Chapter 6
Connectivity Estimation Approaches for Internet of Things-Enabled Wireless Sensor Networks

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ABSTRACT

Internet of things (IoT) envisions a network of billions of devices having various hardware and software capabilities communicating through internet infrastructure to achieve common goals. Wireless sensor networks (WSNs) having hundreds or even thousands of sensor nodes are positioned at the communication layer of IoT. In this study, the authors work on the connectivity estimation approaches for IoT-enabled WSNs. They describe the main ideas and explain the operations of connectivity estimation algorithms in this chapter. They categorize the studied algorithms into two divisions as 1-connectivity estimation algorithms (special case for k=1) and k-connectivity estimation algorithms (the generalized version of the connectivity estimation problem). Within the scope of 1-connectivity estimation algorithms, they dissect the exact algorithms for bridge and cut vertex detection. They investigate various algorithmic ideas for k connectivity estimation approaches by illustrating their operations on sample networks. They also discuss possible future studies related to the connectivity estimation problem in IoT.

1. INTRODUCTION

Internet of Things (IoT) will include billions of computational devices communicating through Internet infrastructure (Xu, 2014) (Giri, 2017) (Lee, 2017) (Rehman, 2017) (Balaji, 2019) (Yugha, 2020). A robust network for IoT must deal with the malfunctions without losing its connectivity. Robust networks are one

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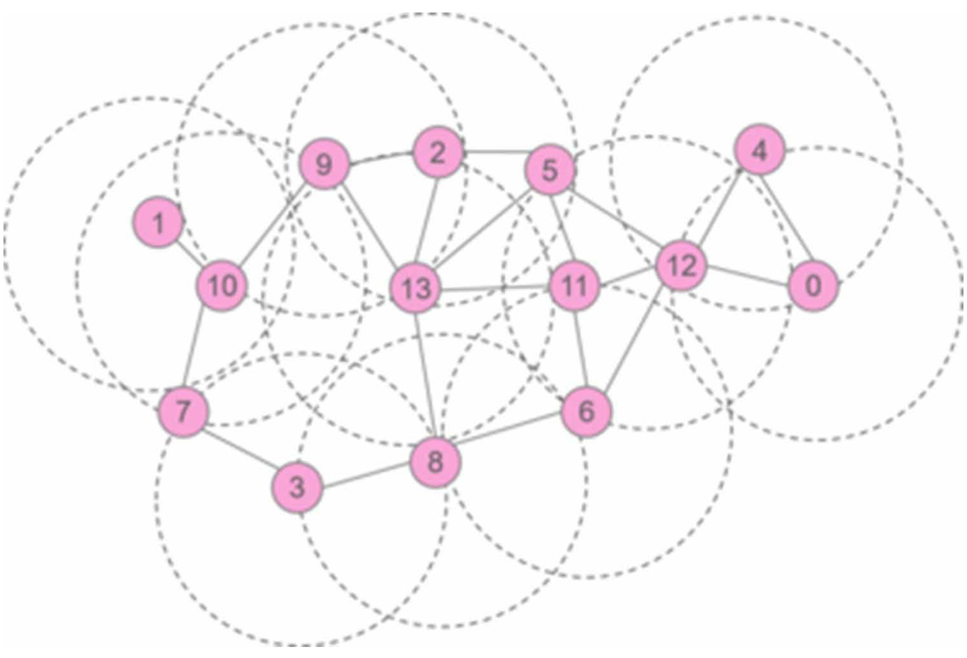
of the important requirements in Internet of Things (IoT) because they provide a reliable infrastructure for communication of other devices. The nodes (vertices) in IoT systems are usually connected to each other over wireless channels and communicate by message passing. Hence failures in relay nodes can destroy the data transmission paths among nodes and waste many active resources. So, the underlying communication infrastructure of a reliable IoT should be able to tolerate the failures and keep the connectivity of active nodes.

Wireless sensor networks (WSNs) compose of motes which have the abilities of sensing from the environment and transmission of the collected data in a wireless manner (Akyildiz, 2002) (Arampatzis, 2005) (Paradis, 2007) (Alemdar, 2010) (Rawat, 2014) (Jino Ramson, 2017). WSNs are crucial technologies for IoT and positioned at the communication layer. WSNs can be used in various practical scenarios such as smart cities, healthcare, military surveillance, target tracking and habitat monitoring. Generally, WSNs include at least one special node called the sink in which the data is collected. An example WSN modeled with a graph is given in Figure 1. In this network model, there are 14 sensor nodes, and the ID of each node is written inside it. The vertex set V={0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13}. Transmission ranges are depicted as dashed circles. Possible communication channels (edges) between nodes are drawn with solid lines. The edge set E={(0,4), (0,12), (1,10), (2,5), (2,9), (2,13), (3,7), (3,8), (5,11), (5,12), (5,13), (6,8), (6,11), (6,12), (7,10), (8,13), (9,10), (11,12), (11,13)}.

Figure 1. Network Model



A WSN is connected if at least one communication path between every pair of nodes is present. Since WSNs are designed to operate in a distributed manner, maintaining network connectivity is of utmost importance to achieve common application goals by transmitting messages between nodes. If a vertex's removal partitions the communication network into disjoint segments, we call this vertex as cut vertex