Achieving wireless distributed networks with super-high reliability and super-long life

Koji ISHIBASHI Laboratory

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Summary of Research

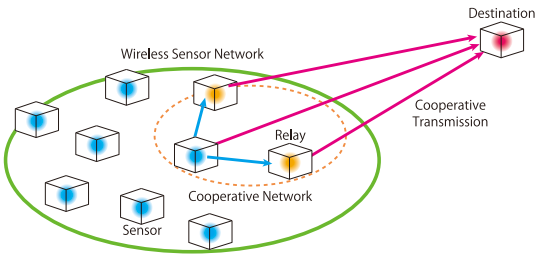
Improving the Robustness of Wireless Communication to Ensure Uninterruptible Connections, Addressing the Problem of Finite Battery Power

Mobile phones and wireless communication equipment continue to advance year after year and have already achieved anytime/anywhere connectivity to an extent that might lead one to believe nothing more is needed. In reality, many issues remain to be solved, as revealed by the disaster caused by the Great East Japan Earthquake of 2011. The powerful earthquake destroyed wireless telecommunication base stations, rendering wireless communication devices useless in the affected areas. Furthermore, the lack of electrical power slowed restoration work. In this instance, functioning mobile phones would have saved countless additional lives. However, even if wireless connections had remained intact, the lack of electrical power would have made it impossible to charge the batteries required by telecommunication terminals. Dead batteries would have prevented communication, even if other factors had not.

Our laboratory engages in various research activities whose goal is to improve the robustness (that is, the systems or functions intended to shore up resistance to the effects of external factors) of wireless communication through revolutionary methods, safeguarding against communication interruptions and failures, maintaining connections at all times, initiating self-repairs in the event of communication problems, and eliminating the problem of finite battery power.

Data Communication Through Wireless Distributed Networks Using a Bucket Relay System

The wireless distributed network is one idea used to achieve the above objectives. We believe transmitting data through a wireless distributed network via nearby mobile terminals in bucket relay fashion will enable reliable communications, even if wireless telecommunication base stations are rendered nonfunctional. This approach will allow the use of properly functioning terminal devices for communications, even if base stations are destroyed, as in the case of the earthquake disaster mentioned above.



Cooperative transmission achieves reliable communication by using nearby terminals to increase the number of data transmission routes.

In ordinary wireless communication using radio waves, data is exchanged via base stations. This means radio waves must first be transmitted to a base station, even when communicating with someone close by, a wasteful step. In contrast, wireless distributed networks send data to the destination (data receiving device) by connecting to closely located terminals and transferring data via a bucket relay system, eliminating wasteful radio transmissions.

Advantages

Extensive Knowledge of Information Theory and Wireless Communication Technologies, Capacity to Achieve Practical Specifications

Assistant Professor Ishibashi's previous research activities ranged widely, from information theory to programming, device circuit designs, microprocessors, sensor networks, and electric power optimization. His extensive research experience provides familiarity with both theory and technology, a key advantage offered by our laboratory.

Keywords

Energy salvage, energy harvesting, mobile phone, electric power conservation, dynamic cooperation, wireless communication, wireless distributed network, robustness

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Member	Koji Ishibashi, Associate Professor

Many researchers active in the areas of information theory and communication systems concentrate on constructing original theories based on many idealized assumptions, in accordance with the mathematical model formulated by Claude Shannon. In contrast, researchers active in the area of devices and systems focus on optimizing electrical circuits. The field of communications is comprised of multiple layers; few researchers are capable of interconnecting these layers based on an understanding of the overall system. The achievements of Assistant Professor Ishibashi stem from research from the perspectives of both theory and technology.

Conserving Electric Power Based on a Wireless Distributed Network and Dynamic Cooperative System

In ordinary relay communications, direct data transfers can result in communication failures. To improve reliability, data is sent to terminals other than those used for the bucket relay, allowing retransmission from another terminal in case of transmission failures. However, since this method involves sending the same data several times, it has the drawback of relatively lengthy communication times.

In response, Assistant Professor Ishibashi is currently exploring a method called dynamic cooperation, based on an ingeniously designed error correction code. In this system, a relay terminal reconstructs the transmitted data during data transmission. As soon as the relay terminal successfully receives the data, it dynamically superimposes auxiliary information onto the signal from the transmitting terminal, then sends the data. The receiving terminal receives the correct data by combining the auxiliary information from two signals.

Dynamic superimposition of auxiliary information dramatically improves communication efficiency and ensures stable transmission of data by the bucket relay method. In general, reliable transmission of data over long distances requires powerful radio waves. In contrast, this system allows reliable communication even with weak radio waves. An additional benefit of this approach is lower power consumption. The results of Assistant Professor Ishibashi's research are expected to lead to new possibilities in relay transmission.

Energy Salvage Mechanism and Energy Harvesting Technologies

No matter how much we reduce the electric power required for communications, the batteries that power our communication devices have finite capacity and eventually run out. Our laboratory pursues research on energy salvage mechanisms that will allow terminal devices to collect unnecessary electromagnetic waves and reuse them as electric power. Alongside this effort, we are working on energy harvesting technologies capable of converting solar light, ambient light, radiant heat, vibrations, and radio waves into electric power. Ultimately, our goal is to create a communication environment that eliminates the problem of limited battery power.

A Network of Contacts Around the World

After graduating from the University of Electro-Communications, Koji Ishibashi held positions at various universities, building an extensive personal network of contacts in Japan and overseas. The individuals with whom he maintains contact include colleagues at Harvard University. This global network of contacts is one of our laboratory's strengths.

Future Prospects

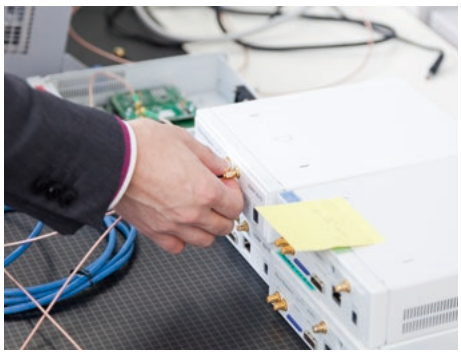
Making Anytime/Anywhere Connectivity for Mobile Phones and Wireless Communication Equipment a Cornerstone of the Social Infrastructure

One of our goals is to make anytime/anywhere connectivity for mobile phones and wireless communication equipment a cornerstone of future social infrastructures. Once this goal is attained, the familiar indications of signal strength on mobile phone screens will be rendered obsolete. Now, mobile phones and wireless communication equipment are currently viewed as examples of technology, in large part because these technologies have not been perfected. Take paper, as an example: Paper is an excellent display that utilizes external light to present information. Nevertheless, no one in our era regards paper as an example of technology. Similarly, as wireless communications continue to evolve and become increasingly prevalent in our society, they will eventually be taken for granted and no longer regarded as an example of technology.

An experiment at our laboratory

Eliminating the Roadblock of Limited Battery Power and Achieving Wireless Power Supply to Mobile Phones

Eliminating the problem of limited battery power for communication terminals is another research topic addressed by our laboratory. Although mobile phones are wireless devices, they still require power supply cables to charge their batteries. Understood literally, wireless means cordless. Our research focuses on ways to circumvent the limitations imposed by finite battery power by supplying electric power wirelessly so that mobile phones will truly be cable-free.



Software-defined wireless device

A discussion referencing collected data