Random Networks

1. A script "pbcast_randsim.tcl" is provided. Get the tcl script from here. This script takes two command-line arguments: the name of the scenario-file, and the re-broadcast probability. Script usage is : ns pbcast_randsim.tcl -scenfile (scenario-file) -prob (probability)

2. We shall now consider random networks of 400 nodes. Use the "scengen" utility available with ns2 to generate 5 random topologies of 400 nodes over a 2500m x 2500m area, each with a min speed of 1.0 m/s and a maximum speed of 2.0 m/s.

3. For each topology, run the simulation with the same probability values as in part 1. Obtain the same two statistics, as in part 1, for each topology and plot them vs. the re-broadcast probability. There should be only 2 graphs, one for each statistic.

4. Run the simulation for probability values: 0.1, 0.2, 0.3, 0.4, 0.45, 0.5, 0.6, 0.7, 0.8, 0.9 and 1.0. Remember that probability=1.0 is equivalent to complete flooding. Obtain the following statistics and plot them vs. the probability value: Avg. no. of message copies received per node, Fraction of nodes that receive the message at least once.

Broadcasting in a MANET

A MANET consists of a set of mobile hosts that may communicate with one another from time to time. No base stations are supported. Due to considerations such as radio power limitation, channel utilization, and power-saving concerns, a mobile host may not be able to communicate directly with other hosts in a single-hop fashion. In this case, a multi-hop scenario occurs, where the packets sent by the source host are relayed by several intermediate hosts before reaching the destination host.

The broadcast problem refers to the sending of a message to other hosts in the network. The problem considered here is assumed to have the following characteristics.

1. ***The broadcast is spontaneous.*** Any mobile host can issue a broadcast message at any time. For reasons such as host mobility and lack of synchronization, preparing any kind of global topology knowledge is prohibitive. Little or even no local connectivity information may be collected in advance.
2. ***The broadcast is unreliable.*** No acknowledgement mechanism will be used. However, an attempt should be made to distribute a broadcast message to as many hosts as possible without paying too much effort.
    i. *a host may miss a broad-cast message because it is off-line, it is temporarily isolated from the network, or it experiences repetitive collisions,*
    ii. *acknowledgements may cause serious medium contention (and thus, another "storm") surrounding the sender, and*
    iii. *in many applications (e.g., route discovery) in a 100% reliable broadcast is unnecessary.*

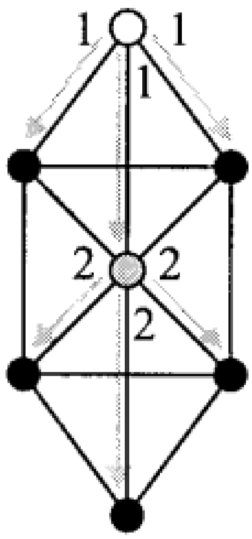
Assumption that a host can detect duplicate broadcast messages prevents endless flooding of a message. One way to do so is to associate with each broadcast message a tuple (source ID, sequence number).

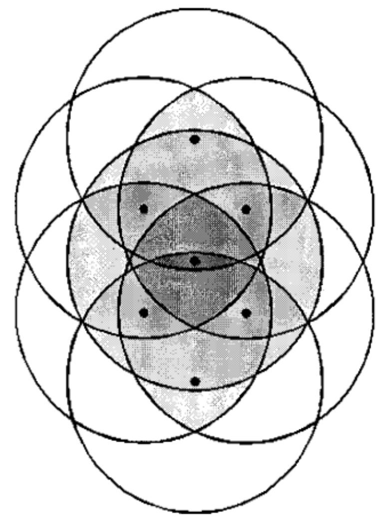
Broadcast storm caused by flooding

A straight-forward approach to perform broadcast is by flooding. A host, on receiving a broadcast message for the first time, has the obligation to rebroadcast the message. Clearly, this costs n transmissions in a network of n hosts. In a CSMA/CA network, drawbacks of flooding include:

1. ***Redundant rebroadcasts.*** When a mobile host decides to rebroadcast a broadcast message to its neighbors, all its neighbors already have the message.
2. ***Contention.*** After a mobile host broadcasts a message, if many of its neighbors decide to rebroadcast the message, these transmissions (which are all from nearby hosts) may severely contend with each other.
3. ***Collision.*** Because of the deficiency of back off mechanism, the lack of RTS/CTS dialogue, and the absence of CD, collisions are more likely to occur and cause more damage.

Collectively, the above problems are referred as **Broadcast storm problem.**

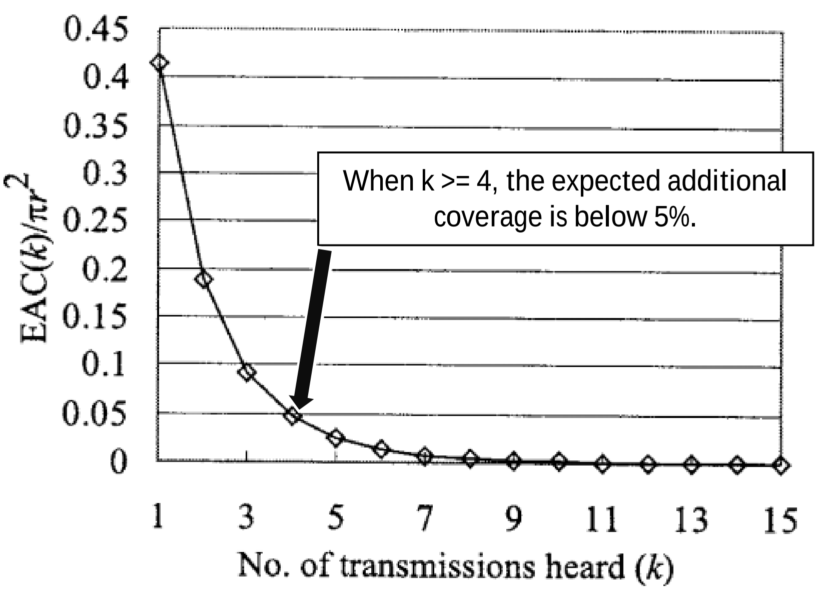




Only 2 transmissions required to transmit a message from source white node.

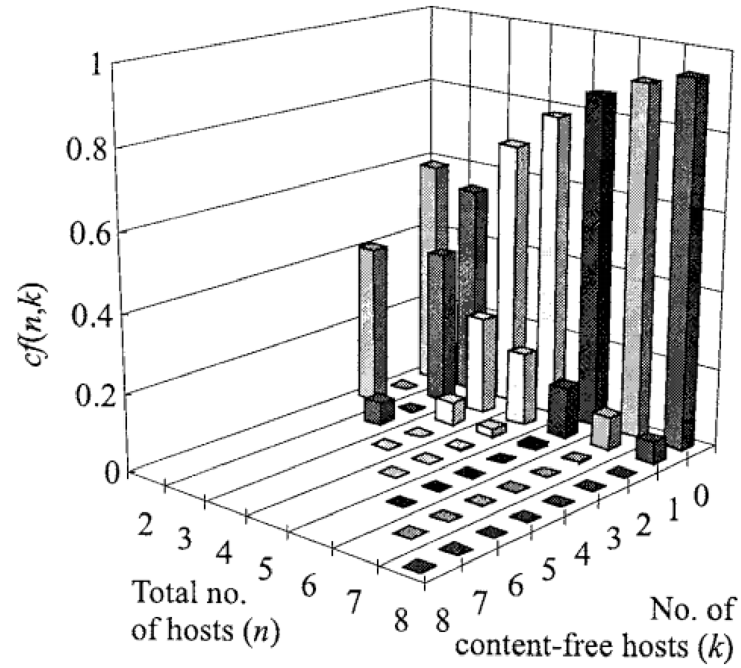
Flooding: 7 transmissions.
(5 redundant broadcasts)

Analysis of redundant rebroadcasts



EAC (k) = Expected Additional Coverage can be obtained from simulation by randomly generating k hosts in a host X's transmission range and calculating the area covered by X excluding those areas already covered by the other k hosts.

Analysis of contention



cf (n, k) = Probability that k hosts among these n hosts experience no contention in their rebroadcasting. The probability of all n hosts experiencing contention (i.e., cf (n, 0)) increases quickly over 0.8 as n>=6. So the more crowded the area is, the more serious the contention is. On the other hand, the probability of having one contention-free host (i.e. cf (n, 1)) drops sharply as n increases. Further, it is very un-likely to have more contention-free hosts (i.e. cf (n, k) with k>=2). Note that having k = n−1 contention-free hosts implies having n such hosts, so cf (n, n−1) =0.

Analysis of collision

The CSMA/CA mechanism requires a host to start a back-off procedure right after the host transmitted a message, or when a host wants to transmit but the medium is busy and the previous back-off has been done. To perform a back-off, a counter is first set to an integer randomly picked from its current back-off window.

Now consider the scenario where several neighbor hosts hear a broadcast from host X. There are several reasons for collisions to occur. First, if the surrounding medium of X has been quiet for enough long, all of X's neighbors may have passed their back-off procedures. Thus, after hearing the broadcast message (and having passed the DIFS period), they may all start rebroadcasting at around the same time. This is especially true if carriers cannot be sensed immediately due to such as RF delays and transmission latency. Second, because the RTS/CTS forewarning dialogue is not used in a broadcast transmission, the damage of collision is more serious. Third, once collision occurs, without collision detection (CD), a host will keep transmitting the packet even if some of its foregoing bits have been garbled. And the longer the packet is, the more the waste.

Probabilistic scheme

An intuitive way to reduce rebroadcasts is to use probabilistic rebroadcasting. On receiving a broadcast message for the first time, a node in the network broadcasts a message with probability P and takes no action with probability 1−P. Clearly, when P=1, this scheme is equivalent to flooding.

NS2 Commands

To generate scenario file.

```
setdest -v 2 -n 400 -p 0 –m 1 –M 2 -t 10 -x 2500 -y 2500 > scenario-file
```

Running the script.

```
ns pbcast_randsim.tcl –prob {probability} –scenfile scenario-file
```

Running nam.

```
nam pbsim.nam
```

Performance analysis:

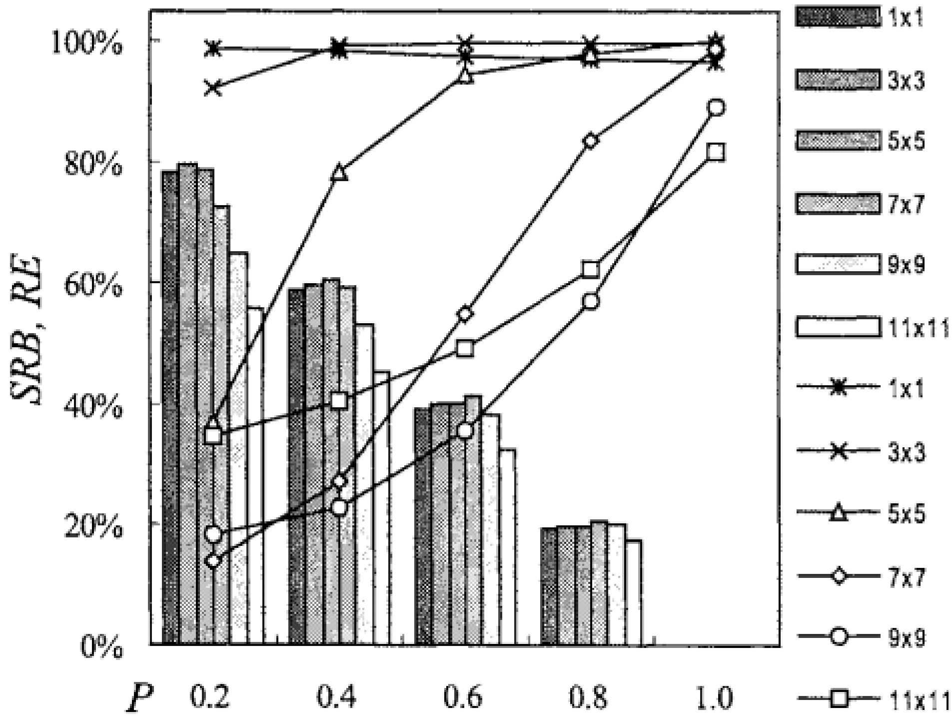
Reachability (RE): the number of mobile hosts receiving the broadcast message divided by the total number of mobile hosts that are reachable, 4directly or indirectly, from the source host. <u>(Avg. no. of message copies received per node).</u>

Saved ReBroadcast (SRB): (r−t)/r, where r is the number of hosts receiving the broadcast message, and t is the number of hosts that actually transmitted the message. <u>(Fraction of nodes that receive the message at least once).</u>

Through a simulation run of 10,000 broadcast requests, the graph below shows the observed RE and SRB when applying the probabilistic scheme.

In a small map (which implies a dense host distribution), a small probability P is sufficient to achieve high reachability. But a larger P is needed if the host distribution is sparse.

The amount of saving (SRB) decreases, roughly proportionally to (1−P), as P increases. The performance of broadcasting by flooding can be found at the position where the probability P =1.



Probability P versus reachability RE (shown in lines) and saved rebroadcast SRB (shown in bars).
1x1 = 500 m x 500 m
2x2= 1000mx 1000m
And so on…….

Conclusions

Identified an important issue in a MANET, the broadcast storm problem and demonstrated, through analyses and simulations, how serious this problem could be. Simulation results based on different threshold values are presented to verify and compare the effectiveness of probabilistic scheme as compared to the basic flooding approach.