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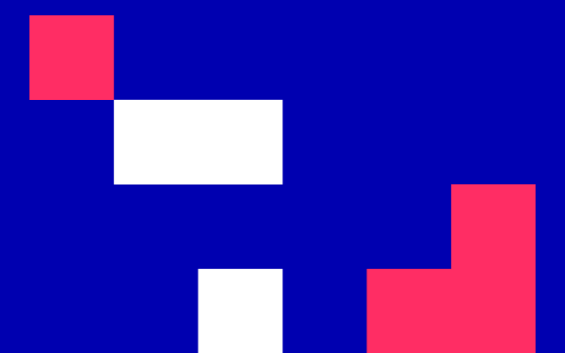


University of Cyprus

# MAI650 Internet of Things

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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 Business Value - Advanced

**CONTENTS**

1. The first IoT Device
2. Examples of IoT technologies in the business area
3. Examples of IoT applications in the business world
4. Use cases: successfully IoT applications

## INTENDED LEARNING OUTCOMES

Upon completion of this introductory unit, students will be :

1. familiar with different IoT applications/solutions that exist.
2. familiar with the benefits of IoT solutions
3. presented with real-life examples of successful IoT applications

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# The first IoT Device

## The first IoT Device

- A humble Coke machine in Pittsburgh, Pennsylvania that could report its content through a network.
- **The story:**  
One day in the early 1980s, David Nichols, a graduate student in Carnegie Mellon University's computer science department, was in his office on campus craving a soda, but his office was a long way from the building's Coke machine. Considering his fellow student's caffeine habits, he knew there was a good chance it would be empty, or the remaining sodas inside would be tragically warm.



## The first IoT Device

# The Idea

The content of the Coke machine is determined from afar by keeping close tabs on its lights. The machine had six columns with glass soda bottles. When a purchase was made, the corresponding column will flash a red light for a few seconds before it turns back. The light will only stay on, if the column is empty and will last until the sodas were replaced.

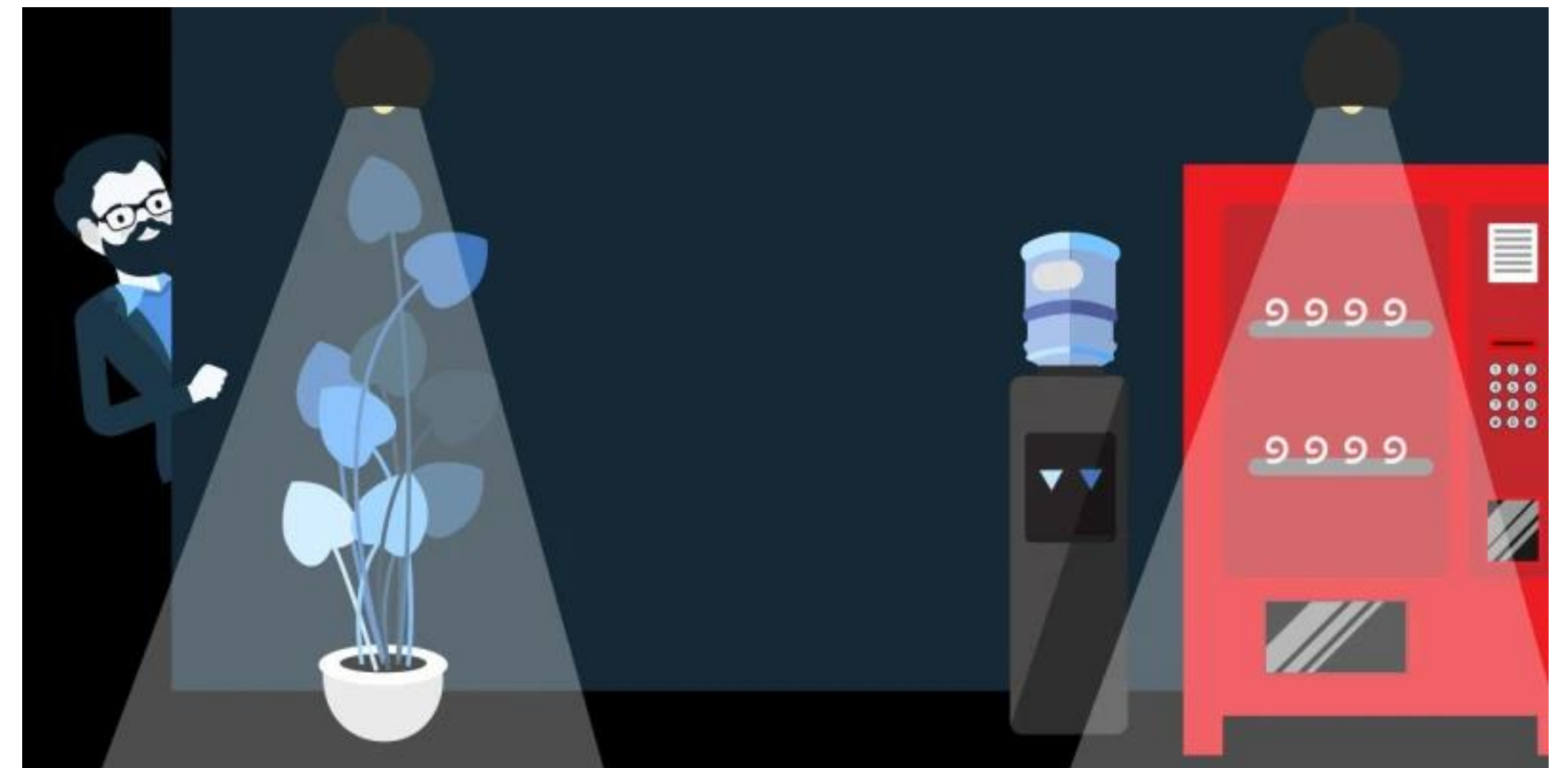
- Nichols wrote to a few friends about his idea in tracking the machine's contents remotely. The implementation of this project was done by Nichols, Zsarnay and Kazar.





## A modified Coke Vending Machine

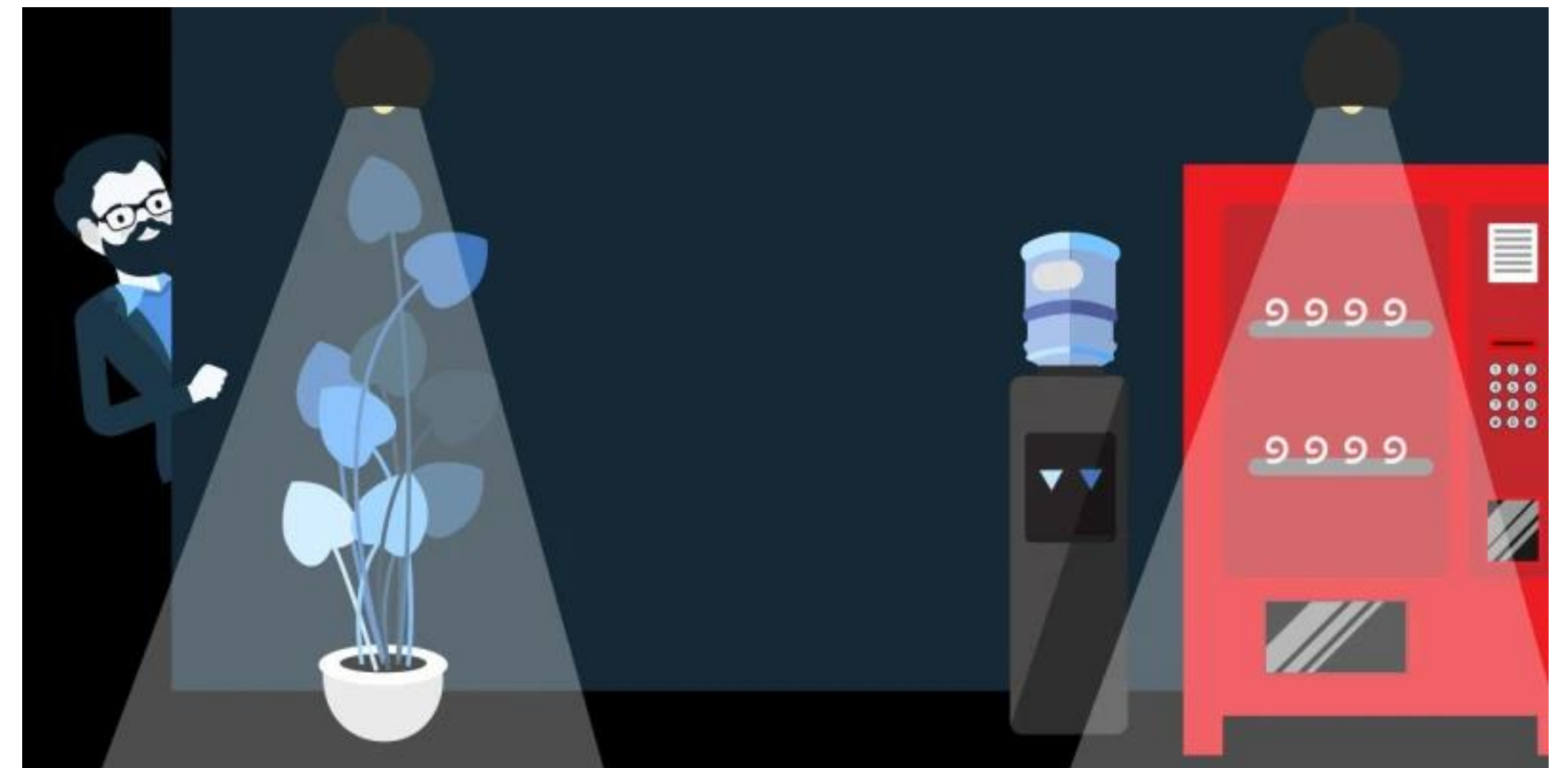
To pull data from the machine, Zsarnay installed a board that sensed the status of each of the indicator lights. A line from the board ran to a gateway for the department's main computer, which was connected to the ARPANET—a precursor to today's Internet, which, at the time, served less than 300 computers worldwide.





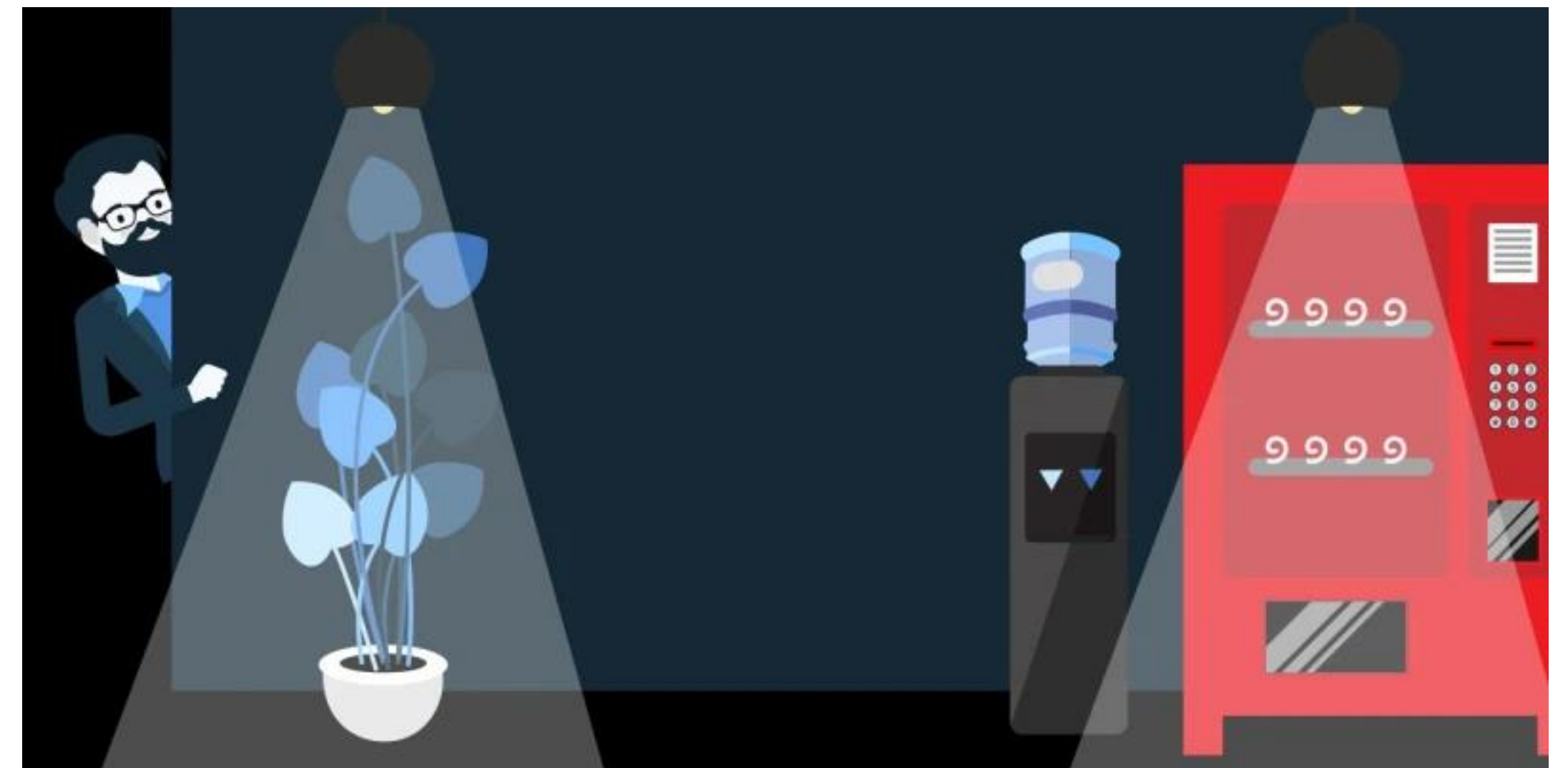
## A modified Coke Vending Machine

Kazar wrote a program for the gateway that checked the status of each column's light a few times per second. If a light transitioned from off to on but then went off again a few seconds later, it knew that a Coke had been purchased. If the light stayed on more than five seconds, it assumed the column was empty. When the light went back off, the program knew that two cold Cokes were now available for purchase, while the rest of the bottles were still warm. The program tracked how many minutes the bottles had been in the machine after restocking.



## A modified Coke Vending Machine

The group added code to the main computer's finger program, which allowed anyone on a computer connected to the ARPANET—or anyone connected to Carnegie Mellon's local Ethernet—to access information about the machine. With a few simple keystrokes, they could find out if there were any Cokes in the machine, and, if so, which ones were cold.



# Examples of IoT Technologies in the business area



## Examples of business areas using IoT Technologies

- Examples of different business areas using IoT Technologies.
- The following areas are discussed:
  - Insurance Business
  - HR Management
  - Tourism
  - Stock Balance Inventory
  - Transport and Car Industry
  - Energy Industry
  - Healthcare

## Examples of business areas using IoT Technologies

# Insurance Business

- Using IoT in the Insurance Business world, it will be possible to offer personalized products depending on the client's lifestyle.
- Based on the large amount of data received from the different sensors, the insurance company will be able to anticipate possible damage, rather than reimburse it.
- By receiving information directly and immediately from the sensors, being the source, the insurance companies will be able to send their representatives to where people need help as soon as possible.
- When a device gets damaged, the insurance company will be able to get the information immediately.

## Examples of business areas using IoT Technologies

# HR Management

- IoT technology can be used as an HR management improvement tool.
- IoT technology can use physical activity sensors to stimulate and promote a healthy lifestyle among employees.
- IoT technology can also be used in monitoring productivity and more efficient task allocation.
- With the use of IoT technologies, a company can get a real-time picture of where their people are and where they are more needed, making HR management more flexible.



## Examples of business areas using IoT Technologies

# Tourism

- Many companies of this area are already using IoT elements and experiment with their wider application.
- Airlines use sensors to track real-time flight data, optimize fuel consumption and predict the need for maintenance.
- Hotels use sensors to control heating, air conditioning, ,utilities and security systems.

## Examples of business areas using IoT Technologies

# Stock Balance Inventory

- The real revolution relies on how companies monitor and manage their inventory stock.
- Devices that track stocks of goods at a certain position are already used.
- To free up time for employees to solve more complex and interesting tasks, devices will be used to comprehensively monitor changes in balances at higher level.

## Examples of business areas using IoT Technologies

# Transport and Car Industry

- The analysis of the situation on the roads and the exchange of data between cars, can be used to avoid traffic jam and reduce the time of commuting.
- Integrating the city infrastructure's road with sensors will provide data that can be used to analyze the city traffic situation and adjust traffic lights to minimize traffic jams or even eradicate it entirely.



## Examples of business areas using IoT Technologies

# Energy Industry

- Smart electricity meters can monitor consumer consumption and receive feedback from the central system of the company.
- This two-way communication can probably avoid breakdowns during peak demand, as well as inform engineers about malfunctions.
- Using IoT technologies in the energy industry will change the traditional methods of doing business by energy companies.

## Examples of business areas using IoT Technologies

# Healthcare

- Data collected from a variety of wearable devices will significantly improve patient care, as well as achieving higher level of efficiency in terms of patient-information monitoring accuracy, which will make their life saver.
- Malfunction notifications and repair necessity from the devices can be send though the internet to the responsible employee directly. This is very important since an equipment breakdown can be a matter of life and death for the patients.

# Examples of IoT applications in the business world



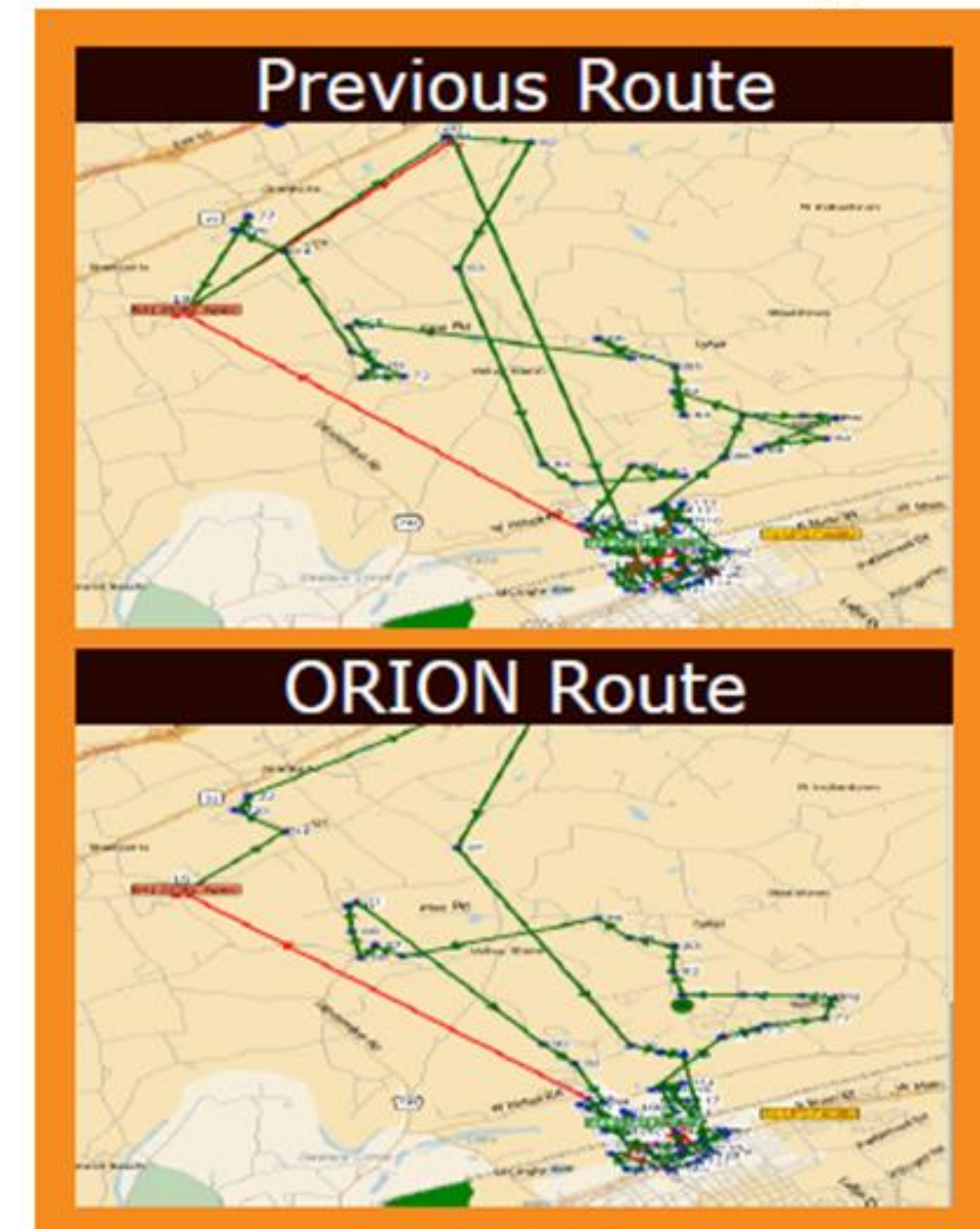
## Examples of IoT in Business

- Many businesses take advantage of the Internet of Things in several ways, to keep the competition in high levels.
- Some examples of how the IoT is being used in the business world are the following:
  - United Parcel Services (UPS)
  - Johnnie Walker
  - Walt Disney World
  - BT Group

**Examples of IoT in Business**

# United Parcel Service (UPS)

- In 2008, UPS installed GPS devices in its delivery vehicles.
- ORION (On-Road Integrated Optimization and Navigation) system was developed to identify the shortest and most fuel-efficient routes
  - Allowed them to save an estimated 1.5 million gallons of fuel over 10,000 courses.

**UPS's ORION Technology**



**Examples of IoT in Business**

# Johnnie Walker

- To bolster its marketing strategy, the parent company of Johnnie Walker, Diageo, started to use IoT.
- In March 2015, a smart label for the flagship Blue Label Whiskey was introduced.
- The smart label can assist consumers when purchasing the product.
- It can also sense if the bottle is open or closed.
- After opening the bottle, the label can send information to the consumer on the best way to enjoy the product.



**Examples of IoT in Business**

# Walt Disney World

- MagicBand is a wrist bands that have an RFID chip inside with a short range transmitter for scanning it at various locations in the parks and a long range transmitter which is used for location purposes.
- It acts as room key, park admission, a method of payment entry to FastPass+ lines, memory maker photo pass and are used to spend your Disney Dining Plan credits, as well as a pool access pass.
- The park can collect the data and determine on which attractions are the most popular and where attention needs to be taken to improve the experience of the guests.





## Examples of IoT in Business

### BT Group

- BT Group has developed a collar that are worn by livestock to monitor their health.
- The Silent Herdsman is a collar that can report the amount of milk a cow produces, its fertility cycle and when it has given birth.
- It can also locate animals that have wandered away or been stolen.



## Examples of IoT in Business

# Fitness First

- Fitness First is a gym that uses IoT technology.
- They can track who is entering their gym and based on these information they can grow their business by reaching out to current customers that regularly visit the gym to encourage them to invite their friends.
- Tracking usage of particular exercise machines will help the company make better choices when outfitting new gyms.





**Examples of IoT in Business**

# Siemens Wind Turbines

- It invests in renewable energy and generating power from wind turbines.
- Sensors are employed on the turbines to keep them running at peak efficiency as well as to help protect them at powerful winds.
- It is important in areas that are not readily accessible by maintenance crews.



# Use cases: successfully IoT applications



## Case Studies

- The following topics will be discussed as case studies:
  - Smart farming
  - Automotive Industry



## Case Studies

# Case study: Smart agriculture





## Smart Agriculture

- Modern agriculture can be referred to with many ways.
  - AgriTech refers to the general application of technology in agriculture.
  - Smart Agriculture refers to the IoT solutions in agriculture.
- Smart agriculture refers to the collection of food and agriculture production with the use of Internet of things, big data and advanced analytics technology.
- The most common IoT apps in smart agriculture are:
  - Sensor based systems that are used to monitor any factor influencing the production, such as soil, fields, livestock.
  - vehicles, drones, autonomous robots and actuators used for smart agriculture.
  - Smart greenhouses or hydroponics that are connected agriculture spaces.
  - Data analytics, visualization and management systems.

## Benefits of Smart Agriculture

- Excelled efficiency
- Expansion
- Reduced resources
- Cleaner process
- Agility
- Improved product quality



## IoT Challenges in Agriculture

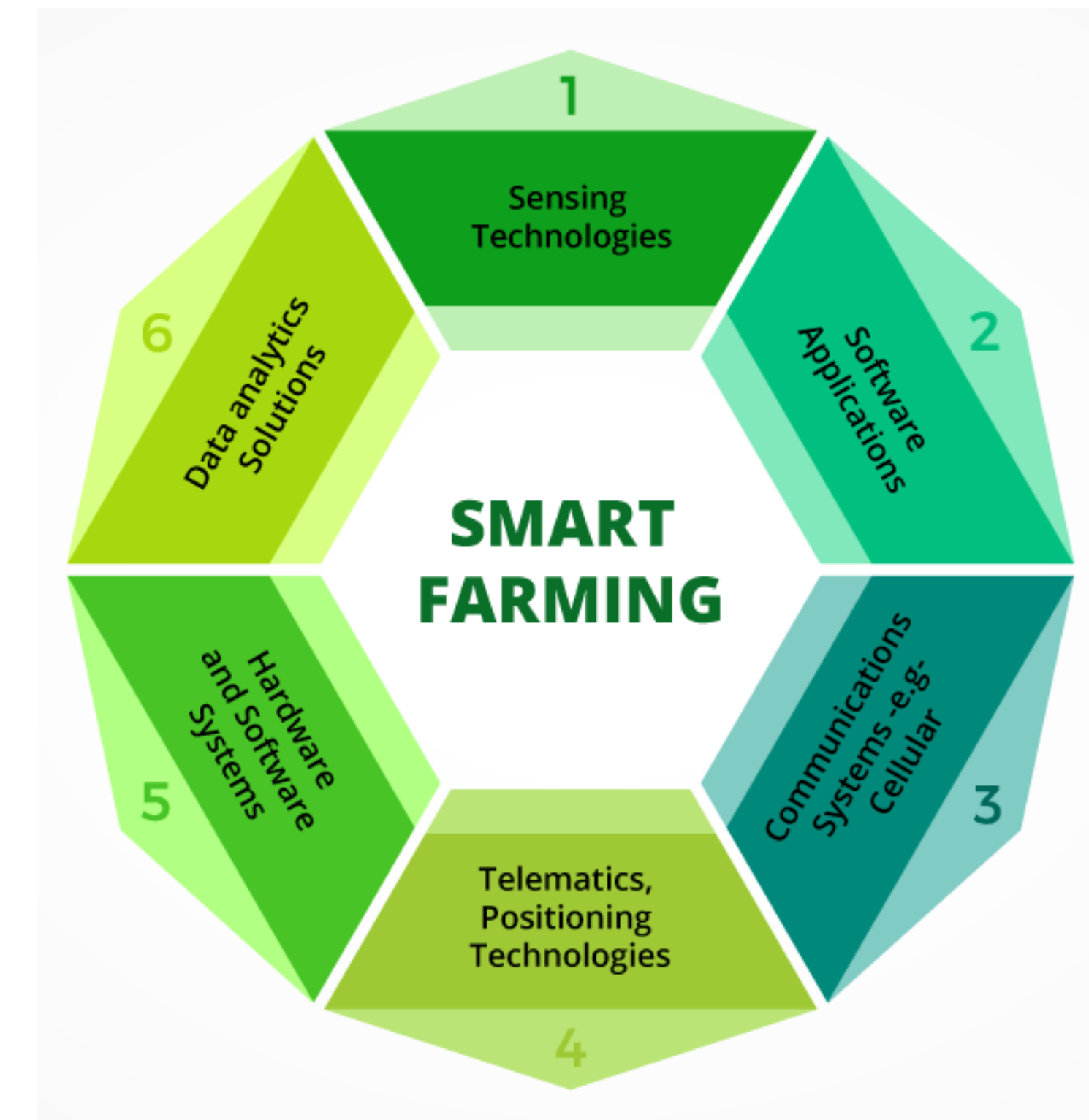
- The process of upgrading the traditional technology into IoT and big data technology can not be done without any problems.
  - **Connectivity:** An IoT system needs connectivity to be provided throughout the agriculture environment in order to work. In general, the connectivity creates a problem in IoT solutions due to the diversity of the system using different protocols and data transmission methods.
  - **Design and durability:** Any IoT system used for agriculture needs to be able to handle outdoor space conditions. For this reason, the design of each needed solution must be uncomplicated and functional.
  - **Limited resources and time:** The constantly changing environment and lack of time are two parameters that need to be considered in the IoT solutions provided in the area of agriculture.

**Smart Farming**

Smart Farming is a concept of farming management using modern Information and Communication Technologies in order to increase the quantity and quality of products.

## Technology used in Smart Farming

- **Sensing Technologies:** water, soil, light, humidity, temperature management.
- **Software Applications:** specified solutions that target specific farm types.
- **Communication Technologies:** cellular, LoRa, etc.
- **Positioning Technologies:** GPS, Satellite, etc.
- **Robotics:** autonomous tractors, processing facilities, etc.
- **Data Analytics:** underlie the decision making and prediction processes.



## 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

## Benefits of Smart Agriculture

# 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.

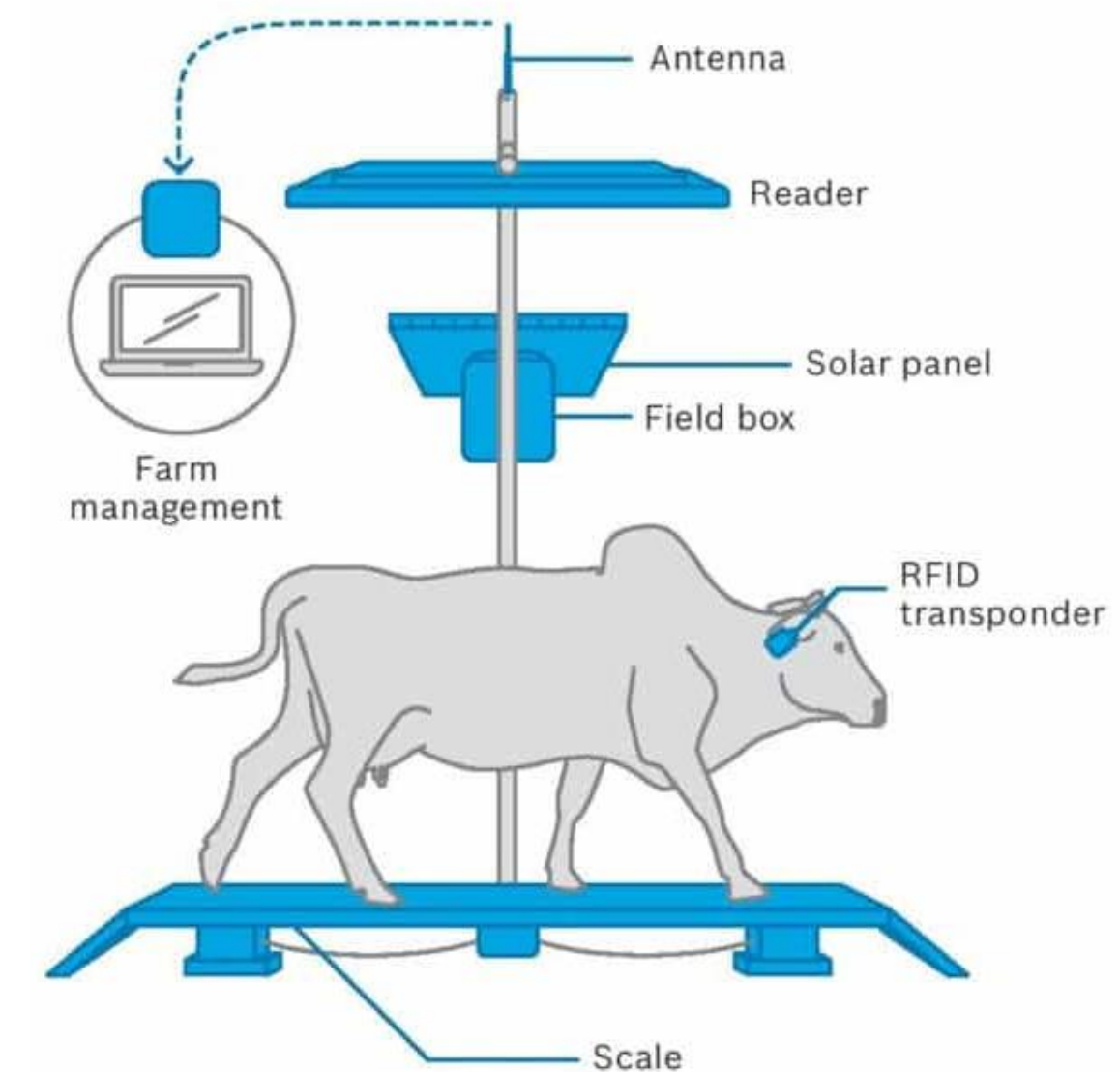
**Benefits of Smart Agriculture**

## 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

**Benefits of Smart Agriculture****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





**Benefits of Smart Agriculture****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.





**Benefits of Smart Agriculture**

# 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









## Automotive Industry

- Automotive industry refers to all companies and activities that are involved in the manufacture of motor vehicles.
- These companies are involved in the design, development, manufacturing, marketing and selling of motor vehicles.
  - It includes engines and bodies, but excludes tires, batteries and fuel.
- Their principal products are passenger automobiles and light trucks. However, commercial vehicles are secondary priority.

## How IoT is transforming the Automotive Industry

- Here are 5 ways that IoT can transform not only automotive industry but also roads:
  1. It will change the way people drive
  2. It can improve road safety
  3. It can help solve traffic congestion in cities
  4. It will lead to better roads
  5. It can help reduce pollution and energy expenditure

## How IoT is transforming the Automotive Industry

# 1. Change the way people drive

- Standard cars could be evolved from merely assisting drivers to fully taking control.
- Integrated cars equipped with sensors will be able to recognize and communicate with upgraded road signs, marking and through a network of cameras.
- The vehicles will be able to do tasks for drivers.
- Vehicles could be able to pay for their own insurance.



## How IoT is transforming the Automotive Industry

### 2. Improve road safety

- Detecting accidents and bad driving through alerts.
- IoT technology can reduce the majority of accidents caused by human error.
  - By monitoring driving habits
  - Sending recommendations to drivers.
- Accidents will be reduced due to more vehicles becoming autonomous.
  - The more data will be used to improve the driving habits of the vehicles on the road.

## How IoT is transforming the Automotive Industry

### 3. Solve traffic congestion

- IoT technology can be used for swarm intelligence in traffic.
- Traffic operators will coordinate cars in order to reduce congestion.
- Common chokepoints as well as the time of day the roads are busiest can be identify.
- It can help engineers and road experts to alleviate traffic conditions.

## How IoT is transforming the Automotive Industry

### 4. Reduce pollution and energy expenditure

- Information about city roads can be revealed from IoT data and used to create greener solutions.
- Investing in road sensors, phased traffic lights and smart parking, can help reduce the toxic gas emissions.
- Unnecessary electricity consumption can be saved by tracking the movement of streetlights on a road and determine when the light is needed.



## How IoT is transforming the Automotive Industry

### 5. Lead to better roads

- IoT technology can be used to build roads that can help detect:
  - Road maintenance needs
  - Traffic usage
  - Accident statistics
- It ensures that roads are not left in a poor condition.
- In the future, roads can be turned into energy sources.
  - They can be used for solar energy power in order to power electric vehicles.



## IoT Applications in the Automotive Industry

- IoT applications open up new opportunities for vehicles.
- The following two apps are further explore:
  1. Vehicle Tracking
  2. Connected Cars



## IoT Applications in the Automotive Industry

# Vehicle Tracking

- Monitoring the location of each vehicle with the use of a GPS-enabled trackers that communicate with a local low-power wide area network.
- Salespeople can quickly find vehicles by displaying on a user interface the vehicle location and information.
- From the consumer perspective a vehicle tracking device can be used to find the parking location, if it is stolen or even if their children have taken it out for a ride.
- Tracking vehicles is done by plugging a GPS-enabled device into a vehicles' diagnostic port.

## IoT Applications in the Automotive Industry

# Connected Cars

- Connected Cars are built from the cooperation of automobile manufacturing companies, telecommunication service providers and software companies.
- A connected car is a car that is equipped with Internet access, which allows the car to share internet access as well as data with other devices that are either inside or outside of the vehicle.
- Nowadays, only a small number of cars that are internet enabled exist, but it is expected that the number will rise in less than a decade's time.

**IoT Applications in the Automotive Industry**

# 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





## IoT Applications in the Automotive Industry

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## Connected Cars: Applications/Services

- **Infotainment:** an in-vehicle system that delivers a combination of information and entertainment. It is worth mentioning that infotainment options need to be organized well and their accessing features should be intuitive in order to avoid drivers to be distracted.
- **Vehicles and Smartphones Integration:** using on-board diagnostics port, which monitors emissions, mileage, speed and other data, can be displayed to the driver's smartphone information about the vehicle, like engine problems or crucial parameters, as well as sent them to service providers for analysis.

## IoT Applications in the Automotive Industry

# Connected Cars: Applications/Services

- **Driving Insight - Analytics:** using a smartphone's sensors in the vehicle, data collected from its sensors can be used to model the driving behavior.
- **On-board Diagnostics for Predictive maintenance:** the on-board diagnostics port is used for self-diagnosis and reporting any occurrence of issues that may or have already occurred within the system of the vehicle
- **Safety:** Real Time driver Monitor: real-time monitoring systems of vehicles are developed to control the speed and fatigue level of the driver in order to prevent accidents.



**IoT Applications in the Automotive Industry**

# Connected Cars: Applications/Services

- **Geofencing and Speed Monitoring:** using speed sensors to measure the speed of the vehicle it is possible to alert the driver at times of exceeding the predefined speed threshold. Additionally, using location tracking sensors, like GPS, it is possible to alert the driver if it has gone out of a predefined geographical area.
- **Stolen Vehicle Tracking:** when a vehicle is stolen, it is possible to track it with the use of IoT technology on the vehicle. Using the GPS and GSM hidden in the vehicle it is possible to monitor and track the location of it.
- **Biometrics Information for Driver Identification:** identify and authenticate the driver is possible with biometric information. Monitoring the health condition of the driver is also useful in preventing accidents.

## Vehicle Communication

- With the emerge of more connected cars and the in-vehicle embedded connectivity becoming common, new vehicle communication arise:
  - **Vehicle to Vehicle (V2V)**: a wireless network communication between vehicles. Each vehicle broadcasts a message with its speed and location to its nearby vehicles over an ad hoc mesh network in order to prevent accidents.
  - **Vehicle to Infrastructure (V2X)**: a wireless information transmission between vehicle and roadside infrastructure in order to avoid or mitigate accidents, as well as providing a wide range of other safety, mobility and environmental benefits. Vehicles can communicate with roads, digital signage, traffic lights, safety and control systems in order to avoid crashes and traffic congestion.
  - **Vehicle to Retail (V2R)**: retail companies present to drivers location-based advertisements.

## Intelligent Transportation with IoT

- **Smart Parking:** is a system that will allow people to reserve a parking space, which optimizes the use of parking space and will result in efficient parking and smoother traffic flow.
- **Smart Street Lighting:** is the system where the street lights are dimmed or switched off when no activity is detected, but brightens when movement is detected.
- **Intelligent Traffic Control with priority for emergency vehicles:** is a system that gives priority to selected types of users, like public transport or emergency services.
- **Emissions and Air Quality Monitoring:** an IoT-based technology system used for monitoring and controlling vehicle emission.



## New Generation Cars

- Autonomous/Self driving car: a vehicle that is designed to sense its environment and navigate without any human input.
- Electric car: a vehicle that is powered by an electric motor using electrical energy stored in array of rechargeable batteries.

## Summary

- ❑ **The first IoT Device**
- ❑ **Examples of IoT technologies in the business area**
  - ❑ Insurance Business
  - ❑ HR Management
  - ❑ Tourism
  - ❑ Stock Balance Inventory
  - ❑ Transport and Car Industry
  - ❑ Energy Industry
  - ❑ Healthcare
- ❑ **Examples of IoT applications in the business world**
- ❑ **Use cases: successfully IoT applications**
  - ❑ Smart Agriculture
  - ❑ Automotive Industry IoT

