Networking Research with COVID-19

Enabling networking research
by means of networking research itself

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1 Introduction

In the University of Tokyo, as many other universities in Japan, we have almost shutdown the campus after the Japanese government’s so called “Emergency Declaration” due to the outbreak of COVID-19 pandemic. Many of us are not allowed to enter the campus unless there is absolute need to work physically at school. As many schools employ the same techniques, we use remote on-line tools such as web conference applications to hold meetings, give lectures, enable student gatherings, and so on, so that we can pursue our university’s role of research and education. We realize that physical contact must be prohibited to prevent further spread of the COVID-19 pandemic.

The president of the University of Tokyo, Professor Makoto Gonokami, has quickly responded to this unfortunate situation and has published messages in a timely fashion to the members of the university including Activity Restrictions Index [1] where research and education activities are restricted to the designated level on the scale of 0 to 4, namely, 0, 0.5, 1, 2, 3 and 4, where 4 is the severest and all on-campus activities must be suspended in principle.

The index not only restricts activities, but also is interpreted that we need to continue research and education with caution not to spread the virus further. This means, although it is important to observe the global restriction rule within the organization, yet we are obliged to still pursue our research activity.

According to the spirit of the University of Tokyo stated above, as network researchers, several professors on campus decide to exercise their own expertise, ranging from advanced 5G / LPWA wireless, to wired, to software defined radio, to IoT sensing technologies to monitor our own activities and behaviors on campus. We posit that our best practice to live with COVID-19 while continuing research and education with caution, is to put forth enabling networking research by means of network research itself.

We strongly believe that networking research being the most effective research field to enable remote communication must play the center role of actively monitoring and visualize
our own daily activities, and to let us exercise our own control over cautious yet aggressive research activities.

In this short report, we introduce what our research laboratory, NakaoLab, has done to enable networking research \textit{with} COVID-19 as best practice.

2 Enabling Networking Research By Networking Research Itself

2.1 Self-Control Research Activities

Network researchers must take initiative to enable self-controlled research activities on campus. This applies not only to networking research field but also the other areas of studies.

During the past three months of research and education operations at the university, we have learned that it is crucial for network researchers to take the following steps to let us be aware of the significance of self-control of our research activities.

1. Realtime monitoring of human behaviors on campus
2. Privacy consideration and data-governance of the monitoring process
3. Visualization of the human behaviors
4. Encourage self-control of research activities by the visualization
5. Make every step above \textit{“networking research”} especially focusing on rapid development of ideas and their readily realization.

Among all the steps above, we personally believe that the last bullet is most important and interesting. Usually, we conduct research with producing high-quality outcome in our mind, but to deal with pandemic like COVID-19 we must take into account the readiness of the research accomplishments.

Although it becomes tougher in the pandemic situation to conduct research with quality and readiness than usual, lots of students show a great deal of interest in these steps, probably because of the nature of the subject. We must cooperate to continue research activities while carefully preventing the spread of COVID-19 viruses. Of course the students conducting networking research shows interests, but students with different major for example ones majored in user experience (UX) designs are interested in visualizing the results of our monitoring of human behaviors on campus. Sometimes, they seem to even enjoy being engaged in projects as the research subject has a great impact on continuing our university operation, despite the fact that we are actually in the unfortunate situation.

Several professors (including the author) on campus have been trying to develop tools to measure population density on campus so that we can monitor close contact of students and teachers by means of various networking technologies, ranging from monitoring cellular
phones cell locations in collaboration with mobile network operators, collecting BLE (blue-tooth low energy) signals transmitted from smartphones for inferring population density on campus, examining the power consumption per campus (note that we have three campuses in the University of Tokyo), collecting university WiFi access record, etc.

The caveat is that we may not be allowed to violate privacy such as collecting exact locations, behaviors of individuals. Either anonymization after collection of data or utilization of scrambled information at the time of collection is necessary.

In the rest of the report, we introduce two research projects we have pursued only within three months since April 6th, when the Japanese government has announced the “emergency declaration” up to present.

2.2 BLE transmission scanning

![Figure 1: BLE Scanning System for Inferring Population Density on Campus](image-url)
As Google and Apple have recently developed API called Apple-Google Exposure Notification Framework (AGF) so that smart phones may trace peoples close contact, and more and more people are installing the smartphone application utilizing this API [2]. The smartphone operating system allows safe exchange of encrypted code (RPI) of close contacts among multiple smartphones so that one can track the close encounter with COVID-19 people later, while preserving the privacy, i.e., without disclosing the identify of the individual who turns out to be COVID-19 positive. The privacy of infected people are protected as only RPI codes are checked only after the fact of infection is revealed.

The Japanese government has developed a smartphone application called COCOA [3] utilizing AGF. All the nation is encouraged to install the application so that after positive infectant is discovered, we can track down all the possible infectants who have the close encounter.

However, for enabling “self-controlled research activity” on campus, we need to know population density of designated areas on campus, such as cafeterias, libraries, and lecture halls, where we expect people to gather, so called hot-spots once activity restrictions index gets lighten in near future. As people are in fact coming back on campus when the univer-
Figure 3: Population Density Inference at Central Cafeteria (top: the number of devices with COCOA application, bottom: the number of BLE devices)

As the university’s activity restriction level is being relaxed, we must monitor in realtime our population density on these areas so that we may exercise cautions to avoid creating a dense cluster of people.

Therefore, we have started a project of monitoring population densities as the university allows researchers to come to school for conducting research on prevention of the virus spread while the other research may not be conducted within the campus. The project aims to deploy small sensing devices to “observe” BLE broadcast transmission (advertisement) to collect the number of smartphones around the sensing devices as shown in Figure 1. Counting the number of devices transmitting a particular service UUID in BLE advertisement guarantees differentiation of individual devices. BLE announcement of AGF can be used for that purpose. Therefore, we encourage the installation of this to all the members of the University of Tokyo, from students to professors.

We decide to deploy solar-powered LoRa base stations connected to NakaoLab cloud
database via LTE communication, mainly for quick and wide deployment of such devices on campus, regardless of complication of individual setting WiFi of the buildings, and of getting the approval of device connections from IT department. Private 5G connectivity would be ideal, but due to the time constraint, we chose CAT-M1 low power LTE. In future, we plan to use private 5G (called Local5G) to further enable customized low power communication utilizing private frequency bands. We have quickly deployed the solar-powered LoRa base stations about a dozen locations on campus which covers the entire campus, thus, anywhere on campus, we can deploy small sensing devices.

As a result, we can realtime monitor the population density around more than 30 locations in total over the two campuses of the University of Tokyo. We are deploying more and more sensing devices around the campus. For example, we can figure that the largest cafeteria (now restricted capacity of 70 people, but used to be utilized by over 200 people) is getting full at the peak time 2. Thus, Population density is currently not well controlled. We plan to open this information to public that people can wisely adjust time of getting lunch, e.g., by time-shifting.

More and more requests for deployment of sensing devices are coming from departments and the other campus, but thanks to the portability of our sensing system, we can quickly deploy our system anywhere on campus within several tens of minutes.

We have recently enabled sensors to detect the power of the signals received, that is, RSSI measurement so that we can infer the distance from smartphones transmitting the signals to the sensor. The simplistic relations between RSSI and distance D is represented as

\[ RSSI = TXPower - 20 \cdot \log(D) \]

where \( TXPower \) is the transmission power of the signal from the smartphone 3.

Graduate students and staffs in our Nakao lab are willing to participate in the project. A graduate student has published one technical report on the project already. The subject is on dynamic transmission scheduling using shift-phase manipulation in LoRa networks, where we improve ALOHA MAC layer by a simple improvement over the ACK mechanism [4].

Through the project we are also learning that careful consideration of data governance and privacy is crucial. People are concerned about privacy most, so we need to be able to communicate with such people carefully explaining there is no privacy violation in our system. Our slides to explain the system detail and data governance amount to 25 pages of power point slides.

We plan to expand the project before the activity restriction index is reinstated back to normal, but expect to see people utilize the visualization of monitoring the human behavior on campus to continue “self-controlled research activities”.

### 2.3 Cellular Communication Statistics

In Japan, there are four mobile network operators (MNOs), NTT Docomo, KDDI, Softbank and Rakuten Mobile. As Rakuten Mobile has recently participated in the market, it does not acquire many customers just yet.

We decide to work with former three MNOs to get anonymized statistical distribution data of mobile phones over the campus areas. Every MNO has population statistics services
that are commercially available but they all have different approaches to collect data to infer population density. Although we are at the stage of evaluating the validity and usefulness of these MNOs’ different approaches, we plan to improve the accuracy and timeliness of these statistical data, because these data are originally targeted at marketing purposes [5], not for the purpose of preventing the COVID-19 pandemic.

Although, at the time of writing, we are not allowed to disclose the source of information, we can introduce the project with one MNO. In this particular measurement project, we define geo-fence, a virtual geographic boundary, defined by GPS, so that smartphones within the geo-fence can be counted by mobile communication characteristics. Although this number does not account for the population on campus, considering that we can project the result according to the ratio of the number of contracts with all the MNOs to infer the population on campus at the time of measurement. Also we can compare the population of a particular date of this year with that of the last year to tell how population on campus is affected by the virus situation.

The result (the pure number of subscribers without projection using the contract ratio) is shown in Figure 4.

Before the announcement of emergence declaration, the activity restriction index is set to level 1. The population ratio compared to the last year is 70% at this time. After that, the level is changed to level 3, and most research activities are not allowed on campus, except that we can conduct research related to COVID-19. At this time, the population ratio becomes 22-38%. Finally, when we change the level to 1 again on June 4th, the
population ratio gets back to 42-56%.

From Figure 4 we can confirm that the president message of activity restriction level is observed accordingly and also get feedback of what kind of message is effective and what not.

We make the visualization such as Figure 4 to the department chairs on the entire university and expect the members of the university to change the behaviors in response to the result shown in the visualization. We are all expected to wisely adjust the activity level according to the collected data in realtime.

3 Research-based Education

At the time of the writing, the education activity is restricted to teaching subjects over online conference tools and lab-based project course work are hard to be conducted. However, as the president of the university has announced, our research activities regarding developing methods and techniques to deal with the virus situation is encouraged on campus.

As mentioned earlier, due to the nature of the research projects such that we all work to enable continuous operations of the university, we easily see that many students are interested in participating in the projects introduce in the previous section.

We are currently discussing among colleague professors how the research activities engage students. For example, in a lab-based course that would create and use the measurement infrastructure and build models and make inferences based on the measured data such as follows, regarding the two projects mentioned above.

- Enable efficient data collection systems using LPWA and Private 5G communications and designing readily available and scalable monitoring systems.

- Investigation of the relationship between the population density measurement range and BLE radio field intensity, calibrating with consideration of indoor/outdoor environments including removal of background radiation of BLE.

- Population data analysis using machine learning and prediction of near future human behaviors for agile precaution against spread of the virus infections.

- Effective visualization of data analytics results.

The project ideas are clearly not limited to this list.

4 Conclusion

Our efforts are still continuing. One obvious thing is that we must not cease the networking research activities and take lead on wisely enabling self-controlled research activities. Enabling Networking research by means of networking research, with rapid development and deployability in our mind is a key to the success of overcoming this unfortunate situation on the globe.
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References


