



Chapter 5: The Broadcast Storm Problem in MANETs

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Storms of Nature







T-Storm in St. Louis







"Touchdown" of a Tornado







Can Human Create Storms?



ering





The Storms in the Internet

Subject: <u>我有六千一百萬筆最新Email名單,我只賣 NT\$3000元</u>!

Date: Sun, 11 Jul 1999 18:47:21 +0800 (CST)

From: ****@***.university.edu

To: <yctseng@csie.ncu.edu.tw>

你想要賺錢嗎?

你可以在花費極少的情形下,接觸到全世界六千萬一百萬人! 是的!沒錯!我有六千一百萬筆最新Email名單,我只賣NT\$3000元!!! 這些都是最新的地址,基本上可說包含了網際網路上所有的人, 而且這些地址沒有一個是重複的!!! 並且都已經過排序整理過了,可以立即上手使用!!! 這可能是當今市場上所能找到最物超所值的交易了!!! 想想看,賣一個五十塊錢的商品,如果回收率只有千分之一, 就有三百零五萬元進到你的口袋了!!!

(a 3-page long email ...)





Call for Papers

<u>Dear Friends,</u>

Sorry if you receive the duplicate messages. But please distribute the following message to your friends.

Prof. ***, University of %%%

Call for Papers International Conference on ???? IC???'99 to be held in ???, ???, September ???, 1999 http://www.???/conf/ic???99

THEME:

. . .

Research on mobile computing is gaining more and more attention ...

The Storms in the Internet

Subject: Hold on! Don't throw out this message yet! Date: Wed, 30 Jun 1999 07:35:40 +0800 (CST) From: Rory.Bellows@chu.edu.tw To: you@chu.edu.tw

Dear Sir or Madam,

Allright, I'm not going to give you any bull. This is "junk" mail, but if you will please just give me 60 seconds of your time and read the next paragraph, maybe I can change your mind. Just 60 seconds. What have you got to lose?

Below is a message I got last month. I said "junk," and was dragging the icon to my trash can when I figured "what the hell," and began reading it. I ALWAYS throw stuff like this out. But I read. And now I'm rolling in \$\$\$. This works and I'm not kidding. At first it sounds like your typical "pyramid scheme" scam, but it's not - the difference is that you're actually selling a product! I won't go into the details right now, if you're interested you can keep reading the rest of the message. I just want to say a couple things. First, don't take my word for it that this works. Use your own head. Just read this message and think about the process logically. You'll see that it won't fail! Second, just make sure you follow the instructions TO THE LETTER. I can't stress that enough. ...

JUST DO IT !! Yeah, it's a long message to read, but it's worth it!

Thanks,

Rory

... (a 5-page-long email)





Broadcast Problem

Broadcast: the sending of a message to other hosts

- Ex: Route search in a MANET
- Ex: DSR, AODV, ZRP protocols.

Assumptions:

- The broadcast is spontaneous.
 - ➢ no synchronization
 - > no prior global topology knowledge
- The broadcast is unreliable.
 - > no acknowledgement of any kind
 - \checkmark not to cause more contention
 - \checkmark 100% reliability is unnecessary for some application
- No RTS/CTS dialogue.







Broadcast by Flooding

- □ A straight-forward approach
 - A host **rebroadcasts** the message on receiving a broadcast message for the first time.

Broadcast storm problem:

- redundant rebroadcasts
- contention problem
- collision problem



Serious Redundancy

Optimal broadcasting vs. Flooding
(a) optimal = 2 steps

(b) optimal = 2 steps

Severity of Redundant Coverage.









Analysis on Redundancy

Additional Coverage provided by a rebroadcast.

- The max. additional coverage is 61%.
- The coverage is 41% in average.



The expected additional coverage $EAC(k)/\pi r^2$ after a host heard a broadcast message *k* times.





Analysis on Contention

- When a host broadcasts, its neighbors are likely to contend with each other for the medium.
 - A ==> B, C, D
 - B, C, D could seriously contend with each other.
- *cf(n, k):* The probabilities of having *k* contention-free hosts among *n* receiving hosts.









Analysis on Collision

- □ Higher Possibility of Collision:
 - Rebroadcasts are likely to start at the same time.
 - > Backoff window runs out if medium is quiet for a while.
 - lack of RTS/CTS dialogues
 - lack of collision detection (CD) if collision occurs
 - hidden terminal problem







Broadcast Storm Problem Summary

Redundancy

Contention

Collision

How to derive an efficient scheme for broadcasting in a MANET?





Possible Broadcast Solutions

- Probabilistic Scheme
- **Counter-Based Scheme**
- Distance-Based Scheme
- Location-Based Scheme
- **Cluster-Based Scheme**





Probabilistic Scheme

Rebroadcast by "Tossing a Die"

A host always rebroadcasts with a certain probability P.

- When P = 1, this is flooding.
- A smaller P will reduce the storm effect.







Simulation Parameters

- \Box no of hosts = 100
- transmission radius = 500 meters
- \Box packet size = 280 bytes
- ☐ transmission rate = 1 M bits/sec
- □ broadcast arrival rate: 1 per sec. to the whole map
- \square map: (1 unit = 500 meters)
 - 1x1, 3x3, 5x5, 7x7, 10x10
- **o** roaming pattern: random walk
 - speed: $0 \sim 10$ km/hr in a 1x1 map, $0 \sim 30$ km/hr in a 3x3 map, etc.
- □ IEEE 802.11 without PCF (point coordination function)



RE = REachability (in lines) SRB = Saved ReBroadcast (in bars)

NTPUCSIE

Latency







Observation

Reachability:

- In smaller maps, a low P is sufficient to achieve high reachability.
- A larger P is needed in a larger map.

Saved Rebroadcast:

linear with respect to P

Latency:

• Interestingly, in smaller areas, broadcast tends to complete in a slower speed.





Counter-Based Scheme

□ If a host has received a broadcast packet > C times,

• then do not rebroadcast.



- 1 time -> 41%
- 2 times => 19%
- 3 times => 9%
- 4 times => 5%
- > 4 times, very little extra area







Performance of Counter-Based Scheme

 \Box We vary C = 2, 3, ..., 6 to observe the performance.

• A larger C means more rebroadcast.







Observation

Reachability:

• $C \ge 3$ can offer a reachability close to flooding.

Saved Rebroadcast:

• In denser area, there is more saving. In sparser area, there is less saving.

□ Latency:

• Higher latency is smaller area.





Distance-Based Scheme

Calculate the distance to the sending host.

 $\Box d_{min} = Min\{ \text{the distance to each sending host} \}$

□ If d_{min} < D (a threshold), then do not rebroadcast.

□ How to find distance:

- signal strength
- GPS devices







Performance of the Distance-Based Scheme

 \Box We vary D = 147, 72, 37, 20, 11 to observe the effect.

• Smaller D means more rebroadcasting.







Observation

Why choosing D=147?

• addition coverage = 0.187, equal to that of C=2

Reachability:

All look good, close to flooding.

Saved Rebradcast:

not much

Latency:

• smaller area has higher latency





Location-Based Scheme

□ From GPS to obtain the sender's location.

- □ Let (x_1, y_1) , (x_2, y_2) , (x_3, y_3) , ..., (x_k, y_k) be locations of senders.
 - We can accurately calculate the additional coverage of this rebroadcast.







Difficulty

Involve complicated math to calculate the extra coverage.

• A lot of calculus!

Approximation:

• grid simulation

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Performance of the Location-Based Scheme

□ We vary A (addition coverage) from 0.1 to 0.01.

• Smaller A means more rebroadcast.







Observation

□ Why choosing A=0.187?

• This is additional coverage offered by C=2.

Best performance over all the above schemes!



Polygon Test:

- If a node is within the polygon formed by the locations of senders, then DO NOT rebroadcast. (Fig. (a))
- Otherwise, rebroadcast. (Fig. (b))
- If a host is within the convex, the maximum additional coverage is well below 22%. (Fig. (c))







A Short Summary

Main Concern:

• Extra coverage of a rebroadcast

Different levels of accuracy:

• probabilistic, counter, distance, location, polygon

Performance:

 Flooding < Probabilistic Scheme < Counter-Based Scheme < Distance-Based Scheme < Location-Based





Relationship between Reachability and Saving

□ Points closer to the upper-right corner are better.













Conclusions

Broadcast Storm:

- a newly identified problem that could affect the performance of MANET
- deserve more debate in the future
- high severity:
 - ➢ redundancy, contention, collision

Solutions:

- based on the expected additional coverage of a rebroadcast
- probabilistic ==> counter ==> distance ==> location





- 1. What's the "broadcast storm" problem ?
- 2. How to reduce the "broadcast storm" problem ?