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IT402
Internet of Things

Lecture 1



Introduction to the Internet of Things (IoT)

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Internet of Things

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Learning Objectives:

- 1.1 Define IoT and its significance
- 1.2 Understand the building blocks of IoT systems
- 1.3 Identify real-world use cases
- 1.4 Recognize advantages in IoT implementation

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What is the Internet of Things (IoT)?

The Internet of Things (IoT) encapsulates a vision of a world in which billions of objects with embedded intelligence, communication means, and sensing and actuation capabilities will connect over IP (Internet Protocol) networks. Our current Internet has undergone a fundamental transition, from hardware-driven (computers, fibers, and Ethernet cables) to market-driven (Facebook, Amazon) opportunities. This has come about due to the interconnection of seemingly disjoint intranets with strong horizontal software capabilities.

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What is the Internet of Things (IoT)?

The IoT calls for open environments and an integrated architecture of interoperable platforms. **Smart objects and cyber-physical systems – or just “things”** – are the new IoT entities: the objects of everyday life, augmented with micro-controllers, **optical and/or radio transceivers, sensors, actuators, and protocol stacks** suitable for communication in constrained environments where target hardware has limited resources, allowing them to gather data from the environment and act upon it, and giving them an interface to the physical world. These objects can be worn by users or deployed in the environment.

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What is the Internet of Things (IoT)?

They are usually highly constrained, with limited memory and available energy stores, and they are subject to stringent low-cost requirements. Data storage, processing, and analytics are fundamental requirements, necessary to enrich the raw IoT data and transform them into useful information. IoT as shown in Figure 1.1.

- IoT is the intersection of the Internet, Things and Data.

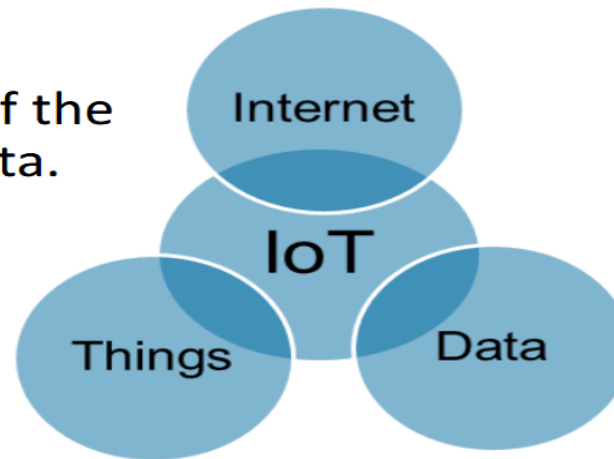
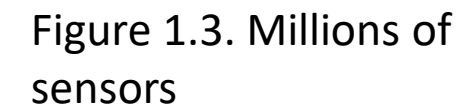


Figure 1.1 . Components of IoT

Figure 1.2 IoT definition

After excluding computers and handheld devices (e.g., cellphones and tablets), there are 16.5 billion connected things in 2020 Worldwide. IoT collects that data from millions of sensors embedded in everything from cars, to refrigerators, to space Capsules as shown in Figure 1.3.



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What is the Internet of Things (IoT)?

IoT sensing: more sensors than ever: E.g. current smartphones are equipped with a number of embedded sensors.

- A Mobile Smartphone can provide a lot of context information about you and your activities:
 - your mobility (even without GPS)
 - your movement between floors in a building
 - Your speech
 - Your contacts
 - Your interaction with other objects



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What is the Internet of Things (IoT)?

IoT sensors and Actuators:

- **Sensor:** a connected device enabling the sensing of physical parameters of the scenario or controlled environment, whose values are transformed into digital data.
- **Actuator:** a connected device enabling the activation of actions on the controlled environment.



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What is the Internet of Things (IoT)?

IoT sensors and Actuators:

- **Controller:** a connected device implementing an algorithm to transform input data in actions.
- **Smart things:** digital devices providing service functions realized by the synergy between sensors, actuators and controllers (possibly implemented by local/distributed execution platforms and M2M/Internet communications).

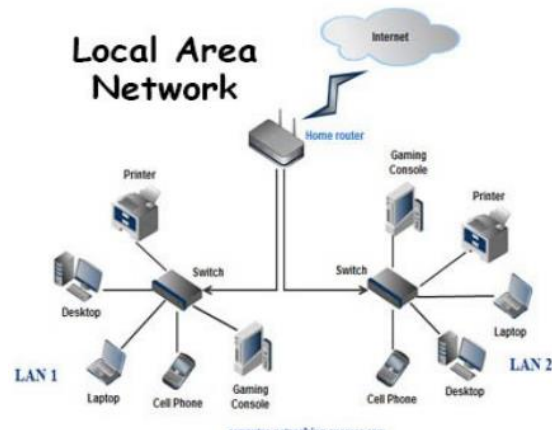


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IoT - Historical Perspective

Yesterday

local Area Networks (LAN), Static services (email, web)

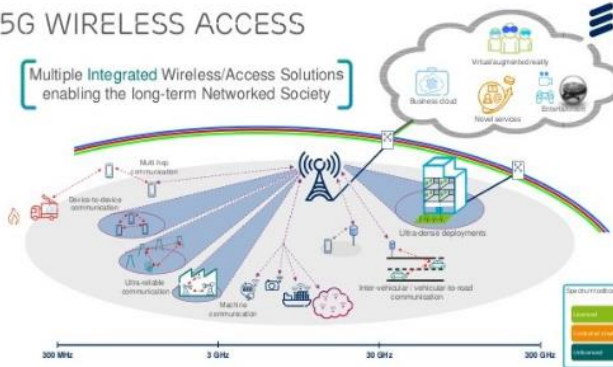


Today

Wireless Mobile, ubiquitous Internet access, Cloud Mobile Services & Resources

5G WIRELESS ACCESS

[Multiple Integrated Wireless/Access Solutions enabling the long-term Networked Society]



Today/Tomorrow

Machine to machine (M2M), Internet of Things (IoT), Smart World services



Evolution

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IoT Domains

With sensors becoming increasingly ubiquitous, there is tremendous potential for innovative IoT applications across a wide variety of domains as shown in Figure 1.4.

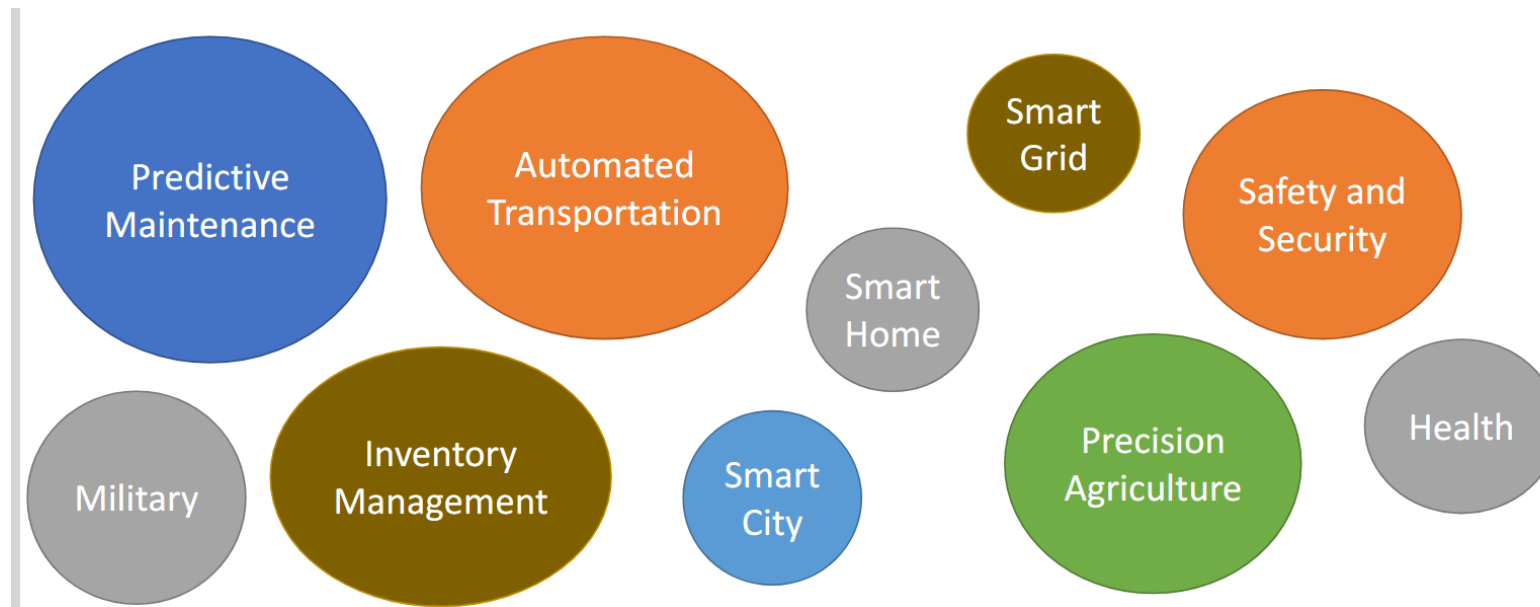


Figure 1.4. IoT domains

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IoT-enabled Applications

The IoT touches every facet of our lives. IoT-enabled applications are found in a large number of scenarios, including : home and building automation, smart cities, smart grids, Industry 4.0, and smart agriculture. In each of these areas, the use of a common (IP-oriented) communication protocol stack allows the building of innovative applications.

Home and Building Automation: The smart home market is maturing with growing investment, leading to diverse home automation applications tailored to specific audiences, creating fragmented vertical market segments. Key applications include:

Home Security: IoT-enabled systems for monitoring and protecting homes.

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IoT-enabled Applications

Energy Efficiency: Solutions for energy saving and management, such as smart lighting and room control.

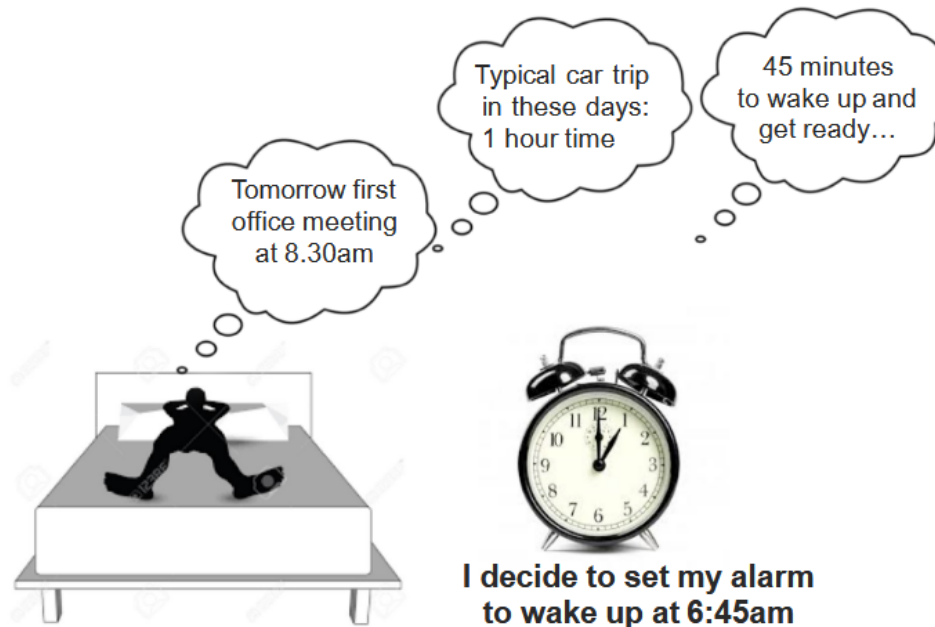
Healthcare Applications: IoT supports the physically less mobile (e.g., elderly), disabled, or chronically ill through remote health monitoring and air-quality monitoring, addressing needs in aging populations.

Building Automation: Beyond homes, building automation is expanding from luxury, security, and comfort to broader, interconnected solutions.

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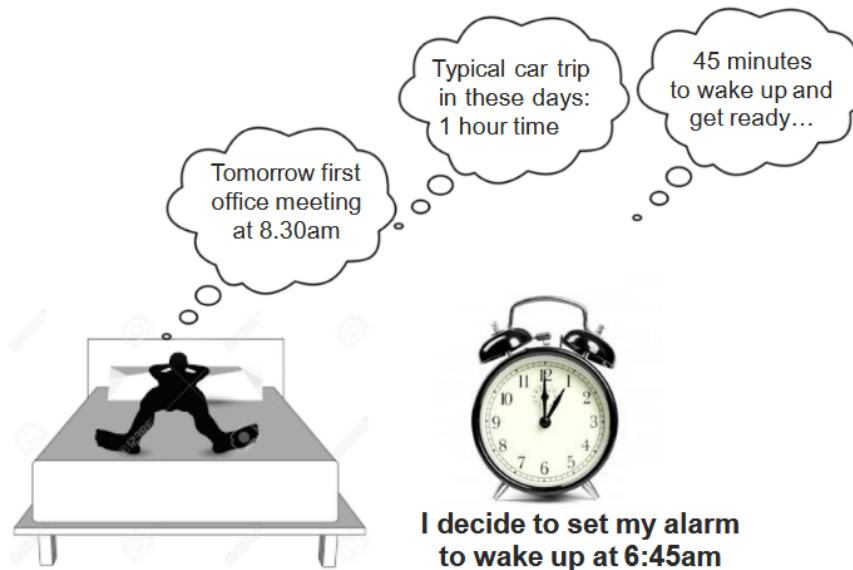
A Smart Home Example

- One typical evening planning next working day...



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A Smart Home Example



What could (will) possibly go wrong?

- 1) At 4.30am it starts snowing
- 2) Truck obstruction along the usual path
- 3) Traffic congestion on alternative paths
- 4) No parking at destination
- 5) Bathroom cold when having shower
- 6) Coffee cold when having breakfast
- 7) Left my car keys at home when in garage
- 8) Elevator busy when leaving my flat
- 9) Total time to get ready+breakfast: 55 min.

Leaving 10 minutes late + 30 minutes additional travel time

I missed the morning meeting!

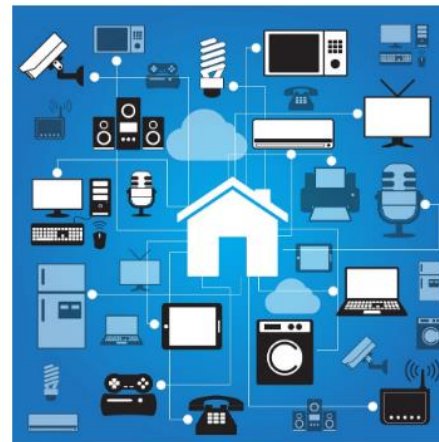
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A Smart Home Example

Define your user's objective!



Smart IoT Services



45 minutes to wake up and get ready...

Typical car trip in these days: 1 hour time

Based on my typical habits decides to set my alarm to wake up at 6:45am



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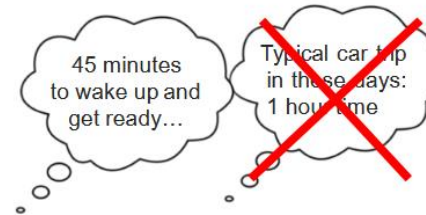
A Smart Home Example

This is the PROGRAMMING effort!



Based current info
decides to set my alarm
to wake up at 6:30am

Smart IoT Services



What could (will) possibly go wrong?

- 1) At 4.30am it starts snowing

Get notified in real time by the weather monitoring system or device.

Based on forecasts it anticipates the alarm clock to 6:30am (15 minutes before)



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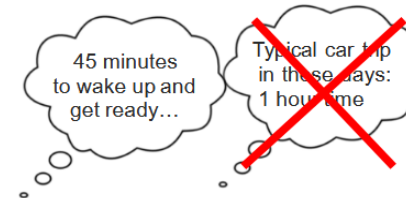
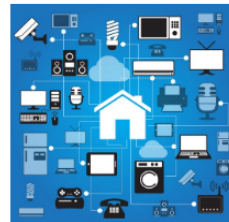
A Smart Home Example

This is the **PROGRAMMING** effort!



Based current info
decides to set my alarm
to wake up at **6:30am**

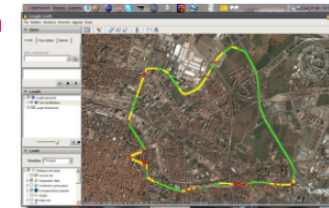
Smart IoT Services



What could (will) possibly go wrong?

- 1) At 4.30am it starts snowing
- 2) Truck obstruction along the usual path
- 3) Traffic congestion on alternative paths

Get notified in real time by the Traffic monitoring information.



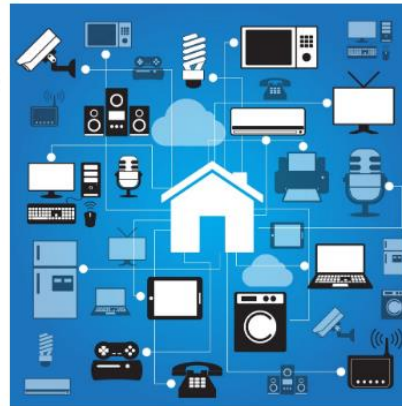
Computes a new path and evaluates congestion delay, it further anticipate alarm clock to **6:00am** (30 minutes before)

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A Smart Home Example

Define your user's objective!

Smart IoT Services



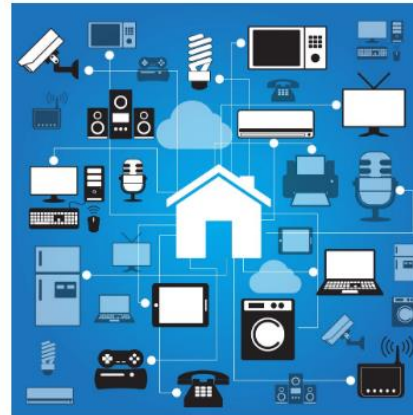
45 minutes to wake up and get ready...

6) Coffee cold when having breakfast

The mirror notifies I am leaving the bathroom, and while I get dressed in my bedroom, the COFFEE MACHINE is activated in the kitchen, and the warming up of the bathroom is switched off.



Smart IoT Services



When I leave my home passing through the main door I got a message on my phone advising me that I do not have the CAR KEYS with me...

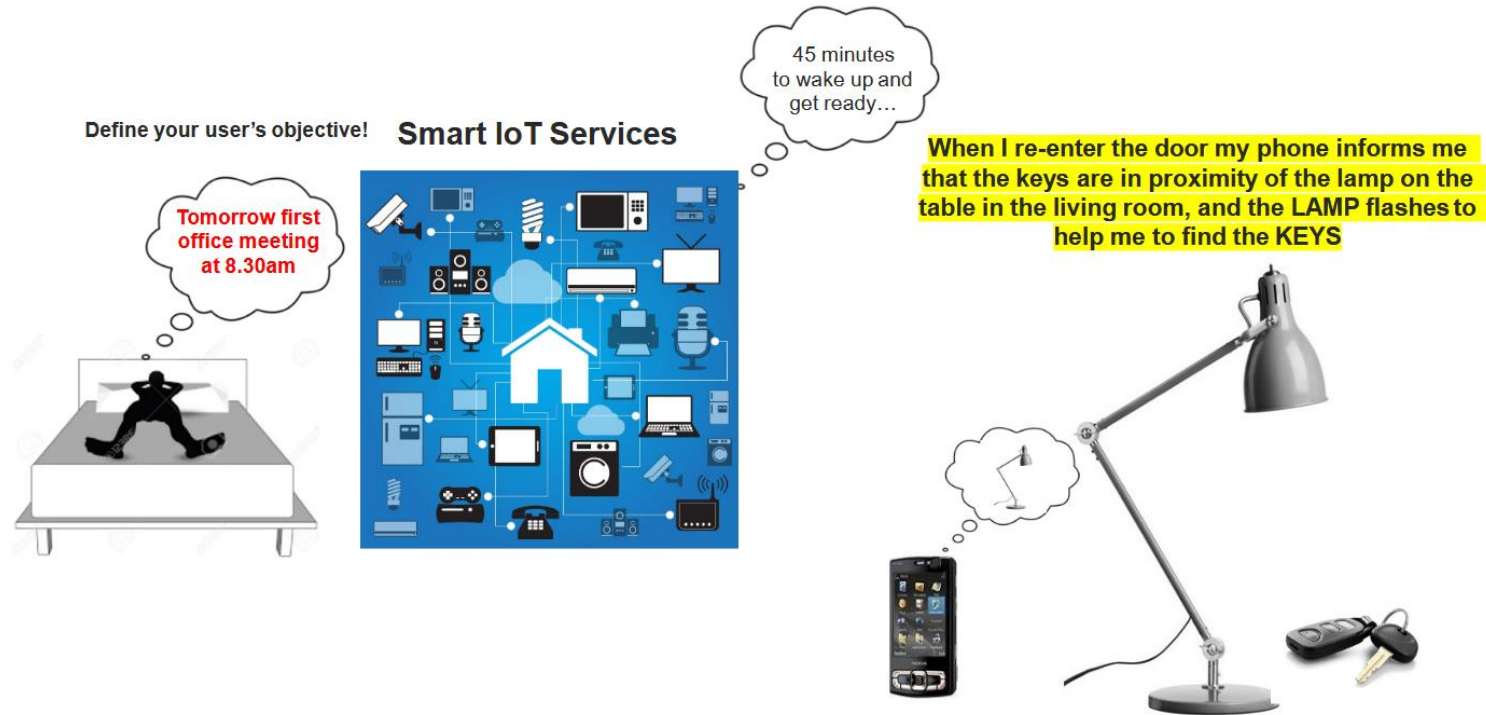


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A Smart Home Example

Define your user's objective!

Smart IoT Services



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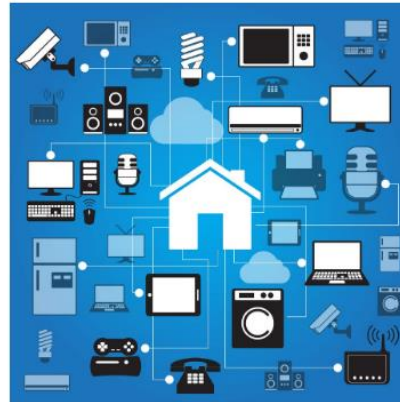
A Smart Home Example

Define your user's objective!

Tomorrow first
office meeting
at 8.30am



Smart IoT Services



Resolved all
the troubles...

I participate at the 8:30am meeting
Right in Time!



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Smart Cities

- **Smart Cities:** Cities are complex ecosystems, where quality of life is an important concern. In such urban environments, people, companies and public authorities experience specific needs and demands in domains such as healthcare, media, energy and the environment, safety, and public services. A city is perceived more and more as being like a single “organism”, which needs to be efficiently monitored to provide citizens with accurate information. IoT technologies are fundamental to collecting data on the city status and disseminating them to citizens. In this context, cities and urban areas represent a critical mass when it comes to shaping the demand for advanced IoT-based services.

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IoT in Agriculture: Smart Farming

- **Smart Agriculture:** Food is an integral part of life without which we cannot survive. However, it is an unfortunate fact that a lot of food is wasted in developed countries like America while people starve in poorer countries. One way to feed everyone is through better agricultural practices which can be enhanced using IoT applications. This can be done by first collecting data for a farm such as soil quality, sunlight levels, seed type, and rainfall density from various sources like farm sensors, satellites, local weather stations, etc. and then using this data with Machine Learning and IoT to create custom recommendations for each farm that will optimize the planting procedure, irrigation levels required, fertilizer amount, etc. All this will result in better yield or crops with a focus on reducing world hunger in the future. This is done very efficiently by SunCulture, a top IoT application, which is an initiative by Microsoft AI for Earth.

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IoT in Agriculture: Smart Farming

By using **IoT sensors to collect environmental**, farmers can make informed decisions, and improve every aspect of their work – from livestock to crop farming.



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IoT in Agriculture: Smart Farming

Monitoring Climate Conditions: Weather stations combine various smart farming sensors. Weather stations collect various data from the environment and send it to the cloud. These measurements can be used to map the climate conditions. It can be also used to choose the appropriate crops, and take the required measures to improve their capacity (i.e. precision farming).



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IoT in Agriculture: Smart Farming

Cattle Monitoring and Management:

- IoT agriculture sensors that can be attached to animals on a farm to monitor their health and log performance.
- Livestock tracking and monitoring help collect data on stock health, well-being, and physical location.
- Such sensors can identify sick animals so that farmers can separate them from the herd and avoid contamination.
- Using drones for real-time cattle tracking also helps farmers reduce staffing expenses.



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IoT in Agriculture: Smart Farming

Agricultural Drones:

Also known as UAVs (unmanned aerial vehicles), drones are better equipped than airplanes and satellites to collect agricultural data.

Drones can also perform a vast number of tasks that previously required human labor such as planting crops, fighting pests and infections, agriculture spraying, crop monitoring, etc.



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IoT in Agriculture: Smart Farming

Crop Management: Crop management devices, just like **weather stations**, can be placed in the field to collect data specific to crop farming such as **temperature, leaf water potential, overall crop health**, etc. Farmers can **monitor their crop growth and any anomalies to effectively prevent** any diseases or infestations that can harm the yield.



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Smart vehicles

Smart Vehicles: Smart vehicles or self-driving cars are **lot applications** as they can be called are pretty dependent on **IoT**. These cars have a lot of features that are integrated with each other and need to communicate such as the sensors that handle navigation, various antennas, controls for speeding or slowing down, etc. Here the **Internet of Things technology is critical**, especially in the sense that self-driving cars need to be extremely accurate and all the parts need to communicate with each other in milliseconds on the road. **Tesla Cars** are quite popular and working on their self-driving cars. **Tesla Motors'** cars use the latest advancements in **Artificial Intelligence** and the **Internet of Things**. This top IoT application has gained a lot of advancement in recent years

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Smart Healthcare

Smart Healthcare: in the Healthcare Industry where doctors can monitor patients remotely through a web of interconnected devices and machines without needing to be in direct contact with them. This is very useful if the patients don't have any serious problems or if they have any infectious diseases like COVID-19. One of the most common uses of IoT applications in healthcare is using robots. These include surgical robots that can help doctors in performing surgeries more efficiently with higher precision and control. There are also disinfectant robots that can clean surfaces quickly and thoroughly using high-intensity ultraviolet light (which is pretty useful these days!) Other types of robots also include nursing robots that can handle the monotonous tasks that nurses have to perform for many patients day in and day out where there is little risk to the patients.

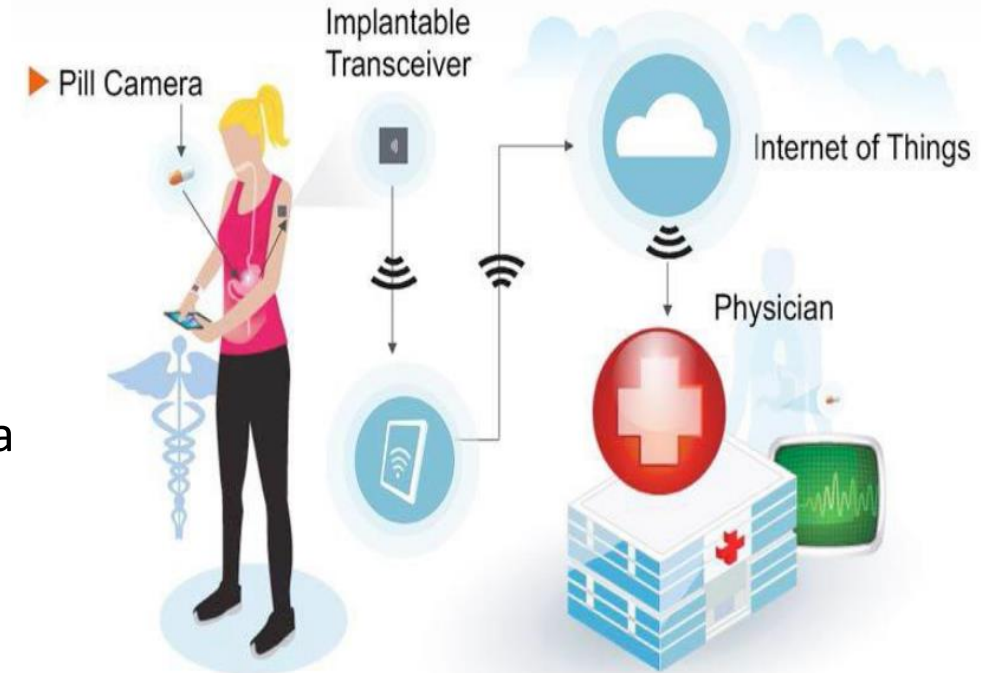
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Smart Healthcare

Smart Healthcare:

Patient Monitoring: Sensors collect patient data

- Microcontrollers process, analyze, and wirelessly
- communicate the data .
- Microprocessors enable rich graphical user interfa



- Healthcare-specific gateways through which sensor data is further analyzed and sent to the cloud.

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Wearables Functionalities and Application Areas

Wearables and smart devices: IoT-enabled wearables and smart devices are enhancing banking experiences through **contactless payments and financial habit monitoring:** Devices like NFC-enabled smartphones, fitness trackers, rings, and smartwatches provide easy access to credit/debit cards and checking accounts for secure, on-the-go transactions. 7 Ring is an example of a contactless wearable IoT payment device. Clients can set spending limits on their wearable devices, which track daily transactions. When spending approaches the set limit, the device sends alerts, helping users manage their finances and reduce overspending.



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Wearables and smart devices

Wearables Examples:

Samsung's Galaxy Gear

- Android-based smart watch
- Synchronizes with a cellphone to achieve smartphone-like capabilities



Sony Core

- Wrist-worn waterproof wearable smart band with a built-in sensor
- Records activity levels throughout the day



Garmin SmartWatch

- Built-in sports apps
- Smart scales with wireless connectivity
- Enables a more active lifestyle



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Advantages of the IoT

Advantages of the IoT:

1. It can assist in the smarter control of homes and cities via mobile phones. It enhances security and offers personal protection.
2. By automating activities, it saves us a lot of time.
3. Information is easily accessible, even if we are far away from our actual location, and it is updated frequently in real time.
4. Electric Devices are directly connected and communicate with a controller computer, such as a cell phone, resulting in efficient electricity use. As a result, there will be no unnecessary use of electricity equipment.

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Advantages of the IoT

Advantages of the IoT:

5. Personal assistance can be provided by IoT apps, which can alert you to your regular plans.
6. It is useful for safety because it senses any potential danger and warns users. For example, GM OnStar, is a integrated device that system which identifies a car crash or accident on road. It immediately makes a call if an accident or crash is found.
7. It minimizes human effort because IoT devices connect and communicate with one another and perform a variety of tasks without the need for human intervention.
8. Patient care can be performed more effectively in real time without the need for a doctor's visit. It gives them the ability to make choices as well as provide evidence-based care.
9. Asset tracking, traffic or transportation tracking, inventory control, delivery, surveillance, individual order tracking, and customer management can all be made more cost-effective with the right tracking system.

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Summary

1. IoT connects devices for data-driven solutions
2. IoT sensors and Actuators
3. Wide applications
4. Advantages of IoT



Thank You