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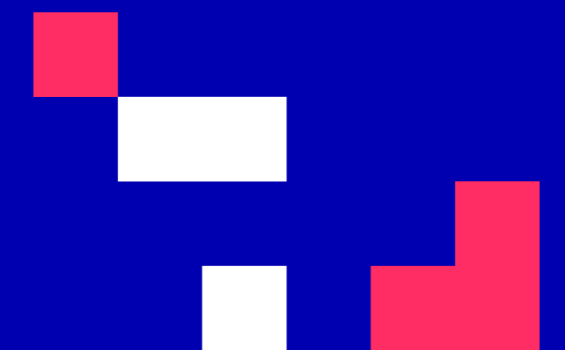


University of Cyprus

MAI650 Internet of Things

Vasos Vassiliou

September - December 2023





CS6xx Internet of Things (8 ECTS)

Course purpose and objectives: The purpose of the course is to provide an overview on IoT tools and applications and to introduce to students hands-on IoT communication concepts through lab exercises.

Learning outcomes: Upon completion of this course, students will be able to explain the definition and usage of the term “Internet of Things” in different contexts. More specifically, the students will know how to apply the knowledge and skills acquired during the course to build and test a complete, working IoT system involving prototyping, programming and data analysis

Teaching methodology: interactive face-to-face lectures, group activities and discussions, in class/lab activities, student presentations and guest lectures or significant recorded public lectures

Assessment: Final exam (50%), midterm exam (20%) and assignments/project (30%).

Main text:

Rajkumar Buyya, Amir Vahid Dastjerdi, Internet of Things Principles and Paradigms, Morgan Kaufmann; 1st edition, 2016

J. Biron and J. Follett, "Foundational Elements of an IoT Solution", O'Reilly Media, 2016.

Other reading:

Jamil Y. Khan and Mehmet R. Yuce, Internet of Things (IoT) Systems and Applications, 2019, ISBN 9789814800297

David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, and Jerome Henry, IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, 2016, Cisco Press.



INTRODUCTION

IoT Devices

CONTENTS

1. Smart City Environment
2. Smart Home
3. Healthcare IoT

INTENDED LEARNING OUTCOMES

Upon completion of this introductory unit, students will be:

1. familiar with different smart environments

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Smart City Environment

What is a Smart City?

A smart city is a framework that predominantly is composed of Information and Communication Technologies in order to develop, deploy and promote sustainable development practices to address growing urbanization challenges. A big part of this ICT framework is essentially an intelligent network of connected objects and machines that transmit data using wireless technology and the cloud. Cloud-based IoT applications receive, analyze, and manage data in real-time to help municipalities, enterprises, and citizens make better decisions that improve quality of life.



Components of Smart Cities

Connectivity

- Smart cities use IoT Devices equipped with sensors to gather information about current events.
- All of this data is connected to one another, forming an information nexus.

Components of Smart Cities

Intelligence

- Environmental monitoring through the use of IoT devices
- Smart cities are intelligent because they have the ability to obtain and utilize knowledge and information.

Components of Smart Cities

Responsiveness

- A smart city may respond to this the information in a variety of ways, all towards making everything more efficient

Components of Smart Cities

Sustainability

- The major goal of a smart city is to create a system where resources are used conservatively, and preserved, while creating a sustainable system of operations.

Smart Transportation and Mobility



Smart Transportation

- Smart transportation refers to the integrated application of modern technologies and management strategies in transportation systems.
- These IoT technologies aim to provide innovative services relating to different modes of transport and traffic management and enable users to be better informed and make safer and 'smarter' use of transport networks.

Smart Transportation Benefits

- Smart transportation is one of the main ways smart cities are improving the daily lives of citizens and improving sustainability.
- It includes:
 - Information systems that collect data about traffic, vehicles, and usage of different modes of transport.
 - IoT smart devices are the few transport technology that upgrades existing modes of transport or introduces new ones.
- Main goal: to reduce the reliance on private cars, make private transport more attractive and incentivize city residents and visitors to switch from private to public transport.

Elements of Smart Transportation

- The smart transportation system component of a smart city has many elements, both technical and organizational.
- The four important elements are:
 - connected cars
 - smart parking
 - Mobility as a Service (MaaS) systems
 - Advanced Traffic Management Systems (ATMS).



Smart City Environment

Connected Cars

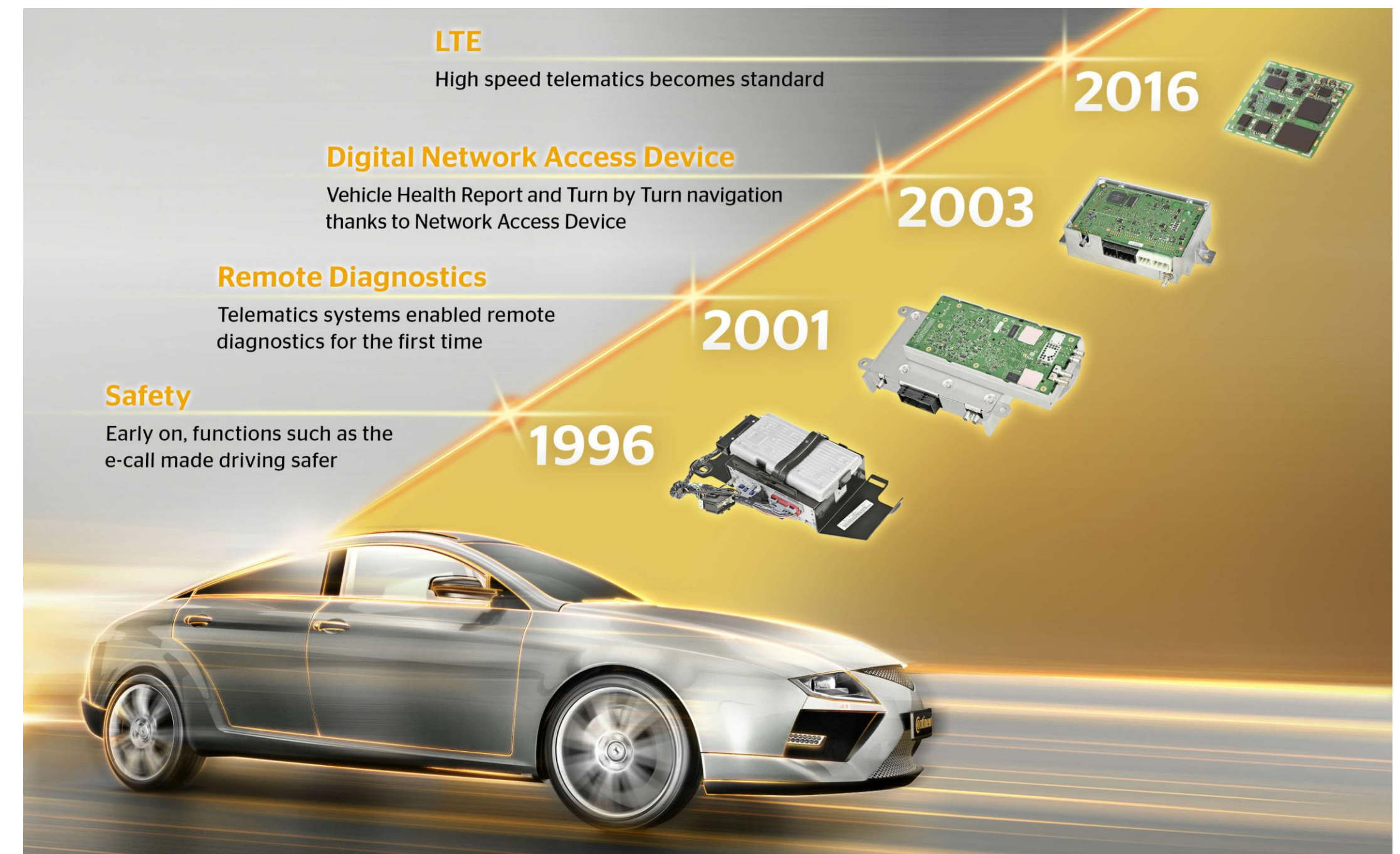


What is a Connected Car?

- IoT Car Versions
- A connected car is a car that is able to communicate bidirectional with other systems outside of the car.
- This allows the car to share internet access, as well as data, with other devices both inside and outside of the vehicle.

The First Connected Cars

- In 1996, General Motors was working with Motorola Automotive and introduced the OnStar cars.
- In 2001 remote diagnostics was introduced. 2003 marked the introduction vehicle health reports, turn-by-turn directions and a network access device.
- In 2007 Continental introduced data-only telematics. In the summer of 2014 Audi A3 was the first automaker to offer 4G LTE Wi-Fi Hotspots access and the first mass deployment of 4G LTE was by General Motors.



Connected Cars Characteristics

1. Sensors
2. Battery life
3. Infrastructure
4. Location Services
5. Navigation
6. Maintenance
7. Dashboards
8. Remote control
9. Zero emission



Types of Connectivity

- V2I - "Vehicle to Infrastructure"
 - The technology captures data generated by the vehicle and provides information about the infrastructure to the driver. The V2I technology communicates information about safety, mobility or environment-related conditions hardware
- V2V - "Vehicle to Vehicle"
 - The technology communicates information about speed and position of surrounding vehicles through a wireless exchange of information. The goal is to avoid accidents, ease traffic congestions and have a positive impact on the environment.
- V2P - "Vehicle to Pedestrian"
 - The technology senses information about its environment and communicates it to other vehicles, infrastructure and personal mobile devices. This enables the vehicle to communicate with pedestrians and is intended to improve safety and mobility on the road.
- V2C - "Vehicle to Cloud"
 - The technology exchanges information about and for applications of the vehicle with a cloud system. This allows the vehicle to use information from other, though the cloud connected industries like energy, transportation and smart homes and make use of IoT.
- V2X - "Vehicle to Everything"
 - The technology interconnects all types of vehicles and infrastructure systems with another. This connectivity includes cars, highways, ships, trains and airplanes.

Connected Car Features

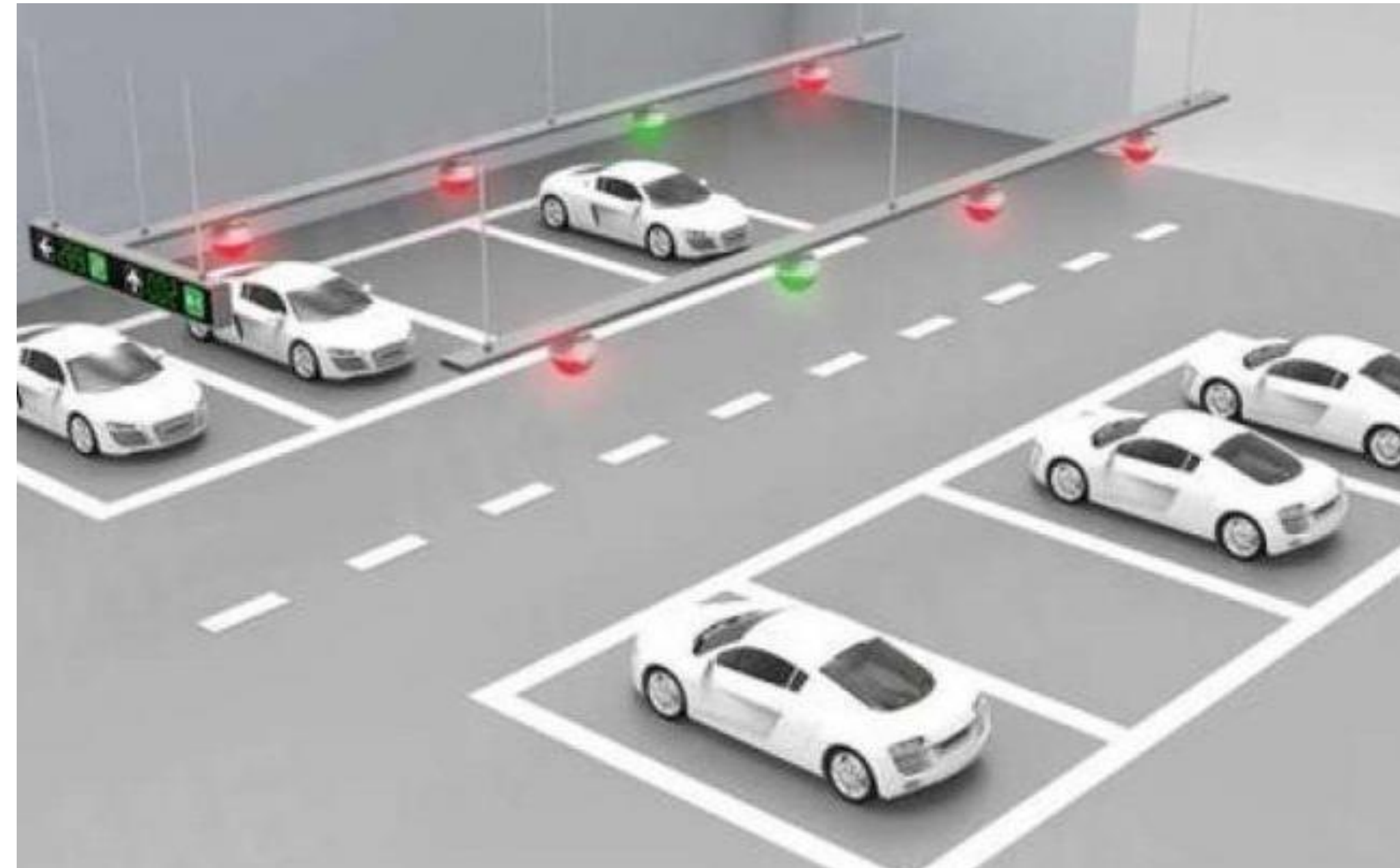
- Internet Connectivity in Cars
 - All connected-car consumers want to have as a standard feature of a connected car the OnStar.
 - OnStar was launched with the first telematics system, so the new editions of connected cars have as a standard feature of a 4G LTE WiFi.
 - these cars will work as a digital hotspot in order to be used to access the Internet from phone or laptop.
- App to Car Connectivity
 - The use of smartphone applications is giving to the consumers easy access to their cars.
 - Consumers are able with the use of this app to lock and unlock their car remotely, check their car's fuel status and locate their car on a real-time map.
- Google Earth-enabled Navigation System
 - Connected cars are embedded with navigation systems that let the car owners navigate, check real-time traffic and compare the prices of nearby gas stations
- Protecting Young Drivers with “Curfews”
 - New connected cars features are able to offer to parents the opportunity to keep track of their young drivers.
 - These features include the ability of tracking the exact location of the young driver as well as the knowledge of how long they are behind the wheel.
- Air Updates
 - The company is able to update the software of the car without the car owner be forced to bring the car to the company.
- Driver Assistance and Hands-free support
 - A driver assistant can suggest a faster route or warn of traffic on the road.
 - A hands-free support system allows the user to communicate without touching the device. .

Connected Car Safety Features

- Around View Monitors
 - It provide a 360-degree view of the car by processing input from four cameras located on the front, rear and sides of the vehicle's body.
 - It helps drivers visually confirm the vehicle's position relative to the lines around parking spaces and adjacent objects.
- Automatic Emergency Braking (AEB)
 - Sensors placed near the front and rear bumper is helpful to alert the driver while approaching vehicles or objects while backing up.
 - When an object is detected, the system applies brief braking pressure while the vehicle is moving backward, and can actually stop the vehicle in time to prevent impact with obstacles or, more importantly, people.
- Night Vision Safety Technology
 - Connected cars use far-infrared imaging that are able to scan the road for pedestrians and other moving objects up to four times beyond the headlight range.
 - The infrared camera registers people and animals based on their body heat and movements, and then alerts the driver.
 - It can also work to identify objects that may be hidden by fog or smoke.
- Pedestrian Detection & Braking
 - These systems employ radars and/or camera technology in order to detect pedestrians or cyclist in front of the vehicle and bring the car to a full stop at speeds of 10 mph or below.

Smart City Environment

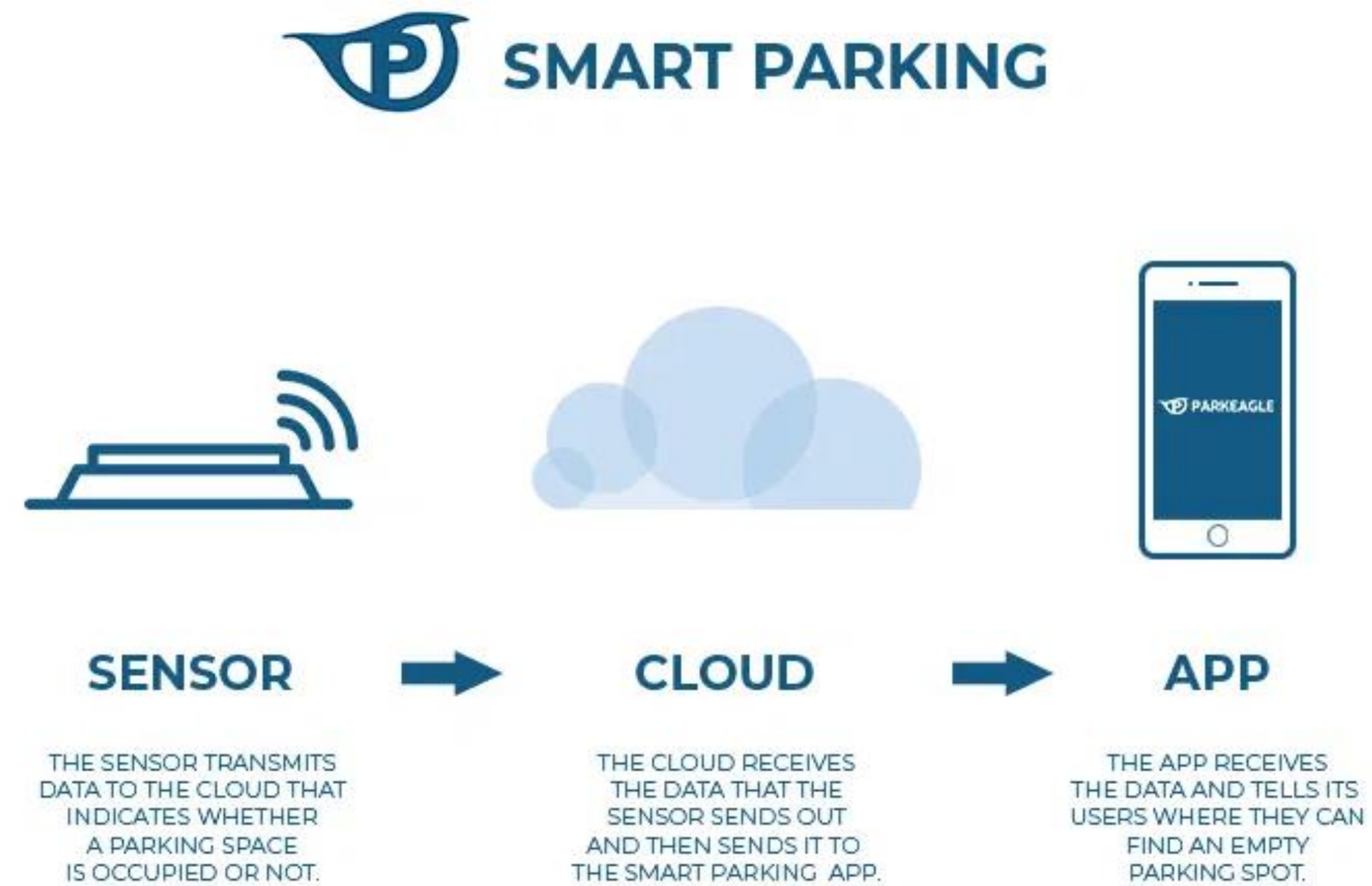
Smart Parking



What is Smart Parking?

- Smart parking is a parking solution that includes IoT technology.
- This technology uses in-ground sensors, camera or counting sensors.
- These devices are usually embedded into parking spots or positioned next to them to detect whether parking bays are free or occupied.
- This happens through real-time data collection.

How does Smart Parking work?



Benefits of Smart Parking

- Real-time monitoring of parking space
 - Parking IoT solutions help find a space in a new town and track the occupancy of the facility in real time to ensure a driver's time is not wasted driving around jam-packed parking lots.
- Providing better control for consumers, businesses, and law enforcement representatives
 - Smart parking solutions promote safety by notifying drivers when they are about to leave a vehicle in a no-parking area.
- Optimizing space and time in a tight and busy urban environment
 - IoT-based parking facility management tools will help business owners make the most out of the space available.
- Foresee the flow of vehicles by analyzing parking routines in malls, business stores, airports
 - IoT-based parking facility management tools will help business owners make the most out of the space available.

Mobility as a Service (MaaS) systems



What is a MaaS system?

- Mobility as a Service, also known as MaaS and sometimes referred to as Transportation as a Service, is a consumer-centric model of people transportation.
- This system is the integration of various forms of transport services into a single mobile service accessible on demand and in real-time.

What does a MaaS system include?

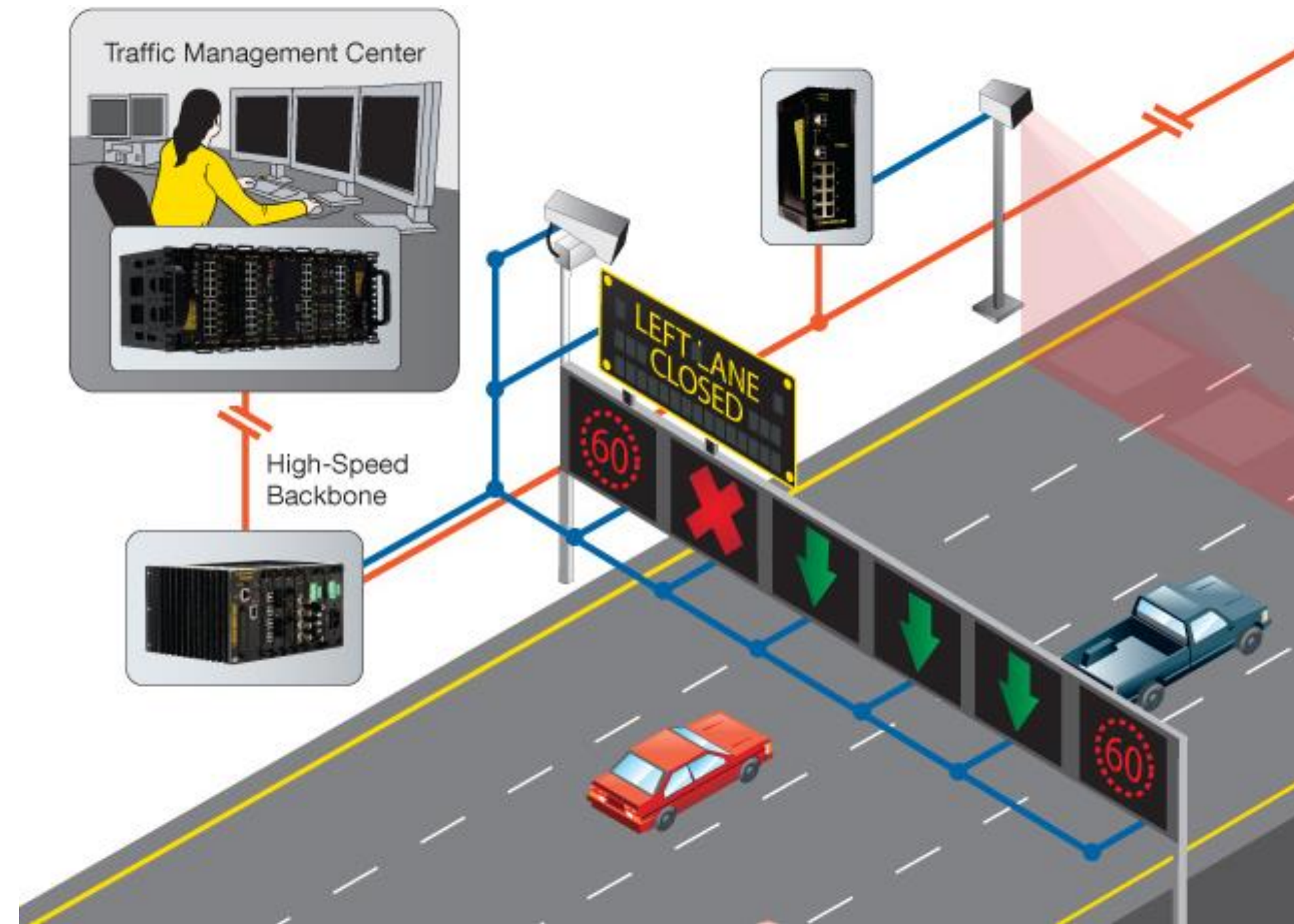
- The MaaS system includes a menu of transport options, such as they public transport, ride-, car- or bike-sharing, taxi or car rental/lease, or a combination.
- The system provides to the user everything about transportation, from travel planning to payment.

Benefits of MaaS systems

- Easy route planning
 - Real-time route planning allows users to plan journeys using multiple transport methods, based on intelligent suggestions derived from their personal preferences.
- Simplified payments
 - MaaS users can pay for transportation using phones, smartwatches and bank cards, before or after their journey, or on a subscription basis.
 - The payment operation is done more easily and efficiently by using a single payment channel instead of multiple ticketing and payment operation.
- The personal touch
 - MaaS is a fully personalized service that builds relationships between users and the transport provider. By using big data, two-way communication and constant user feedback, MaaS systems become the ultimate customer-focused transportation platforms.

Smart City Environment

Advanced Traffic Management Systems (ATMS)



What is ATMS?

- Advanced Traffic Management system is an integrated solution in order to manage highway traffic through real-time information collection, process, analysis and dissemination to the user.
- To ensure round the clock safety, it is of prime importance to provide real time and precise information to users about the road condition, traffic situations, incidents and weather conditions on the highway.

ATMS Components

Smart Traffic Management System

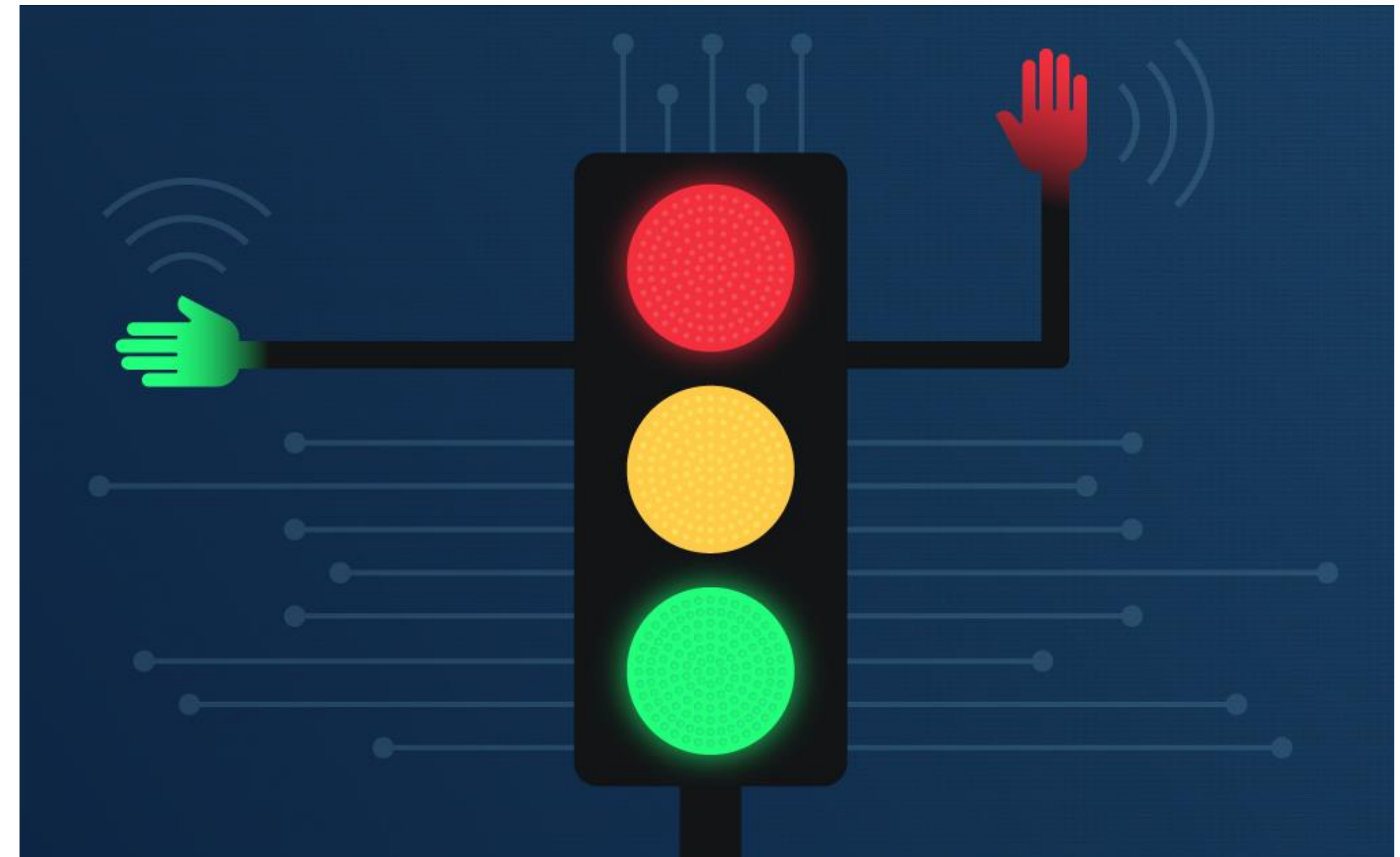
- It is a system used to regulate the city traffic.
- It uses sensors and traffic signals to monitor, control and respond to traffic conditions.
- These centrally managed sensors and traffic signals are found on the main roads of cities.



ATMS Components

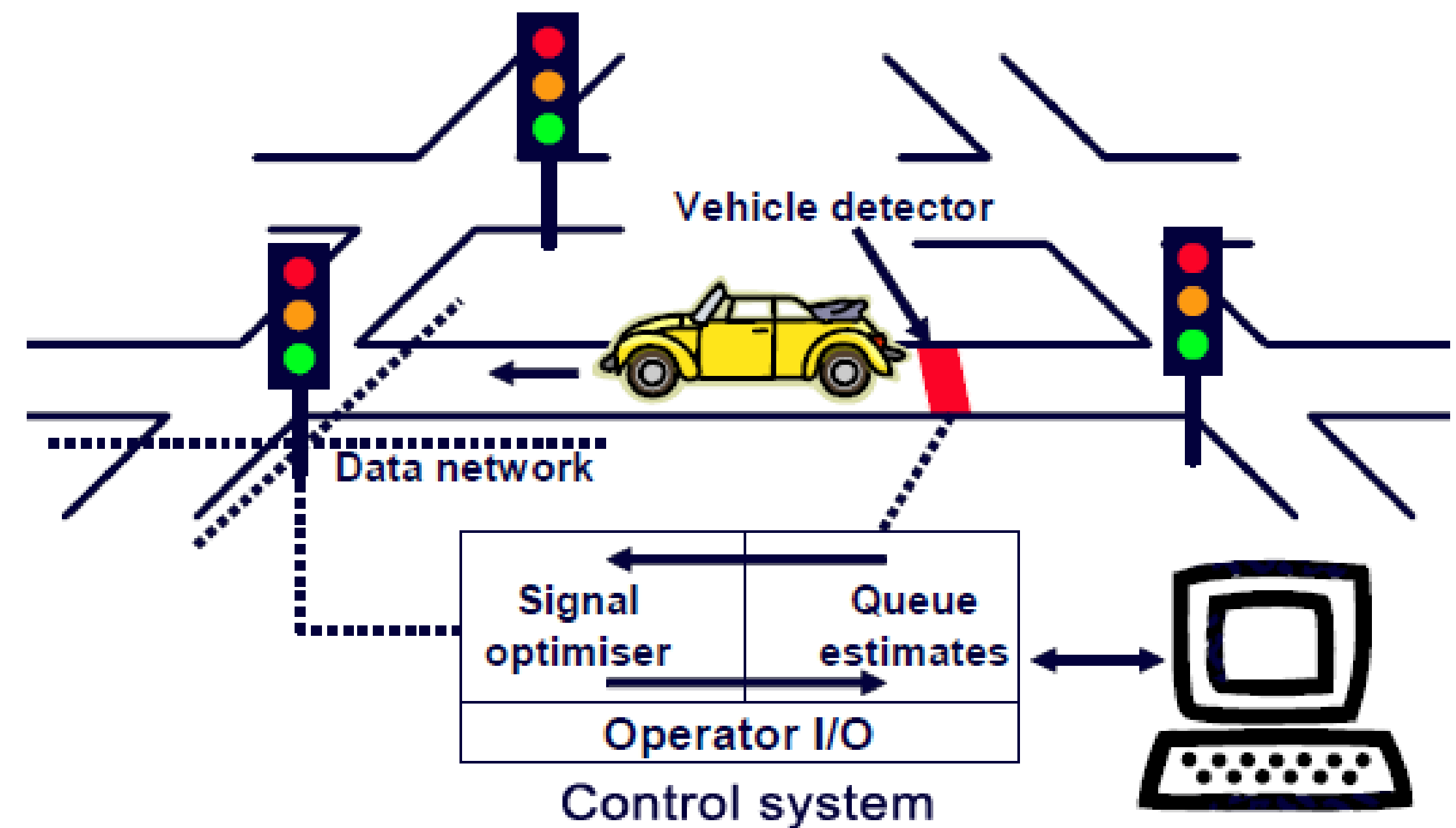
Smart Traffic Lights

- Smart traffic lights are a vehicle traffic control system that combines the traditional traffic lights with IoT technology sensors.
- Smart traffic systems acquire data and update signal lengths according to traffic demands.
- Smart traffic control systems generally use three devices:
 - a central control system
 - smart traffic lights
 - cameras and queue detectors



How does it work?

- The system consists of three components, traffic lights, queue detectors, cameras and a central control system.
- The queue detectors are buried in the road and tell the control system the state of traffic flow on all the main road of a city.
- The system in turn controls the lights in order to maintain a free flow of traffic within the city.



Autonomous Buildings



Autonomous Buildings

- An autonomous building is a building that is designed to be operated independently from infrastructural support services.
- These services includes electric power grid, gas grid, municipal water systems, sewage treatment systems, storm drains, communication services, and in some cases, public roads.



Smart City Environment

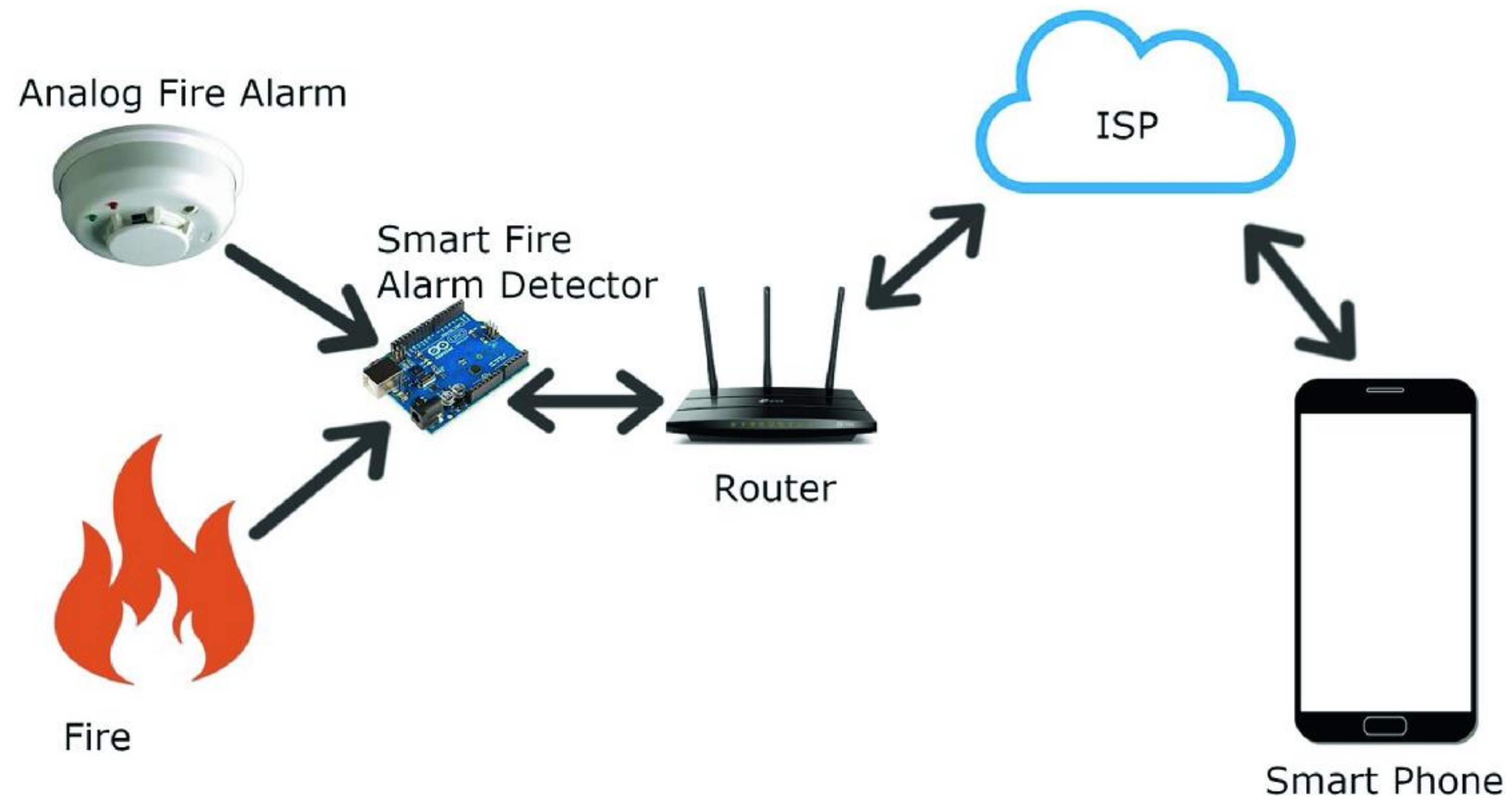
Smart Fire Detector



What is a Smart Fire Detector?

- Smart fire detector is the system that is responsible to detect fire and uses smart smoke detectors.
- Smart smoke detectors are smart devices connected to the internet that are able to alert the user in case of fire.
- The alerts can be done either through a smartphone notification or automatically turning the lights on, as well as the classic loud and piercing alarm sound.

How does it work?



Smart Fire Detector Example

- The Google Nest Protect is a smart smoke detector that uses a smartphone application to notify the user in case of fire.
- Alarms are varied, integrated lighting is color-coded based on the type of threat, and the product includes helpful voice alerts when activated



Smart Waste Management



What is a Smart Waste Management system?

- A smart waste management system is the smart solution for the traditional waste collection city service.
- The smart waste management solutions use sensors placed in waste receptacles to measure fill levels and to notify city collection services when bins are ready to be emptied.
- Historical data collected by sensors can be used to identify fill patterns, optimize driver routes and schedules, and reduce operational costs.

Smart Garbage Bins

- A smart bin is an intelligent waste management system. The bin has wireless ultrasonic fill-level sensor embedded inside that is able to detect the amount of its fullness.
- Through the wireless communication, the data from the sensor are sent to a cloud-based monitoring and analytics platform.
- On the basis of this data, waste collection services can optimize their routes and frequency.



Smart Garbage Bins

- Smart bins also use a solar-powered trash compactor which activates at a pre-set level, enabling them to hold a great deal more waste (up to 8 times) and avoid overflowing.
- Intelligent safety sensors are also installed which stop compaction if a hand is detected and, if fire is detected, will alert the monitoring station and automatically begin extinguishing the fire.



Smart City - Advantages

- Efficient distribution of resources
 - Smart cities have an overall better organization and infrastructure.
 - A complex interplay consists of all the sectors involved in order to simplify the everyday life for people who live and work in the city.
- Seamless communication
 - The communication between the various systems and sensor in a smart city is very important.
 - Without these factors, a smart city is not able to efficiently redistribute resources and make the live of the citizen better.
 - Smart cities bring about a different, equally efficient communication—the communication between the citizens and the government of the particular city.
- Speed of implementation
 - The points that need improvements have already been identified, so the implementation becomes easier.
 - All the automation, analytics, and sensors contribute to making it easier for most of the changes to be implemented remotely, creating a seamless flow of change from conception to execution.

Smart City - Disadvantages

- Systemic Vulnerability
 - Skilled individuals have always used malicious methods to extract data from online archives and then used them for sabotage methods.
 - It is possible that these cyber criminals are able with the same skill set requirements to create and maintain data from the information network of smart cities, just like the way it is required to hack them.
 - It is necessary that smart cities focus as much resources as they do in creating an internet-based system, for the defending of this system.
- Reduced privacy
 - might pose a significant threat to privacy
 - The systems used depend on an ubiquitous system of surveillance and proposals incorporate extensive facial recognition technology into the platforms. These have the potential to increase security, at the same time it can undermine privacy

Case Study: Amsterdam



From a Normal City to a Smart City

- Amsterdam, the Dutch capital city, was one of the early adopters of the smart city concept in Europe.
- Following a holistic strategy to become smarter that launched in 2009, it has become one of the leading smart cities in Europe.
- In 2016, was named the European Capital of Innovation by the European Commission.

Smart Public Lighting in municipality of Renkum

- The municipality of Renkum wants to switch to smart public lighting throughout the municipality and at the same time build an infrastructure for future Smart City applications.
- Project partnership: Luminext (smart lighting), CityTec (service partner) and Primevest Capital Partners (financing).

Smart Public Lighting in municipality of Renkum

Goal of the Project

- With the use of smart Luminext products, the street lighting is able to be dimmed and monitored remotely.
- In combination with LED luminaires, this results in an energy savings that is expected to be about 60%.
- In the next 2.5 years, around 3,000 lighting columns and 6,000 luminaires will be replaced in Renkum.

Future Steps of the Project

- The lighting columns are suitable for implementing new technologies, such as sensors for measuring air quality and regulating traffic flows.
- The lighting columns can also be used for mobile internet applications, such as WiFi and 5G.

What can other cities learn?

- How to start smart lighting and build an infrastructure that uses IoT devices for future Smart City applications with minimal investment.
- How to save energy and to manage and control the public lighting.

EyeBeacons: Wayfinding in Public Spaces

- The big question: “how can new technologies, like as beacon technology, smartphone and smartwatch, support people with a visual impairment when navigating through the city?”
- Navigating from A to B is an essential part of our daily lives.
- Unknown routes, busy places and unexpected obstacles are a big challenge for everyone, regardless of what your eyesight is.
- For people with a visual impairment, this process is primarily a task because they have limited use of spatial orientation and directions in the environment.

EyeBeacons: Wayfinding in Public Spaces

Goal of the Project

- The EyeBeacons project investigated how new technologies can support people with a visual impairment when navigating through the city.
- The main goal of this research project EyeBeacons is to improve the mobility of the target audience like people with a visual impairment.

Project Results

- A demo smartphone and smartwatch app.
- It can provide extensive navigation instructions and can provide information about the area.

Future Steps of the Project

The aim is to scale-up this project by enhancing the exposure and applications of the EyeBeacons smartphone and smartwatch app in Amsterdam but also in other municipalities in the Netherlands and abroad.

What can other cities learn?

- During the research we learned that other existing navigation apps can offer people extra support when navigating through the public space

StreetSense

- StreetSense is an IoT street sensor designed to take every street online.
- This smart device does not only counts passing vehicles, but also tells the user if the street surface is dry, wet, overheating, frozen or gritted.
- StreetSense was initiated and developed by Mobility Sensing and tested with trailblazing smart cities in The Netherlands.

StreetSense

Goal of the Project

- The real-time traffic information is very low with combination of the big amount of city streets constructions and maintenance.
- StreetSense will be able to take every street of the city online and by monitoring them it will be able to continuously tell about the street's condition and how it is used.

Future Steps of the Project

- The next step is to find launching customers to join their large scale beta trial.

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Smart Home

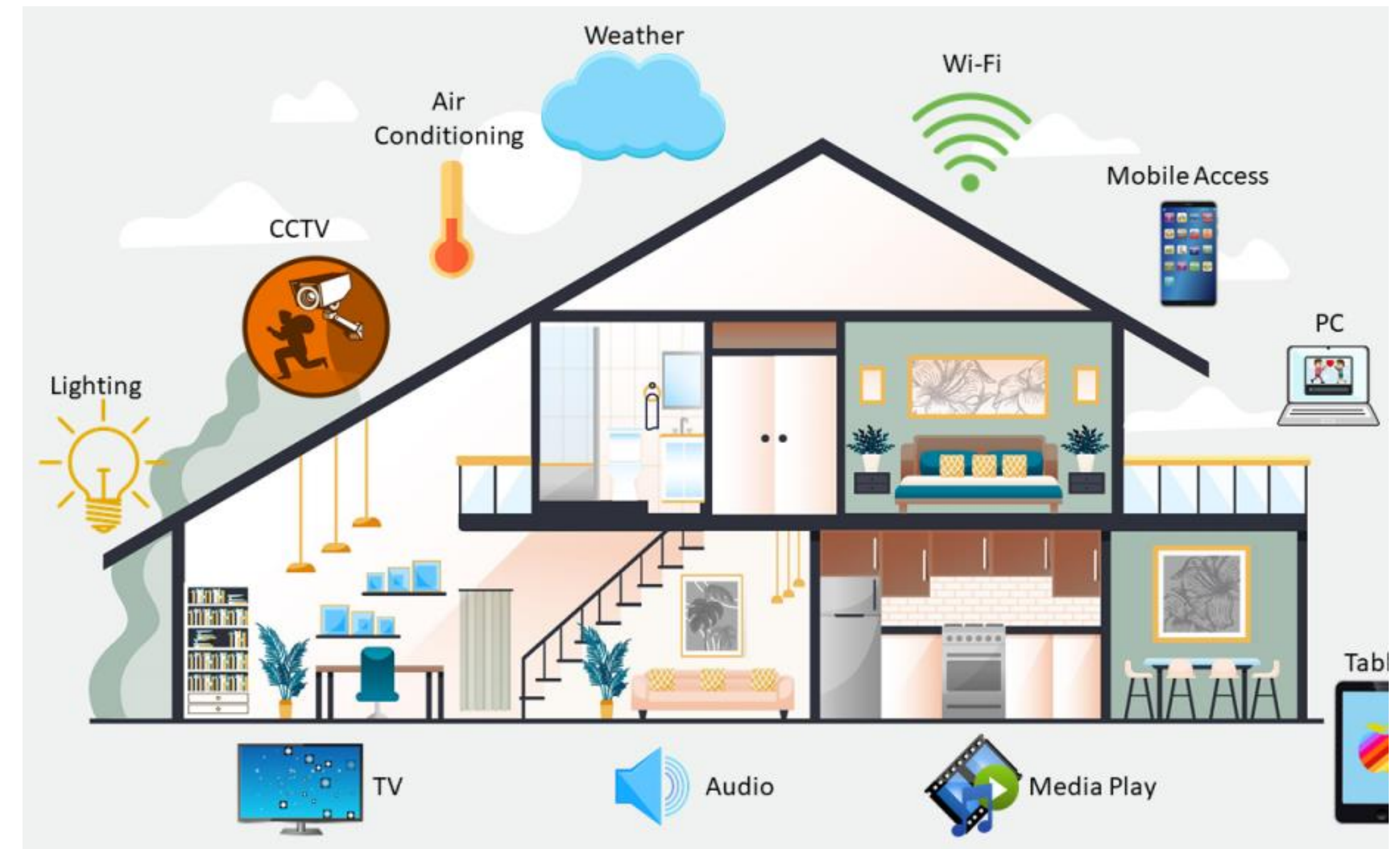
What is a Smart Home?

- A smart home is a residence that uses internet-connected devices to enable remote monitoring and management of appliances and systems.
- A smart home's devices are connected with each other and accessible through one central point – a smartphone, tablet, laptop or game console.



Smart Home Components

- Internet
- In order to create a smart home you will need to have one or more of the followings:
 - Smart Hubs
 - Smart Energy Management System
 - Smart Security Management System
 - Smart Lighting
 - Smart Appliances



Smart Hubs

Smart Hubs

- With a smart hub, the users can connect all of their connected gadgets and control them from one app, instead of using many.
- A smart hub works as the nerve center of the home automation system, that can tie all of the smart devices together.
- A smart device can connect through the Internet to the hub and the hub is connected to the smartphone application, where the user is able to control it.



Smart Energy Management System

- The use of smart devices gives the user the possibility to measure the energy consumed.
- The benefit of this procedure is that based on the smart device it is possible to gather information on where, when and how much energy is used, which can result reducing the consumption and generally the costs.
- The devices can be divided into:
 - Smart thermostat
 - Smart water management



Smart Energy Management System

Smart Thermostat

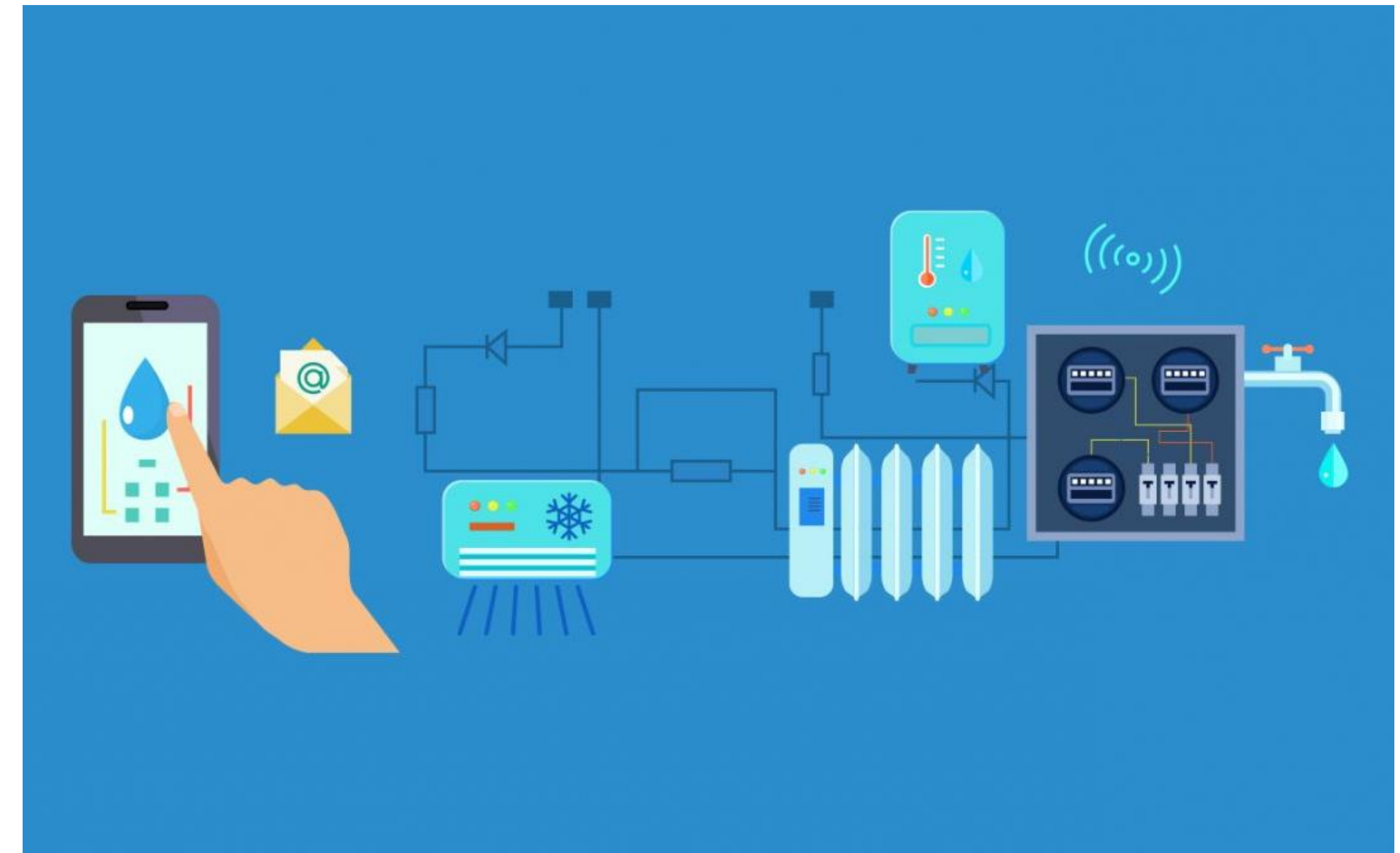
- A smart thermostat is a thermostat that can be used with home automation.
- It is responsible for controlling the heating and/or the air conditioning of the home.
- It allows the user to control the heating and/or air conditioning from other Internet-connected devices.
- The user can control the thermostat remotely.
- It collects data about the internal/external temperature, the time of the system running as well as alert the need of air filter replacement.



Smart Energy Management System

Smart Water Management

- A smart water management system provides a more resilient and efficient water supply system.
- The main goal is to reduce costs and improve sustainability.
- The water section needs to be expanded with the use of high-technology solutions using IoT devices.
- These devices include digital meters and sensors, supervisory control and data acquisition (SCADA) systems, and geographic information systems (GIS).



Smart Security Management System

- A smart security management system uses wireless technology, home networks and the prevalence of smartphones in order to integrate the security.
- This category consists of:
 - Smart locks
 - Smart home security systems
 - Smart Surveillance Cameras



Smart Security Management System

Smart Locks

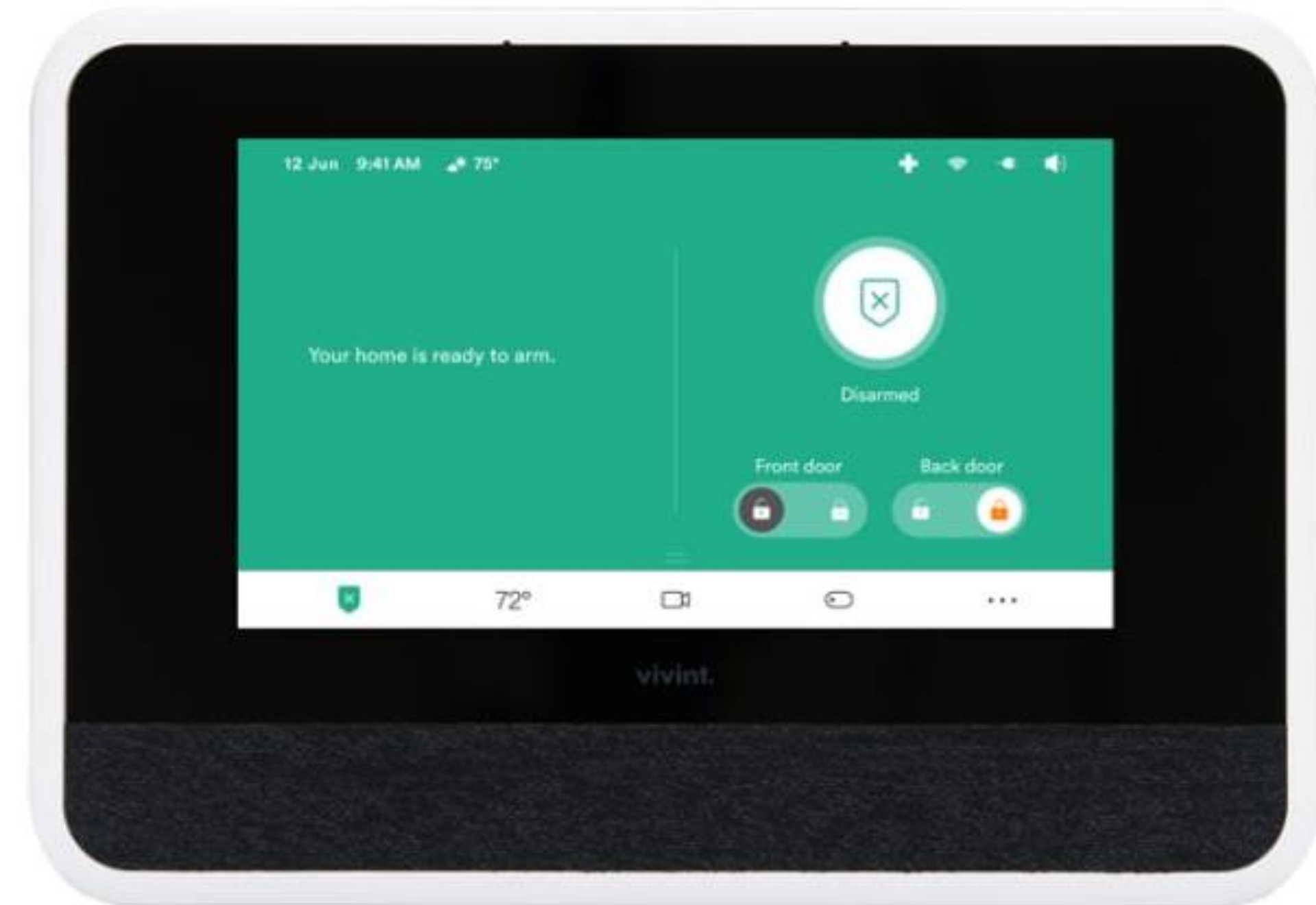
- The August Smart Lock is a proven reliable security IoT device.
- It allows the user to manage their doors from any location hassle-free.



Smart Security Management System

Smart Home Security

- The Vivint Smart Home security system is a full-blown home security system that gives you 24/7 monitoring and full control over door locks, cameras, thermostats, and lights.
 - It can even monitor the cars while they are on the road.
- It provides speedy emergency response times in testing and is easy to control via a colorful, 7-inch touch-screen video panel, a mobile companion app, or Alexa and Google Assistant voice commands.



Smart Security Management System

Smart Surveillance Cameras

- Arlo Ultra is an outdoor camera that streams and records video in true 4K, or Ultra High Definition (UHD).
- It includes automatic zooming, motion tracking, color night vision, an integrated spotlight and siren, one-click 911 connectivity, a 180-degree field of view, etc.



Smart Lighting

- Smart lighting is a lighting technology designed especially for energy efficiency.
- The smart lighting system consists of smart bulbs that are wirelessly connected between them. These bulb are controlled either by a master bulb or a smart hub.
- The application enables the user to change the brightness of the bulbs, as well as the colors of it, only when the bulbs have colored LEDs.



Smart Lighting

Philips Hue Family

- The Philips Hue line delivers with bulbs that let you control not only the intensity of the light, but also the color.



Smart Lighting

Wyze Bulb

- The Wyze Bulb is a white LED light that can be controlled by voice, phone, and lots of other smart home devices.



Smart Home Appliances

- Smart home appliances are specialized equipment programmed to run from a central system.
- Any domestic device can be a smart appliance.
- Each device is connected to the Internet and the users can control it through an application of their smartphones.



Smart Home Appliances**Amazon Basics Microwave**

- The AmazonBasics Microwave is a small, simple microwave oven that is able to respond to Alexa voice commands.



Smart Home Appliances

Samsung Family Hub 4-Door French Door Smart Refrigerator

- This smart refrigerator not only stores food but is able to set expiration notifications for the food stored, plan meals based on the available ingredients in it and see the content inside it from anywhere.
- Photos can be shared and calendars on the screen can be synced, as well as be able to control smart home devices like lights, thermostats, and doorbells, and stream music, with voice commands.



Smart Home Appliances**Ecovacs Deebot N79S**

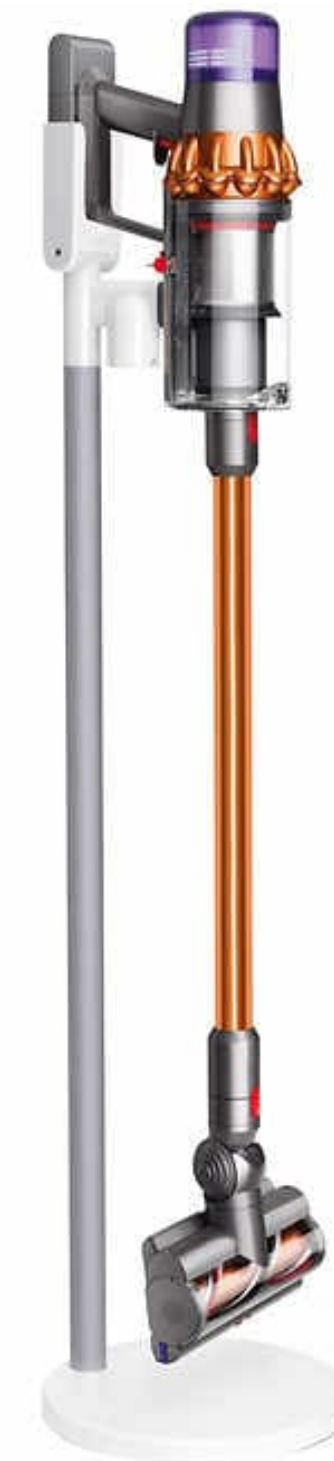
- The Ecovacs Deebot N79S robot vacuum is a powerful cleaning device with app control and Alexa voice command support.



Smart Home Appliances

Dyson V11 Torque Drive

- Dyson's V11 Torque Drive is a smart cordless stick vacuum that can automatically detect the type of surface and switch the motor speed accordingly, in order to blend right the power and battery life.
- An LCD on top of the handle shows remaining battery life (down to the second), your current power mode, reminds you to clean the filter, and tells you how to clear any blockages.



Smart City – Advantages

- Managing all your home devices from one place.
 - The ability to manage all home devices from one place and more specifically one device is the most convenience factor of smart home.
 - By keeping all the technology in your home connected through one interface is a massive step forward for technology and home management.
 - Theoretically, all you'll have to do is learn how to use one app on your smartphone and tablet, and you'll be able to tap into countless functions and devices throughout your home.
- Flexibility for new devices and appliances.
 - Smart home systems tend to be wonderfully flexible when it comes to the accommodation of new devices and appliances and other technology.
 - No matter how state-of-the-art your appliances seem today, there will be newer, more impressive models developed as time goes on.
- Remote control of home functions.
 - All smart home function can be controlled from either inside or even far outside.
- Maximizing home security.
 - Using security and surveillance features.
 - It is also possible to receive security alerts on various devices, as well as monitoring the activities in real-time, from wherever the user is.
- Increased energy efficiency.
 - The energy efficiency is increased depending on how the smart home technology is used.
- Improved appliance functionality.
 - Smart homes can help by running all appliances better.
- Home management insights.
 - It is able to have a home management insights based on how the home is operates.
 - From these insights, it is able to analyze the daily habits and behaviors, and make adjustments to live the lifestyle of your desire.

Smart City – Security Risks

- Man-in-the-middle
 - An attacker breaches, interrupts or spoofs communications between two systems.
 - For example, fake temperature data ‘generated’ by an environmental monitoring device can be spoofed and forwarded to the cloud.
 - An attacker can disable vulnerable HVAC systems during a heat wave, creating a disastrous scenario for service providers with affected models.
- Data and identity theft
 - Data and identity theft is another security risk that comes with the scenario of smart homes.
 - Smart appliances and wearables that are unprotected and generate data, are easy targets for cyber attackers.
 - Cyber attackers are provided with an ample amount of targeted personal information that can be exploited for fraudulent transactions or even identify theft.
- Device hijacking
 - An attacker is able to hijack and effectively assume control of the device.
 - These attackers are quite difficult to detect due to the fact that the attacker is not changing the basic functionality of the device.
 - It only takes one device to potentially re-infect all smart devices in the home.
- Distributed Denial of Service (DDoS)
 - It attempts to render a machine or network resource unavailable to its intended users by temporarily or indefinitely disrupting services of a host connected to the Internet.
 - It is rising rapidly, primarily due to the lack of security in IoT Devices.
- Permanent Denial of Service (PDoS)
 - The permanent denial of service attack is also known as phlashing.
 - This attack damages the device so badly that it requires a full replacement or reinstallation of hardware.

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Healthcare IoT

What is Healthcare IoT?

- Healthcare is the maintenance or improvement of health via the prevention, diagnosis, treatment, recovery, or cure of disease, illness, injury, and other physical and mental impairments in people.
- Healthcare IoT or The Internet of Medical Things (IoMT) is the combination of the traditional healthcare and the Internet of Things technology. In healthcare IoT, medical devices and application that are connected to the healthcare IT system collect data through online computer networks.



Examples of Healthcare IoT

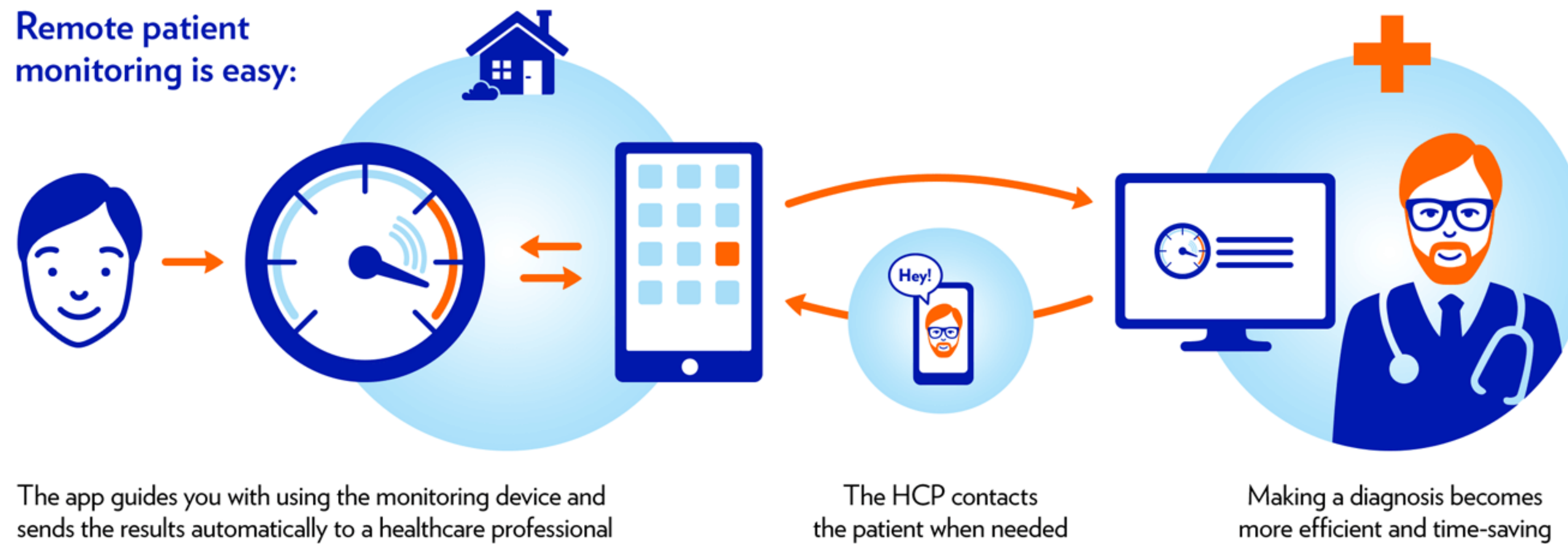
Remote Patient Monitoring

- RPM is the technology that enables monitoring patients outside of conventional clinical settings.
- The monitoring can take place in the patient's home or in other remote areas.
 - It can increase the access to care and at the same time decrease the healthcare delivery costs.
- The access to care is increased and the healthcare delivery costs are decreased.



Remote Patient Monitoring

RPM Example



Elisa Remote Patient Monitoring

Examples of Healthcare IoT

Glucose Monitoring

- The use of IoT application in combination of smart wearables or embedded body sensors that can continuously monitor and send data of the sugar level in the blood, can minimize the sick of death by diabetes.
- These smart devices, that can test the blood sugar level at any time, are important in understanding the diabetes and how different foods, medication and activities affect the patients' diabetes.
- By keeping track of the blood glucose, the doctor can help the patient by creating a plan to manage its condition.



Examples of Healthcare IoT

Connected Inhaler

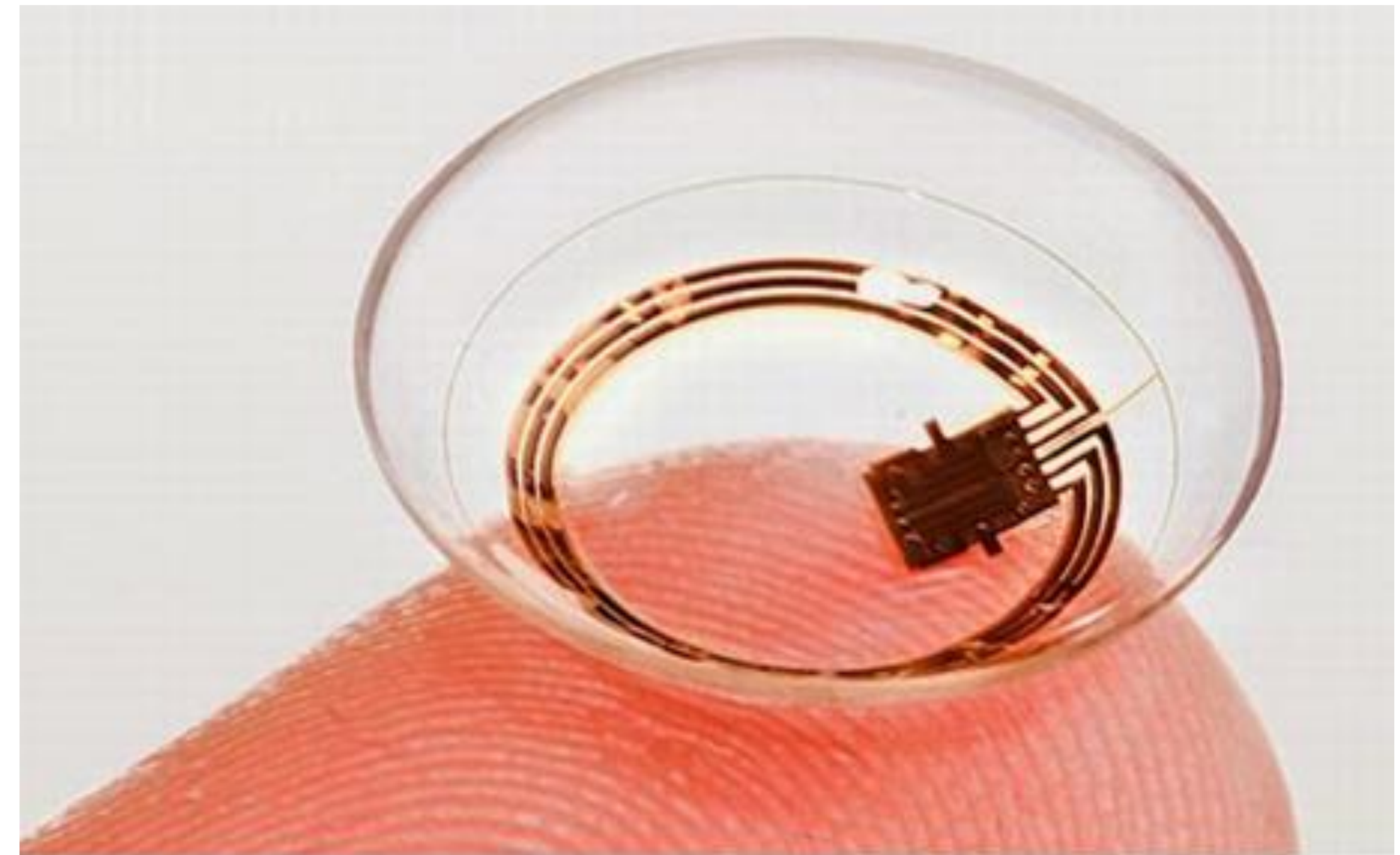
- Asthma is a not curable disease, but it can be controlled with the use of an inhaler.
- A **connected smart inhaler** can alert the patient by triggered factors, such as air pollution, temperature, in order to prevent an asthma attack.



Examples of Healthcare IoT

Connected Contact Lenses

- Tears are the most important factor of the eye, which create a thin layer of it in order to keep it working.
- The combination of sensors and contact lenses will be able to detect symptoms of various diseases.
- An example of possible by IoT based contact lenses detection is an early diabetes detection from the tear glucose levels.



Examples of Healthcare IoT

Smart Watches for Depression

- Every year lots of people take treatment for depression
- Apple started working on their smartwatch to add the ability in detecting depression levels.
- This smart device can track and suggest actions in case of depression.



Examples of Healthcare IoT

Parkinson Patient Monitoring

- A movement disorder API can detect abnormal footstep, as well as instability of stride length in patients to draw a graph pattern.
- The doctor can analyze and check the collected data from the cloud and suggest to the relatives of the patients what to do.



Parkinson Patient Monitoring

OneRing

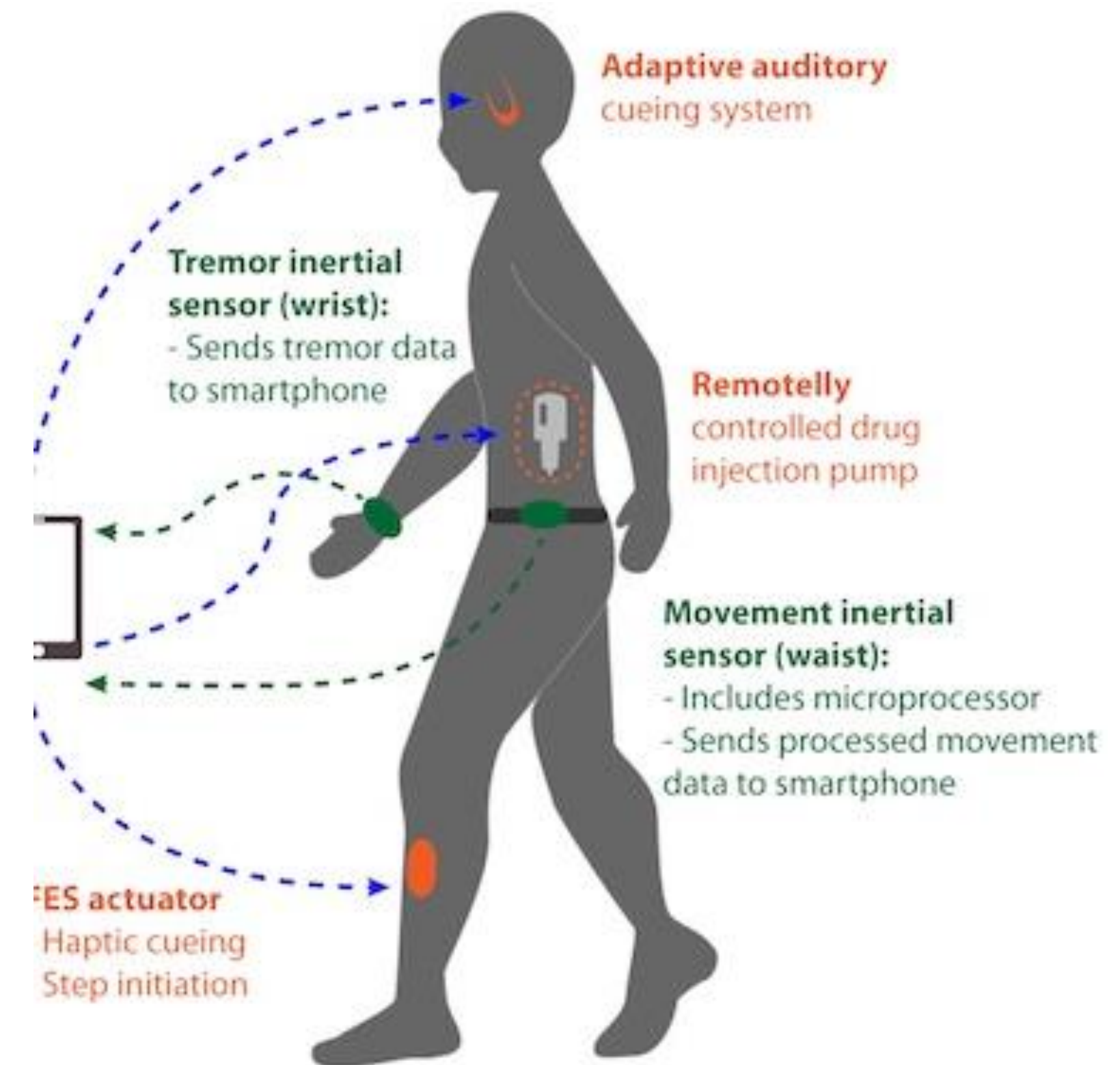
- The OneRing is a smart ring that can identify Parkinson's motor symptoms.
- The ring is placed on the patient's finger and generates daily patient reports that help the healthcare professional to prescribe medication more accurately.



Parkinson Patient Monitoring

European project REMPARK

REMPARK, which stands for Personal Health Device for the Remote and Autonomous Management of Parkinson's Disease, uses devices with IoT technology in order to process information about the patient's disease.



What is Mobile Health (mHealth)?

- Mobile Health or mHealth is the way of watching and taking care of someone's health via mobile.
- The mobile health contributes heavily to both critical situations and regular treatment instances.
- The use of smartphone applications serve as the management means for health tracking devices.



mHealth Types

- Symptom Checkers
 - the app is responsible to examine symptoms for a specific disease or purpose.
- Healthcare Professional Finders
 - the app can help the user find a healthcare professional in respect of its needs, including type of professional and location.
- Managing Clinical and Financial Records
 - the app is responsible to manage all the clinical and financial records of the patient.
- Condition Education and Management
 - the app is able to help the patients to manage as well as educate them about a specific condition. In most cases, these apps are about chronic diseases.
- Self-Monitoring
 - the app is able to help the user to monitor itself. In these type of apps, the user is responsible to add different symptoms about its condition in daily bases or the app can track activity for the user based on his preferences.

mHealth Examples**Medication management apps**

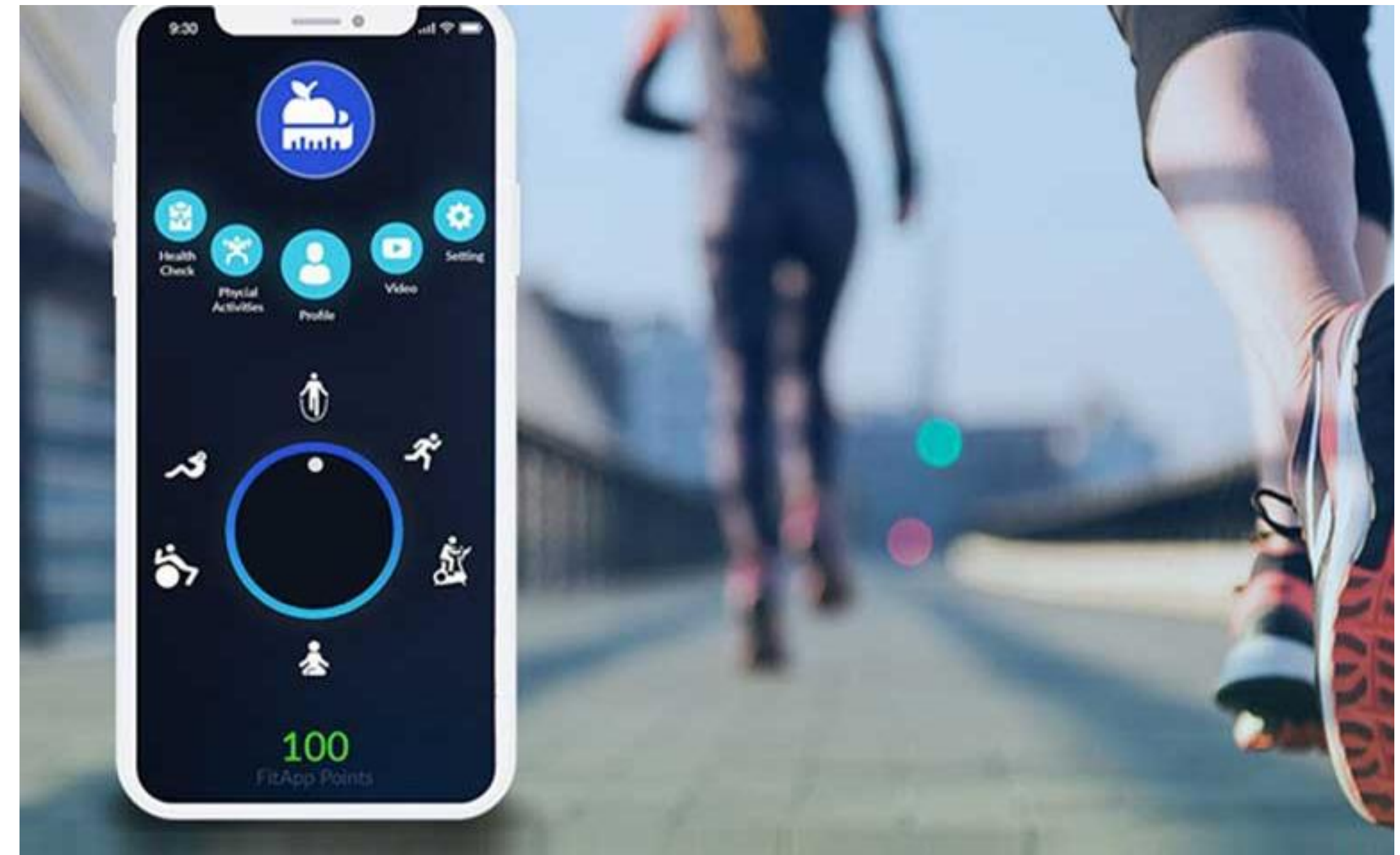
- The medication information of a user is managed.
- The user enter information about each medication.
- Reminders are schedule based on the times of the medication is needed to be taken.



mHealth Examples

Fitness apps

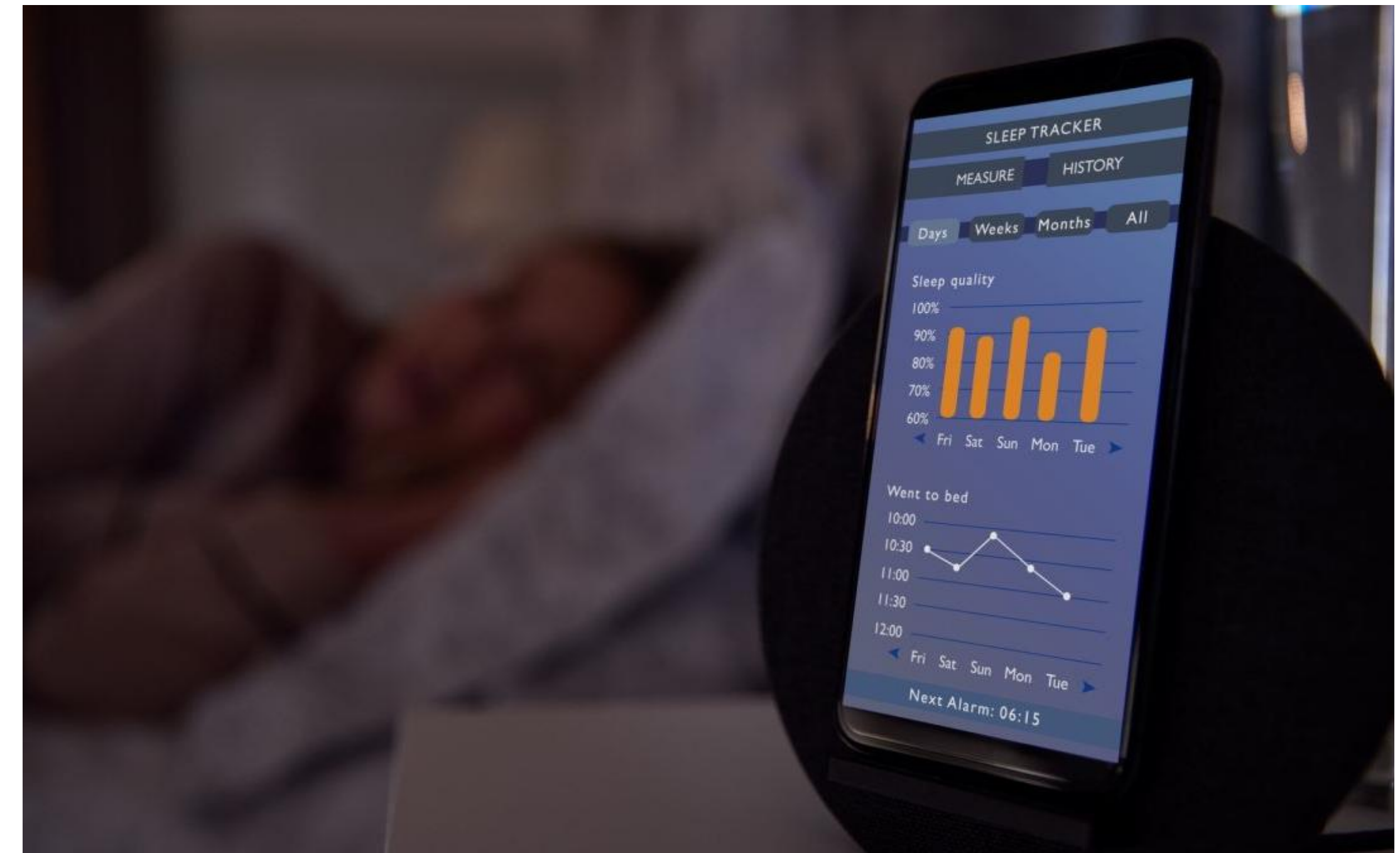
- It helps the users fitness situations.
- Help the user meet his fitness goals.
- Different applications are perfect for different goals based either on the type of the user using it or the purpose of the apps.



mHealth Examples

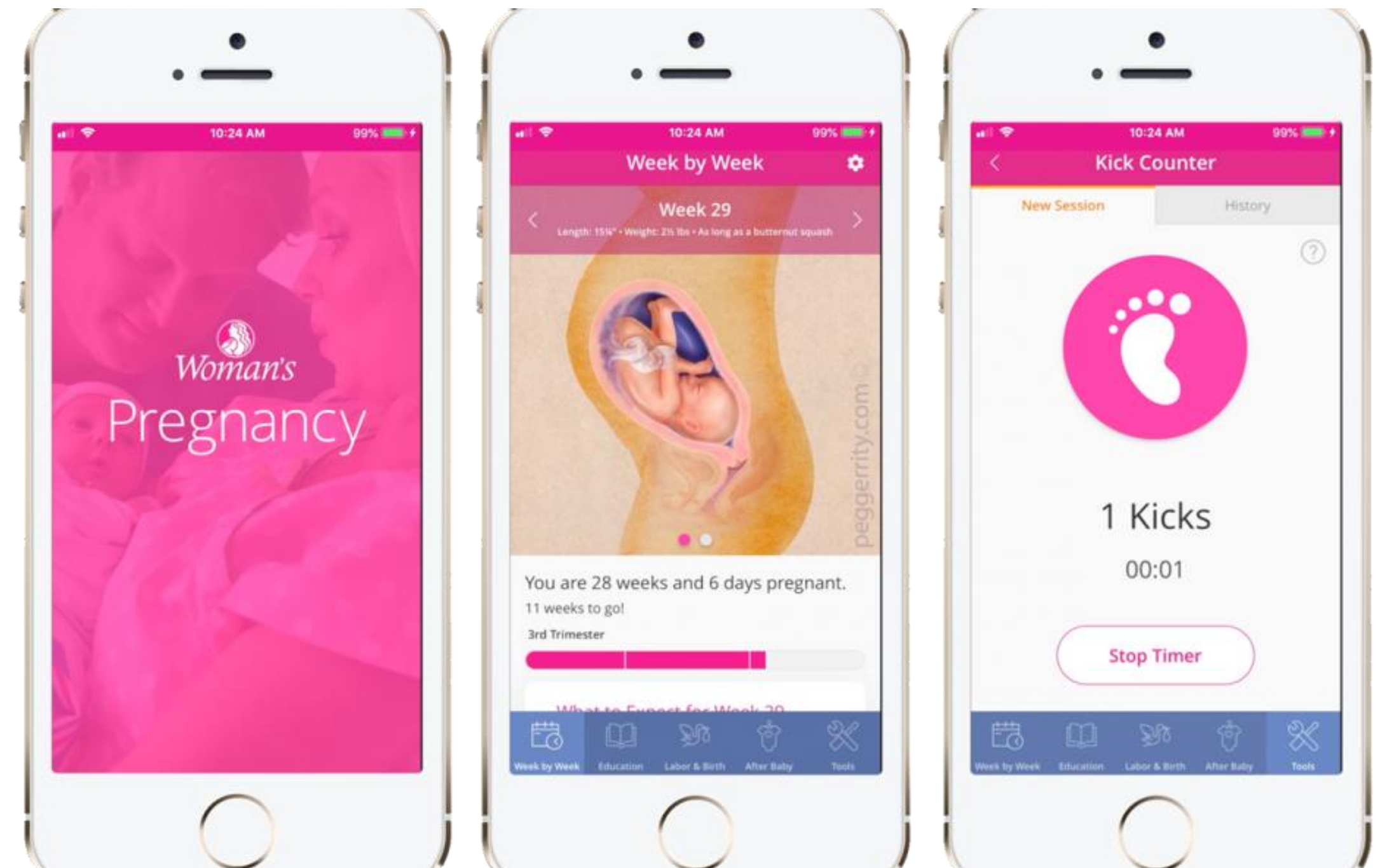
Sleep tracking apps

- These applications are used by users to track their sleep patterns.
- These type of applications track the user's sleep in order to provide sleep patterns in response some actions of the daily life of the user.
- Some applications are able to track the different stages of sleep a user changes during the night, as well as provide improving information for a better sleep experience.



mHealth Examples**Pregnancy monitoring apps**

- These apps are responsible to monitor the whole pregnancy phase of a woman, by providing many detail about the current status of her pregnancy.
- These apps are able to combat morning sickness, keep track of the scheduling for the doctor's visit, inform about taking prenatal vitamins.
- It is also able to guide the pregnant woman of her current state day by day as well as week by week, with tracking the baby's growth when the due date is plugged in.

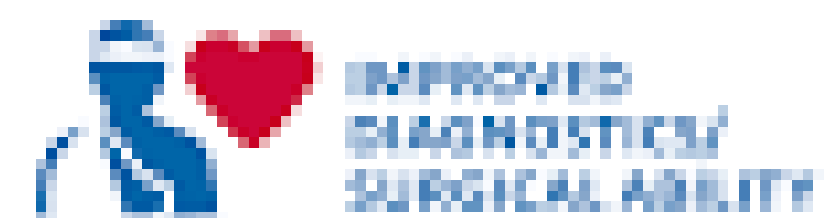
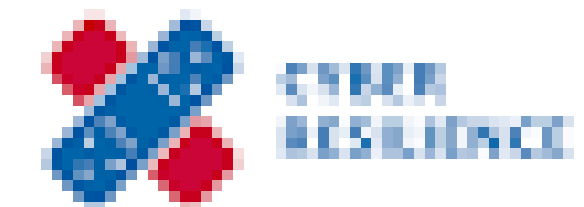
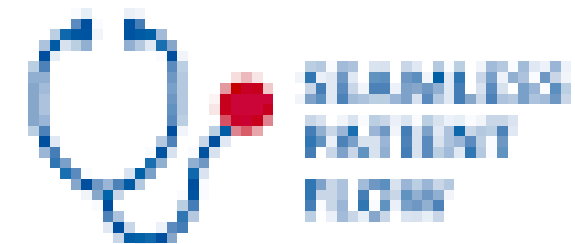


What are Smart Hospitals?

- The idea of a smart hospital aims in avoiding these problems, through interconnection of all instances and integration of the most modern communication technologies.
- A smart hospital is created when to the whole healthcare organization ecosystem consists of connected medical devices are connected to clinical information systems.



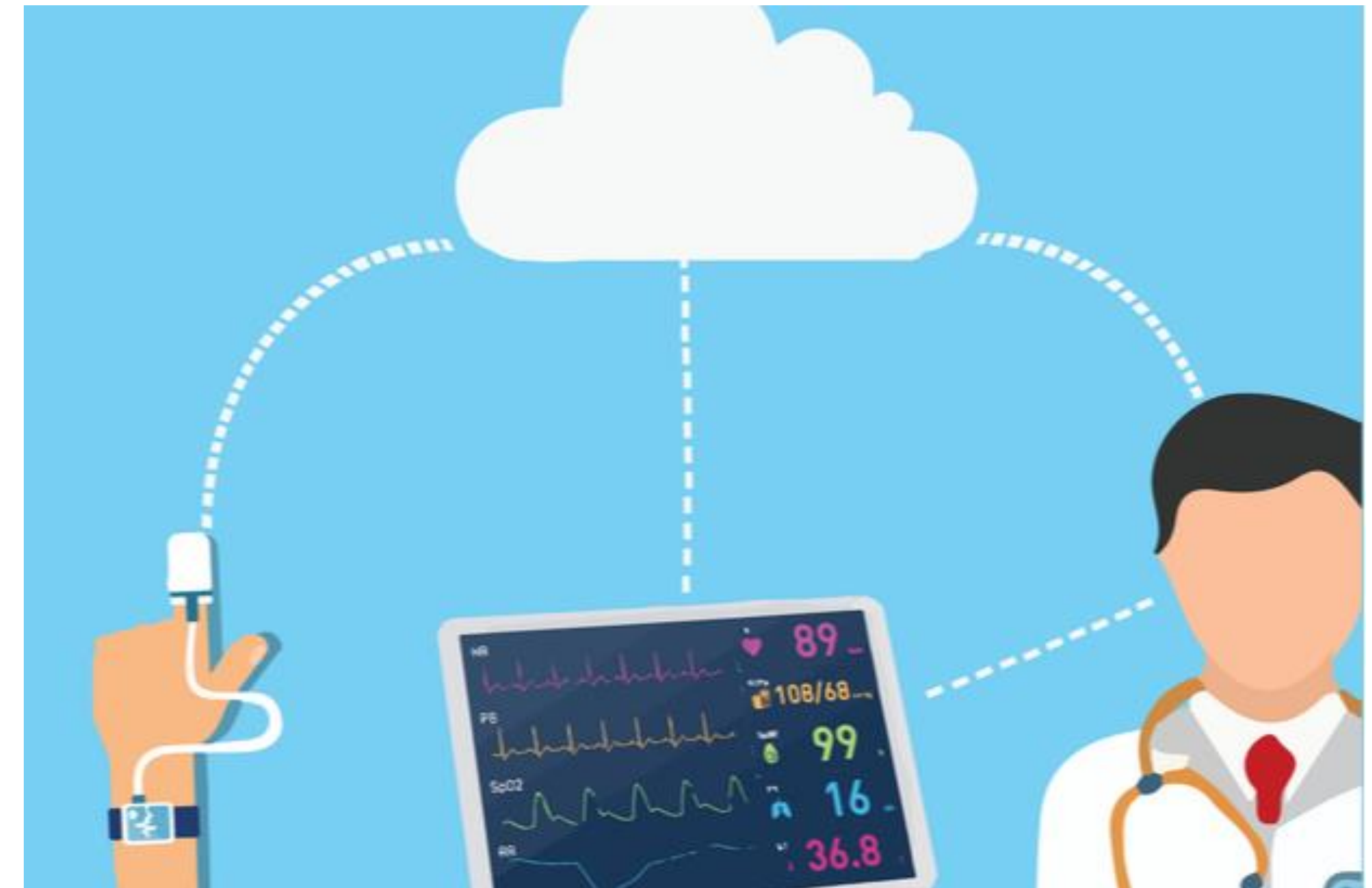
Smart Hospital Objectives



Smart Hospital Objectives

Remote medical care

- Various medical devices, such as implantable devices, wearable devices and other mobile ones, introduce the ability to perform real-time patient monitoring through measurement of key vital signs.
- These measurements are readily available to all hospital staff and system via the network connections.
- With these type of care, patient admission to hospitals can be limited which results in reduction of patient care costs and improved patient experience.



Smart Hospital Objectives

Enhanced patient safety

- Enhancing healthcare delivery and patient flow also increases patient and clinical safety.
- It is important though that healthcare delivery and patient flow do not improve at the expense of safety.



Smart Hospital Objectives

Cyber Resilience

- Cyber Resilience refers to the ability of a hospital to ensure the availability and continuity of its services that rely on ICT assets.
- In smart hospitals, achieving this is more challenging than in traditional hospitals because the number of components that could lead to and be affected by service unavailability is much higher.



Smart Hospital Objectives

Trustworthiness

- Being perceived as trustworthy and having a good reputation is a competitive issue in areas where choosing between different providers is an option.
- Trustworthiness also affects adherence to medications and continuity of care, which has implications for the outcomes a hospital can achieve.



Smart Hospital Objectives

Seamless patient flow

- Efficient healthcare as well as efficient patient flow can reduce waiting times and the duration of hospital stays, reduce errors, increase revenues and boost patient satisfaction.
- ICT can be deployed to identify, analyze and resolve bottlenecks and thereby contribute to efficient healthcare and patient flow.



Electronic Health Records (EHR)

- The goal of this piece is to digitalize all patient records in the cloud in order to have a direct access during office visits or hospital stays.
- The cloud needs to be able to collect different types of information for each patient's clinical picture that includes diagnostic findings, allergies, prescription data, laboratory data, x-rays, electrocardiograms and medications.
- Patient data can be analyzed by using statistical methods that can lead to better preventive health care.



Healthcare IoT– Advantages

- Simultaneous reporting and monitoring
 - Real-time monitoring via connected devices can save lives in event of a medical emergency.
 - The IoT device collects and transfers health data, which are delivered to the doctor or physician.
- End-to-end connectivity and affordability
 - The use of IoT technology in the area of healthcare enables interoperability, machine-to-machine communication, information exchange, and data movement that makes healthcare service delivery effective
 - Healthcare personnel can change the way they spot illness and ailments in patients and can also innovate revolutionary ways of treatment.
- Data assortment and analysis
 - If accessing the cloud is unavailable, the data is hard to store and manage for real-time application that healthcare devices send at short time periods.
 - IoT devices are able to collect, report and analyze the data in real-time and reduce the need to store the original data.
 - Healthcare operations allow organizations to get vital healthcare analytics and data-driven insights which speed up decision-making and is less prone to errors.
- Tracking and alerts
 - On-time alert is critical in event of life-threatening circumstances.
 - Reports and alerts give a firm opinion about a patient's condition, irrespective of place and time.
 - It helps make well-versed decisions and provide on-time treatment.
- Remote medical assistance
 - Mobile apps are used to contact doctors anywhere for an emergency.
 - The medics are able to instantly check the patients and identify the ailments on-the-go with the use of mobility solutions.
- Research
 - IoT for healthcare can also be used for research purposes
 - It enables the introduction of bigger and better medical treatments.

Healthcare IoT– Disadvantages

- Data security & privacy
 - IoT devices lack in data protocols and standards.
 - There is also a significant ambiguity in regard of data ownership regulation
 - The data is highly susceptible to cybercriminals.
- Integration: multiple devices & protocols
 - Integrating multiple devices can cause hindrance in the implementation of healthcare IoT.
 - No consensus is reached in regard of communication protocols and standards.
 - The process of data aggregation is complicated and hindered due to the difference of the communication protocol.
- Data overload & accuracy
 - The tremendous amount of data is becoming extremely difficult for doctors, which results in ultimately affects the quality of decision-making.
 - This concern is rising as more devices are connected which record more and more data.
- Cost
 - While IoT promises to reduce the cost of healthcare in the long-term, the cost of its implementation in hospitals and staff training is quite high

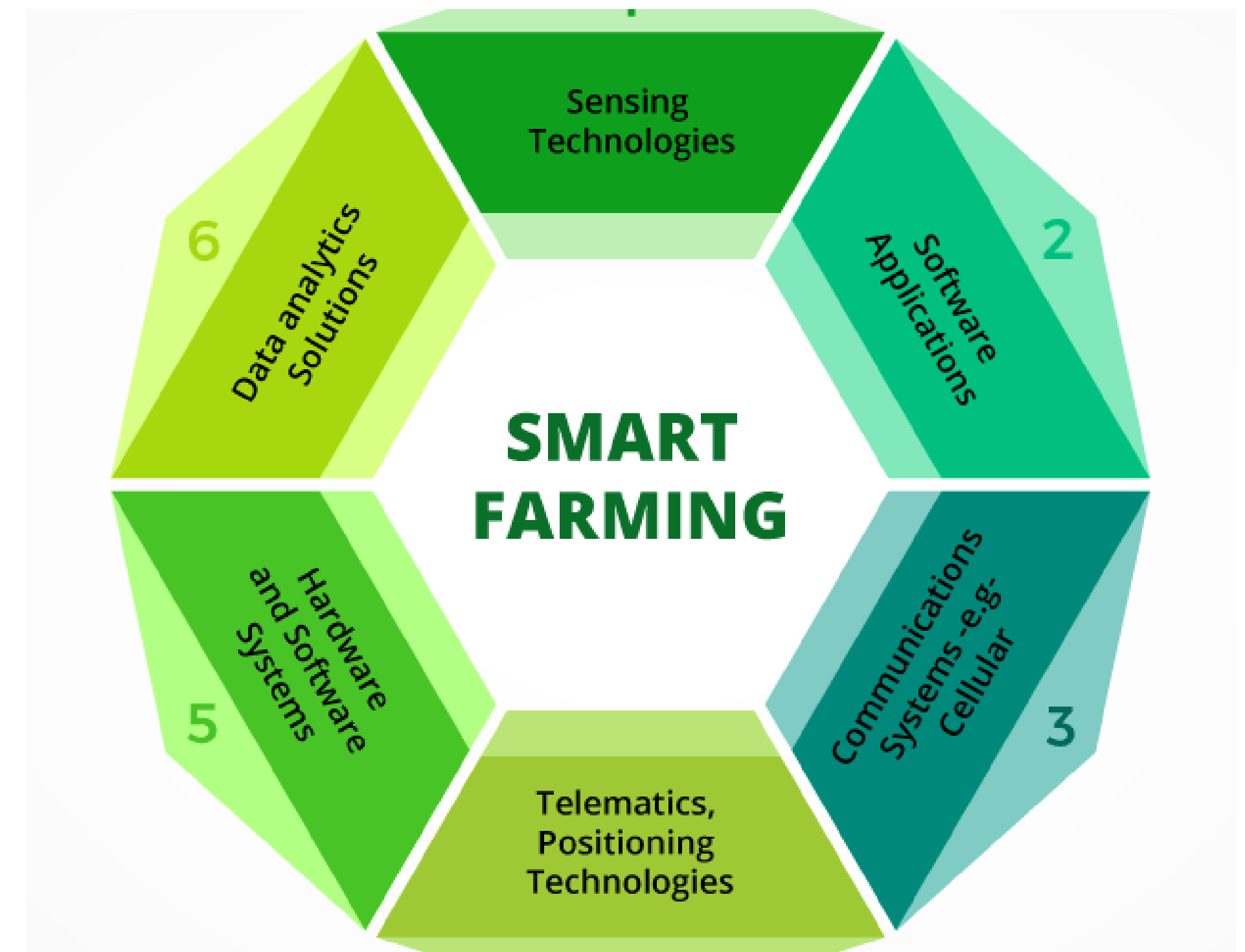
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Smart Agriculture

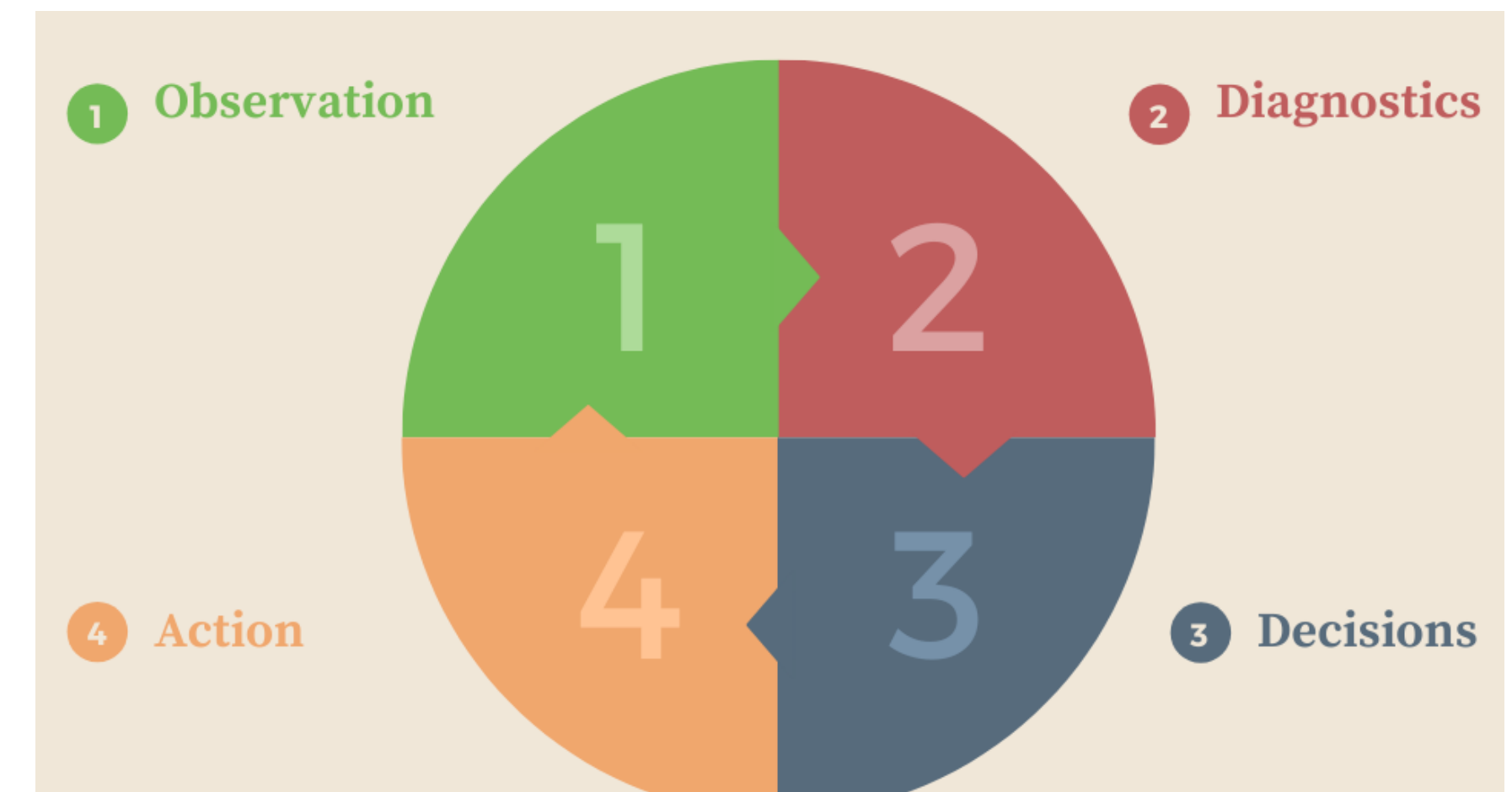
Technology used in Smart Farming

- Sensing technologies
 - These technologies include soil scanning, water, light, humidity, temperature management.
- Software applications
 - These applications include specialized software solutions that target specific farm types
- Communication technologies
 - These technologies include cellular communication
- Positioning technologies
 - These technologies include GPS
- Hardware and software systems
 - they enable IoT-based solutions, robotics and automation
- Data analytics
 - It underlies the decision making and prediction processes.



IoT-based farming cycle

- Observation
 - sensors record observational data from the crops, livestock, soil or atmosphere.
- Diagnostics
 - the values of the sensors are fed to specific software with predefined decision rules and models.
- Decisions
 - after the issues are revealed, the software determines whether location specific treatment is necessary and if that is the case which treatment to use.
- Implementation
 - the treatment needs to be performed in order to correct the operation of the machines.
- After evaluation, the cycle repeats from the beginning.



Benefits of Smart Farming

- The benefits of using smart farming are the followings:
 - Data collected by smart agriculture sensors.
 - Better control over the internal processes which results to lower production risks.
 - Cost management and waste reduction thanks to the increased control over the production.
 - Increased business efficiency through process automation.
 - Enhanced product quality and volumes.
- All of these factor can result in higher revenue.

IoT Solutions to Agricultural Problems

- IoT can add value to all areas of farming, from growing crops to forestry.
- IoT can revolutionize the following two major areas of agriculture:
 1. Precision farming
 2. Farming automation / robotization

Precision Farming

- It makes farming more controlled and accurate.
- Each plant and cattle get the precisely treatment needed that is determined from the machines with superhuman accuracy.
- The biggest difference from the classical approach:
 - The decision of the precision farming is made per square meter or even per plant rather than for a field.
- Advantage:
 - To precisely measure variations within a field, the farmers can boost the effectiveness of pesticides and fertilizers or even use them selectively.



Farming Automation/Robotization

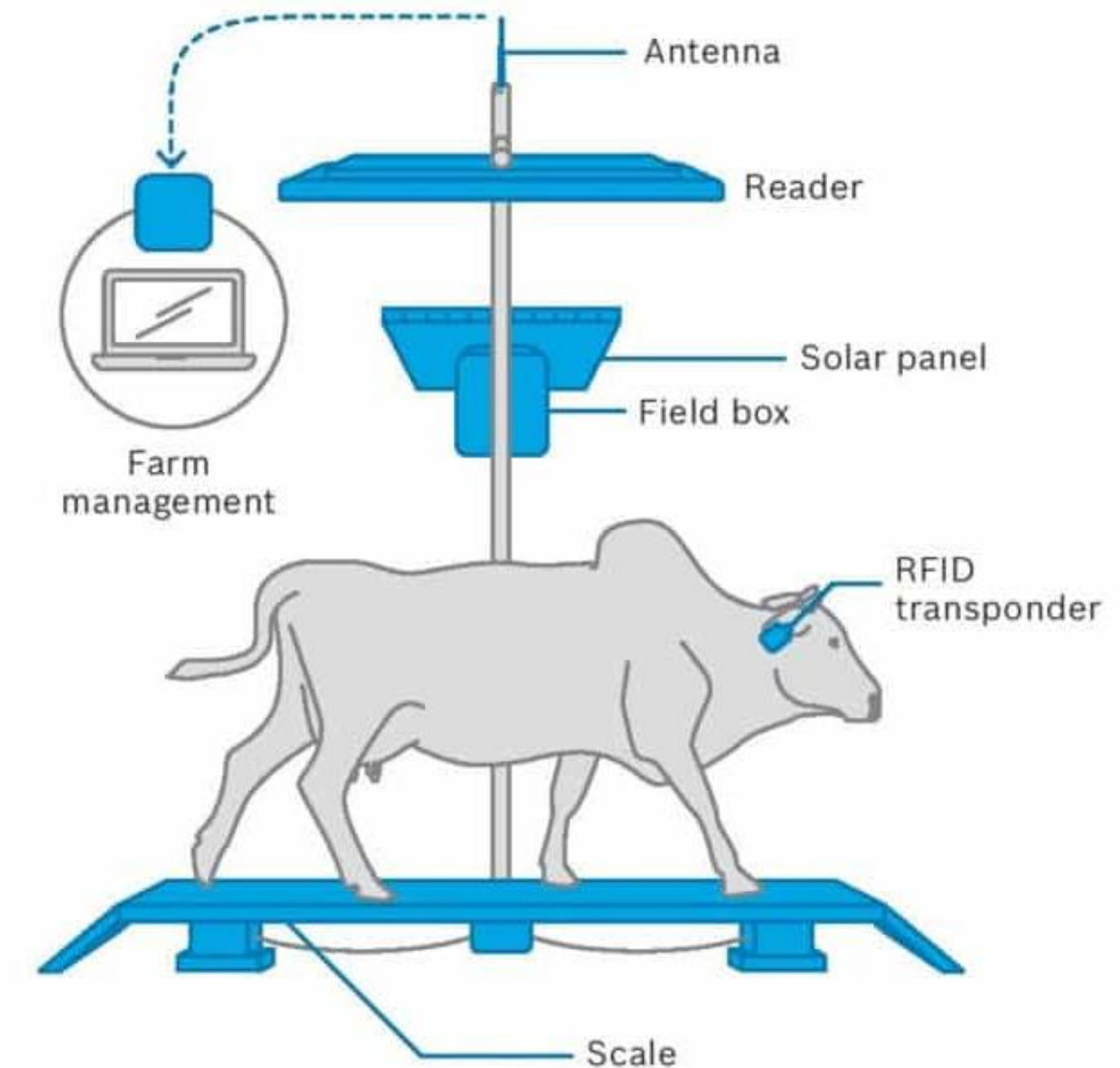
- It enables farmers to better monitor the needs of their animals individually and adjust their nutrition accordingly, while preventing disease and enhancing herd health.
- The use of automation and robotics in the farming world can be seen in the following areas:
 - Precision Livestock Farming
 - Automation in Smart Greenhouses
 - Agricultural Drones



Farming Automation/Robotization

Precision Livestock Farming

- Using wireless IoT applications, a farm owner can:
 - Monitor the location of their cattle
 - Well-being of their cattle
 - Health of their cattle
 - Identify sick animals



Farming Automation/Robotization**Automation in Smart Greenhouses**

- An IoT-driven smart greenhouse can intelligently monitor and control the climate, eliminating the need for manual intervention.
- Various sensors are deployed in order to measure the environmental parameters according to the specific requirements of the crop.
- The data collected, are stored in a cloud-based platform for further processing and control.



Farming Automation/Robotization

Agricultural Drones

- The drones collect multispectral, thermal and visual imagery while flying.
- The data collected provides the farmers with insights in different metrics, such as:
 - Canopy cover mapping
 - Field water pond mapping
 - Scouting reports
 - Stockpile measuring
 - Chlorophyll measurement
 - Nitrogen content in wheat
 - Drainage mapping
 - Weed pressure mapping



Smart Agriculture - Advantages

Advantages

- It allows farmers to maximize yields using minimum resources such as water, fertilizers, seeds etc.
- Solar powered and mobile operated pumps save cost of electricity.
- Smart agriculture use drones and robots which helps in many ways. These improves data collection process and helps in wireless monitoring and control.
- It is cost effective method.
- It delivers high quality crop production.

Disadvantages

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Summary

- Smart City
- Smart Home
- HealthCare IoT
- Smart Agriculture

