Spectrum aspects of Internet of Things

Capacity Building Workshop

Day1
IoT Standardization & Connectivity

01

IoT Concept

IoT Infrastructure
Between the Physical &Information worlds

02

IoT Standardization

IoT Standards for the communication, development and deployements of IoT Technologies

03

IoT Connectivity & Business Models

The Wireless Access between IoT devices & Business Models depending on the IoT Connectivity Solutions

01

IoT Concept

Introduction

- IoT Concept & Reference Model
- Introduce IoT Standardization and the involved Organizations
- IoT Connectivity means & its impact on changing Business mindsets and creating recurring revenues

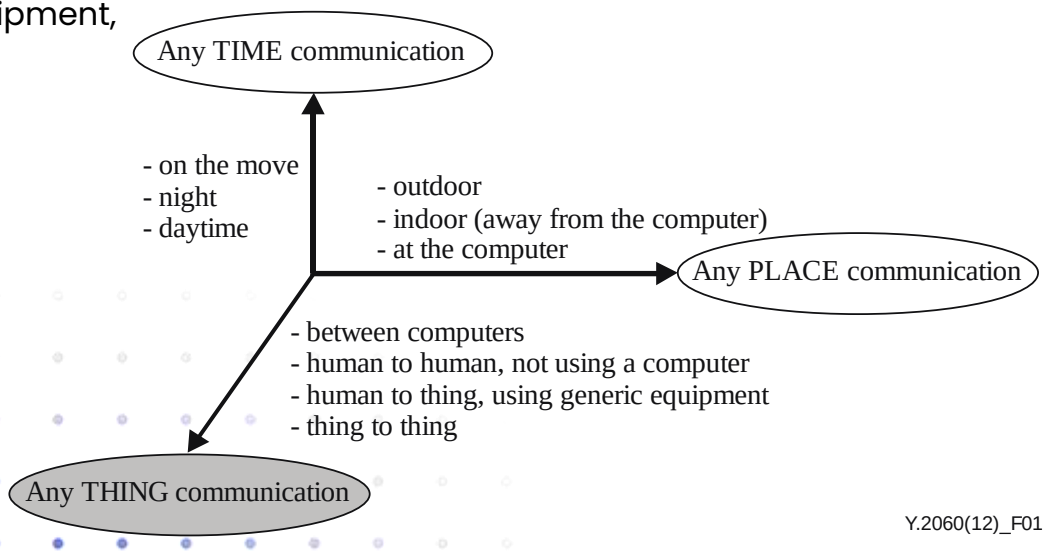
“The IoT can be viewed as a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies (ICT)”

Rec. ITU-T Y.2060 (06/2012)

IoT Concept

The IoT adds the dimension "Any THING communication" to the information and communication technologies (ICTs) which already provide "any TIME" and "any PLACE" communication

- Physical things are everything capable of being sensed, actuated and connected;
  - industrial robots, goods and electrical equipment, etc
- Virtual things are the data (information) that are capable to be stored, processed and accessed;
  - include multimedia content & software applications



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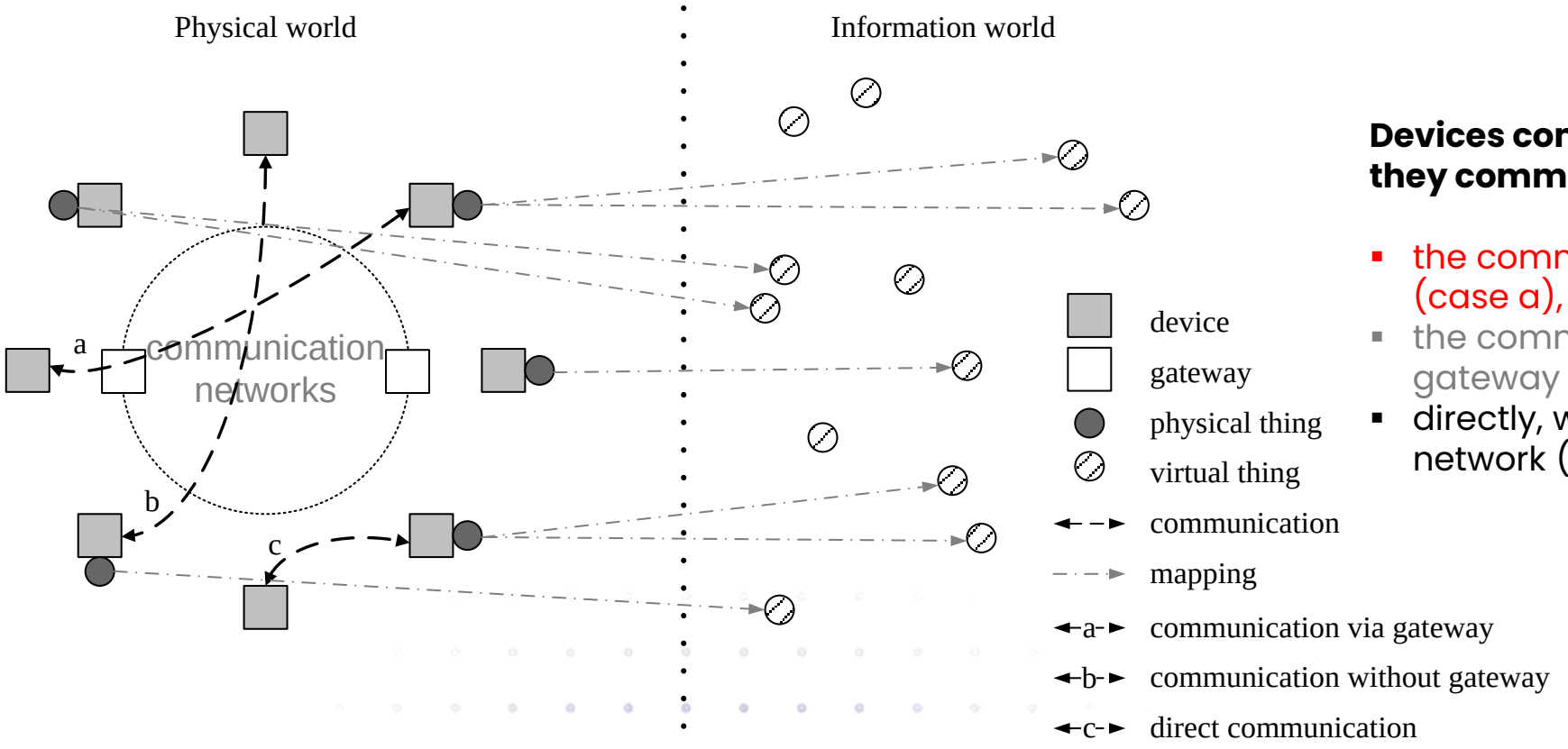
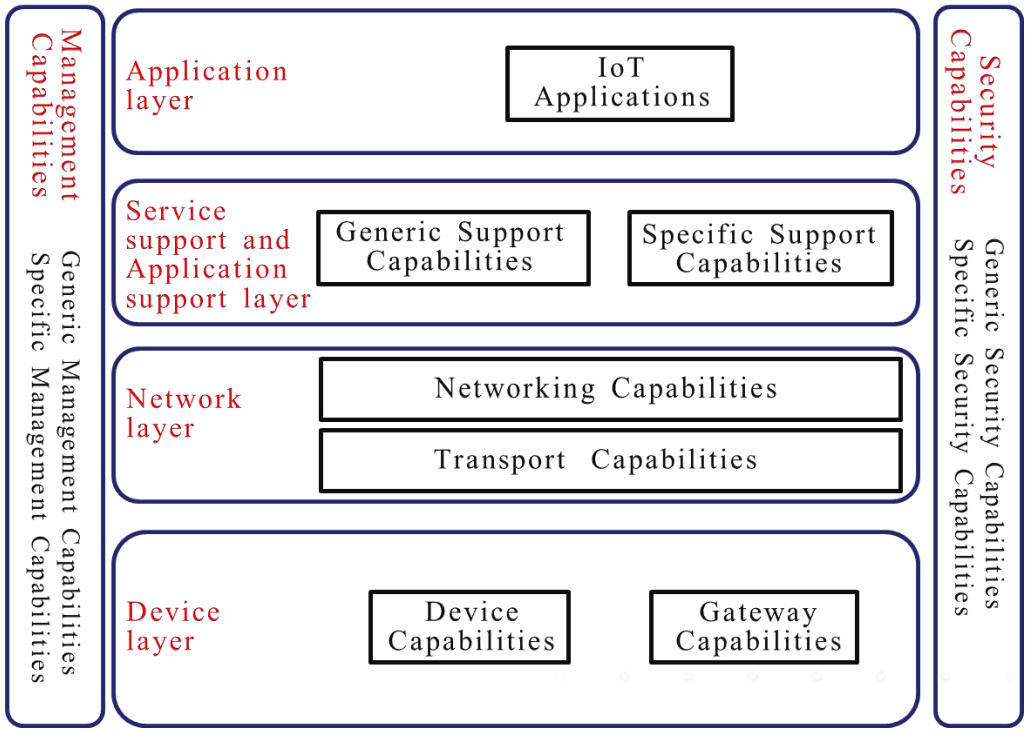
IoT Concept
Technical overview of the IoT



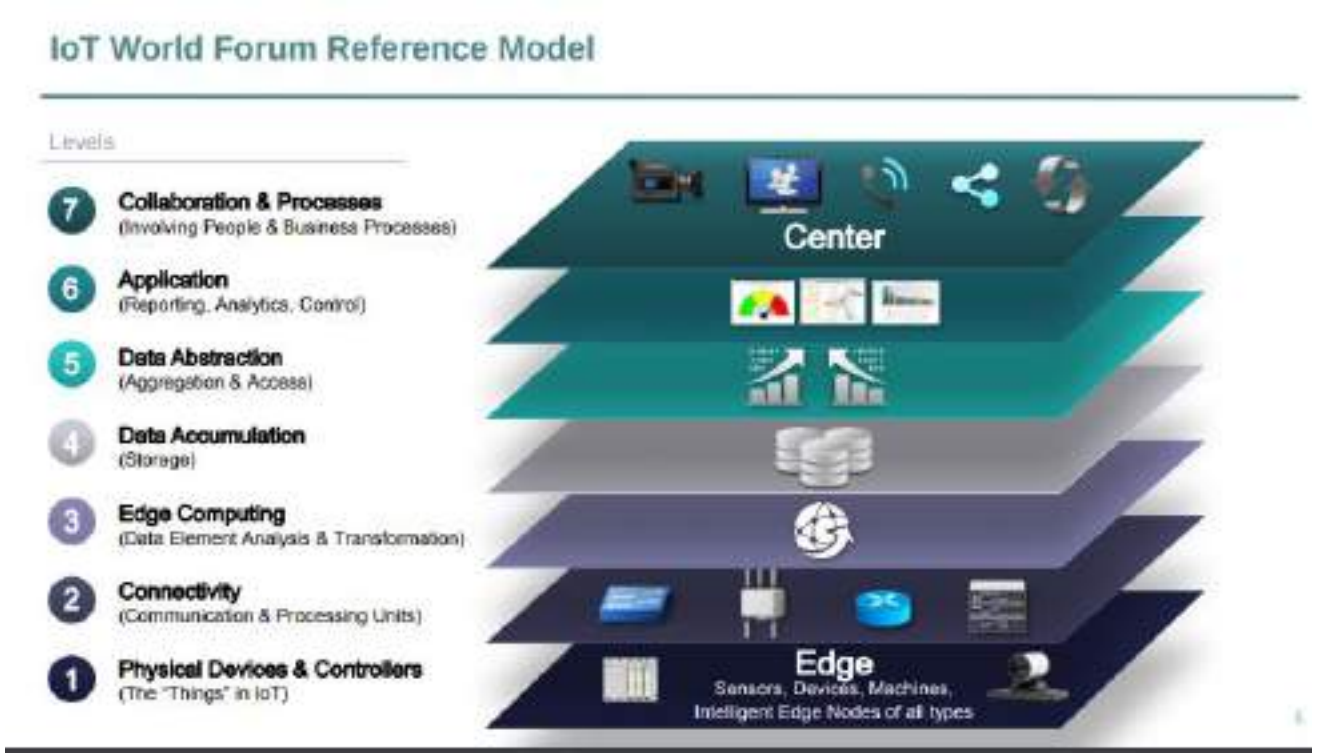
Devices communicate with other devices; they communicate through

- the communication network via a gateway (case a),
- the communication network without a gateway (case b) or
- directly, without using the communication network (case c)

IoT Concept
IoT Reference Model



ITU Reference Model

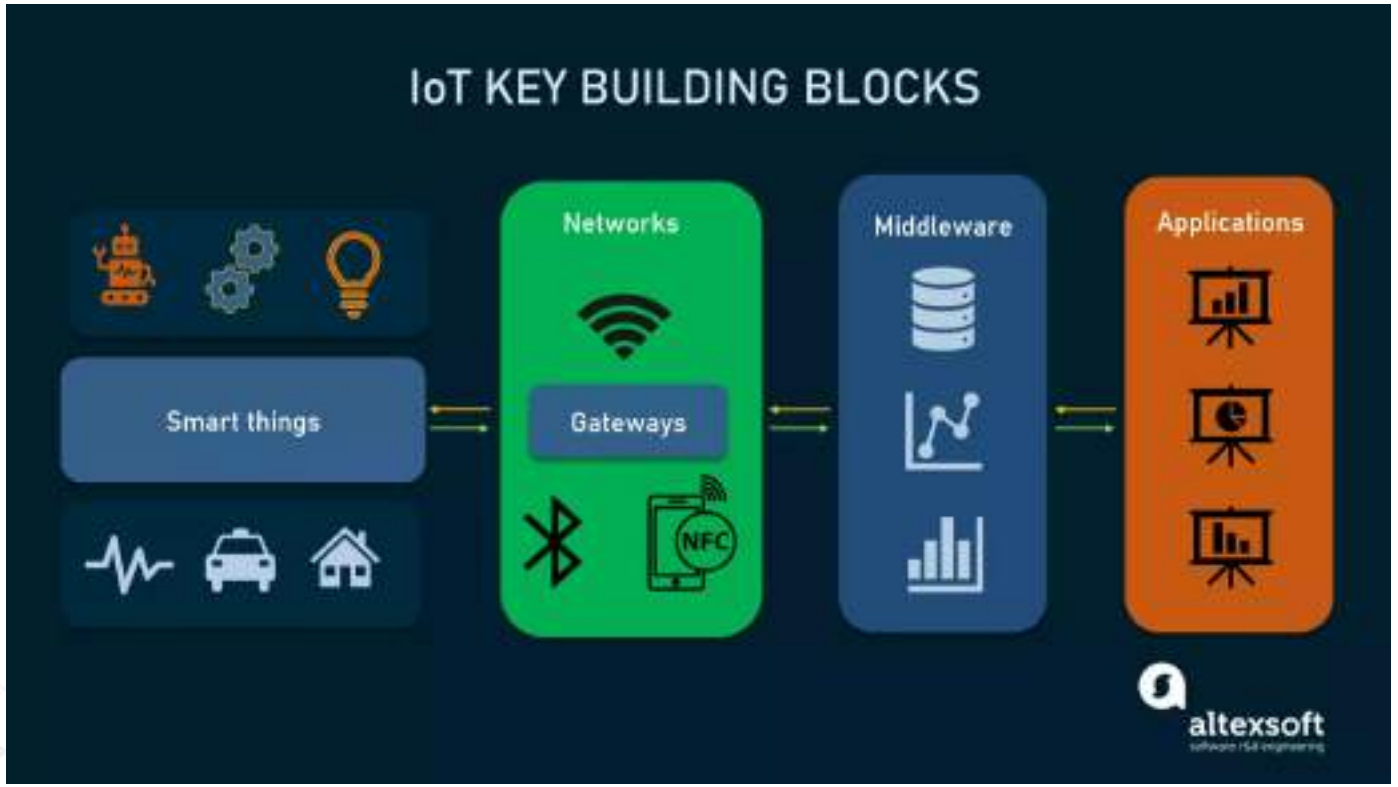


The standardized architectural model proposed by IoT industry leaders.
Source: Internet of Things World Forum

IoT Concept
IoT Reference Model

Networks and Gateways

Applications



Smart Things

Middleware or IoT Platforms

02

IoT Standardizations

IoT Standardizations

Why Standardization is essential in IoT?

IoT applications becoming a common part in our daily life activities

- ✓ In our homes
- ✓ In our personnel activities
- ✓ In our Cars
- ✓ at doctors' offices,
- ✓ In our oceans and skies,

Businesses increasingly rely on them for a wide range of purposes

Consequently, the number of IoT devices is enormously increasing and the data generated from these devices is huge.

Therefore, these devices & sensors in order to communicate effectively, smoothly & securely between each others need standards & protocols help enterprises make better purchase decisions and build more secure, robust IoT networks

IoT Standardizations

Standardization is key to achieving universally accepted specifications and protocols between devices and applications, it ensures;

- Interoperability
- Reliability across IoT devices, platforms, and applications
- Cost effective solutions

And, Allows the market to reach its full potential By development and deployment of IoT technologies

The more things are connected, the greater the security risk;
Smart objects produce large volumes of data. This data needs to be managed, processed, transferred and stored securely

- Security standards are needed to protect the individuals, businesses and governments which will use the IoT

IoT Standardizations
IoT Protocols and Standards

Protocols

- Determine how IoT devices should work and communicate

Standards

- Ensure that all IoT devices have a minimum level of compatibility with one another and with other related devices and applications

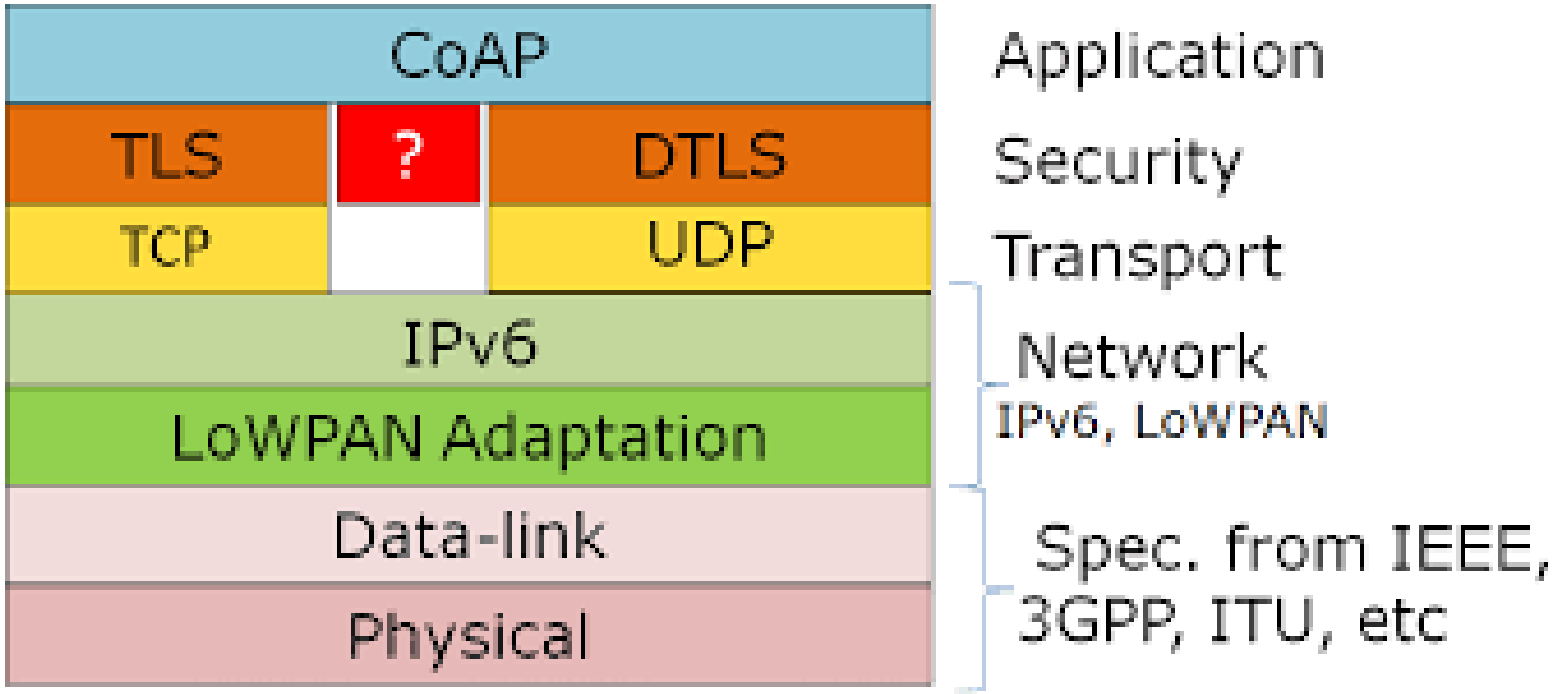
IoT protocols and Standards typically function in a single layer as a distinct part of a larger network

- The application layer
- Middleware layer

although not exclusively; Bluetooth and Wi-Fi operate on the network layer

IoT Standardizations

IoT Protocols and Standards



IoT Standardizations

IOT based ISO/IEC & IEEE Standards

Major Standard Development Organizations: *ISO/IEC* and *IEEE*
Other Important Organizations: ITU, CEN/CENELEC, ETSI

IoT Standardizations

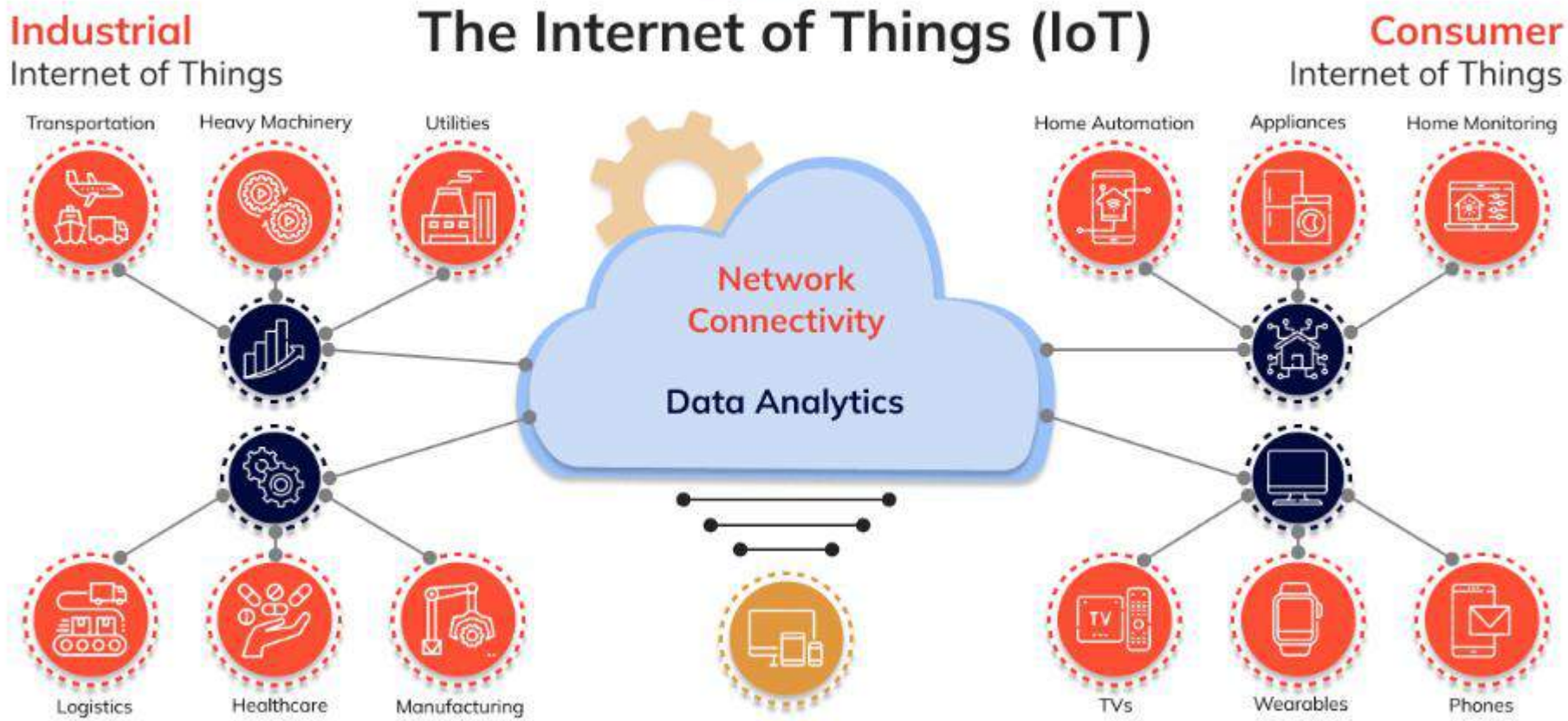
IoT Protocols and Standards

Key Organizations who play a vital role in defining IoT standards;

- **ITU (International Telecommunication Union)**
  - Develops global standards for telecommunications and radio spectrum
- **IEEE (Institute of Electrical and Electronics Engineers)**
  - Offers a range of IoT-related connectivity standards, including IEEE 802.15.4 (for low-rate wireless personal area networks) and IEEE 802.11 (Wi-Fi)
- **IETF (Internet Engineering Task Force)**
  - Focuses on Internet protocols relevant to IoT
- **3GPP (3rd Generation Partnership Project)**
  - Mobile IoT standards, including Narrowband IoT (NB-IoT) and LTE-M
- **ETSI (European Telecommunications Standards Institute)**
  - Develops standards, such as the Machine-to-Machine (M2M) standard
- **SIG Bluetooth (Special Interest Group)**
  - Defines Bluetooth standards, including those for IoT applications
- **Zigbee Alliance**
  - Focuses on wireless IoT standards like Zigbee and Thread
- **LoRa Alliance**
  - Develops standards for long-range, low-power IoT communication (LoRaWAN).

IoT Standardizations

Commercial IoT & Industrial Standards



IoT Standardizations

Commercial IoT Standards And Protocols

Commercial IoT is a huge & still-growing industry

Smart home tech is creating high demand for devices in the consumer electronics market

- Protocols and Standards are emerging to ensure consumers get a streamlined, user-friendly experience
- Some of these standards are also used in industrial applications but their biggest benefits stand out most in commercial settings

A few commercial IoT standards and protocols are so widely used they have become ubiquitous

- Bluetooth and
- Wi-Fi, for example.

IoT Standardizations
Commercial IoT Standards And Protocols

❑ WPANs

It uses wireless personal area networks (WPANs); Allows for short-range data transmission using radio waves, such as smartwatches and wireless headphones.

❑ Bluetooth

Was one of the first IoT communication protocols to open the door for a boom in consumer IoT devices.
Most (if not all) consumer electronics today use Bluetooth standard for wireless device-to-device communication

- Every new smartphone, tablet, and laptop includes Bluetooth support as a standard feature

Bluetooth was originally standardized by the world's largest technical professional organization, the IEEE, in 2005 under standard IEEE 802.15.1

Though updates ceased in 2018, Bluetooth remains an extremely popular IoT protocol—particularly among consumer electronics.

❑ DDS "Data Distribution Service "

Originally published in 2004 by the Object Management Group, which maintains it today, it is a middleware protocol for standardizing machine-to-machine communication using the publisher-subscriber model.
The Data Distribution Service (DDS) protocol and standard is designed for communication across hardware and software platforms

- Its main benefits include easy scalability, high reliability, and low-latency connectivity
- DDS is great for ensuring all the IoT components in a system can maintain high-quality data transfers.

DDS is popular across commercial and industrial IoT applications.

IoT Standardizations

Commercial IoT Standards And Protocols

❑ Matter

Matter is a communication and interoperability standard designed to address the issue of smart home device communication between brands;

- It ensures that smart home devices from participating manufacturers work together natively

❑ Wi-Fi

- Among the oldest IoT standards and one of today's most widely used
- Its invention dates back to 1942, It evolved over the decades until the first WiFi standard was created in 1997
- The IEEE 802.11 family is the first set of standards outlines how communication over wireless local area networks (WLANs) should work
- It also establishes a minimum data transfer speed of 2 megabytes per second
- The IEEE continues to maintain the 802.11 standards, and Wi-Fi is still found in most consumer electronics and commercial IoT devices, such as smart home appliances and sensors

❑ XMPP

- Extensible Messaging and Presence Protocol (XMPP) was originally developed for human-to-human communication in 2002
- Evolved In the 20-plus years into a machine-to-machine communication protocol popularly used by smart appliances
- Today, XMPP is an open-source protocol maintained by the XMPP Standards Foundation
- A lightweight middleware system that standardizes communication and XML data
- XMPP runs in the application layer, where it can provide near-real-time data transfers
- his responsiveness and highly accessibility, makes it ideal for communicating with smart home devices like appliances

IoT Standardizations

Industrial IoT Standards And Protocols

- The industrial IoT market is among the strongest-performing in the world,
- Applications of IoT in manufacturing, logistics, and construction
- Industrial IoT (IIoT) is considered its own distinct niche
- IoT communication standards ensure sensors send real-time alerts successfully, regardless of the brand or model

IIoT standards and protocols are becoming increasingly important as businesses grow to rely on their IoT devices

For instance, a manufacturer in a smart factory might use IIoT sensors to send maintenance alerts, which could affect employee safety

IoT Standardizations

Industrial IoT Standards And Protocols

- **Lightweight M2M (LWM2M)**
  - A protocol specifically for remote device management in IoT or machine-to-machine environments
  - It is purpose-built for IoT sensors, making it a highly useful protocol for industrial application
  - Its light weight means it doesn't require much power, storage, or computing resources to run
  - Was originally published in 2017 and is still active and maintained by **OMA SpecWorks**
  - LWM2M works over TCP/TLS, MPTT, and HTTP
  - The 2020 update to the protocol added compatibility with edge networking and 5G, making LWM2M a cutting-edge standard for today's industrial environment
- **MQTT (Message Queuing for Telemetry Transport)**
  - is an application-layer protocol for machine-to-machine communication using the publisher-subscriber model
  - Was developed in 1999 and is a popular open-source protocol for standardizing communication between industrial IoT devices
  - Is particularly well-suited for IIoT sensors due to its lightweight nature and tolerance for low bandwidth
  - It essentially acts as a bridge to applications.

IoT Standardizations

Industrial IoT Standards And Protocols

❑ Zigbee

- Zigbee is a highly popular network protocol specifically for mesh networks used in automation
- Used by Consumer and industrial devices
- Although its emphasis on automation and various applications makes it ideal for business
- Was developed by the Connectivity Standards Alliance, which also created Matter
- Zigbee's top benefits include low power consumption and a high degree of flexibility
- It's designed for short range, similar to Bluetooth
- One feature that's particularly beneficial in the industrial space is its high level of security
- Zigbee includes encryption and authentication by default while staying lightweight

Industrial users can build a mesh network of IoT devices with security features without using excessive power and computing resources

IoT Standardizations

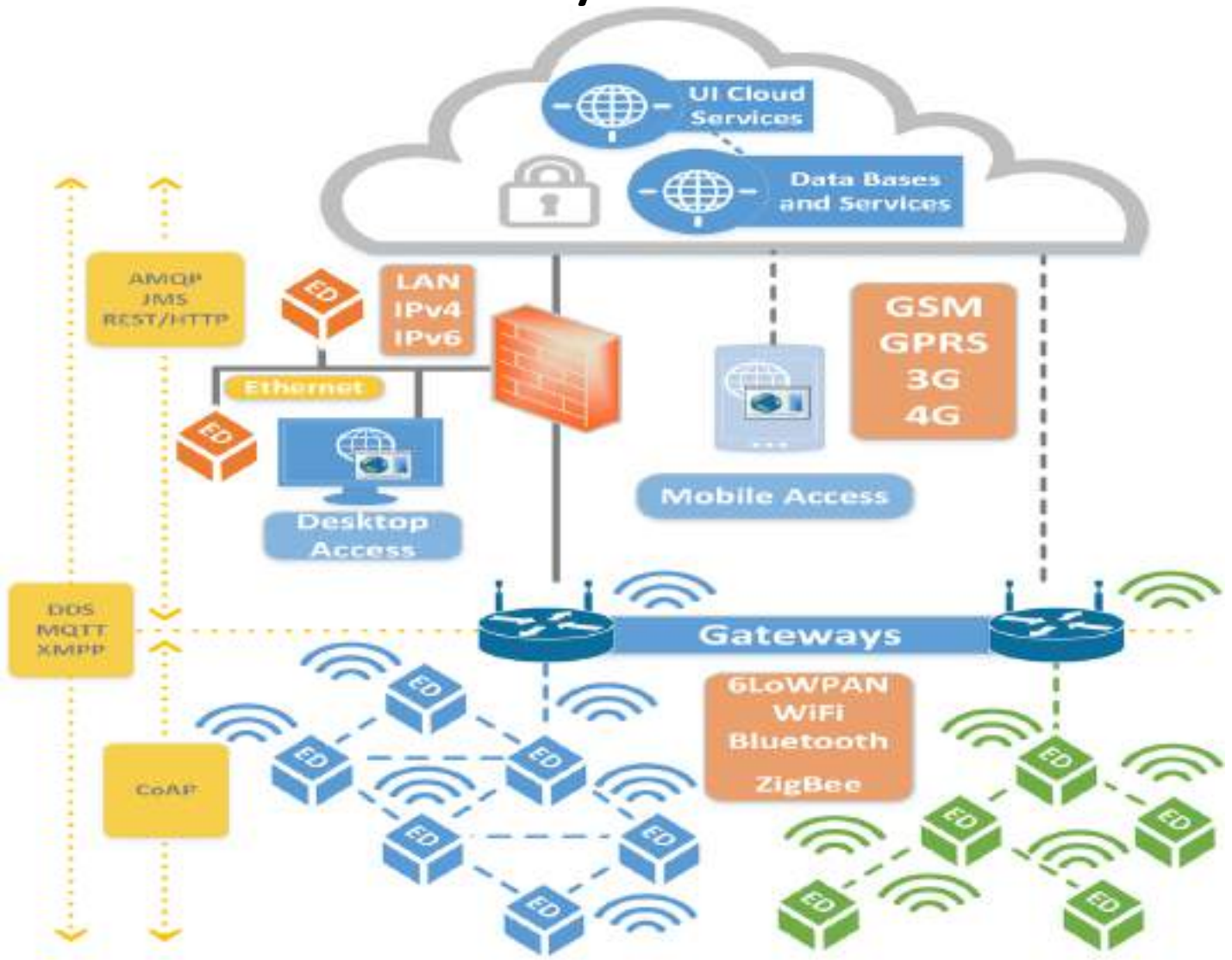
IOT based ISO/IEC & IEEE Standards

- **ISO/IEC 30141 — Internet of Things (IoT) - Reference architecture** provides an internationally standardized IoT Reference Architecture, which the organization said will help ensure that connected systems are "seamless, safer and far more resilient." It aims to achieve this by providing a common framework for IoT application
- **ISO/IEC 27400 — Cybersecurity — IoT security and privacy – Guidelines**
- **ISO/IEC 27402 — Cybersecurity — IoT security and privacy - Device baseline requirements**
- **ISO/IEC 27402.2 — Cybersecurity — IoT security and privacy – Guidelines**
- **ISO/IEC 30149 ED1: Internet of Things (IoT) - Trustworthiness Principles**
- **ISO/IEC 30161-1 ED1: Internet of Things (IoT) - Data exchange platform for IoT services - Part 1: General requirements and architecture**
- **ISO/IEC 30165: Internet of Things (IoT) — Real-time IoT framework**
- **ISO/IEC 21823-1: Internet of Things (IoT) - Interoperability for IOT Systems —**
- **ISO/IEC 21823-2: Internet of Things (IoT) - Interoperability for IOT Systems — Part 2: Transport Interoperability standard**
- **IEEE P1912, Standard for Privacy and Security Architecture for Consumer Wireless Devices**
- **IEEE 1451-99, Standard for Harmonization and security of IoT**
- **IEEE P2413 - Standard for an architectural framework for IOT**
- **EEE 802.15.4-2015 - IEEE Standard for Low-Rate Wireless Networks**

03

IoT Connectivity & Business Models

IoT Connectivity



IoT Connectivity

What does IoT connectivity means?

The different ways in which we connect IoT devices, including;

- Applications,
- Sensors,
- Trackers,
- Gateways and network routers

In the IoT industry, IoT connectivity also refers to the different IoT network solutions that can power this kind of connectivity, including Wi-Fi and cellular or LPWAN solutions

IoT Connectivity

How to choose the best Connectivity Technology?

- Bandwidth Capacity (speed)
  - If IoT devices will need to send and receive a lot of data, so you'll need to choose a network that can handle the right amount of data for your needs
- The Coverage Range
  - If your devices are physically spread out over a wide distance, you'll need to choose a network that offers sufficient range
- Power consumption
  - Most IoT devices are battery-powered, but some are hard-wired when they need high power & durability
  - Data requirements, and deployment considerations specific to each application

Question

Does the perfect Connectivity Exist?

Answer

The perfect connectivity option would consume extremely little power, have huge range, and would be able to transmit large amounts of data (high bandwidth)

Unfortunately, this perfect connectivity doesn’t exist!

Each connectivity option represents a tradeoff between power consumption, range, and bandwidth

IoT Connectivity

Connectivity Options

I. High Power Consumption, High Range, High Bandwidth

- Wirelessly send a lot of data over a great distance, it takes a lot of power

Ex. Smartphones

Connectivity options in this group include **Cellular** and **Satellite**.

- ✓ Cellular is used when the sensor/device is within coverage of cell towers
- ✓ Satellite for sensors/devices too far apart ex.in the middle of the ocean, etc..

II. Low Power Consumption, Low Range, High Bandwidth

- To decrease power consumption and still send a lot of data, you have to decrease the range

Connectivity options in this group include **WiFi**, **Bluetooth**, and **Ethernet**.

Ethernet is a hard-wired connection, so the range is short because it's only as far as the wire length

WiFi and Bluetooth are both wireless connections with high bandwidth and lower power consumption

IoT Connectivity

Connectivity Options

III. Low Power Consumption, High Range, Low Bandwidth

- Increase range while maintaining low power consumption, you have to decrease the amount of data that you're sending.

Connectivity options in this group are **Low-Power Wide-Area Networks (LPWAN) or LoRaWAN**.

LPWANs send small amounts of data which allows them to operate at very low power with ranges in miles rather than feet

LPWANs are extremely useful for many IoT applications. They allow tons of sensors to collect and send data over broad areas while lasting years on battery life. Although they can't send much data, most sensors don't need to

Question

A case where LPWANS is the best Solution

Answer

Moisture sensor for agricultural purposes

- doesn’t need to send a lot of data, just number “the moisture level” every few hours
- Cannot let the sensor consume a lot of power because it needs to run on battery (plugging it into an outlet in the middle of a field just isn’t realistic)
- Agriculture covers a wide area, WiFi and Bluetooth lack the range

Solution

- LPWANS

IoT Connectivity

How to choose the best Connectivity Technology?

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  - Data requirements, and deployment considerations specific to each application

IoT Connectivity

Common IoT connectivity technologies and their most frequent use cases

RFID

Radio Frequency Identification (RFID) send small amounts of data to a nearby reader

- Data transfers happen between very short distances

Use cases;

1. **Smart shelves**
   - Smart shelves use RFID tags and readers to track inventory in a retail setting automatically
   - also allows employees to monitor the store remotely and promptly resolve or mitigate any issues
2. **Smart mirrors**
   - Smart mirrors can augment fitting rooms for an interactive and efficient experience
   - Smart mirrors use RFID technology to track the item a customer is trying on and display other available sizes, colors, or complimentary items

IoT Connectivity

Common IoT connectivity technologies and their most frequent use cases

Ethernet

The dominant wired connection option

- Cheap and reliable way to connect your IoT devices if you already have the required infrastructure to hook your devices up
- Low latency, ethernet is a particularly attractive option when you need a strong connection with little lag
- Speed & Robustness (things like floors, walls, or the length of a room won't interfere with the connection)

Ethernet is most suitable for stationary devices. Some common uses include;

1. **Security cameras**

At a business or home where security cameras are in use, an ethernet connection can be a simple way to reliably connect cameras and stream real-time footage without worrying about signal drops

2. **Stationary medical devices**

Some medical devices, particularly ones that stay put in a specific room or location in a doctor's office or hospital, may use ethernet to quickly and reliably transmit data to an online health records management system.

IoT Connectivity

Common IoT connectivity technologies and their most frequent use cases

Bluetooth

Bluetooth is another connectivity option that works well for small, battery-powered devices

- Bluetooth's range is small (usually about 30 feet)
- Bluetooth also often has a lower bandwidth

Bluetooth-enabled devices Or Bluetooth low energy (BLE) devices, also offer an added benefit of low energy consumption

- meaning your devices can run on small batteries for longer amounts of time

Use cases;

- **Smartwatches or fitness trackers**

Often connected to a cell phone, provide quick data transfers back to an app a user can then look at on their phone
A BLE-enabled device will also minimize the number of times a user has to recharge their watch or tracker

- **Sensors in small areas-**

Whether they measure temperature, light, or movement, many sensors transmit data through Bluetooth. Bluetooth-enabled sensors can be ideal in a small business or home setting when tracking data over a period of time.

IoT Connectivity

Common IoT connectivity technologies and their most frequent use cases

Wi-Fi

Used by many people at home or offices;

- It has the ability to secure the network in private settings and
- There is no cost limitations on the amount of data transferred
- But it's unreliable and has limited range

Situations where Wi-Fi makes the most sense include;

1. Smart gadgets

. If your IoT ecosystem is confined to a specific area; like a home or an office

- Wi-Fi may be a simple and effective option.
- Everything from smart TVs, lightbulbs, and fridges can easily operate using your established Wi-Fi network

2) Digital Signage

Wi-Fi is a great choice for digital signage since the screens typically remain in one place

- Popular in restaurants and commercial spaces, because many of these stores will already have a Wi-Fi router installed, it may be the easiest and most cost-effective connectivity option

IoT Connectivity

Common IoT connectivity technologies and their most frequent use cases

LPWANs

Networks like SigFox, LoRaWAN, NB-IoT, LTE-M, or RPMA are all classified as **low power wide area networks** (LPWANs)
Unlike cellular or Wi-Fi networks, LPAWNs support much smaller data transfers in infrequent intervals over wide areas

- This keeps them power-efficient and makes them ideal for expansive IoT projects
- Optimized for low-power consumption, you won't have to constantly change a sensor or device's

LPWANs send small amounts of data infrequently, they're not the best option for high-bandwidth/time sensitive projects

Some places LPAWNs where might make sense;

1. **Smart parking garages** Sensors placed throughout a parking garage could be used to inform attendants and customers of open spaces and capacity limits
2. **Small shared rental vehicles** Sensors could be placed on small rental vehicles, like bikes, scooters, or mopeds to track the vehicle's location (This could be particularly helpful if a customer does not have to return the vehicle to the same place they picked it up)

IoT Connectivity

Common IoT connectivity technologies and their most frequent use cases

Mesh Protocols (ZigBee, Z-Wave, Thread)

Like Bluetooth, these mesh protocols are most frequently used in domestic and consumer products

- These networks work well in **medium-range** settings;
  - Across an entire home. when you want to connect multiple devices by creating a "mesh" network,

Otherwise described as a decentralized network, each in-range device can communicate with any other device

- This is particularly beneficial if one device drops out of the network
  - Since all of the devices are connected, losing one won't impact the network's overall strength
- These networks are often deployed when linking and automating smart devices so that when one meets certain conditions, another activates

1. **Home automation**
   - mesh networks are the solutions for ultimate smart house, where all devices respond automatically conditions arise
   - Mesh Devices like security systems, lightbulbs, or outlets, may be compatible with mesh networks
1. **Environmental monitoring**
   - Mesh networks are becoming more and more popular in the agricultural and environmental industries for devices such as smart irrigation systems and water filtration systems

IoT Connectivity

Common IoT connectivity technologies and their most frequent use cases

Cellular

Cellular networks are already part of everyday life; Phones, Tablets and Smartwatches

- Cellular connectivity allows you to benefit from established mobile network infrastructure
- Cellular connectivity is often the ideal choice for highly-mobile IoT systems

There are many benefits to a cellular IoT system, including;

- Wide-range coverage,
- reliability, and
- higher levels of security compared to Wi-Fi or other connectivity options

Some possible use cases for cellular connectivity

1. **Point of sale and kiosks** Vending machines, kiosks, and other points of sale systems won't need Wi-Fi or a wired internet connection if they operate on a cellular network
2. **Delivery tracking** Cellular connectivity can be used to track real-time delivery and ensure accurate arrival time estimates, it's important to have reliable information When transporting materials needed for other parts of a logistics or supply chain Using an IoT SIM with automatic carrier switching means connectivity will never be lost, even if the cargo is in the middle of the ocean

IoT Connectivity

Common IoT connectivity technologies and their most frequent use cases

High data rate cellular (3G/4G/LTE/5G)

Offering impressively fast Mbps, high data rate cellular connectivity is a perfect choice for data-heavy IoT applications

- highly mobile devices, and real-time video streaming
- Wide coverage, Reliable access, Established infrastructure
- high data rate cellular provides even faster data rates and larger bandwidths

As 5G deployment continues, IoT devices connected across a wide area, also known as "massive IoT," will become a reality, connecting thousands of IoT devices across large areas

1. **Health monitoring**
   - Wearable and implantable health monitors; like those that monitor cardiac or diabetic health
- can send real-time, critical data back to healthcare centers regardless of the wearer's movements

2. **Mobile Wi-Fi**

It's becoming common to find Wi-Fi in moving vehicles like buses, trains, motorhomes, and even some cars using an onboard modem with a SIM card and router, Wi-Fi has never been so mobile

IoT Connectivity by Segment & Technology

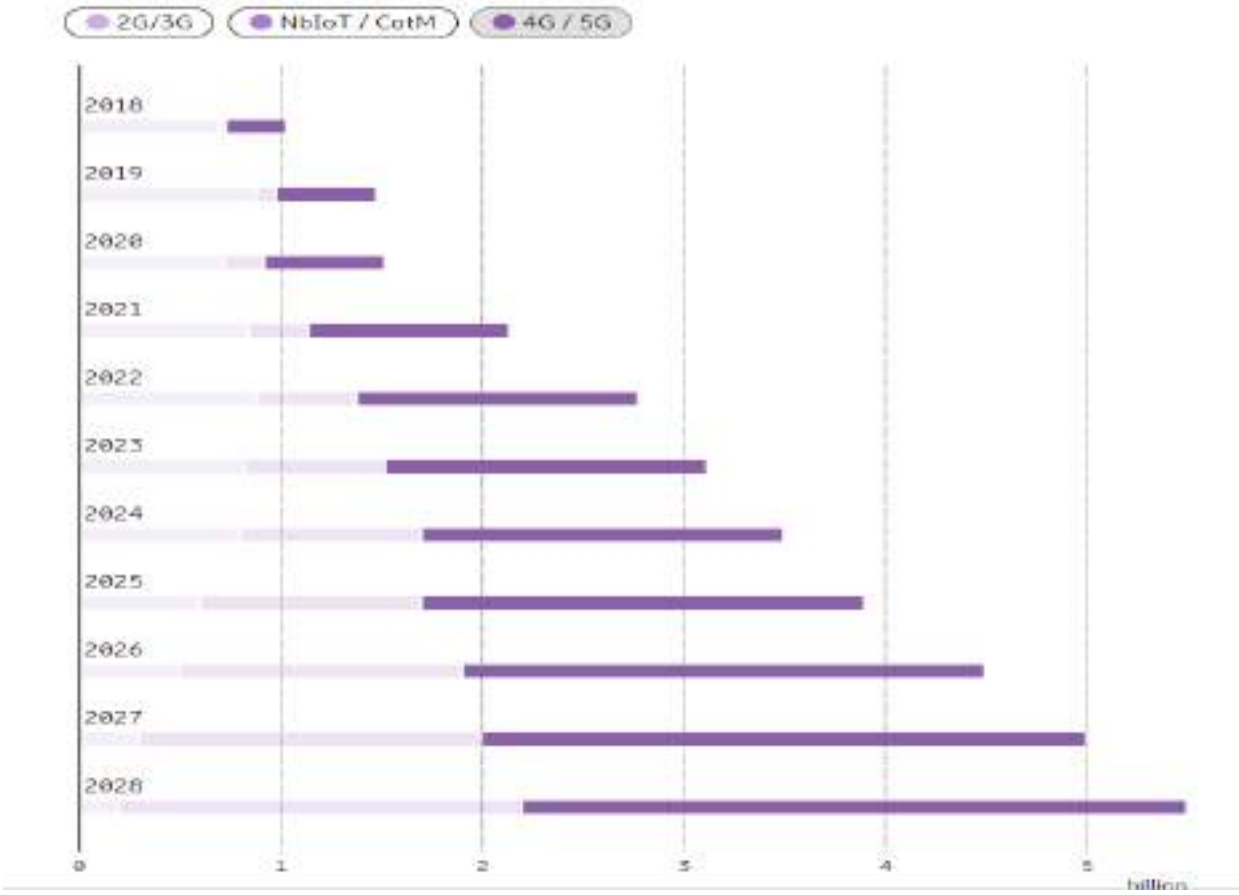
Key findings

- LTE Cat-1 devices are increasingly being used for a variety of use cases.
- The number of IoT devices connected via 2G and 3G is in slow decline.
- In 2022, broadband IoT (4G/5G) reached 1.3 billion connections.

IoT	2022	2028	CAGR
Wide-area IoT	2.9	6.0	13%
Cellular IoT[2]	2.7	5.4	12%
Short-range IoT	10.2	28.7	19%
Total	**13.2**	**34.7**	**18%**

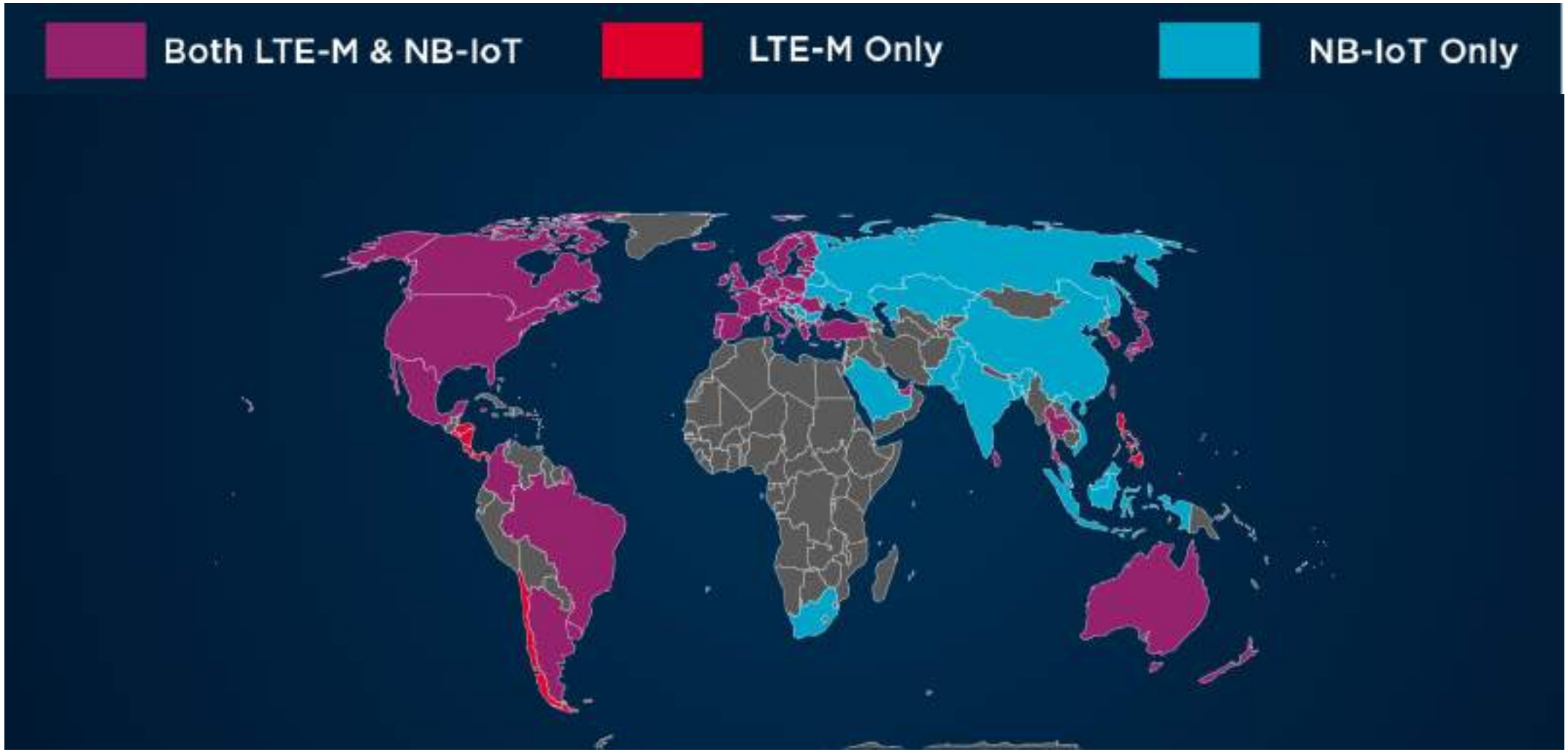
Note: Based on rounded figures.

Figure 8: Cellular IoT connections by segment and technology



Ericsson

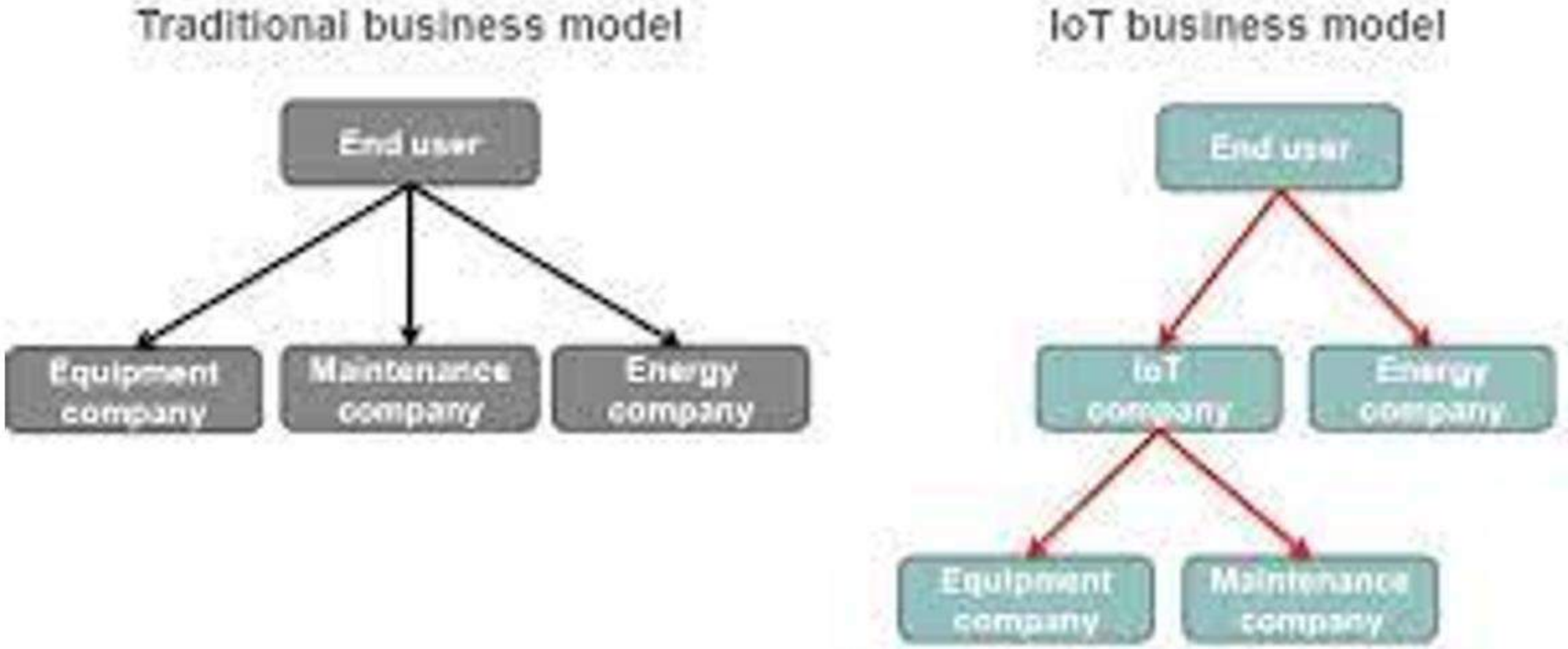
Mobile IoT Deployment Map



GSMA

IoT Business Models

IoT Business Models

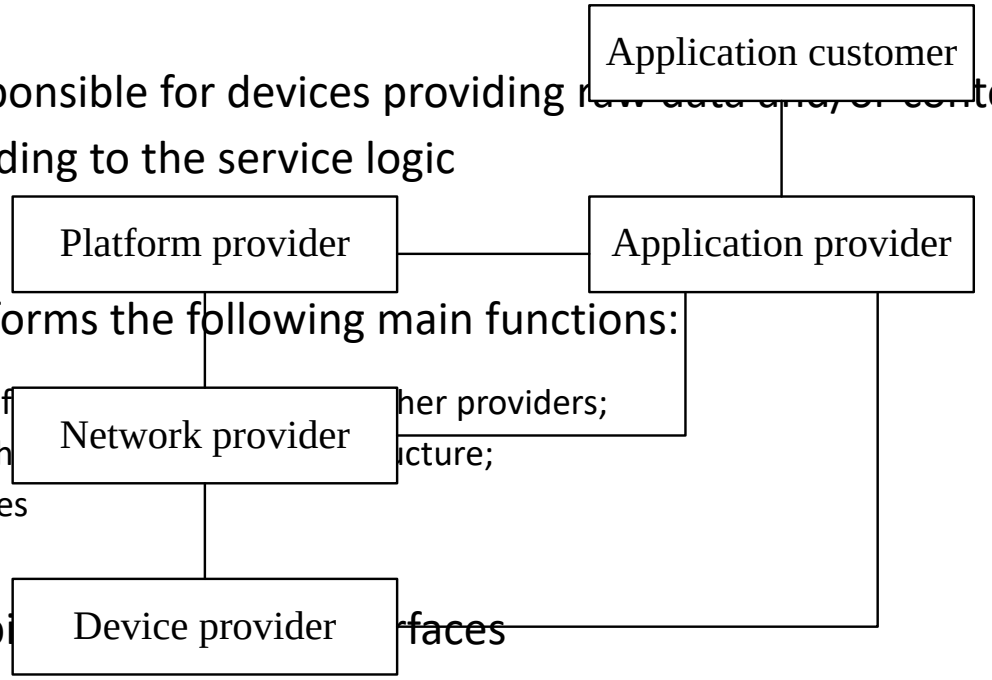


IoT Business Models

The IoT ecosystem is composed of a variety of business players

- **Device provider**

The device provider is responsible for devices providing raw data and/or content to the network provider and application provider according to the service logic



- **Network provider**

The network provider performs the following main functions:

  - Access and integration of her providers;
  - Support and control of th cture;
  - Offering of IoT capabilities

- **Platform provider**

Provides integration capabi faces

- **Application provider**

Utilizes capabilities or resources provided by the network, device and platform providers

- **Application customer**

Is the user of IoT application(s) provided by the application provider

IoT Business Models

- IoT can provide significant innovation in Business Models
- Business Models innovations will have more impacts when IoT Company interact with the Customers
- IoT Opened limitless possibilities for businesses to build novel connections to their customers

IoT Business Models
Main Business Models

There are 5 main business models enabled by IoT between the IoT company and the customer

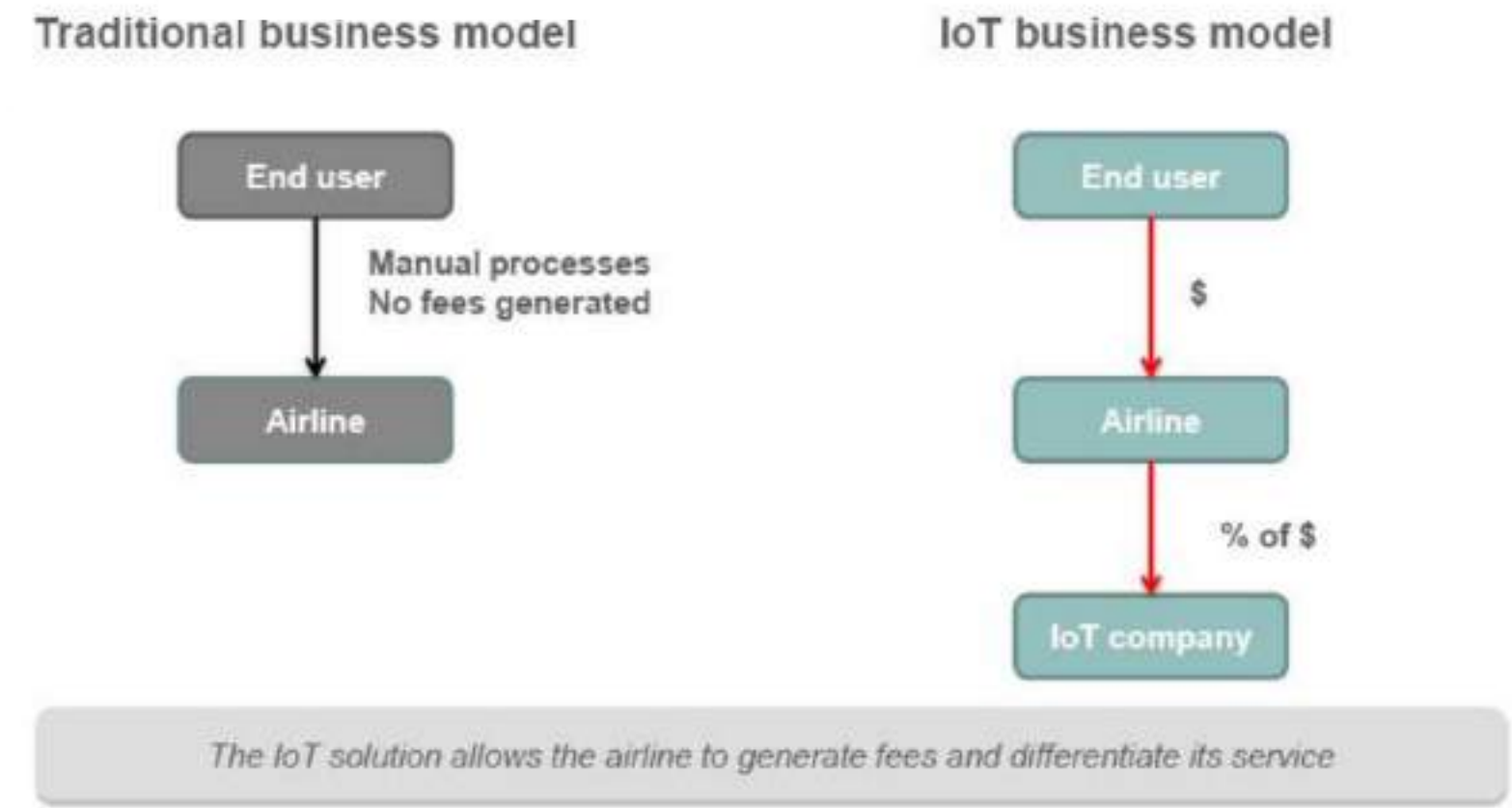
Business Models
Revenue Sharing
Cost-Saving Sharing
Product Sharing
Performance as a Product
Transactional

IoT Business Models
Revenue Sharing

Problem	Luggage lost in air transit.
Traditional solution	• The airline would try to find the lost luggage using manual processes, which are costly, time consuming and generate customer dissatisfaction.
IoT solution	• A tracking device is placed inside the luggage and transmits its location using 2G. The user can track his luggage using a smartphone app.
IoT business model	• The airline charges a fee to its customers for using the luggage tracking service, or offers the service for no charge to premium customers. A share of the revenue generated is paid to the IoT company, which maintains the IoT solution.

Source: ITU

IoT Business Models
Revenue Sharing



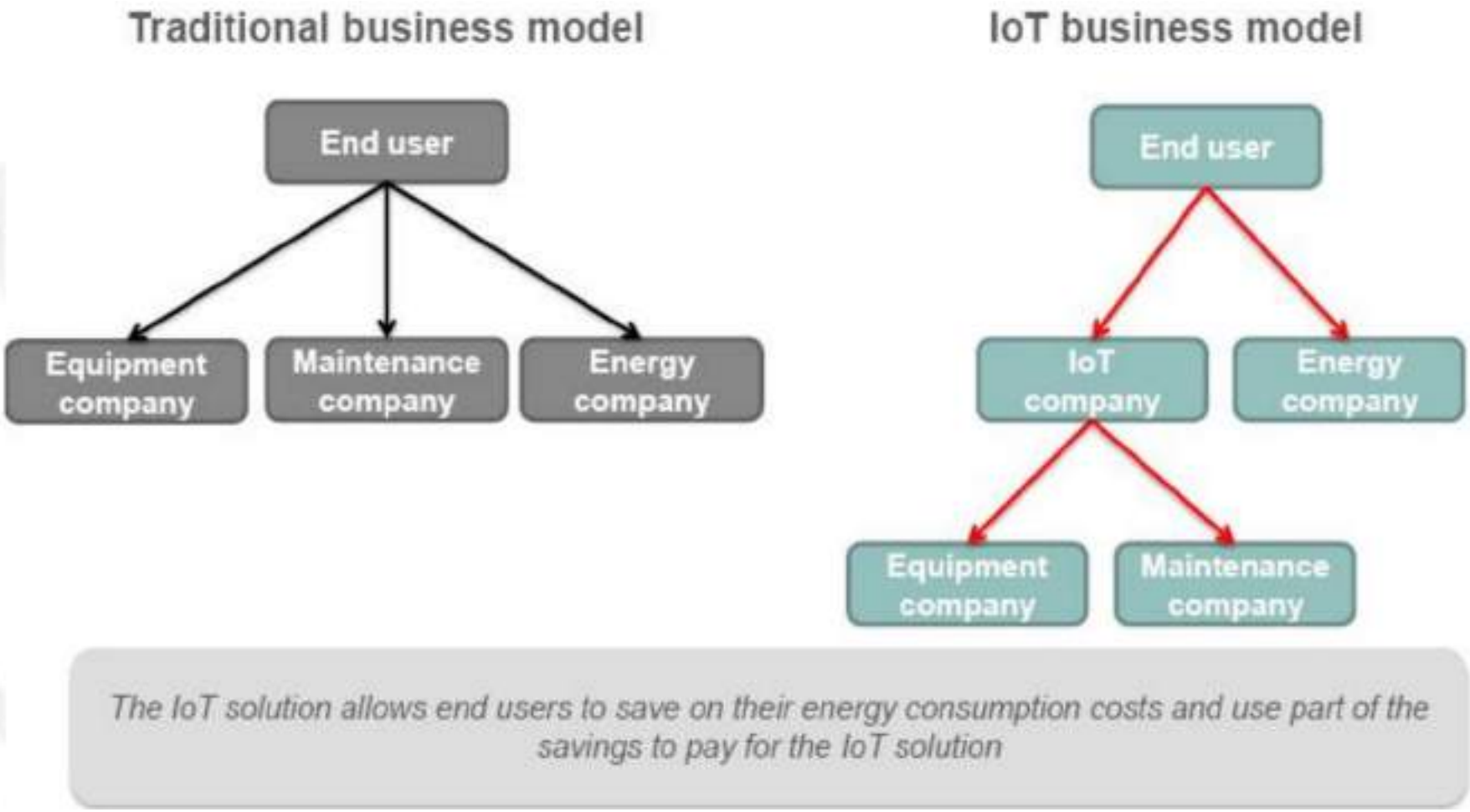
Source: ITU

IoT Business Models
Cost Savings Sharing

Problem	Home/building energy consumption.
Traditional solution	• The end user pays for the Heating, Ventilating and Air Conditioning (HVAC) system and its maintenance, and also pays the energy company pays for its power consumption.
IoT solution	• The end user installs equipment to monitor and control the HVAC system, so it can automatically adjust to the user's requirements and optimise its energy consumption.
IoT business model	• The IoT company installs the monitoring and control equipment with no up-front fees. • The end user pays for the equipment rental from the energy savings generated by the IoT solution. If the savings amount to $100 and the rental is $40, the end user keeps $60 as overall savings.

Source: ITU

IoT Business Models
Cost Savings Sharing



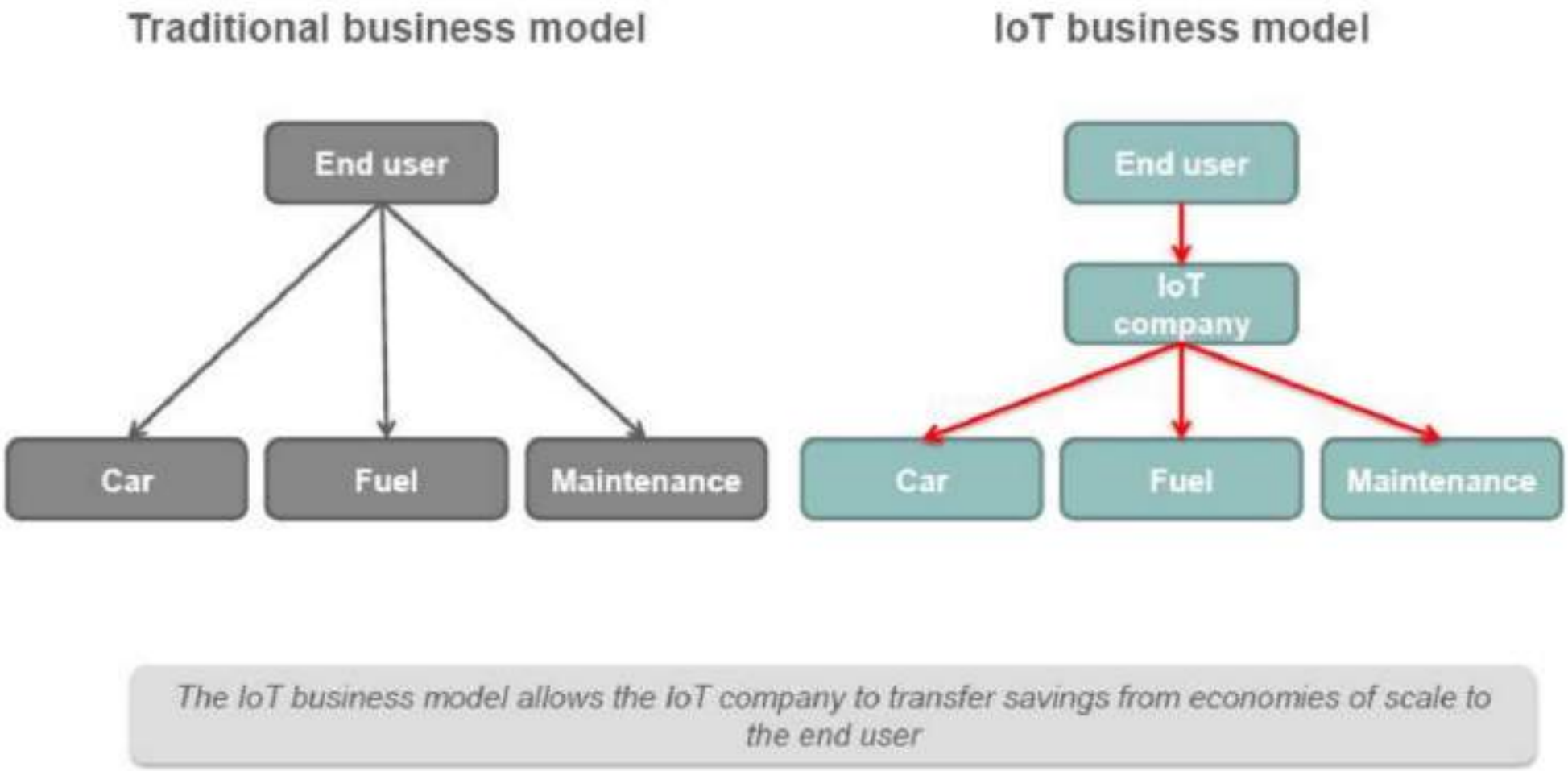
Source: ITU

IoT Business Models
Product Sharing

Problem	Relatively high investment and maintenance costs of a car.
Traditional solution	• The end user buys the car upfront and pays for its ongoing maintenance, fuel and insurance.
IoT solution	• The end user can drive a number of cars made available across a city, without needing to own one. • All car related costs are managed by the IoT company. A smartphone app, allows users to reserve the car, locate and unlock it.
IoT business model	• The IoT company charges end users by the minute for using a car. The fees include the cost of the car, its maintenance, fuel and insurance. • From managing a large fleet of vehicles, the IoT company can achieve economies of scale, which can be translated into competitive prices for the end user.

Source: ITU

IoT Business Models
Product Sharing



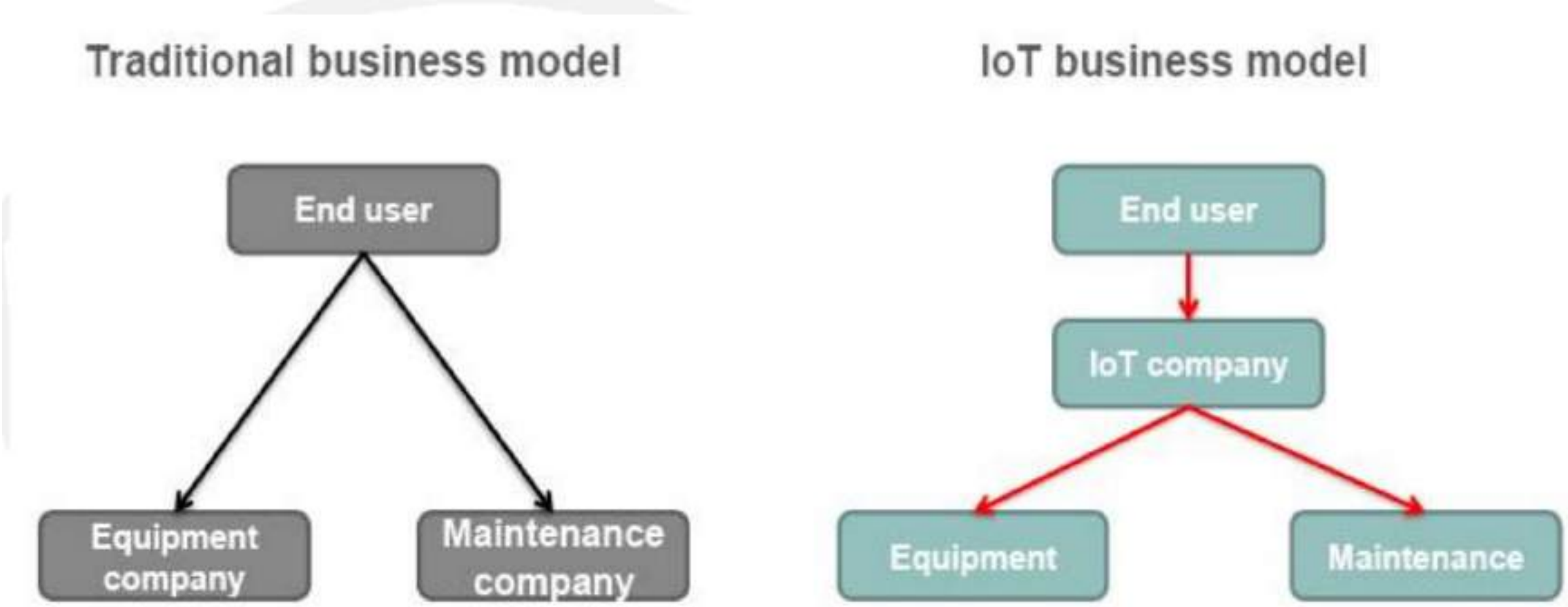
Source: ITU

IoT Business Models
Product as a Service

Problem	High investment and maintenance cost of heavy medical equipment.
Traditional solution	• The user (e.g. hospital) buys the equipment upfront and can face high maintenance costs. Different suppliers may be involved in selling and supporting the equipment.
IoT solution	• The hospital pays for the equipment and maintenance to the IoT company. • The equipment is remotely monitored in terms of usage and performance, allowing the IoT company to perform predictive maintenance. As a result, the end user can benefit from reduced or no disruption from equipment downtime.
IoT business model	• The IoT company charges a recurring fee to the hospital. This fee includes the use of the equipment and its maintenance. • The equipment is owned by the IoT company, who by actively monitoring it, may pre-empt potentially serious issues resulting in expensive maintenance.

Source: ITU

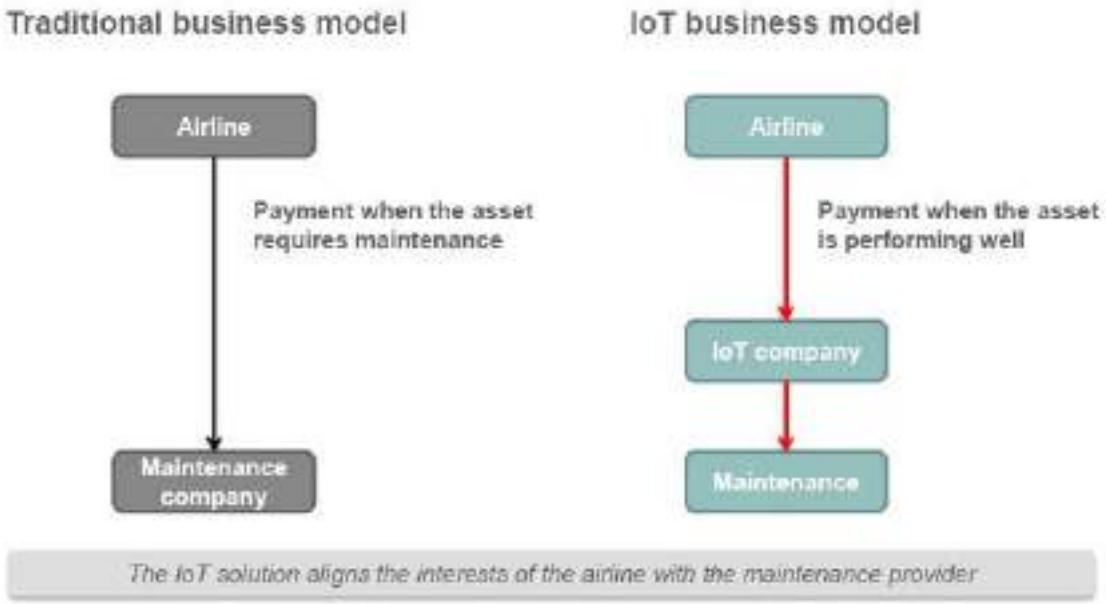
IoT Business Models
Product as a Service



Source: ITU

IoT Business Models
Performance as a product

Problem	Uncertain aircraft engine maintenance cost.
Traditional solution	• Airlines would buy the engine from manufacturers such as Rolls-Royce and take on the risk of the engine becoming inoperable and possible high maintenance cost.
IoT solution	• The aircraft engines have embedded sensors that send data back to the engine manufacturer (IoT company). • This information is used by the IoT company to identify and fix problems remotely, minimising the risk of engine downtime.
IoT business model	• Rolls-Royce's TotalCare program is sold to airlines as a solution to make the engine's maintenance costs predictable. • Under this program, Rolls-Royce is responsible for the engine's maintenance and only gets paid if the engine is operational. Its revenues equal a fixed fee per flying hour.



Source: ITU

Case Study
Farm water Monitoring

Problem: How do I know if my water tanks need to be refilled?

Customers	• Farmers
Needs to address	• Water availability for animals. This is particularly relevant in dry lands (e.g. certain areas of Africa)

IoT solution & benefits

IoT solution	• A sensor is placed in the water tanks and troughs to monitor the water level sending an alert to the controlling station (or via SMS text or email) if water levels flow or pressures go outside a pre-configured range
Benefits	• The solution increases the efficiency in the water usage, which can be particularly important in developing countries and in dry lands

Technologies

Feature	Requirement	Comment
Network Area	• Wide	Extended fields in remote locations can require significant signal coverage
Spectrum	• Shared / Dedicated	Quality of service of transmission is not a crucial factor
Battery life	• Long	The sensors may be placed in remote points of the field and need to have long battery life. Solar panels may contribute to extending battery life
Connectivity cost	• Low	Associated to the low bandwidth requirement
Module cost	• Medium	Price may be an issue in developing countries
Bandwidth	• Low	Data needed to monitor water level is limited

Technologies: LPWA | 2G

Case Study

Farm water monitoring –most likely business models

Business models	Revenue of the IoT company	Device ownership
Revenue-sharing	Recurring	IoT company
Cost-savings sharing	Recurring	IoT company
Product-sharing	Usage	IoT company
Product-as-a-Service	Recurring	IoT company
Performance-as-a-Product	Usage	User
Transactional	Upfront	User

Most likely business models

Case Study

Farm water monitoring –most likely business models

Liability

Liability

- Establishing responsibility needs to be clear in the event of damages resulting from the IoT solution
- If the solution fails and animals die because of lack of water, who is to blame:
  - The local reseller installer?
  - The IoT technology company?
  - The network operator?
  - The farmer?