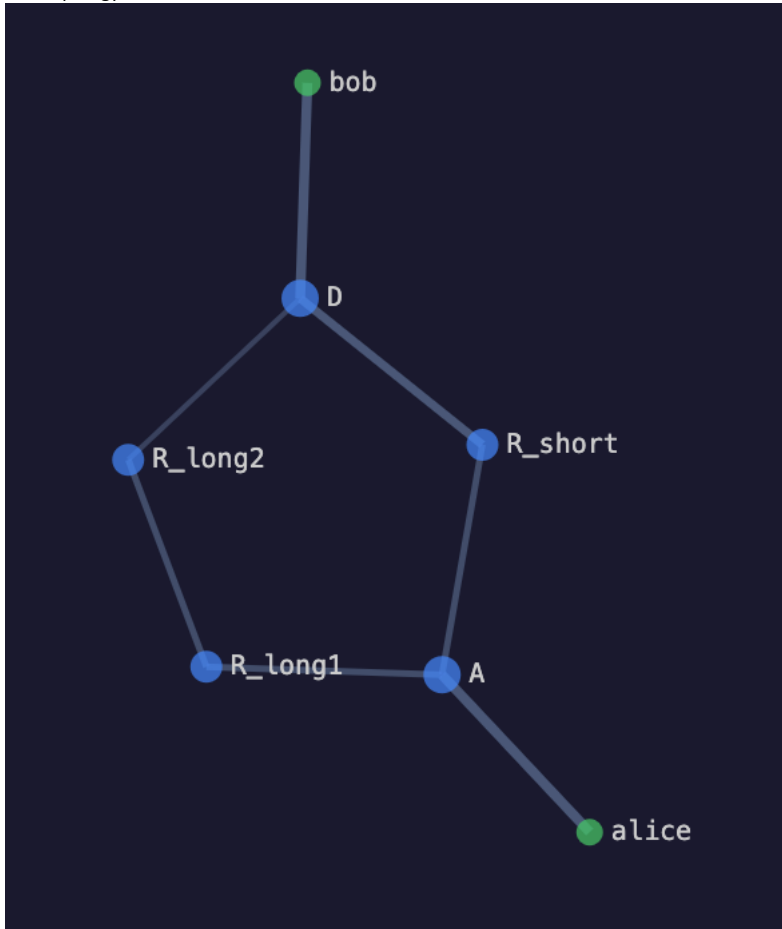


Test topology



Topology source:

```
"simulation": {
  "duration_ms": 100000,
  "step_ms": 2,
  "warmup_ms": 5000,
  "hot_start": true,
  "seed": 42,
  "radio": {
    "sf": 8,
    "bw": 62500,
    "cr": 4,
    "cad_miss_prob": 0.0
  }
},
"nodes": [
  { "name": "alice", "role": "companion" },
  { "name": "A", "role": "repeater" },
  { "name": "R_short", "role": "repeater" },
  { "name": "R_long1", "role": "repeater" },
  { "name": "R_long2", "role": "repeater" },
  { "name": "D", "role": "repeater" },
  { "name": "bob", "role": "companion" }
],
"topology": {
  "links": [
    { "from": "alice", "to": "A", "snr": 15.0, "rssi": -65.0, "bidir": true },
    { "from": "A", "to": "R_short", "snr": 10.0, "rssi": -70.0, "bidir": true },
    { "from": "A", "to": "R_long1", "snr": 10.0, "rssi": -70.0, "bidir": true },
    { "from": "R_short", "to": "D", "snr": 13.0, "rssi": -67.0, "bidir": true, "_note": "strong arm" },
    { "from": "R_long1", "to": "R_long2", "snr": 10.0, "rssi": -70.0, "bidir": true },
    { "from": "R_long2", "to": "D", "snr": 8.0, "rssi": -72.0, "bidir": true, "_note": "weak arm" },
    { "from": "D", "to": "bob", "snr": 15.0, "rssi": -65.0, "bidir": true }
  ]
}
```

...

Test starts with hot phase – advert without collisions (not required, but to stabilize mesh).

Test 1 – all delays 0

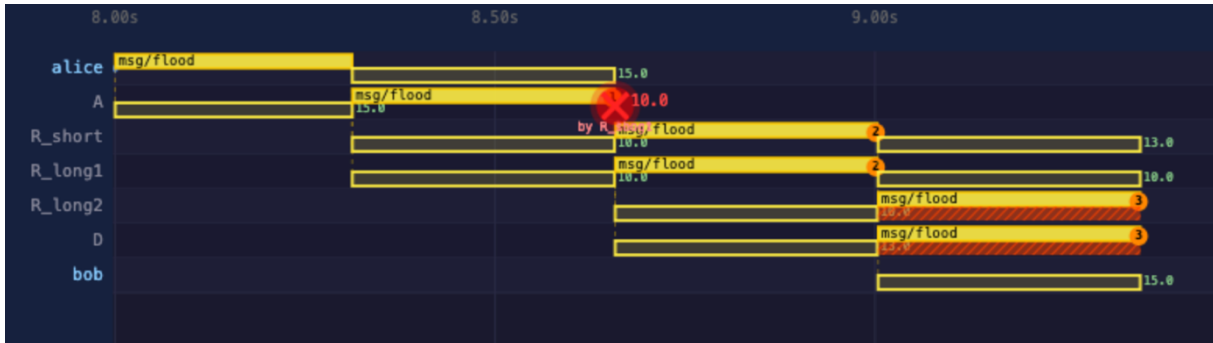
```

"commands": [
  { "at_ms": 5001, "node": "@repeaters", "command": "set txdelay 0", "_phase": "1: zero delays" },
  { "at_ms": 5001, "node": "@repeaters", "command": "set direct.txdelay 0" },
  { "at_ms": 5001, "node": "@repeaters", "command": "set rxdelay 0" },

  { "at_ms": 8000, "node": "alice", "command": "msga bob p1_msg1" },
  { "at_ms": 11000, "node": "alice", "command": "msga bob p1_msg2" },

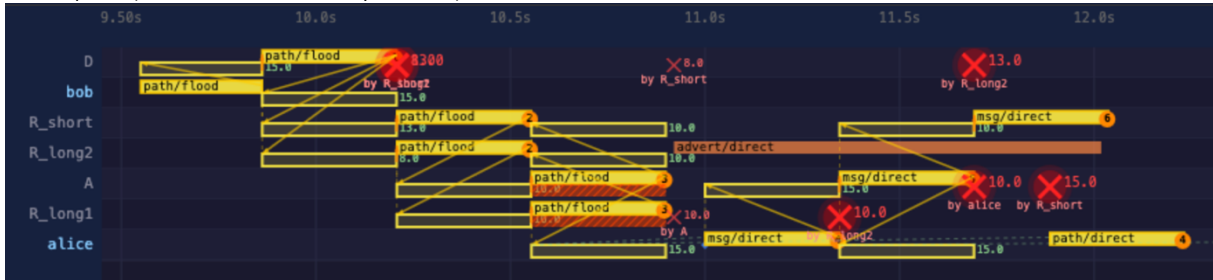
```

....



8.00s tx	alice	312ms
8.00s rx	A	alice→A snr=15.0 312ms
8.31s tx	A	345ms
8.31s rx	alice	A→alice snr=15.0 345ms
8.31s rx	R_short	A→R_short snr=10.0 345ms
8.31s rx	R_long1	A→R_long1 snr=10.0 345ms
8.66s tx	R_short	345ms
8.66s collision	A	R_short→A snr=10.0
8.66s rx	D	R_short→D snr=13.0 345ms
8.66s tx	R_long1	345ms
8.66s collision	A	R_long1→A snr=10.0
8.66s rx	R_long2	R_long1→R_long2 snr=10.0 345ms
9.00s tx	D	345ms
9.00s drop_halfduplex	R_long2	D→R_long2 345ms
9.00s rx	R_short	D→R_short snr=13.0 345ms
9.00s rx	bob	D→bob snr=15.0 345ms
9.00s tx	R_long2	345ms
9.00s drop_halfduplex	D	R_long2→D 345ms
9.00s rx	R_long1	R_long2→R_long1 snr=10.0 345ms

Path response (there is also advert sent by firmware)



Time	Type	Node	Detail
9.55s	tx	bob	312ms
9.55s	rx	D	bob→D snr=15.0 312ms
9.86s	tx	D	345ms
9.86s	rx	R_short	D→R_short snr=13.0 345ms
9.86s	rx	R_long2	D→R_long2 snr=8.0 345ms
9.86s	rx	bob	D→bob snr=15.0 345ms
10.2s	tx	R_short	345ms
10.2s	rx	A	R_short→A snr=10.0 345ms
10.2s	collision	D	R_short→D snr=13.0
10.2s	tx	R_long2	345ms
10.2s	rx	R_long1	R_long2→R_long1 snr=10.0 345ms
10.2s	collision	D	R_long2→D snr=8.0
10.6s	tx	A	345ms
10.6s	drop_halfduplex	R_long1	A→R_long1 345ms
10.6s	rx	alice	A→alice snr=15.0 345ms
10.6s	rx	R_short	A→R_short snr=10.0 345ms
10.6s	tx	R_long1	345ms
10.6s	drop_halfduplex	A	R_long1→A 345ms
10.6s	rx	R_long2	R_long1→R_long2 snr=10.0 345ms
11.0s	tx	alice	345ms
11.0s	rx	A	alice→A snr=15.0 345ms
11.3s	tx	A	345ms
11.3s	rx	alice	A→alice snr=15.0 345ms
11.3s	rx	R_short	A→R_short snr=10.0 345ms
11.3s	collision	R_long1	A→R_long1 snr=10.0
11.7s	tx	R_short	345ms
11.7s	collision	A	R_short→A snr=10.0
11.7s	collision	D	R_short→D snr=13.0
11.9s	tx	alice	345ms
11.9s	collision	A	alice→A snr=15.0

Second message from Alice – as Alice knows path – it sends path/direct message.



14.0s tx	alice	345ms
14.0s rx	A	alice→A snr=15.0 345ms
14.3s tx	A	345ms
14.3s rx	alice	A→alice snr=15.0 345ms
14.3s rx	R_short	A→R_short snr=10.0 345ms
14.3s rx	R_long1	A→R_long1 snr=10.0 345ms
14.7s tx	R_short	345ms
14.7s rx	A	R_short→A snr=10.0 345ms
14.7s rx	D	R_short→D snr=13.0 345ms
15.0s tx	D	312ms
15.0s rx	R_short	D→R_short snr=13.0 312ms
15.0s rx	R_long2	D→R_long2 snr=8.0 312ms
15.0s rx	bob	D→bob snr=15.0 312ms

Ack – send back/flood

15.6s tx	bob	181ms
15.6s rx	D	bob→D snr=15.0 181ms
15.7s tx	D	214ms
15.7s rx	R_short	D→R_short snr=13.0 214ms
15.7s rx	R_long2	D→R_long2 snr=8.0 214ms
15.7s rx	bob	D→bob snr=15.0 214ms
15.9s tx	R_short	214ms
15.9s rx	A	R_short→A snr=10.0 214ms
15.9s collision	D	R_short→D snr=13.0
15.9s tx	R_long2	214ms
15.9s rx	R_long1	R_long2→R_long1 snr=10.0 214ms
15.9s collision	D	R_long2→D snr=8.0
16.2s tx	A	214ms
16.2s drop_halfduplex	R_long1	A→R_long1 214ms
16.2s rx	alice	A→alice snr=15.0 214ms
16.2s rx	R_short	A→R_short snr=10.0 214ms
16.2s tx	R_long1	214ms
16.2s drop_halfduplex	A	R_long1→A 214ms
16.2s rx	R_long2	R_long1→R_long2 snr=10.0 214ms

Test 2: - 40.0 – seed 1

```
{ "at_ms": 35000, "node": "@repeaters", "command": "set txdelay 0.5"},
{ "at_ms": 35000, "node": "@repeaters", "command": "set direct.txdelay 0.3" },
{ "at_ms": 35000, "node": "@repeaters", "command": "set rxdelay 0" },
{ "at_ms": 36000, "node": "alice", "command": "reset_path bob" },
{ "at_ms": 36000, "node": "bob", "command": "reset_path alice" },

{ "at_ms": 40000, "node": "alice", "command": "msga bob p2_msg1" },...
```



Path growth

Hop	Sender	Path
1	A	A
2	R_short	A → R_short
2	R_long1	A → R_long1
3	D	A → R_short → D
3	R_long2	A → R_long1 → R_long2
5	D	D
6	R_short	D → R_short
6	R_long2	D → R_long2
7	R_long1	D → R_long2 → R_long1

Time	Type	Node	Detail
40.0s	tx	alice	312ms
40.0s	rx	A	alice→A snr=15.0 312ms
41.0s	tx	A	345ms
41.0s	rx	alice	A→alice snr=15.0 345ms
41.0s	rx	R_short	A→R_short snr=10.0 345ms
41.0s	rx	R_long1	A→R_long1 snr=10.0 345ms
42.2s	tx	R_long1	345ms
42.2s	collision	A	R_long1→A snr=10.0
42.2s	rx	R_long2	R_long1→R_long2 snr=10.0 345ms
42.2s	tx	R_short	345ms
42.2s	collision	A	R_short→A snr=10.0
42.2s	rx	D	R_short→D snr=13.0 345ms
42.8s	tx	D	345ms
42.8s	rx	R_short	D→R_short snr=13.0 345ms
42.8s	rx	R_long2	D→R_long2 snr=8.0 345ms
42.8s	rx	bob	D→bob snr=15.0 345ms

```

43.2s tx      R_long2 345ms
43.2s rx      R_long1 R_long2→R_long1 snr=10.0 345ms
43.2s collision D      R_long2→D snr=8.0
43.3s tx      bob      312ms
43.3s rx      D        bob→D snr=15.0 312ms
44.1s tx      D        345ms
44.1s rx      R_short D→R_short snr=13.0 345ms
44.1s rx      R_long2 D→R_long2 snr=8.0 345ms
44.1s rx      bob      D→bob snr=15.0 345ms
44.7s tx      R_long2 345ms
44.7s rx      R_long1 R_long2→R_long1 snr=10.0 345ms
44.7s rx      D        R_long2→D snr=8.0 345ms
45.3s tx      R_short 345ms
45.3s collision A      R_short→A snr=10.0
45.3s rx      D        R_short→D snr=13.0 345ms
45.4s tx      R_long1 345ms
45.4s collision A      R_long1→A snr=10.0
45.4s rx      R_long2 R_long1→R_long2 snr=10.0 345ms

```

Spread tree

```

alice TX@40.0s (312ms)
└─ A RX@40.0s snr=15.0 → relay
  └─ A TX@41.0s (345ms)
    └─ alice RX@41.0s snr=15.0
      └─ R_short RX@41.0s snr=10.0 → relay
        └─ R_short TX@42.2s (345ms)
          └─ D RX@42.2s snr=13.0 → relay
            └─ D TX@42.8s (345ms)
              └─ R_short RX@42.8s snr=13.0
                └─ R_long2 RX@42.8s snr=8.0
                  └─ bob RX@42.8s snr=15.0
                    └─ response path-flood @43.3s
                      └─ bob TX@43.3s (312ms)
                        └─ D RX@43.3s snr=15.0 → relay
                          └─ D TX@44.1s (345ms)
                            └─ R_short RX@44.1s snr=13.0 → relay
                              └─ R_short TX@45.3s (345ms)
                                └─ D RX@45.3s snr=13.0
                                  └─ A COLLISION@45.3s by R_long1 (margin 3.0dB)
                                └─ R_long2 RX@44.1s snr=8.0 → relay
                                  └─ R_long2 TX@44.7s (345ms)
                                    └─ R_long1 RX@44.7s snr=10.0 → relay
                                      └─ R_long1 TX@45.4s (345ms)
                                        └─ R_long2 RX@45.4s snr=10.0
                                          └─ A COLLISION@45.4s by R_short (margin 6.0dB)
                                        └─ D RX@44.7s snr=8.0
                                          └─ bob RX@44.1s snr=15.0
                                            └─ A COLLISION@42.2s by R_long1 (margin 6.0dB)
                                  └─ R_long1 RX@41.0s snr=10.0 → relay
                                    └─ R_long1 TX@42.2s (345ms)
                                      └─ R_long2 RX@42.2s snr=10.0 → relay
                                        └─ R_long2 TX@43.2s (345ms)
                                          └─ R_long1 RX@43.2s snr=10.0
                                            └─ D COLLISION@43.2s by bob (margin 10.0dB)
                                          └─ A COLLISION@42.2s by R_short (margin 6.0dB)

```

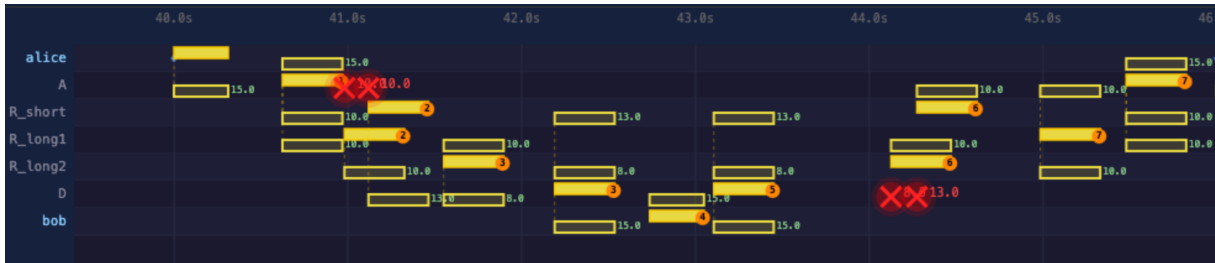
39.8s

Alice never receive path (ACK) response

The same example (40.0s of simulation) – with a different rnd seed:

```
{ "at_ms": 35000, "node": "@repeaters", "command": "set txdelay 0.5"},
{ "at_ms": 35000, "node": "@repeaters", "command": "set direct.txdelay 0.3" },
{ "at_ms": 35000, "node": "@repeaters", "command": "set rxdelay 0" },
{ "at_ms": 36000, "node": "alice", "command": "reset_path bob" },
{ "at_ms": 36000, "node": "bob", "command": "reset_path alice" },

{ "at_ms": 40000, "node": "alice", "command": "msga bob p2_msg1" },...
```



Path growth

Hop	Sender	Path
1	A	A
2	R_short	A → R_short
2	R_long1	A → R_long1
3	D	A → R_short → D
3	R_long2	A → R_long1 → R_long2
5	D	D
6	R_short	D → R_short
6	R_long2	D → R_long2
7	A	D → R_short → A
7	R_long1	D → R_long2 → R_long1
8	alice	A → R_short → D
8	alice	A → R_short → D
8	A	R_short → D
9	A	R_short → D

Time	Type	Node	Detail
40.0s	tx	alice	312ms
40.0s	rx	A	alice→A snr=15.0 312ms
40.6s	tx	A	345ms
40.6s	rx	alice	A→alice snr=15.0 345ms
40.6s	rx	R_short	A→R_short snr=10.0 345ms
40.6s	rx	R_long1	A→R_long1 snr=10.0 345ms
41.0s	tx	R_long1	345ms
41.0s	collision	A	R_long1→A snr=10.0
41.0s	rx	R_long2	R_long1→R_long2 snr=10.0 345ms
41.1s	tx	R_short	345ms

41.1s collision A R_short→A snr=10.0
 41.1s rx D R_short→D snr=13.0 345ms
 41.6s tx R_long2 345ms
 41.6s rx R_long1 R_long2→R_long1 snr=10.0 345ms
 41.6s rx D R_long2→D snr=8.0 345ms
 42.2s tx D 345ms
 42.2s rx R_short D→R_short snr=13.0 345ms
 42.2s rx R_long2 D→R_long2 snr=8.0 345ms
 42.2s rx bob D→bob snr=15.0 345ms
 42.7s tx bob 312ms
 42.7s rx D bob→D snr=15.0 312ms
 43.1s tx D 345ms
 43.1s rx R_short D→R_short snr=13.0 345ms
 43.1s rx R_long2 D→R_long2 snr=8.0 345ms
 43.1s rx bob D→bob snr=15.0 345ms
 44.1s tx R_long2 345ms
 44.1s rx R_long1 R_long2→R_long1 snr=10.0 345ms
 44.1s collision D R_long2→D snr=8.0
 44.3s tx R_short 345ms
 44.3s rx A R_short→A snr=10.0 345ms
 44.3s collision D R_short→D snr=13.0
 45.0s tx R_long1 345ms
 45.0s rx A R_long1→A snr=10.0 345ms
 45.0s rx R_long2 R_long1→R_long2 snr=10.0 345ms
 45.5s tx A 345ms
 45.5s rx alice A→alice snr=15.0 345ms
 45.5s rx R_short A→R_short snr=10.0 345ms
 45.5s rx R_long1 A→R_long1 snr=10.0 345ms

And both one to other – same time window, different rnd seed

