**Question #10**

## Adaptive Frequency Hopping

The purpose of using frequency hopping in a radio system is to provide diversity that allows data throughput to be maintained even if interfering radio systems or the physical environment (e.g. multipath fading) render some RF channels unusable. In the 2.4 GHz ISM band, the sheer amount of radio systems and the severity and dynamic nature of indoor fading phenomena in typical operating environments require the use of this kind of diversity if a minimum data throughput is to be assured (as audio streaming requires).

Frequency hopping systems can either implement a fixed sequence of channel hops or adapt its hopping sequence dynamically to the changing environment it operates in. In order to maximize its own chances of delivering audio data in time and to co-exist amicably with other fixed-frequency or adaptive frequency hopping systems, PurePath Wireless uses an adaptive frequency hopping (AFH) scheme that adapts to changing conditions within tens of milliseconds.

PurePath Wireless divides the 2.4 GHz band into 18 RF channels with 4 MHz bandwidth. The protocol master controls the adaptive frequency hopping scheme for the audio network, and maintains a table with an entry for each RF channel and an associated quality-of-service (QoS) estimate for each. Each time an RF channel is used the QoS estimate is updated based on what happens during the timeslot.

The frequency hopping algorithm separates the 18 RF channels into two sets:

- A set of 4 *active channels*
- A set of 14 *trial channels*

The active channel set contains the preferred RF channels that have proven that they provide sufficiently good quality-of-service. The trial channel set contains the remaining RF channels that are only evaluated occasionally in order to be able to maintain an accurate picture of their quality-of-service. If the QoS estimate of an RF channel in the active set goes beyond a minimum threshold this channel is swapped out with the RF channel in the trial channel set that has the best QoS estimate. Other factors play in when selecting a new RF channel to the active channel set, such as trying to maintain a certain minimum distance in frequency between the different active channels.

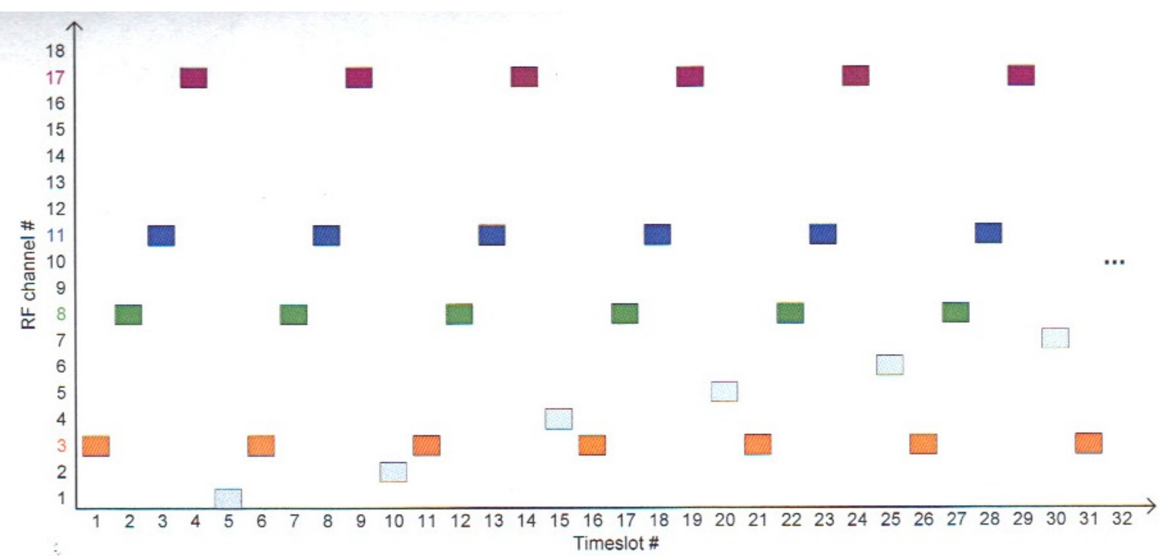


**Figure 36 – Example of AFH hop sequence (active set in color, trial set in black/gray)**

The frequency hopping algorithm, when using all 18 channels and no swaps between the active and trial channel sets occur, goes through a sequence of 70 hops over the course of which every RF channel has been used.

This 70-hop *macrosequence* consists of 14 repetitions of a

- 5-hop *microsequence* during which
  - Each of the four active RF channels are used once
  - One of the trial RF channels is used once
    (cycling through all trial channels over the course of a macrosequence)

Figure 36 illustrates this concept. This gives an average steady-state RF channel usage of:

- Each of the four active channels are used 20% of the time
- Each trial channel is used 1.43% of the time

## RF Coexistence Mechanisms

The two main mechanisms that allow a PurePath Wireless system to co-exist amicably in close proximity to other 2.4 GHz radio systems (including other PurePath Wireless networks) are:

- The adaptive frequency hopping scheme described in section 2.4.3 that ensures that RF channels used by other radio systems are avoided

- Listen-before-talk mechanism that measures energy in RF channel before transmitting and avoids transmitting if the channel is already in use

These mechanisms together ensure that other radio systems are minimally impacted by a PurePath Wireless audio network in normal circumstances. However, since a low-latency audio network by its very nature transports a very time-critical data stream, both mechanisms have adaptive thresholds to ensure that the audio network is given its fair share of RF spectrum in very crowded RF environments.