Jitter Consideration for Reactive Protocols in Mobile Ad Hoc Networks (MANETs)

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Jitter - RFC5148

Network Working Group
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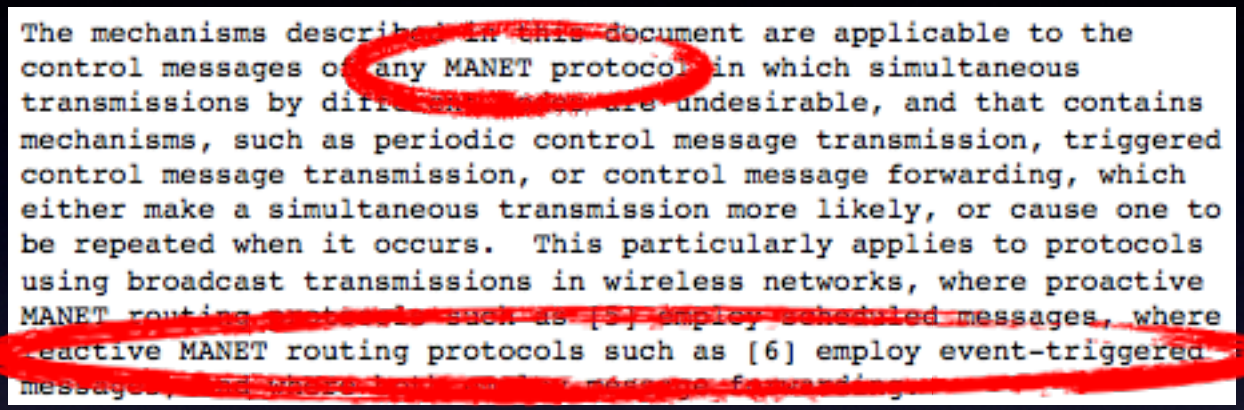
Jitter Considerations in Mobile Ad Hoc Networks (MANETs)

Abstract

This document provides recommendations for jittering (randomly modifying timing) of control traffic transmissions in Mobile Ad hoc NETwork (MANET) routing protocols to reduce the probability of transmission collisions.

The mechanisms described in this document are applicable to the control messages of any MANET protocol in which simultaneous transmissions by different nodes are undesirable, and that contains mechanisms, such as periodic control message transmission, triggered control message transmission, or control message forwarding, which either make a simultaneous transmission more likely, or cause one to be repeated when it occurs. This particularly applies to protocols using broadcast transmissions in wireless networks, where proactive MANET routing protocols such as [5] employ scheduled messages, where reactive MANET routing protocols such as [6] employ event-triggered messages, and where [illegible] message forwarding.

Jitter - RFC5148



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Proactive protocol:

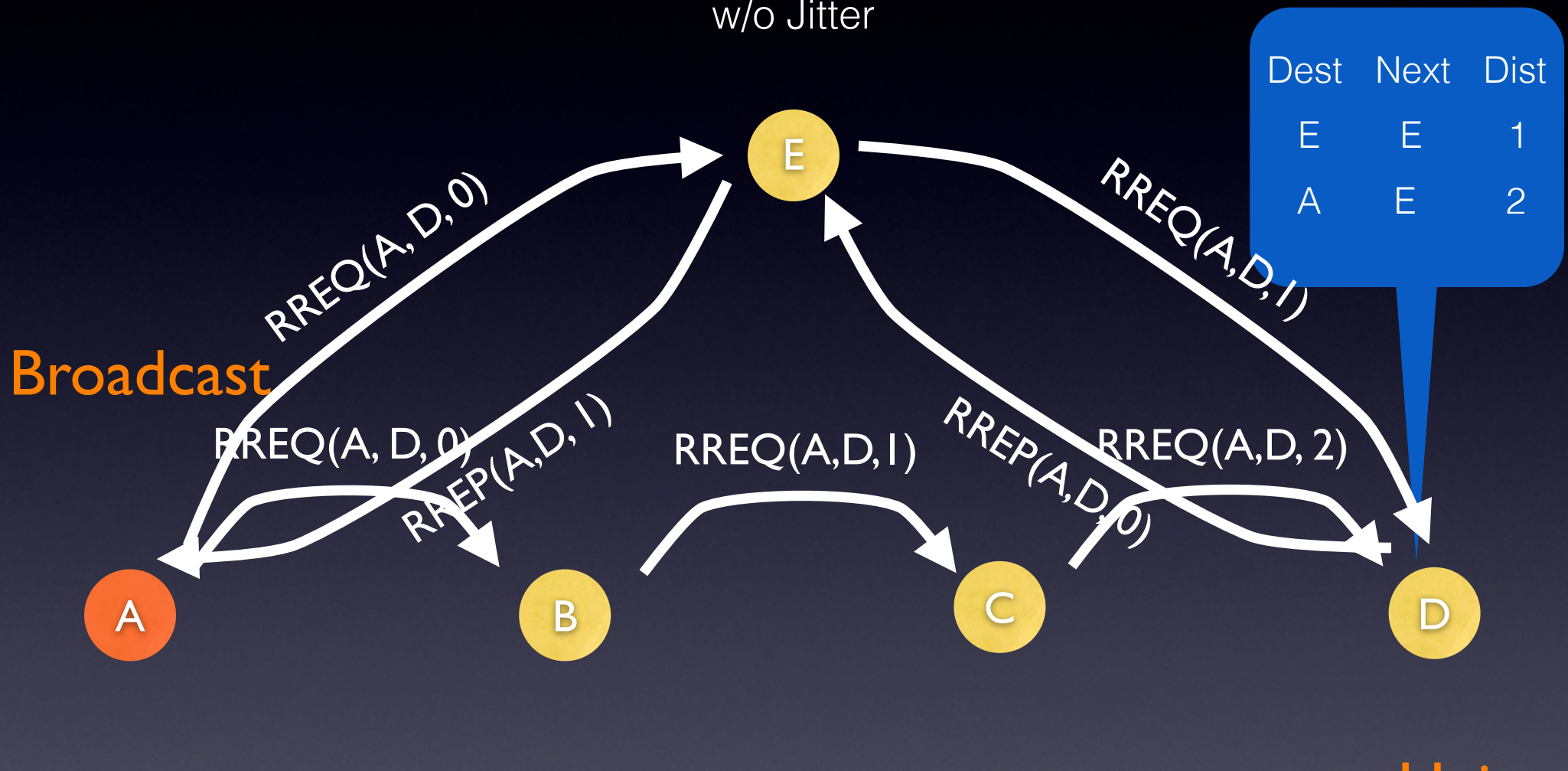
- TCs/LSAs etc. carry adjacency information only
- Flooding path independence

Reactive protocols:

- RREQs carry implicit path information

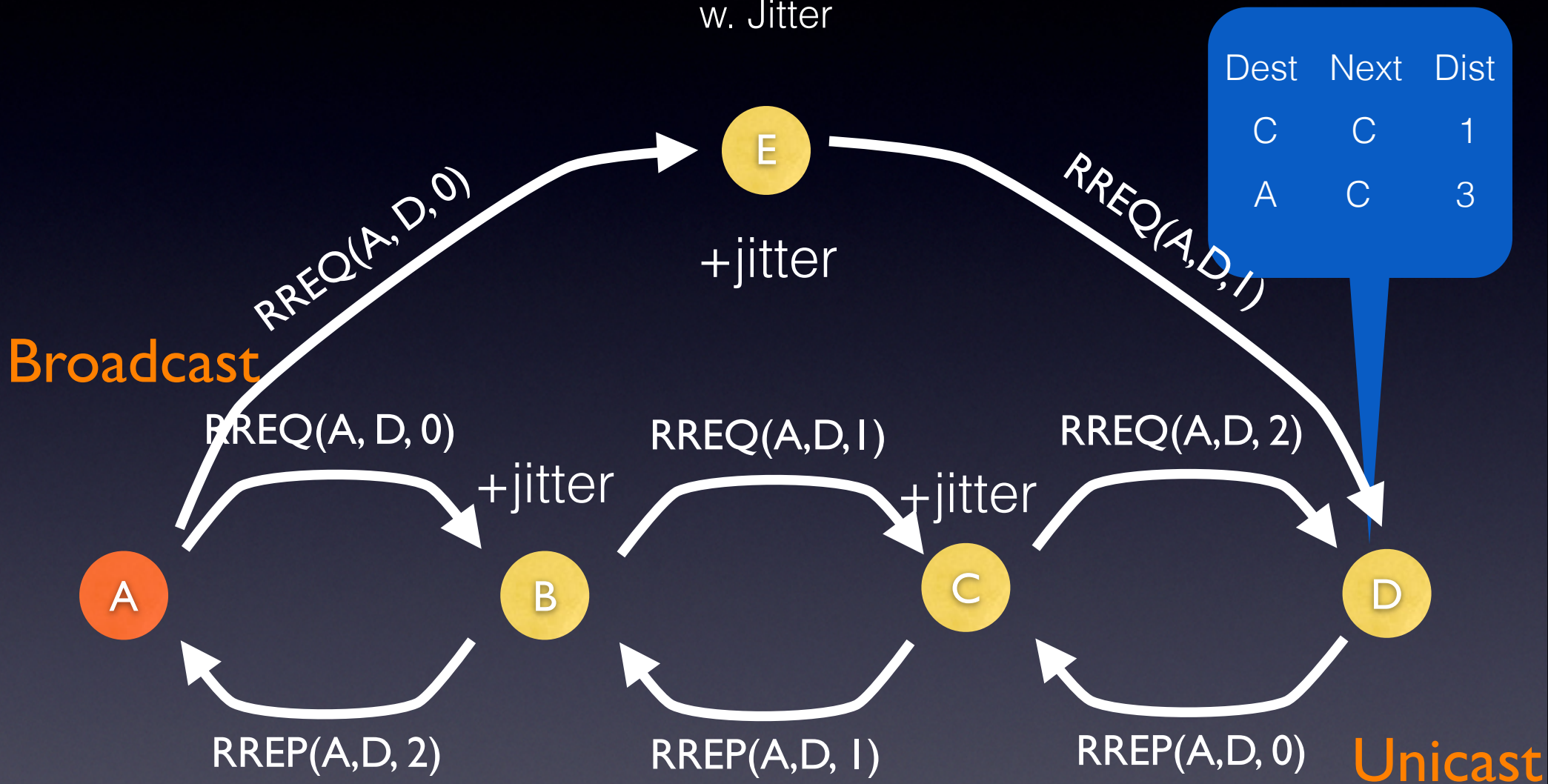
Reactive Routing

w/o Jitter



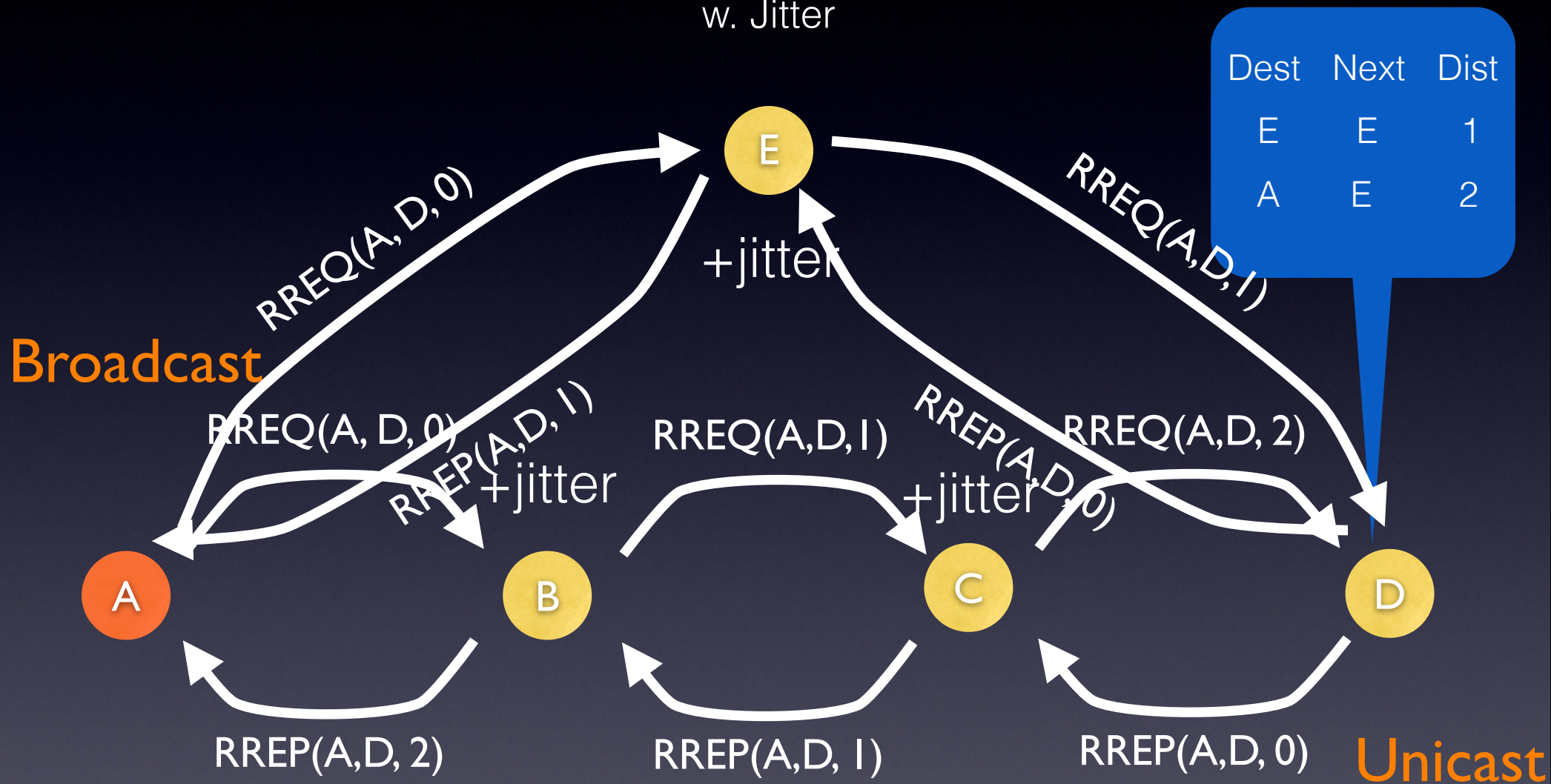
Reactive Routing

w. Jitter



Reactive Routing

w. Jitter



Reactive Routing

“Delay Inversion”

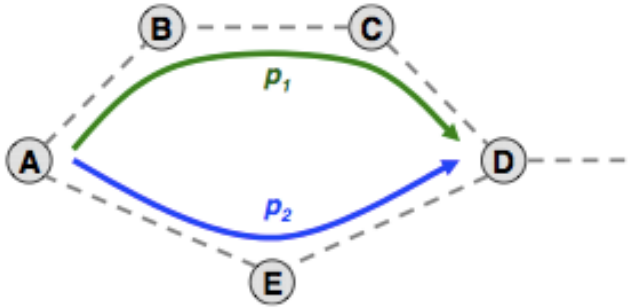
> “Turning a longer (worse) path into a path, which is traversed faster”

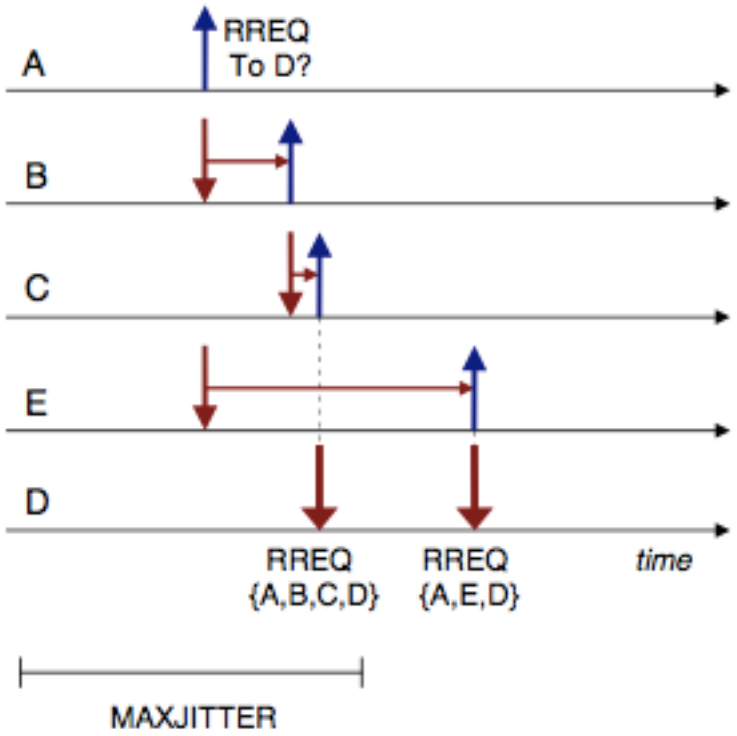
Path sub-optimality

(and/or)

Increased control traffic

What does RFC5148 say....





5.2. Externally Triggered Message Generat

An internal or external condition or ev
generation by a node. Depending upon t
may trigger generation of a single mess
limited to, an acknowledgement message)
message schedule, or rescheduling of ex
Collision between externally triggered
if more than one node is likely to resp
reduce this likelihood, an externally triggered message SHOULD be jittered by delaying it by a random duration; an internally triggered message MAY also be so jittered if appropriate. This delay SHOULD be generated uniformly in an interval between zero and MAXJITTER.

Important Points...

These behaviors not *just* of academic interest ... **observed** in LOADng-routed networks (AMI, sensor networks, ...)

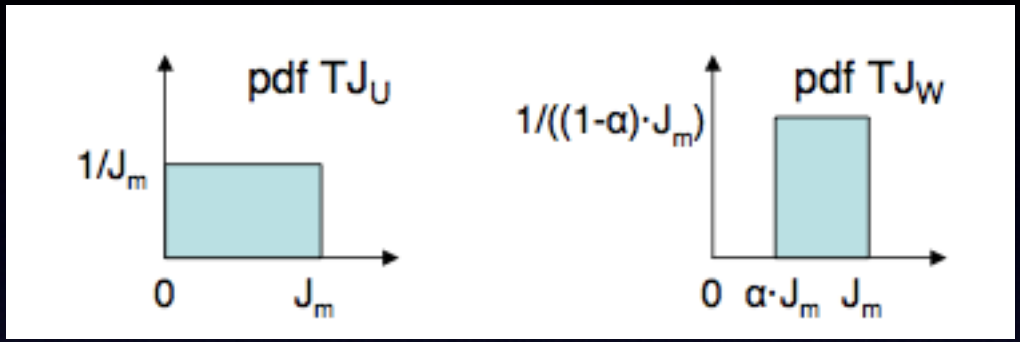
Analysis has revealed that "delay inversion" occurs with **significant probability** when using jitter according to RFC5148, and this independently from the jitter interval length, and proportional to absolute path lengths.

LOADng:
Clausen, T., Verdiere, A., Yi, J., Niktash, A., Igarashi, Y., Satoh, H., Herberg, U., Lavenu, C., Lys, T., and J. Dean, "The Lightweight On-demand Ad hoc Distance-vector Routing Protocol - Next Generation (LOADng)", draft-clausen-lln-loadng-10 (work in progress), October 2013.

Jitter Analysis:
Yi, J., Fuertes, J., and T. Clausen, "Optimization of Jitter Configuration for Reactive Route Discovery in Wireless Mesh Networks", Proceedings of IEEE WiOpt 2013, IEEE International Symposium on Modeling and Optimization in Mobile, Ad Hoc and Wireless Networks, 2013.

Fuertes, J., Yi, J., and T. Clausen, "Jitter Considerations in On-demand Route Discovery for Mobile Ad Hoc Networks", Proceedings of the 16th International Conference on Network-Based Information Systems, 2013. September 2012.

Window Jitter



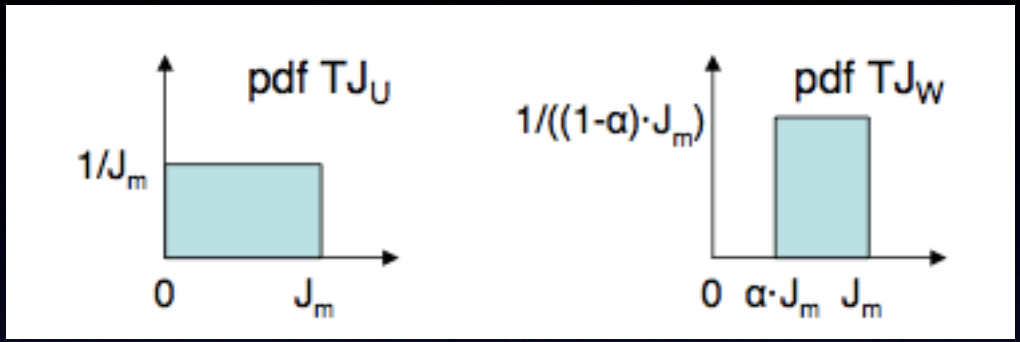
$TJ_W \sim \text{uniform}[\alpha \cdot J_m , J_m]$

Uniform Jitter (RFC5148)

Window Jitter

- Reduces randomness, increases (deterministic) dependency of the total delay on the path length
- Increases the probability that the RREQ packet traverses faster through a ”shorter” path
- Hop-count metric implicitly assumed.....

Window Jitter



$TJ_W \sim \text{uniform}[\alpha \cdot J_m , J_m]$

Uniform Jitter (RFC5148)

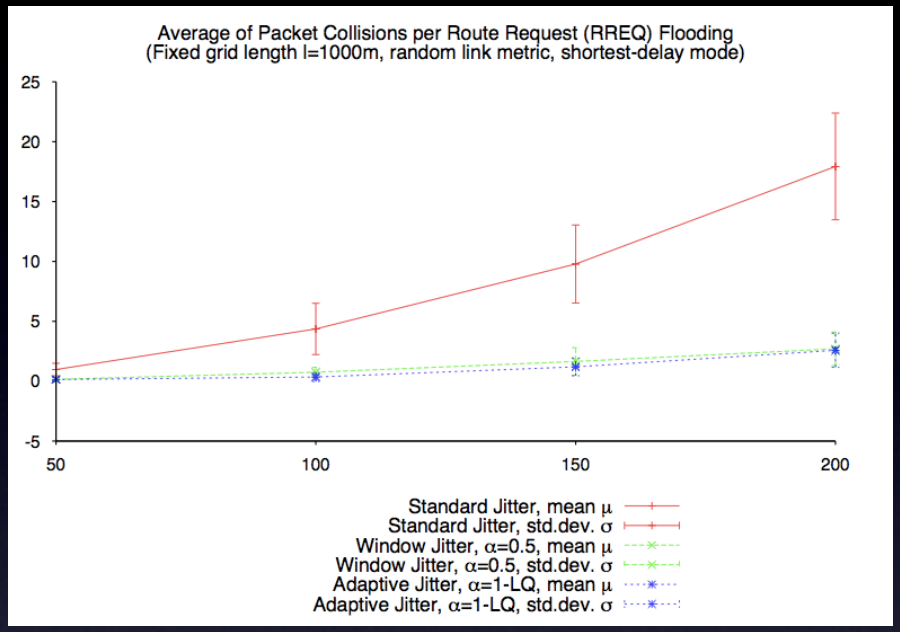
Window Jitter

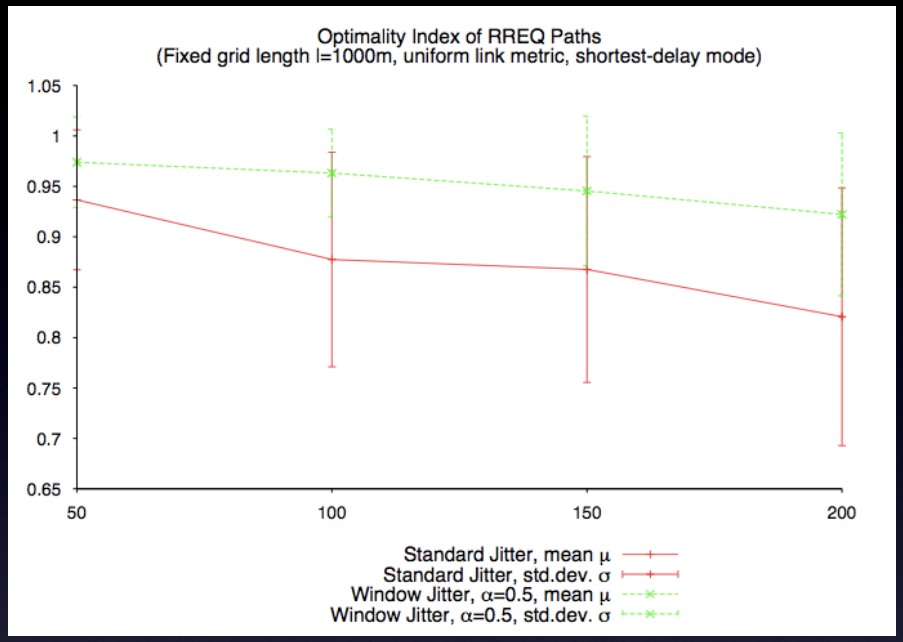
Adaptive Jitter

Generalization of Window Jitter for **non-trivial** metrics

$LQ \in (0,1)$; $[(1-LQ)\cdot J_m , J_m]$

Analysis


Average of Packet Collisions per Route Request (RREQ) Flooding
(Fixed grid length l=1000m, random link metric, shortest-delay mode)
25
20
15
10
5
0
-5
50
100
150
200
Standard Jitter, mean μ
Standard Jitter, std.dev. σ
Window Jitter, α=0.5, mean μ
Window Jitter, α=0.5, std.dev. σ
Adaptive Jitter, α=1-LQ, mean μ
Adaptive Jitter, α=1-LQ, std.dev. σ


Optimality Index of RREQ Paths
(Fixed grid length l=1000m, uniform link metric, shortest-delay mode)
1.05
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
50
100
150
200
Standard Jitter, mean μ
Standard Jitter, std.dev. σ
Window Jitter, α=0.5, mean μ
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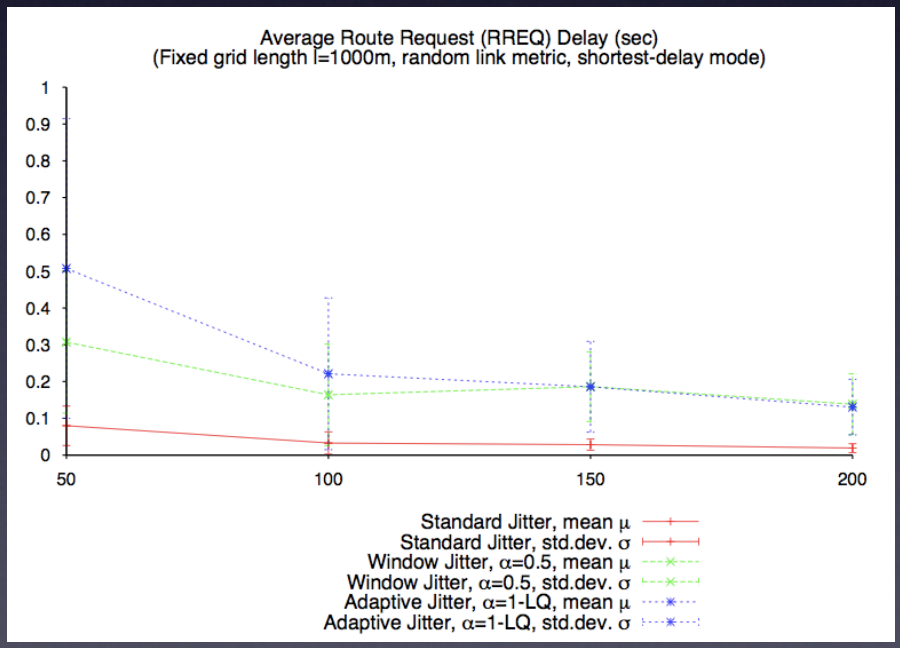
Average Route Request (RREQ) Delay (sec)
(Fixed grid length l=1000m, random link metric, shortest-delay mode)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
50
100
150
200
Standard Jitter, mean μ
Standard Jitter, std.dev. σ
Window Jitter, α=0.5, mean μ
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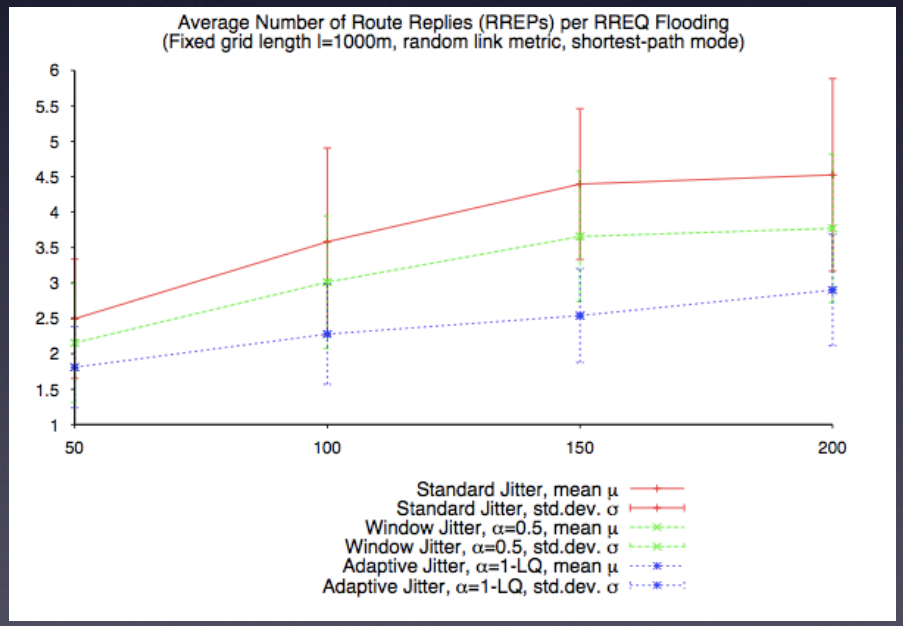
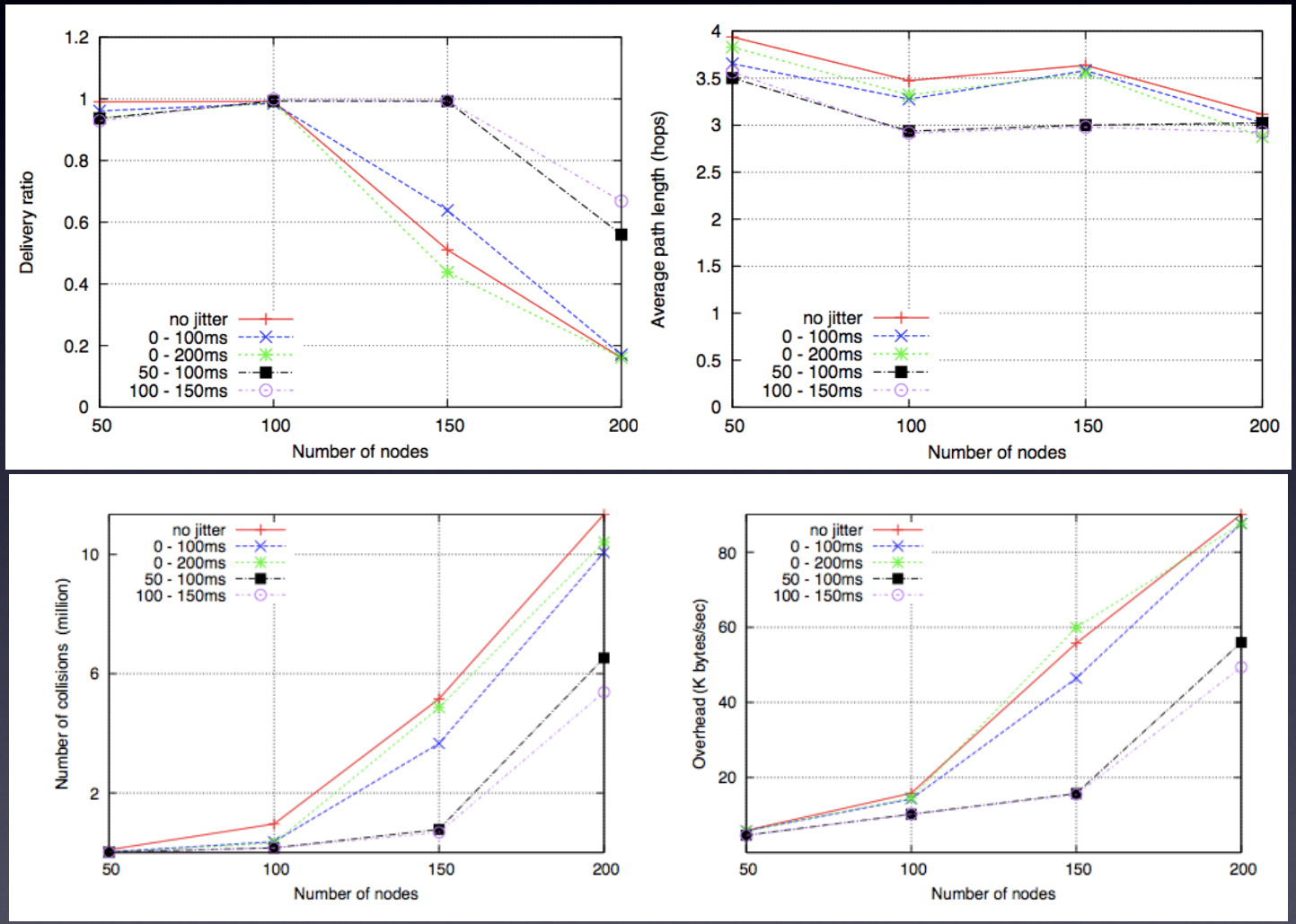

Average Number of Route Replies (RREPs) per RREQ Flooding
(Fixed grid length l=1000m, random link metric, shortest-path mode)
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
50
100
150
200
Standard Jitter, mean μ
Standard Jitter, std.dev. σ
Window Jitter, α=0.5, mean μ
Window Jitter, α=0.5, std.dev. σ
Adaptive Jitter, α=1-LQ, mean μ
Adaptive Jitter, α=1-LQ, std.dev. σ

- 802.11 MAC, 1km x 1km field, 2-way ground, 100 s.
- 30 concurrent route discoveries launched every 2s
- Reactive routing protocol of choice: LOADng

NS2

- No jitter.
- Standard RFC 5148 jitter, Jm = 100ms. Jitter is selected within [0, 100] ms (mean, 50ms).
- Standard RFC 5148 jitter, Jm = 200ms. Jitter is selected within [0, 200] ms (mean, 100ms).
- Window jitter, α = 1/2, Jm = 100ms. Jitter is selected within [50, 100] ms (mean, 75ms).
- Window jitter, α = 2/3, Jm = 150ms. Jitter is selected within [100, 150] ms (mean, 125ms)



Concluding Remarks (1)

- Jitter is a Very Good Idea for reducing collisions in flooding operations in wireless networks.
- RFC5148 based on observations and operational experiences with proactive OLSR and OLSRv2.
- RFC5148, applied to the flooding operation of RREQs in reactive routing protocols, causes *delay inversion* - which leads to longer paths and higher control traffic overhead.

Concluding Remarks (2)

- Window-Jitter and Adaptive Jitter are simple modulations of RFC5148-Jitter, perhaps better adapted for reactive routing protocol RREQ flooding. Seems to, substantially, reduce the probability of experiencing delay inversion, and therefore yields:
  - Shorter paths
  - Lower control traffic load
  - Fewer collisions
- Not without a cost, alas:
  - Longer route discovery delays
- Generally applicable to reactive routing protocols