Quality-prediction Technology for Optimal Use of Multiple Wireless Access Networks

Keisuke Wakao, Kenichi Kawamura, and Takatsune Moriyama

Abstract

Amid changes brought on by digitalization, wireless communications for connecting people and things are increasing in importance while available frequency bands and wireless access standards are becoming increasingly diversified. At the same time, the quality of wireless communications can change from moment to moment depending on user conditions, so there are times when the user has to consciously select the most appropriate means of wireless access. Against this background, our goal is to achieve a world in which wireless communications can be automatically and naturally used without a person or thing having to select and connect to a wireless access network. To this end, we are developing technology for proactively controlling the wireless environment based on wireless-quality-prediction technology using machine learning.

Keywords: wireless communications, quality prediction, AI

1. Introduction

As social changes brought on by digitalization increase, wireless communications are taking on an even greater role in many aspects of daily life, including increasing the communications capacity of smartphones and interconnecting all manner of things as the Internet of Things continues to expand. At the same time, a variety of wireless communications standards have appeared to support an increasing variety of wireless communications applications. In addition, the frequency bands available for wireless communications have expanded from several 100 MHz to several 10 GHz, so it has become necessary to select from a variety of frequency bands with radio waves that differ in their characteristics and from various wireless standards depending on the situation. In such a complicated heterogeneous wireless environment, we can envision an ideal world in which users can use the most suitable wireless standard at all times automatically and naturally.

The quality of wireless communications can change from moment to moment depending on user conditions and can lack stability due to interference from surrounding systems. To enable optimal use of wireless access under such conditions according to the purpose of use, there is a need for technology that can control the quality of wireless communications. Recognizing the importance of such technology, NTT has undertaken research and development (R&D) for controlling wireless quality through technologies that can proactively form communication areas and link multiple means of wireless access according to the user's situation. The aim is to create a communications environment in which the user need not be conscious of the actual wireless network being used. This group of wireless-access-control technologies is called "Cradio" [1] as an element of NTT's Innovative Optical and Wireless Network (IOWN). NTT is now accelerating the R&D of Cradio.

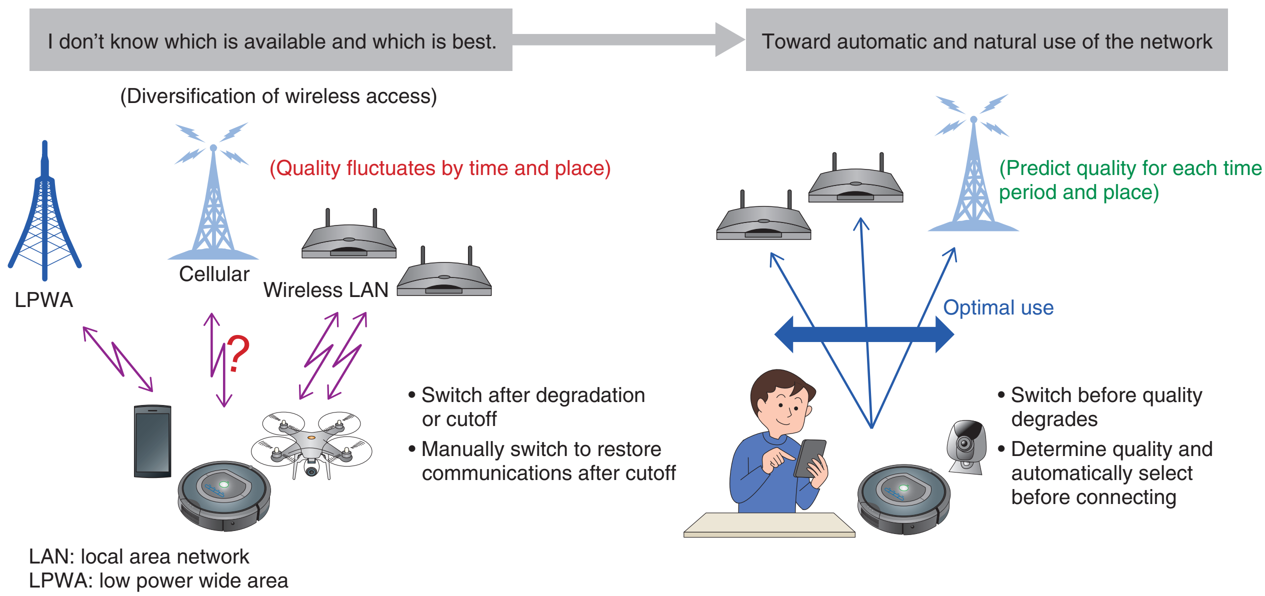

Fig. 1. Wireless-quality-prediction technology for optimal use of multiple means of wireless access.

2. Wireless-quality-prediction technology

One of the technologies in the Cradio wireless-access-control technologies is wireless-quality-prediction technology for proactively predicting changes in wireless quality. This technology uses machine-learning techniques [2], the application of which to wireless communications has been actively investigated in recent years. Wireless-quality-prediction technology improves quality by flexibly changing the configuration of a communications area and switching the radio base station or type of wireless access that the terminal is connected to before quality deteriorates (**Fig. 1**).

The base station that a wireless terminal uses has been selected based mainly on the strength of received signals from various base stations. However, in an environment in which the number of wireless communications users has jumped dramatically, increasingly diversified conditions such as the degree of congestion, model-specific terminal conditions, and application characteristics are making this an unrealistic approach. With the technology we are developing, however, a server collects detailed information continuously measured at the terminal, analyzes that information by machine learning*, calculates the predicted throughput, latency, jitter, and packet-loss values in the wireless communications of that terminal, and passes those results to the terminal side. This technology will enable switching to an optimal wireless base station for each terminal or application and select the wireless access method to be used. An overview of this technology is shown in **Fig. 2**. The wireless-quality-prediction engine runs on a network server installed on the cloud or within the management network. The detailed information measured at the terminal—such as location information, terminal model, wireless access method, wireless-environment scan data, and actual values of communications quality—is regularly uploaded to the wireless-quality-prediction engine to become history information accumulated in a database. The machine-learning algorithm is trained at this engine based on the content of this database. The terminal engaged in wireless access sends an inquiry to the wireless-quality-prediction engine affixing location information, wireless-environment information, etc. and receives, in turn, predicted values on the quality (throughput, latency, jitter, packet loss) that can be expected when connecting to a base station in the peripheral area. Based on these predicted values and taking into account application characteristics, the terminal selects the base station to be connected to. This approach achieves a means of optimally selecting

* Machine learning: A mechanism that enables a computer to learn useful decision-making criteria through statistical processing of sample data.

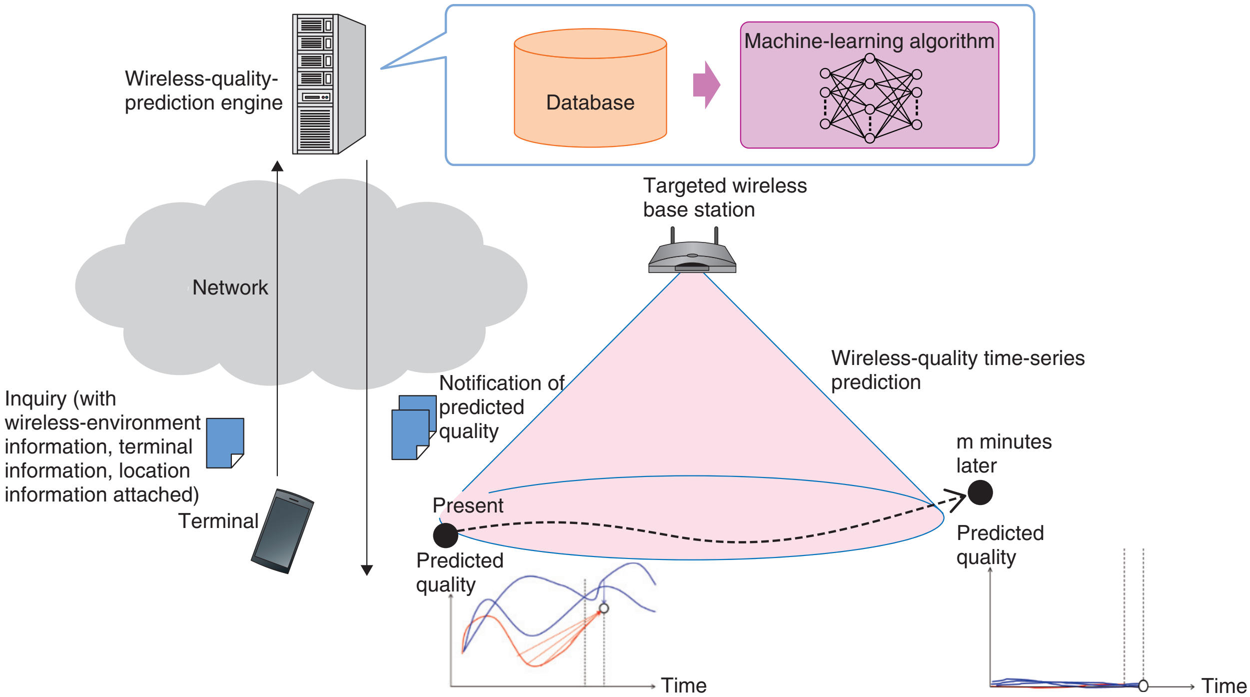

Fig. 2.   Overview of wireless-quality-prediction engine.

the type of wireless access to use from predicted values of quality based on past results.

One benefit of using a wireless-quality-prediction engine is that it enables the efficient collection of data while shortening processing time in machine learning. As described above, carrying out quality prediction from certain types of input information in machine learning requires that such input information as well as past predicted values be collected beforehand, but doing so only at the terminal targeted for prediction would take considerable time. In contrast, deploying a wireless-quality-prediction engine and using it to collect data not only from the target terminal but also from many other terminals makes it possible to efficiently collect a sufficient amount of data and quickly carry out the processing required for machine learning. Nevertheless, this technique presents other issues. For example, simply integrating the data collected from all terminals and applying them blindly to machine learning does not promote useful learning since terminal performance differs from one model to another. Moreover, since the types, definitions, etc. of information that a terminal can collect depend on the model and area in question, there is also the problem that such information cannot be input as-is into a common machine-learning algorithm. In the R&D on the wireless-quality-prediction engine of Cradio, we are stepping up studies of a machine-learning algorithm that can overcome this issue and use the data collected from many and varied terminals in common. Our goal is to establish wireless-quality-prediction technology that enables the user to automatically and naturally use the wireless access network.

We envision one application example of this technology as communication control for maintaining stable wireless communications in automatic guided vehicles commonly used today in large-scale warehouses. This would be needed in such an environment because of the many structures and obstacles that hinder wireless communications and significant fluctuation in signal congestion due to the effects of various types of office equipment.

3. Future outlook

We plan to improve wireless-quality-prediction technology through the use of various types of environmental data and enhancing machine-learning algorithms. Our ultimate goal is technology that enables people to use wireless communications more naturally and intuitively.

References

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