A SURVEY ON FOG COMPUTING FOR ITS VARIOUS APPLICATIONS

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Abstract : Due to fast development in industrial Internet of Things (IOT)s , the emergence of the Fog Computing provides many applications for IOT such that environmental monitoring, infrastructure management, home automation, including smart traffic lights, home energy management and augmented reality which supports many features like low latency, location awareness and geographic distribution .

IndexTerms **– Fog computing, Internet of Things.**

I. Introduction

A large number of physical objects are being connected to the Internet of Things (IoT). It is the internetworking of various objects and network connectivity that allows these objects to communicate and exchange data, including sensors, smart meters, smart phones, smart vehicle etc. The interconnection of these devices enables advanced IoT applications, e.g., product tracking, environment monitoring, patients surveillance and energy management, and expands the automation to our daily life.

One of the IoT applications is smart home, which enables residents to automatically open their garage when arriving home, start air condition, prepare coffee, and control lights, TV and other appliances. IoT also plays an increasingly important role in other domains, including smart city, smart grid, e-healthcare, intelligent transportation, industrial automation and disaster response. It opens the door to innovations that facilitate new interactions among "things" and human, and provides new opportunities to applications, infrastructures and services that improve the quality of our daily life.

The concept of fog computing was introduced by Cisco in 2012, which is defined as "an extension of the cloud computing paradigm that provides computation, storage, and networking services between end devices and traditional cloud servers"
Fog computing: 'Fog computing' term is defined as "a scenario where a huge number of heterogeneous and decentralized devices communicate and potentially cooperate among them and with the network to perform storage and processing tasks without the intervention of third parties. These tasks can be for supporting basic network functions or new services and applications that run in a sandboxed environment. Users leasing part of their devices to host these services get incentives for doing so."

II. OVERVIEW OF FOG COMPUTING APPLICATIONS

Fog Computing supports low bandwidth, latency, and reliability constrain. Basically, fog computing has a huge potential to fulfill the diverse requirements in various applications ranging from smart cities, transportation, surveillance and healthcare to large-scale industries.

Some of the typical applications and how fog computing can be applied to overcome the major limitations in these applications are summarized here. The details are presented as follows:

2.1 Smart Traffic Lights:

Here, a fog node detects the flashing lights of an ambulance or a police car using video cameras and automatically changes traffic lights to open the lines for fast driving through. The fog nodes also can use the deployed sensors on roads to detect the presence of pedestrian and bicycles and measure the driving speed and distances of approaching vehicles, and thereby change traffic lights to make convenient to pedestrian and bicycles. In addition, neighboring fog nodes coordinate to send warning signals to the approaching vehicles to avoid collision. Therefore, the smart traffic lights can do rapid response to the approaching pedestrian, bicycles and vehicles based on the collected data from video cameras and sensors. Therefore, smart traffic lights can contribute to create green traffic for vehicles and pedestrian.

2.2 Healthcare and Activity Tracking

Fog computing can play an important role in smart e-healthcare systems. For example, fog computing can be used to detect, predict and prevent falls for stroke patients and sudden cardiac death for cardiovascular patients. The fog nodes (i.e., smart phones) can start alarms and send warning signals to hospitals once they detect sudden events happening, such that the chance of survival can be dramatically improved. Moreover, fog nodes can provide automatically personal care for patients in hospitals. They can collect data from sensors deployed on the body of patients to discover emergent events and thereby take actions timely to give intensive care. Therefore, smart healthcare systems can definitely shorten the time of first aid and improve the success rate in rescuing patients.

2.3 Decentralized Vehicular Navigation

Real-time traffic information is essential to monitor congestion and navigate for drivers. How to collect real-time road conditions and respond proper paths to drivers timely is a critical problem in navigation systems. Fog computing plays an important role in local data collection and navigation result response. Specifically, fog nodes, which are upgraded roadside units that stretch to have computational capabilities and storage spaces, can maintain traffic information reported by the driving vehicles in their coverage areas. If a fog node receives a navigation request from a vehicle, it can cooperate with other fog nodes to generate a proper driving path for the querying vehicle to its destination, and rapidly returns the path to the querying vehicle. Thus, the vehicle can enjoy real-time navigation services flexibly and take actions to avoid being stuck in traffic congestion promptly.

In addition, fog computing enables other low-latency and autonomous local IoT applications, such as home energy management, augmented reality and gaming, indoor location and navigation and network resource management.

2.4 Shopping Cart Management

Fog computing can improve users' experience in online shopping. Traditionally, a user's shopping cart is maintained on the cloud, the update of shopping cart view may take time depending on network bandwidth and server loads. This delay may be longer for mobile devices due to the low bandwidth of wireless network. With fog computing, when a user accesses the shopping cart, the fog node caches it and performs the updating operations until the user loges out the cart. To keep the consistency of shopping cart, the fog node sends the final version to the cloud to permanently update the shopping cart. Therefore, fog-based shopping cart management can reduce the delay of shopping cart update and increase users' satisfaction.

2.5 Smart Cities

Fog computing plays an important role to monitor plant growth and climate condition with smart sensor nodes. In such cases, location-awareness, and real-time response are important factors by incorporating the context information. In these scenarios, the data collection and aggregation model in fog computing are highlighted. In addition, water management, greenhouse gases control, and retail automation are some of the examples where fog computing can be widely adopted in the smart cities.

As an application of smart cities, in smart urban surveillance, fog computing can be used for critical and dynamic tasks. In fog computing-based system tracks the vehicles in real-time and enables multi-target tracking using single tracking algorithm.

2.6 Smart Energy Management

As power grid becomes very popular with micro grids which are comprised of the widely distributed generator, power supply, and loads, energy management is essential to balance power generation and consumption for the residential, industrial, and commercial domain. Several organizations such as U.S. Department Of Energy (DOE) aims to reduce the national energy consumption in both residential and commercial buildings. Faruque et al. considered Home Energy Management (HEM), as an application of sophisticated and low-cost energy management system, and found the main research challenges while implementing energy management platform as:

- Performance, interoperability, and interactivity among heterogeneous devices in energy management platform.
- Ability to customize the services, adaptability, and scalability of the energy management platform for various types of buildings, homes, and applications.
- Cost of implementing the energy management platform, hardware, and software stack

Cloud computing, a centralized approach for computing, provides the customers with infrastructure, platform, software, and sensor networks. However, as services with reliability and performance agreements are essential for the energy management platform, increasing the number of devices in the energy management system are not always suitable for some delay-sensitive devices with timing requirements. In contrast, fog computing provides the capability of pre-processing the data while meeting the low latency requirements. However, fog computing must satisfy the above-mentioned requirements in energy management system.

The devices in hardware architecture of energy management platform are mainly categorized as connecting devices, gateway, sensors, actuators, and computing devices. The gateway device maintains the compatibility between multiple devices. Various kind of sensors gathers analog signal generated by the environment. Actuators, which can be optimized for energy consumption, may be either locally or globally controlled. The computing device implemented in the sophisticated controller can store, process, and analyze data. The open source and user-configurable routers can be used as computing node to configure the controller easily. Different routing and discovery algorithm for collecting data can be programmed on the low-powered wireless sensors, e.g., TelosB module with TinyOS.

The energy management, which was implemented on fog computing platform can be used for any buildings and various domains of operation, e.g., home or micro grid. The energy management may have various purposes like 1) monitoring and metering the power consumption of each device, e.g., home power consumption; 2) managing the energy consumption by controlling the devices efficiently, e.g., intelligent lighting, Electric Vehicle (EV) charger, Heating, Ventilation, and Air Conditioning (HVAC) management. The energy management platform is a system of systems. Thus, the hardware, software, and communication architectures should be defined and integrated properly to design the platform for these systems.

2.7 Remote Gaming: Gaming as-a-Service

As mobile gaming is one of the most demanding applications, remote gaming becomes very popular. In a remote gaming system, EUs do not need to download or install any games to tablets, phone, or other devices, instead they can play the game from a server over the Internet. In a remote cloud gaming, the game is being executed and processed in the cloud and users can receive the video and audio streaming while they can control the game from their end. In this way, a user can save a lot of energy of handheld devices. From a game company point of view, some attractive benefits are as follows: 1) gaming-as-a-service can protect the games from privacy, 2) upgrading of games becomes very easy, 3) use more homogeneous platform for developing of games, 4) cheating can be prevented due to storing all game state at the server, and 5) publishing game sessions becomes easier to attract new users.

However, the hand-held devices in EUs suffer from limited energy. The approach to offload the on-demand is one of the possible ways to use mobile as a thin-client and handle all remaining computing at the server side. Mobile computing either aim to save energy or platform the task that cannot be performed solely by the mobile devices. Gaming anywhere was adopted as a gaming platform that is designed for high extensibility, portability and re-configurability is a promising open-source project to implement remote gaming on the mobile devices.

2.8 Intelligent Transportation System

Intelligent Transportation System (ITS) is one of the places where fog computing would be very useful. With the emergence of cloud computing, vehicular networks have gained a significant attention to ensure safety, traffic efficiency, and public convenience. Application architecture that uses transportation and vehicular devices exploits the cloud computing, where developed applications are executed in cloud and data are collected from the vehicular network. However, the large cloud-to-EU delay is one major limitation for the real-time vehicular application. For example, in autonomous driving, one of the ITS applications, the vehicle needs to control the speed, which depends on real-time feedback from road-side infrastructure, traffic flow, and passengers activities.

Fog computing is well suited in VANET because of its geo-distribution, real-time load balancing, and local decision-making mechanism. Vehicles, roadside units, and other transportation infrastructure play an important role in computation process. It is true that the development of fog computing in VANET applications is very challenging than cloud computing-based VANET applications due to high-mobility and latency-sensitive applications.

Heterogeneity, dynamic nature of smart transportation and large-scale co-ordination are some of the main research challenges in fog computing-based transportation systems. Since smart transportation system consists of various devices with different computing capability, heterogeneity becomes an essential issue from fog computing perspective. Also, due to dynamic nature of smart transportation system, there is always a trade-off between the adaptation of system-wide implementation and application layer. Therefore, flexible execution platform is required to balance between difficulty to implement and burden on the developer. As all entities are spread over a large geographical area, smart transportation systems need to handle a huge number of connected devices. As a result, since intelligent transportation systems do not inherit routing layer as in the traditional WSN, large-scale co-ordination becomes a challenging task.

III. Acknowledgment

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