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ABSTRACT

Presented herein are techniques to address Personal Area Network (PAN) change failures. The techniques presented herein take advantage of, for example, a DODAG Information Object (DIO) poisoning mechanism, a Destination Advertisement Object (DAO) sequence in DAO/DAO ACK, and/or a NS/NA mechanism to address the issues associated with PAN change failures caused by the use of a compresses PAN identifier (ID) in Upper Layer Application Data (ULAD).

DETAILED DESCRIPTION

Internet of Things is a growing field that is of interest to a large number of consumers. As such, vendors have developed grid mesh networks for use with Internet of Things applications, such as the smart grid in Advanced Metering Infrastructure (AMI) networks and distribution automation (DA) gateway. In addition, the Wireless Smart Utility Networks (Wi-SUN alliance) has been developed to promote interoperable wireless standards-based solutions for the Internet of Things.

In a Wi-SUN Field Area Network (FAN), the Technical Profile Specification (TPS) section 6.3.2.1.6, requires that the PAN ID field be compressed in unicast Upper Layer Application Data (ULAD) frames to reduce the packet length. This compression causes several problems. For example, when receiving a unicast ULAD from a neighbor, a mesh node (or connected grid router (CGR)) is unable to determine whether the packet is from the correct PAN. This could result in PAN change failure, as shown below in Figure 1.

5896X

Changed PAN ID from 1->2

CGR

DAO

DAO-ACK
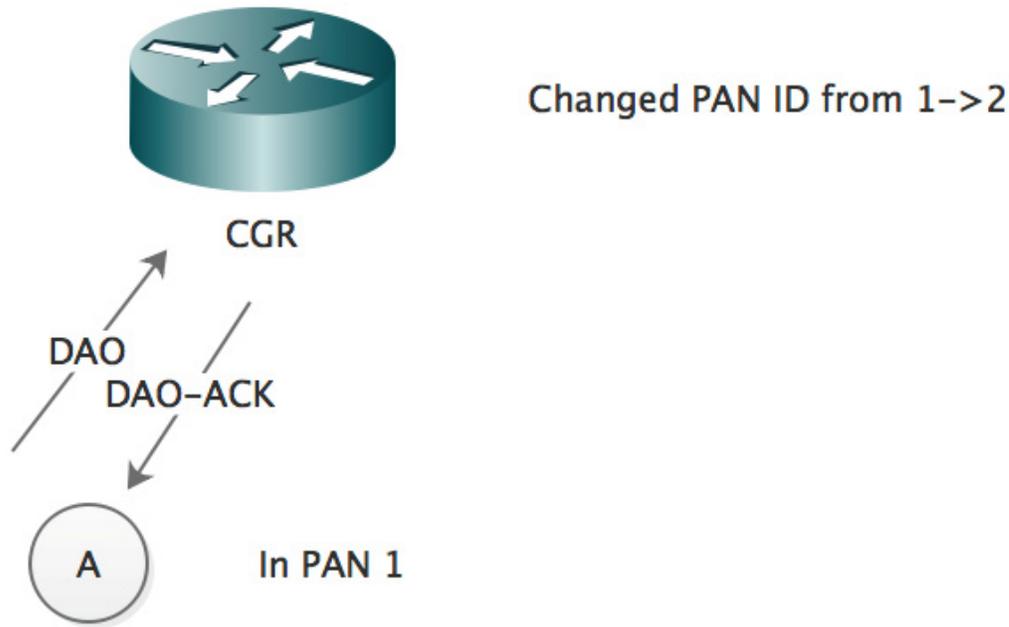
A   In PAN 1

Figure 1

In Figure 1, after the CGR changes the PAN ID from 1 to 2, conventional mechanisms do not inform node A of this event (i.e., node A would stay at/in PAN 1). As a result, node A will continue to send Destination Advertisement Object (DAO) frames to CGR to refresh the route table. Since the PAN ID is compressed in the DAO frames, the CGR would create a new route entry for node A, even though the DAO frame is sent from node A of the old PAN. The CGR sends a DAO-ACK to node A, since the PAN ID in DAO-ACK is also compressed. As such, node A will treat the PAN 1 as still alive, and thus will stay at PAN 1.

The techniques presented herein provide a mechanism to fix this issue of PAN change failure caused by the compression of the PAN ID in ULAD. In particular, after the network manager changes the PAN ID on the CGR command line, the CGR is proposed to stay at the old PAN for a period of time. The CGR will send out a DIO with infinity rank (65535) to poison the RPL instance.

2   5896X
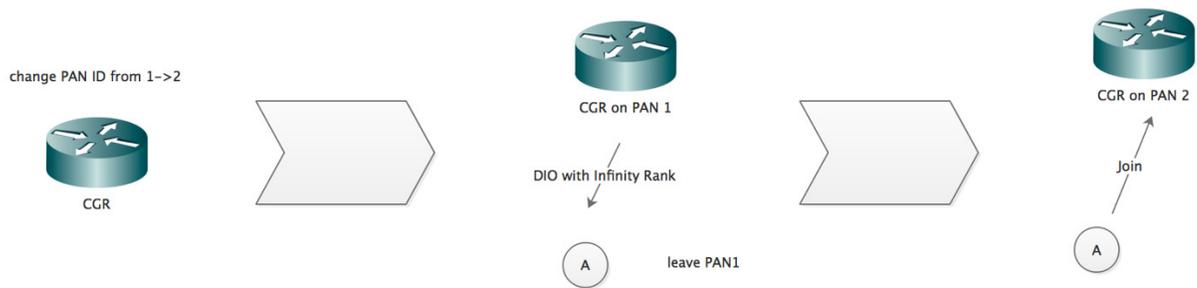
Figure 2

In Figure 2, above, after the PAN ID is changed from 1 to 2, the CGR would stay at PAN 1 for a period of time so as to send a poison DIO. This poisoning will decrease the time needed for node A to leave PAN 1, thereafter CGR can move to PAN 2.

The techniques presented herein also proposed the use of a DAO **s**equence in DAO/DAO-ACK frame for use in judging whether the DAO is from the old PAN. An initial value range for the DAO sequence in proposed for the case that DAO-ACK is not received in some scenario.

Section 7.2 of RFC 6550 specifies that a counter is initialized to something, e.g., >= 128 and the range of 128 to 255 is used once and then 0 to 127 is used continuously ("lollipop counter"). The RFC states that: "If a node sends a DAO message with newer or different information than the prior DAO message transmission, it MUST increment the DAOSequence field by at least one." In certain cases, the DAO is not initially ACKed (e.g., due to it being lost) and then, while the node is re-sending the DAOs, it changes parents (i.e., the contents of the DAO has also been changed, the fixed initial value cannot be used in this case). As such, an initial DAO sequence range is proposed. For example, the initial DAO range is proposed to be [129,139]. If the initial value is 129, has not been asked, and the DAO info changed, the next DAO sequence should be 130. If DAO-ACK is received with DAO sequence 130, then the next DAO sequence should be 140. In this case, CGR can treat the DAO sequence value in [129,139] as an initial DAO.

3   5896X
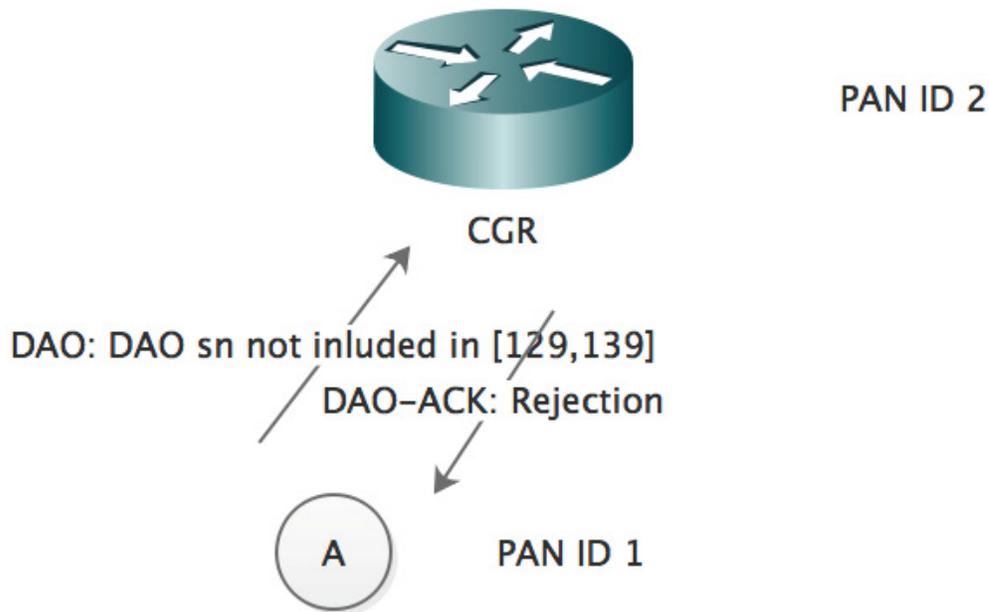
Figure 3

In Figure 3, after the PAN ID is changed from 1 to 2, the CGR receives the first DAO with a DAO sequence that does not belong to the initial DAO sequence range [129.139]. As such, the CGR will treat node A as still being in the old PAN and will send back a DAO-ACK with status Rejection to node A in order to force node A to leave the old PAN. These additions enable the PAN change failure problem to be corrected and can be promoted to Wi-SUN, as RPL is mandatory for Layer 3 routing in Wi-SUN.

In certain examples, a Global/Link-local IP on neighbor solicit (NS) may be used for judging whether the ULAD is from old PAN. In certain meshes and/or Wi-SUN, the IP address in the first NS message from node should be a Link-Local address.
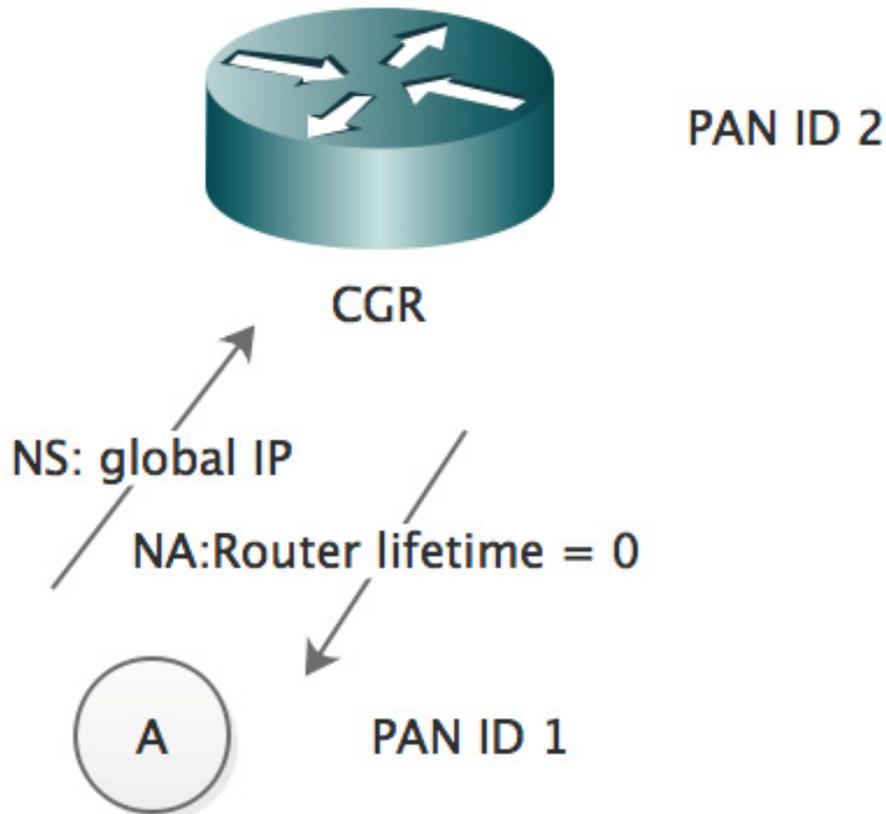
Figure 4

In Figure 4, after the PAN ID is changed from 1 to 2, the CGR receives the first NS with a global IP. As such, the CGR will treat node A has still being part of the old PAN, and will send back a neighbor advertisement (NA) with Router lifetime:0 in order to force node A to leave the old PAN. These additions enable the PAN change failure problem to be corrected and can be promoted to Wi-SUN without compatibility issues with old software versions.

In certain examples, expiration of all existing GTK may be provided and a new GTK added on WPAN of the CGR automatically, after the CGR changes the PAN ID. The GTK can be refreshed (e.g., expire old and add new) by FND or CGR automatically. After the GTK is refreshed, the node cannot communicate with the CGR via ULAD until it joins the new PAN because of the key for encrypting ULAD is changed.

5   5896X