Debugging Joining in a ZigBee Network

Introduction

In a ZigBee network, routers and end devices must discover and join a network before they can communicate with other ZigBee devices. The XBee ZB firmware includes a number of AT commands that can be used to configure the ZigBee joining parameters (i.e. scan channels, PAN ID, permit join, security settings, etc). See the XBee ZB product manual for details on the joining process and related AT commands.

When becoming familiar with the concept of joining in ZigBee, there are a number of factors that determine which network(s) a device can join. When an XBee fails to join a desired ZigBee network, the AI command can be used to determine the reason the join attempt failed. This application note provides guidance on how to resolve joining problems based on the information contained in the AI command value.

AI Command

The AI command reports the association status from the last join attempt on an XBee router or end device. If AI is set to 0, the XBee has successfully joined a ZigBee network. If AI is set to 0xFF, the XBee is currently scanning one or more channels, searching for a valid ZigBee network to join. For all other AI values, the XBee is not joined, and the AI code indicates a failure code from the last join attempt.

The AI command can be queried in AT firmware by entering AT command mode and sending an "ATAI" command followed by a carriage return. In API firmware, the following is an example API frame to query AI:

7E 00 04 08 01 41 49 6C

XBee Joining Behavior Review

When attempting to join a network, the XBee scans the channels included in the SC (scan channels) bitmask until a valid PAN is found, or until all SC channels have been scanned. If a join attempt fails on a given channel, the XBee will continue scanning on the next higher channel until all remaining SC channels have been scanned.

After scanning all SC channels, the XBee will delay for a time (with the receiver disabled) before starting a new scan. To satisfy ZigBee requirements, the XBee scans all channels up to 9 times per minute for the first 5 minutes (since being powered on), and up to 3 times per minute thereafter.

The remainder of this document provides guidance on how to solve joining problems based on the AI code. Each page lists an AI code (orange oval) and steps to identify the root cause and correct the problem (blue rectangles). The following AI codes are included:

AI Code	Description
0x21	No PANs found
0x22	PAN(s) found with invalid PAN ID
0x23	Joining not allowed
0x27	Join failure
0x2B	Discovering coordinator
0xAD	Security key not received
0xAF	Pre-configured link key error
0xFF	Attempting a new join scan

0x21 - No PANs

0x21 indicates that a ZigBee network (with a matching stack profile) was not found.

Solution #1:

The XBee can often return 0x21 for a brief time after leaving a network. When it leaves a network, it continues scanning at the next higher channels in the SC bitmask until it finds a new network, or until it scans all remaining SC channels. If a network is not found on the higher channels (from the channel it left), it will report 0x21 until it starts a new scan.

If the 0x21 code is shortly replaced with a new code, see the new code to diagnose the problem.

Solution #2:

Read the CH command (operating channel) on a device that is on the network. Now read the SC command value on the joining device. Does the SC bitmask (scan channels) on the joining device include the operating channel?

For example, if the CH command returns 0x0C, then SC on the joining device should have bit1 set (i.e. 0x0002). If the CH command returns 0x11, then SC on the joining device should have bit6 set (i.e. 0x0040).

Solution #3:

Read the ZS command (ZigBee stack profile) command on a device that is on the network. Does the ZS value on the joining device match?

0x22 - Wrong PAN

0x22 indicates the XBee found at least one ZigBee network, but the XBee parameters do not match the parameters of the discovered PAN(s).

Solution #1:

An AI value of 0x22 indicates the XBee found at least one ZigBee network. Often times a 0x22 code indicates the PAN ID setting is wrong, or joining is not enabled on the desired network. If there are multiple ZigBee PANs in the area, it may not be scanning the channel of the desired PAN. It is also possible the security settings do not match.

Solution #2:

Read the OP command value on a device that has joined the desired ZigBee network. Now read the ID command value on the joining device. Is ID set to 0 (join any PAN ID)? If not, is it set to a value that matches the OP value of a device on the desired ZigBee network?

Solution #3:

If more than 1 ZigBee network are operating in the area, read the CH command on a device that has joined the desired network. Now read the SC command value on the joining device. Does the SC bitmask (scan channels) on the joining device include the operating channel?

For example, if the CH command returns 0x0C, then SC on the joining device should have bit1 set (i.e. 0x0002). If the CH command returns 0x11, then SC on the joining device should have bit6 set (i.e. 0x0040).

0x23 -
Joining Not Allowed

0x23 indicates the XBee found at least one valid ZigBee network (that it could try to join), but joining was not enabled on the network.

Solution #1:

Read the NJ command on a device that has joined the desired network, preferably one within range of the joining device. If NJ is set less than 0xFF, joining might be disabled on the network. Do any nearby devices on the network have NJ set to 0xFF? If not, joining may be disabled.

If joining may be disabled, any of the following could be used to enable joining on a device that is already part of the network:
- Press the commissioning button 2 times,
- Issue the CB2 command, or
- Set NJ to a different value
- Send a ZDO Permit-Join request to one or more devices to enable joining

0x27 - Join Failure

0x27 indicates the XBee attempted to join a ZigBee network but the join attempt failed.

Solution #1:

Read the EE command on a device that has joined the desired network. Now read the EE command on the joining device. Do the values match? Was the KY value set on devices that already joined the network? Does the joining device have the same KY setting? (KY is a write-only command so it cannot be read.)

Solution #2:

Read the CH command on a device that has joined the desired network. Now read the SC command value on the joining device. Does the SC bitmask (scan channels) on the joining device include the operating channel?

For example, if the CH command returns 0x0C, then SC on the joining device should have bit1 set (i.e. 0x0002). If the CH command returns 0x11, then SC on the joining device should have bit6 set (i.e. 0x0040).

Solution #3:

If the joining device is an end device, the network may not have enough end device capacity for the joining device. (Each router and coordinator can only allow a finite number of end device children to join.) To check end device capacity, read the NC command on all routers and coordinator in the network. If NC reports a non-zero value on at least one device, then that device can allow more end devices to join. Otherwise, if NC=0 on all routers and the coordinator, then the network cannot allow any more end devices to join. Add more routers to increase the number of end devices that can join.

0x2B – Discovering Coordinator

0x2B indicates the XBee has joined a ZigBee network and is attempting to discover the coordinator.

Solution #1:

If JV is set to 1, the XBee will attempt to discover the coordinator on a network before considering itself joined. It does this by sending a ZDO broadcast to discover the 64-bit address of the coordinator. If AI returns 0x2B, the XBee has sent the address discovery ZDO request and is waiting for a response. Within a very short time, the AI code should change to 0 if the address is discovered. If AI does not change to 0, then the address discovery failed.

If joining fails, is the coordinator powered on?

Solution #2:

Read the CH command on the coordinator. Now read the SC command value on the joining device. Does the SC bitmask (scan channels) on the joining device include the coordinator's operating channel?

For example, if the CH command returns 0x0C, then SC on the joining device should have bit1 set (i.e. 0x0002). If the CH command returns 0x11, then SC on the joining device should have bit6 set (i.e. 0x0040).

Solution #3:

Are there routers in the area that are part of a separate ZigBee network? Is the joining device joining a second network that does not have a coordinator?

0xAD -
Security Key Not Received

0xAD indicates the XBee did not receive the network security key from the network it joined, when it expected to receive a network key.

Solution #1:
The XBee must have EE set to 1 and then join a network where security is not enabled to get this code. Is security enabled on the desired network? Should EE be set to 0 on the XBee?

0xAF -
Link Key Error

0xAF indicates the XBee joined a secure network, but the network has a pre-configured link key and the joining device does not.

Solution #1:
To fix this problem, set the pre-configured link key (KY) on the joining device to match the pre-configured link key (KY) on devices in the network.

0xFF -
Attempting Join

The XBee reports an AI code of 0xFF at the beginning of each new channel scan.

Solution:
This value should be replaced by another value after a short time.