INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

Internet of Things (IoT) has emerged as a transformative technology, enabling connectivity of physical devices to the Internet for data exchange and intelligent decision-making across various application domains. The Industrial Internet of Things (IIoT) has evolved and gained prominence in the industrial domain to meet the demands of industrial automation, predictive maintenance, and large-scale communication. The IEEE 802.15.4e Time Slotted Channel Hopping (TSCH) protocol is a key enabler for IIoT. The IPv6 over the TSCH mode of IEEE 802.15.4e network (called 6TiSCH) is designed to ensure high reliability, low latency, and longer network lifetime for various IIoT. TSCH uses link scheduling for data communication, which determines how the nodes in a network communicate with each other by allocating communication resources in terms of time and frequency. However, the TSCH standard does not specify how the schedule should be formed and maintained, although the network performance relies heavily on the effectiveness of the constructed link schedule. Thus, Internet Engineering Task Force (IETF) published the Minimal Scheduling Function (MSF) (RFC 9033) and 6TiSCH Operation Sublayer (6top) Protocol (6P) (RFC 8480) as important components in 6TiSCH protocol stack. This dissertation addresses several challenges associated with link scheduling in 6TiSCH networks, with a focus on the design, management, and security of the link scheduling function and its associated 6P protocol. An Improved Minimal Scheduling Function (IMSF) is proposed to reduce 6P control overhead while improving end-to-end latency and reliability. To address random cell selection during cell allocation, a Receiver-based Traffic rate agnostic Distributed link Scheduling function (RTDS) is proposed. Further, a Latency-aware Cell Deletion (LCD) scheme is proposed to minimize average end-to-end latency and energy consumption. To address schedule collision detection and mitigation, an Enhanced Collision Detection (ECD) mechanism and a receiver-based cell relocation strategy along with ECD, called ECDR, is proposed. Furthermore, this thesis demonstrates the feasibility of two different types of attacks called cell depletion attack and schedule instability attack in link scheduling. To counter these vulnerabilities, two novel mitigation schemes, namely SCSF-PC and SCSF-WELA, are proposed. Finally, all the proposed solutions are evaluated by extensive simulation experiments using the 6TiSCH simulator. The results demonstrate significant improvements in network performance, making the contributions of this thesis valuable for the advancement of IIoT networks.