Multi-Channel Design Considerations

ABSTRACT

This application note addresses some important considerations that ANT developers should take into account when designing multi-channel solutions. Potential problem areas that can arise in multi channel systems are discussed, along with some best practices when using more than a single channel.

TABLE OF CONTENTS

LIST OF FIGURES

1 Introduction

As the ANT protocol and hardware matures, the solutions being implemented are becoming increasingly complex. Currently, many ANT based devices do not take full advantage of one of the fundamental features of ANT, that being support for multiple simultaneous channels on a single device.

This application note is intended to address some of the important considerations that ANT developers should take into account when designing more complicated multi-channel solutions. Some of the potential problem areas that can arise in a multi-channel system are discussed, along with best practices of using more than one channel. Typical applications of multi-channel usage are also discussed.

Basic knowledge of single channel ANT development is implied in this document.

2 Relevant Documents

It is strongly recommended that the following documents be reviewed and understood prior to using this application note:

- ANT Message Protocol and Usage
- ANT Chip / Module Datasheet
- AN11: ANT Channel Search and Background Scanning Channel
- AN04: Burst Transfers

3 ANT Channel Overview

To understand multi-channel ANT, it is important to have an understanding of the concept of an ANT channel.

The ANT channel is the basic building block of ANT. It is the mechanism by which two devices communicate with each other.

At the physical layer, ANT only has a single radio. ANT channels are a higher layer construction where the total available payload bandwidth of the radio is shared through a TDMA scheme. An ANT device may currently have up to eight independent channels/connections to other devices.

It is important to recognize that the bandwidth of the radio is shared. The maximum data rate of an ANT device is approximately 20 kbps (burst) or 200 Hz (broadcast) and these maximum rates remain constant regardless of whether there is one active channel or eight active channels.

3.1 Why Use Multiple Channels?

Some applications are certainly better suited to use a single ANT channel, but there are also instances where taking advantage of the multi-channel capabilities of ANT can lead to improved performance. In some cases, adding more channels may allow for the reduction of physical devices in a design.

Another advantage of using multiple channels is that a device may move from being either a master or a slave to being **both** a master and a slave, transmitting and receiving multiple data types simultaneously.

Adding more channels may also allow a developer to take advantage of more advanced ANT features such as having a "dedicated" search channel for new devices.

3.1.1 Example Multi-Channel Applications

A few of the typical ways that multiple channels have been used in actual ANT designs are given below:

Display/Collector Devices: These are devices that are intended to receive and display data from a number of sources. For example, an ANT+ enabled watch is capable of receiving several simultaneous signals, such as heart rate from a heart rate strap and speed and cadence from a foot pod. Different channels are used to listen for different devices.

Multi-Function Sensors: Some sensors, such as bike power sensors, need to listen to data from other sensors before sending the combined data on to a master device.

Relay Devices: Some ANT devices are intended to relay information from one location to another. They may listen on many channels for information that is then passed along on a separate transmit channel.

Advanced Network Topologies: The ANT protocol allows for several different types of network to be established. Using multiple channels enables more complex network designs such as star networks or personal area networks (PANs).

4 Design Considerations

There are several factors that play into multi-channel design that need to be considered by developers. Using more than one channel usually requires more thought than simple, single channel designs.

4.1 Dedicated Background Scanning Channel

One of the simplest ways to use multiple channels is to incorporate a dedicated background scanning channel into a design.

A background scanning channel will continuously search for devices in the area without acquiring any particular device or interfering with any other open channels. Any data messages received while searching are relayed to the host application along with the channel ID of the transmitter. The host may then decide whether it wants to connect to a particular device using another channel.

One typical use case is an application that can track devices entering or leaving its range on an ongoing basis. Another is an application that allows for finding all the devices in the vicinity before making a pairing decision, allowing flexibility in how pairing is handled.

4.2 ANT Networks

There are three main types of networks available to ANT devices: public, managed (such as the ANT+ network), and private networks. Channels cannot communicate between networks, but a single device may access multiple networks by assigning different channels to different networks.

Up to a maximum of three network keys can be assigned to different channels on a device, as illustrated in Figure 1.

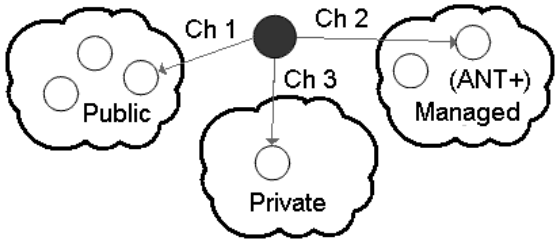

Figure 1. Multi-Network Channels

As shown in the figure, the only way to communicate between networks is via an intermediary device that has access to both. For this reason, multi-network, multi-channel applications need to pay be aware of things such as search priority, discussed in section 4.5.2.

4.3 Power Considerations

Typically, adding channels comes at some cost to power consumption. The more channels that are added, the more the radio will be "on" and using power.

However, channels can still be added to a device without breaking a device's power budget. This can be achieved by managing channel periods to keep the overall radio usage the same or lower. For example, a device may listen for ANT+ heart rate on a second channel at 1 Hz instead of the standard 4 Hz if this rate is acceptable.

4.4 Channel Collision

As discussed in section 3, ANT channels on a single device share a single radio. In most cases, this sharing works seamlessly, but there are circumstances where more than one channel tries to access the radio simultaneously and not all of the channels can be serviced. This event is known as a "channel collision" and it occurs at the chip or device level (not in the RF space).

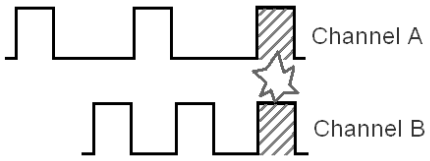

Figure 2. Graphic Example of Channel Collision

In this case, only one of the competing channels will "win" access to the radio. For slave channels, the data in the channel that is denied access is lost. For master channels in a collision, the data will remain in the buffer and be retried on the next channel period, assuming the application does not overwrite this buffer in the meantime. This behavior may be controlled by listening for the EVENT_CHANNEL_COLLISION message, described below.

It is important to recognize that a channel collision is not an error. **Under certain multi-channel configurations channel collision is a known and expected event**. Channel collision only becomes a problem when it occurs at such a frequency that one or more other channels in a system are starved for data. Steps can be taken in a multi-channel application to both minimize the chances of collision and properly deal with potential consequences of channel collision outcomes (such as a channel dropping into search due to extended receive failures). These configurations are discussed in the following sections.

4.4.1 EVENT_CHANNEL_COLLISION

On some ANT devices an explicit channel event is raised when ANT detects that a channel collision has occurred. This is raised through the Channel Response / Event (0x40) message. The AP1 device does not generate this event.

Applications may listen for this event and choose

to take action, if necessary. It should be noted that most ANT applications are designed to accommodate minor loss of data without any explicit actions being taken.

For specific event codes refer to the "Ant Message Protocol and Usage" document.

4.4.2 Causes of Channel Collision

Common circumstances that can cause a channel collision may include some or all of the following. Developers should be aware of these factors and create designs that minimize these factors.

High Channel Periods

Channel periods in the area of 8 Hz and higher are particularly susceptible to collisions in multi-channel applications. Developers should make efforts to reduce the channel periods in their design.

Channel Periods that Drift / Overlap

Frequencies such as 4.06 Hz (ANT+ Heart Rate) and 4.005 Hz (ANT+ Bike Power) will periodically "drift" into each other, or into other channel periods that may be present in the vicinity. During this overlap, channel collisions may occur as the radio can only service channel at a time.

Sometimes this drifting behavior can be intentionally used to resolve collision problems. When two channels on fixed channel periods are colliding for long periods of time, intentionally selecting a drifting period can help alleviate this under certain circumstances.

Using Too Many Simultaneous Channels

Some ANT devices can currently have up to 8 simultaneous channels. Unused channels do not add any overhead to a design, but each time an additional channel is opened on a device, the amount of free radio bandwidth is decreased, which in turn increases the odds of channel collision occurring. The severity of this is application specific, but it becomes more of a concern when using slave channels mixed with master channels.

Searching

A slave channel dropping into search can cause a high level of channel collisions on a device. This is discussed in more detail in section 4.5.

Channel collision can also cause a receiver to drop into search because it was starved for data. This can have further unintended consequences, particular if an application does not anticipate this happening.

4.5 Searching

Searching is the method by which an ANT slave device finds and establishes communication with a master. In a multi-channel application, searching has the potential to impact other channels.

There are two main types of search available to ANT devices: low priority and high priority search. As shown in Figure 3, the difference between low and high priority search is in the behavior that occurs in the event that a search waveform overlaps with a channel. For a high priority search, the search will take precedence and the channel will be blocked, while for a low priority search the channel will take precedence and the search will be blocked.

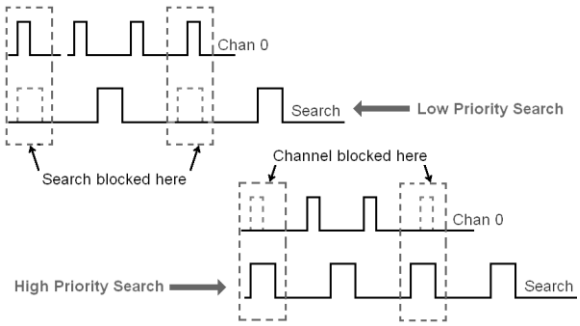

Figure 3. Graphic Example of Channel Collision

In a multi-channel application, it is important to select the type of priority search that is most appropriate for the application.

4.5.1 Search Timeouts

Search timeouts are another aspect of searching that should be carefully considered in a multi-channel system. Long timeouts increase the likelihood of finding other devices, but at the cost of increasing the chance of channel collisions. This may have further consequences for other channels in the system (i.e. other channels dropping to search).

It is important to note that search can impact both master and slave channels. Channels using acknowledged messages are particularly susceptible, as acknowledged messages effectively use double the radio bandwidth of regular broadcast messages.

In general, shorter search timeouts are safer in a multi-channel use case, but the consequences of a search ending without acquisition (and channels closing) must also be considered.

4.5.2 Searching on More Than One Channel

ANT has the ability to perform parallel searches on multiple channels, but only if all the searches are on the **same network** and the **same RF frequency**. If searches are occurring on more than one network or frequencies, the search timeouts will stack up (i.e. when one channel finishes searching, the other search will begin).

For more information on searching, refer to the "ANT Channel Search and Background Scanning Channel" application note.

4.6 Bursting

The ANT Burst transfer mode offers a fast and efficient method for transferring bulk data across an ANT channel. Rather than using an increased message rate, the ANT Burst transfer mode can achieve higher data throughput while maintaining a simple serial protocol and interface.

As illustrated in Figure 4 below, burst mode uses the entire resources of the radio and preempts any other channels from sending or receiving.

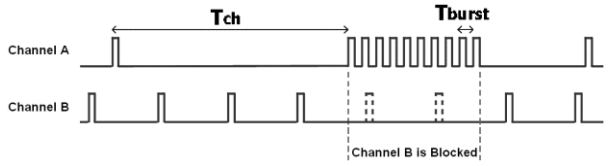

Figure 4. Bursting with Two Channels

Applications must carefully control the length of bursting to ensure that any other channels are not starved for data. Slave channels that are starved for too long may drop into search mode.

For more information on bursting, refer to the "Burst Transfers" application note.

It should be noted that ANT FS uses bursting and the same rules apply to using ANT-FS with more than one channel.

5 Common Misconceptions

A few common misconceptions regarding multiple channels are as follows:

Misconception: The high priority search is somehow faster or better than the low priority search.

Truth: In most instances, there will be no visible difference in acquisition time between a low and high priority search. The difference lies in whether the search channel or other channels take priority in the event of a collision. Whether high, low, or both types of search are used depends on the application.

Misconception: Adding channels to a device can increase the overall output of a device.

Truth: Adding channels does not add more device throughput. The max data rate of an ANT device is approximately 20 kbps (burst) or 200 Hz (broadcast). This bandwidth is shared between all of the channels.

Misconception: Unused channels burden a device.

Truth: Unused channels do not impact device performance.

Misconception: All channels in a device all need to operate on the same parameters.

Truth: There are no dependencies between channel parameters – they can all be on different channel periods, frequencies, and networks (max three).

6 General Multi-Channel Best Practices

In addition to the guidelines for best practices of using multiple channels found throughout this document, a few high level multi-channel design best practices are:

1) Use ANTware II to mock up channel configurations as one of the first steps of the design process.

Often devices reach a late stage of development before multi-channel issues such as channel collision or search problems are encountered. In many cases, these issues can easily be exposed using ANTware II without writing any code.

2) Try to minimize the following in designs:

- The number of different radio frequencies used.
- The number of networks used.
- The channel periods (message rates).

Reducing these will reduced the likelihood of channel collisions and other design problems related to using multiple channels.

3) Manage Searching:

- Use low priority search whenever possible, as to not interfere with other channels.

- Be aware of the consequences on all channels on both sides of a system if one channel goes into search, even unexpectedly.

4) Take advantage of the additional features on the newer ANT chips. Features such as the low priority search, a background scanning channel, and "EVENT_CHANNEL_COLLISION" event messages are only available on the newer chips.

7 Closing Remarks

This application note has detailed how to develop ANT devices using multiple channels. Although multi-channel devices generally require more thought during design than single channel devices, the guidelines in this document can help to make development easier.

If any of the concepts presented in this application note are unclear or for any further inquiries, please contact ANT technical support.