Multi-user coded cooperative communication scheme for relay channel using Fountain codes

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COOPERATIVE COMMUNICATION

- Relay channel
  - Broadcast channel + Multiple Access Channel

- Cooperative communication
  - Achieves the transmit diversity

- Multi-user cooperative communication

- Multi-user cooperative communication via network coding
**COOPERATIVE COMMUNICATION**

- **Coded cooperative communication**
  - Cooperative communication using channel coding

- **The effective scheme is needed**
  - Network coding helps to improve the throughput
  - Channel coding is essential to guarantee the performance
  - Network coding and channel coding should be processed jointly, not separately
RELATED WORKS

- **Using convolutional codes**
  - Source-relay channel is protected by only the convolutional code
  - This yields the performance degradation

![Diagram showing convolutional codes and their effects at source, relay, and destination.](image)
RELATED WORKS

- Using bilayer LDPC codes
  - The relay generates additional parity by Density Evolution which optimizes the degree of overall LDPC code
Block diagram for the proposed scheme

- For simplicity, 2 users are assumed to cooperate
**PROPOSED SCHEME**

- **Each source node**
  - Encodes the information with LDPC code
  - So that the (S-R) channel is protected by LDPC code

- **The relay node**
  - Decodes the received blocks separately
  - And then encodes the recovered blocks jointly with LT code

- **The destination node**
  - Decodes all information block using overall graph
FOUNTAIN CODES

- **Fountain code**
  - Rate-less codes
  - Any number of input symbols can be applied
  - Infinitely many output symbols are available
    - This makes the code to be effective for various channel condition
  - Simple and fast encoding is possible (linear time)

- **But**

  \[
  m_{o,i}^{(l)} = 2 \tanh^{-1} \left( \frac{\tanh(Z_o/2) \prod_{i' \neq i} \tanh \left( m_{i',o}^{(l)}/2 \right)}{2} \right)
  \]

  **Disadvantage of fountain codes: Many iterations are needed than LDPC codes**
In the proposed scheme

- If the source-dest. channel is available then the intermediate nodes of fountain code are received at the destination.

The situation that a meaningless value is obtained do not occur.
Therefore Fast decoding is possible.

- If the source-dest. channel is not available then the same decoding process is performed.
**DISCUSSION**

- **Compared to the scheme based on convolutional code**
  - Better performance

- **Compared to the scheme based on bilayer LDPC code**
  - Low complexity
  - High flexibility

- **The rate-less property**
  - Makes the system works adaptively
    - If the channel condition is good, the relay transmits only the small number of symbols
    - If the channel condition is not good, the relay can generate and transmit more symbols until the decoding is succeed
  - Makes any number of source nodes can cooperate
SIMULATION

- Transmission model

  - All links are assumed to be AWGN channel with the same SNR
    - user-relay, user-destination and relay-destination
  
  - LDPC used for each user is assumed to be the same
    - Rate 2/3, block length 576
  
  - Fixed-rate LT code is assumed for simplicity
    - The number of output symbols generated are 576
  
  - BP decoding and not global iteration is assumed at dest.
SIMULATION RESULT

SNR (dB) vs. Bit Error Rate using bilayer-LDPC and Fountain code.