

Why Flood DM Paths Vary, Why Directed Paths Fail, and Why Strong Paths Remain Stable in MeshCore Networks

Introduction

Flood-based Directed Messages (DMs) in MeshCore often take different paths between the same two nodes, even when two messages are sent to the same destination seconds apart. This path variability—commonly described as the DM path “jumping around”—is not a malfunction. It is a natural outcome of MeshCore’s probabilistic forwarding model, random backoff delay (based on txdelay), receive-window desynchronization, and real-time RF variability. This document explains why flood paths vary, why directed paths sometimes fail, why flood retries succeed, why repeating the DM again produces a different path, and why strong paths remain stable and do not change.

1. A Direct Message is Composed of Two Components

A Directed DM/Flood DM path followed by an ACK Flood path

These two paths are independent:

<u>Component</u>	<u>How it moves</u>	<u>Deterministic?</u>	<u>Uses path list?</u>
Directed DM	Narrow, explicit path list	Yes	Yes
Flood DM	Opportunistic broadcast flood	No	No
Flood ACK	Opportunistic broadcast flood	No	No

The Directed DM is a strict, hop-by-hop traversal of the path list.

The Flood is a chaotic, nondeterministic RF storm.

The ACK flood is a chaotic, nondeterministic RF storm.

The DM and ACK are not linked.

2. How Flood DMs Propagate

Flood DMs rely on opportunistic forwarding rather than deterministic routing. The process is:

- The DM sender (originating Companion) broadcasts the flood packet.
- All neighbors that hear it and independently decide whether to forward.
- Forwarding by your neighboring repeaters and the subsequent repeaters in the path list depends on hop count, duplicate suppression, timing windows, and local airtime.
- Each forwarder becomes a new origin for the next hop.
- The flood continues until it reaches the DM receiver (destination Companion) or expires.

Because each repeater makes forwarding decisions under different RF conditions, the resulting path is inherently non-deterministic.

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3. How Directed DMs Propagate

Directed DMs rely on deterministic routing; the path is contained in the message. The Directed DM is a strict, hop-by-hop traversal of the path list.

The process is:

- The DM sender (originating Companion) Transmits the Directed DM packet.
- All neighbors that hear it independently decide whether to forward.
 - Only the repeater that is at the head of the path list forwards the packet
 - All other repeaters discard it
- The repeater at the head of the path removes its ID and transmits the packet for the next hop.
- This repeats until it reaches the DM receiver (destination Companion)

Because each repeater only transmits the packet once, the forward progress can stop at any of the hops due to: different RF conditions, a packet error (Collision, ECC failure, Preamble not detected to a too low SNR, etc.)

Although the path is deterministic, it is not guaranteed to succeed.

4. DM Acknowledgment

If the DM is received by the destination, a small Flood ACK packet is transmitted to acknowledge the receipt.

- The ACK flood is a chaotic, nondeterministic RF storm that transverses the mesh to the destination (the original sender)
- The flood ACK does not follow the Directed DM's path, but it may traverse some or all of the same nodes.
- Because it is a Flood many ACKs can be received by the destination

All of the received ACKs are used to construct the return path. The returned ACK flood can pass through the same nodes as the original Directed Path

Even though the ACK flood is nondeterministic, it may:

- pass through the same nodes the Directed DM used
- pass through some of them
- pass through none of them
- pass through nodes that were never on the DM path
- skip hops
- take shortcuts
- take a longer path

This is why the displayed path is not guaranteed to match the DM path — but it can match it by coincidence.

5. When the ACK flood overlaps the DM path, the displayed path looks “correct”

Here’s the key:

- The displayed path is built from the ACK flood, not the DM.
- But if the ACK flood happens to traverse the same nodes as the DM, the displayed path will look like the DM path.

This is why operators sometimes see:

DM path: A → B → C → D
Displayed path: A → B → C → D

And other times:

DM path: A → B → C → D
Displayed path: A → F → G → D

Or even:

DM path: A → B → C → D
Displayed path: A → D

All of these are normal.

6. Why the displayed path can match the DM path

Because the ACK flood is huge and redundant, it may:

- reach the sender through the same chain the DM used
- reach the sender through a subset of that chain
- reach the sender through a superset of that chain
- reach the sender through a completely different chain

If the ACK flood’s earliest ACKs per hop happen to align with the DM path, the displayed path will match the DM path.

But this is coincidence, not routing logic.

7. Why Flood Paths Vary from One DM to the Next

A. Random backoff delay (based on “*txdelay*”)

MeshCore introduces a random backoff delay preventing synchronized transmissions. This randomness means:

- Different neighbors forward the same flood at slightly different times. They choose different backoff values.
- The node that “wins” the timing race in one flood may lose in the next.
- The earliest successful forwarder determines the next hop.

Even tiny differences in backoff timing cascade into large path differences.

B. Collision dynamics and airtime contention

Floods create bursts of simultaneous transmissions. Depending on:

- Which nodes collide,
- Which nodes back off,
- Which nodes successfully decode, the set of nodes that forward the packet changes from flood to flood.

C. Receive-window desynchronization (*rxdelay*)

Nodes do not listen at identical times. Their *rxdelay* values spread out receive windows, causing:

- Some nodes to hear the flood earlier or later,
- Occasional misses of the first copy,
- Forwarding of later copies by different nodes.

This desynchronization is a major driver of path variability.

D. Environmental variability and RF noise

RF conditions fluctuate constantly due to:

- Multipath fading,
- Shadowing,
- Movement of people, repeaters (mobile repeater) or objects,
- Temperature and humidity changes
- In-channel interference

These micro-variations change which neighbors hear the flood first—or at all.

E. Neighbor-table differences

Nodes maintain neighbor tables based on their own hearing history. Because each node has a unique RF perspective:

- Some nodes consider certain neighbors “strong” while others see them as “weak.”
- A node that forwards in one flood may suppress forwarding in the next.

F. Duplicate suppression behavior

Nodes suppress forwarding if they detect that another node has already forwarded the packet. Because:

- The first forwarder varies,
- The hearing order varies,
- The suppression timing varies,

The set of nodes that forward the packet changes each time.

8. Why Directed Paths Sometimes or Always Fail

Directed DMs rely on a single chosen next hop at each stage. This makes them vulnerable to:

- Asymmetric links (good in one direction, poor in the other),
- Marginal Signal to Noise Ratio (SNR) that fluctuates moment-to-moment,
- Temporary shadowing from people, vehicles, or terrain,
- Collisions at the exact moment the directed hop transmits,
- Neighbor table staleness (the chosen next hop is no longer optimal),
- Hidden-node interference.
- The repeater has failed or was permanently removed from service

Directed routing is efficient but brittle: if the one chosen hop fails, the entire directed DM fails.

9. Why the Flood Retry Succeeds

Flood retries succeed where directed paths fail because they exploit **path diversity** and **timing diversity**:

- Multiple neighbors attempt to forward, not just one.
- Random backoff delay ensures at least one forwarder escapes local collisions.
- Nodes with better instantaneous SNR may forward even if they weren't chosen for the directed path.
- The flood can route around temporary obstructions or asymmetric links.

Floods are robust because they explore all viable paths simultaneously.

10. Why Repeating the DM Again Produces a Different Flood Path

Even when a flood succeeds, repeating the DM often produces a different path because:

- Random backoff delay reshuffles who forwards first,
- Collisions occur differently each time,
- Receive-window timing shifts,
- Environmental conditions fluctuate,
- Duplicate suppression changes which nodes decide to forward,
- Neighbor tables evolve.

Each flood is a fresh race among neighbors. Because the winner changes, the path changes.

11. Why Strong Paths Succeed and Do Not Change

A strong path is one where every hop has a consistently high SNR, low airtime contention, and stable bidirectional reachability. When these conditions hold, the forwarding behavior becomes far more deterministic.

A. Strong links dominate the timing race

Even with random backoff delay:

- Strong links decode earlier,
- Enter their backoff window sooner,
- Win the timing race more consistently.

B. Weak competitors suppress themselves

Nodes with weaker links:

- Hear the packet later,
- Decode less reliably,
- Enter backoff later,
- Often suppress themselves after hearing the strong forwarder.

C. Low collision probability keeps the path clean

Strong paths often exist in areas with:

- Fewer hidden nodes,
- Lower airtime congestion,
- Better spatial separation.

This reduces the chance that a strong forwarder's transmission is lost.

D. Environmental stability preserves the link order

Strong links are less sensitive to:

- Minor multipath changes,
- Small movements of people or objects,
- Temperature or humidity shifts.

Their SNR margin keeps the hearing order stable.

E. Neighbor-table confidence reinforces the same route

Strong links:

- Stay at the top of neighbor tables,
- Are consistently selected for directed forwarding,
- Are preferred by duplicate suppression logic.

F. Directed DMs over strong paths rarely fail

When all hops are strong:

- The chosen next hop is almost always reachable,
- Retries are rarely needed,
- The ACK returns reliably,
- The routing engine reinforces the same path.

G. Why strong paths do not jump around

When all hops are strong:

- The same neighbor hears the packet first,
- The same neighbor forwards first,
- Duplicate suppression silences all others,
- The same hop sequence repeats.

Weak paths are chaotic; strong paths are deterministic.

Conclusion

The resultant path of a flood DM “jumps around” because MeshCore’s flood forwarding is probabilistic, timing-driven, and sensitive to real-time RF conditions. Directed paths fail when a single chosen hop is weak or temporarily obstructed. Flood retries succeed because they exploit path diversity and timing diversity. Repeating the DM again produces a different path because of random backoff delay, collisions, receive-window shifts, environmental noise, and duplicate suppression all vary from moment to moment.

Strong paths, however, remain stable. When every hop has high SNR, low contention, and consistent bidirectional reachability, the same nodes win the timing race, the same nodes suppress competitors, and the same route is reinforced repeatedly. This stability is a hallmark of a healthy, well-connected mesh.

MeshCore’s design embraces both behaviors: variability where the network is weak, and stability where the network is strong.

NOTE For New Users to MeshCore:

When sending Direct Messages (DMs) to others expect the result can be “Failed” or “Delivered” and can change from message to message. It doesn’t mean that the message didn’t reach the destination, it may or may not have, but a fail certainly means the acknowledgement (ACK) didn’t get sent or make it back. They can fail and change to Delivered a few seconds later. When you see Delivered you know it got there and the ACK came back.

At first when you send a DM, you will likely always get Failed. You may think, as I did, that something was wrong or broken: Why can I send a message to my friend 125 miles away but I can’t send a message

to someone down the street. This is because the other user, will not be able to read your message, it is encrypted. You must be in their Contact List (they have received an Advert from you). This is because they must have your Public Key to de-encrypt your message (they get it in an Advert from you). DMs are always encrypted and private, without the key, the message is just a jumble of random characters and rejected.

Once you see your DMs failing, and you are tired of waiting for it to unsuccessfully send for four attempts, you can hit the Reset Path (the vertical ... at the top) and it will then be sent via a Flood (not with a path). You may be able to reach them on the first one sent and receive back an immediate Delivered. Flood DMs are attempted three times, and if an ACK is not received it will report as Failed. The destination is unreachable today, but maybe not tomorrow.

