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INTER PERSONAL AREA NETWORK BACKUP

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ABSTRACT

Techniques are described herein for realizing an intra Personal Area Network (PAN) backup. The data traffic interrupt duration may be significantly reduced after the Field Area Router (FAR) goes down. These techniques may also keep the intra-PAN logical group stable after a FAR power cycle.

DETAILED DESCRIPTION

In Low-Power and Lossy Networks (LLNs), devices autonomously join a Personal Area Network (PAN) and form routes to the Field Area Router (FAR). Sometimes, the devices may need to switch to a different PAN in a process called PAN migration.

One typical cause of PAN migration is the loss of connectivity to the FAR (e.g., the FAR is down due to loss of power). Figure 1 below illustrates an example system. If the FAR in PAN1 goes down, all the devices in PAN1 will migrate to PAN2 or PAN3. If the FAR in PAN1 comes back up again, the devices need to migrate back to PAN1. In one specific example, the FAR in PAN1 goes down, causing all nodes from PAN1 to try to migrate to PAN2/PAN3. This leads to an interrupt of data traffics (e.g., metering data) on those nodes until the migration is complete.

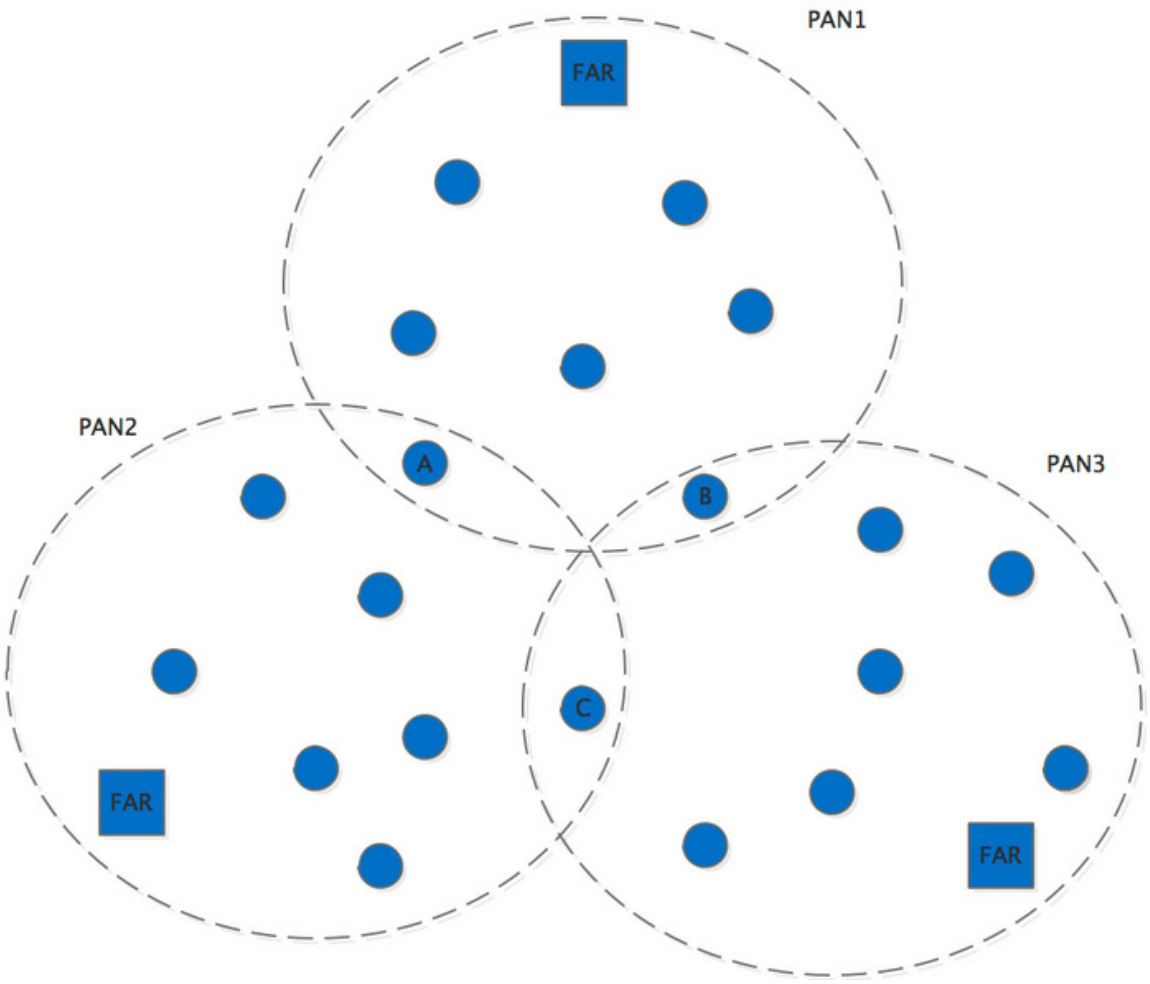

Figure 1

In a typical smart unity network application, there can be thousands of devices connected to a FAR. If one FAR goes down, thousands of devices need to migrate to other PANs simultaneously. One challenge is to accelerate the process to alleviate the migration impact. Meanwhile, nodes (e.g., nodes A, B, and C in Figure 1) in the overlapping area of two different PANs may oscillate between those PANs, resulting in PAN instability. However, stabilizing the PAN may slow down the PAN migration.

Thus, the problem is that when the FAR is down, accelerating PAN migration speed can alleviate the migration impact, but data traffic interrupt on migrating nodes cannot be avoided. There could be thousands of nodes in PAN, and considering that some nodes may oscillation between PANs, the time cost of migration may be very high. Furthermore, some nodes may be integrated as a logical group, which are always expected to remain together

even when the PAN root is down. However, PAN migration may break apart the original logical group.

A mechanism for inter-PAN backup to avoid PAN migration is provided to address the aforementioned problems. In one example, a node in the overlapping area of multi-PANs may be configured as candidate local root, meaning that it can join in multiple PANs but can only join in one global Internet Protocol version 6 (IPv6) Routing Protocol for LLNs (RPL) instance which is broadcast by the FAR.

As illustrated in Figure 2 below, after nodes A and B join PAN1 and are configured as candidate local roots, node A joins PAN2 without leaving PAN1, and node B joins PAN3 without leaving PAN1. As nodes A and B already joined in the global RPL instance from FAR1, nodes A and B do not join the global RPL instance from FAR2 or FAR3.

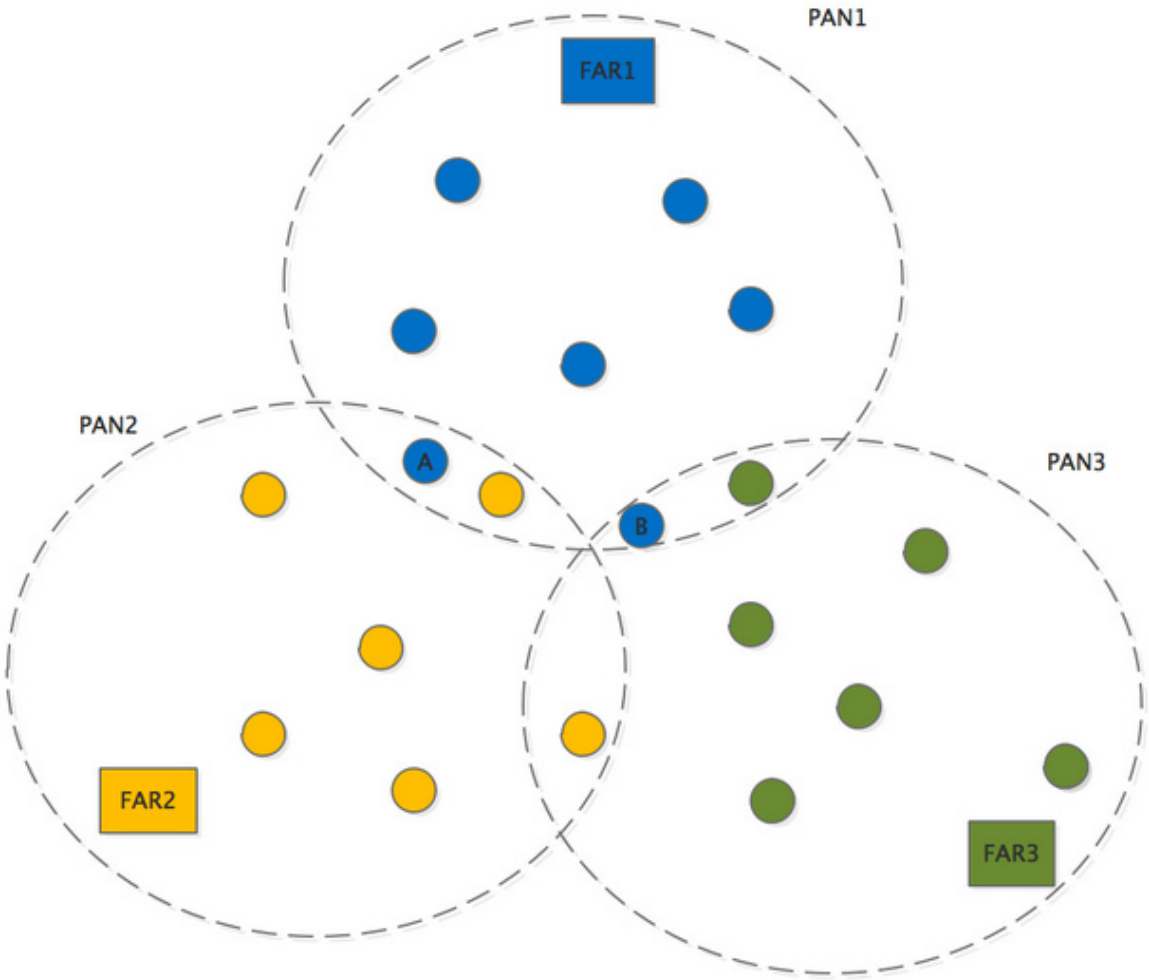

Figure 2

Each node may join multiple RPL instances. Only one instance is a global instance from a FAR, and the other instances are local instances from the candidate local root. As illustrated in Figure 3 below, after nodes A and node B are set as candidate local roots, they broadcast their instances in PAN1, prompting all nodes to join the RPL instance of local instance A, local instance B, and the global instance from FAR1.

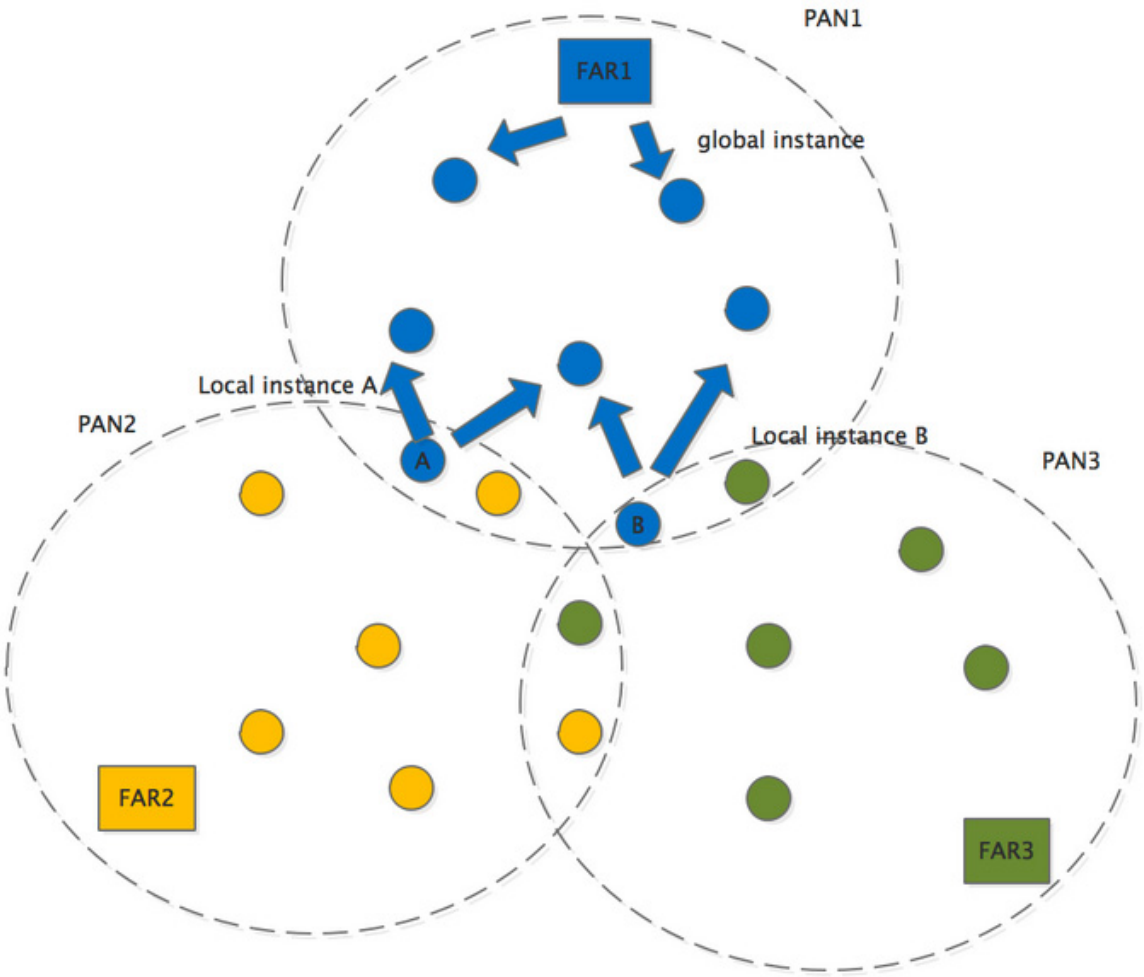

Figure 3

After the FAR goes down, the candidate local root with the minimal routing metric may be selected as the new root, and as the proxy to forward upward data traffic to the Internet. An example routing metric formula may be used as follows:

PAN_metric = PAN_size x PAN_size_weight + route_cost x route_cost_weight

After FAR1 goes down:

PAN_metric(A in PAN2) = PAN2_size x PAN_size_weight + route_cost (A to FAR2) * route_cost_weight

PAN_metric(B in PAN3) = PAN3_size x PAN_size_weight + route_cost (B to FAR3) * route_cost_weight

Because PAN2_size < PAN3_size, and route_cost (A to FAR2) < route_cost (B to FAR3), PAN_metric(A in PAN2) is the minimal routing metric. Node A may be selected as the new root. As illustrated in Figure 4 below, Node A may forward upward the data packet to the Internet. In particular, Node A quickly joins in the global RPL instance from FAR2, and then all data traffic generated in PAN1 may be forwarded to the Internet via Node A. After the FAR is restored, all nodes that belong the global RPL instance of that FAR may re-join it.

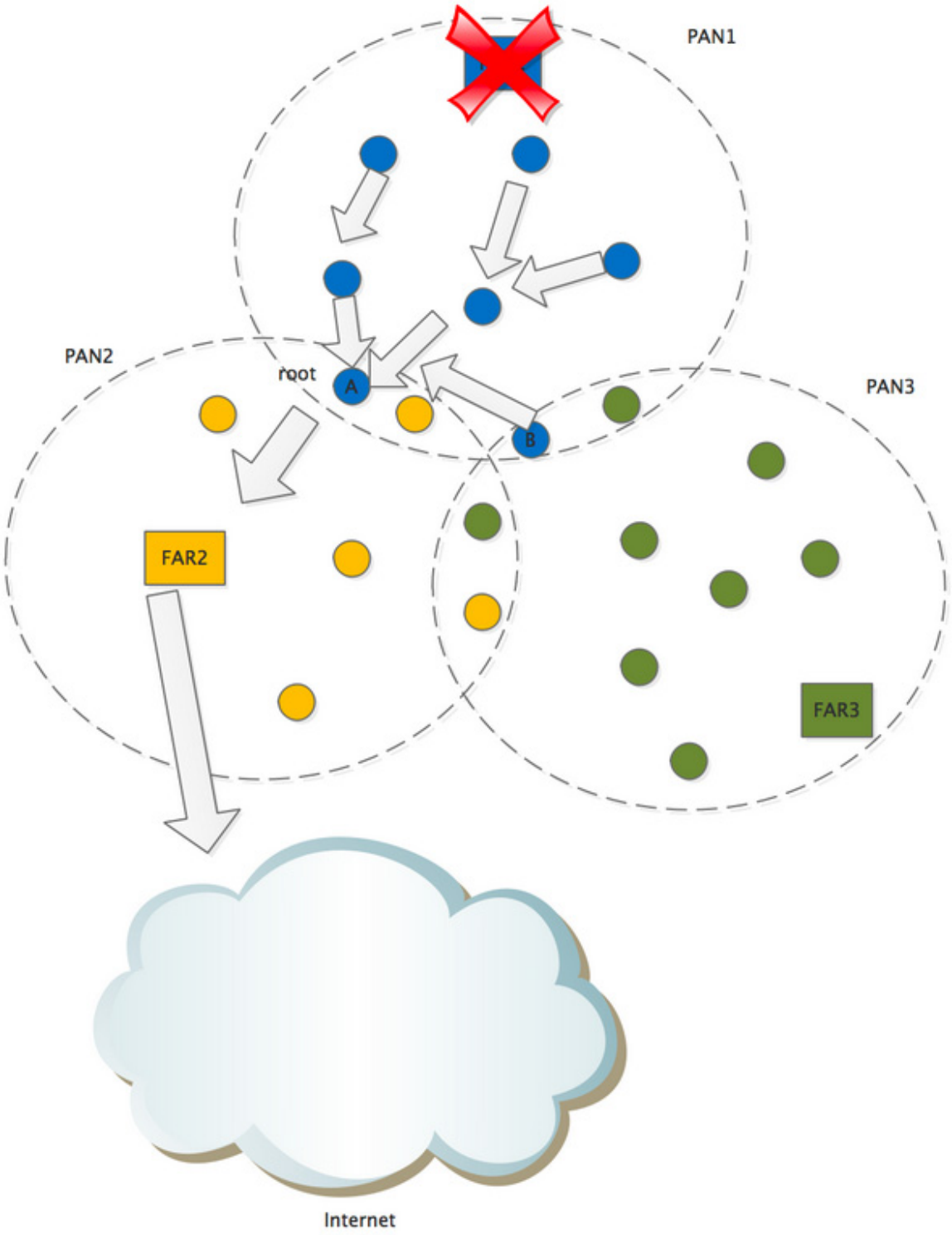

Figure 4

As described herein, even when the FAR is down, nodes in the PAN do not need to migrate to another PAN. Thus, after the FAR goes down, the duration of data traffic interrupt can be significantly reduced. Furthermore, intra-PAN backup may be realized. Even if one FAR goes down, the data traffic may be forwarded to the Internet without PAN migration. After the FAR has recovered, the network convergence time may be very short as there is no PAN migration during the process. Even if the FAR goes down, any intra-PAN logical groups may not be affected.

In summary, techniques are described herein for realizing an intra PAN backup. The data traffic interrupt duration may be significantly reduced after the FAR goes down. These techniques may also keep the intra-PAN logical group stable after a FAR power cycle.