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DIFFERENTIATED RETRANSMISSION IN WIRELESS MESH NETWORKS

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ABSTRACT

Techniques are described herein for enabling diverse retries at a lower layer based on possibilities provided by routing operations. An anycast model is used to indicate a set of next hops and forwarding interfaces that enable indicating raw constraints such as bounded latency to perform a transmission.

DETAILED DESCRIPTION

Figure 1 below illustrates a wireless mesh network wherein upstream traffic is sent to the border router through multiple hops.

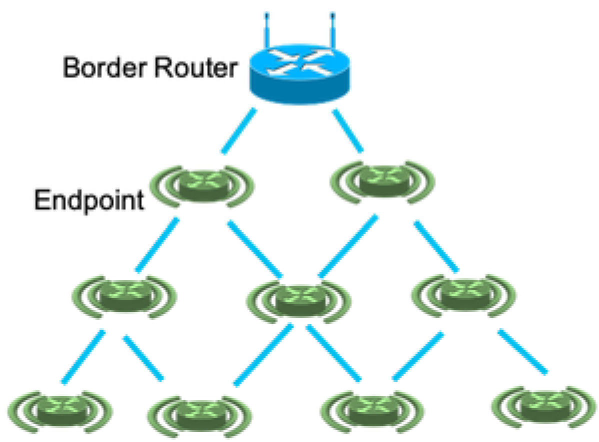

Figure 1

Figure 2 below illustrates a procedure performed by the endpoint when an application at the endpoint attempts to send a packet to the border router. As shown, the application creates the packet and passes it to the network layer through the socket interface. The network layer adds an Internet Protocol (IP) header (e.g., source and destination IP addresses) to the packet, and passes it to the Media Access Control (MAC) layer. The MAC layer adds a MAC header to the packet and passes it to the physical layer, after which the packet is sent.

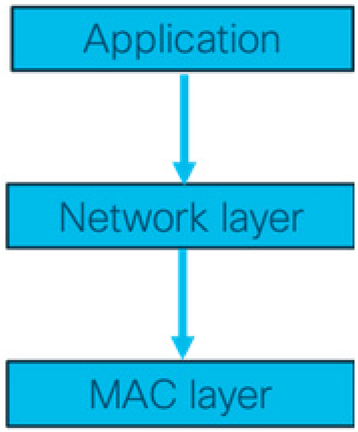

Figure 2

In wireless mesh networks, the packet is usually sent to the primary parent P1. Figure 3 below illustrates an example packet format.

SRC_MAC	DST_MAC (P1)	SRC_IP	DST_IP (P1)	DATA

Figure 3

If the transmission to P1 fails, the application needs to re-create the packet and retransmit it to the secondary parent P2 (and possibly other parents in turn). Figure 4 below illustrates an example packet format.

SRC_MAC	DST_MAC (P2)	SRC_IP	DST_IP (P2)	DATA

Figure 4

Figure 5 below illustrates a system-level overview of this process.

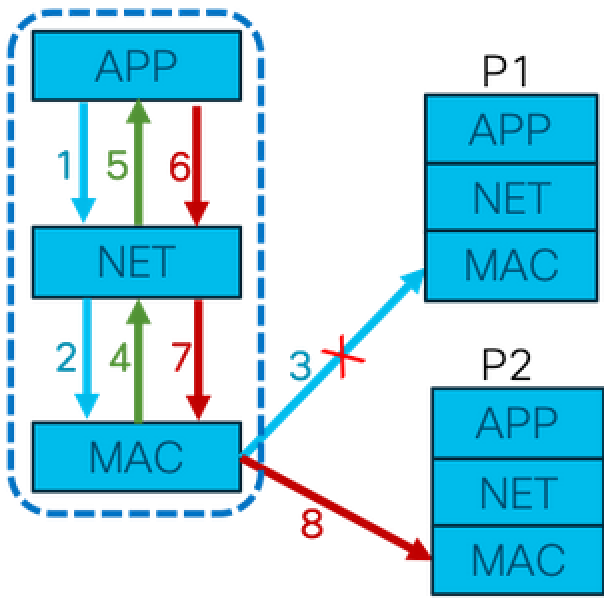

Figure 5

There are several problems with the aforementioned approach. When the transmission fails, the node's MAC layer needs to notify its upper layer (e.g., the application layer) to re-create the packet. This is difficult to implement since it leads to cross-layer violations. Furthermore, in some cases, it might be impossible for the MAC layer to notify its upper layer and choose an alternative parent, since the application layer is not aware that the transmission failed. In addition, re-creating the packet at the application layer causes extra overhead. Accordingly, described herein are techniques for handling retransmissions in wireless mesh networks.

As systems become increasingly layered and distributed, interfaces such as the socket interface become increasingly standardized. In a similar fashion, Internet of Things (IoT) devices such as so-called motes can be split in an application processor and a network processor, and a protocol is needed between the two. The same applies to Network Interface Cards (NICs) in servers becoming increasingly intelligent and capable of offloading the main processors. Typically the IP waistline and a protocol such as Dynamic Link Exchange Protocol (DLEP) provide an interface within the distributed box.

A form of an anycast address is provided to indicate a next hop router (as opposed to conventional anycast addresses, which indicate the destination). Typically, a router manipulates a link local address of each of its neighbors and uses that to indicate the next hops in routing (e.g., through a routing protocol) and forwarding (e.g., passing a packet to the lower layer for transmission) operations. The anycast address described herein replaces a link local address in the Routing Information Base (RIB), Forwarding Information Base (FIB), and socket interfaces and allows the lower layer to select which of the possible next hop routers that match that anycast address receive the packet.

This pseudo-internal anycast address may be leveraged through any suitable method. The address is generated inside the system and associated to multiple neighbors. For example, for a northbound packet, any one of four best RPL parents is a feasible successor. Instead of obtaining the link local address of a parent, a route lookup returns the anycast address that represents any parent. That indication is provided as the forwarding instruction to the lower layer, leaving to the lower-level functionality the responsibility of selecting one parent, or more importantly attempting a series of parents when transmissions fail.

A raw packet may progress within bounded latency. When a transmission fails (e.g., no Layer 2 (L2) acknowledgment), retrying the same operation (e.g., including frequency, next hop, radio technology, etc.) has an increasingly lower chance of success as more retries are performed. Diversity in time and frequency can be achieved with the same next hop, but using radio and path diversity or replication requires an augmented socket. Interface parameters are associated to the transmission layers to indicate that bounded latency and the list of possible next hops can be indicated as the anycast address described herein. This anycast address may be present on more than one interface.

Differentiated retransmission methods may be utilized for wireless mesh networks depending on whether the operation is performed within one interface or over multiple interfaces.

In one example method, the retransmission is handled by the MAC layer and is transparent to the application layer. An anycast address is defined for all parents. The anycast address is handled by the sender stack.

For example, when a node attempts to send an upstream packet, it first sends the packet to the primary parent P1. Figure 6 below illustrates an example packet format.

SRC_MAC	DST_MAC (P1)	SRC_IP	DST_ANYCAST_IP	DATA

Figure 6

Figure 7 below illustrates a system-level overview of this process.

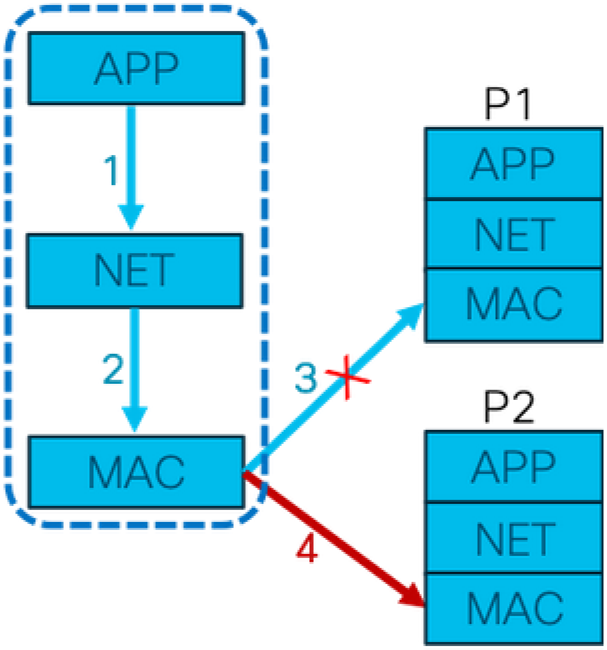

Figure 7

As illustrated in Figure 8 below, when the transmission to P1 fails, the node MAC layer replaces the DST_MAC address as P2 and re-transmits the packet to P2.

SRC_MAC	DST_MAC (P2)	SRC_IP	DST_ANYCAST_IP	DATA

Figure 8

At least eight steps are required to complete a retransmission without the anycast address described herein, whereas only four steps are required using the anycast address.

In another example method, the retransmission is handled during routing resolution. Figure 9 below illustrates a system-level overview of this process. As shown, the application layer creates a packet and passes it to the network layer. During routing resolution, it resolves multiple next hop addresses and passes them to the MAC layer as metadata. The MAC layer tries the next hop addresses in turn when the transmission fails.

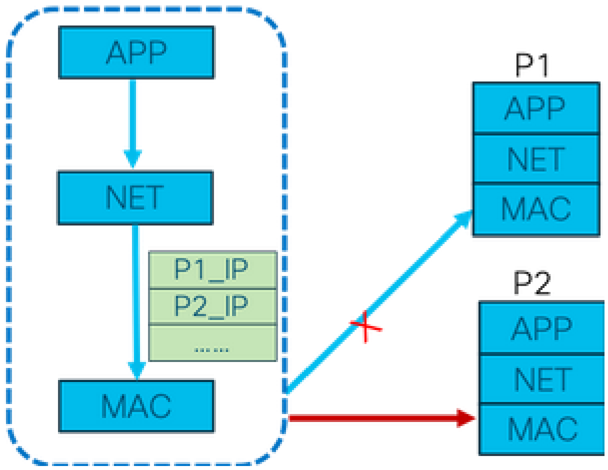

Figure 9

In summary, techniques are described herein for enabling diverse retries at a lower layer based on possibilities provided by routing operations. An anycast model is used to indicate a set of next hops and forwarding interfaces that enable indicating raw constraints such as bounded latency to perform a transmission.