Post-disaster networking, IoT

Age-effective information updating over intermittently connected MANETs

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Abstract

Immediately after the occurrence of a natural disaster, communication infrastructure such as wireless base stations may become unavailable. Even under such circumstances, it is important to keep continuous operation of Internet of Things (IoT) based monitoring systems for rapid information acquisition and enhanced safety. The Delay/Disruption/Disconnection Tolerant Networking (DTN) technology has been studied extensively as a method to realize remote communication without relying on infrastructure. However, these studies have been conducted without targeting the use for monitoring systems. In particular, investigations on the key design factors, such as the frequency of sensing data transmission, have not been addressed so far. In this study, we established a method to mathematically analyze the system from the viewpoint of "information freshness," which is of key importance when applying the DTN technology to monitoring systems.

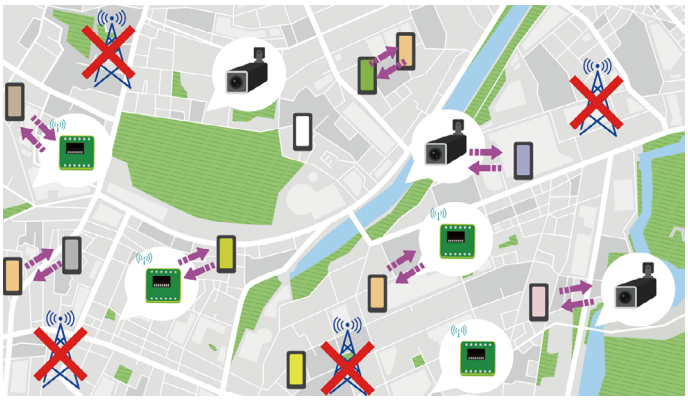
Background & Results

As exemplified by the term Internet of Things (IoT), recent years have seen a growing interest in utilizing information sensed by numerous devices to improve the safety and convenience of our daily lives. The concept of incorporating such functions throughout an entire city is known as the smart city, and it is expected to transform our lives in the near future. Toward the realization of the smart city, efforts are being made in various fields, such as miniaturization and enhancement of sensing devices, development of communication infrastructure for information aggregation, and machine learning technology for analyzing collected information.

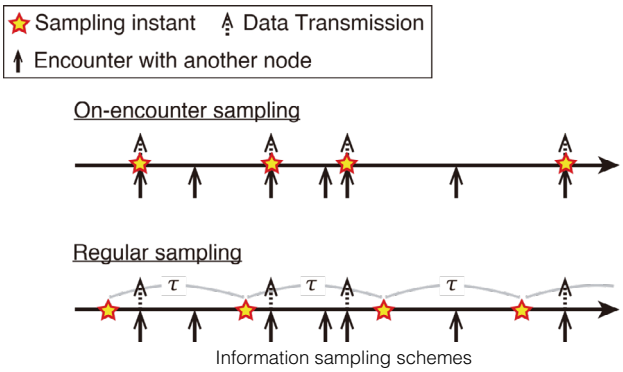
While these studies aim to enhance functions of the city during "normal" times of daily life, it is desirable to maintain such enhanced functions, even if only partially, during "emergencies" such as immediately after the occurrence of a natural disaster. In particular, it is important to assume a scenario in which communication infrastructure such as wireless base stations become unavailable. The Delay/Disruption/Disconnection Tolerant Networking (DTN) technology has been studied for a long time as a technology to realize remote communication in situations where communication infrastructure is unavailable. In DTN, information is delivered to the destination by repeating exchanges of copies of the transmitted information between nearby mobile devices; it is called the epidemic routing as it behaves like an infectious disease. Conventional research on DTN has mainly focused on the delivery of a single message from a source device to a destination device. However, in the context of the smart city mentioned above, it is necessary for source devices to periodically send out sensing data according to some interval, and in this case, it is important to maintain high "freshness" of the information held by the destination device. Our study is the first to provide a mathematical method to analyze the information freshness in DTN systems, where we derived some new mathematical results for infinite-server queueing models, and we characterized the information freshness in DTN systems by combining these results with Markov analysis.

Significance of the research and Future perspective

Although numerous research efforts are currently put on enhancing functions of cities using IoT from a variety of perspectives, enough attention has not been paid to their continuation in emergency situations such as immediately after the occurrence of a natural disaster. Also, while DTN technology has long been studied as a communication method for emergencies, its use for monitoring, the key application of the IoT, has remained largely unexplored. It is expected that this study will serve as a springboard for further research on the continuity of IoT systems during emergencies.



A DTN-based monitoring system



Information sampling schemes

Patent

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