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Comparison of Mesh Network Standards

Introduction

A mesh network is a network structure in which each node connects directly to the surrounding nodes. The participating nodes can dynamically determine the most efficient route for data from one point to another. This structure allows mesh networks to cope with the failure of nodes, by dynamically re-routing around the failed node [1]. Since there is no pre-determined network hierarchy, mesh networks excel at interconnecting a variable number of mobile nodes (e.g. between boats in a sailboat race). This paper is a review of the standards available for implementing mesh networks.

Mesh Network Theory

As described above, nodes in a mesh network have multiple connections to other nodes in the network. This method of interconnection results in multiple paths between any given pair of nodes in the network. Messages can be passed from source to destination in two ways: flooding or routing. The flooding method is the simplest, but also the most inefficient method of message-passing. When a node wishes to send a message to another node, it sends the message to all the nodes it has connections to. Each of those nodes then re-transmits the message to all the nodes they have connections to. This continues until the message reaches the intended destination. The routing method is more complicated, but also more efficient than the flooding method. Instead of a node sending messages to all connected nodes, it can learn the best routes between a given pair of nodes (the exact methods to do this can vary) [2]. Messages sent between a pair of nodes will only follow the best route. However, the mesh network will need to re-calculate the best routes as node positions and connections change. This can be accomplished by using algorithms such as Shortest Path Bridging.

Mesh Network Standards

There are many main standards available for mesh network implementations. One such standard is Thread: a low-power wireless mesh networking protocol built on the IEEE 802.15.4 radio standard [3]. Since Thread is built on 802.15.4, mesh networks using it can communicate in either the 900 MHz range or the 2.4 GHz range. With a maximum distance of approximately 100 meters between nodes, and a limit of 16 hops between source and destination, a mesh network can span up to 1.6 km [4] [5]. Thread's biggest advantage is its use of Internet Protocol version 6 (IPv6) for routing between nodes. Not only does this

mean that software libraries designed for inter-system communication on a regular network can also be used for communication on a Thread network, it also means that a Thread network can easily be connected to the Internet [6]. Thread does not require any specific application layer to be used on the mesh network, unlike competing solutions. Commercial applications of the Thread standard include Nest Guard and Nest Detect, components of the Nest Secure alarm system [7]. The Thread standard is free to use and implement, any radio hardware that implements 802.15.4 can run Thread.

Another common mesh network standard is Zigbee. Like Thread, Zigbee is also built on IEEE 802.15.4, which means that it can operate on the same frequencies and hardware as Thread [8]. The Zigbee standard can support up to 10 hops between source and destination [9]. Combined with the 802.15.4 max node-to-node distance of 100m, this means that a Zigbee mesh network can span up to 1 km. Zigbee uses its own network layer on top of 802.15.4, which means that a Zigbee mesh network cannot be easily connected to the Internet. Also, applications that communicate over a Zigbee mesh network need to use the Zigbee application layer [10]. Applications of the Zigbee technology include wireless sensor networks, as well as various home automation systems [11]. Zigbee mesh networks can be developed using Xbee modules, for approximately $20/module.

Z-Wave is yet another option for mesh networks. Unlike the previously discussed options, Z-Wave is a proprietary solution: both the hardware and software are only supplied by a single company [12]. A Z-Wave mesh network operates in the 900 MHz range. It is limited to a maximum of 4 hops between source and destination. With a maximum distance of 100 feet between nodes, this means a Z-Wave mesh network can only span approximately 100 meters, significantly less than the previously discussed solutions. Since Z-Wave is a proprietary solution, it has its own network and application layers which applications need to use. Commercial applications of the Z-Wave standard include the Samsung SmartThings ecosystem of devices, as well as a multitude of home automation and security-related devices [13]. Since Z-Wave is a proprietary solution, a Z-Wave development kit is needed to develop a mesh network with Z-Wave. The cost of such a kit ranges from $150 to almost $2000 [14].

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