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Cooperative Multicast Transmission Strategy for Energy-Efficient Dynamic Network Coding

Guoyan Zhang, *et al*

Beijing University of Posts and Telecommunications (BUPT)

Outline

- Background
- My Work
- Conclusion

Background

- Reducing energy consumption has drawn much attention in wireless multicast services.
- Previous work to achieve the energy efficient communication
  - Network coding
    - recombines several input packets into a combined version for forwarding
    - reduces the retransmission times
  - Cooperation communication
    - copes with error-prone and unstable characteristics of wireless channels' conditions from the BS to users
  - Relay selection
    - Selects considerable number of relays in the 1st stage of the two-stage cooperation
    - Reduces energy consumption with power control

My work

- In this paper:
  - Apply network coding to the relays in 1st stage of the two-stage cooperation.
    - Saves the retransmission times
    - Reduces the energy consumption for this time
  - Two network coding strategy will be investigated
    - XOR-network coding ,applying xor operation to two packets,
    - Dynamic network coding ,selecting coefficients of the packets from the Galois Field(q)
  - Defined the waiting time cost
    - Trade off between the waiting time for the users in the second stage and the energy saved for the communication system
    - The relay users can decide when to stop accumulating the packets from BS and enter the second stage

My Work--System Model

- The BS multicasts q different data on the row to the entire users with a high rate S_1.The q selects from *Galois Field (q)*.
- According to the principle that the closer to the users, the better transmission quality will be gained from the channel, the users in U_S who are closer to the users in U_F are likely to be chosen as the relays.
- In 2nd stage, selected relay users deliver packets to the users in U_F.

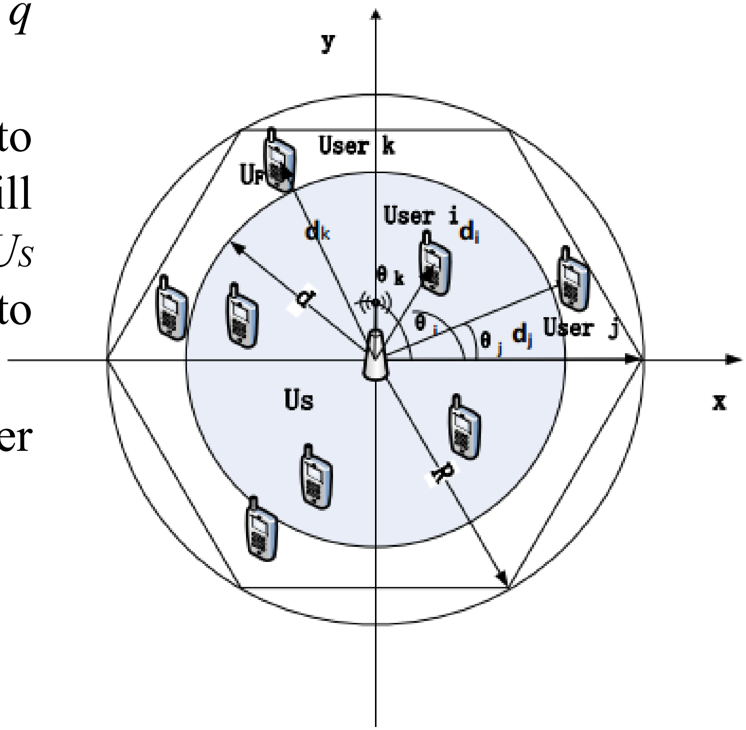


Fig.1

My Work--Network Coding Strategy

- For the first stage, T_1 stands for the time duration of BS transmitting packets to all the users
- $t1$ stands for the time duration of BS transmitting one packet to the entire users.
- As for the second stage, T_2 stands for the time duration of users in U_S transmitting the packet(s) to the users in U_F.

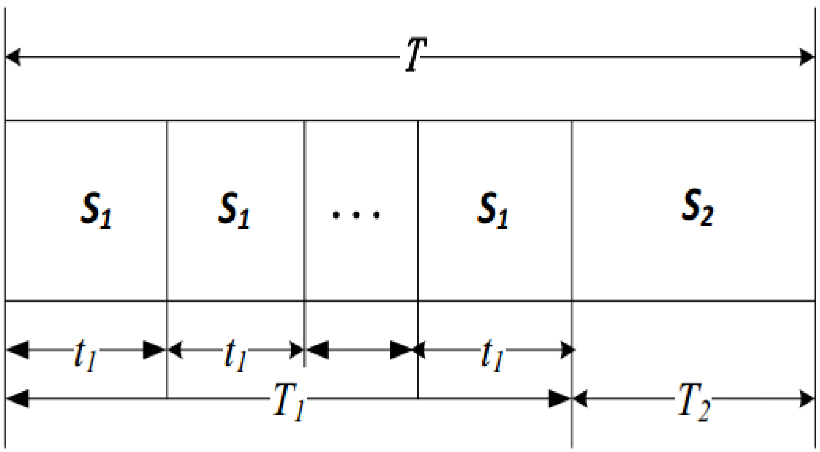
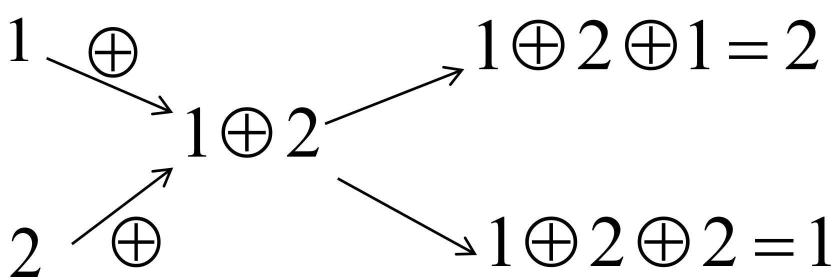


Fig. 2

My Work—XOR-Network Coding

Tab .1Receiving State of the users U_F

	Pattern 1		Pattern2		Pattern 3		Pattern 4	
User A	1	X	X	2	X	2	X	X
User B	1	X	X	2	1	X	X	X



$$(1\oplus 2)\oplus(1\oplus 2)=0!!!$$

Assume that the four patterns in Tab.1 are independent and identically distributed

$$\text{retransmission times}=\frac{1}{4}\times(1+1+1)+\frac{1}{4}\times 2=\frac{5}{4}$$

My Work—Dynamic Network Coding

What can we do with pattern 4?

Dynamic network coding!!!

$$[X]\begin{bmatrix}1\\2\end{bmatrix}=[Y] \tag{1}$$

$$\begin{bmatrix}x_{11} & x_{12}\\ x_{21} & x_{22}\end{bmatrix}\begin{bmatrix}1\\2\end{bmatrix}=\begin{bmatrix}y_1\\y_2\end{bmatrix} \tag{2}$$

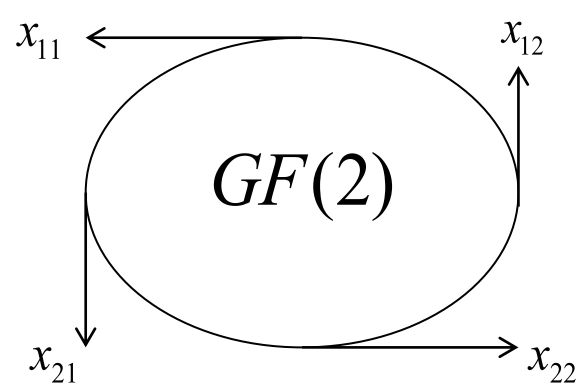


Fig.3

- Since relay users shall also broadcast the packets, one user in U_F would received the packets transmitted from several relay users, those packets form the matrix Y.
- Obviously, by applying dynamic network coding, the number of retransmitting packet(s) in stage II is reduced to 1

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My work—Waiting time cost

- However, if q *is* infinite, users in U_F have to wait for a quite long time.
- Trade off between the time and saved energy.
- Define the waiting time cost, relay users decide when to stop accumulating the packets from BS and enter the second stage.

My Work—STPEC

- **Energy consumption:**

$$EC = P_{bs} \cdot T_1 + P_{ue} \cdot T_2 \qquad (1)$$

transmit power of BS (P_{bs})

Transmit power of relay (P_{ue})

- **System throughput:**

$$ST = \frac{1}{T}(P_S \cdot S_1 \cdot T_1 + S_2 \cdot T_2 \cdot M) \qquad (2)$$

successfully receiving probability of the first stage (P_S)

The number of relays participating in stage II according to min-SNR principle (M)

Simulation Results

- With the number of the users mounting, the energy consumption is increasing.
- This is because that more users in U_F need adding and more energy is spent on the relay users in the second stage.
- Obviously ESS-XOR outperforms the ESS. Because of the pattern 4, the gap is not very big. However, pattern has no influence on ESS-DNC, which has the best performance of the three schemes.

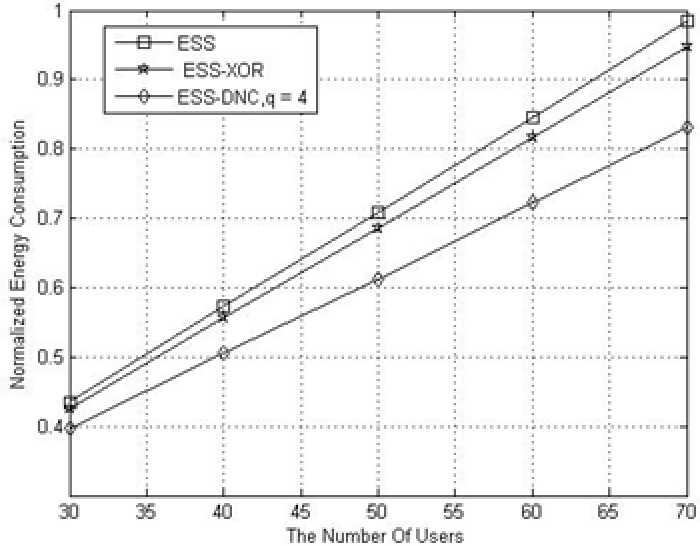

Fig. 4 Normalized Energy Consumption for ESS, ESS-XOR and ESS-DNC with $q = 4$

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Simulation Results

- With the number of users increasing, the gain is firstly increasing and when the number of user is approximately 60 the gain is decreasing.
- This is because that when the number of users mounting, more users belong to U_F , and more relay users and energy are needed to help the users in U_F.
- Compared with ESS, the ESS-XOR has significantly improved the system throughput per energy consumption. Moreover, the ESS-DNC also has better performance than ESS-XOR.

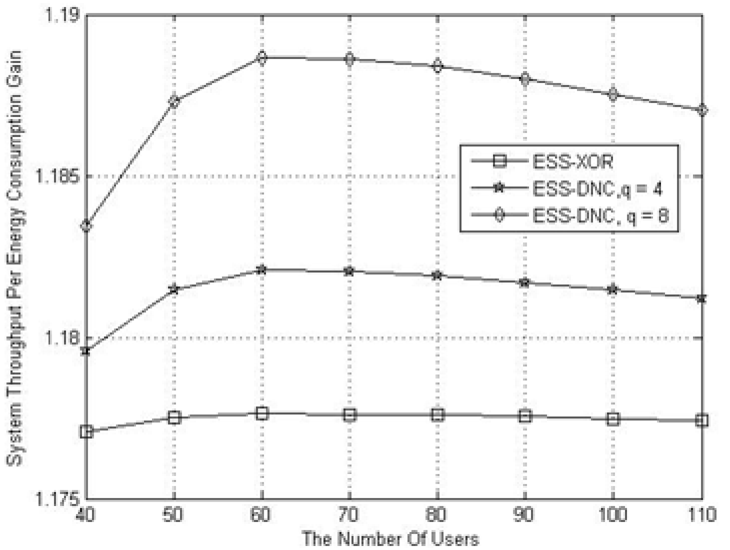

Fig.5 The system throughput per energy consumption gain for ESS-XOR,ESS-DNC with $q = 4$ and $q = 8$.

Simulation Results

- Fig.6 shows how the value *q* influences the *STPEC*(System throughput per energy consumption).
- With the number of users fixed, the increasing of *q* can make the energy more efficient for one transmission contains more information.

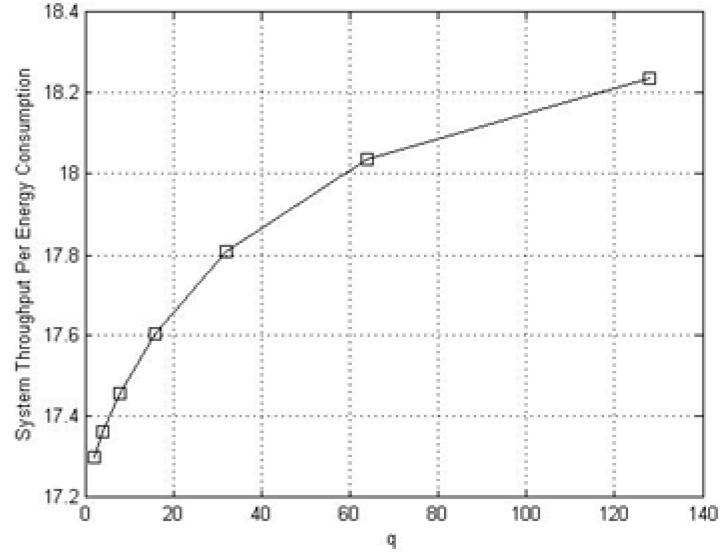

Fig.6 The system throughput per energy consumption with fifferent *q*

Simulation Results

- Fig.7 presents the time waiting cost is increasing when q is mounting.
- This is because that in order to applying dynamic network coding to the received packets, the relay users have to accumulate more packets by extending T_1.
- However, according to the given waiting time cost, the relay users could determine when to stop waiting and enter the second stage and the corresponding q can also be decided.

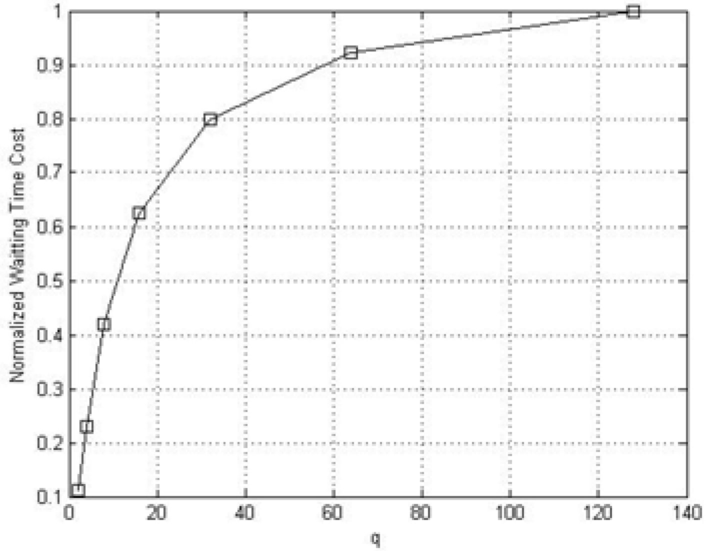

Fig.7 The standardized wating time cost for different q

Conclusion

- This paper
  - By applying xor-network coding to the two-stage cooperation, the retransmission times can be reduced to 5/4.
  - By applying dynamic network coding to the two-stage cooperation, the retransmission times can be reduced to 1.
  - By defining waiting time cost, the relay users can trade off between the saved energy of the system and the waiting time for the users in the second stage.
  - The energy consumption decreases as the retransmission times be reduced.
  - Energy efficient communication is achieved by using the network coding strategy in the two-stage cooperative scheme

THANK YOU！

Q&A?