Vehicular IoT

Introduction to IoT

S. Misra, A. Mukherjee, A. Roy

Overview

Introduction

- The number of vehicles is increasing rapidly across the globe.
- The number of on-road accidents and mismanagement of traffic is also increasing.
- The increasing number of vehicles gives rise to the problem of parking.
- Vehicular IoT systems have penetrated different aspects of the transportation ecosystem, including on-road to off-road traffic management, driver safety for heavy to small vehicles, and security in public transportation.
- The vehicles are capable of communicating and sharing their information.
- IoT enables a vehicle to sense its internal and external environments to make certain automatic decisions.
- A vehicle owner residing in Earth's can very easily track his vehicular asset remotely.

Vehicular IoT

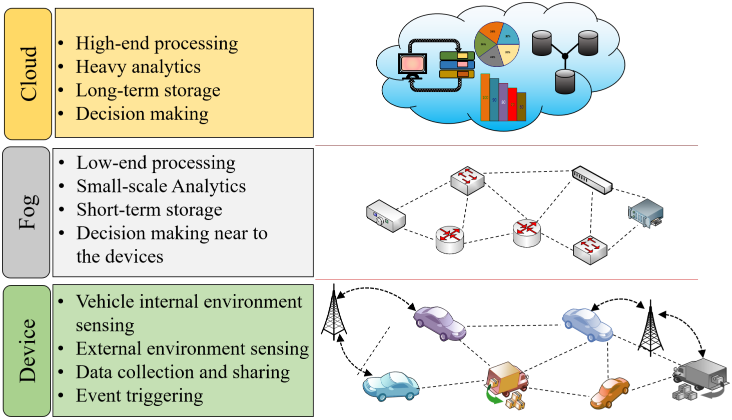

Figure: An architecture of vehicular IoT

Vehicular IoT

- **Device layer**
  - Consists of basic infrastructure of connected vehicles scenario.
  - Includes the vehicles and road side units (RSU).
  - Vehicles contain certain sensors which gather the internal information of the vehicles.
  - The RSU works as a local centralized unit that manages the data from the vehicles.

Vehicular IoT

- **Fog layer**
  - Fast decision making is pertinent to avoid accidents and traffic mismanagement.
  - Fog computing plays a crucial role by providing decisions in real-time.
  - The fog layer helps to minimize data transmission time in a vehicular IoT system.

Vehicular IoT

- **Cloud layer**
  - Fog computing handles the data processing near the devices and makes an instant decision.
  - For the processing of huge data, fog computing is not enough.
  - In a vehicular IoT system, cloud computing helps to handle processes that involve a huge amount of data.
  - For long-term storage, cloud computing is used as a scalable resource in vehicular IoT systems.

Components of Vehicular IoT

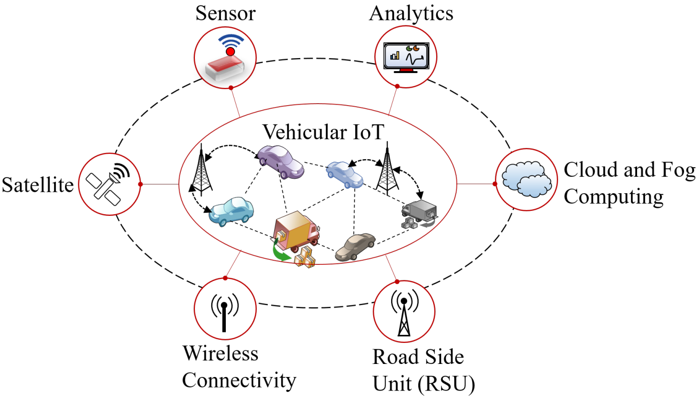

Figure: Components of vehicular IoT

Components of Vehicular IoT

- **Sensors**:
  - In vehicular IoT, the sensors monitor different environmental conditions and help to make the system more economical, efficient, and robust.
  - Traditionally, two types of sensors – internal and external – are used
    - Internal: These types of sensors are placed within the vehicle. Examples – GPS, fuel gauge, ultrasonic sensors, proximity sensors, accelerometer, pressure sensors, and temperature sensors.
    - External: These sensors quantify information of factors outside the vehicle. Examples – rainfall, and light sensors.
- **Satellites**:
  - In vehicular IoT systems, automatic vehicle tracking and crash detection are among the important available features.
  - Satellites help the system to track vehicles and detect on-road crashes. The satellite image is also useful for detecting on-road congestion and road blocks.

Components of Vehicular IoT

- **Wireless connectivity**:
  - Communication is an important enabling component in vehicular IoT
  - For transmitting the sensed data from multiple sensors to RSU (roadside unit) and from RSUs to the cloud, connectivity plays an indispensable role
  - Different communication technologies, such as Wi-Fi, Bluetooth, and GSM, are common in the vehicular IoT systems.
- **Road Side Unit (RSU)**:
  - The RSU is a static entity that works collaboratively with internal and external sensors.
  - The RSUs are equipped with sensors, communication units, and fog devices.
  - The fog devices attached to the RSUs process the sensed data and take necessary action promptly
  - Sometimes, these RSUs also work as an intermediate communication agent between two vehicles.

Components of Vehicular IoT

- **Cloud and fog computing**:
  - Fog computing handles the light-weight processes geographically closer to the vehicles than the cloud.
  - For faster decision making, fog computing is used in vehicular IoT systems.
  - For a heavy-weight process, fog computing may not be a suitable option.
  - The choice of the application of fog and cloud computing depends on the situation.
- **Analytics**:
  - Similar to different IoT application domains, in vehicular IoT, analytics is a crucial component.
  - Vehicular IoT systems can be made to predict different dynamic and static conditions using analytics.

Advantages of vehicular IoT

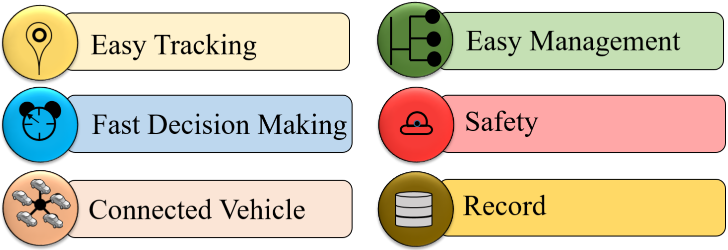

Figure: Advantages of vehicular IoT

Advantages of vehicular IoT

- **Easy tracking**:
  - The tracking of vehicles is an essential part of vehicular IoT.
  - the system must know from which location and which vehicle the system is receiving the information.
  - The tracking of vehicles is straightforward; the system can collect information at a remote location.
- **Fast decision making**:
  - Most of the decisions in the connected vehicle environment are time-critical.
  - The fast and active decision making are pertinent for avoiding accidents.
  - Cloud and fog computing help to make fast decisions with the data received from the sensor-based devices.

Advantages of Vehicular IoT

- **Connected vehicles**:
  - A vehicular IoT system provides an opportunity to remain connected and share information among different vehicles.
- **Easy management**:
  - Vehicular IoT systems consist of different types of sensors, a communication unit, processing devices, and GPS
  - The management of the vehicle becomes easy.
  - The connectivity among different components in a vehicular IoT enables systems to track every activity in and around the vehicle.
  - The IoT infrastructure helps in managing the huge number of users located at different geographical coordinates.

Advantages of Vehicular IoT

- **Safety**:
  - Safety is one of the most important advantages of a vehicular IoT system.
  - With easy management of the system, both the internal and external sensors placed at different locations play an important role in providing safety to the vehicle, its occupants, as well as the people around it.
- **Record**:
  - Storing different data related to the transportation system is an essential component of a vehicular IoT.
  - The record may be of any form, such as video footage, still images, and documentation.
  - By taking advantage of cloud and fog computing architecture, the vehicular IoT systems keep all the required records in its database.

Case Study

Crime assistance in a smart IoT transportation system

- The system highlights a fog framework for intelligent public safety in vehicular environments (fogFISVER) [1]
- The primary aim of this system is to ensure smart transportation safety (STS) in the public bus services.
- The system works through the following three steps:
    1. The vehicle is equipped with a smart surveillance system which is capable of executing video processing and detecting criminal activity in real-time.
    2. A fog computing architecture works as the mediator between a vehicle and a police vehicle.
    3. A mobile application is used to report the crime to a nearby police agent.

Case Study

Architecture:

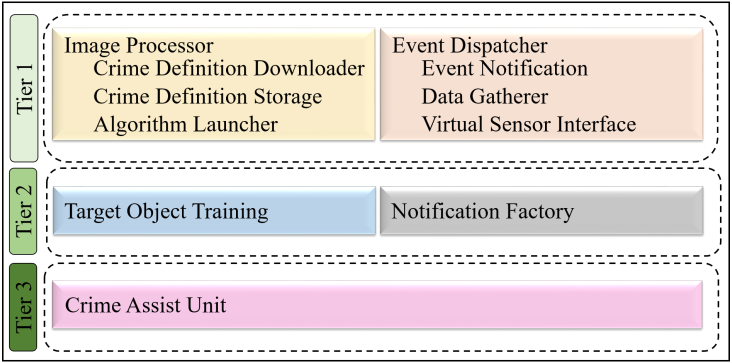

Figure: Architecture of Fog-FISVER

Case Study

Tier 1 - Invehicle FISVER STS Fog:

- A fog node is placed for detecting criminal activities.
- Tier 1 accumulates the real sensed data from the vehicle and processes it to detect possible criminal activities inside the vehicle.
- This tier is responsible for creating crimelevel metadata and transferring the required information to the next tier.
- For performing all the activities, Tier 1 consists of two subsystems – Image processor and event dispatcher

Case Study

Image processor:

- Similar to the human eye for detecting criminal activities.
- Developers of the system used a deep-learning-based approach for enabling image processing techniques in the processor.
- To implement the fog computing architecture in the vehicle, a Raspberry-Pi-3 processor board is used
- Raspberry-Pi-3 is equipped with a high-quality camera.
- The architecture uses template matching and correlation to detect the presence of dangerous articles (such as a pistol or a knife) in the sub-image of a video frame.
- The image processor stores a set of crime object templates in the fog-FISVER STS fog infrastructure.

Case Study

Image processor:

- **Crime definition downloader**:
  - This component periodically checks for the presence of new crime object template definitions in fog-FISVER STS fog infrastructure.
  - If a new crime object template is available, it is stored locally.
- **Crime definition storage**:
  - In order to use template matching, the crime object template definition is required to be stored in the system.
  - The crime definition storage is used to store all the possible crime object template definitions.
- **Algorithm launcher**:
  - This component initiates the instances of the registered algorithm in order to match the template with the video captured by the camera attached in the vehicles.
  - If a crime object is matched with the video, criminal activity is confirmed.

Case Study

Event dispatcher:

- **Event notifier**:
  - It transfers the data to the fog-FISVER STS fog infrastructure, after receiving it from the attached sensor nodes in the vehicle.
- **Data gatherer**:
  - This is an intermediate component between the event notifier and the physical sensor; it helps to gather sensed data.
- **Virtual sensor interface**:
  - Multiple sensors that sense data from different locations of the vehicle are present in the system.
  - The virtual sensor interface helps to maintain a particular procedure to gather data.
  - This component also cooperates to register the sensors in the system.

Case Study

Tier 2 - FISVER STS Fog Infrastructure:

- Tier 2 works on top of the fog architecture.
- Primarily, this tier has three responsibilities – keep updating the new object template definitions, classifying events, and finding the most suitable police vehicle to notify the event.
- FISVER STS fog infrastructure is divided into two sub-components – Target Object Training and Notification Factory

Case Study

Target Object Training:

- This sub-component of Tier 2 is responsible for creating, updating, and storing the crime object definition.
- The algorithm launcher uses these definitions in Tier 1 for the template matching process.
- The template definition includes different features of the crime object such as color gradient and shape format.
- A new object definition is stored in the definition database.
- The database requires to be updated based on the availability of new template definitions.

Case Study

Notification Factory:

- This sub-component receives notification about the events in a different vehicle with the installed system.
- This component receives and validates the events.
- In order to handle multiple events, it maintains a queue.

References

1. A. J. V. Neto, Z. Zhao, J. J. P. C. Rodrigues, H. B. Camboim and T. Braun,““Fog-Based Crime-Assistance in Smart IoT Transportation System,” Specicial Issue on Cyber-Physical-Social Comuting and Networking, IEEE Access, Vol. 6, pp.11101-11111, 2018
2. C. Roy, A. Roy, S. Misra, and J. Maiti, “Safe-aaS: Decision Virtualization for Effecting Safety-as-a-Service,” in IEEE Internet of Things Journal, vol. 5, no. 3, pp. 1690-1697, June 2018.

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