“Endcast” for Disaster Management

Dr. Sulochana Sooriyaarachchi

University of Moratuwa

Sri Lanka

APAN India

12-17 February 2017

ndia Habitat Centre, New Delhi

Outline

- Disaster scenario
- Mobile Adhoc Networks (MANET) for communication
- Traditional MANET routing
- Mobile stateless routing
- Endcast
- Proposed endcast protocol
- Simulation results
- Conclusions

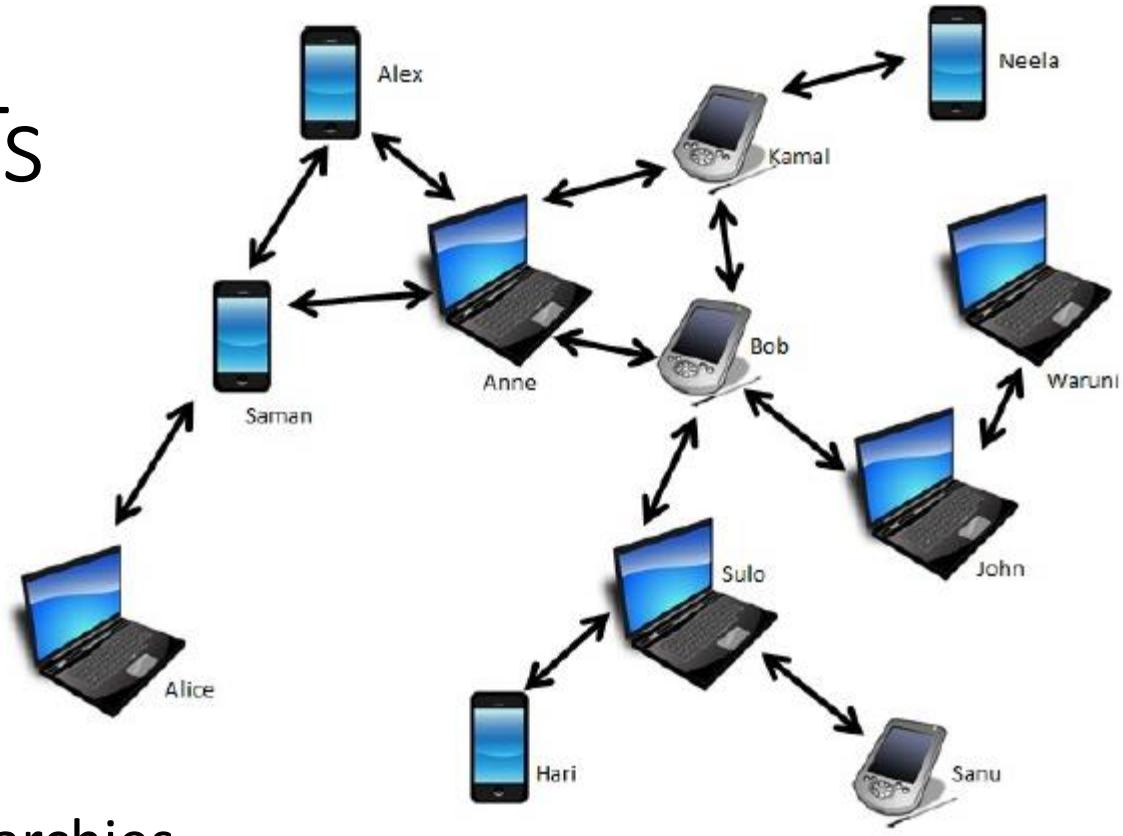
Disaster Scenario

- A medical team member contacting food team ?
  - Damaged infrastructure
  - Large crowd
  - Low power devices

A dense MANET

Routing in dense MANETs

- Traditional routing
  - Proactive
  - Reactive
  - Hybrid
- Costs
  - Route discovery, maintenance, control overhead, frequent updates, node hierarchies



No robust unicast mechanism

MANETs almost not deployed

Novel approach: *mobile stateless routing*

- No route discovery and maintenance
- No node hierarchies
- No global states (e.g. routing tables)
- No special nodes

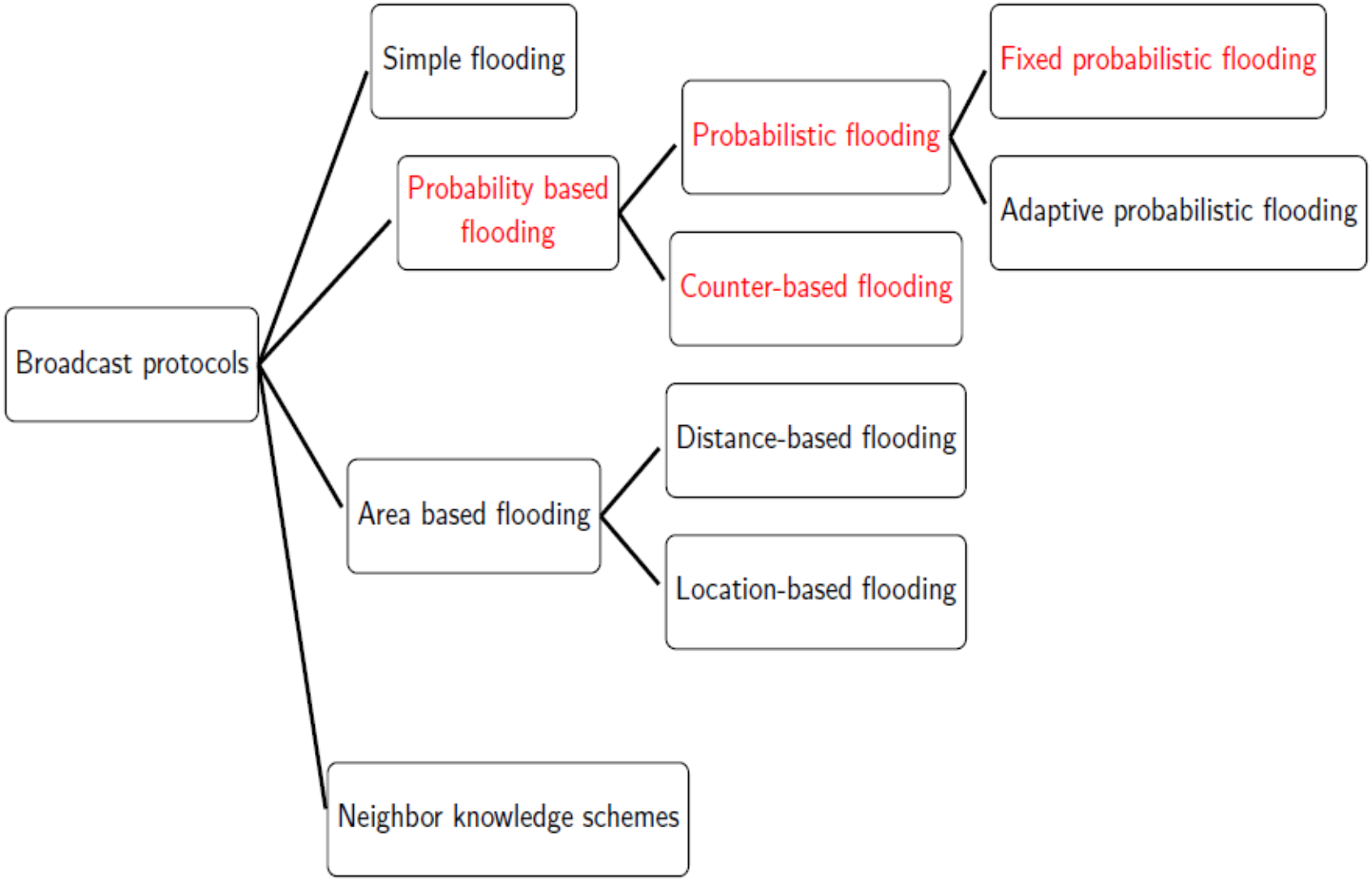
Free to go Mobile!

How?

~~Blind rebroadcasting~~

Simple flooding ?

Efficient flooding schemes



Endcast

- Unicast : a single sender and a single receiver through point to point path
- Anycast : a single sender to any one of a group of receivers
- Multicast : a single sender to a group of receivers
- Broadcast: a single sender to all members of the network
- Endcast : a single sender via all or some intermediate receivers to a single destination

Problems in endcast

Broadcast storm condition

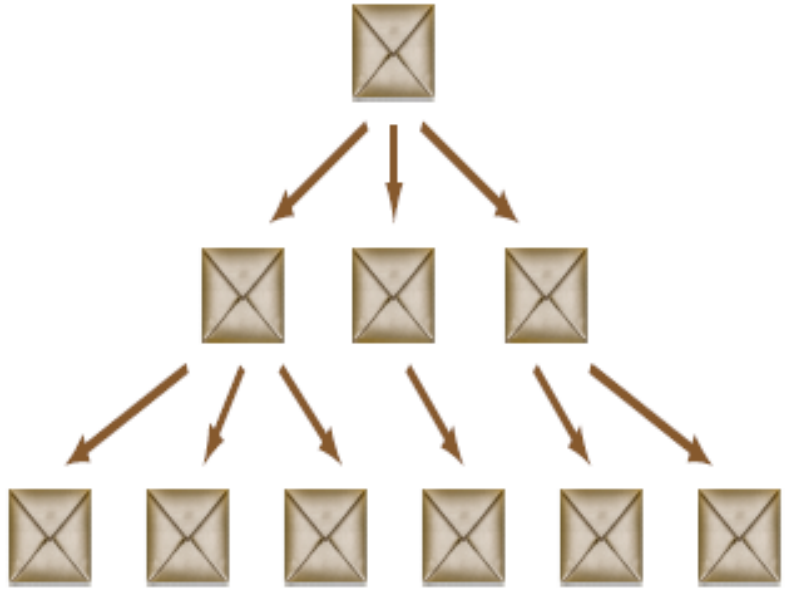
The serious redundancy, contention and collision that occur in fooding networks [1]

Broadcast flood condition

Propagation of the messages beyond the destination (we defined)

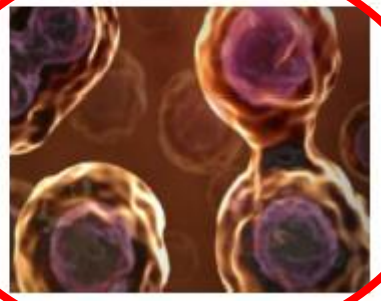
An endcast scheme

- Simplest mobile-stateless mechanism
  - blind rebroadcasting
- Broadcast storm control
  - biologically inspired mechanisms
- Broadcast flood control
  - negative acknowledgement

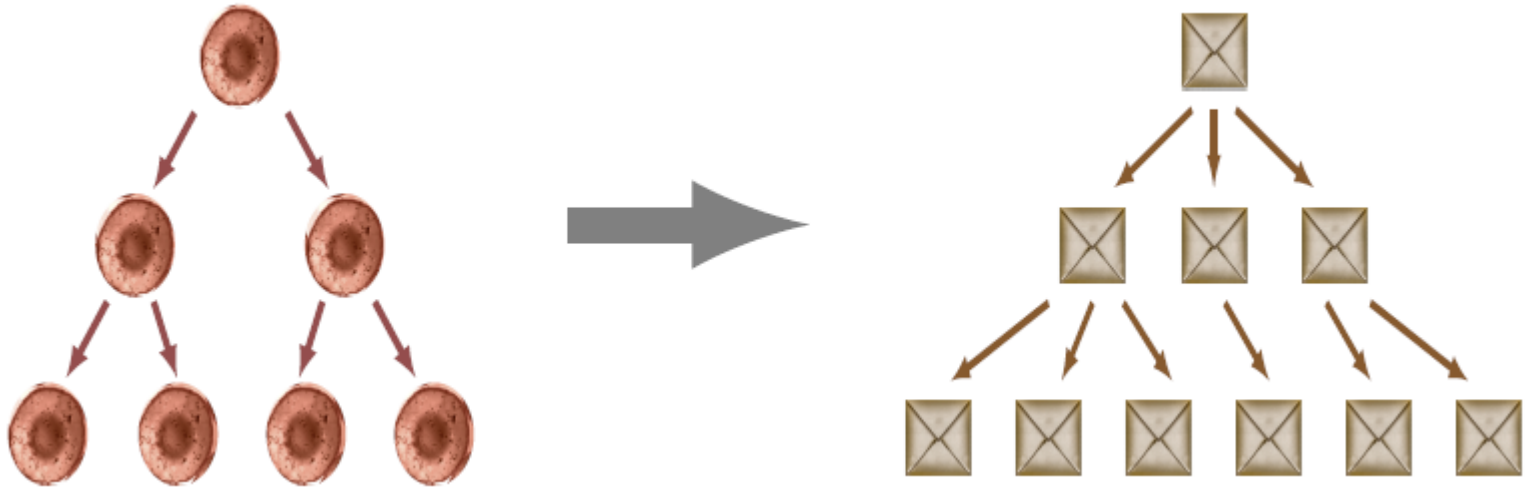


Biological inspirations for storm control

Large populations
Cooperating
To achieve a common goal
With simple interactions



Cell proliferation Vs blind rebroadcasting



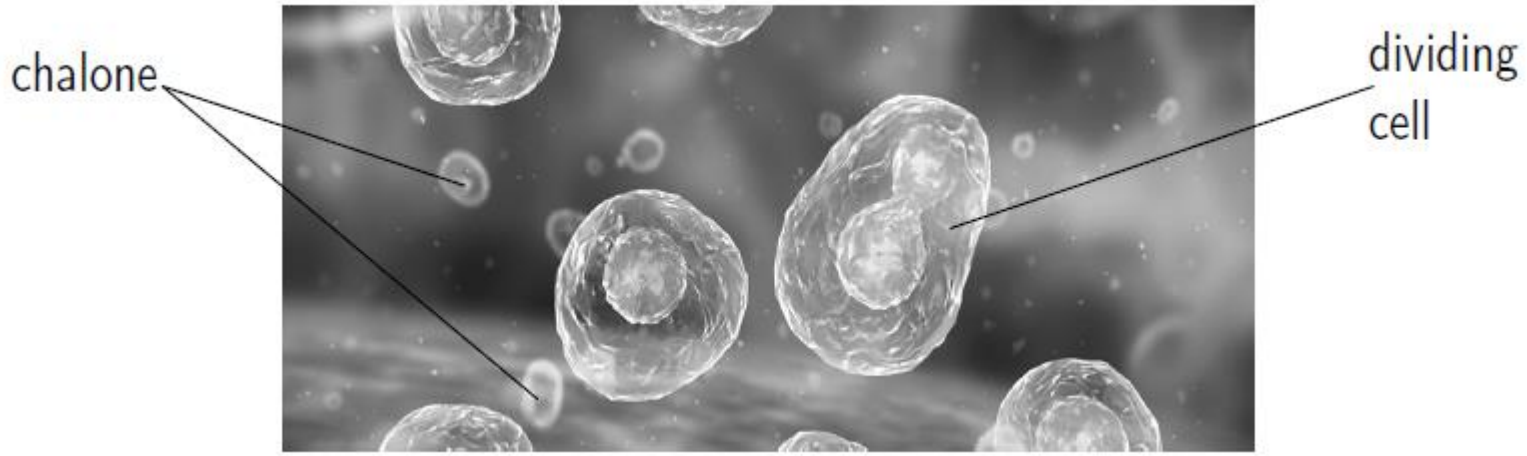
- *Cell proliferation*: cells increase in number due to division into two identical cells

  On what basis our ears stop growing after reaching a particular size?"

- Growth regulation using *chalone mechanism*

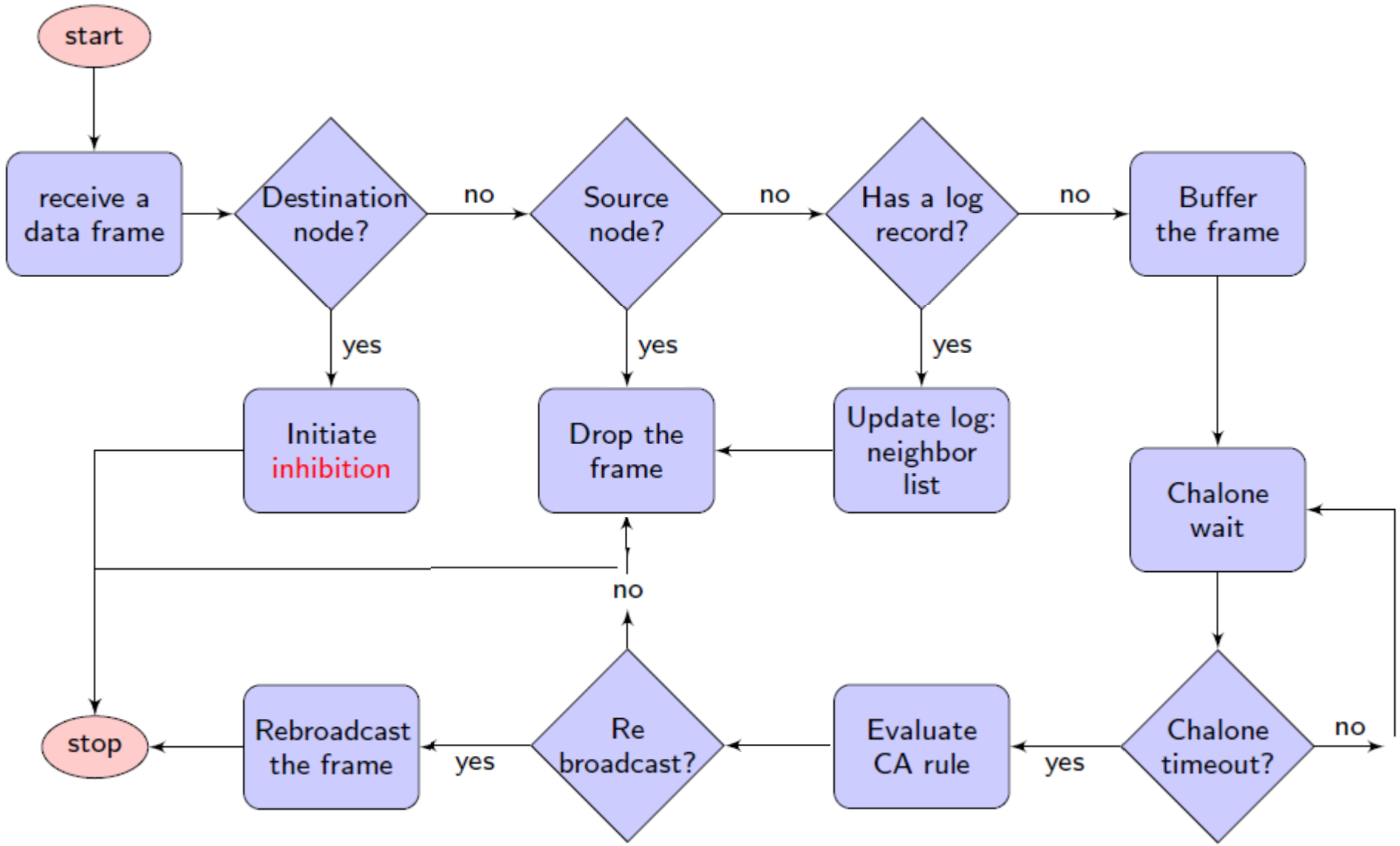
Chalone Mechanism

- Cells secrete a molecule called chalone
- Chalone concentration increases with number of cells
- Cells stop proliferating when the chalone concentration reaches a threshold



Mapping from biological system to MANET

Biological System	**MANET**
Biological cell	Data frame in a node
Cell division	Frame rebroadcasting
Chalone	The received data frames from the neighbors. Neighbors are the nodes within the transmission range of a node.
Chalone concentration	Number of neighboring nodes who have already broadcast the Data Frame.


start
receive a data frame
Destination node?
no
Source node?
no
Has a log record?
no
Buffer the frame
yes
yes
yes
Initiate inhibition
Drop the frame
Update log: neighbor list
Chalone wait
no
stop
Rebroadcast the frame
yes
Re broadcast?
Evaluate CA rule
yes
Chalone timeout?
no

Flood control by inhibition

- Negative acknowledgement messages

  inhibitor

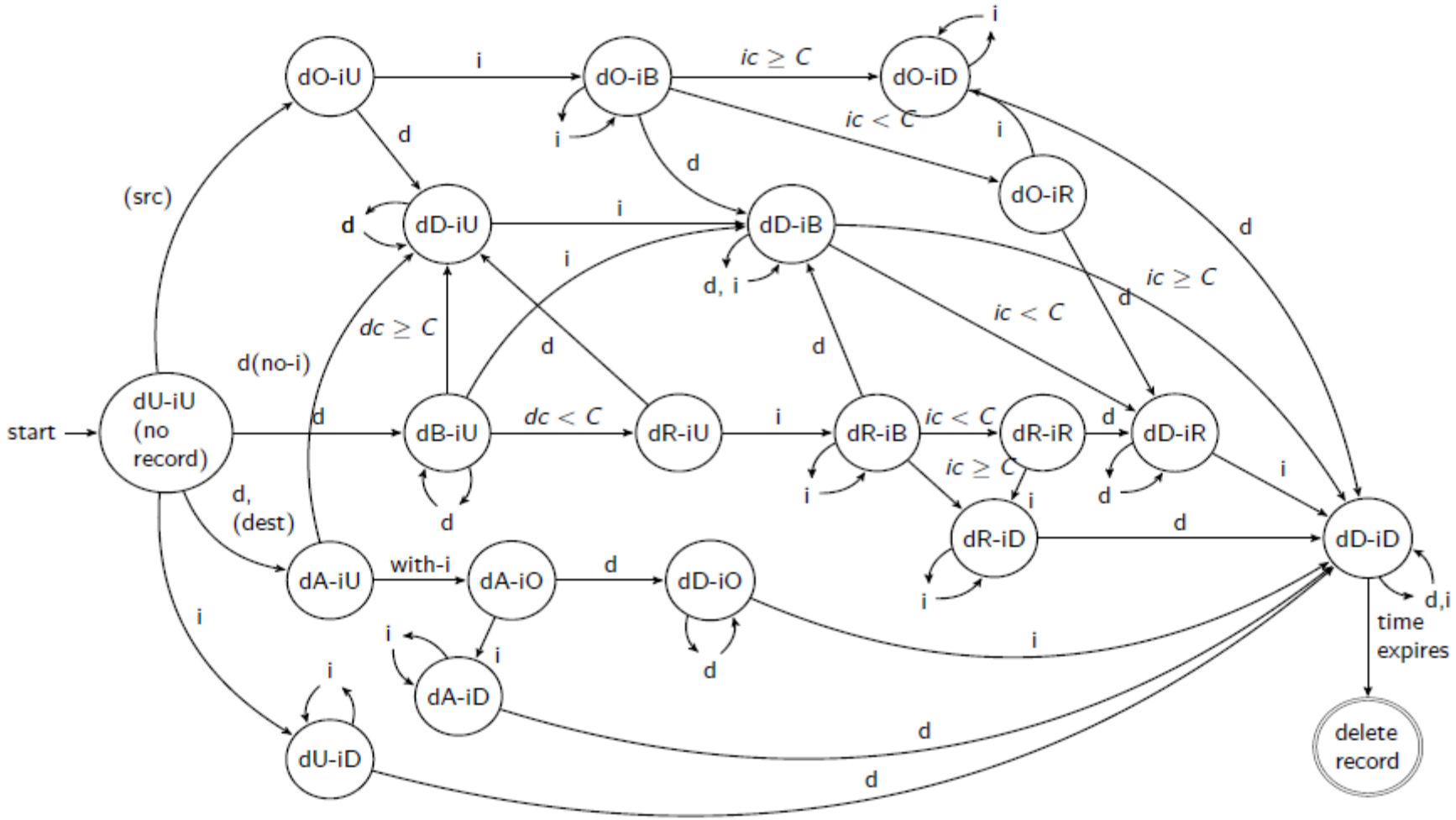
- Propagates via counter-based flooding
- Inhibitor size < data frame
- Inhibitor wait < chalone wait
- Inhibitor is rebroadcast only when there are relevant log records

Protocol highlights

- Chalone wait: RAD for assessing frame count selected uniformly from the range 0 to Tmax
- Chalone threshold: Adjust to tradeoff between redundancy and reachability
- Inhibitor wait: Should be less than chalone wait to catch and stop flooding wave
- Data buffer: Frame to be buffered until rebroadcast decision
- Frame log:

time stamp	source MAC	destination MAC	seq number	data state	inhibitor state	inhibitor count	data count

State transition diagram



d-data, i-inhibitor, U-unknown, O-originated, B-buffered, R-rebroadcast, D-discarded, A-accepted, c-concentration, C-threshold

Simulation study

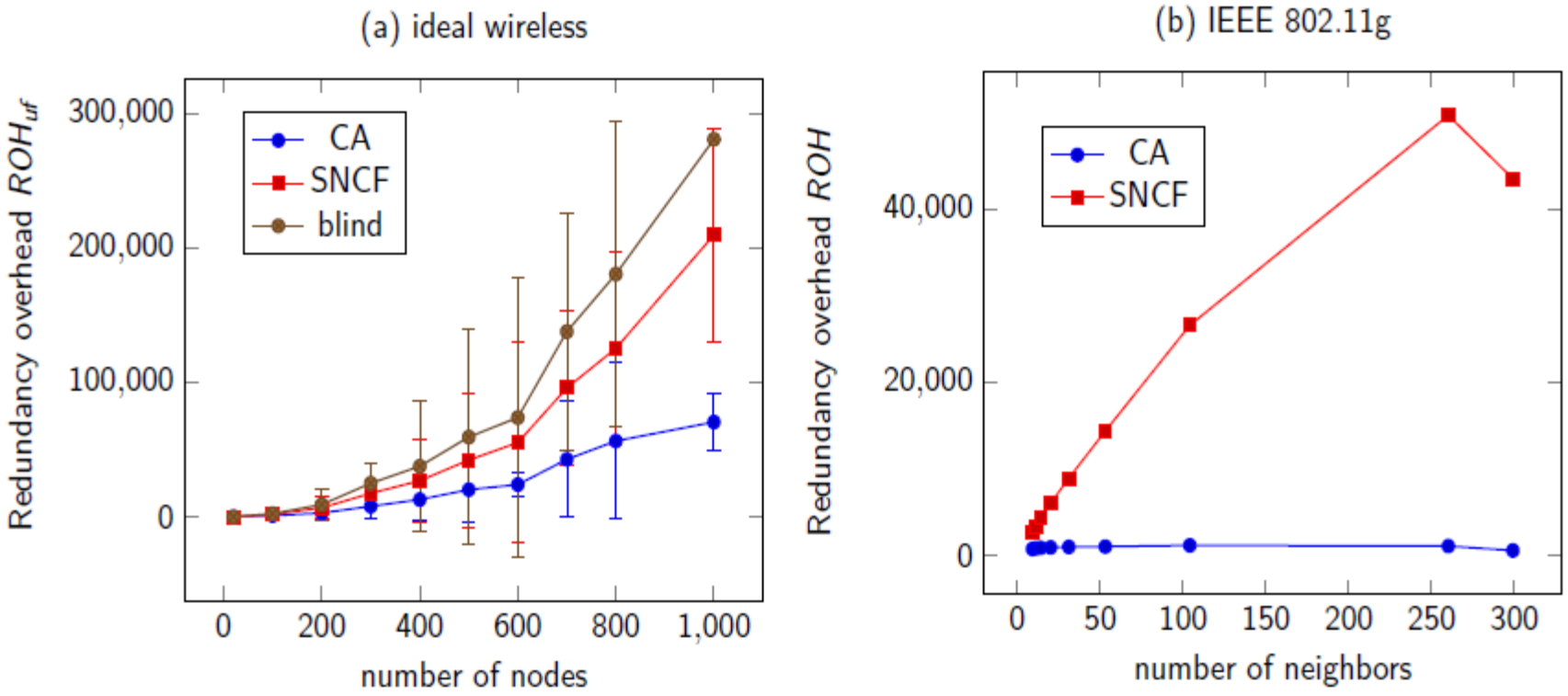
- In ideal network conditions

Parameter	Value
Playground size	600 m × 400 m
Transmitter range	200 m
Chalone timeout	0.1 μs
Chalone threshold	1 to 3

- In realistic network conditions

Parameter	Value	
number of nodes	300	
transmission range	40 m	
playground sizes	meeting room	disaster site
	20m×20m	450m×450m
chalone wait	0 to 6 sec	
flooding wait	0 to 6 sec	
threshold	1	

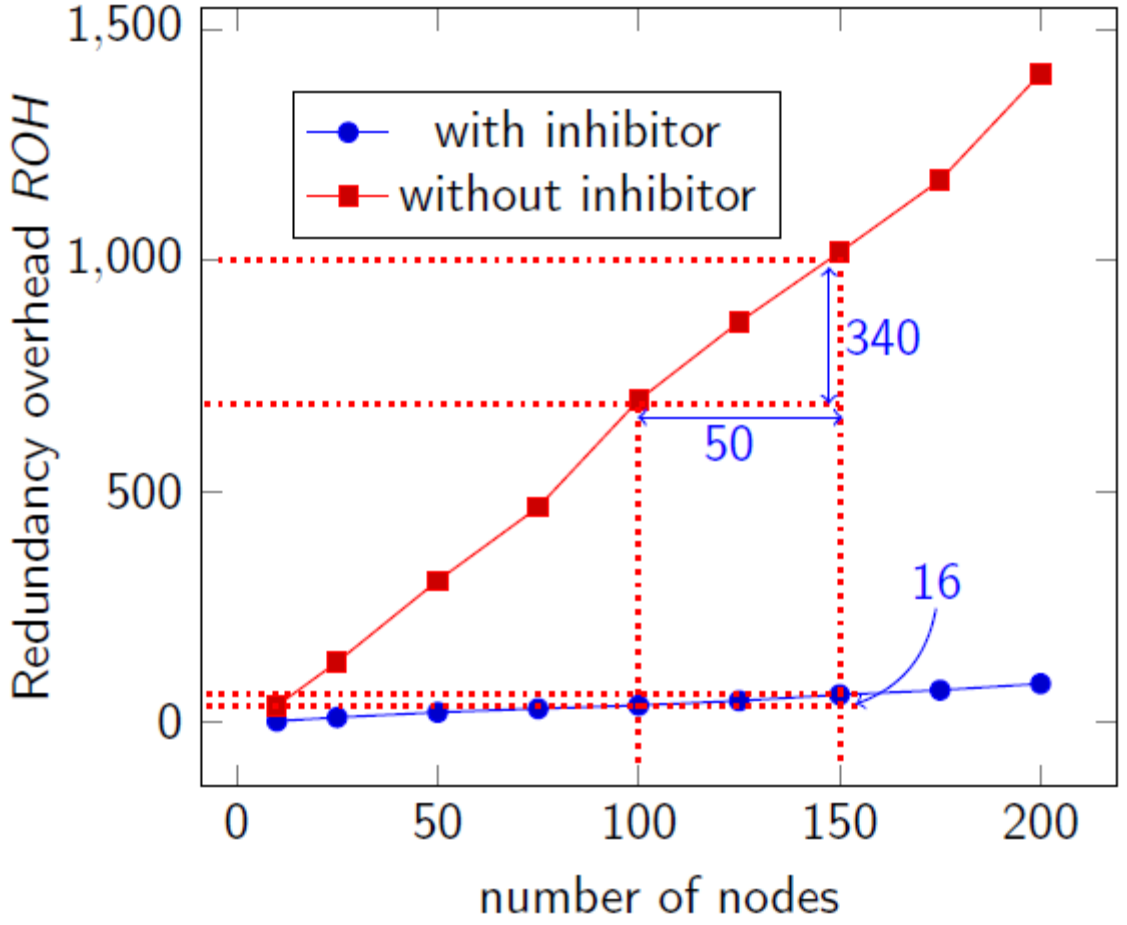
Simulation results - effect of storm control



SNCF - simple flooding, CA - proposed cellular automate based protocol

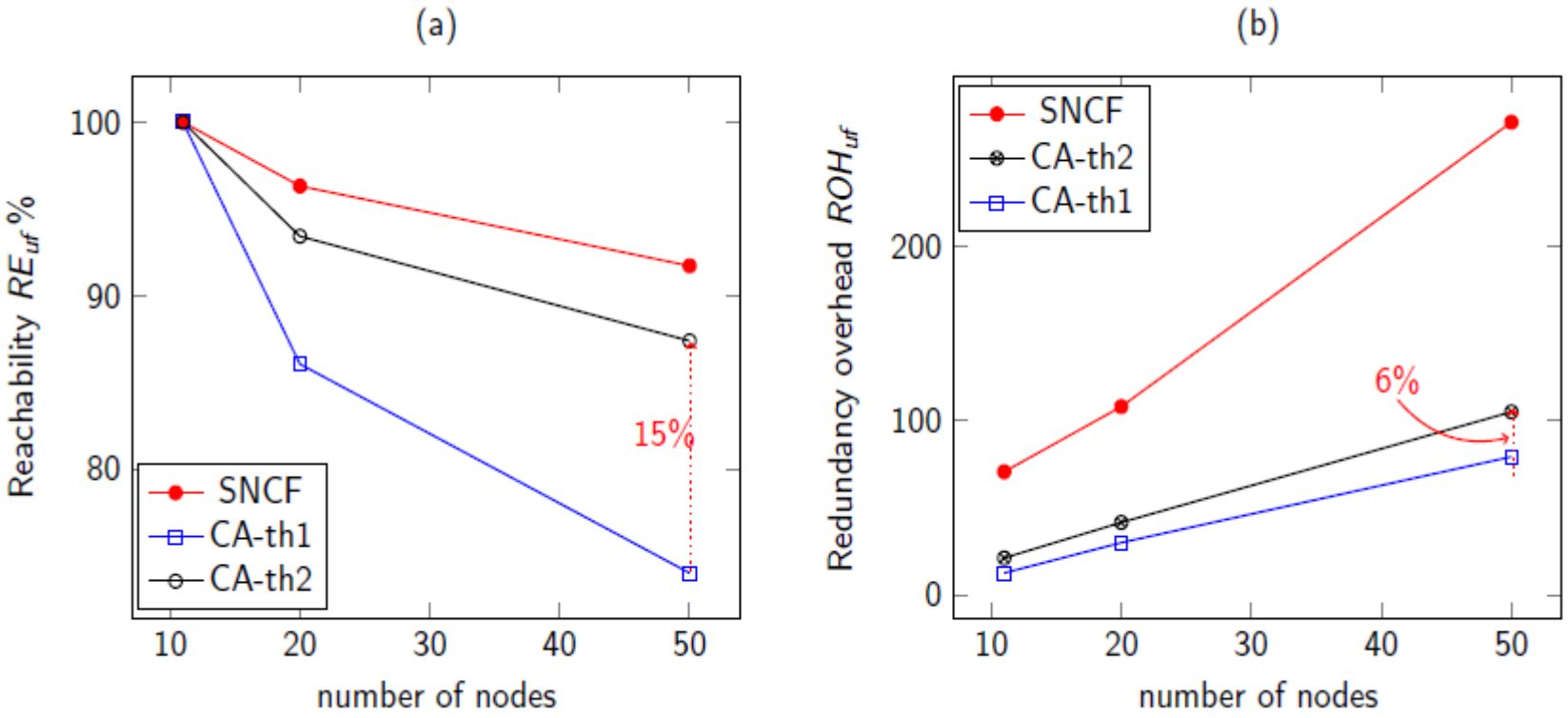
Saves over 45% redundant frames compared to SNCF saving increases with network size and density

Simulation results - effect of flood control



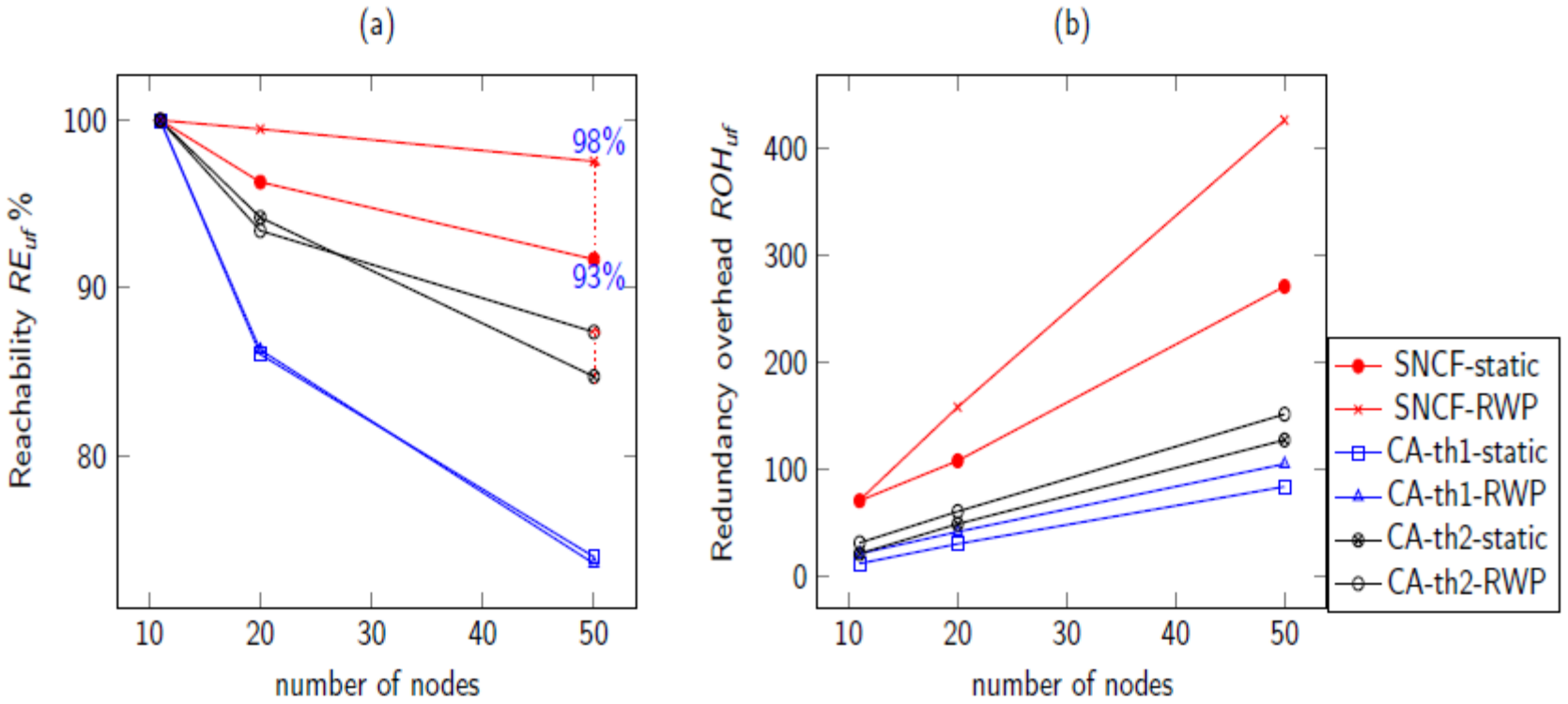
Rate of growth with inhibitor < that without inhibitor

Simulation results - effect of chalone threshold



Threshold can be tuned to tradeoff between reachability and redundancy

Simulation results - effect of mobility



Mobility assists data delivery in flooding as in *opportunistic networks*

Comparison of proposed protocol with routing approaches

- Fixed-stateful paradigm: key nodes to perform routing, keep global states e.g. routing tables
- Mobile-stateless paradigm: nodes are free to move, no special roles to play, no global states maintained
- Proposed protocol: local state (frame log), no key nodes, no global states

Conclusion

- Proposed the concept of endcast for mobile-stateless routing
- Built a theoretical model for endcast to model and analyse
  - the effect of mobility on flooding performance
  - the effect of MAC layer characteristics on flooding operation
  - the effect of efficient flooding parameters on flooding performance
  - time domain aspects (e.g. RAD)
  - broadcast storm and flood problems in endcast
- Limitations and future research
  - Applying the complete model on proposed protocol
  - Testing the protocol on a real testbed

Q&A

Acknowledgement

- APAN for fellowship
- LEARN for airfare support
- Dr. Chandana Gamage – research supervisor
- Prof. Gihan Dias – encouraged APAN participation
- CITes (University of Moratuwa NoC)
  - Dr. Shantha Fernando, Mr. Sarada, Mr. Nadeesha
- Colleagues at CSE and UoM
- Your attention!

Thank you