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Editorial

Advances in Mobile Networking for IoT Leading the 4th Industrial Revolution

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The explosion of connected lightweight devices is starting the era of the Internet of things (IoT) where physical world devices have a digital presence on the Internet. Today, connected embedded devices are being placed everywhere in our everyday life, and tens of billions of these devices are expected to be connected to the Internet in the near future. Technologies for thing-to-thing communication between these devices, along with machine-learning and big data technologies, will be one of the key enablers for the truly autonomous and distributed IoT leading the 4th industrial revolution. However, there are still several technical challenges remaining before the next industrial revolution. For example, how to efficiently distribute and manage networking resources for more scalable services, as well as how to improve the energy efficiency and bandwidth utilization of the whole system, is a significant challenge impeding the development and implementation of truly autonomous and distributed applications and services for IoT.

This special issue has focused on technical challenges that can enable IoT. We called for manuscripts presenting and discussing the most recent advances in networked systems for IoT. Until the deadline of the special issue, 20 manuscripts have been received worldwide. After the review process, 14 manuscripts have been accepted by this special issue. The accepted research manuscripts have focused on large-scale industrial IoT services, SDN and network virtualization for IoT, efficient communication methods for IoT, and various emerging IoT applications. Accepted manuscripts present the important research findings, and these advances will contribute to the development of IoT leading the 4th industrial revolution. We provide a summary of the accepted papers below.

Large-scale industrial IoT services are emerging in smart factory domains such as factory clouds which integrate distributed small factories into a large virtual factory with dynamic combinations based on orders of consumers. Since a smart factory has many industrial elements including various sensors/actuators, gateways, controllers, application servers, and IoT clouds and their connections and relations are complex, it is hard to handle them in a point-to-point manner. To address this challenge, a novel software-defined network multicast based on the group-shared tree is proposed which includes the near-receiver rendezvous point selection algorithm and group-shared tree-switching mechanism. The proposed multicast mechanism can reduce packet loss and delay compared to the legacy methods under severe congestion condition.

In smart manufacturing, production machinery and auxiliary devices, referred to as industrial Internet of things (IIoT), are connected to a unified networking infrastructure for management and command deliveries in a precise production process. However, providing autonomous, reliable, and real-time services for such a production is an open challenge since these IIoT devices are assumed lightweight embedded platforms with limited computing performance. To overcome this challenge, a pattern-identified online task scheduling (PIOTS) mechanism for the networking infrastructure is proposed where multitier edge computing is provided to handle the offloaded tasks in real time. Historical IIoT task patterns in every timeslot are used to train a self-organizing map (SOM), which represents the features of the task patterns within defined dimensions. Consequently, offline task scheduling among edge computing-enabled entities is performed on the set of all SOM neurons using the Hungarian method to determine the expected optimal task assignments. Whenever a task arrives at the infrastructure, the expected optimal assignment for the task is scheduled to the appropriate edge computing-enabled entity.

Making SDN data plane flexible enough to satisfy the various requirements of heterogeneous IoT applications is desirable in terms of software-defined IoT (SD-IoT). For this purpose, a new in-network data-processing scheme for the SD-IoT data plane is proposed that defines an event-driven data-processing model which can express a variety of in-network data-processing (e.g., the sensing-data aggregation from thousands of sensor nodes) cases in the SD-IoT environment. Also, the proposed model comprises a language for the programming of the data-processing procedures, while a flexible data-plane structure that can install and execute the programs at runtime is additionally introduced.

Container-based virtualization can offer advantages such as high performance, resource efficiency, agile environment, and ease of management for IoT devices. However, different network modes of containers and their performance issues have not been investigated so far. Thus, an analysis of the container network performance on an IoT device is presented. The results show that the network performance of containers is lower than that of the native Linux, with an average performance difference of 6% and 18% for TCP and UDP, respectively. In addition, the network performance of containers varies depending on the network mode. When a single container runs, the bridge mode achieves higher performance than the host mode by 25%, while the host mode shows better performance than the bridge mode by 45% in the multicontainer environment.

Remote and personalized healthcare is one of the key applications for IoT. Many of these applications are built on mobile devices connected to the cloud. Although appealing, however, prototyping and validating the feasibility of an application-level idea is yet challenging without a solid understanding of the cloud, mobile, and interconnectivity infrastructure. A solution to this is provided by proposing a framework called HealthNode, which is a general-purpose framework for developing healthcare applications on cloud platforms with a focus on ease of implementation. HealthNode presents an explicit guideline while supporting necessary features to achieve quick and expandable cloud-based healthcare applications. A case study applying HealthNode to various real-world health applications suggests that HealthNode can express the architectural structure effectively within an implementation and that the proposed platform can support system understanding and software evolution.

The cognitive radio network is a key technique for the IoT and can effectively resolve the spectrum issues for IoT applications. In this context, a novel method for IoT sensor networks is proposed to obtain the optimal positions of secondary information-gathering stations (SIGSs) and to select the optimal operating channel. The objective is to maximize secondary system capacity while protecting the primary system. In addition, an appearance probability matrix for secondary IoT devices (SIDs) is proposed to maximize the supportable number of SIDs that can be installed in a car, in wearable devices, or for other monitoring devices, based on optimal deployment and probability. Fitness function is proposed based on the above objectives and also considers signal-to-interference-plus-noise ratio (SINR) and position constraints. The particle swarm optimization (PSO) technique is used to find the best position and operating channel for the SIGSs.

Demand for autonomous vehicles is increasing rapidly owing to their enormous potential benefits. However, several challenges such as vehicle localization are involved in the development of autonomous vehicles. A simple and secure algorithm for vehicle positioning is proposed without massively modifying the existing transportation infrastructure. For localization, vehicles on the road are classified into two categories: host vehicles (HVs), which are the ones used to estimate other vehicles' positions, and forwarding vehicles (FVs), which are the ones that move in front of the HVs. The FV transmits modulated data from the tail (or back) light, and the camera of the HV receives that signal using optical camera communication (OCC). In addition, the streetlight (SL) data are considered to ensure the position accuracy of the HV. Using photogrammetry, the distance between FV or SL and the camera of the HV is calculated by measuring the occupied image area on the image sensor. Comparing the change in distance between HV and SL with the change in distance between HV and FV, the positions of FVs can be determined.

The vehicular communication network allows vehicles on the road to communicate with other vehicles or nodes in the Internet. However, in the highway environment with sparsely placed roadside units (RSUs), communications between RSUs and vehicles are frequently disconnected due to high vehicular speeds. To resolve this problem, an enhanced routing mechanism based on AODV is proposed which utilizes both V2I and V2V communications so that RSUs can provide continuous services to vehicles which may be intermittently located outside the coverage areas of RSUs. To reduce the route recovery time and the number of route failures in the sparsely placed RSU environment, backup routes are established through the vehicles with longer direct communication duration with the RSU. For efficient handover to the next RSU, the route-shortening mechanism is also proposed.

Eye-blinking detection or eye-tracking algorithms have various applications in mobile environments such as a countermeasure against spoofing in face recognition systems. In resource-limited smartphone environments, however, one of the key issues is their computational efficiency. To tackle the problem, a hybrid approach combining the two machine learning techniques SVM and CNN is proposed such that the eye-blinking detection can be performed efficiently and reliably on resource-limited smartphones. Experimental results on commodity smartphones have shown that the proposed approach achieves a precision of 94.4% and a processing rate of 22 frames per second.

Finally, head-mounted displays (HMDs) are currently attracting great attention since they can provide an immersive virtual reality (VR) experience at an affordable cost. At the same time, 3D maps such as Google Earth and Apple Maps 3D mode in which users can navigate in 3D models of the real world are widely available in current mobile and desktop environments. However, traditional interface methods such as keyboard and mouse are inappropriate for the navigation through 3D maps in VR environments because the manipulation method does not resemble actual actions in reality. Motivated by this, an immersive gesture interfaces for the navigation through 3D maps are proposed which are suitable for HMD-based virtual environments. An algorithm to capture and recognize the gestures in real time using a Kinect depth camera is also proposed.

Conflicts of Interest

The editors declare that they have no conflicts of interest.

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