# USING FREQUENCY AGILITY IN WIRELESS SENSOR NETWORKS REQUIRING RF COEXISTENCE

# MESHSCAPE 5424

## *1.0 OVERVIEW*

### 1.1 Coexistence in 2.4GHz ISM band

Because the 2.4GHz portion of the radio spectrum is shared by WiFi, Bluetooth, cordless phones, etc., users need to consider coexistence with other RF signal sources occupying the same frequency band. Millennial Net's MeshScape 5424 product uses DSSS and frequency agility to permit coexistence. Frequency agility allows users to change the radio channel of their network at the MeshGate gateway (network access point). Upon changing the gateway to a less congested RF channel, the entire network of mesh nodes and end nodes automatically locate and use the new, more reliable RF channel. This gives flexibility in solving the coexistence problem, provides easy reliable RF channel selection at a single point, and preserves low latency, low power consumption and scalability features required in many wireless mesh network applications.

### 1.2 Frequency Agility in MeshScape 5424

To move all network nodes from a congested channel to a new channel, the MeshGate gateway's default channel need only be changed and all other nodes in the network will automatically locate the new channel and resume network communication without the need for user intervention.

All nodes are manufactured and programmed with a default radio channel which is stored in nonvolatile memory. On power up, each node reads the channel and starts to communicate to its peer nodes on the default channel. If the gateway is set to this channel, the nodes find the gateway, thereby allowing the network to form. When the gateway is set to a different RF channel, the nodes initially will not be able to find the network on the default channel. Upon detecting the loss of the default channel, all nodes will automatically search for a new network channel until the network channel is located. Once they have rejoined the network, each node will save the new channel as the default channel and will subsequently start communication on this new channel at power up.

The following sections detail how each of the MeshGate gateway, mesh node and end node performs the frequency agility function.

# *2.0 MESHGATE*

## 2.1 Detecting Interference

Radio channel interference can be determined by performing a site audit of frequency usage, conducting a radio channel survey or monitoring for network activity.

The site audit should gather information of frequency usage for all Wi-Fi, cordless phone and other potentially competing wireless devices.

To conduct a survey, a spectrum analyzer can be used to measure the energy across the RF bands of interest and determine whether there is any radio interference on the default channel. This is usually a more accurate way to determine whether a channel can be used for reliable communication. It is important when utilizing a spectrum analyzer to record frequency congestion that the capture period be long enough to acquire all frequency usage of all potential RF sources.

If a spectrum analyzer is not available, insights into the network reliability can be gained by monitoring the network activity via the MeshScape Network Monitor, looking specifically for the unreliable delivery of packets from all nodes in the network. If the network performance degrades significantly within a certain geographical region, it is most likely that radio interference exists, especially if the network has been operating properly before. It is important to monitor the network for an extended period of time (depending on system node count – consult Millennial Net for guidelines) before switching to a different channel, especially during a new network installation. Since networks may suffer from congestion and packet collision during initial network formation, allowing time for network to settle down is advisable.

## 2.2 New Channel Selection

Channel search can be initiated by the user by manually changing the MeshGate gateway's default RF channel.

In the 2.4GHz ISM band, there are currently 16 channels available, from channel 11 to channel 26. Each channel is spaced 5MHz from adjacent channels.

To determine which channel should be selected, you should identify the source of the interference. If the source of the interference is from Wi-Fi or a cordless phone using DSSS, it is recommended that a new channel be selected following the rules below:

- To avoid interference from Wi-Fi, which has a channel width of 22MHz, choose a channel that is at least 5 channels apart from current one.
- To avoid interference from a cordless phone using DSSS, which has a channel width of 5 to 10MHz, choose a channel that is at least 2 channels from current one.

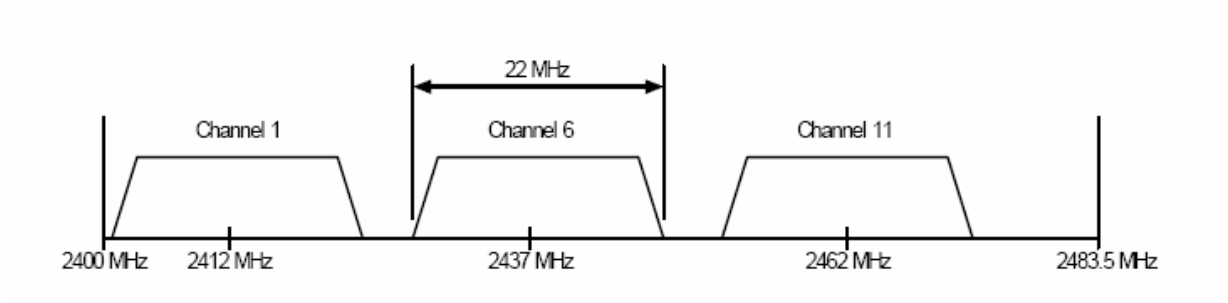
For all other interference sources, any other available channel should keep the network away from the current interference.

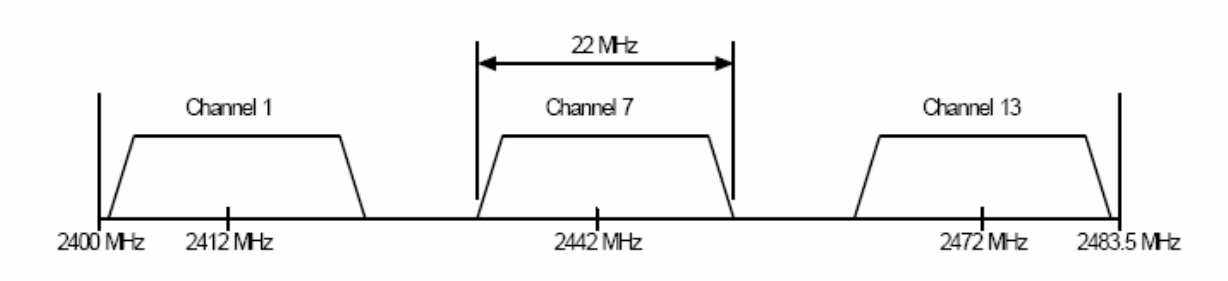
### *2.2.1 Default Channel*

Since Wi-Fi presents the most risk in term of interference and the preferred setting for multi-access point system uses three IEEE 802.11b/g channels (1, 6, 11 for North America and 1, 7, 13 for Europe), Millennial Net chose the default channel to be 15, as this channel falls in the guard bands between the 802.11 channels. While the energy in this guard space will not be zero, it will be lower than the energy within channels; resulting in minimized interference between systems.

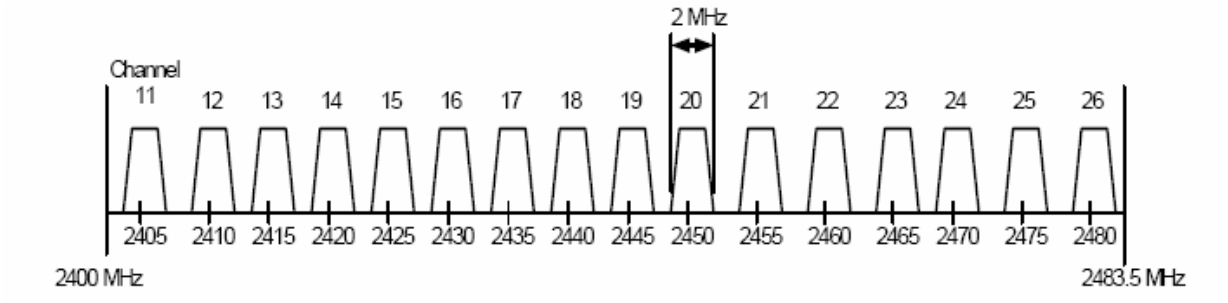
The relationship between IEEE 802.11b/g (non-overlapping sets) and Millennial Net 5424 channels are shown in the Figures below.




a) IEEE 802.11b North American channel selection (non-overlapping)




b) IEEE 802.11b European channel selection (non-overlapping)




c) Millennial Net MeshScape 5424 channel selection

**Figure 1—IEEE 802.11b and MeshScape 5424 channel selection**

### 2.3 Programming New Channel

Once the desired channel is determined, the MeshGate gateway can be configured to use a new radio channel. For details on programming operations, please refer to the "5424 User Guide", in Appendix B, section "Performing MeshScape Programmer Operations", and sub-section "Reprogramming the Target Device's Radio Configuration".

## *3.0 MESH NODE AND END NODE*

Mesh nodes and end nodes both will start channel searching after detecting the loss of network connection. Due to the different power profiles for mesh nodes and end nodes, different searching schemes are employed.

### 3.1 Channel Search

#### *3.1.1 Mesh Node*

The "always on" feature of the mesh node allows it to search for channels more aggressively and thus rejoin the network faster. For example, in a network with 80 nodes, of which 20 are mesh nodes and 60 are end nodes, it typically takes 2 to 3 minutes for all mesh nodes to rejoin the network upon MeshGate gateway channel change

#### *3.1.2 End Node*

In order to extend battery life, end nodes take a longer period of time to complete the channel search and rejoin network. For example, in the same network above, it can takes 20 to 30 minutes for all end nodes to rejoin the network, regardless of the sampling interval.

### 3.2 Channel Search Mask

A factory configurable channel search mask is stored in each node's nonvolatile memory. This mask specifies the channels available to users. Due to regulatory requirements in different countries, not all 16 channels may be available for use in a given country. The channel mask will allow unusable channels to be defined so that the system does not use them during search or other operations.

## *4.0 MESHSCAPE 5424 PRODUCT INFORMATION*

The MeshScape 2.4Ghz products use patent-pending Persistent Dynamic Routing (PDR) to form a self-configuring, wireless sensor network. PDR uses a node-initiated network formation for efficient topology discovery and uses "best route" information for network re-formation required in ever-changing RF environments. With MeshScape, you can deploy industrial-class wireless sensor networks which are:

- **Robust:** Network ensures reliable data transmission
- **Responsive:** Network quickly adapts itself to changes in topology or RF environment
- **Power efficient:** Can run for years on a single battery or be completely energy independent
- **Scalable:** Can scale with the application to hundreds of sensor nodes with minimal overhead
- **Frequency agile:** mesh and end nodes automatically locate and use higher reliability channel

Millennial Net provides a ***complete wireless networking system***. You can use mesh node and end node modules to interface to sensors and/or control devices, or embed the MeshScape software using Millennial Net professional services. The MeshScape Gateway is the heart of the wireless sensor networking system and can be connected to a Microsoft® Windows® XP or Linux PC or to a third-party controller.

The MeshScape products include gateways, mesh nodes, and end nodes all of which use a 2.4 GHz direct sequence spread spectrum (DSSS) radio that is resistant to RF interference.

Product information is available at: http://www.millennialnet.com/products/

## *5.0 REFERENCE*


- IEEE P802.15.4-REVb/D1 - Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (LR-WPANs), January 2005.

## *6.0 HOW TO REACH US*

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