Annual Report of Technical Committee on Network Systems

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1. Introduction
This report covers the annual activities of the IEICE Technical Committee on Network Systems (NS). It describes activities at the monthly technical meetings, recent research topics of the committee, and the research awards for 2020.

2. Technical Meetings
The schedule from April 2020 to March 2021 consists of 10 NS technical meetings, one workshop [1], and additionally, three technical meetings of Network Software (NWS) sub-committee (as shown in Table 1). Several meetings are co-located with the OCS (Optical Communication Systems), PN (Photonic Network), SeMI (Sensor Network and Mobile Intelligence), RCS (Radio Communication Systems), SR (Smart Radio), RCC (Reliable Communication and Control), IN (Information Networks), CS (Communication Systems), NV (Network Virtualization), ICM (Information and Communication Management), or CQ (Communication Quality) technical committees. In addition, the technical meeting in May was co-located with the Study Group of “Thinking Network” led by Prof. Akihiro Nakao, the Univ. of Tokyo. This co-location was newly started from 2018. All technical meetings in 2020 were held Online due to COVID-19.

Recently, presented papers mainly focus on technologies that support new generation networks, wireless and mobile networks, IoT, applications, security issues, network virtualization, SDN/NFV, cloud computing, Mobile Edge Computing (MEC), ICN/CCN, blockchain, and Quality of Service/Experience (QoS/QoE). In addition, the number of presented papers related to AI and machine learning is increasing rapidly in recent years.

At each technical meeting, we host lectures by invited speakers who are experts in their research fields. During this fiscal year, we have had invited lectures on network virtualization and softwarization, applications of AI and machine learning, network design, IoT, and other topics. In fiscal 2020, we had 143 presentations from academia and 45 from industry in the NS technical meetings.

Table 1 Technical meeting schedule for fiscal 2020. (Gray cells indicate technical meetings of NWS sub-committee)

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Theme</th>
<th>Co-location with</th>
<th>Co-location with</th>
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<tbody>
<tr>
<td>April 16–17</td>
<td>Online</td>
<td>Traffic, Network Evaluation, Resource Control and Management, Network Reliability and Resilience, Network Intelligence and AI, etc.</td>
<td>The Study Group of “Thinking Network”</td>
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<tr>
<td>June 5</td>
<td>Online</td>
<td>Network Software for IoT System</td>
<td>OCS, PN</td>
<td></td>
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<tr>
<td>June 18–19</td>
<td>Online</td>
<td>Core/Metro System, Photonic Network System, Optical Network Design, Traffic Engineering, Signaling, GMPLS, etc</td>
<td>SeMI, RCS, SR, ROC</td>
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<tr>
<td>July 8–10</td>
<td>Online</td>
<td>AI/ML–based Network, M2M (Machine-to-Machine), D2D (Device-to-Device), IoT (Internet of Things), etc.</td>
<td>IN, CS, NV</td>
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<tr>
<td>September 10–11</td>
<td>Online</td>
<td>SIP, IMS, Cloud/Data Center Network, SDN/NFV, IPv6, Machine Learning, etc.</td>
<td>IN, CS, NV</td>
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<td>October 7–9</td>
<td>Online</td>
<td>Network Architecture (Overlay, P2P, Ubiquitous Network, Active Network, NGN, New Generation Network), Grid, etc</td>
<td>OCS, PN</td>
<td></td>
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<tr>
<td>October 22–23</td>
<td>Online</td>
<td>Network Software for Telework</td>
<td>OCS, PN</td>
<td></td>
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<tr>
<td>November 26–27</td>
<td>Online</td>
<td>Network Quality, Network Measurement and Management, Network Virtualization, Security, Network Intelligence, etc.</td>
<td>ICM, CQ, NV</td>
<td></td>
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<tr>
<td>December 17–18</td>
<td>Online</td>
<td>Multi-hop/Relay/Cooperation, Sensor/Mesh, Ad-hoc Network, D2D/M2M, Wireless Network Coding, VoIP, IoT, Edge etc.</td>
<td>RCS</td>
<td></td>
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<tr>
<td>January 21–22</td>
<td>Online</td>
<td>Network Software, Network Application, SOA/SDP, NGN/IMS/API, Distributed Control/Dynamic Routing, etc.</td>
<td>IN, NS Workshop</td>
<td></td>
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<tr>
<td>March 4–5</td>
<td>Online</td>
<td>General, IN/NS Workshop (March 4)</td>
<td>IN</td>
<td></td>
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Since June 2003, we foster the works of young researchers who have presented papers at NS technical meetings by inviting them to give a follow-up talk some months later. We call these the “encouragement talk.” We invited 3 young researchers to give such talks in the past year. We will continue this activity.

3. Research Awards 2020

The Technical Committee selected the recipients of Network System Research Award from among 220 regular papers that had been presented at monthly NS technical meetings from January to December in 2020. The award is given to each of the authors of the three or four best papers of each year. The abstracts of the four papers that won the award in 2020 are as follows.


Wireless multi-hop networks realize autonomous relay communications by wireless terminals so that they do not rely on a centralized control by a base station. Because of the characteristics, the network is expected as a way to cover an area such as a mountain station. Because of the characteristics, the network is unstable due to terminal mobility and radio interference. Therefore, it is important for the multi-hop routing in such dynamic environment to adaptively establish a high robustness route. Hence, the authors focus on a route construction ability of a true slime mold called Physarum Polycephalum during its foraging behavior, and its mathematical model called physarum solver (PS).

Slime mold transfers nutrition to the entire body through its tubular structure while foraging. Here, the slime mold optimizes the transfer efficiency by adaptively changing the number, length, and thickness of tubes. Therefore, slime mold realizes an autonomous distributed and adaptive path construction by its characteristics which microscopic variations of each tube appear as a macroscopic result that a change of a route. PS expresses the slime mold’s foraging behavior as a mathematical model for a flow network to solve complex routing problems. PS regards each characteristic of the slime mold as the network parameters; a total amount of flows corresponds to that of nutrition, and a capacity and cost of a link correspond to the thickness and length of the tube. The amount of flow on each link finally converges to an appropriate value by calculating them iteratively from the initial parameter values of the amount of flow, and the capacity and cost of each link. We have proposed a wireless multi-hop routing that allocates the bandwidth of each link adaptively based on the maximum bandwidth and the transmission delay of each link by applying PS to a wireless multi-hop network. However, the existing work has an issue that bandwidth allocation may not continue to fit the latest network status if the network status changed while executing PS’s calculation.

To solve the above issue, in our paper, we propose a physarum-based adaptive wireless multi-hop routing in anticipation of its implementation by using an allocated bandwidth sequentially in the convergence process as the index of path selection. In the computer simulation, the proposed method reduced the delay to update the allocated bandwidth and an error between the calculation result and the theoretical value of the approximate solution at each time.


With the advancement of image analysis technology, a wealth of information can now be obtained from images captured by camera equipment. The Internet Protocol (IP) camera is relatively easy to install, so it is a promising sensor for smart applications that perform wide-area safety monitoring. However, since cameras in public spaces take pictures of people indiscriminately, we need to be very careful in handling the data. In this study, we propose network system called the multi-access edge computing (MEC)-mobile computing resource (MCR)-centric model, which assumes the use of 5G/ MEC infrastructure as an implementation form of a camera-based wide-area safety monitoring system. This system takes advantage of the limited communication coverage of edge computing and suppresses the leakage of picture data that may contain private information. We compared and evaluated our model with existing system configuration models (cloud, edge, and their similar models) and found that our system performed the best. Since MEC is expected to expand with the spread of 5G infrastructure, the proposed system has a key advantage in that it will be easy to implement in society using the future infrastructure. In future work, we will investigate and quantitatively evaluate the implementation of a demonstration system to clarify the usefulness of this concept. In addition, since the MCR is a terminal node that requires portability, which means its hardware resources are limited, we will investigate how to improve the power-performance ratio of the data processing to solve this limitation.


The spread of infectious diseases such as COVID-19 increases the demand for a social infrastructure to estimate routes of infection. In fact, applications for detecting contact with COVID-19 infected people are developed in many countries. In particular, the ExposureNotification API, an API developed by Google and Apple to detect contact with infected people while maintaining anonymity, is used by public health authorities. In Japan, the Coronavirus Contact...
Confirmation Application (COCOA) is used for a Bluetooth-based smart-phone application that uses the Exposure Notification API.

However, COCOA has the following challenges in tracing a route of infection. First, since it manages only direct contacts, it is difficult to detect infection caused by indirect contact. Infectious diseases may be transmitted indirectly by surface infection with a time lag, but it is impossible to detect such infection by using COCOA. Second, it is difficult to identify locations where diseases are likely to spread since COCOA does not use location information for privacy protection.

To solve the challenges, we propose a novel people flow reconstruction method. In our method,

Bluetooth sensors are deployed at each intersection in a smart city and they collect the anonymous passage information composed of passage time and position without personal identifiers. On the basis of observation, our proposal algorithm estimates the trajectory set of infected people. By using this method, it is possible to find people in indirect contact with infected people and to identify the location where the infection is spreading. In our work, we formulate a problem of trajectory set estimation based on anonymized passage information in general networks. Our method assumes that each trajectory follows a Markov process and estimates transit time for each edge in networks and transition probability of its Markov process. On the basis of its estimation, our method can find multiple trajectories with maximum likelihood by solving a minimum cost flow problem. We evaluate the performance of our method by experiments using simulation data and actual people flow data.


In recent years, there have been several incidents of crop damage and injury caused by harmful animals in various areas of Japan each year, amounting to about 15.8 billion yen in 2018. As a countermeasure against damage caused by injurious harmful animals, the hunters attempt to capture them by setting traps and/or fences. However, these countermeasures require the hunter to patrol the condition of the equipment, which is a great burden for the hunter.

In order to reduce the burden, a new technology that can remotely monitor the location and the condition of the harmful animals through the Internet is attracting attention. However, the existing systems require that the sensing devices (e.g., camera, beacon) should always be running, which makes it inappropriate for installation in mountainous areas where electronic power is difficult to be supplied to the system.

In this research, we propose a new harmful animals detection system that can detect not only the approaching of animals to the equipment but also their species and postures by combining various sensing technologies. First, the beacon sensing attempts to detect the passage of moving objects by analyzing changes in received signal strength. After that, a small computer is activated to measure one-dimensional distance to the target object using a laser radar. The time-series data of the measured distance is analyzed to estimate the type of the moving object (e.g., human or animal). If the moving object is judged as a harmful animal, the depth camera is activated to acquire two-dimensional distance data of the target animal. The acquired distance data is also analyzed to estimate the posture of the harmful animal. By gradually activating the sensing devices with higher power consumption, the proposed system attempts to reduce the total power consumption.

The proposed system has been installed in a real field and the measurement data of each device has been analyzed by the various machine learning technologies. Through the experimental evaluation, we have clarified that the proposed system can accurately specify the condition of the target with reasonable power consumption.


With the diversification of mobile applications, the need for application-specific network slicing is increasing to meet their diverse requirements. To achieve such traffic control, we need to identify the application of the encrypted flows, which occupy more than 90% of the overall traffic on the Internet. Many researchers have proposed high-accurate classification methods using machine learning. However, existing research on application identification does not discuss the impact of slice allocation errors due to misclassification and the decrease in QoE due to classification delays. Specifically, the classification delay degrades the QoE of the recent applications, such as video applications, which adjust their quality based on link conditions. Moreover, these applications ramp up bandwidth rapidly; hence the delay in traffic isolation causes congestion during the classification and reduces the other applications’ QoE. In addition, misclassification may degrade the application's QoE to be classified and other applications' QoE due to the discrepancy between the slice QoS and the application bandwidth requirements.

We propose a new architecture called Progressive Slicing, which adaptively allocates the flow into slices with high bandwidth according to the state and result of the classification. We can maintain the QoE by allocating a small bandwidth to the new flow and adaptively transitioning it to a slice with a larger bandwidth according to the classification results. Progressive Slicing can mitigate the QoE degradation by isolating the flows based on the classification status, which avoids congestion during the classification. In addition, by performing multiple classifications, we can assign the flows to the slices according to each result,
making slicing more tolerant of misclassification. We evaluate the QoE improvement and the amount of data consumed during the classification based on the multiple user scenarios on the Android VM. We show that this method can reduce the search time in Twitter and the rebuffering on the video streaming application compared to the existing classification architecture.

4. Future Plans

The Technical Committee will have 10 NS technical meetings in this fiscal year. Although on-site meetings in some months may be impossible due to concerns about COVID-19, the meetings will be held online.

(For more information, please see our home page.
URL: https://www.ieice.org/cs/ns/eng/index.html)

5. References


