University of Essex Online

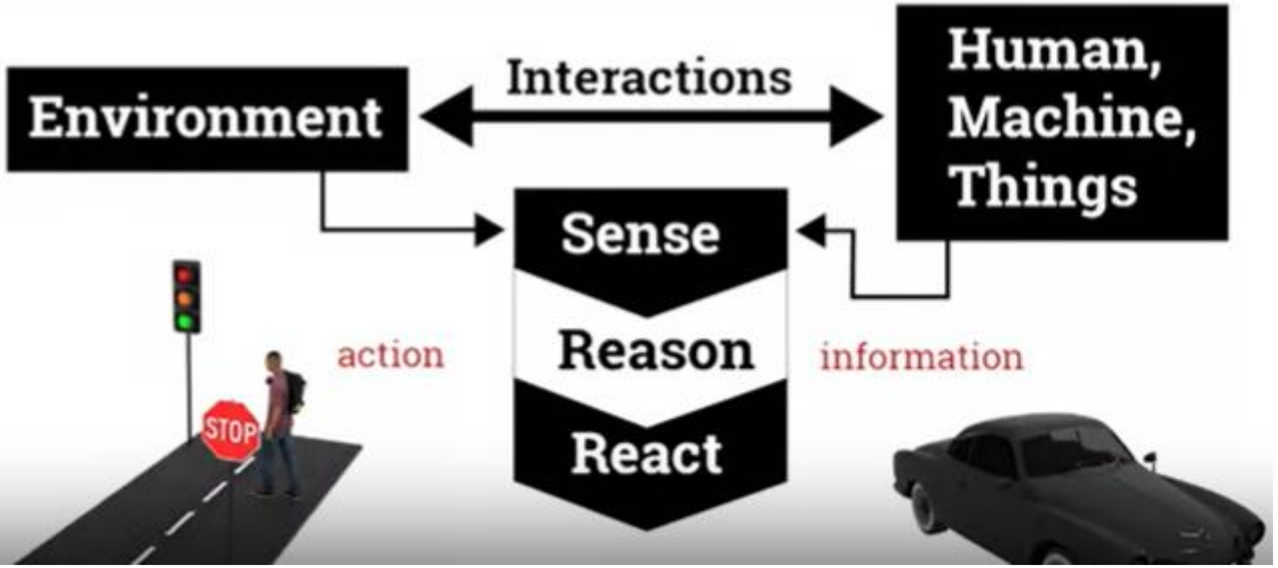
ASIIN e.V. accredited degree program

Lecture
ITEC 442
IOT and Cyber Security
Introductions

Introduction - What is Physical Computing?

Physical computing involves the *creation or use of physical hardware devices* that can *sense, reason,* and *react* to the world around them.

- *i.e., Self-driving cars*



IoT

Consider the following scenario as you use IoT technologies to start your day.

- **6:34 A.M.**—Your alarm clock has been monitoring your sleep cycles, and awakens you at the optimal time, when you'll feel completely rested.
- **6:52 A.M.**—Your refrigerator door shows a recommended breakfast, with nutritional information based on your food preferences, weight goals, and what is in your kitchen.
- **6:53 A.M.**—Your smart speaker informs you of all the meetings and appointments you have today. Traffic is congested on your normal route, so the speaker tells you that your autonomous car has prepared an alternate route that will save you 10 minutes but take two minutes longer than your normal route.
- **7:12 A.M.**—Your electric car warmed up its interior just in time for you to get in. A speaker in the car informs you that your work colleague has signed the contracts, and will have them delivered to you before your first meeting.
- **8:50 A.M.**—Your smartwatch reminds you of your 9:00 A.M. meeting.
- **8:51 A.M.**—A delivery drone enters your office, bearing a package containing signed contracts for the meeting.

Not too long ago, this scenario may have seemed to be science-fiction hype, but each of the technologies described is available today through the *Internet of Things* (IoT).

Introduction - Internet-of-Things (IoT)

- "...is the concept of ***connecting any device*** (...) ***to the Internet*** and to other connected devices. The IoT is a ***giant network of connected things and people*** – all of which collect and share data about the ***way they are used*** and about the ***environment around them***." IBM

IoT Ingredients

- **IoT devices** that are:
  - **Sensing:** Able to measure the world around them, such as local temperature, humidity, or water level, or number of cars passing by
  - **Active:** Able to take local action as necessary, such as turning off a light, opening a valve, or sounding an alarm
  - **Connected:** Able to share data with other systems in the cloud
  - **Smart:** Able to:
    - Perform initial processing and filtering of sensor data
    - Determine whether immediate (real time) action should be taken in response to locally acquired data
    - Take action based on remote instructions from the cloud
- **The Cloud**, where powerful cloud applications can:
  - Collect data from IoT devices
  - Combine IoT device data with other data sources
  - Perform data analytics to reveal trends, identify problems, predict the future
- **Client applications** that enable users to:
  - Access and view data processed in the cloud
  - Issue commands to remote IoT devices

IoT Devices

- **Agricultural sensors:** Based on measurements of soil quality and geographic location, controls the application of chemicals and amendments to the soil in real time.
- **Air quality monitor:** Monitors air quality in a room and sends alerts via the smartphone app, providing useful data for people with allergies or who otherwise have a need to monitor air quality in their living or working environment.
- **Augmented reality (AR) headset:** Wearing the headset, can look around and see the local view augmented with data from the Internet, which could be useful in tourism and travel, real estate sales, museums, and many similar situations.
- **Connected universal remote control:** Televisions and home audio have long been controllable through remote controls, but with many other devices in the smart home now accessible through the home network, a universal remote control can control much more than entertainment devices. Likewise, devices like smart speakers can also be used to control functions that previously were the domain of the universal remote.
- **Dash button:** A single-purpose connected button. The concept is named after a device sold by Amazon that automatically places an order for a consumable product like detergent when pressed. The concept has been expanded to perform tasks such as starting a car, opening a garage door, and enabling users to create their own custom tasks, such as sending an email or activating a remote buzzer.
- **Home systems monitor:** Monitor home systems such as heating, cooling, and drainage to alert the user when there are problems, when systems need to be tuned or maintained, and so forth.
- **Industrial control:** Sensors and actuators in production equipment enable operations staff to monitor and control production and implement process automation.
- **Remote-controlled mood lighting:** Enables users to define various lighting schemes involving numerous lights throughout their home. With a single command and through pre-programmed scripts, lights can be set in a combination of light intensities and colors.
- **Scientific instruments:** Scientists can monitor and control instruments in remote locations, including places that people can't easily reach, such as the poles, the ocean, other planets, within living organisms, and so forth.
- **Smart battery:** Smart batteries can transform your conventional devices into IoT devices. For example, a smart battery in a smoke or carbon monoxide alarm could warn you through text messages and other notifications when the power is getting low. The smart battery could also immediately notify you if the alarm sounds and you're not at home to hear it.
- **Smart door lock:** Enables users to use an electronic device such as a smartphone or fob as a key, eliminating having to fumble for a key. Also enables an owner to lock and unlock a door from a remote location using a smartphone app (to enable someone without a physical key to enter under the owner's control, for example). The device can monitor and log activity at the door, activating cameras and alerting the owner through a notification on their smartphone that someone is at the door.

IoT Devices

- **Smart speaker:** A cloud-connected speaker that responds to a wide range of voice commands, enabling the user to control music streaming, command home automation devices (such as smart thermostats and smart outlets), communicate with other smart speakers (like an intercom), order products online, and perform web searches using voice and audio.
- **Smart thermostat:** Monitors and controls home heating, cooling, and air flow functions, enabling remote control and data logging through other devices, automatically sensing when users are at home and adjusting the home environment accordingly, logging use of heating and cooling systems, and suggesting ways to reduce energy costs.
- **Traffic monitoring:** Traffic patterns on roads, highways, sidewalks, and hallways can be monitored to provide data related to safety, civil engineering, and timing of traffic.
- **Wireless breath analyzer:** People tend to think of breath analyzers that detect levels of alcohol consumption, and certainly there are IoT applications for such devices, but breath analyzers can also be used to monitor various health-related conditions, such as dangerous ketone levels in diabetes patients, airway inflammation in asthma patients, and many other potential health problems.
- **Wearable device:** Wearable devices can monitor for conditions such as heart irregularities, low blood oxygen levels, and so forth, to provide users with early warning of impending medical problems. They can also be used to monitor babies, patients, pets, and others who require a caretaker. Caretakers can be alerted if their charge leaves a particular area, and the device can provide data on the wearer's health and well-being.
- **Weather sensors:** Sensors mounted outdoors can monitor local weather conditions, such as temperature, humidity, and air pressure. The user can read and analyze their weather data on a mobile or desktop application. Using a *crowdsourcing* approach, data from weather stations owned by many different individuals can be aggregated to provide detailed weather data on a global scale, as done by Weather Underground.


Consumer
Industry
75
SmartMeter
kWh

Enabling Technologies

Enabling Factor	Description
Miniaturization	Significant processing power is available in a small package, with relatively powerful processors embedded in compact devices such as smart phones, smart watches and other wearable devices, home appliances, and other everyday things.
Connectivity	The ability to wirelessly connect devices, even those in remote locations, through a wide variety of technologies such as cellular data, Wi-Fi, Bluetooth®, RFID, and others, enable them to share data and respond to remote control.
Advanced power sources and power management	The ability to operate on very small amounts of electrical energy, using rechargeable batteries or harvesting energy from the surrounding environment, enable devices to function in mobile applications or remote locations, away from the power grid.
Inexpensive processors, sensors, and actuators	Relatively inexpensive components enable the proliferation of small, capable devices that can measure their local environment, process data, and respond accordingly.
Cloud-based processing	The ability to delegate data collection and analysis tasks to more powerful computers in the cloud enable IoT devices to remain compact and operate on minimal power.
Ubiquitous computing	More than ever before, people are often just an arm's length away from a computing device, whether it be a smartphone, tablet, desktop computer, wearable device, smart appliance, or some other device that provides a user interface through which users can receive notifications and run applications to control or pull information from remote devices and services.

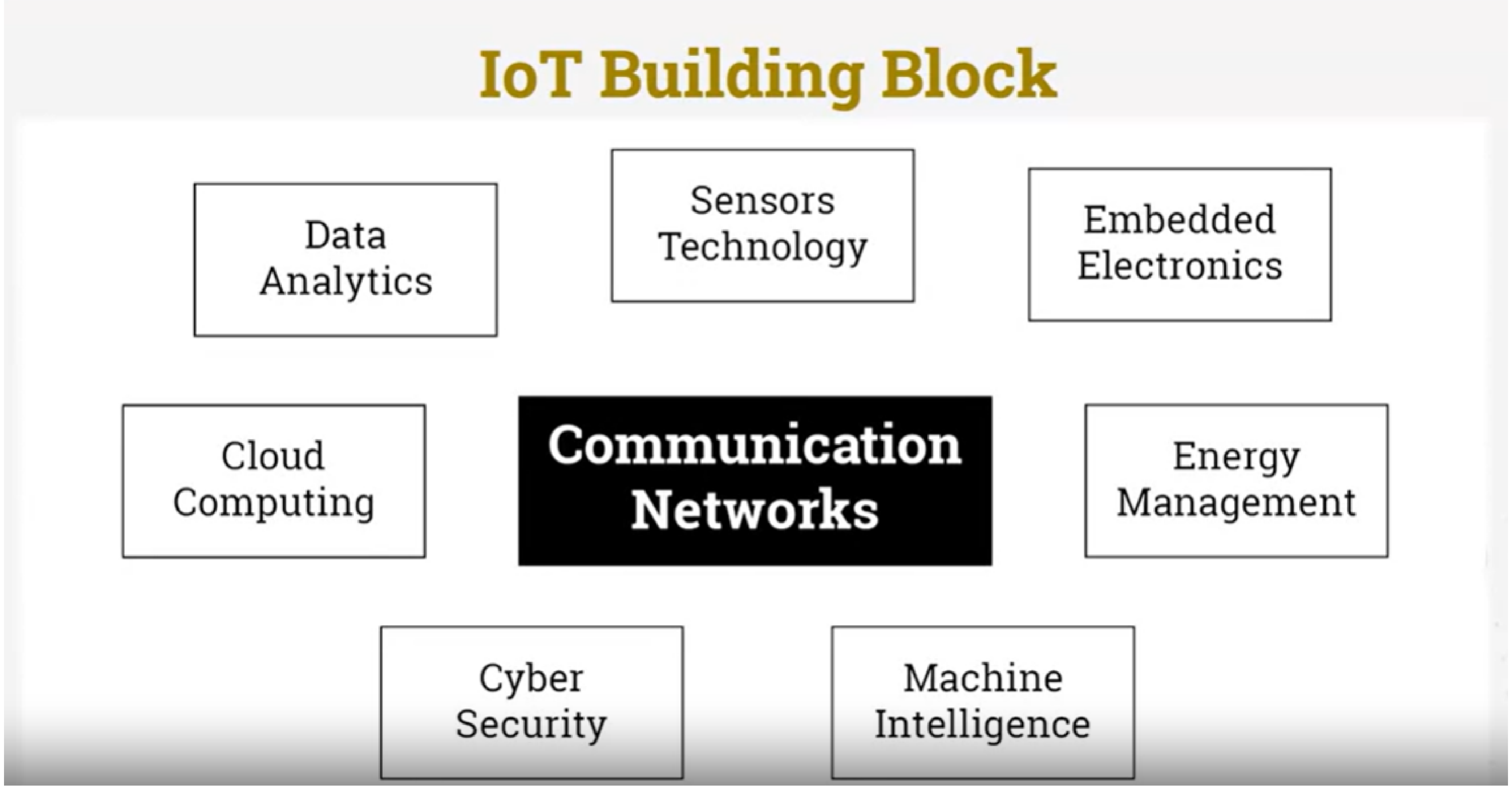
IoT Boom

IoT Boom
- 6.4 Billions by 2016, (Garter)
- 29 Billions by 2022, (Ericsson)
- 30.9 Billions by 2025 (Statista)
- $3.9 trillion to $11.1 trillion a year by 2025 (McKinsey Institute)

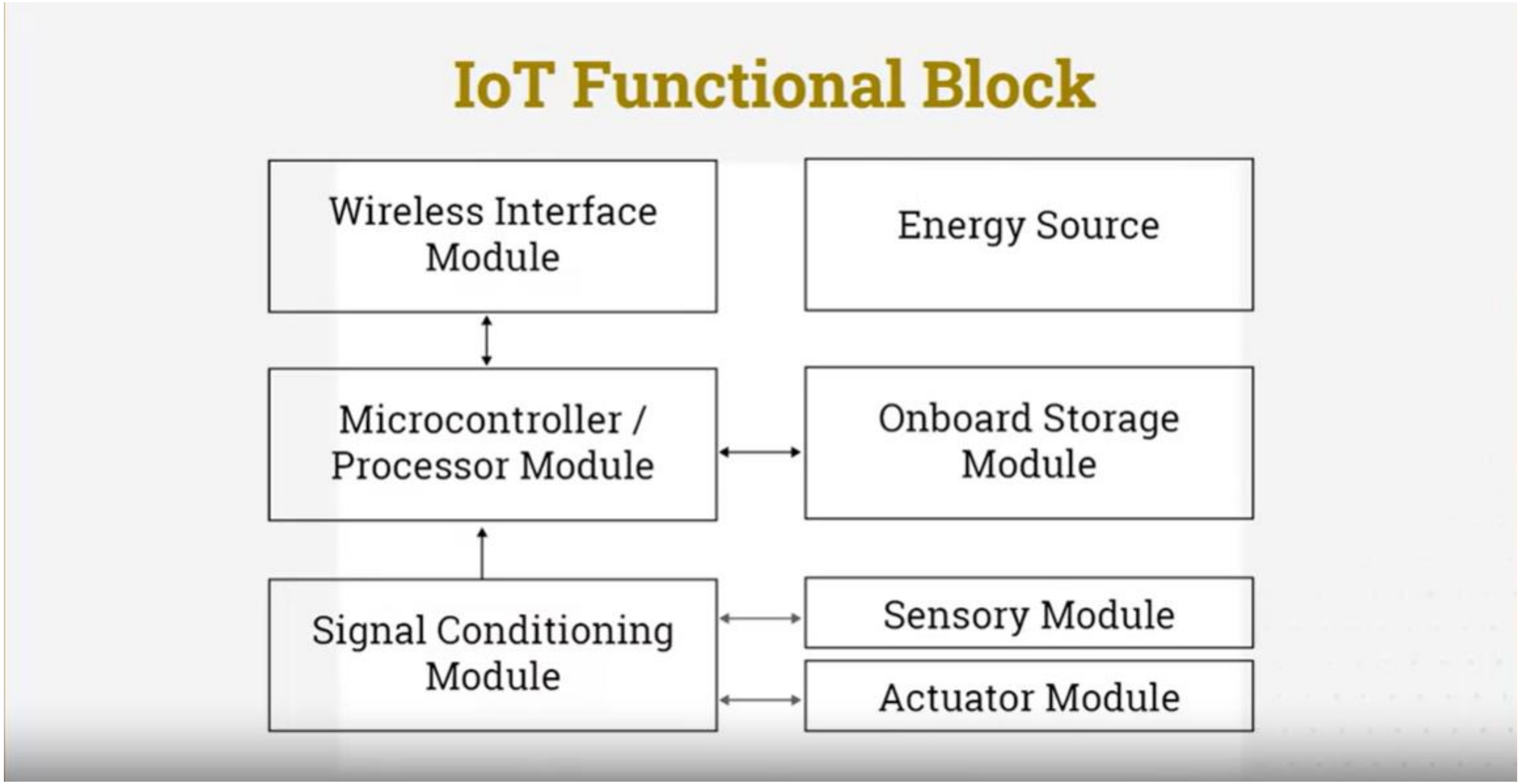
IoT Adaptation
- Consumer IoT (cIoT)
- Industrial IoT (iIoT)
- Internet of Medical Things (IoMT)
- Internet-of-Vehicles (IoV),
- Smart Cities,
- Smart Homes,
- Smart Grid, ...

Other Names
- Web-of-Things (WoF)
- Network-of-Things (NoT)
- Machine-to-Machine (M2M)
- Internet-of-Everything (IoE)

IoT Building Block



Functional Block



Question:

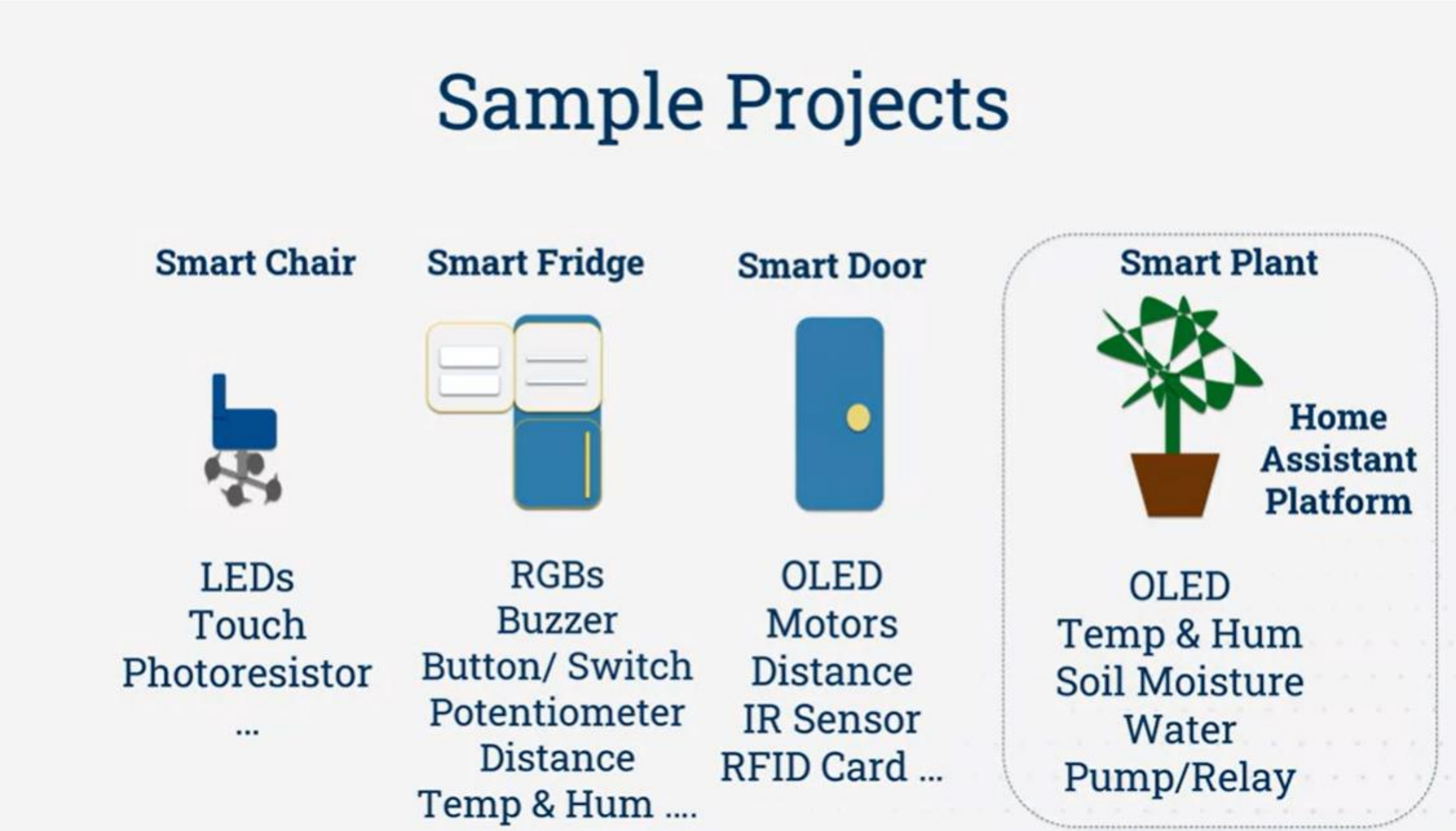
Example Projects

- Smart Chair
- Smart Fridge
- Smart Door

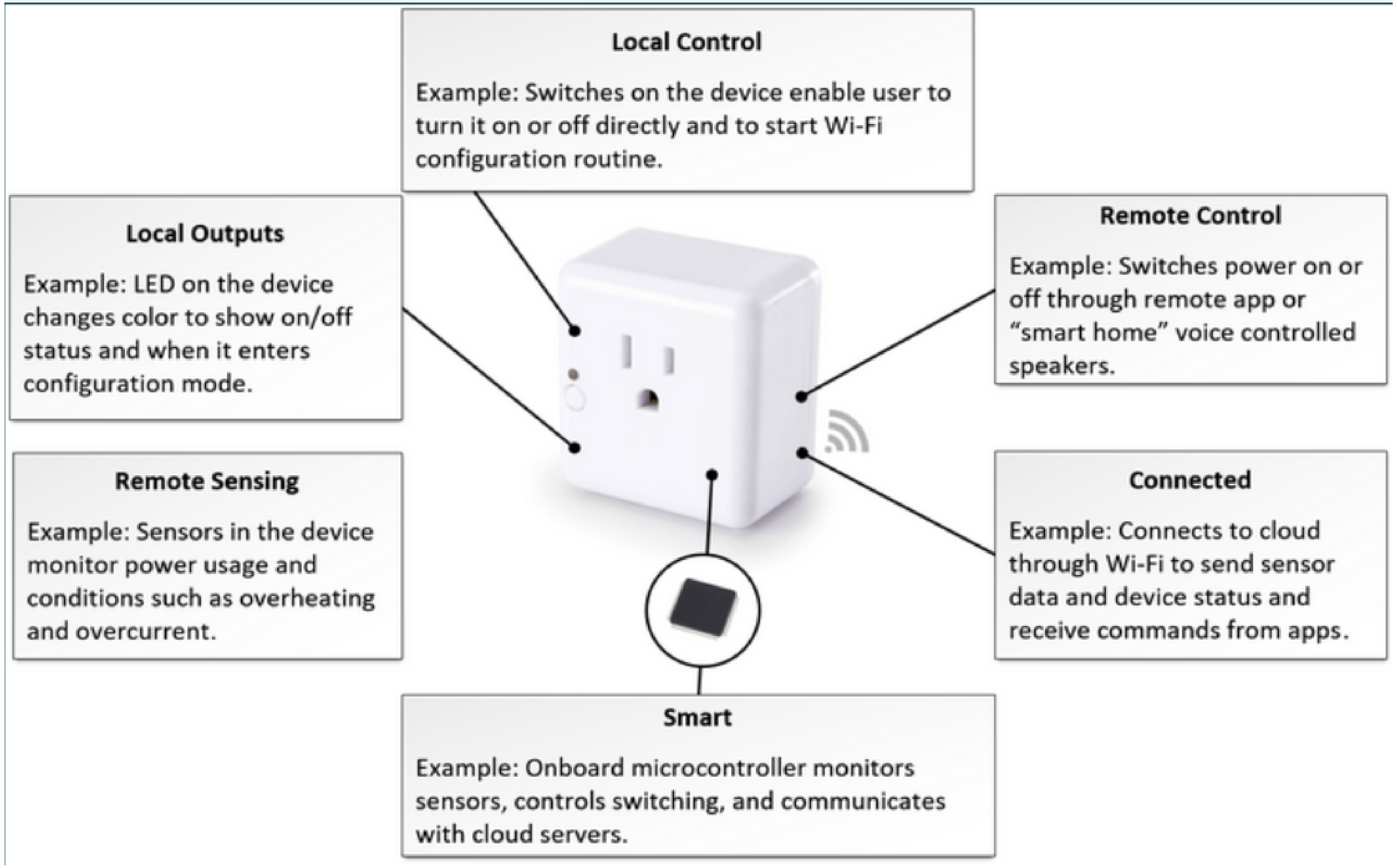
Prerequisites

- Programming Language
  1. C/C++, HTML/CSS, XML
- Software
  1. Arduino IDE
  2. Home Assistant *
- Hardware
  1. ESP8266 x3
  2. Sensors kits x2
  3. Breadboards
  4. Jumper wires

Projects


Sample Projects
Smart Chair
LEDs
Touch
Photoresistor
...
Smart Fridge
RGBs
Buzzer
Button/ Switch
Potentiometer
Distance
Temp & Hum ....
Smart Door
OLED
Motors
Distance
IR Sensor
RFID Card ...
Smart Plant
Home
Assistant
Platform
OLED
Temp & Hum
Soil Moisture
Water
Pump/Relay

Projects



Local Control
Example: Switches on the device enable user to turn it on or off directly and to start Wi-Fi configuration routine.
Local Outputs
Example: LED on the device changes color to show on/off status and when it enters configuration mode.
Remote Control
Example: Switches power on or off through remote app or "smart home" voice controlled speakers.
Remote Sensing
Example: Sensors in the device monitor power usage and conditions such as overheating and overcurrent.
Connected
Example: Connects to cloud through Wi-Fi to send sensor data and device status and receive commands from apps.
Smart
Example: Onboard microcontroller monitors sensors, controls switching, and communicates with cloud servers.

Projects


Hardware Components
Microcontroller Development Boards
ESP12E V2/ V3
x3
OPTIONAL
ESP12E WiFi Weather Station Kit
x1
Plant Watering Kit
x1
Raspberry Pi 3+ Starter kit
x1
Sensors and Accessories Kit
RFID Starter Kit (204 Items)
x1
Raspberry Pi Starter Kit (27 Items)
x1
Micro USB
x3

Question:

What is the difference between physical computing and IoT?
Please select two right answers.

1 point

The physical computing concept involves interacting with hardware components and IoT concepts to make those components accessible over a network.

Physical computing is an underpinning technology to drive IoT applications.

IoT is better than physical computing devices.

A physical computing device is an independent device that cannot connect to other devices whereas IoT devices can.

Questions:

What is the correct statement for the physical computing concept?

1 point

A physical hardware component that can sense and respond to the world around it.

An intangible software installed on the embedded microcontroller-based system that can sense, reason and transmit/receive data to another device.

None of the above

A virtual interactive system that can simulate the world around it and/or control the outputs, such as lights, displays and motors.

Question 2
What can we do with a physical computing device?
All of these.
Transmit and receive data to another device.
Sense, reason and react.
Embed microcontrollers within Things!

Questions:

Question 2
What can we do with a physical computing device?

1 point

All of these.

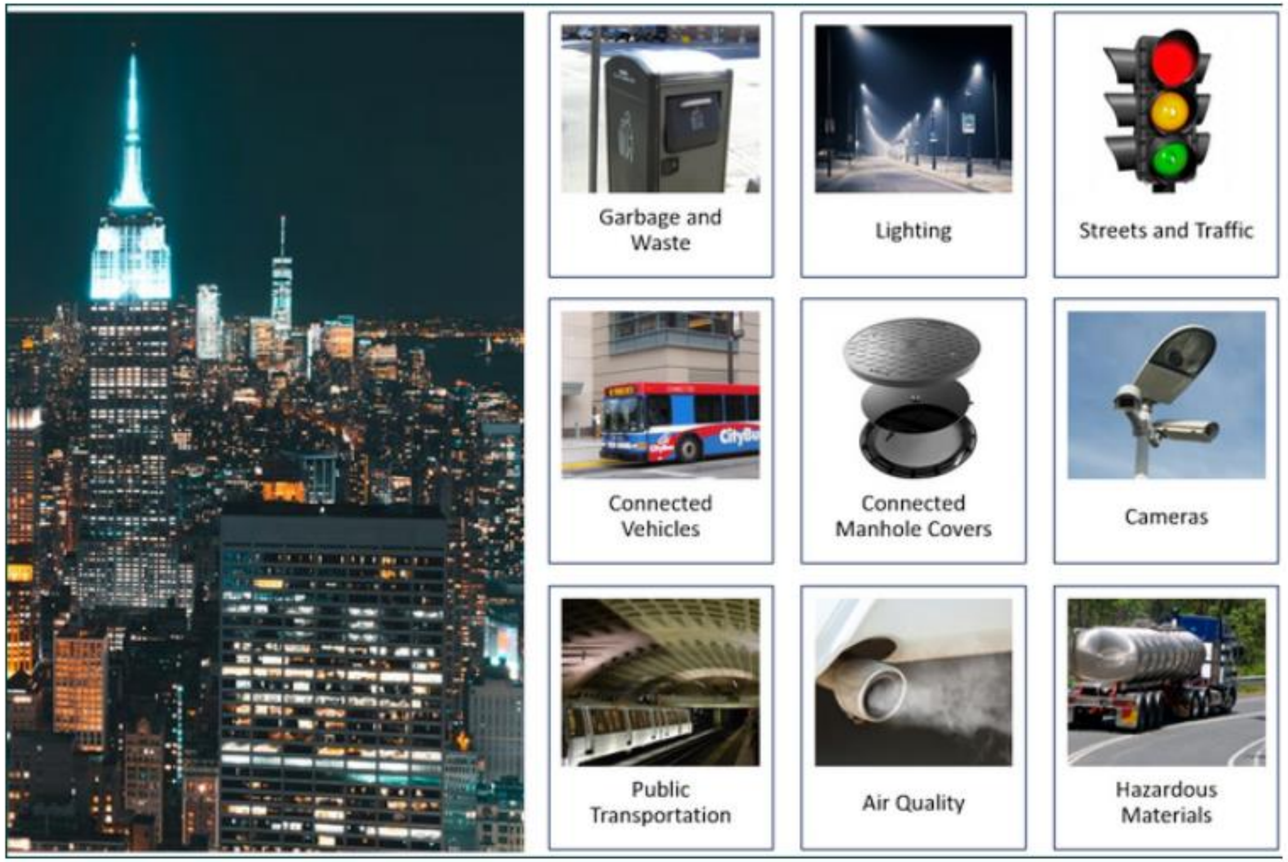
Transmit and receive data to another device.

Sense, reason and react.

Embed microcontrollers within Things!

Smart City

Smart City



Smart City

Garbage and Waste

Waste bins can be monitored so pickup routes can be optimized based on demand, saving operational costs, improving timeliness of collection, and reducing unnecessary traffic. Similar concepts can be applied to sewage systems, adjusting the flow of water pumps based on need and reducing water usage when demand for water increases elsewhere within the municipality.

Streets and Traffic

Sensors can measure traffic patterns of pedestrians, cyclists, automobiles, and public transportation through pressure sensors in walkways, turnstiles, and so forth, which can be used to improve long-term planning of city layouts. Smart parking meters can monitor parking, enabling apps and smart signs to direct drivers to open parking spaces through smartphone apps, GPS units, and smart cars. Inputs from traffic sensors throughout a city can be analyzed in real time and coordinated with messaging sent to street signals, signs, and directly to citizens' IoT devices (smart phones, smart cars) to efficiently coordinate traffic flow out of the city during emergencies or other high-traffic situations.

Lighting

Based on reduced need as measured by sensors measuring automobile and foot traffic, ambient light, and other inputs (such as scheduled sports events, festivals, etc.), street lamps can reduce or increase their light levels appropriately.

Smart City

Public Transportation

Digital signs in train stations, bus stops, and smartphone apps can provide real-time updates on estimated arrival times and suggest alternate routes when appropriate, to keep riders informed, improve the public transportation experience, and encourage wider use of public transportation. Based on real-time data such as air quality (smog levels from automobiles), available parking spaces, and so forth, temporary discounts on public transportation prices can be offered to provide citizens with incentive to avoid driving. Real-time data regarding traffic flow, road closings, working accidents, number of people waiting at bus stops, number of seats already filled, and so forth can be used to dynamically optimize routes and the number of vehicles in service, to make the best use of resources while meeting demand.

Safety and Security

Sensors strategically located throughout the city can detect specific types of risks, such as the presence of chemical, biological, explosive, or radioactive devices, and authorities can be alerted. Sensors can monitor for impending natural disasters such as earthquakes, tsunamis, and landslides. Early warnings to citizens, road closures, evacuations, and other measures can be taken. Personal IoT devices such as smartphones and wearables can be used to send timely alerts to users as a supplement to traditional warning and messaging systems. In situations that unfold quickly, such as floods, landslides, and active shooting situations, the ability to quickly inform the public can save lives. Security and safety services, such as police presence and active visual monitoring, can be better coordinated based on sensor data that identifies such things as traffic patterns. While targeted tracking of individuals raises privacy issues, general tracking of numbers of people, noise levels, and so forth is less controversial. Analysis of ambient noises within a city can identify gunshots, car crashes, and other noise signatures that can alert authorities to an active situation in real time.

Environment

Air quality in cities varies widely based on weather conditions, traffic, industrial processes, the operation of heating and power plants, and other factors. Various microclimates based on terrain, buildings, and other factors result in uneven air quality throughout the city on a given day. Sensor data from municipal systems and citizen-owned devices can be collected and analyzed to enable appropriate countermeasures to be taken as needed, such as coordinating the use of alternate energy sources, rerouting traffic, and so forth.

Industry


Industrial Control Systems
Transportation and Distribution
Wearables
Environment
Inspection and Quality
Maintenance

Industry

Transportation and Distribution

Logistics, the detailed coordination of people, facilities, and supplies involved in manufacturing, production, and fulfillment, is often the primary difference between businesses that succeed and those that fail. Tracking of goods from their source to their destination has usually required someone scanning a barcode at each junction. However, using devices like radio-frequency identification (RFID) tags, this process can be automated. Goods in transit can connect to the cloud and share data on their status and location, eliminating most human intervention. The status of the entire supply chain can be evaluated and communicated at any time. This includes raw materials, components, production machinery, finished products, material handling equipment, packaging, transportation vehicles, other means of transport, delivery, and distribution.

Wearables

Wearable IoT devices such as watches, vests, jackets, and shoes can monitor workers operating in dangerous environments. They can detect exposure to chemicals, radiation, or other agents. They can sense when the wearer has lost consciousness or mobility (due to a cave-in in a mine, medical conditions like apoxia, stroke, or heart attack). They can detect falls from heights, and attempts to lift excessively heavy loads. Actuators in wearable devices can notify workers when someone nearby is in distress, through an audible alarm or through vibrations when the environment is loud or hearing protection is in use.

Environment

IoT devices can be used to monitor the quality of air, water, and soil in areas where contamination is a risk to provide early detection of leakage or contamination. Natural disasters such as tornadoes, floods, earthquakes, tsunamis, avalanches, mudslides, and forest fires can be detected. Early detection enables problems to be quickly identified and remediated. Affected systems can be quickly shut down to minimize the impact, and personnel can be notified.

Inspection and Quality

Data regarding quality parameters can be analyzed in real time, before the manufacture of a part is even completed, and necessary adjustments can be made. Quality control data from individual machine tools can be collected and sent to the cloud, where it can be analyzed remotely.

Connected Cars

Maintenance

Information such as location, fuel level, fuel consumption, maintenance data, load, and weight can be tracked for individual vehicles within a fleet. Analytics tools can be used to correlate that information for the entire fleet, facilitating scheduling, routing, and planned maintenance. Based on fleet data and local fuel/energy costs, and using connected cars, smartphones, or other onboard communication, drivers can be provided with information on where to find optimal refueling locations on their route. Connected cars can monitor driving patterns and assess the wear and tear on a vehicle. Insurance companies can monitor this information and calculate fairer premiums that are based on usage and maintenance of the vehicle. Service stations can use the diagnostic information to perform predictive analysis and contact vehicle owners to schedule a proactive service appointment.

Economy and Environmental Impact

Connected cars enable the driver to travel quickly, safely, and cost effectively. When vehicles can communicate with traffic signals and other infrastructure, they manage the accelerator better, slowing down before reaching a signal, and the highway infrastructure can also adjust the timing of lights to reduce unnecessary stops. These features will reduce fuel consumption and save drivers time.

Navigation

Many modern cars are equipped with GPS navigation systems, but connected cars will take this further, combining smart navigation features with services based on location and the car's servicing requirements, such as prompting you to stop and refuel. The car could determine the distance to the nearest fueling station and automatically guide you there using the navigation system.

A connected car could integrate with your personal calendar to help you take the best route to your next meeting, based on real-time traffic and weather conditions. Based on your travel history, your current bearing, and traffic conditions, a connected car might figure out where you are headed and offer suggestions on alternate routing if you're approaching an accident, construction work, or other delay.

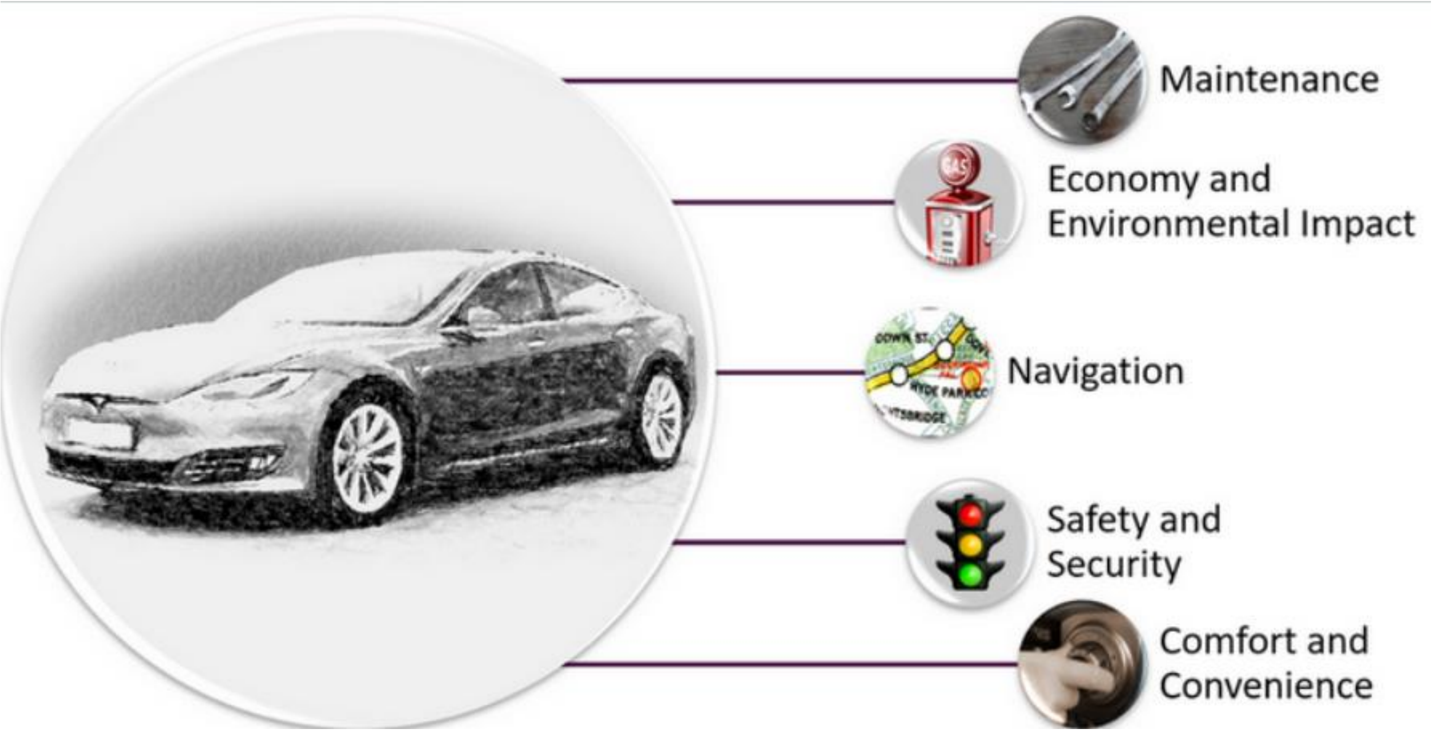
Safety and Security

When connected cars and infrastructure such as smart roads are able to communicate, traffic flow can be coordinated better, not only reducing stops and saving fuel, but also potentially reducing traffic accidents. Connected cars can avert collisions by tracking the speed and the proximity with other vehicles. Vehicles can provide drivers with real-time alerts regarding road and weather conditions and nearby accidents. A connected car can track its location and coordinate with owner data to inform customers when their vehicle may have been stolen and support its safe retrieval. A vehicle could capture the state of the driver through cameras and sensors, and warn them when they suffer from fatigue and tiredness. The system can even optimize the temperature, music, and seat functions to ensure the driver remains alert.

Industry

https://internetofbusiness.com/maersk-ericsson-iot-success/

Connected Cars



Medical sciences

Medical sciences

Medical Devices

Home-use medical devices such as *continuous positive airway pressure (CPAP)* devices (which facilitate a patient's healthy breathing while sleeping), defibrillators, cardiac monitoring devices, and insulin pumps are now commonly designed to be connected devices that can be set up and monitored by clinicians in a remote location using a Wi-Fi or cellular data connection.

Hospital Logistics

Safety is a primary concern for healthcare organizations. A critical component of safety is the ability to track assets such as medical staff, patients, and equipment throughout the medical campus, and to know the status of all devices and instruments. IoT and real-time location systems facilitate asset tracking, making it possible to know the location and status of the people and things involved in any healthcare scenario.

IoT's ability to track logistics—the location and status of goods—in real time has been demonstrated through retail industries like Amazon. Logistics capabilities can help solve the problem of verifying the chain of custody in the pharmaceutical supply chain. New regulations require organizations to ensure that drugs have been protected from tampering by tracking the global path of a pharmaceutical product from raw material to end consumer.

Medical Services

Cost reduction is a major benefit of IoT in healthcare. Telemedicine, sleep studies, cardiac monitoring, and other tasks that used to be performed in clinics are now often performed outside the clinic, as patients wear small devices that perform the monitoring tasks and go about their normal lives. This reduces the workload of healthcare providers, and frees up space in clinics, reducing overall costs.

Telemedicine can be very beneficial in countries and locations where health facilities are unavailable or inaccessible. The portability of these devices makes them very useful in areas with limited resources such as floods, earthquakes, and war zones.

Robotic surgery provides a number of potential benefits. Robots may be able to perform certain operations with precision exceeding that of a human surgeon. And because robots can be autonomous or controlled from a distance, robotic surgery may have applications in telemedicine as well, enabling procedures to be performed in remote locations that can't easily be reached by a surgeon, and enabling surgeons to extend their coverage. Another type of surgery involves using miniature robots that can perform surgery inside the body, minimizing incisions and exposure to pathogens, and making possible various types of surgery that would previously have been impossible or dangerous to perform.

The IoT development life cycle

The models tend to encompass some form of the following phases.

- **Initiate:** A need is identified, initial goals are set, and the project is initially staffed with those responsible for planning it.
- **Plan:** Planning may include preliminary analysis and development of a system concept. Alternative solutions are examined along with a prediction of costs and benefits. The preliminary analysis may include clarification of the problem and objectives. A decision may be made to leave the system as is, improve it, or develop a new system.
- **Analyze requirements:** Facts are gathered through documentation, interviews, observation, questionnaires, examination of existing systems, and other sources. These facts are interpreted to translate project goals into functional and quality ("non-functional") requirements for the project, with a focus on describing the desired outcomes, rather than the design of the solution.
- **Design:** Based on requirements, a solution is identified and recorded in documentation such as screen layouts, business rules, process diagrams, data flow diagrams, and pseudocode to describe the desired features and operations in detail to those who will develop them.
- **Develop:** Based on requirements and design documents, code is written and other resources (data, images, etc.) are developed for use in the solution.
- **Integrate and test:** All of the pieces are brought together in an environment where they can be tested and checked for errors, bugs, security, privacy, safety, and interoperability with other systems. This phase ends when requirements have all been met, the project is accepted by stakeholders, and development is considered complete. The system is authorized for implementation.
- **Implement:** The system is installed and deployed. It is put into production, and actual business begins operation on the system.
- **Operate and maintain:** The system is monitored and periodically assessed to ensure it maintains proper functioning and performance, continues to meet requirements, and does not become obsolete. Periodic updates must be performed.
- **Dispose:** In this phase, plans are developed for discarding system information, hardware, and software in making the transition to a new system. The purpose here is to properly move, archive, discard, or destroy information, as well as hardware and software that is being replaced, in a manner that prevents any possibility of unauthorized disclosure of sensitive data. The disposal activities ensure proper migration to a new system. Particular emphasis is given to proper preservation and archiving of data processed by the previous system. All of this should be done in accordance with the organization's security requirements.

Thank You

- Any Questions?