Internet of Things
IO 4041

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Quote

"What we usually consider as impossible are simply engineering problems… there's no preventing them. "

By Michio Kaku who is known for
Physics of the Impossible

Objective of the course

To introduce basic concepts and Fundamentals of Internet of Things (IoT) systems and its application

To understand the basic ecosystem/architecture of the Internet of Things

To learn abut enabling technologies to develop IoT applications

To learn about wireless connectivity standards and the underlying Internet

To apply the basics to design and develop a prototype application of the IoT

Helping material

Text Book 1: Interconnecting Smart Objects with IP: The Next Internet

by Jean-Philippe Vasseur and Adam Dunkels

Presentation slides

Research Papers & Articles

Reference Book:

Computer Networking: A top down approach

by James F. Kurose and Keith W. Ross

Course Outline

W1

❖ Introduction to the course (Theory and project)

❖ Grading policy

❖ Project overview- hardware and software

❖ What is IoT (smart objects)? [MB: Ch 1]

❖ What is the IoT ecosystem/architecture? [MB: Ch 1]

W2 & W3

❖ The design principles of the Internet Architecture, OSI reference model and TCP/IP protocol stack [RB: Ch 1]

❖ The design principles of the Internet of Things Architecture, why IP for the IOT? [MB: Ch 1 & 3]

❖ Project team formation and title approval

Course Outline

W4

❖ Application Layer in the Internet and http [RB: Ch 2]

❖ Application Layer: CoAP vs. MQTT [Slides]

W5 & W6

❖ Transport Layer: Why TCP and UDP for Smart Objects? [MB: Ch 6 , RB: Ch 3]

❖ Project Evaluation-1 (Arduino IDE for sensor input)

❖ Sessional-1

Course Outline

W7 & W8

❖ Network Layer: IP and IPv6 [MB: Ch 5, , RB: Ch 4]

❖ 6LoWPAN

❖ **W9 to W12**

❖ Project Evaluation-2 (Sensor input and Cloud connectivity)

❖ Network Layer: Routing in the Internet [MB: Ch 5 & RB: Ch 4]

❖ Network Layer: RPL [MB: Ch 17]

❖ Project Evaluation-3 (Mobile app development)

Course Outline

W13 & W14

❖ Smart Object Hardware and Software [MB: Ch 11]

❖ Communication Mechanisms for Smart Objects [MB: Ch 12]

❖ Project Evaluation-4 (Final prototype)

W15 & W16

❖ Research Paper guidelines

❖ Research Paper Final Submission and Feedback

Marks Distribution
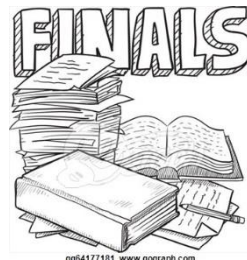
Quizzes   10%

Assignments   10%

Project & Presentation   15%

Midterm   25%

40%

Introduction

A significant development in the fields of

- wireless communication technology,

- information and communication systems,

- industrial designs, and

- electromechanical systems encouragements

progress new technology named as the Internet of Things.

Introduction

- Major intention of the IoT:
  - to connect all or any devices to the internet or other connected devices
- **Scope of IoT** is in each trade of the world
  - engineering, medical, finance, food, energy, agriculture and …

What is Internet of Things?

Internet and **Things**

❖ Every object capable of connecting to the Internet will fall into the "Things" category

Kevin Ashton, coined the term "Internet of Things"

❖ A simple definition:

An IoT is a network of Internet-connected objects which are able to collect and exchange data

What is Internet of Things?

Almost every area, device, sensor, software, etc. are connected to each other.

The ability to access these devices (from a distance) through a smartphone or through a computer is called IoT.
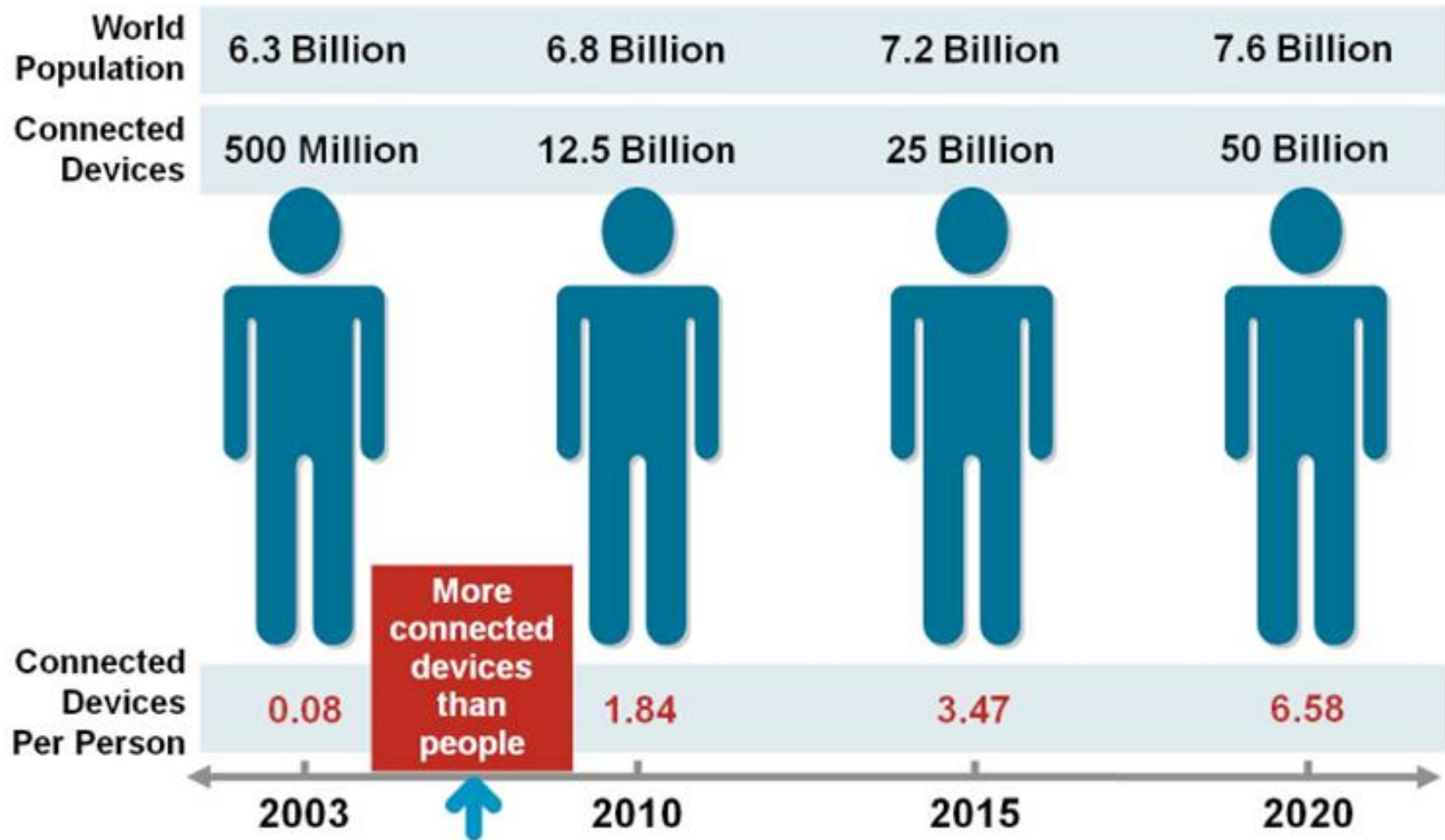
For example, an air conditioner sensor, a refrigerator sensor

Internet of Things?

❖ Detailed definition:

A network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these things to connect and exchange data creating opportunities for more direct integration of the physical world into computer-based systems, resulting in efficiency improvements, economic benefits, and reduced human exertions
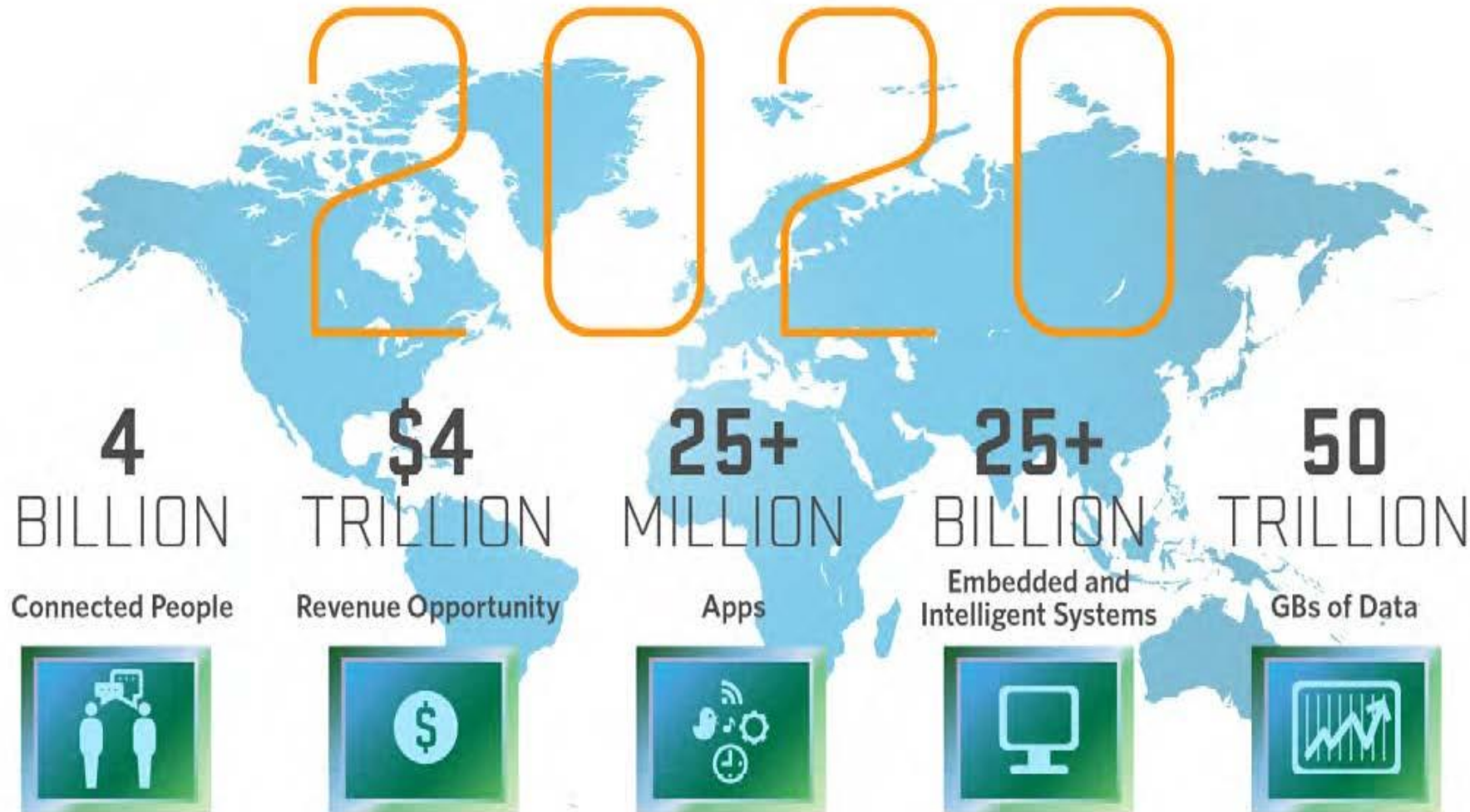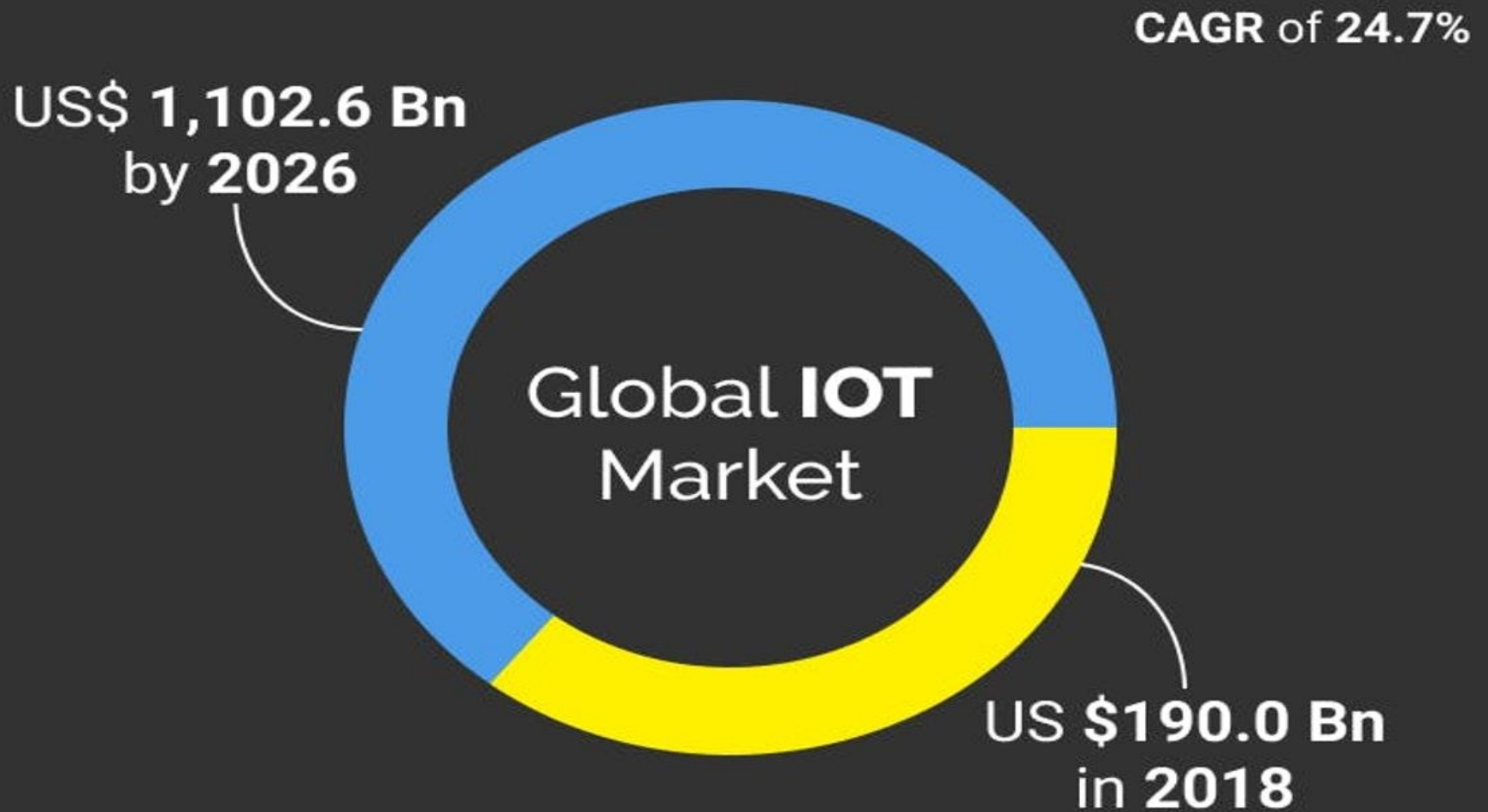
Why IoT is important to our future?

World Population	6.3 Billion	6.8 Billion	7.2 Billion	7.6 Billion
Connected Devices	500 Million	12.5 Billion	25 Billion	50 Billion

More connected devices than people

Connected Devices Per Person	0.08	1.84	3.47	6.58
	2003	2010	2015	2020

Source: Cisco IBSG

Change is the only thing permanent in this world

Next big thing

2020

4 BILLION	$4 TRILLION	25+ MILLION	25+ BILLION	50 TRILLION
Connected People	Revenue Opportunity	Apps	Embedded and Intelligent Systems	GBs of Data

Source: Mario Morales, IDC

Global IoT Market

CAGR of 24.7%

US$ 1,102.6 Bn
by 2026

Global **IOT**
Market

US $190.0 Bn
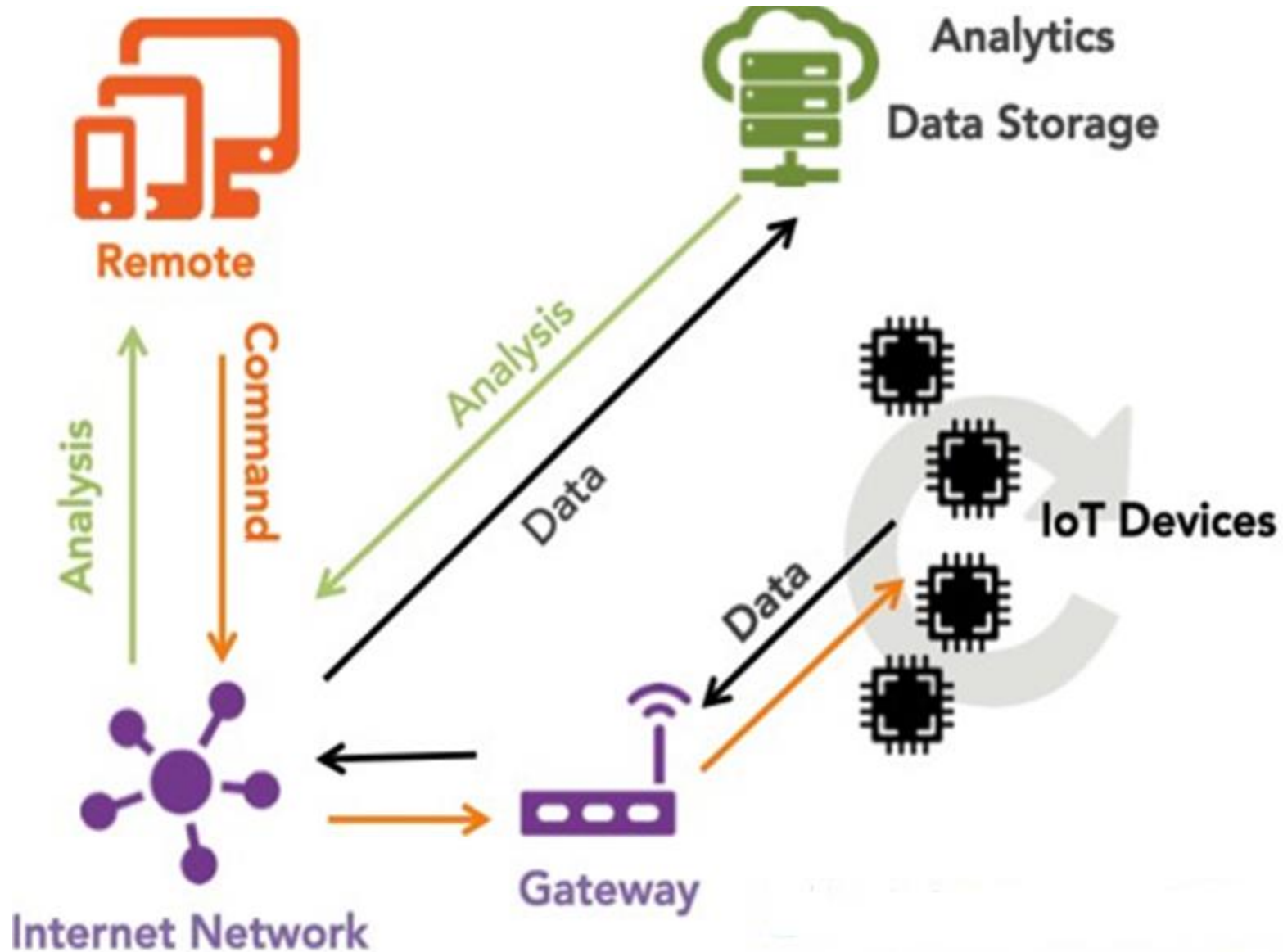in 2018

Internet of Things Ecosystem

Internet of Things Ecosystem

❖ IoT ecosystem brings together all the heterogeneous components of IoT in a managed way to build an efficient system.

❖ It is the integration of devices, operating system, controllers, gateways, middleware, and platform.

❖ All these elements are connected through communication protocol and interfaces like
  ▪ Zigbee,
  ▪ Low-power Wi-Fi,
  ▪ Message Queuing Telemetry Transport (MQTT),
  ▪ Low Power Personal Area Network for IPv6 (6LoWPAN),
  ▪ Near Field Communication (NFC),
  ▪ Bluetooth low energy (BLE), etc.

❖ IoT ecosystem connects a large number of physical devices in a single system.

How IoT works?

- ❖ The whole process begins with the devices themselves,
  - ▪ For example: smartphones, digital watches, electronic appliances securely communicate with an IoT platform
- ❖ IoT platform
  - ▪ gathers and combines data from multiple devices and platforms, and
  - ▪ applies analytics to share the most useful data with applications to cater specific needs.

Management of IoT systems

❖ Limited storage and processing capacity

❖ Heterogeneity

❖ Huge volume of Data

❖ Cloud based infrastructures

❖ Edge Computing

❖ Security and privacy

Enabling Technologies

❖ RFID, WSN, Bluetooth enabled technologies

❖ Smart phones

❖ Smart Objects including powerful sensors

❖ Machine to Machine Communication

❖ Advanced Communication Protocols including 6LoWPAN, Zigbee

❖ Customized firmwares and Operating Systems

Use case: smart home

❖ Sensors

Light, smoke, temperature, soil moisture, Object sensor, cameras

❖ Actuators

Window blinders, water control motor, washing machines, ovens, door locks, air conditioner
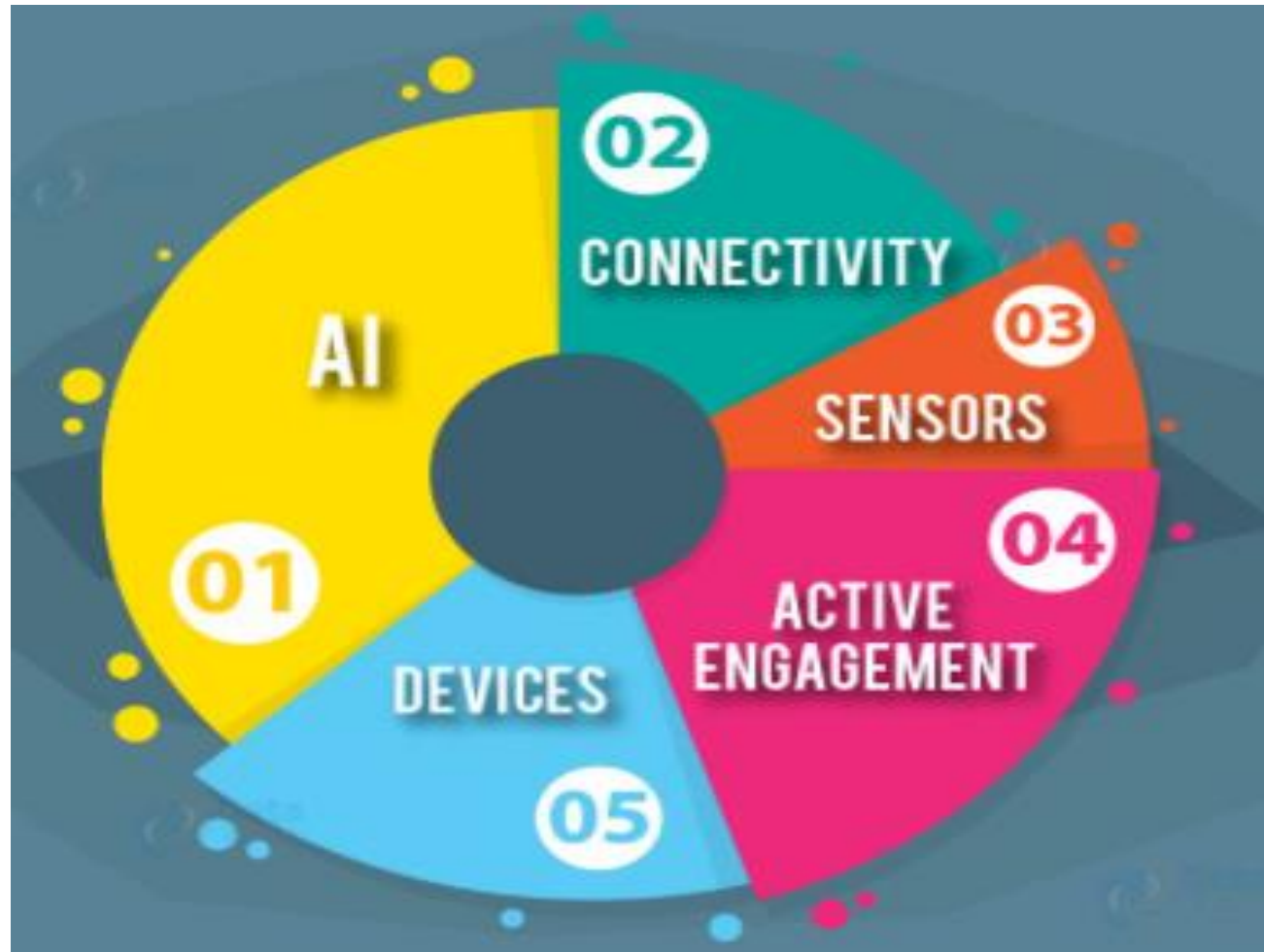
❖ Conrtoller

Arduino, Raspberry PI, Orange PI

❖ Communication

Bluetooth, Wifi, Ethernet, GSM module etc.

Important Features of IoT

Important Features of IoT

AI

❖ Makes things smart

❖ Improves different aspects of life through proper usage of data, networks, and algorithms

❖ **From simple:** improving refrigerator by embedding it with sensors that automatically detect when milk and eggs run low,

❖ **To:** placing an order for items with choice of the grocer.

Important Features of IoT

Connectivity

❖ Networking is not always restricted to large networks

❖ it can work on a smaller and cheaper scale without compromising its efficiency.

❖ IoT creates such small networks between its system devices.

Important Features of IoT

Sensors

- ❖ Sensors are essential for essence of IoT to be truly effective
- ❖ Sensors are basically the main reason and the crux due to which IoT technology stands out
- ❖ Major contributor in defining IoT boundaries
  - by converting it from a passive to an active network.
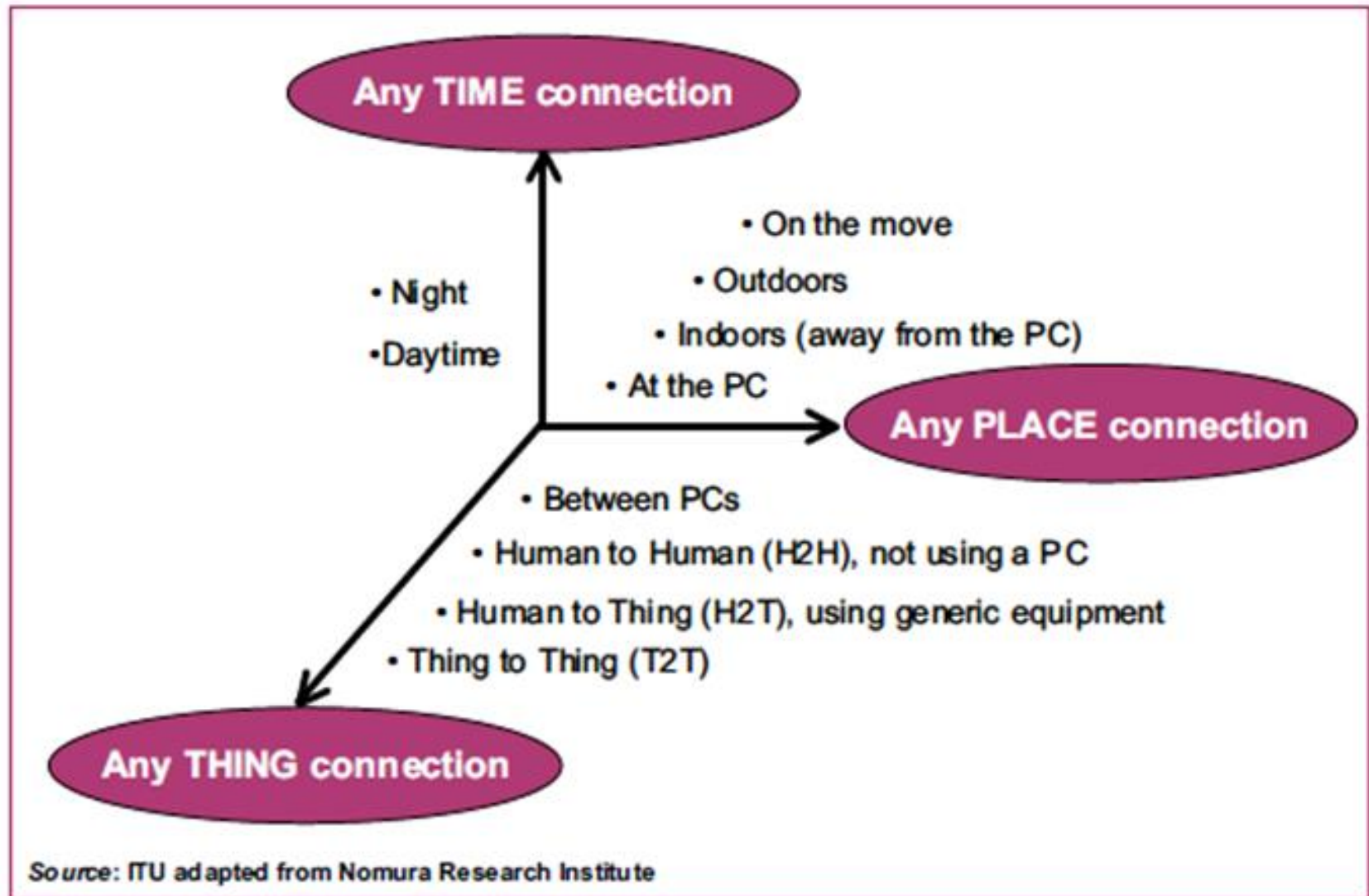
Important Features of IoT

Active engagement

- different connected technologies interact happens through passive engagement
- IoT brings in active content product or service engagement

Devices

- more powerful, cheaper and smaller over time,
- IoT purposely makes use of small devices to deliver its scalability, versatility, and accuracy.

Ubiquitous connectivity

Any TIME connection

- Night
- Daytime

- On the move
- Outdoors
- Indoors (away from the PC)
- At the PC

Any PLACE connection

- Between PCs
- Human to Human (H2H), not using a PC
- Human to Thing (H2T), using generic equipment
- Thing to Thing (T2T)

Any THING connection

Source: ITU adapted from Nomura Research Institute

Ubiquitous connectivity

❖ Support for a diverse set of devices and communication protocols

- tiny sensors capable of sensing and reporting a desired factor
- powerful back-end servers that are utilized for data analysis and knowledge extraction

❖ This also requires integration of mobile devices, edge devices like routers and smart hubs, and humans in the loop as controllers.

Our Expectation from IoT (Applications)

What do we expect from IoT to do for us?

❖ To sustain us (Smart cities)

❖ To move us (Self driving cars)

❖ To heel us (Healthcare)

❖ To feed us (Agriculture)

❖ To make things (manufacturing and packaging)

❖ You can think of even more better ideas

Applications: Sustainability

Smart Waste Management

- ❖ usage of technology in order to be more efficient when it comes to managing waste [IoT]

- ❖ makes possible to plan more efficient routes for the trash collectors who empty the bins,

- ❖ Moreover, lowers the chance of any bin being full for over a week!

- ❖ Huge boost in waste collection efficiency boost

S:

Garbage monitoring

Municipality

Dustin with

Garbage collection truck

Architecture for Garbage Monitoring and Collection System
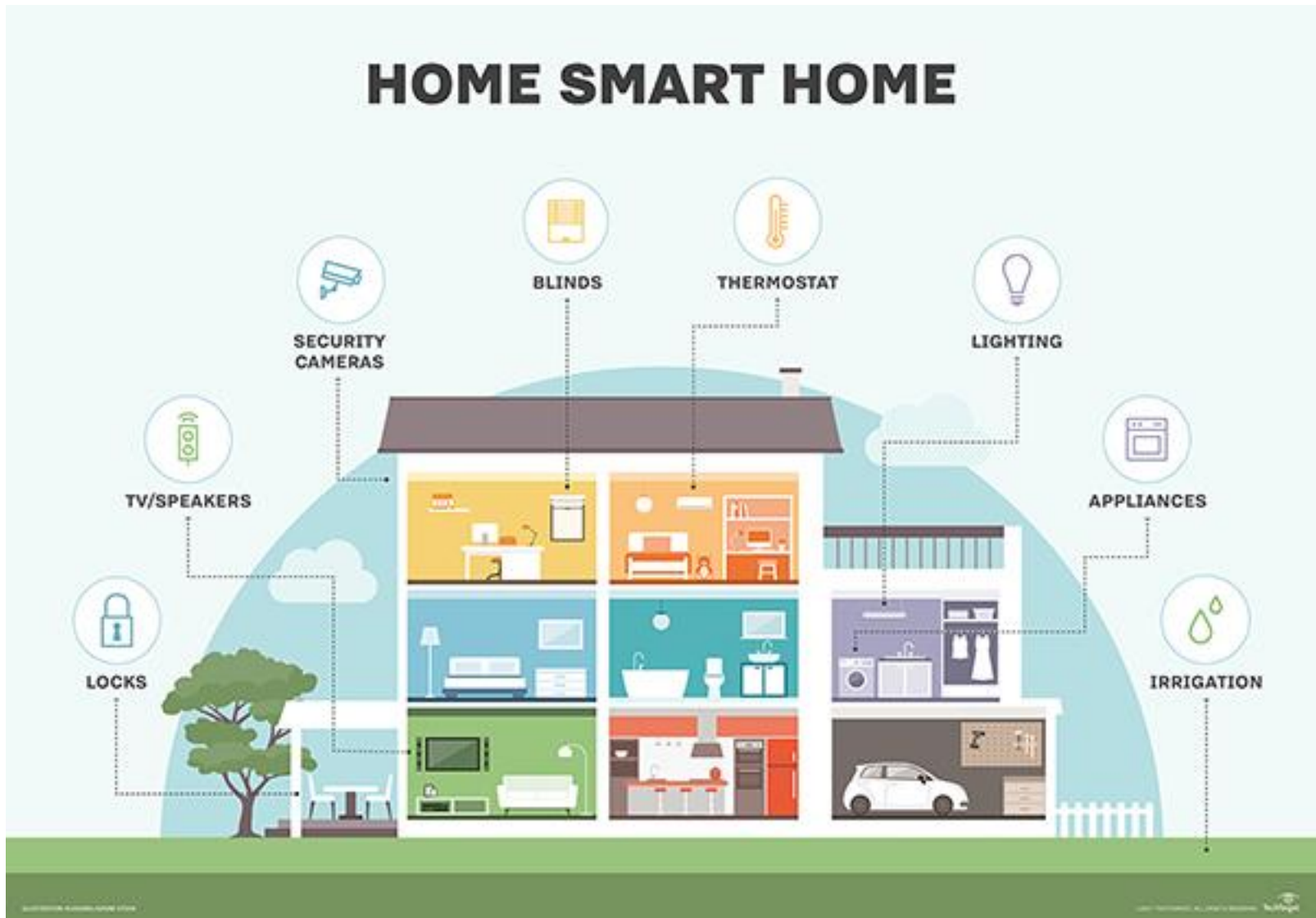
Applications: Sustainability

Smart Street Lights

- ❖ Save energy
- ❖ Reduce light pollution
- ❖ Faster replacement

Smart Street Parking

- ❖ Mounting of infrared and magnetic based sensors on the road surface for vehicle detection
- ❖ Faster replacement
- ❖ Apps to direct drivers to empty spaces
- ❖ Dynamic parking prices
- ❖ Zigbee, LoRaWAN wireless connections

Smart Home

Applications: Mobility

Self driving cars

Connected Vehicles – Combine private and collective transportation: The best of both

1 You call your (autonomous driving) car to pick you up

2 You enter your destination and are dynamically routed to work based on traffic flows through the system

3 Your car travels down an automated roadway with platooned vehicles

4 You are connected to everything you need while you travel in a car personalized for you

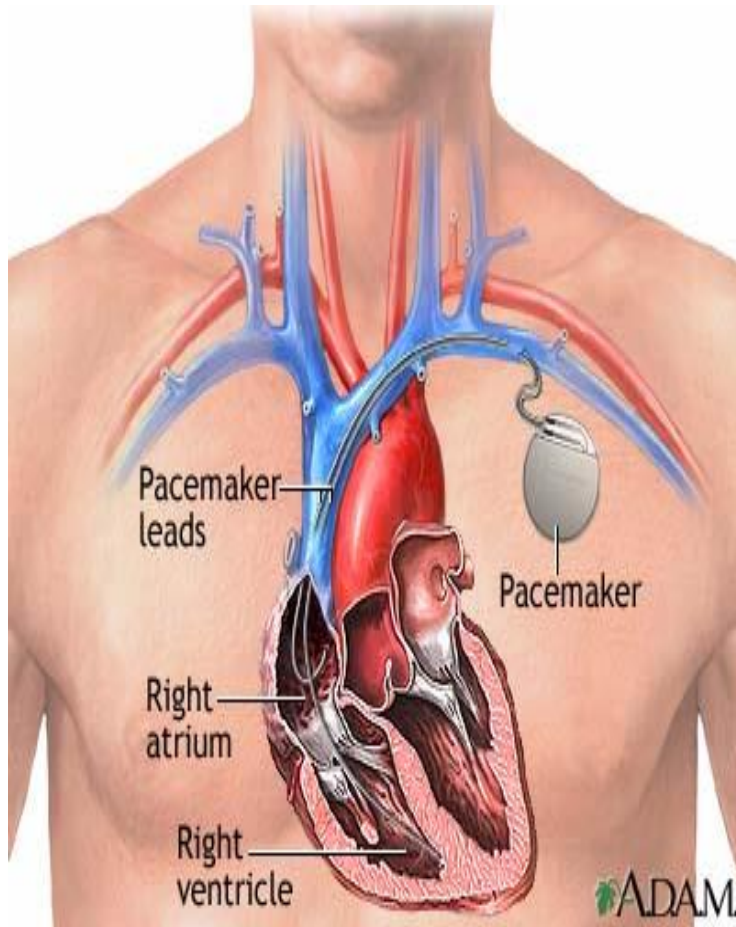5 You are dropped off at the doorstep and the car parks itself

Smart Mobility

❖ A new and innovative way of thinking to get around, that would result in

  ▪ Cleaner environment

  ▪ Safe journey

  ▪ Time and energy efficiency

❖ Multiple modes of transportation including Shared bicycles, rides, Connected buses and trains

Applications: Heeling

Healthcare: Pacemaker

- ❖ helps your heart beat at a regular rate
- ❖ 16-bit RISC Microcontroller
- ❖ Consists of hardware, software, mechanical

Catheters and a battery, all combined for the dedicated purpose to help us live longer

Smart healthcare

❖ A world of possibilities in healthcare due to Internet of things

❖ Smart medical devices when connected to internet can provide

- Invaluable data
- Extra insight into symptoms and trends
- Enable remote care
- More control over patient's live and treatment

Glucose monitoring and Insulin delivery

❖ OpenAPS- Open Artificial Pancreas systems

❖ gauging the amount of glucose in a patient's bloodstream, it also delivers insulin

❖ Benefits

❖ Helps to keep blood glucose within a safe range

❖ Prevent extreme highs and lows levels

- Hyperglycaemia
- Hypoglycaemia

❖ Sleep through nights without danger of dropping blood sugar

Applications: Feeding

https://www.accenture.com/cn-en/insight-accenture-digital-agriculture-solutions
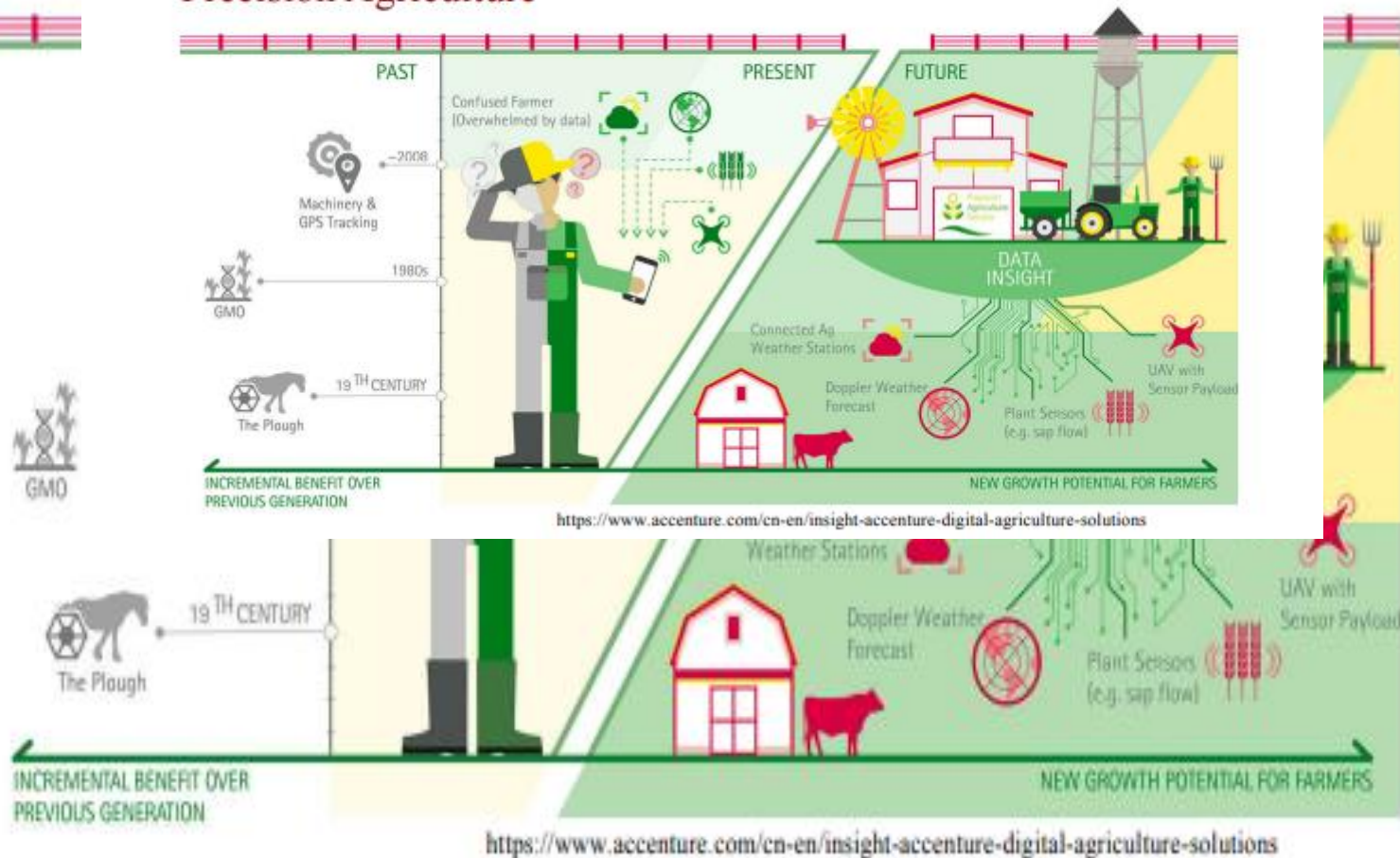
Smart Diary System

The connected cow

Necklace
Connecterra, a Dutch company, makes Fitbit-style necklaces that monitor a cow's movement and feeding habits. The sensor can be used to detect health problems and to tell when the cow is in heat, so that insemination can happen at an optimum time.

Acid monitor
Well Cow, a British company, has developed a bolus that is inserted into the cow's rumen to monitor acidity levels. This helps detect digestive problems.

Tail movements
Moocall, an Irish company, makes a birthing sensor that attaches to the tail. It measures tail movements triggered by labour contractions, and sends a farmer an SMS alert approximately one hour before a cow is due to calve.

Pedometer
Afimilk, based in Israel, makes a pedometer for cows. Cows typically increase their walking as they come into oestrus, so the pedometer alerts farmers to the best time for insemination.

Udder sensors
Automatic milking systems, such as US-based Lely's Astronaut, can be equipped with sensors to monitor the quality of the milk and check for signs of mastitis.

'One of the most important issues is to control and increase the quality of milk through IoT'

Picture: iStock
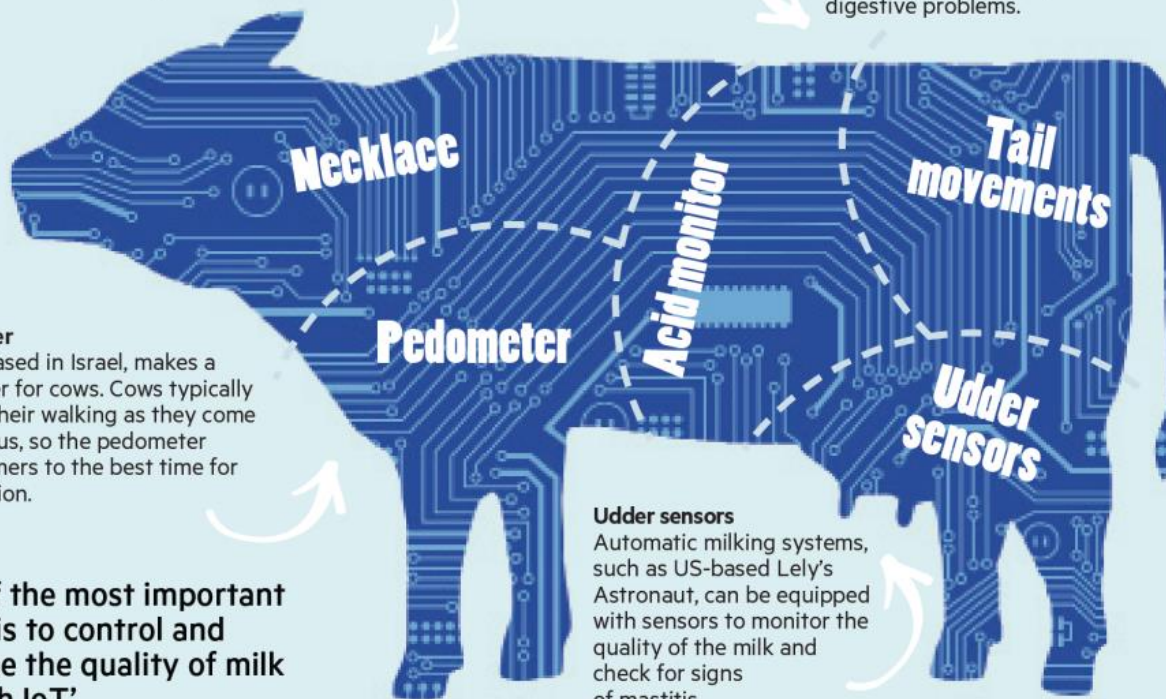
Applications: Making Things

Manufacturing/Packaging