Heterogeneous Physical Layer Network Coding

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Background

What is PNC?

- Sources transmit simultaneously.
- Signals superimposed at the relay.
- Higher spectrum efficiency.

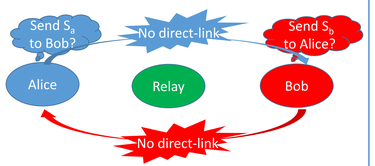

Fig.1 Typical PNC example.

Typical PNC example.

- Two-way-relay-channel (TWRC).
- A and B exchange information.
- Relay process and forward.

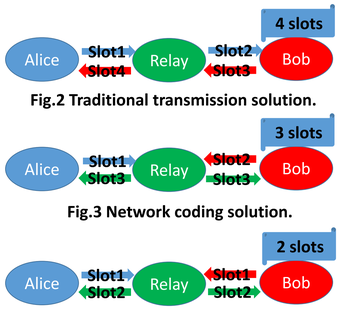

Fig.2 Traditional transmission solution.

Fig.3 Network coding solution.

Fig.4 PNC solution.

HePNC

Motivation.

- PNC uses same modulation for sources.
- Amount of data exchanged are un-qual.
- Channel conditions between A-R and B-R are asymmetric.

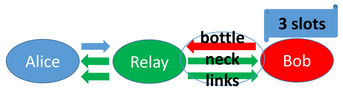

Fig.5 HePNC solution.

Proposed HePNC [1].

- *Source adaptively select different modulations.*
- *Suitable to asymmetric data exchange ratio.*
- *Suitable to asymmetric channel conditions.*
- *Higher spectrum efficiency and energy saving.*

Challenges.

- *Mapping function C(.) design.*
- *Latin square constraint.*
- *Adaptive mapping.*

HePNC example

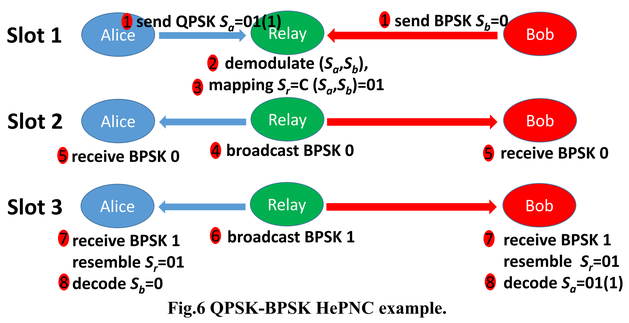

Fig.6 QPSK-BPSK HePNC example.

HePNC example

Step 1: $Y_r = H_a \mathrm{M}_{m_a}(S_a) + H_b \mathrm{M}_{m_b}(S_b) + N_r$

Step 2: $(S_a, S_b) = \arg\min_{(s_1,s_2)\in Z_{2^{m_a}} \times Z_{2^{m_b}}} \left| Y_r - H_a \mathrm{M}_{m_a}(s_1) - H_b \mathrm{M}_{m_b}(s_2) \right|^2$

Step 3: *obtain network coded symbol* $S_r = C(S_a, S_b)$

Step 4 ~ 7: *broadcast and receive* S_r

Step 8: $S_b = \arg\min_{s_2 \in Z_{2^{m_b}}} \left| S_r - C(S_a, s_2) \right|^2$

Latin square constraint **[2]:**

$C(S_a, S_b) \neq C(S_a, S_b')$, for all S_a, and $S_b \neq S_b'$

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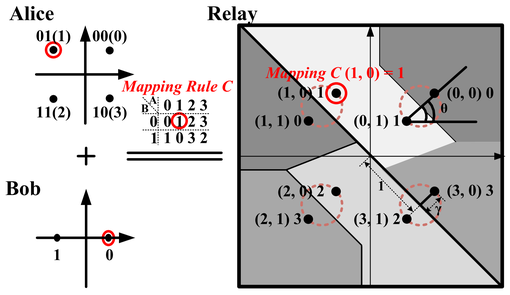
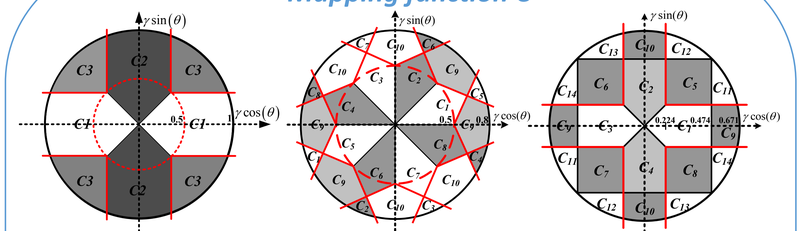


Fig.7 QPSK-BPSK HePNC constellation maps.

Adaptive mapping **[3]:**

Denote $H_b / H_a = \gamma e^{j\vartheta}$, design mapping function C adaptively according to γ and ϑ.

Mapping function C



(a) QPSK-BPSK HePNC. (b) 8PSK-BPSK HePNC. (c) 16QAM-BPSK HePNC.

Fig.8 Adaptive mapping figures.

Table.1 QPSK-BPSK mapping function *C*.

	0	1	2	3
0	0	1	2	3
1(C_1)	1	0	3	2
1(C_2)	3	2	1	0
1(C_3)	2	3	0	1

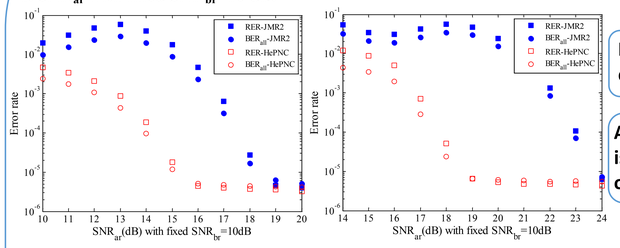
Table.2 8PSK-BPSK mapping function *C*.

	0	1	2	3	4	5	6	7
0	0	1	2	3	4	5	6	7
1(C_1)	1	2	7	6	3	4	5	0
1(C_2)	1	2	3	0	7	4	5	6
1(C_3)	7	2	3	4	1	0	5	6
1(C_4)	7	0	3	4	5	2	1	6
1(C_5)	7	0	1	4	5	6	3	2
1(C_6)	3	0	1	2	5	6	7	4
1(C_7)	5	4	1	2	3	6	7	0
1(C_8)	1	6	5	2	3	4	7	0
1(C_9)	2	7	0	5	3	6	4	1
1(C_{10})	6	3	4	1	2	7	0	5

For all mapping function C, we have $C(S_a, 0) = S_a$.

Performance

1. SNR_{ar} with fixed SNR_{br}=10 dB.



(a) QPSK-BPSK HePNC. (b) 8PSK-BPSK HePNC.

Fig.9 Adaptive mapping and non-adaptive mapping (JMR2) compare.

HePNC BER and RER converge quickly.

A larger SNR_{ar}-SNR_{br} is needed for higher order HePNC.

2. Optimal relay location issue.

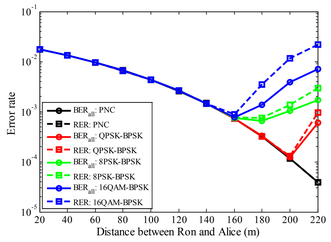


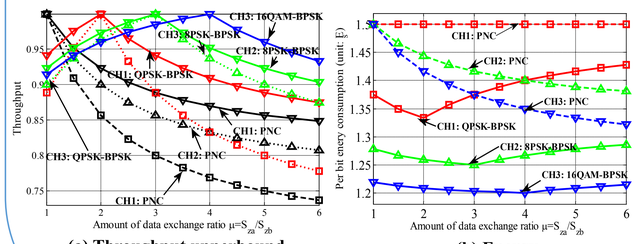
Fig.10 Optimal relay location issue.

Distance between Alice and Bob =600 m, move Relay from Alice towards Bob.

There is an optimal relay location for HePNC. Before the optimal location, HePNC BER and RER performance is the same as traditional PNC.

3. Throughput and energy.

CH1, CH2 and CH3 denotes Link A-R supports QPSK, 8PSK and 16QAM; Link B-R supports BPSK.



(a) Throughput upperbound. (b) Energy.

Fig.11 Throughput upperbound and energy saving.

HePNC achieves throughput gain, energy saving.

Bibliography

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