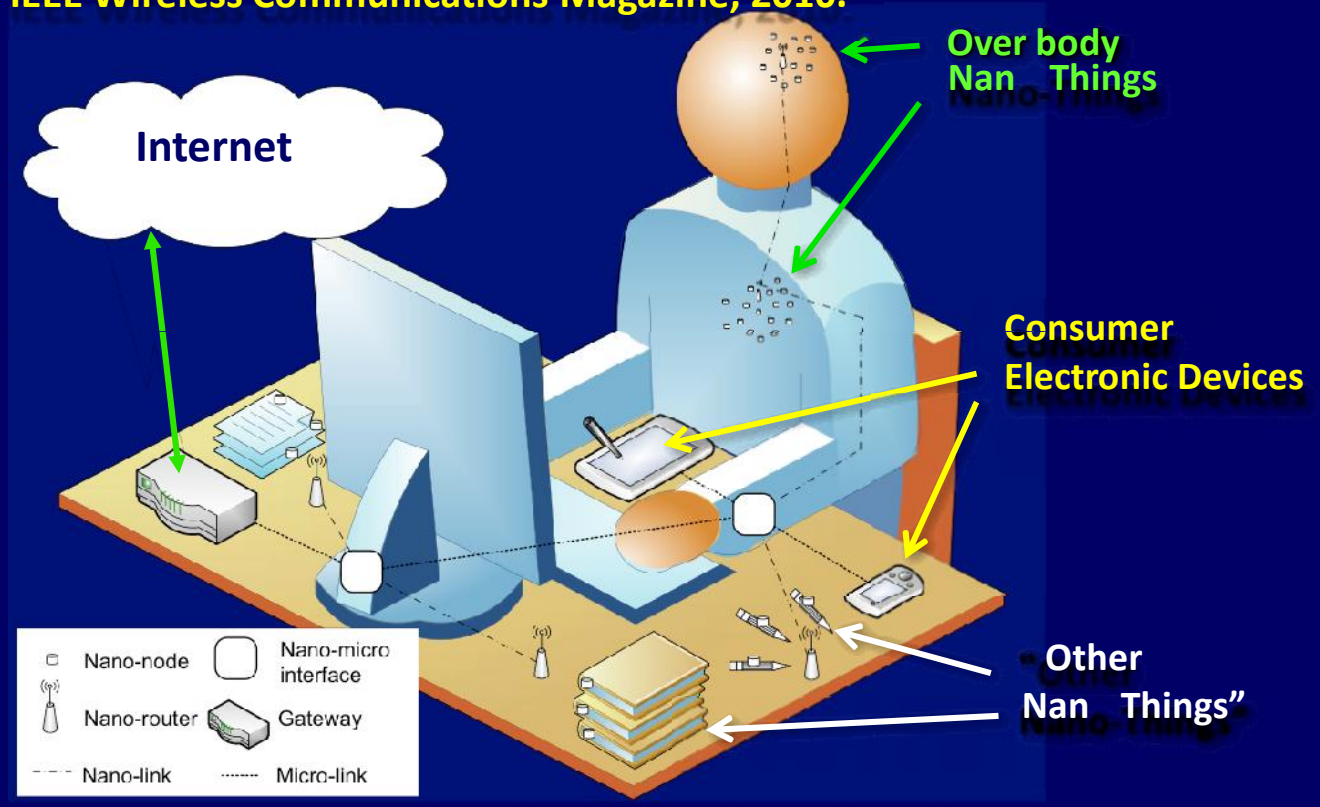
# INTERNET OF SPACE THINGS

Coffee mug size Satellites

Univ of New Mexico

# INTERNET O NANOTHINGS

The Internet of Nan Things,"
IEEE Wireless Communications Magazine, 2010.



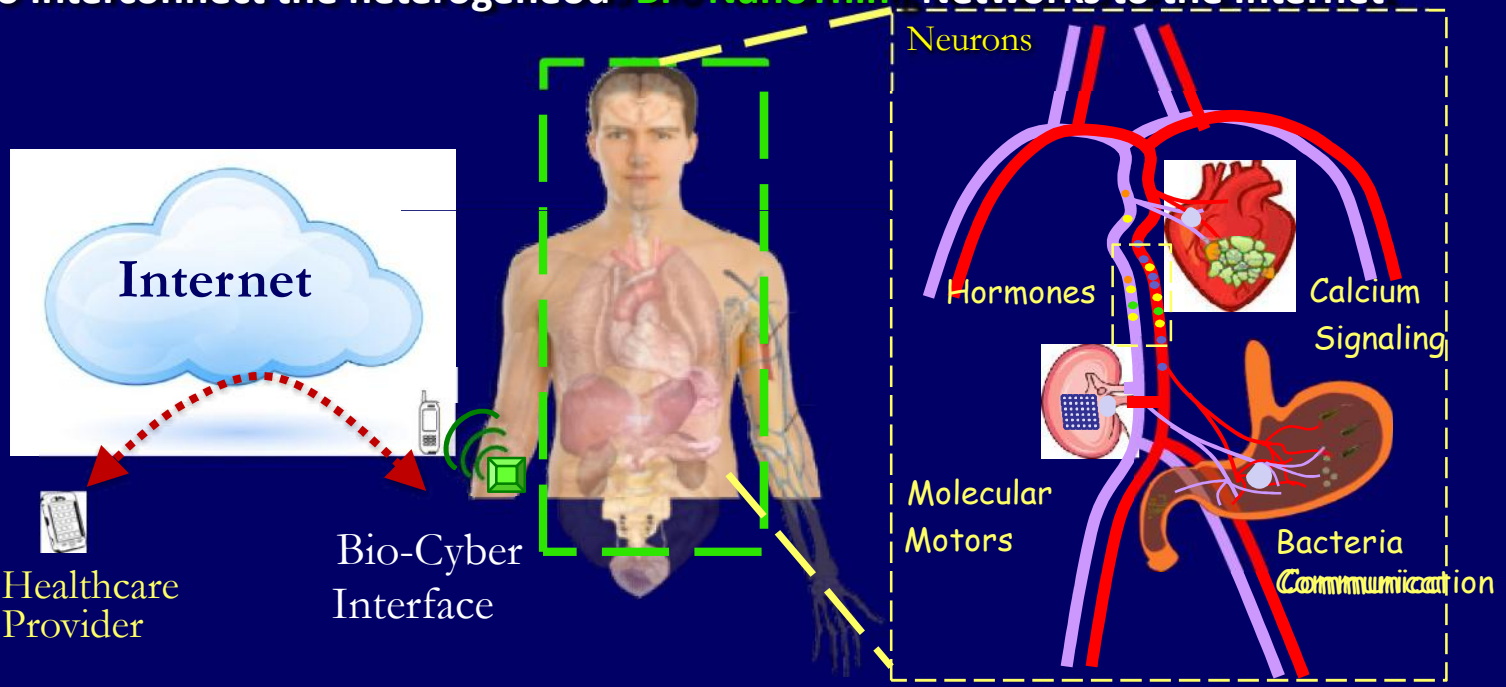
# INTERNET O BI NANOTHINGS

AMANIA , KOUCHERYAV ,

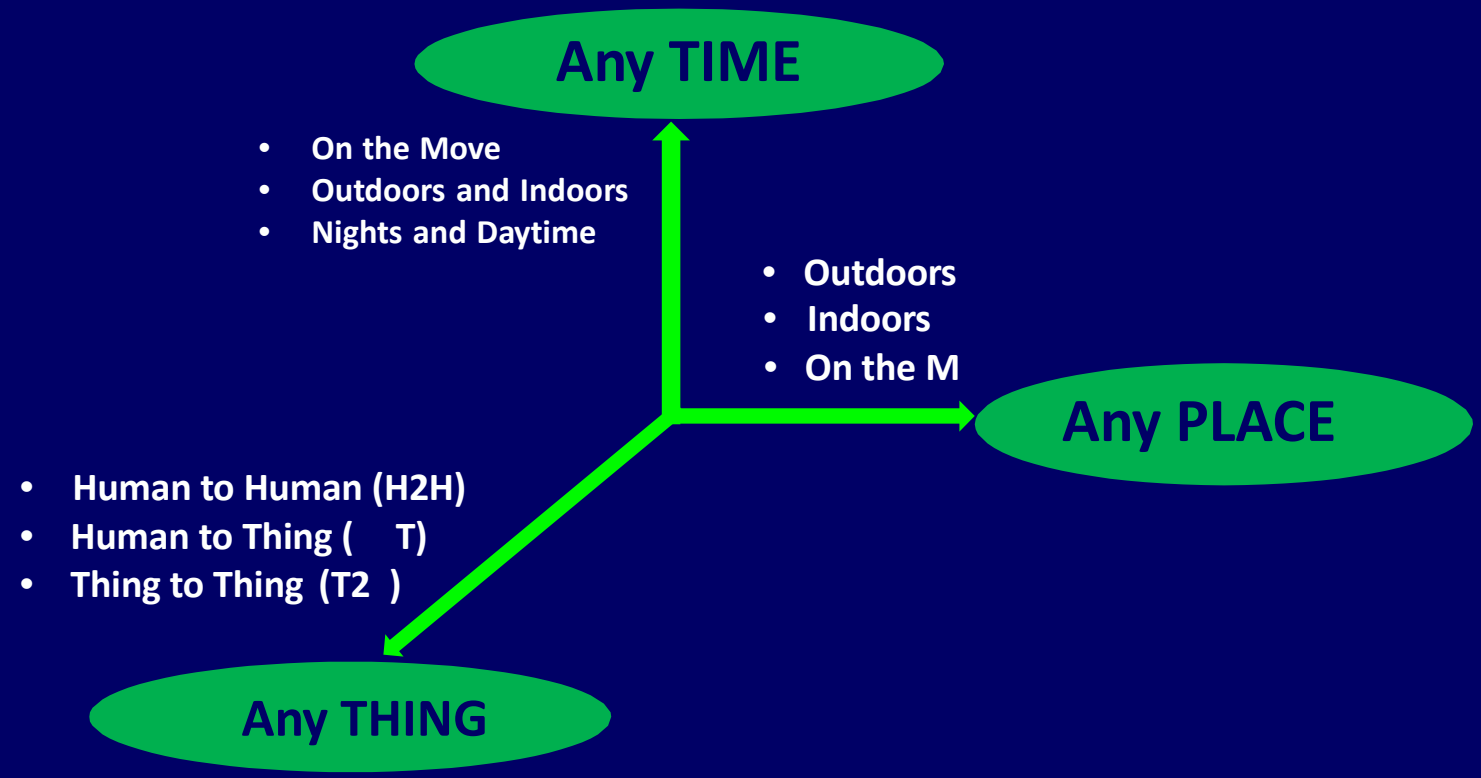
IEEE COMMUNICATIONS MAGAZINE, MARCH 2015

**Objective:**

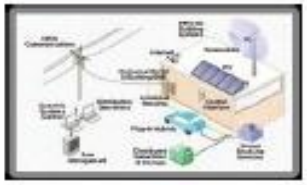
To interconnect the heterogeneou Bi NanoThin Networks to the Internet



# INTERNET OF THINGS: PERSPECTIVE

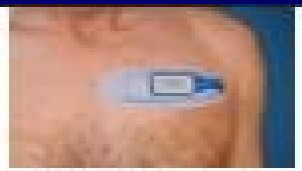
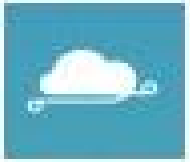


## TOP INDUSTRIES KEY FOR IoT APPLICATIONS DEVELOPMENT AND REVENUE GENERATION

| | | |
|---|---|---|
|  Smart Grid |  Smart Health |  Smart Home |
|  Smart Cities |  Smart Industries |  Smart TV |
|  Smart Watch |  Smart Car |  Smart Kegs |

Automativ & Transportation

# RECENT IoT PRODUCTS

| | | | |
|---|---|---|---|
|  NEST Thermostat |  Corventis: Wireless Cardiac Monitor |  WEMO Remote |  Tractive Pet Tracker |
|  Ninja Blocks |  Revolve Home Automation |  ThingWorx Application Platform |  Lings Cloud Platform |
|  Mbed Development Platform |  Xively Remote Access API |  Intel Quark Processor |  AllJoyn S/W Framework |

# IoT PLATFORMS ON THE MARKET

- GE Predix
- Cisco IoT Cloud
- IBM Watson IoT
- PTC ThingWorx

# GE PREDIX

# PREDIX

- Uses a platform as a service (PaaS) model and is a cloud-based OS
- Built on Cloud Foundry, an open-source platform, and is optimized for secure connectivity and analytics at scale, both in the cloud and on the edge



IFA'2017 17

# CISCO IoT CLOUD

- Designed around six pillars of technology:
  - Network connectivity
  - Fog computing
  - Data analytics
  - Security (cyber and physical),
  - Management/automation, and
  - Application enablement.

Cloud addresses challenges across a wide variety of industries, including manufacturing, utilities, oil and gas, transportation, mining, and the public sector.

# IBM WATSON IoT

Cloud Foundry, Docker®, OpenStack®, Watson IoT Platform development

**Platform connects sensors to cloud applications using IBM Bluemix®**

# PTC® THINGWORX®

- Three pillars of technology:
  - Core application enablement
  - Connection services with device and cloud adopters, and
  - Edge connectivity using the Edge MicroServer and Edge “Always On” devices

(27% market share)

# APPLICATION OF IOT: SMART HOME

(Appliances)

- Remote Monitoring/Control










- Safety:
  When do the doors open/close?
- Energy Management:
  Turn off the lights/AC?
- Maintenance:
  Are the sinks/pipes leaking?
- Entertainment Control



IFA'2017 21

## ADOPTIO O NETWORKS HEALTHCAR INDUSTRY

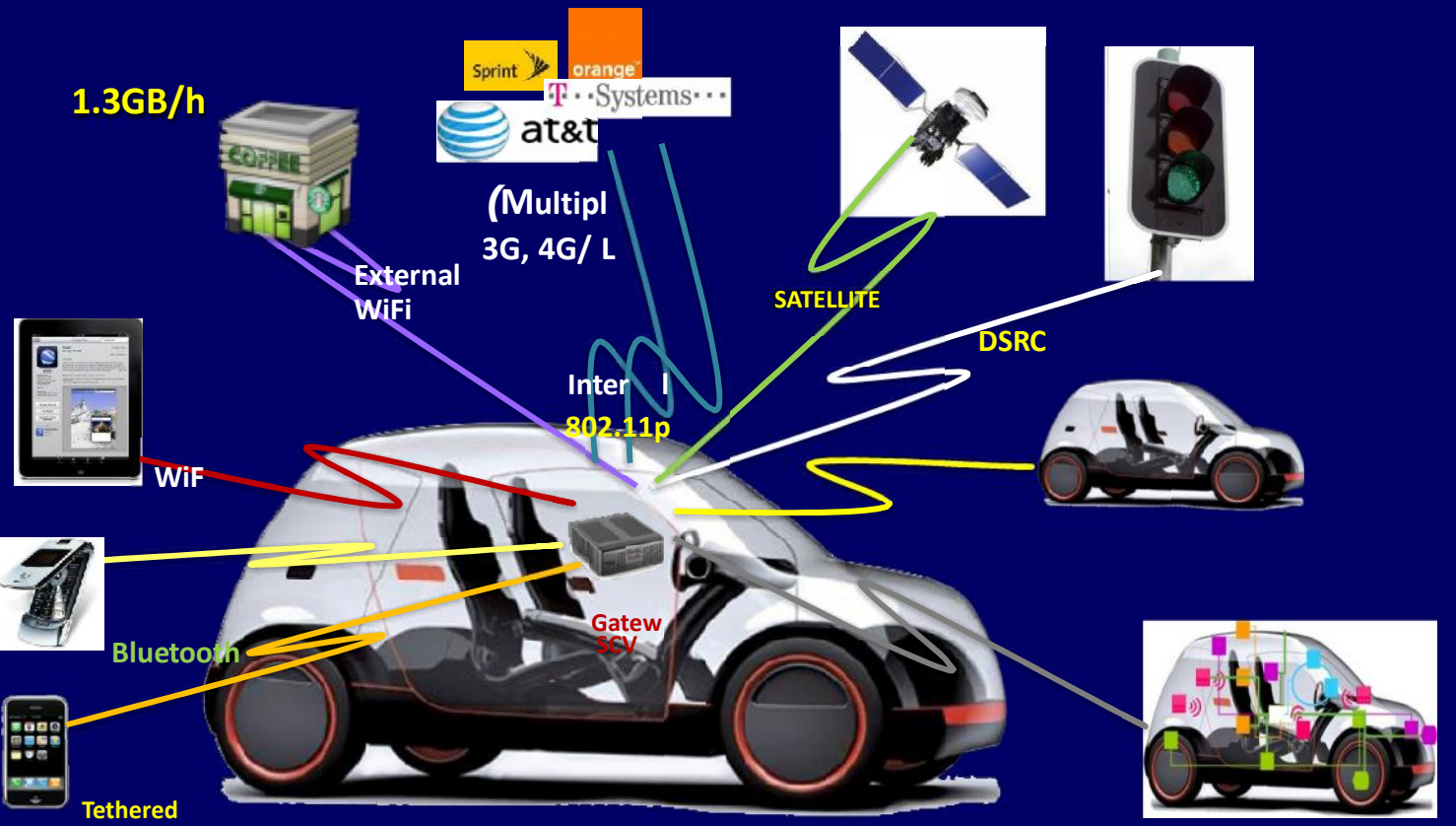
**The global IoT healthcare market is expected to grow from $32.47 billion in 2015 to $163.24 billion by 2020:**

- Remot patient monitorin
- services Mobil healt technology
- Telemedicine
- edication Management
- Improved Clinical Care
- mploye workflow management and
- npatient monitoring

# Adoption of IoT Networks: Transportation

- Save lives and property
- Reduce emissions and
- Cut commuting time and effort

# Adoption of IoT Networks: Transportation

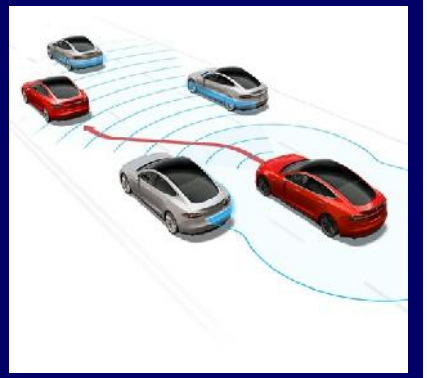




IFA'2017 24

# Intelligent Transportation

- Driver warning, autopilot, emergency self stop, traffic management



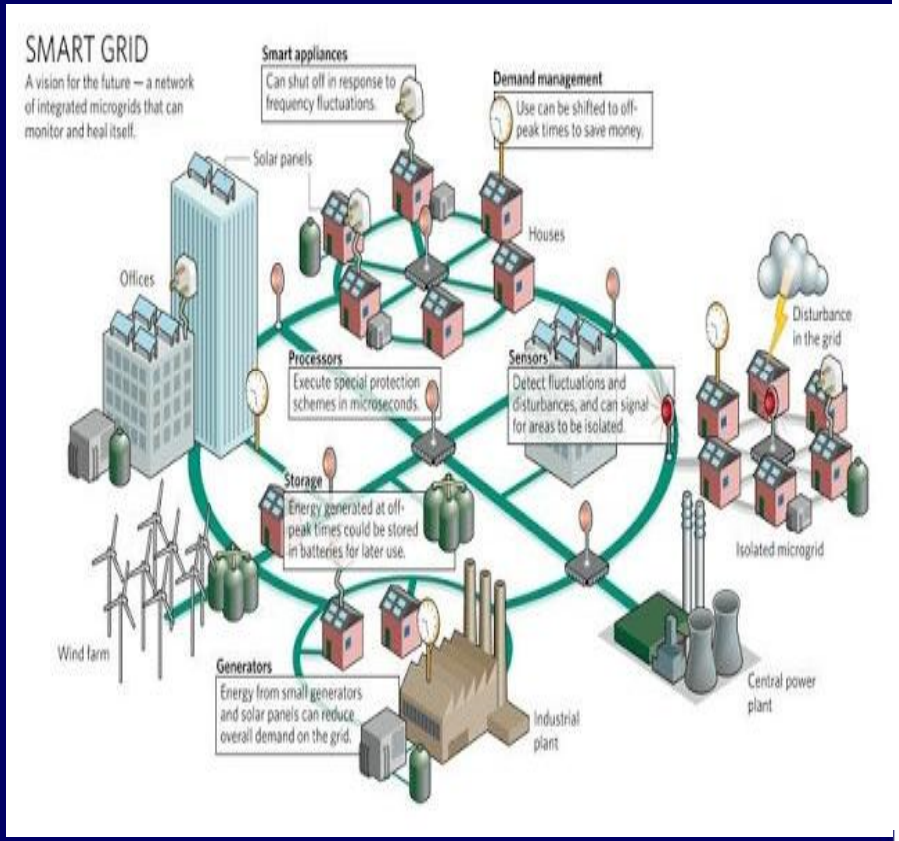
- Real-time vehicle tracking and fleet management
- Route planning information, high-precision estimated arrival times
- Valuable data for insurance companies

# ADOPTION OF IoT NETWORKS : SMART GRID

Utility companies use IoT to improve

* asset performance
* reduce costs
* infrastructure management,
* lower supply chain risks and
* empower employees and consumers
* More efficient and proactive maintenance

By the end of 2017, annual smart grid spending in China could total $20 billion,
with smart meters comprising
$2 billion of that total



# TRENDS IN SPENDING FOR IoT SOLUTIONS

Worldwide IoT market will grow from $655.8 B/2014 to $1.7 T/2020 with a compound annual growth rate of 16.9%.

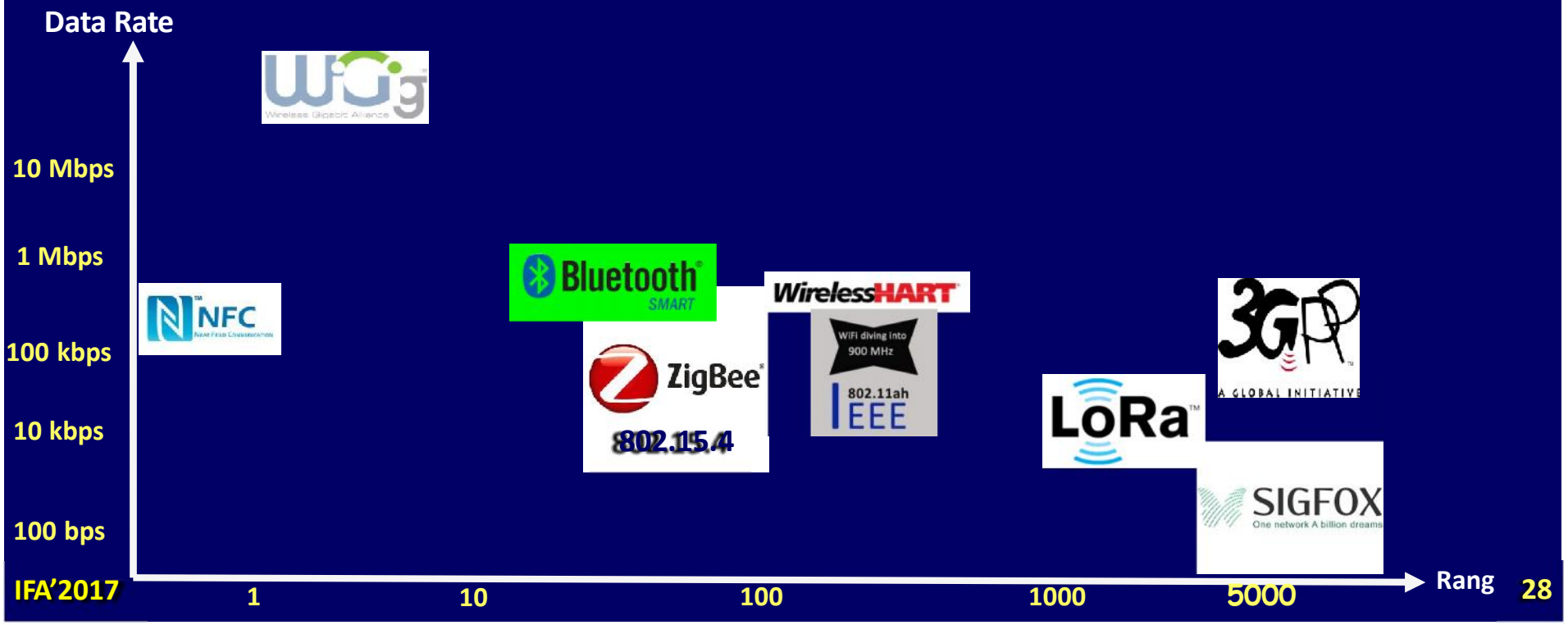
IoT analytics market is estimated to grow at a CAGR of 27.48% from 2015 to 2020 to reach $ 16.35 B by 2020.

Total service spending (including professional, consumer and connectivity services) will reach $482 billion in 2020, growing at a 21% CAGR from 2013.

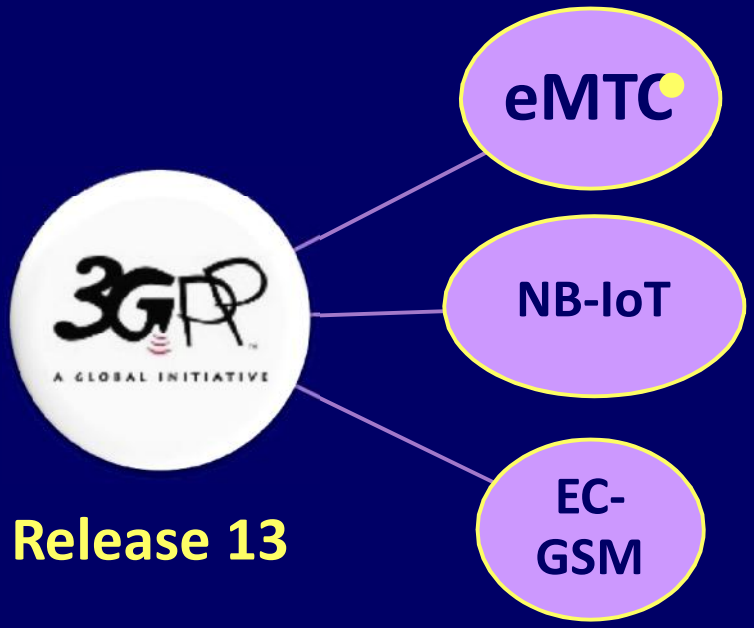
IoT market in manufacturing operations will grow from $42.2B/2013 to $98.8B/2018

Global spending on retail IoT initiatives is expected to grow from $14.3 B/2015 to $35 B/2020.

# IoT CONNECTIVITY COMPETITIVE LANDSCAPE



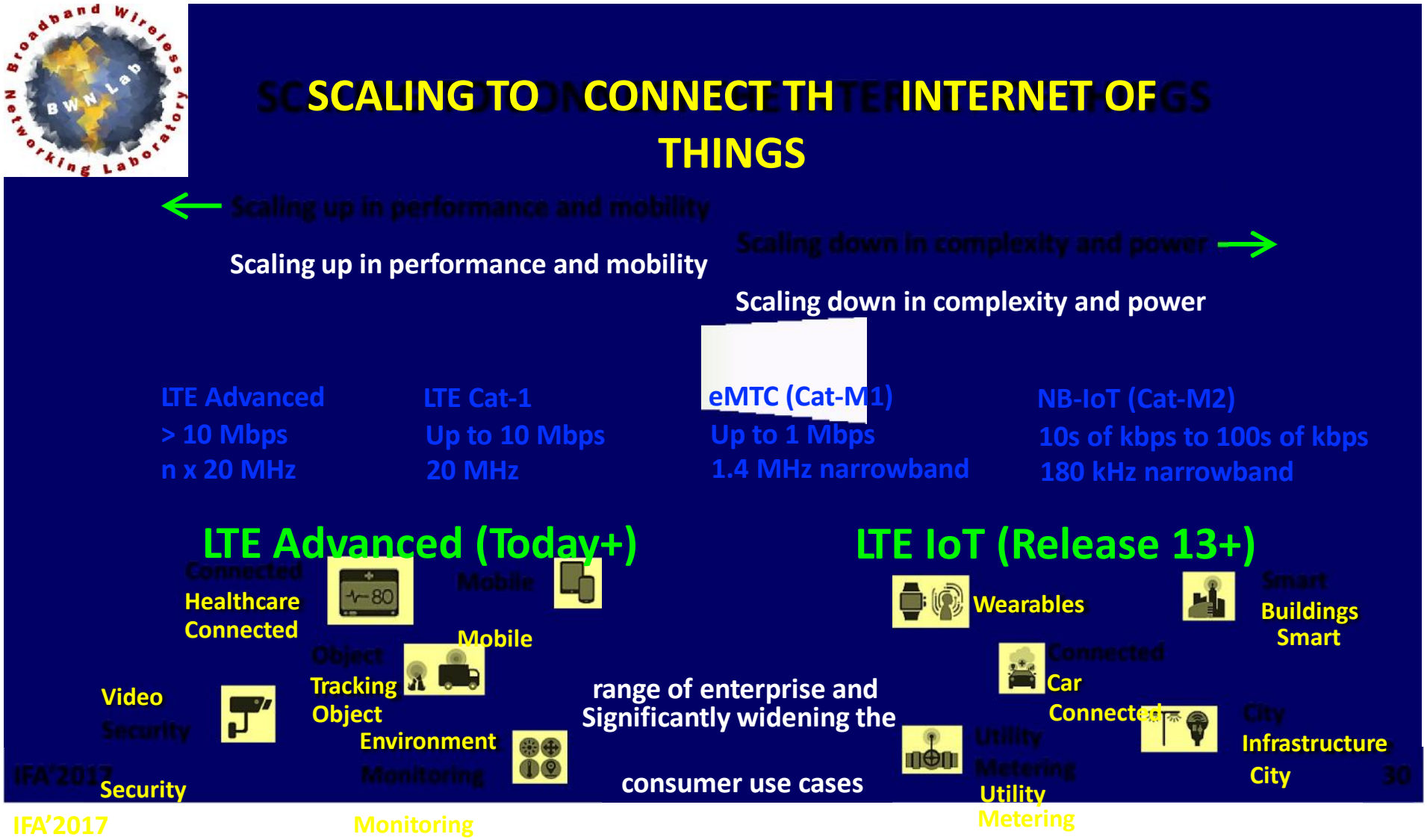
# Current 3GPP Standardization for IoT




Category M device for LTE

Narrowband IoT

Extended Coverage GSM


SCALING TO CONNECT TH INTERNET OF THINGS
Scaling up in performance and mobility
Scaling down in complexity and power
LTE Advanced
> 10 Mbps
n x 20 MHz
LTE Cat-1
Up to 10 Mbps
20 MHz
eMTC (Cat-M1)
Up to 1 Mbps
1.4 MHz narrowband
NB-IoT (Cat-M2)
10s of kbps to 100s of kbps
180 kHz narrowband
LTE Advanced (Today+)
LTE IoT (Release 13+)
Connected
Healthcare
Mobile
Wearables
Smart
Buildings
Mobile
Object
Tracking
Object
Video
Security
Environment
Monitoring
range of enterprise and
Significantly widening the
consumer use cases
Connected
Car
Connected
City
Infrastructure
City
Utility
Metering
Security
IFA'2017
Monitoring
Utility
Metering
IFA'2017
30


# MAJOR OBSTACLES FOR I T DEPLOYMENTS

- High Costs of required investment in IoT infrastructure
- Concerns about security and privacy
- Lack of senior management knowledge/commitment
- Weaknesses in organization's technology infrastructure
- Regulatio (e.g. elating to data privacy)
- Weaknesses in public com infrastructure available to organization
- Immaturity of industry standard around the IoT
- General economic uncertainty
- Undeveloped consumer awareness
- Absence of business case/business model

## WHAT MEASURE THE COMPANIES TAKEN TO USE THE IoT MORE EXTENSIVELY IN THE BUSINESS

- Seeking advice from third party experts/consultants
- Learning from the successes or failures of early movers
- Training existing staff to work with the IoT
- Conducting or sponsoring research to establish market size/demand
- Establishing a cross functional task force to explore and/or pursue IoT opportunities
- Introducing new business models
- Raising fresh capital to explore IoT options
- Hiring talent with IoT capabilities
- Establishing joint ventures or alliances to exploit IoT opportunities
- Establishing an IoT center of excellence
- Acquiring a business or assets with IoT capabilities

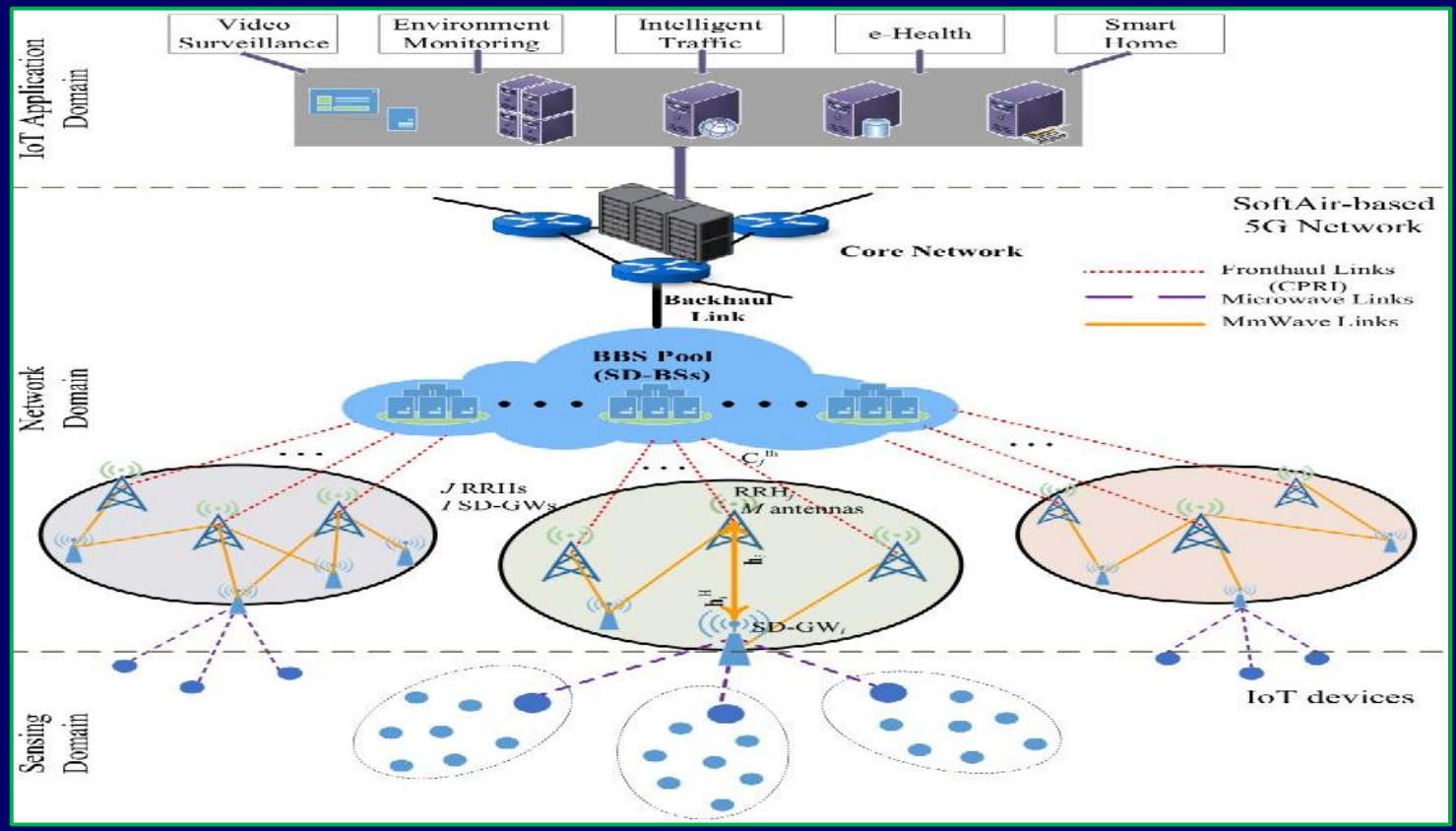

## IoT TRENDS TO WATCH IN THE FUTURE

- IT services (business consulting) → Major Driver
- IoT drives demand for DATA ANALYTICS:
  Data must be managed, integrated and analyzed
- IoT drives demand for CLOUD COMPUTING
- IoT data → DATA BROKER
  IoT generated data is bought, analyzed and sold
  e.g., IBM buys The Weather Company data
- Interoperability Problems
- Security


# RESEARCH CHALLENGES

- Scalability (Massive Number of Devices)
- Handle data generated by 50 billion devices
- Reliable Coverage
- Move cloud services to edge of the network (Fog Computing)
- Reduce data to be stored (Processing and Storage)
- Power Consumption Problem (Energy Harvesting; SW Optimization)
- SDN/NFV Based IoT

# SDN/NFV Based IoT (5G)




# CHALLENGE STANDARDIZATION

- Standardizatio for
  - nteroperability
  - Heterogeneity of Sensors
  - Interfaces to Cloud Servers

# INTERNET OF THINGS
# UNIT-II

**Presented By,**
**G.R.Mahendra Babu,**
**Assistant Professor,**
**Dept of ECE/ FoE / KAHE.**

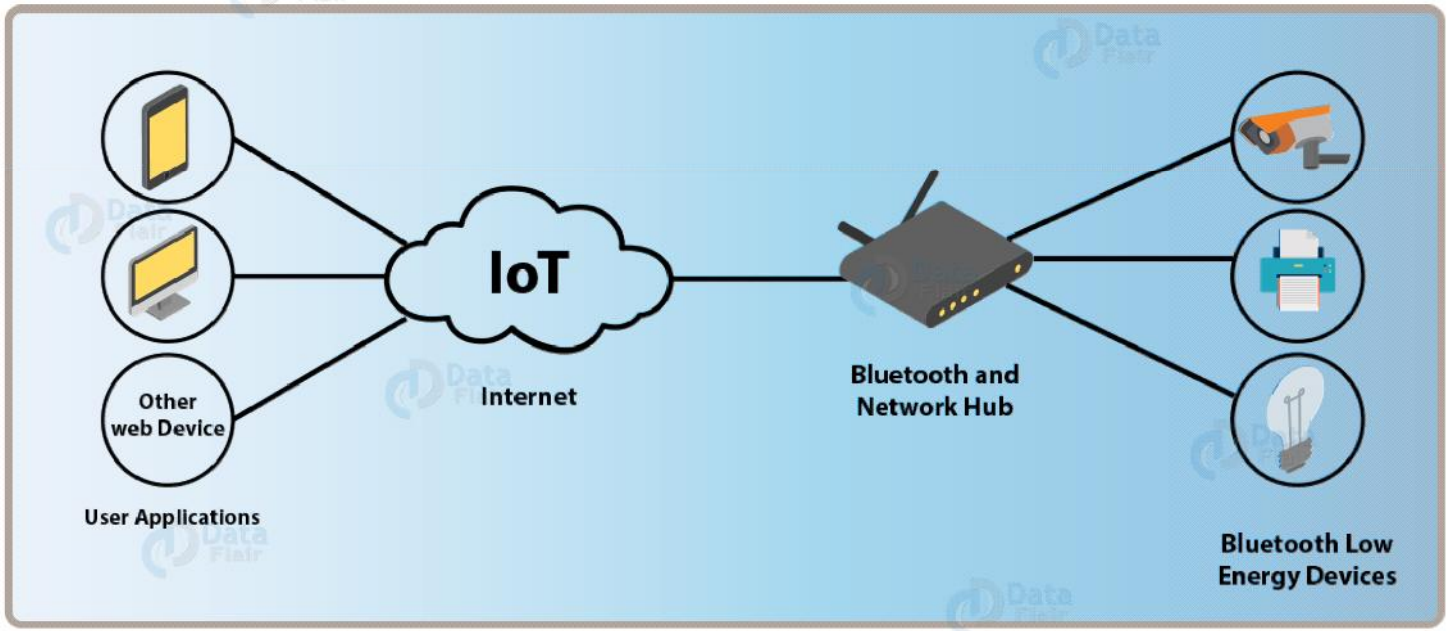
# IOT PROTOCOLS

Several Communication Protocols and Technology used in the internet of Things. Some of the major IoT technology and protocol (IoT Communication Protocols) are Bluetooth, Wifi, Radio Protocols, LTE-A, and WiFi-Direct. These IoT communication protocols cater to and meet the specific functional requirement of an IoT system.

# Bluetooth

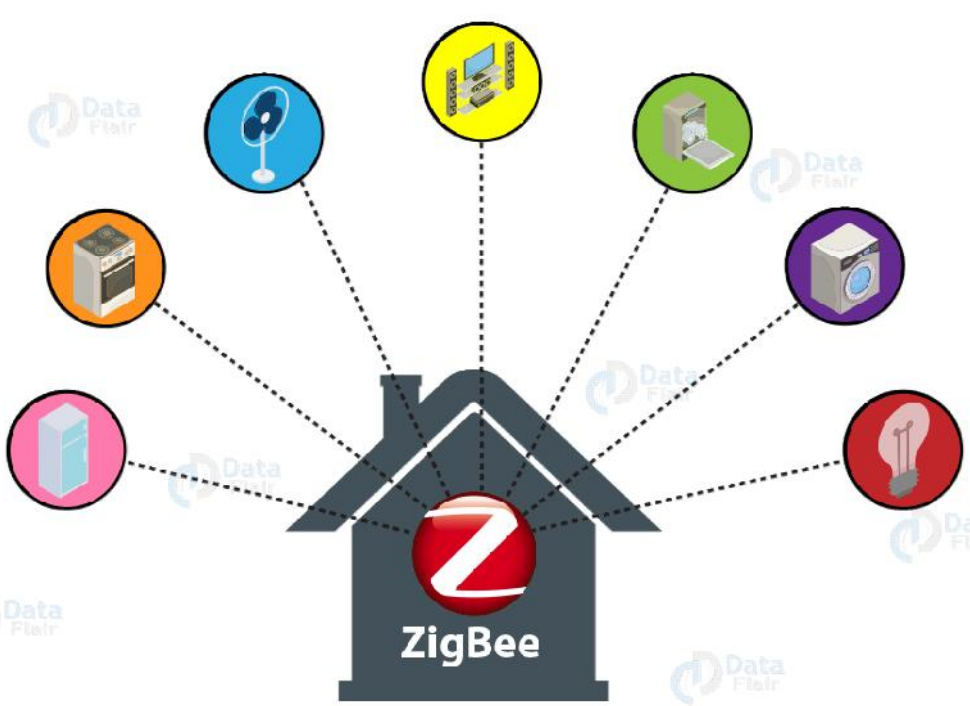
- An important short-range IoT communications Protocols / Technology. Bluetooth, which has become very important in computing and many consumer product markets. It is expected to be key for wearable products in particular, again connecting to the IoT albeit probably via a smartphone in many cases. The new Bluetooth Low-Energy (BLE) – or Bluetooth Smart, as it is now branded – is a significant protocol for IoT applications. Importantly, while it offers a similar range to Bluetooth it has been designed to offer significantly reduced power consumption.
-

# Bluetooth Role in The Future of IoT



# Zigbee

- ZigBee is similar to Bluetooth and is majorly used in industrial settings. It has some significant advantages in complex systems offering low-power operation, high security, robustness and high and is well positioned to take advantage of wireless control and sensor networks in **IoT applications**. The latest version of ZigBee is the recently launched 3.0, which is essentially the unification of the various ZigBee wireless standards into a single standard.


ZigBee

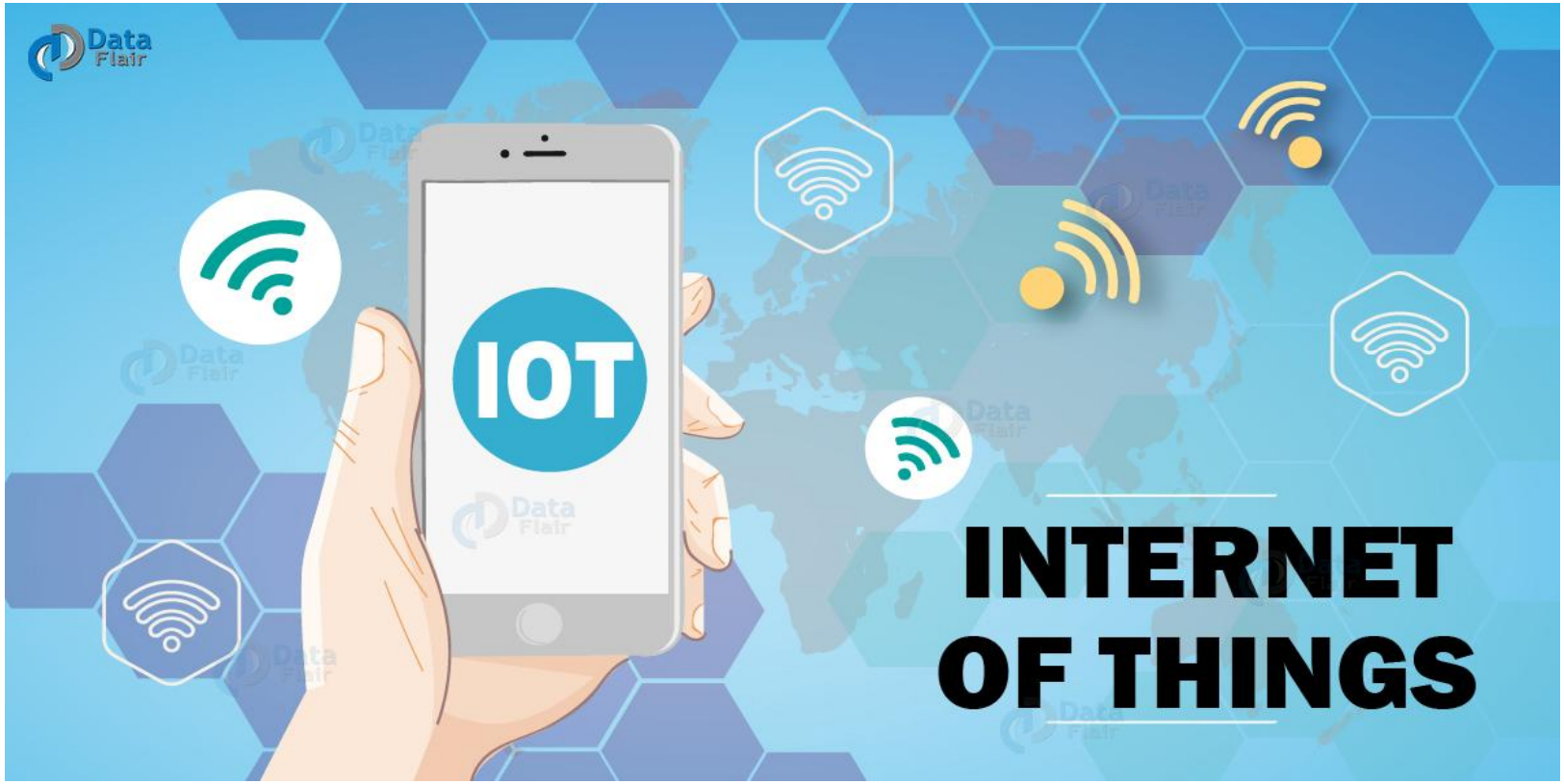
# Z-Wave

- Z-Wave is a low-power RF communications IoT technology that primarily design for home automation for products such as lamp controllers and sensors among many other devices. A Z-Wave uses a simpler protocol than some others, which can enable faster and simpler development, but the only maker of chips is Sigma Designs compared to multiple sources for other wireless technologies such as ZigBee and others.


Z-WAVE

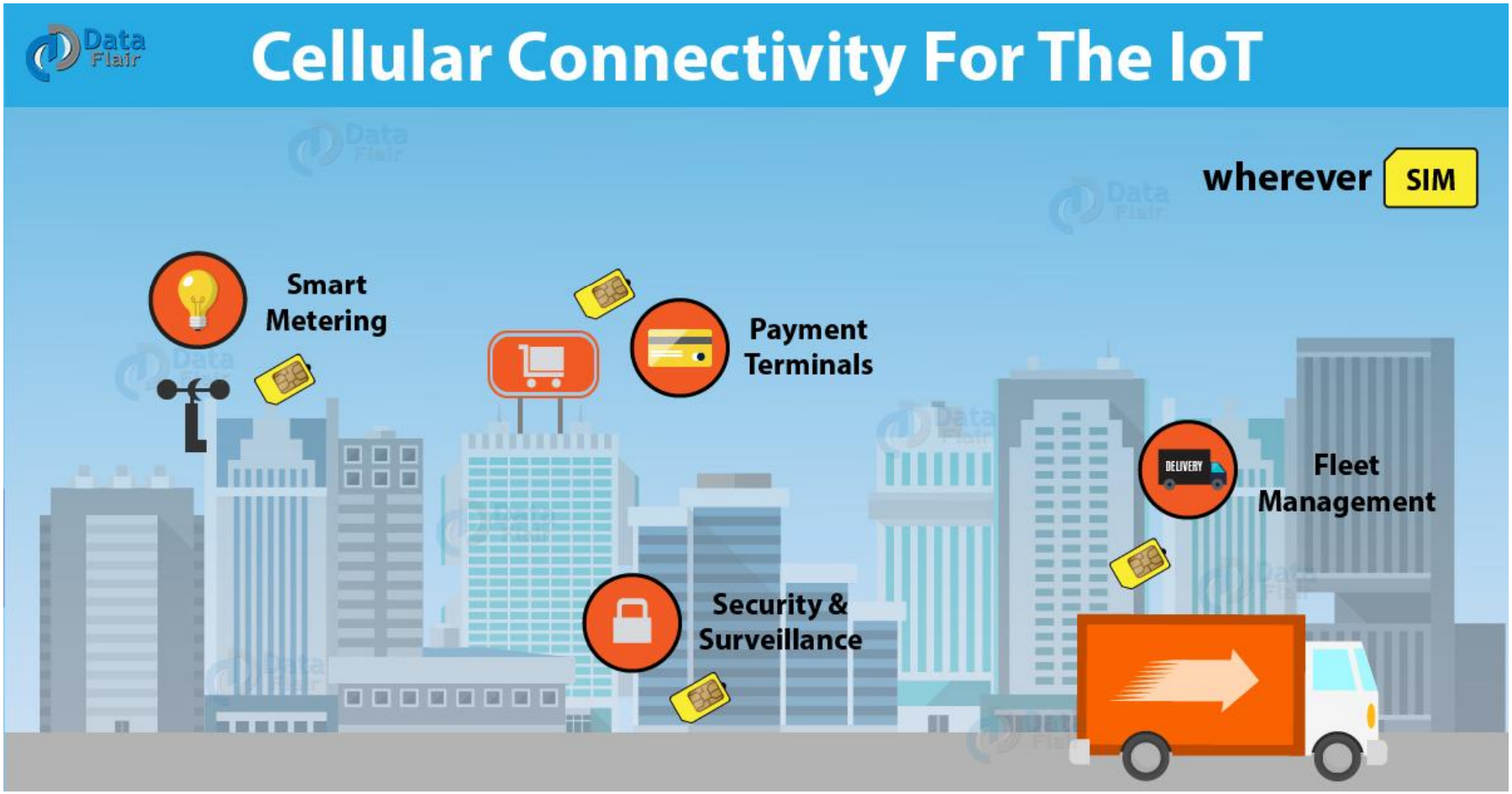
# Wi-Fi

- WiFi connectivity is one of the most popular IoT communication protocol, often an obvious choice for many developers, especially given the availability of WiFi within the home environment within LANs. There is a wide existing infrastructure as well as offering fast data transfer and the ability to handle high quantities of data. Currently, the most common WiFi standard used in homes and many businesses is 802.11n, which offers range of hundreds of megabit per second, which is fine for file transfers but may be too power-consuming for many IoT applications.


Data Flair
IOT
INTERNET
OF THINGS

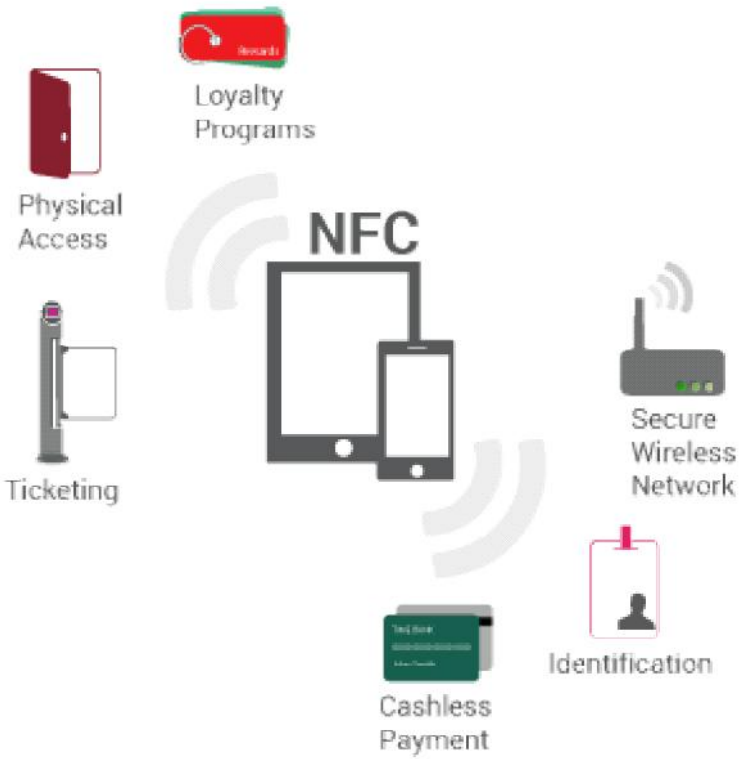
# Cellular

- Any IoT application that requires operation over longer distances can take advantage of GSM/3G/4G cellular communication capabilities. While cellular is clearly capable of sending high quantities of data, especially for 4G, the cost and also power consumption will be too high for many applications. But it can be ideal for sensor-based low-bandwidth-data projects that will send very low amounts of data over the Internet.


Data Flair
Cellular Connectivity For The IoT
wherever
SIM
Smart Metering
Payment Terminals
DELIVERY
Fleet Management
Security & Surveillance

# NFC

- NFC (Near Field Communication) is an IoT technology. It enables simple and safe communications between electronic devices, and specifically for smartphones, allowing consumers to perform transactions in which one does not have to be physically present. It helps the user to access digital content and connect electronic devices. Essentially it extends the capability of contactless card technology and enables devices to share information at a distance that is less than 4cm.


Loyalty
Programs
Physical
Access
NFC
Secure
Wireless
Network
Ticketing
Identification
Cashless
Payment

# LoRaWAN

- LoRaWAN is one of popular IoT Technology, targets wide-area network (WAN) applications. The LoRaWAN design to provide low-power WANs with features specifically needed to support low-cost mobile secure communication in IoT, smart city, and industrial applications. Specifically meets requirements for low-power consumption and supports large networks with millions and millions of devices, data rates range from 0.3 kbps to 50 kbps.


LoRa®

- So,  we learned IoT technology: Zigbee, Z-Wave, LoRaWAN, and Bluetooth. In addition, we discuss IoT Communication protocols like WiFi, NFC, and Cellular. We will be learning more about IOT in detail in the upcoming tutorials. So, stay tuned to learn more interesting things that you can do with this technology.

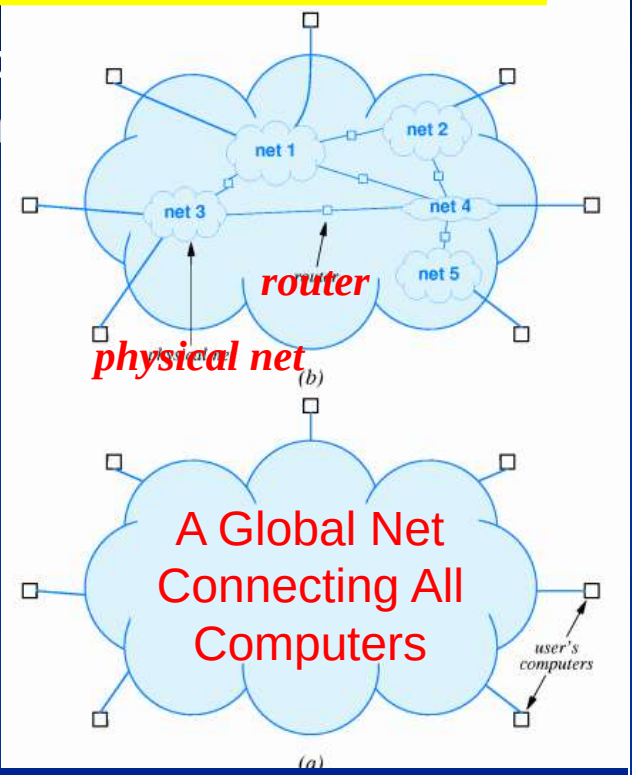
# Lecture 11

# Internet of Things (IoT)
# Web of Things (WoT)

- What are Internet of Things (IoT) & Web of Things (WoT)?
- Characteristics of IoT/WoT
- Potential Applications of IoT/WoT
- Technical Challenges of IoT/WoT

# What are the Internet?

- The **Internet** … a **Network** of **Networks** that co
  private, public, academic, business, and govern
  local to global scope. - *From Wikipedia*
- Originated from the ARPANET around 1970
  Available from 1980, got popular from 1990.
- Key components
  - Hardware: Routers connecting networks
  - Software: TCP/IP protocol suite, IPv4 → IPv6
  - Addressing: 2**32 (IPv4) → 2**128 (IPv6)
  - Naming: DNS → symbolic names




## The Internet → Internet of Computers (**IoC**)

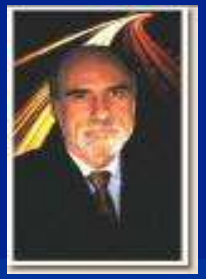
Leonard Kleinrock

Lawrence Roberts

Jon Postel

Steve Crocker

Vinton Cerf



Robert Kahn

# What are the Web?

- The World Wide Web, abbreviated as WWW or the Web, is a system of interlinked documents accessed via the Internet. - *From Wikipedia*
- The Web was originated from ***Tim Berners-Lee*** around 1990.
- The Web, like Email, is one of the services that runs on the Internet.
- Key components
  - Uniform Resource Locator (URL) & Uniform Resource Identifier (URI)
  - HyperText Markup Language (HTML)
  - Hypertext Transfer Protocol (HTTP)
  - Web server and web browser (client)

1st Web Graphical Browser


**The Web → Internet of Documents (IoD)**

Ted Nelson → Hypertext

Tim Berners-Lee

1st Web Server

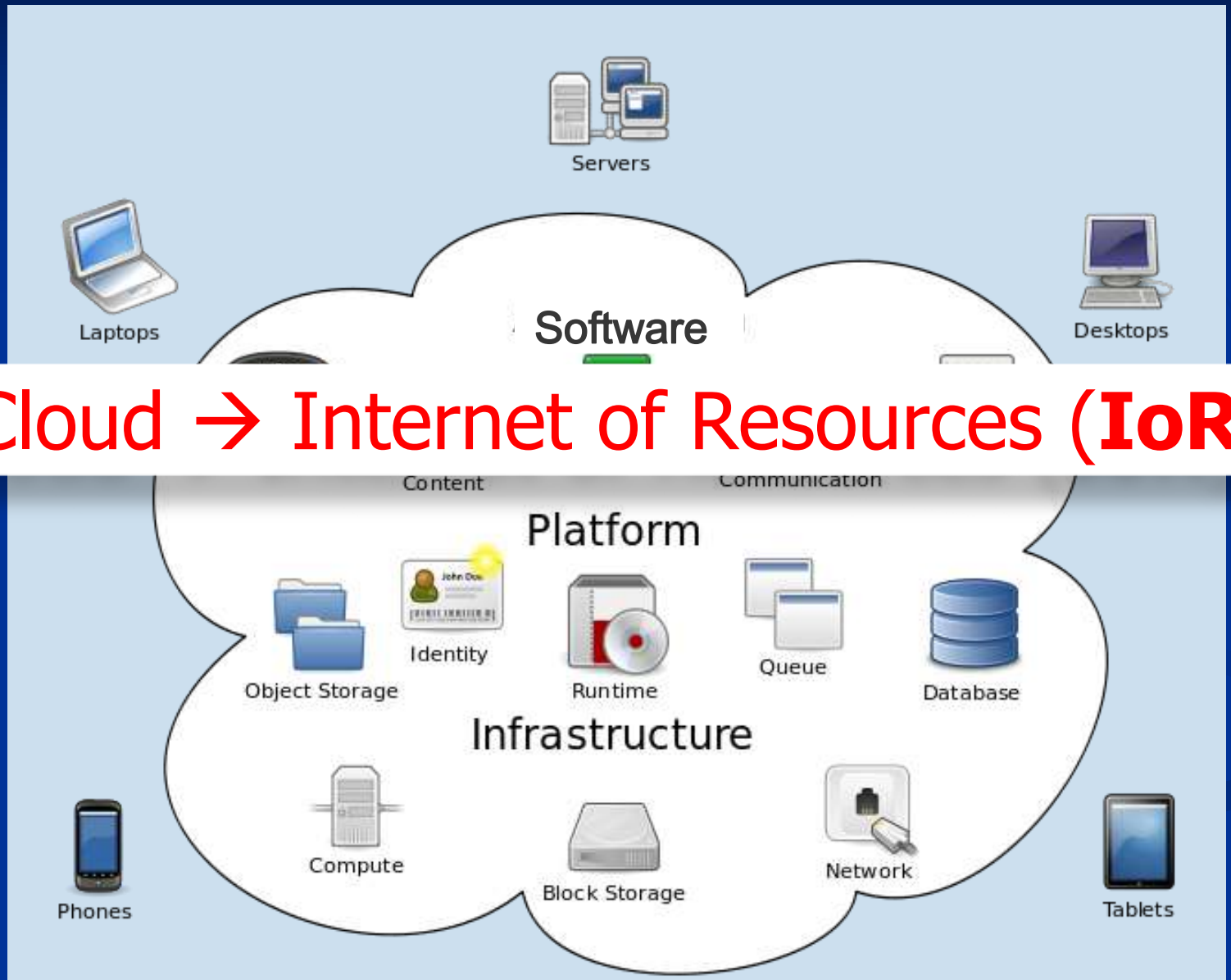
Mark Andreesen


⇩

Netscape

# How about Social Media/Web2.0?

# How about Cloud Computing?




Cloud → Internet of Resources (**IoR**)

# What are Things?

- **Thing** - An **object**, an entity, an idea, or a quality perceived, known, or thought to have its own existence, … *(dictionary)*
- **Object** – A tangible/visible **thing**; a person or thing seen as a focus or target for feelings, thought, etc.; a purpose/objective; ... *(dictionary)*
- Everyday Things/Objects – used in human daily lives
- Inner Things – mind, directly insensible things, ...
- Physical things, digital things, real/virtual things, …

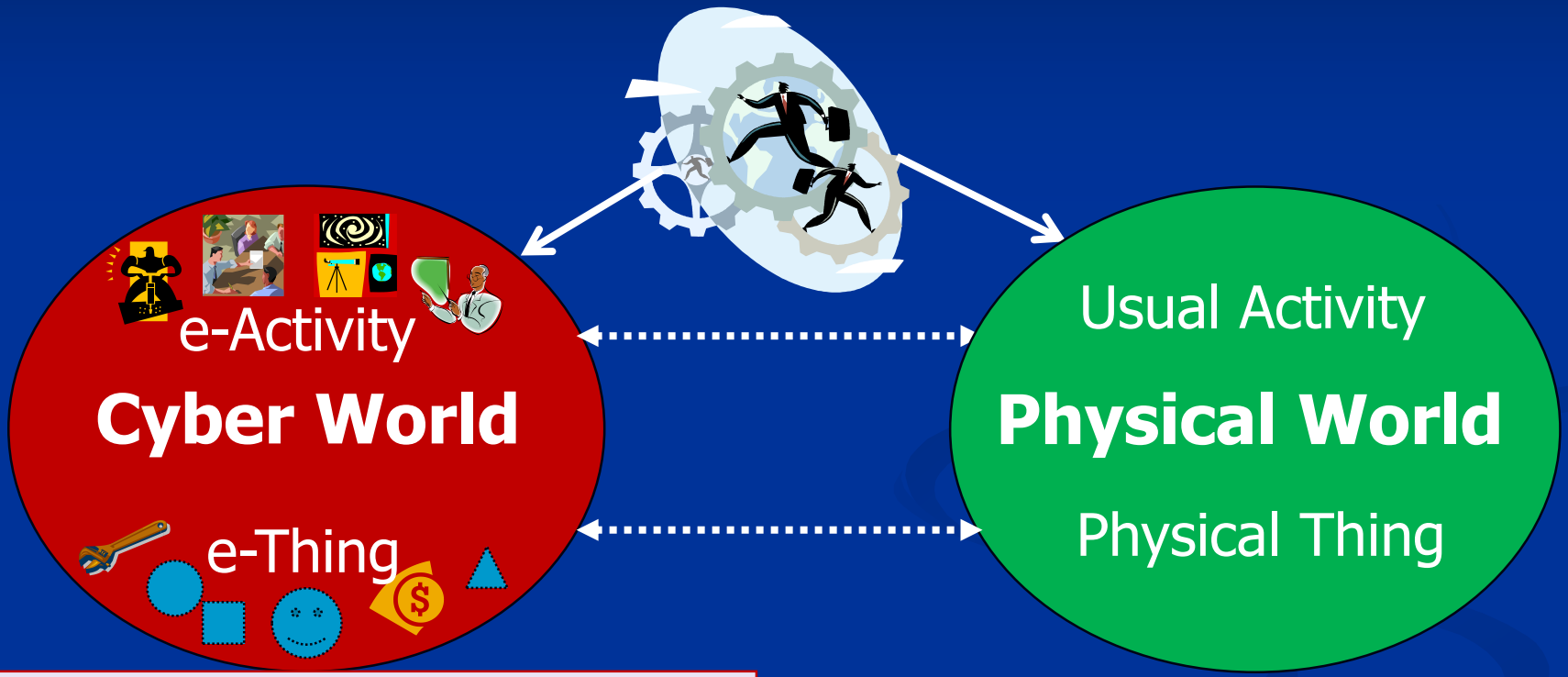
Various Things! → Many **IoX**!

What Kinds of Things in **IoT**?




# e-Thing in Digital/Cyber World

**e-Things**: digital things on cyber space in Cyber World




Web, WbS, SmW, Grid, P2P, XaaS, Cloud

Computers/Networks/Internet

**Cyber Space**

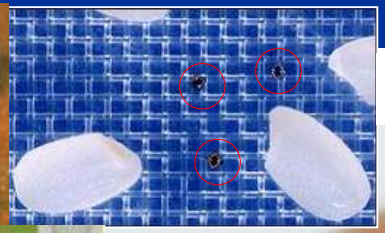
# u-Things → Physical Things with AEB

- Two Fundamental Technology Trends
  - Continuing miniaturization of devices (Moore's law, new material, nanotech., …)
  - Available interconnections by ubiquitous/pervasive wired and wireless networks

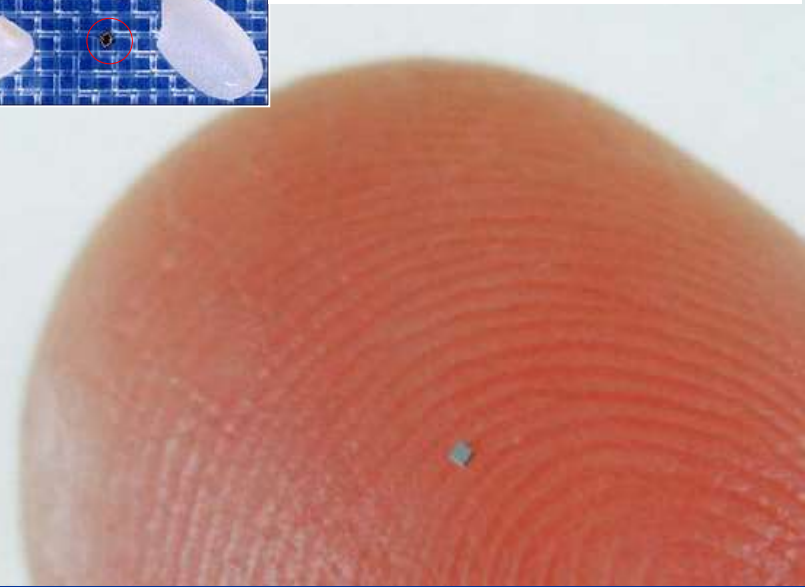
**u-Things**: **Physical things** with some kind of **A**ttachment, **E**mbedment, **B**lending (**AEB**) of computers, sensors, tags, networks, and/or other devices

*By J. Ma, "Smart u-Things: Challenging Real World Complexity", 2005*





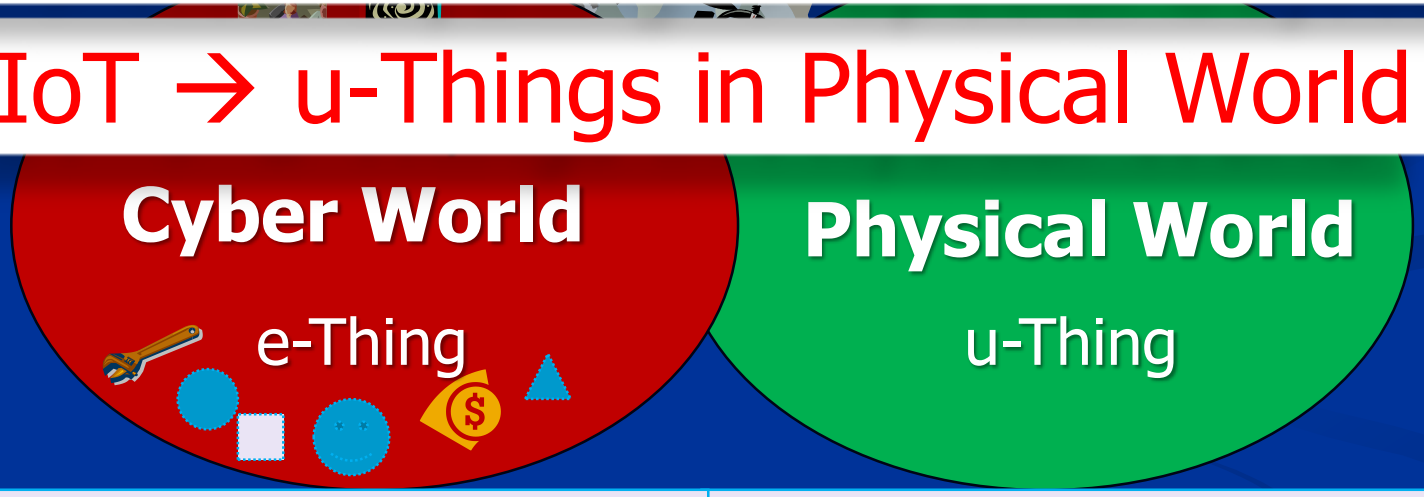
0.15x0.15 mm, Hitachi/06

# u-Things in Physical/Real World

u-Things: on the physical space in physical-digital form

IoT → Not Anything → Special Objects

IoT → u-Things in Physical World




| | |
|---|---|
| WbS, SmW, Grid, P2P, XaaS, Cloud | UC, ID, Context, Emb. Sys., Cloud, … |
| Computers & Networks/Internet **Cyber Space** | Sensor/M/NEMS, Comps & Per. Nets **Physical Space** |

# The Origination of IoT

- The term “Internet of things” was first coined by the former Auto-ID Center, founded in 1999, based at the time at MIT. *(Kevin Ashton and David L. Brock) → RFID-based EPC → Only term!*

- (Sean Dodson, 2003) "IoT" can be expressed as the building of a **global infrastructure for RFID tags**.

  @ You could think of it as a wireless layer on top of the internet where millions of things from razor blades to euro banknotes to car tyres are constantly being tracked and accounted for.

  @ A network … is for computers to identify "any object anywhere in the world instantly".

  @ Put a tag - a microchip with an antenna - on a can of Coke or a car axle, and suddenly a computer can 'see' it.

# Formal Introduction of IoT

"We are heading into a new era of ubiquity, where the users of the Internet will be counted in billions, and where humans may become the minority as generators and receivers of traffic. Changes brought about by the Internet will be dwarfed by those prompted by the ***networking of everyday objects***" – *UN report, 2005*

*Internet of Things will connect the world's objects in both a sensory and intelligent manner through combining technological developments in:*

- *item identification ("tagging things")*
- *sensors and wireless sensor networks ("feeling things")*
- *embedded systems ("thinking things")*
- *nanotechnology ("shrinking things").*

*The ITU also identified as main challenges for the IOT :*

- *Standardization and Harmonization*
- *Privacy and Social and Ethical aspects.*

# Other Definitions of IoT

- The Internet of things, also known as the Internet of objects, refers to the networked interconnection of everyday objects. It is described as a self-configuring wireless network of sensors whose purpose would be to interconnect all things.

*From Wikipedia*

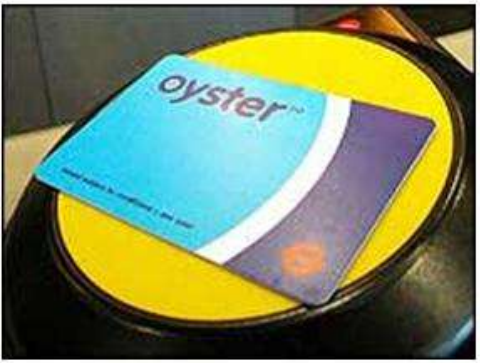
- (IoT is) a network of interconnected computers to a network of interconnected objects, from books to cars, from electrical appliances to food, and thus create an 'Internet of things'. These objects will sometimes have their own Internet Protocol addresses, be embedded in complex systems and use sensors to obtain information from their environment and/or use actuators to interact with it.

*From Internet of Things — An action plan for Europe (2009)*

- "Internet of Things" to refer to the general idea of things, especially everyday objects, that are readable, recognizable, locatable, addressable, and/or controllable via the Internet—whether via RFID, wireless LAN, wide-area network, or other means.

*From SRI Consulting Business Intelligence*

# Examples of Things in IoT





tikitag


# Ubiquitous Networks

## Object-To-Object (O2O), Thing-To-Thing (T2T)


Many physical things are connected, can talk

全てのモノが繋がる世界 → 対話(通信)できる

# Ubiquitous Connection of All Things

# Internet of Everything


"... A myriad of hitherto separate objects are becoming connected to networks, from televisions and cars to industrial machinery and farmland...."

"... In years to come, wireless communications will increasingly become part of the fabric of everyday life... in 15 or 20 years' time, the network will have to accommodate a trillion devices..."

# Videos About IoT

An Introduction of Internet of Things from IBM

IOT will change everything from Cisco (30 videos)

Internet of Things by Dr. John Barrett at TEDxCIT

Harnessing the Internet of Things by Steve Lucas

Freescale's IoT Applications

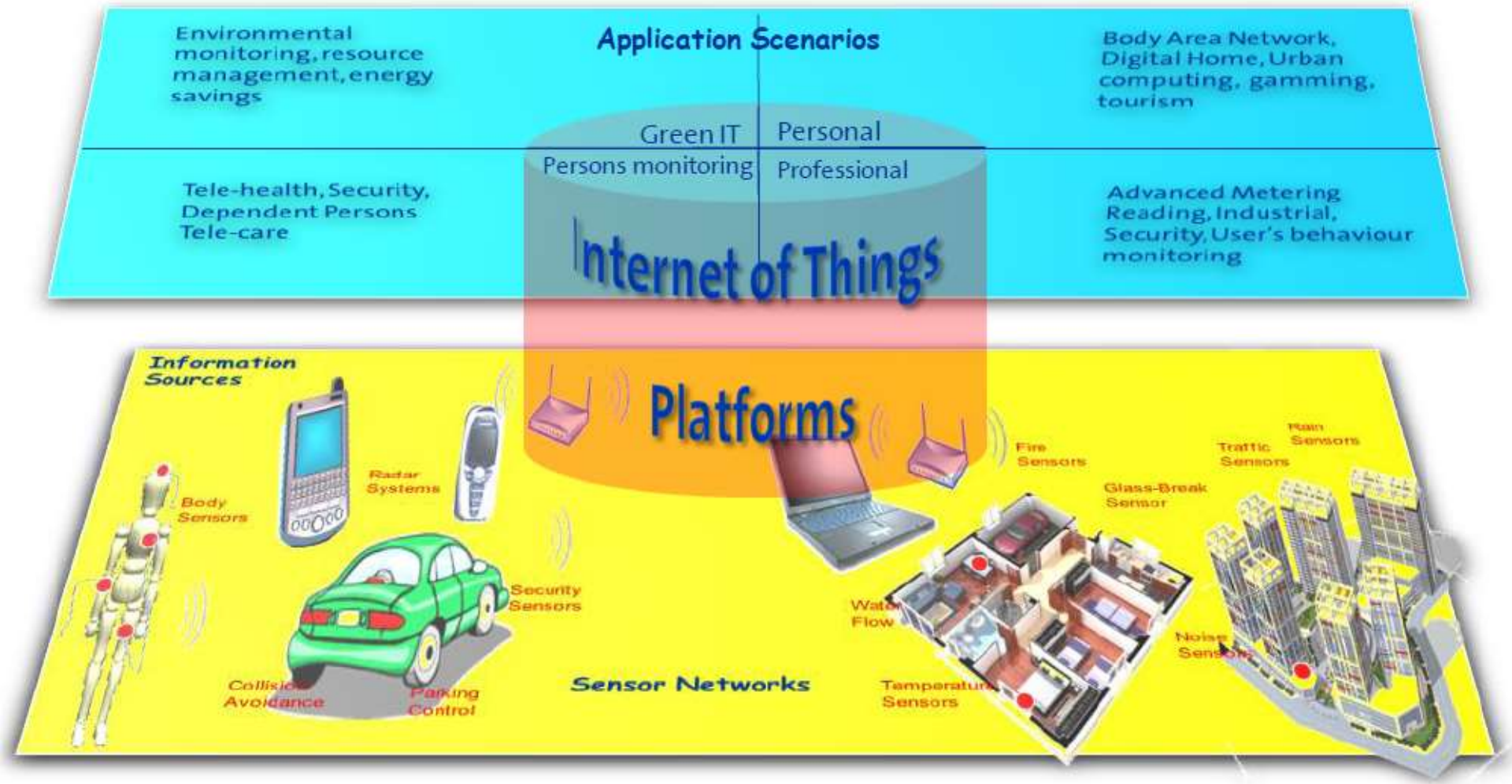
# Identification of a Thing

- What is a thing?
  - We distinguish two classes of things
    - Things that are computers including smart phones equipped with communication interfaces.
    - Things that are not computers, but who are associated with computers equipped with communication interfaces.
- What is the identifier of a thing?
  - They are several proposals:
    - A serial number, such as an EPC code.
    - An IP address, MAC address of Wifi, BlueTooth, SIM card code
    - Other, for example a fix hash value, or ad-hoc naming scheme.
- Authentication
  - Is there a need/way to authenticate a thing?
  - In other words, is it possible and needed to prove the identity of a thing?

# Things Attributives in IoT (SINTEF)

- “Things” would be competing with other “things” on resources, services and subject to selective pressures
- “Things” can create, manage and destroy other “things”
- “Things” can use services that act as interfaces to “things”
- “Things” respect the privacy, security and safety of other “things” or people with which they interact
- “Things” use protocols to communicate with each other and the infrastructure
- “Things” can negotiate, understand and adapt to their environment
- “Things” can extract patterns from the environment or to learn from other “things”
- “Things” are environmentally safe
- “Things” can take decisions through their reasoning capabilities

# IoT Platform and Applications




*From CERP-IOT*

# Applications Empowered by IoT *(IISD)*

**Global Environmental Observation**
- GIS systems
  - Atmospheric
  - Vegetation / Ground Water
  - Surface / Water Temperature
- GHG Tracking
  - Consumption metering
  - Atmospheric measurements
- Reporting Systems
  - Mash-ups / SOA / Web 2.0

**Global Action / Management Plans**
- Early Warning Systems
  - Famine / Drought
  - Natural Disasters
- Environmental Mitigation
  - Carbon-trading
  - Conservation Planning
- International Agreements
  - Ratification
  - Implementation

**Global**

**Observation** ⟷ **Implementation**

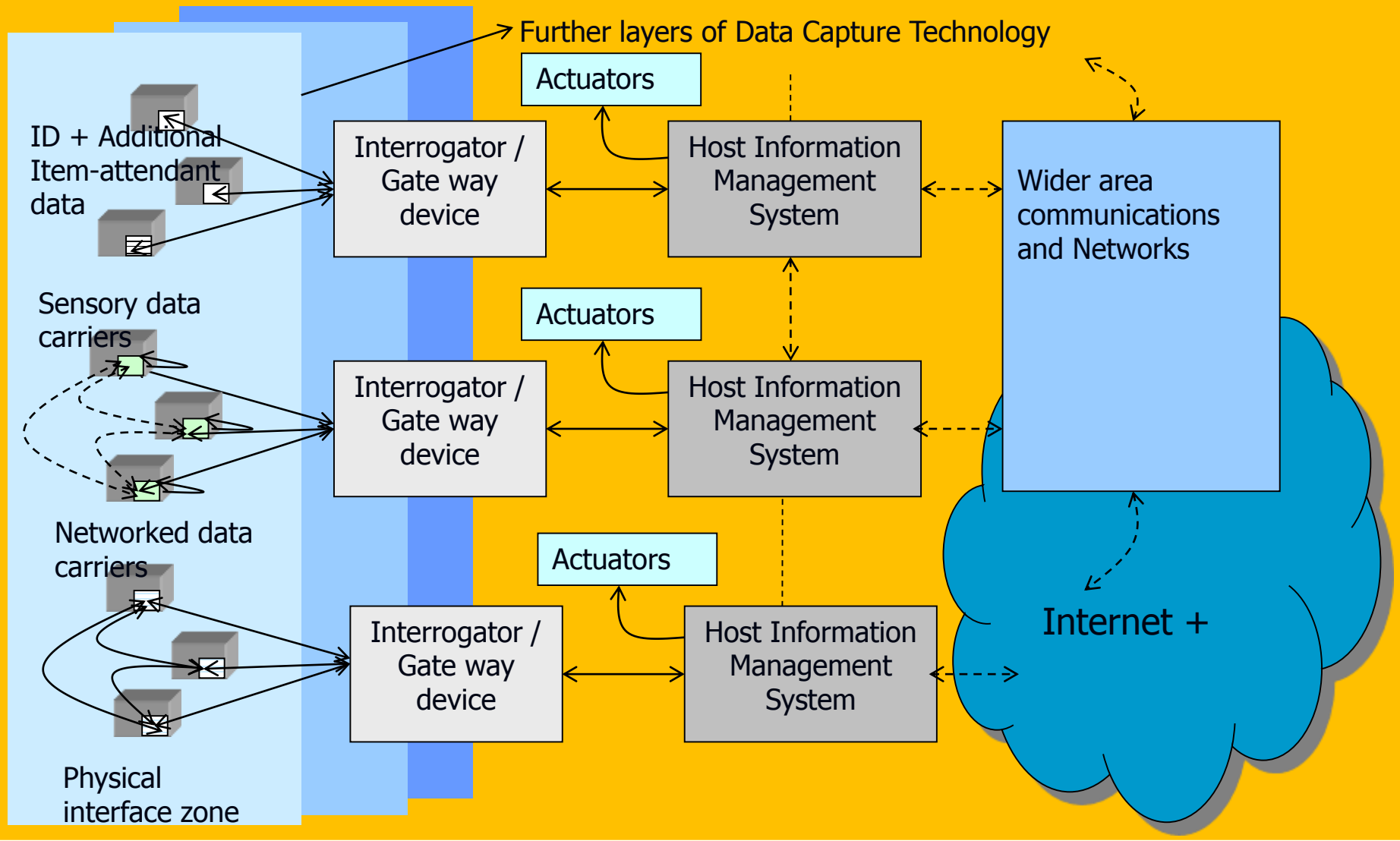
**Local**

**Local Environmental Observation**
- Capacity building
  - Awareness of threats
  - Identifying impact
- Data Entry
  - Web 2.0 / Wiki data logs
- Appropriate Technology
  - SMS / Mobile Phone usage
  - Cultural adaptation

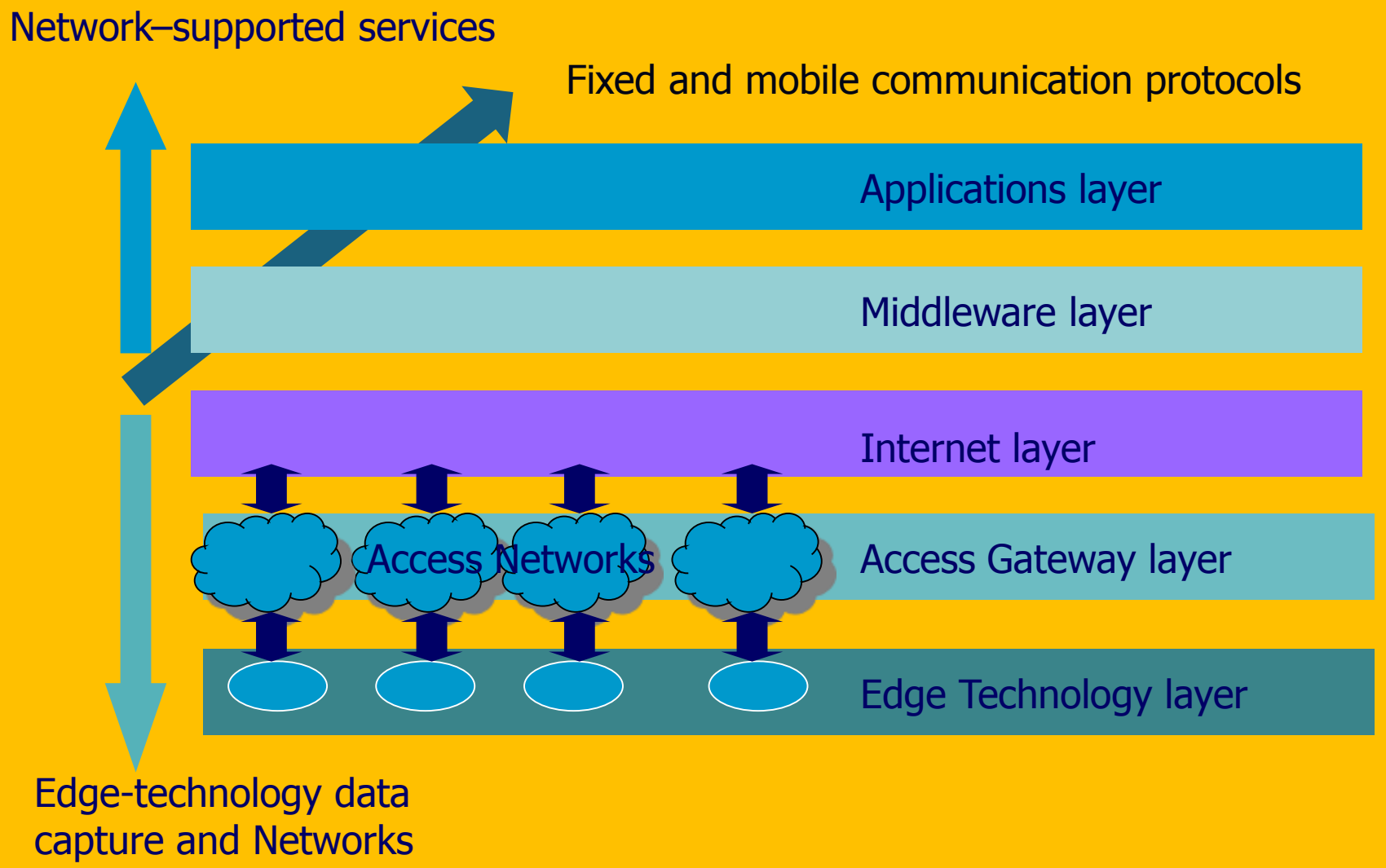
**Local Action / Management Plans**
- Resource Management
  - Access / Allocation
  - Enforcement
  - Support and Funding
- Professional Development
- Response Planning
  - Early warning response
  - Conflict avoidance

# One Conceptual Architecture of IoT

*(GASAGRAS)*



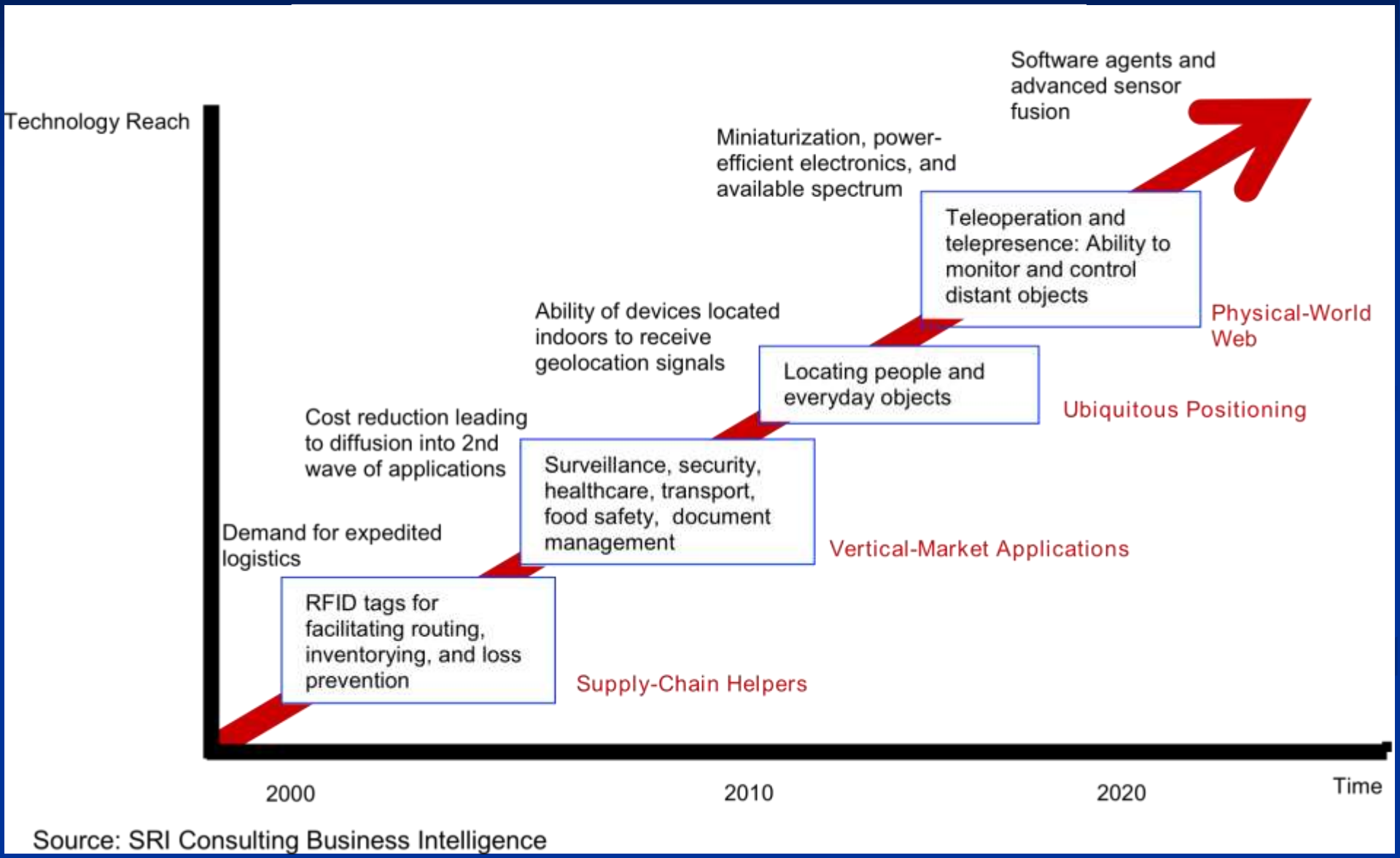
# A Layered Model of IoT *(GASAGRAS)*



# Challenging Issues in IoT

- How is a thing identification structured? (the object naming)
- Who assigns the identifier to a thing? (the assigning authority)
- How and where can additional information about that thing be retrieved, including its history? (the addressing mechanism and the information repository)
- How is information security/privacy/trust/safety ensured?
- Which stakeholders are accountable for each of the above questions, what is the accountability mechanism?
- Which ethical and legal framework applies to the different stakeholders?
- *What are uniform thing naming scheme, communication protocols between various things, thing's data collection, storage, query, management, processing, visualization, use, security, privacy, ….*

# Technological Roadmap of IoT




Source: SRI Consulting Business Intelligence

# What is Web of Things (WoT)?

From Wikipedia

- The Web of Things is a vision inspired from the Internet of Things where everyday devices and objects, i.e. objects that contain an Embedded devices or computer, are connected by fully integrating them to the Web. Examples of smart devices and objects are Wireless Sensor Networks, Ambient devices, household appliances, etc.

- Unlike in the many systems that exist for the Internet of things, the Web of Things is about re-using the Web standards to connect the quickly expending eco-system of Embedded devices built into everyday smart objects. Well-accepted and understood standards and blueprints (such as URI, HTTP, REST, RSS, etc.) are used to access the functionality of the smart objects.

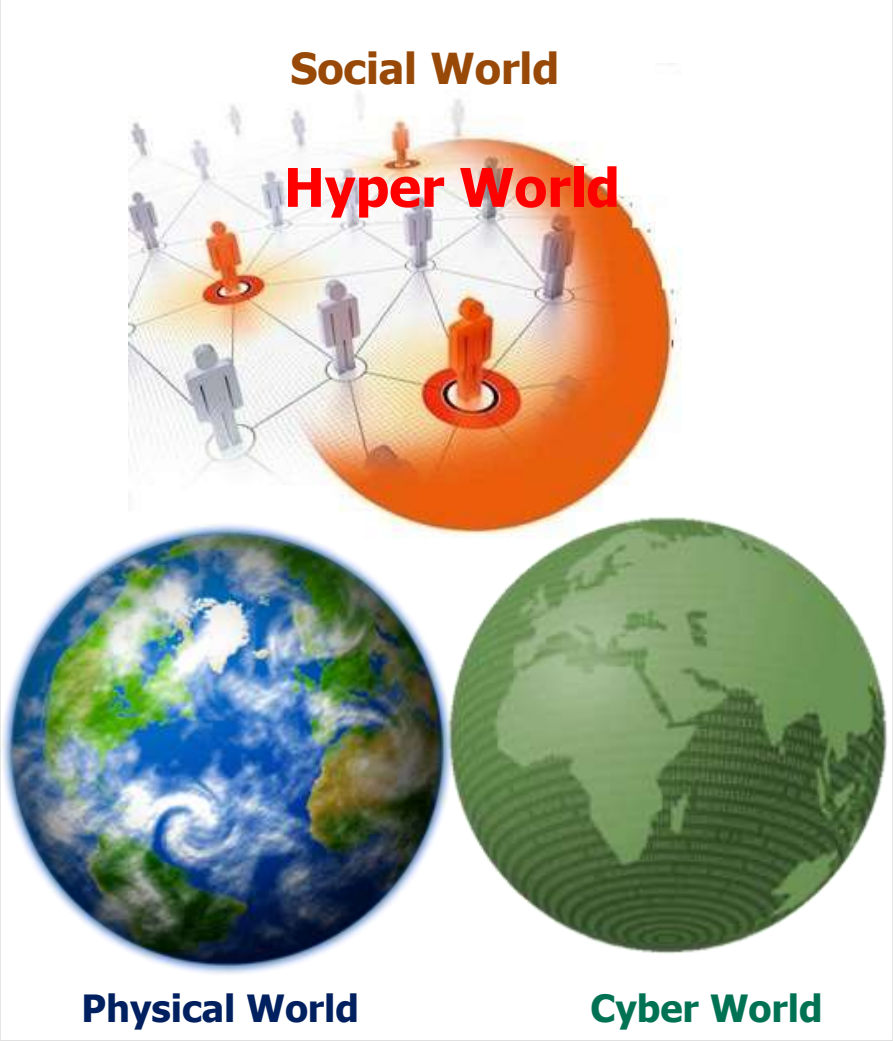
# Technical Characteristics of WoT?

From Wikipedia

- Uses HTTP as an application protocol rather than as a transport protocol as done in the world of WS-* Web Services.
- Exposes the synchronous functionality of smart objects through a REST interface (also known as RESTful API) and more generally respects the blueprints of Resource Oriented Architectures.
- Exposes the asynchronous functionality (i.e. events) of smart objects through the use of largely accepted Web syndication standards such as Atom_(standard) or server-push Web mechanisms such as Comet_(programming).

These characteristics ensure the loose-coupling of services provided by the smart objects, furthermore they offer a uniform interface to access and build on the functionality of smart objects.

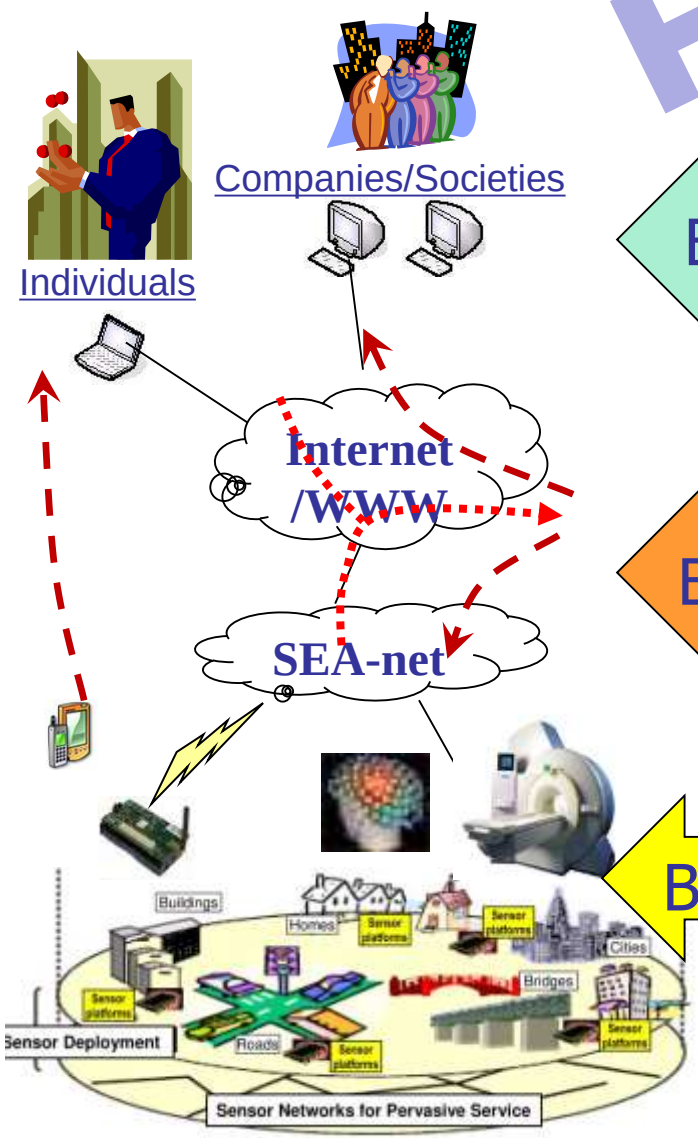
# Wisdom Web of Things (W2T)




- The **Wisdom Web of Things (W2T)** is an extension of the **Wisdom Web** in the **hyper-world**.
- The "**Wisdom**" means that each of things in the **IoT** /**WoT** can be aware of both itself and others to provide the ***right service*** *for the* ***right object*** *at a* ***right time*** *and* ***context.***
- To realize the harmonious symbiosis of humans, computers and things in the hyper-world by using the Intelligent Information Technology

**Research challenges and perspectives on wisdom web of things (W2T).**
***Journal of Supercomputing*, 2010.**
**Ning, Ma, Liu, Huang, Chen, Yao, Zhang**

# Hyper World




Big Data
IoP

Social networks

Social world

IoC
Big Data
IoD

Cyber networks

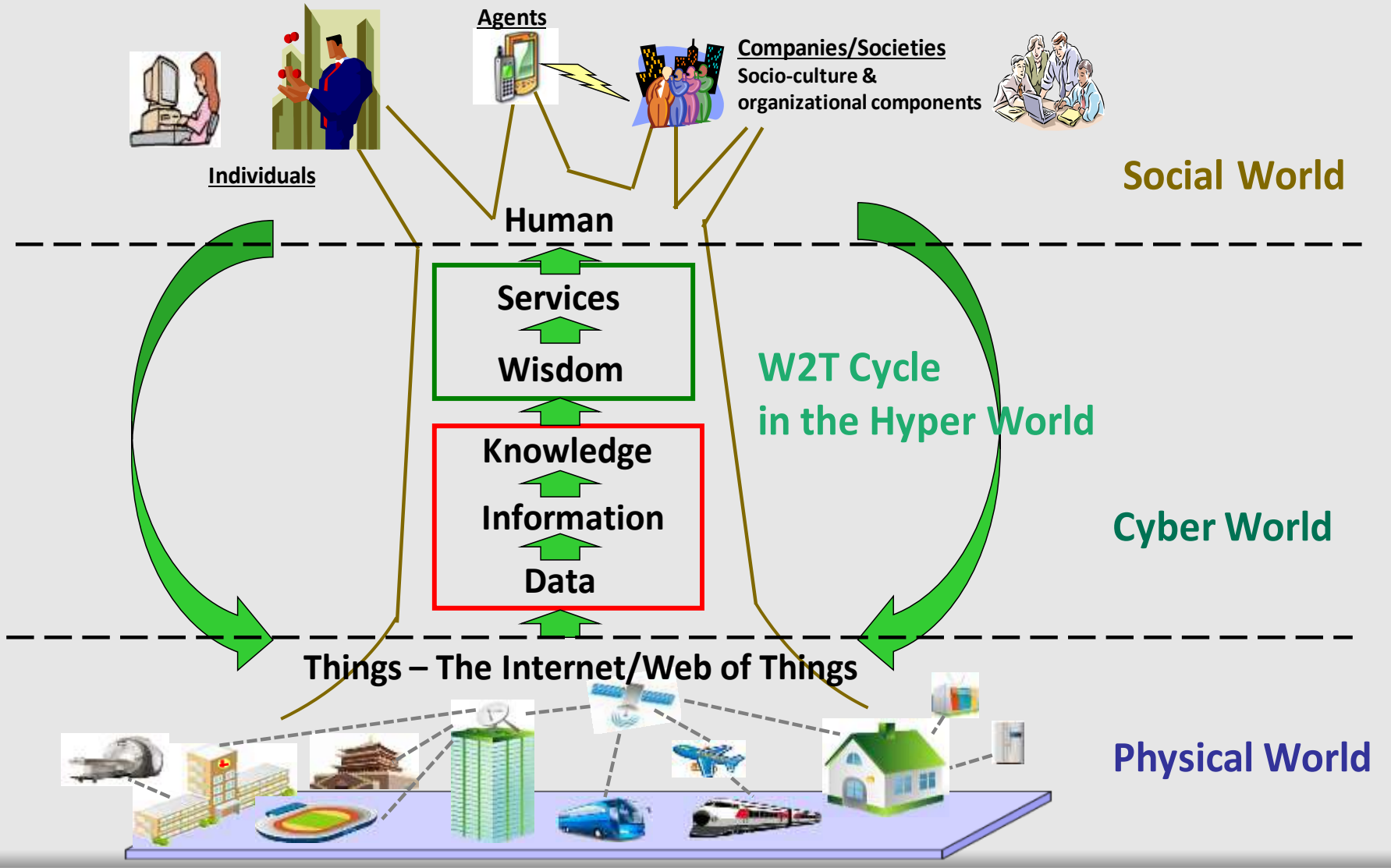
Cyber world

Big Data
IoT

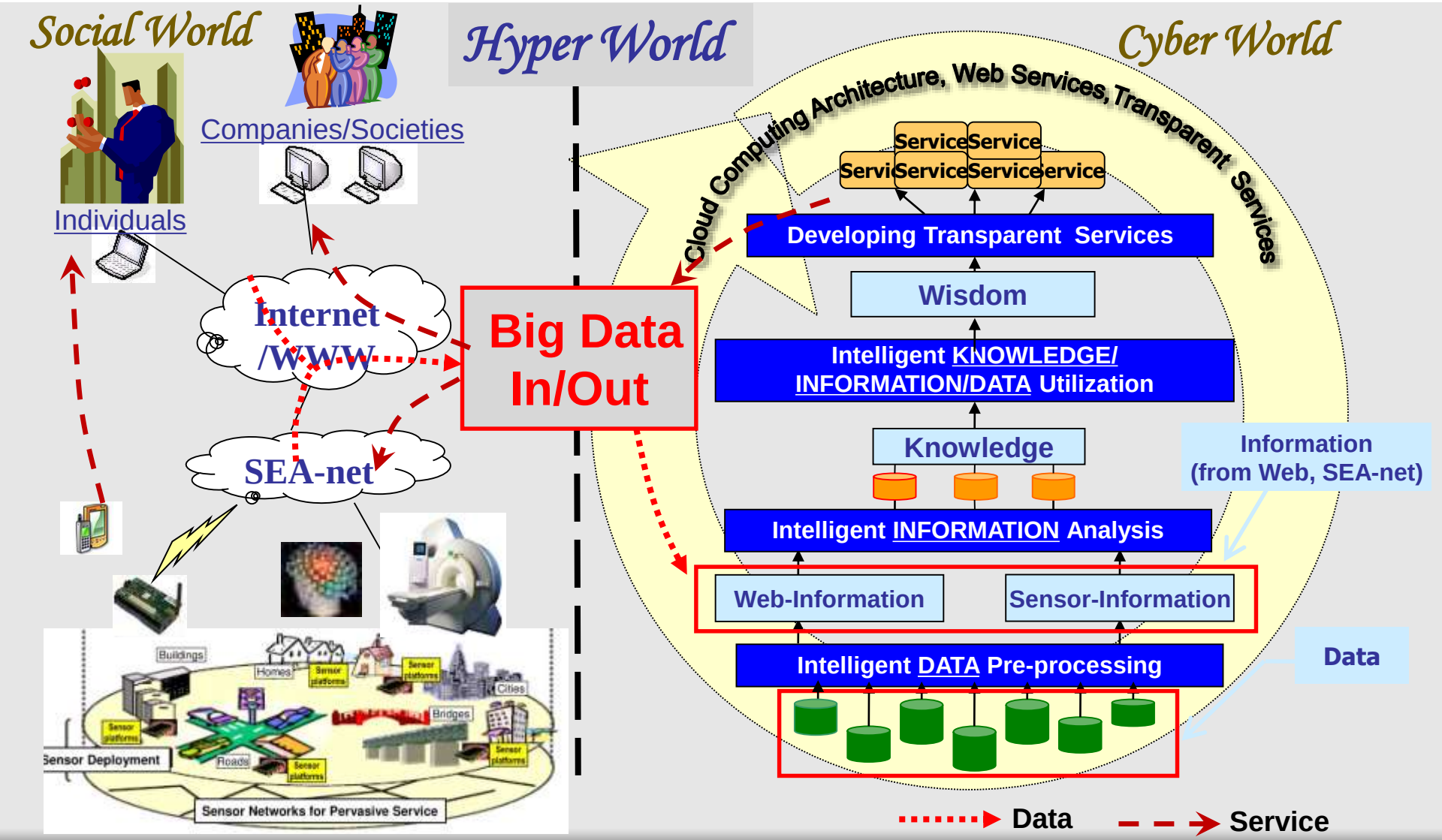
Physical networks

Physical world

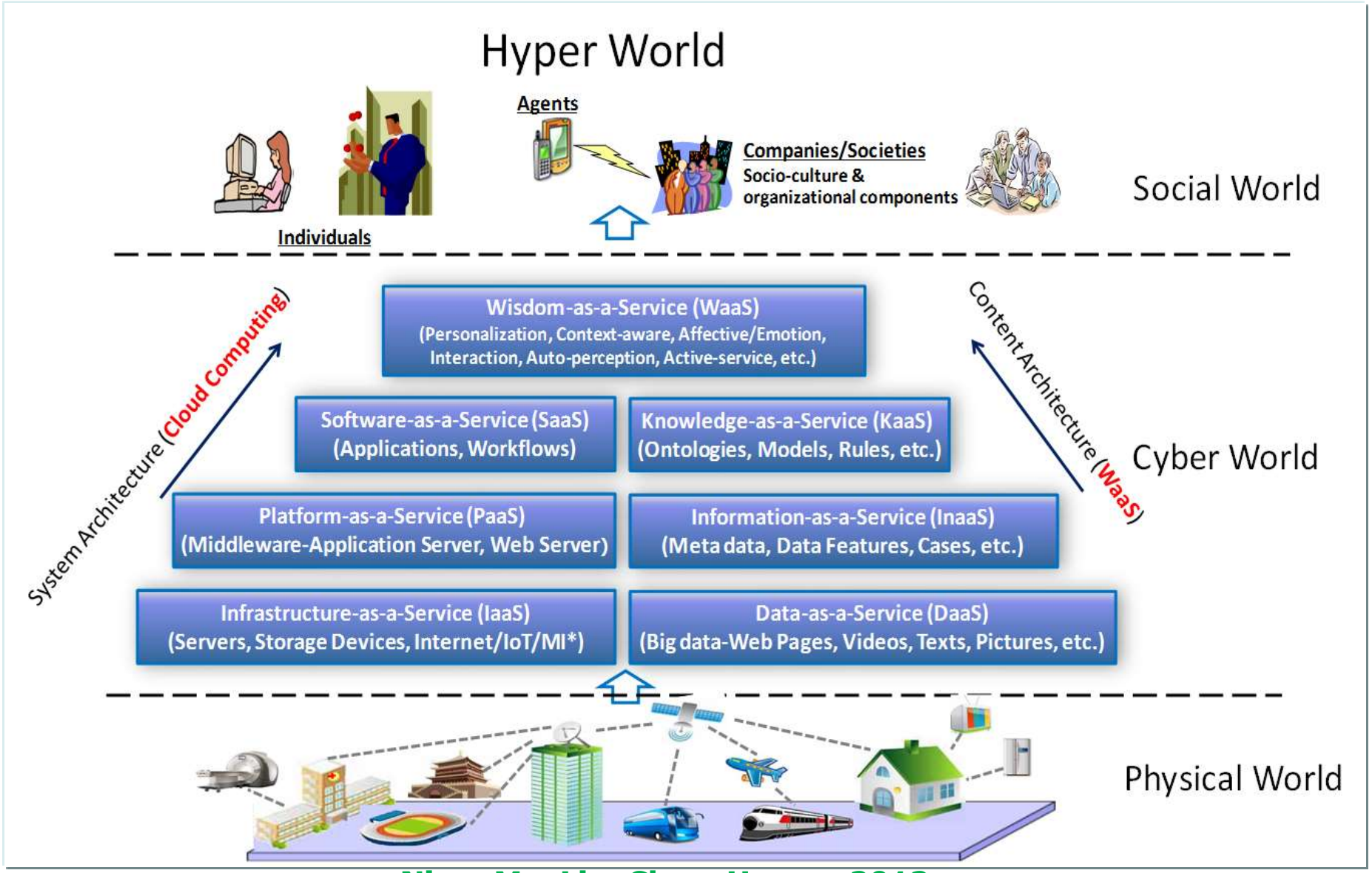
# W2T Data Cycle



# W2T Intelligent Processing



# WaaS: Wisdom as a Service
# An Open Architecture for the W2T Cycle




Ning, Ma, Liu, Chen, Huang, 2012

# Homework

- Browse the videos in previous slide, read the documents below and access the related websites to learn more about IoT & WoT, related concepts, visions, technologies, applications, etc.

- Internet of Things — An action plan for Europe
- Background: The Internet of Things
- A Resource Oriented Architecture for the Web of Things
- Internet of Things – Wikipedia
- Web of Things – Wikipedia
- IoT 2010, Tokyo , IEEE iThings 2013, WF-IoT 2014
- Others you like → Important to get materials from Web!!

**Questions**

The number of elements in the Open IoT Architecture?

Global Sensor Network is built for _____

Drawback of Factory Bootstrap?

Central software management server communicates with the gateway devices in which approach?

Which is the correct operator for power(x^y)?

What is WPA?

The number of elements in the Open IoT Architecture?

MQTT is _____ protocol.

. _____ allows us to control electronic components

MQTT stands for _____

What is WPA?

MQTT is _____ protocol.

Fuzzy Logic is a form of:

._____ involves predicting a response with meaningful magnitude, such as quantity sold, stock price, or return on investment.

Which of the following language is preferred for IoT analytics?

Which one is simplest form of analytics?

HTTP resources are located by

What is the TCP name for a transport service access point

A Denial of Service attack is:

A packet sniffer is
Which environment does Global Sensor Network work on?
Which protocol allows user at one site to establish connection to another site and pass keystroke from local to remote host

How many times setup function runs in Arduino IDE:
Which protocol is lightweight?

What is the use of Ping command:

What is the sensor/protocol used in GSN?

Which is the core wrapper of GSN?

How many times setup function runs in Arduino IDE:
Open IoT manages the registration, data acquisition, deployment of sensors and interconnected of objects, through which network?

HTTP resources are located by

The huge number of devices connected to the Internet of Things has to communicate automatically, not via humans. What is this called?

Internet of Things needs a lot of network connection. What is the proposed “white Space” radio standard called?

A packet sniffer is

IANA stands for:
Standard port number for secure MQTT is:

Bluetooth 5.0 promises:

Terms SSL and TLS stand for:

Which one out of these is not a data link layer technology:
Which transport layer protocols is used by DHCP?

| opt1 | opt2 | opt3 | opt4 | opt5 | opt6 | Answer |
|---|---|---|---|---|---|---|
| 6 elements | 8 elements | 7 elements | 3 elements | | | 7 elements |
| Reducing cost and time for development | Reducing cost and increasing time for development | Increasing cost and increasing time for development | Increasing cost and decreasing time for development | | | Reducing cost and time for development |
| It should not have many gateways | It should not have many devices | Complex circuit can't be handled | It should have many gateways | | | It should not have many gateways |
| Factory Bootstrap | Server limited Bootstrap | Client Initiated Bootstrap | Bootstrap | | | Server limited Bootstrap |
| x^y | x^^y | x**y | None of the mentioned | | | x**y |
| wi-fi protected access | wired process access | wired protected access | wi-fi process access | | | wi-fi protected access |
| 6 elements | 8 elements | 7 elements | 3 elements | | | 7 elements |
| Machine to Machine | Internet of Things | Machine to Machine and Internet of Things | Machine Things | | | Machine to Machine and Internet of Things |
| a. RETful ApI | b. RESTful API c. d. | HTTP | MQTT | | | a. RETful ApI |
| a. MQ Telemetry Things | b. MQ Transport Telemeter | c. MQ Transport Things | d. MQ Telemetry Transport | | | d. MQ Telemetry Transport |

| | | | | |
|---|---|---|---|---|
| wi-fi protected access | wired process access | wired protected access | wi-fi process access | wi-fi protected access |
| Machine to Machine | Internet of Things | Machine to Machine and Internet of Things | Machine and Internet Things | Machine to Machine and Internet of Things |
| a. Hexa state logic | b. Two-valued logic | c. Binary set logic | d. Many valued logic | d. Many valued logic |
| Summarization | Clustering | All of the mentioned | Regression | Regression |
| Python | S | R | All of the mentioned | Python |
| Predictive | Descriptive | All of the mentioned | Prescriptive | Descriptive |
| unique resource locator | unique resource identifier | none of the mentioned | uniform resource identifier | uniform resource identifier |
| none of the mentioned | node | pipe | port | port |
| Connection flooding | Bandwidth flooding | All of the mentioned | Vulnerability attack | All of the mentioned |
| Active receiver | Both of the mentioned | Passive receiver | None of the mentioned | Passive receiver |
| C++ | JAVA | HTML | C | JAVA |
| Telnet | FTP | IP | HTTP | Telnet |

| | | | | |
|---|---|---|---|---|
| None of the above | 10 | 2 | 1 | 1 |
| MQTT | HTTP | CoAP | SPI | MQTT |
| To know network speed | None of the above | To test a host on the network is reachable | To test storage device | To test a host on the network is reachable |
| HTTP protocol | CoAP protocol | MQTT protocol | XMPP protocol | CoAP protocol |
| Serial | UDP | GPSTest | ZeroMQ Wrapper | ZeroMQ Wrapper |
| None of the above | 10 | 2 | 1 | 1 |
| GSN | X-GSN | LSM | HTTP | X-GSN |
| unique resource locator | unique resource identifier | none of the mentioned | uniform resource identifier | uniform resource identifier |
| Skynet | Bot 2 Bot | Machine 2 Machine | Intercloud | Machine 2 Machine |
| Bluetooth | WiMax | Weightless | Zigbee | Weightless |
| Active receiver | Both of the mentioned | Passive receiver | None of the mentioned | Passive receiver |
| Internal Assessment | Internet Association | International Aid for Network Automation | Internet Assigned | Internet Assigned |
| Numerical Access | Numbers Authority | | Numbers Authority | Numbers Authority |
| 1883 | 8000 | 8883 | 8888 | 8883 |

| | | | | |
|---|---|---|---|---|
| 4x Speed, 2x Range, 2x Data | 6x Speed, 3x Range, 3x Data | 2x Speed, 4x Range, 8x Data | 3x Speed, 4x Range, 8x Data | 2x Speed, 4x Range, 8x Data |
| Secure Socket Layers and Transport Layer Session | Secure Socket Layers and Transport Layer Security | Secure Socket Layout and Transport Level Session | Session Socket Layers and Transport Layer Session | Secure Socket Layers and Transport Layer Security |
| Bluetooth RSVP | UART TCP | WiFi DCCP | HTTP UDP | HTTP UDP |

**Questions**

The number of elements in the Open IoT Architecture?

Global Sensor Network is built for _____

Drawback of Factory Bootstrap?

Central software management server communicates with the gateway devices in which approach?

Which is the correct operator for power(x^y)?

What is WPA?

The number of elements in the Open IoT Architecture?

MQTT is _____ protocol.

. _____ allows us to control electronic components

MQTT stands for _____

What is WPA?

MQTT is _____ protocol.

Fuzzy Logic is a form of:

price, or return on investment.

Which of the following language is preferred for IoT analytics?

Which one is simplest form of analytics?

HTTP resources are located by

What is the TCP name for a transport service access point

A Denial of Service attack is:

A packet sniffer is

Which environment does Global Sensor Network work on?

local to remote host

How many times setup function runs in Arduino IDE:

Which protocol is lightweight?

What is the use of Ping command:

What is the sensor/protocol used in GSN?

Which is the core wrapper of GSN?

How many times setup function runs in Arduino IDE:

objects, through which network?

HTTP resources are located by

not via humans. What is this called?

standard called?

A packet sniffer is

IANA stands for:

Standard port number for secure MQTT is:

Bluetooth 5.0 promises:

Terms SSL and TLS stand for:

Which one out of these is not a data link layer technology:

Which transport layer protocols is used by DHCP?

**opt1**
6 elements

Reducing cost and time for development
It should not have many gateways
Factory Bootstrap
x^y
wi-fi protected access
6 elements
Machine to Machine
a. RETful ApI
a. MQ Telemetry Things
wi-fi protected access
Machine to Machine
a. Hexa state logic
Summarization
Python
Predictive
unique resource locator
none of the mentioned
Connection flooding
Active receiver
C++
Telnet
None of the above
MQTT
To know network speed
HTTP protocol
Serial
None of the above
GSN
unique resource locator
Skynet
Bluetooth
Active receiver
Internal Assessment Numerical Access

1883

4x Speed, 2x Range, 2x Data

Secure Socket Layers and Transport Layer Session
Bluetooth
RSVP

**opt2**
8 elements
Reducing cost and increasing time for development
It should not have many devices
Server limited Bootstrap
x^^y
wired process access
8 elements
Internet of Things
b. RESTful API c. d.
b. MQ Transport Telemeter
wired process access
Internet of Things
b. Two-valued logic
Clustering
S
Descriptive
unique resource identifier
node
Bandwidth flooding
Both of the mentioned
JAVA
FTP
10
HTTP
None of the above
CoAP protocol
UDP
10
X-GSN
unique resource identifier
Bot 2 Bot
WiMax
Both of the mentioned
Internet Association Numbers Authority
8000
6x Speed, 3x Range, 3x Data
Secure Socket Layers and Transport Layer Security
UART
TCP

**opt3**
7 elements

Increasing cost and increasing time for development
Complex circuit can’t be handled
Client Initiated Bootstrap
x**y
wired protected access
7 elements
Machine to Machine and Internet of Things
HTTP
c. MQ Transport Things
wired protected access
Machine to Machine and Internet of Things
c. Binary set logic
All of the mentioned
R
All of the mentioned
none of the mentioned
pipe
All of the mentioned
Passive receiver
HTML
IP
2
CoAP
To test a host on the network is reachable
MQTT protocol
GPSTest
2
LSM
none of the mentioned
Machine 2 Machine
Weightless
Passive receiver
International Aid for Network Automation
8883
2x Speed, 4x Range, 8x Data

Secure Socket Layout and Transport Level Session
WiFi
DCCP

**opt4**
3 elements

Increasing cost and decreasing time for development
It should have many gateways
Bootstrap
None of the mentioned
wi-fi process access
3 elements
Machine Things
MQTT
d. MQ Telemetry Transport
wi-fi process access
Machine Things
d. Many valued logic
Regression
All of the mentioned
Prescriptive
uniform resource identifier
port
Vulnerability attack
None of the mentioned
C
HTTP
1
SPI
To test storage device
XMPP protocol
ZeroMQWrapper
1
HTTP
uniform resource identifier
Intercloud
Zigbee
None of the mentioned
Internet Assigned Numbers Authority
8888
3x Speed, 4x Range, 8x Data

Session Socket Layers and Transport Layer Session
HTTP
UDP

**opt5**

**opt6**

**Answer**
7 elements

Reducing cost and time for development
It should not have many gateways
Server limited Bootstrap
x**y
wi-fi protected access
7 elements
Machine to Machine and Internet of Things
a. RETful ApI
d. MQ Telemetry Transport
wi-fi protected access
Machine to Machine and Internet of Things
d. Many valued logic
Regression
Python
Descriptive
uniform resource identifier
port
All of the mentioned
Passive receiver
JAVA
Telnet
1
MQTT
To test a host on the network is reachable
CoAP protocol
ZeroMQWrapper
1
X-GSN
uniform resource identifier
Machine 2 Machine
Weightless
Passive receiver
Internet Assigned Numbers Authority
8883
2x Speed, 4x Range, 8x Data

Secure Socket Layers and Transport Layer Security
HTTP
UDP

**Questions**

What is a firewall in computer networks:
Router operate at ..... layer of OSI reference model?
Each IP packet must contain:
Which one of this is not a networking device:
What is the use of Ping command:
What is Secure Shell (SSH):
What does VNC stand for:
What is the standard length of MAC address:
The method by which companies analyze customer data or other types of information in an effort to identify patterns and discover relationships between different data elements is often referred to as:
What is the purpose of bin directory in Linux environment?
What is Inter Integrated Communication (I2C)?
How many wires does SPI protocol use?
What does LTE stand for?
The number of elements in the Open IoT Architecture?
Global Sensor Network is built for _____
Drawback of Factory Bootstrap?
Central software management server communicates with the gateway devices in which approach?
Which is the correct operator for power(x^y)?
What is WPA?
The number of elements in the Open IoT Architecture?
MQTT is _____ protocol.
. _____ allows us to control electronic components
MQTT stands for _____
What is WPA?
MQTT is _____ protocol.
Fuzzy Logic is a form of:
._____ involves predicting a response with meaningful magnitude, such as quantity sold, stock price, or return on investment.
Which of the following language is preferred for IoT analytics?
Which one is simplest form of analytics?
HTTP resources are located by
What is the TCP name for a transport service access point
A Denial of Service attack is:
HTTP resources are located by
What is the TCP name for a transport service access point
A Denial of Service attack is:
A packet sniffer is
Which environment does Global Sensor Network work on?
Which protocol allows user at one site to establish connection to another site and pass keystroke from local to remote host
How many times setup function runs in Arduino IDE:

**opt1**
A system designed to prevent unauthorized access
Layer 2 (Data Link)
Only Destination IP Address
Router
To know network speed
A router
Various Network computers
16 bits

Customer data management
Contains essential device files
An application layer protocol
2
Long Term Errors
6 elements
Reducing cost and time for development
It should not have many gateways
Factory Bootstrap
x^y
wi-fi protected access
6 elements
Machine to Machine
RETful ApI
MQ Telemetry Things
wi-fi protected access
Machine to Machine
Hexa state logic

Summarization
Python
Predictive
unique resource locator
none of the mentioned
Connection flooding
unique resource locator
none of the mentioned
Connection flooding
Active receiver
C++

Telnet
None of the above

**opt2**
A web browser
Layer 3 (Network)
Only Source IP Address
Switch
None of the above
A firewall
Virtual Network Computing
32 bits

Data mining
Contains essential binary commands
A networking communication protocol for multi-master support
3
Long Term Evolution
8 elements
Reducing cost and increasing time for development
It should not have many devices
Server limited Bootstrap
x^^y
wired process access
8 elements
Internet of Things
RESTful API
MQ Transport Telemeter
wired process access
Internet of Things
Two-valued logic

Clustering
S
Descriptive
unique resource identifier
node
Bandwidth flooding
unique resource identifier
node
Bandwidth flooding
Both of the mentioned
JAVA

FTP
10

**opt3**
The physical boundary of network
Layer 1 (Physical)
None of Above
Bridge
To test a host on the network is reachable
A network protocol
None of the above
48 bits

Data digging
Containing configuration files
An OS for distributed network communication
1
Lengthy Terminal Estimation
7 elements
Increasing cost and increasing time for development
Complex circuit can’t be handled
Client Initiated Bootstrap
x**y
wired protected access
7 elements
Machine to Machine and Internet of Things
HTTP
MQ Transport Things
wired protected access
Machine to Machine and Internet of Things
Binary set logic

All of the mentioned
R
All of the mentioned
none of the mentioned
pipe
All of the mentioned
none of the mentioned
pipe
All of the mentioned
Passive receiver
HTML

IP
2

**opt4**
The Network Operating System
Layer 4 (Transport)
Source and destination IP Addresses
Traffic Analyzer
To test storage device
Python Shell
Virtual Network Communication
64 bits

None of the above
Contains user home directories
A cellular communication protocol
4
Long Term Estimates
3 elements
Increasing cost and decreasing time for development
It should have many gateways
Bootstrap
None of the mentioned
wi-fi process access
3 elements
Machine Things
MQTT
MQ Telemetry Transport
wi-fi process access
Machine Things
Many valued logic

Regression
All of the mentioned
Prescriptive
uniform resource identifier
port
Vulnerability attack
uniform resource identifier
port
Vulnerability attack
None of the mentioned
C

HTTP
1

**opt5** **opt6**

**Answer**
A system designed to prevent unauthorized access
Layer 3 (Network)
Source and destination IP Addresses
Traffic Analyzer
To test a host on the network is reachable
A network protocol
Virtual Network Computing
48 bits

Data mining
Contains essential binary commands
A networking communication protocol for multi-master support
4
Long Term Evolution
7 elements
Reducing cost and time for development
It should not have many gateways
Server limited Bootstrap
x**y
wi-fi protected access
7 elements
Machine to Machine and Internet of Things
RETful ApI
MQ Telemetry Transport
wi-fi protected access
Machine to Machine and Internet of Things
Many valued logic

Regression
Python
Descriptive
uniform resource identifier
port
All of the mentioned
uniform resource identifier
port
All of the mentioned
Passive receiver
JAVA

Telnet
1

**Questions**

IANA stands for:
Standard port number for secure MQTT is:
Bluetooth 5.0 promises:
Terms SSL and TLS stand for:
Which one out of these is not a data link layer technology:
Which transport layer protocols is used by DHCP?
Which layer is called a port layer in OSI model:
IPSec provides security at:
A collection of lines that connects several devices is called .....
A start bit in UART communication is always:

Machine learning is
Gateway software should be smart enough to handle _____
Number of approaches gateway can be installed?
By clicking which key the PubNub will display public, subscribe, and secret keys.
The messageChannel class declares the _____ class attribute that defines the key string.
What is the drawback of using Lockitron?
Sonos is a system that uses _____ wireless speakers.
What is the facility Sonos provides?
PWM stands for:
The number of elements in the Open IoT Architecture?
Global Sensor Network is built for _____
Drawback of Factory Bootstrap?
Central software management server communicates with the gateway devices in which approach?
Which is the correct operator for power(x^y)?
What is WPA?
The number of elements in the Open IoT Architecture?
MQTT is _____ protocol.
. _____ allows us to control electronic components
MQTT stands for _____
What is WPA?
MQTT is _____ protocol.
Fuzzy Logic is a form of:
._____ involves predicting a response with meaningful magnitude, such as quantity sold, stock
Which of the following language is preferred for IoT analytics?
Which one is simplest form of analytics?
HTTP resources are located by
What is the TCP name for a transport service access point
A Denial of Service attack is:
HTTP resources are located by

| |
|---|
| |
| |
| |

**opt1**

Internal Assessment Numerical Access

1883

4x Speed, 2x Range, 2x Data

Secure Socket Layers and Transport Layer Session

Bluetooth

RSVP

Session

Physical Layer

Bus

1

The selective acquisition of knowledge through the use of manual programs

GPS

2 approaches

Pane

command_key

Wastage of more energy

Wifi

It provides high quality 3D audio

None of the above

6 elements

Reducing cost and time for development

It should not have many gateways

Factory Bootstrap

x^y

wi-fi protected access

6 elements

Machine to Machine

RETful ApI

MQ Telemetry Things

wi-fi protected access

Machine to Machine

Hexa state logic

Summarization

Python

Predictive

unique resource locator

none of the mentioned

Connection flooding

unique resource locator

| |
|---|
| |
| |
| |

**opt2**

Internet Association Numbers Authority

8000

6x Speed, 3x Range, 3x Data

Secure Socket Layers and Transport Layer Security

UART

TCP

Application

Network Layer

Cable

none of this

The autonomous acquisition of knowledge through the use of manual programs

Message

3 approaches

Demo Keyset

command-key

Supports in some devices only

Hifi

Can here only to a restricted area

Pulse Width Mode

8 elements

Reducing cost and increasing time for development

It should not have many devices

Server limited Bootstrap

x^^y

wired process access

8 elements

Internet of Things

RESTful API

MQ Transport Telemeter

wired process access

Internet of Things

Two-valued logic

Clustering

S

Descriptive

unique resource identifier

node

Bandwidth flooding

unique resource identifier

| |
|---|
| |
| |
| |

**opt3**

International Aid for Network Automation

8883

2x Speed, 4x Range, 8x Data

Secure Socket Layout and Transport Level Session

WiFi

DCCP

Presentation

Transport Layer

Power line

0

The selective acquisition of knowledge through the use of computer programs

Logging

2 approaches

Portal

commandkey

Won’t work at some conditions

Zigbee

Call connectivity

Pulse With Modulation

7 elements

Increasing cost and increasing time for development

Complex circuit can’t be handled

Client Initiated Bootstrap

x**y

wired protected access

7 elements

Machine to Machine and Internet of Things

HTTP

MQ Transport Things

wired protected access

Machine to Machine and Internet of Things

Binary set logic

All of the mentioned

R

All of the mentioned

none of the mentioned

pipe

All of the mentioned

none of the mentioned

| |
|---|
| |
| |
| |

**opt4**

Internet Assigned Numbers Authority

8888

3x Speed, 4x Range, 8x Data

Session Socket Layers and Transport Layer Session

HTTP

UDP

Transport

Session Layer

Transmission Line

2

The autonomous acquisition of knowledge through the use of computer programs

Sensors

2 approaches

Network

Key_command

Tough installation

Bluetooth

Choose to play what you want in different rooms

Pulse Width Modulation

3 elements

Increasing cost and decreasing time for development

It should have many gateways

Bootstrap

None of the mentioned

wi-fi process access

3 elements

Machine Things

MQTT

MQ Telemetry Transport

wi-fi process access

Machine Things

Many valued logic

Regression

All of the mentioned

Prescriptive

uniform resource identifier

port

Vulnerability attack

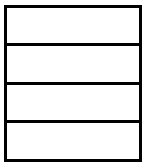
uniform resource identifier

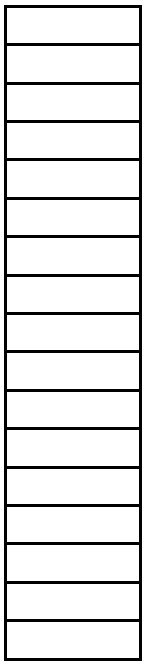
| |
|---|
| |
| |
| |
| |

**opt5**

| |
|---|
| |
| |
| |

**opt6**





**Answer**

Internet Assigned Numbers Authority

8883

2x Speed, 4x Range, 8x Data

Secure Socket Layers and Transport Layer Security

HTTP

UDP

Session

Network Layer

Bus

0

The autonomous acquisition of knowledge through the use of computer programs

Logging

3 approaches

Demo Keyset

command_key

Supports in some devices only

Hifi

Choose to play what you want in different rooms

Pulse Width Modulation

7 elements

Reducing cost and time for development

It should not have many gateways

Server limited Bootstrap

x**y

wi-fi protected access

7 elements

Machine to Machine and Internet of Things

RETful ApI

MQ Telemetry Transport

wi-fi protected access

Machine to Machine and Internet of Things

Many valued logic

Regression

Python

Descriptive

uniform resource identifier

port

All of the mentioned

uniform resource identifier

| |
|---|
| |
| |
| |

**Questions**

_____ Specifies the function that will be called when a successful connection with the PubNub cloud
_____ specifies the function that will be called when a successful re-connection is complete
_____ specifies the function that will be called when the client disconnects.
_____ is a community that is working together to establish an IoT architecture.
_____ provides a middleware and application container for IoT gateway.
. _____ is a modular and cloud based platform.
._____ specifies the function that will be called when a successful re-connection is complete
_____ an open source stack for gateways and the edge.
What is the use of Thermostat in Nest Thermostat E?

What is the main function of Nest Thermostat E?
._____ specifies the function that will be called when a successful re-connection is complete

Function of huge light bulb?
What is the drawback of using Lockitron?
Sonos is a system that uses _____ wireless speakers.

What is the facility Sonos provides?
PWM stands for:

IANA stands for:
Standard port number for secure MQTT is:
Bluetooth 5.0 promises:

Terms SSL and TLS stand for:
Which one out of these is not a data link layer technology:
Which transport layer protocols is used by DHCP?
Which layer is called a port layer in OSI model:
IPSec provides security at:
A collection of lines that connects several devices is called .....
A start bit in UART communication is always:

Machine learning is
Gateway software should be smart enough to handle _____
Number of approaches gateway can be installed?
By clicking which key the PubNub will display public, subscribe, and secret keys.
The messageChannel class declares the _____ class attribute that defines the key string.
What is the drawback of using Lockitron?
Sonos is a system that uses _____ wireless speakers.

What is the facility Sonos provides?
PWM stands for:

The number of elements in the Open IoT Architecture?

Global Sensor Network is built for _____
Drawback of Factory Bootstrap?
Central software management server communicates with the gateway devices in which approach?

**opt1**
Callback
Callback
Callback
Eclipse IoT
Eclipse Kura
Eclipse Kura
Callback
Eclipse Kapua
Save energy

Change the temperature only when we are at home
Callback

To reduce energy and to control lightning
Wastage of more energy
Wifi

It provides high quality 3D audio
None of the above

Internal Assessment Numerical Access

1883

4x Speed, 2x Range, 2x Data

Secure Socket Layers and Transport Layer Session
Bluetooth
RSVP
Session
Physical Layer
Bus
1

The selective acquisition of knowledge through the use of manual programs
GPS
2 approaches
Pane
command_key
Wastage of more energy
Wifi

It provides high quality 3D audio
None of the above

6 elements

Reducing cost and time for development
It should not have many gateways
Factory Bootstrap

**opt2**
Error
Error
Error
Red Hat
Red Hat
Red Hat
Error
Red Hat
Show the use of energy

Reduce the energy used
Error

To create lighting scenes based on your favourite photos
Supports in some devices only
Hifi

Can here only to a restricted area
Pulse Width Mode

Internet Association Numbers Authority
8000
6x Speed, 3x Range, 3x Data

Secure Socket Layers and Transport Layer Security
UART
TCP
Application
Network Layer
Cable
none of this

The autonomous acquisition of knowledge through the use of manual programs
Message
3 approaches
Demo Keyset
command-key
Supports in some devices only
Hifi

Can here only to a restricted area
Pulse Width Mode

8 elements
Reducing cost and increasing time for development
It should not have many devices
Server limited Bootstrap

| |
|---|
| |
| |
| |
| |
| |
| |
| |
| |
| |
| |
| |
| |
| |
| |
| |
| |
| |
| |
| |
| |
| |

**opt3**

Connect

Connect

Connect

Intercloud

Intercloud

Intercloud

Connect

Intercloud

Supports in some devices only

Change the temperature from anywhere

Connect

To reduce energy and to create lighting scenes based on your favourite photos and to control lightning

Won't work at some conditions

Zigbee

Call connectivity

Pulse With Modulation

International Aid for Network Automation

8883

2x Speed, 4x Range, 8x Data

Secure Socket Layout and Transport Level Session

WiFi

DCCP

Presentation

Transport Layer

Power line

0

The selective acquisition of knowledge through the use of computer programs

Logging

2 approaches

Portal

commandkey

Won't work at some conditions

Zigbee

Call connectivity

Pulse With Modulation

**opt4**

Reconnect

Reconnect

Disconnect

Bot 2 Bot

Bot 2 Bot

Eclipse Kapua

Reconnect.

Eclipse Kura

Won't work at some conditions

Powers off when a person is not present

Reconnect.

To controlling lightning and to create lighting scenes based on your favourite photos

Tough installation

Bluetooth

Choose to play what you want in different rooms

Pulse Width Modulation

Internet Assigned Numbers Authority

8888

3x Speed, 4x Range, 8x Data

Session Socket Layers and Transport Layer Session

HTTP

UDP

Transport

Session Layer

Transmission Line

2

The autonomous acquisition of knowledge through the use of computer programs

Sensors

2 approaches

Network

Key_command

Tough installation

Bluetooth

Choose to play what you want in different rooms

Pulse Width Modulation

| | |
|---|---|
| 7 elements | 3 elements |
| Increasing cost and increasing time for development | Increasing cost and decreasing time for development |
| Complex circuit can’t be handled | It should have many gateways |
| Client Initiated Bootstrap | Bootstrap |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |

| opt5 | opt6 | Answer |
| --- | --- | --- |
| | | Connect |
| | | Reconnect |
| | | Disconnect |
| | | Eclipse IoT |
| | | Eclipse Kura |
| | | Eclipse Kapua |
| | | Reconnect. |
| | | Eclipse Kura |
| | | Save energy |
| | | Change the temperature from anywhere |
| | | Reconnect. |
| | | To reduce energy and to create lighting scenes based on your favourite photos and to control lightning |
| | | Supports in some devices only |
| | | Hifi |
| | | Choose to play what you want in different rooms |
| | | Pulse Width Modulation |
| | | Internet Assigned Numbers Authority |
| | | 8883 |
| | | 2x Speed, 4x Range, 8x Data |
| | | Secure Socket Layers and Transport Layer Security |
| | | HTTP |
| | | UDP |
| | | Session |
| | | Network Layer |
| | | Bus |
| | | 0 |
| | | The autonomous acquisition of knowledge through the use of computer programs |
| | | Logging |
| | | 3 approaches |
| | | Demo Keyset |
| | | command_key |
| | | Supports in some devices only |
| | | Hifi |
| | | Choose to play what you want in different rooms |
| | | Pulse Width Modulation |

7 elements

Reducing cost and time for development
It should not have many gateways
Server limited Bootstrap

| | | |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |