Efficient Broadcast in MANETs Using Network Coding and Directional Antennas

INFOCOM 2008

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May 22, 2008

Outline

- Introduction
- Related works
- Efficient Broadcasting using Network Coding and Directional Antennas (EBCD)
- Extensions of EBCD
- Simulation
- Conclusions

Introduction(1/2)

- Broadcasting is the most frequently used operation in mobile ad hoc networks (MANETs)

- Many researches have been proposed to avoid the broadcast storm problem caused by simple blind flooding

Introduction(2/2)

- Network coding combines many forward messages to fewer coded messages
  - Timing problem
  - Multiple sources with multiple messages
- Directional antennas divide the omnidirectional transmission range into several sectors
  - Transmission can be performed only in selected sectors

Related work(1/2)

- Probabilistic broadcast
  - Require relatively high broadcast redundancy to maintain an acceptable delivery ratio
- Deterministic broadcast
  - Nodes select a few forwarding nodes to achieve full delivery
  - Need h-hop neighbor information

Related work(2/2)

- Connected dominating set (CDS)
  - Only CDS nodes rebroadcast
  - Finding minimum CDS is NP-Complete

System assumptions

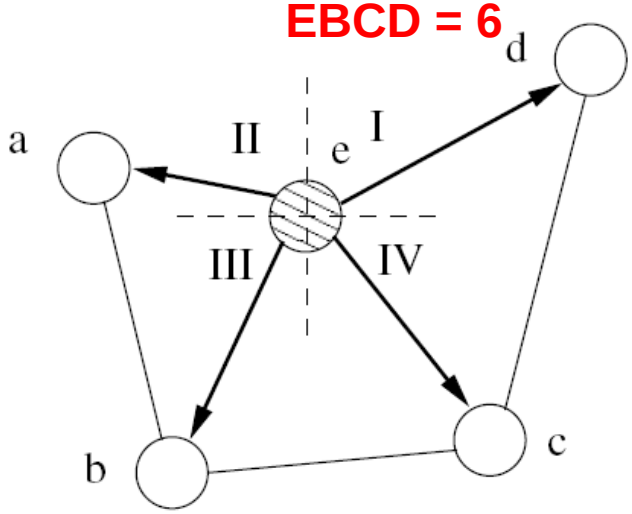
- Each node knows its 2-hop neighbor information by exchanging HELLO messages
- The reception mode of all nodes is omnidirectional
- The consumption of the transmission of one message in one sector is the unit energy consumption

Efficient Broadcasting using Network Coding and Directional Antennas (EBCD)

Traditional broadcasting = 4x4 =16

Broadcasting with network coding = 4x2= 8

EBCD = 6



(a)

	A	B	C	D
a	1	1	0	0
b	1	1	1	0
c	0	1	1	1
d	0	0	1	1
e	1	1	1	1

(b)

$P_1 = A \oplus C$

$P_2 = B \oplus D$

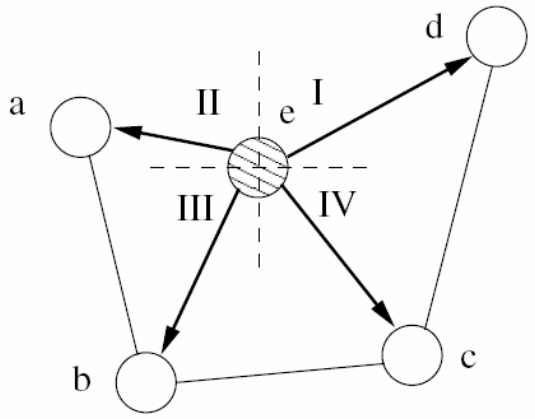
	P_1	P_2
I	1	1
II	1	1
III	0	1
IV	1	0

(c)

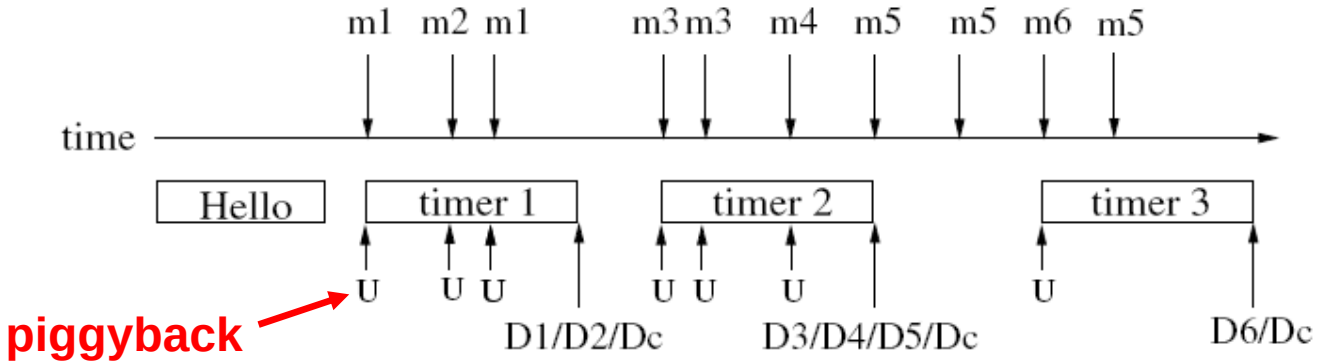
Efficient Broadcasting using Network Coding and Directional Antennas (EBCD)

- Using a greedy approach for network coding
  - Ex. Messages arrive in the order of A,C,B,D
  - At first, P_1=A
  - e tries to make P_1=A⊕C ➔ ok!!
  - e tries to make P_1=A⊕C⊕B ➔ incorrect!!
  - Then P_1=A⊕C
  - The same as P_2=B⊕D

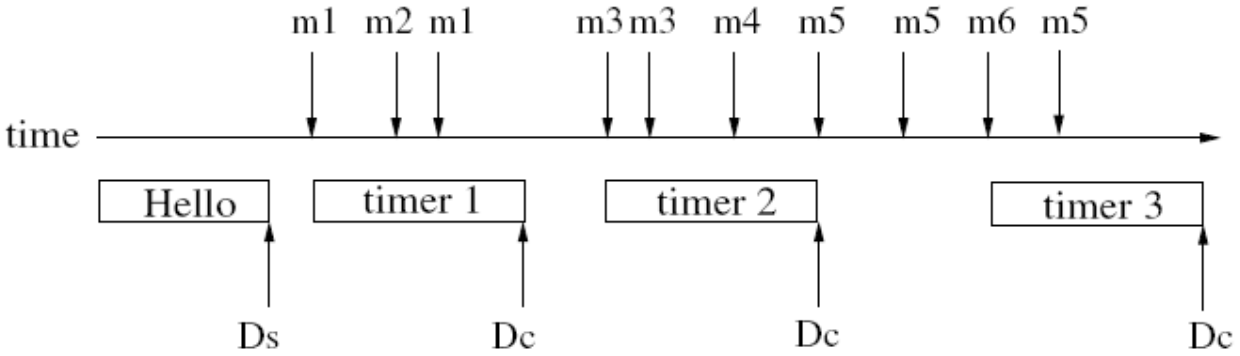
	A	B	C	D
a	1	1	0	0
b	1	1	1	0
c	0	1	1	1
d	0	0	1	1
e	1	1	1	1



Execution of dynamic and static EBCD



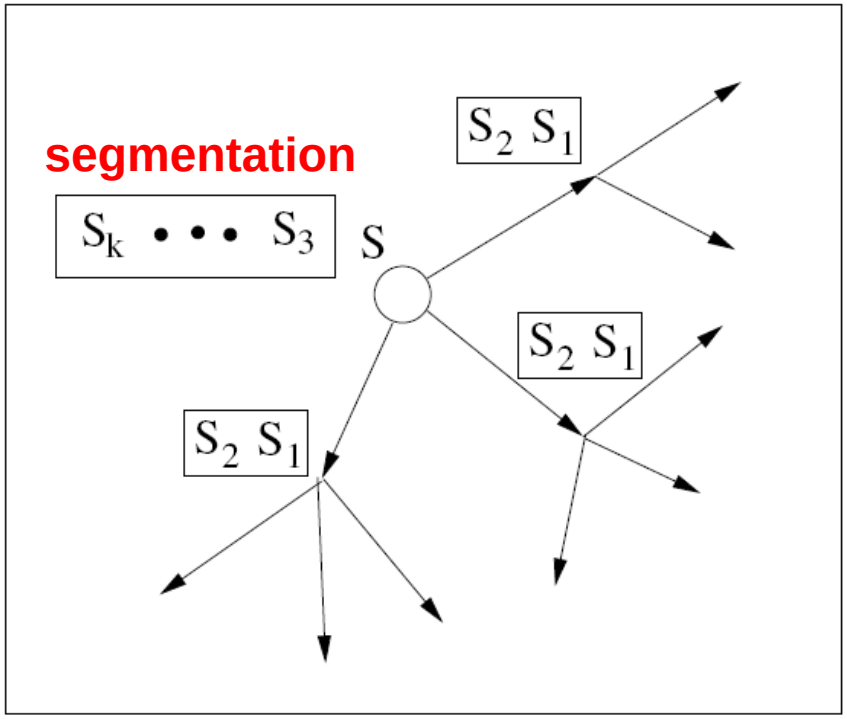
(a) Dynamic EBCD



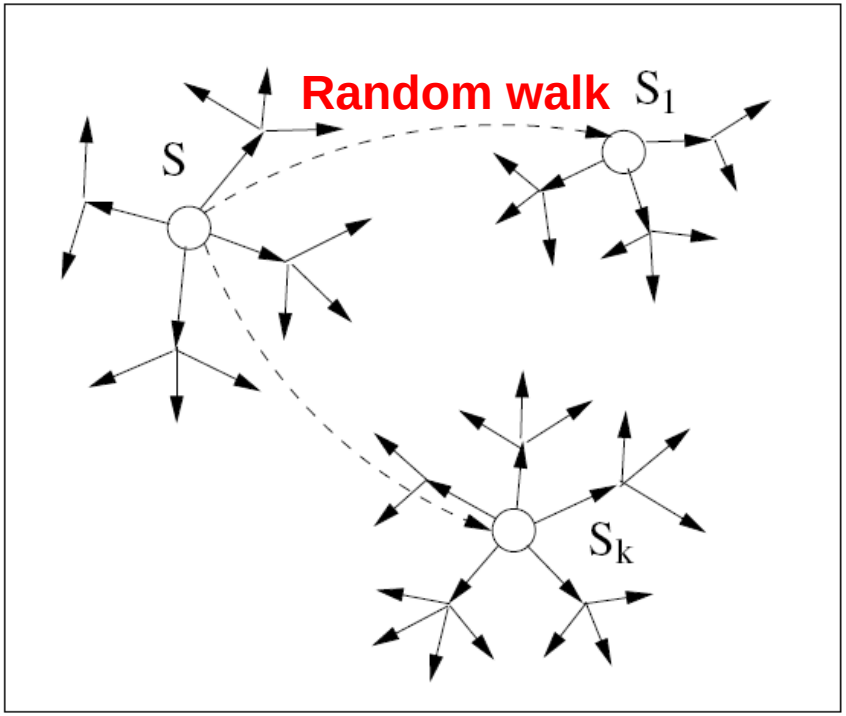
(b) Static EBCD

Extensions of EBCD

- Single source and single message broadcast



(a) Pipeline-based approach



(b) Spread-out approach

Simulation results

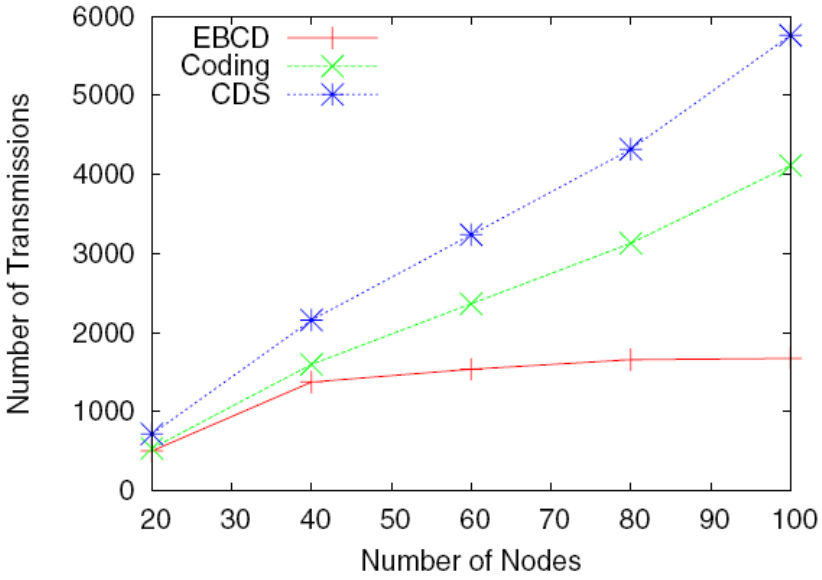
- Network area = 100x100m^2
- Number of nodes = 20~100 nodes
- Broadcast sessions = 20
- Node degrees = 6 for sparse network and
  18 for dense network
- Number of sectors = 4 and 6

Simulation results

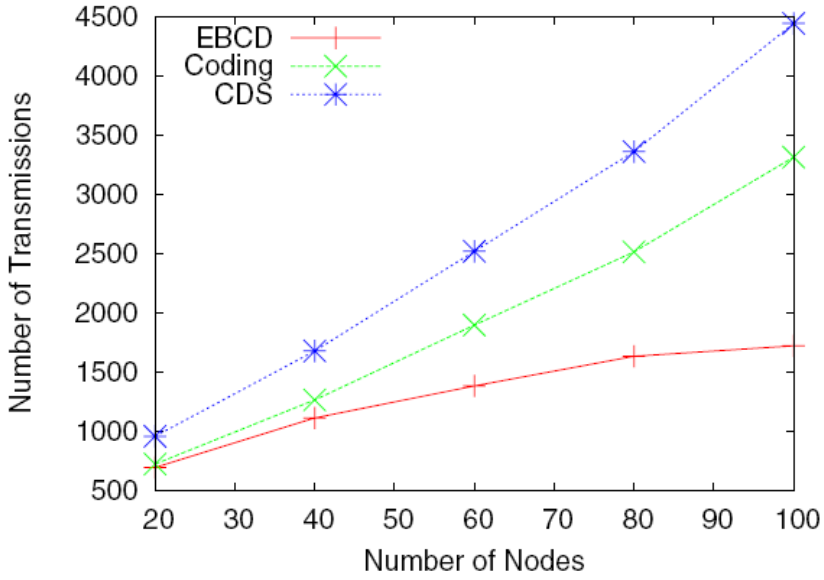
- Three schemes to compare
  - EBCD (Coding + Directional antennas)
  - Coding
  - CDS

Number of transmissions

The reduction rate is higher in dense network!!



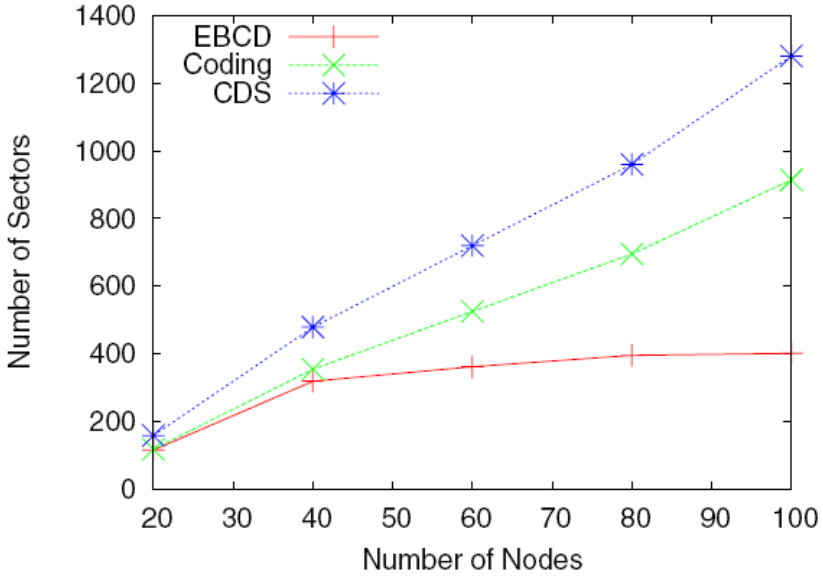
(a) Dense network ($d = 18$)



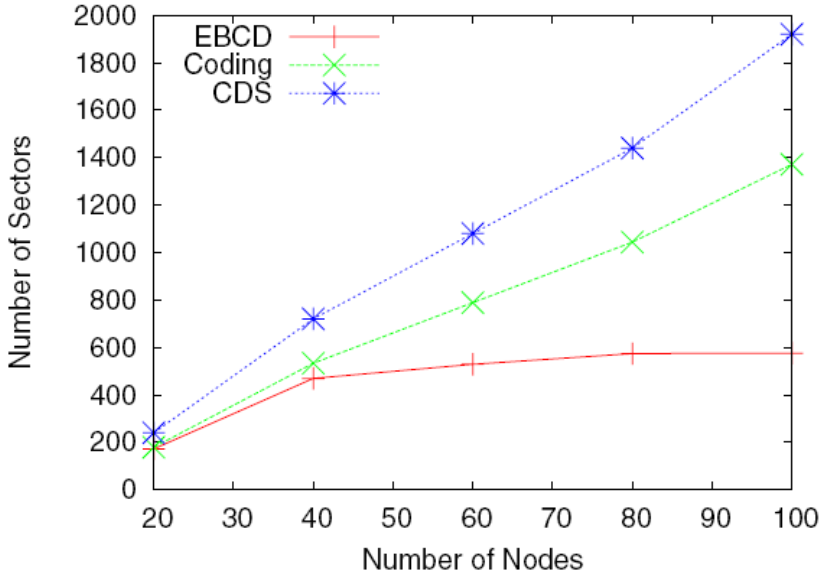
(b) Sparse network ($d = 6$)

Number of sectors

When K is larger, the reduction rate of EBCD is more significant!!



(a) Dense network ($K = 4$)



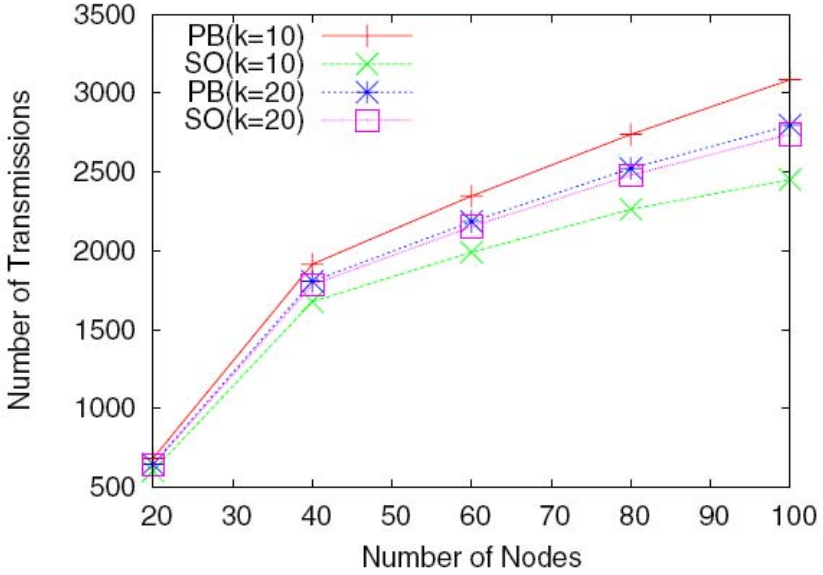
(b) Dense network ($K = 6$)

Comparison of PB and SO in number of transmissions

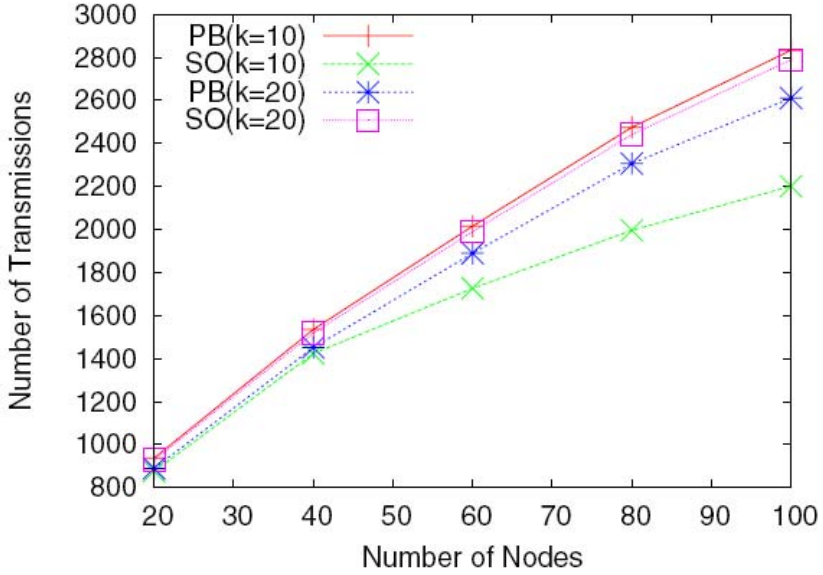
PB : Pipeline-based approach

SO : Spread-out approach

k : segment numbers



(a) Dense network ($d = 18$)



(b) Sparse network ($d = 6$)

Conclusions

- We combine the network coding-based broadcast approach with broadcasting using directional antennas for a more efficient broadcast strategy, developing efficient broadcasting using network coding and directional antenna algorithm (EBCD).

- The proposed EBCD approach has better performance than traditional CDS-based broadcast and the existing network coding-based broadcast in terms of energy consumption and transmission redundancy.

Discussions

- 2-hop (or more) neighbor information is inaccurate in mobile environment

- Timing issues
  - Timer is larger ➔ delay is larger
  - Timer is smaller ➔ coding is inefficient