Single-User MIMO ML SIC Receiver with HARQ-IR Protocol

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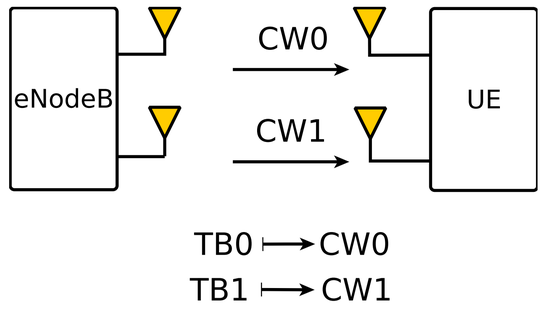
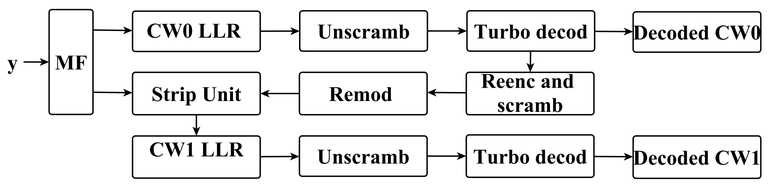
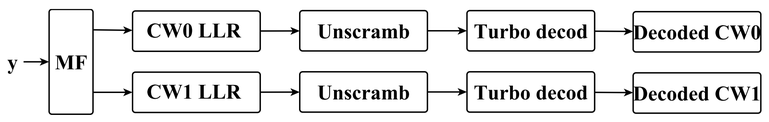
HARQ Retransmission Schemes for CLSM: drive-tests inspired investigation



ML Interference-Aware Receiver Architectures:

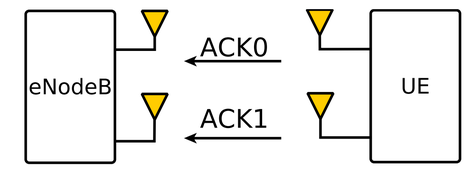


ML Successive Interference Canceling (SIC)

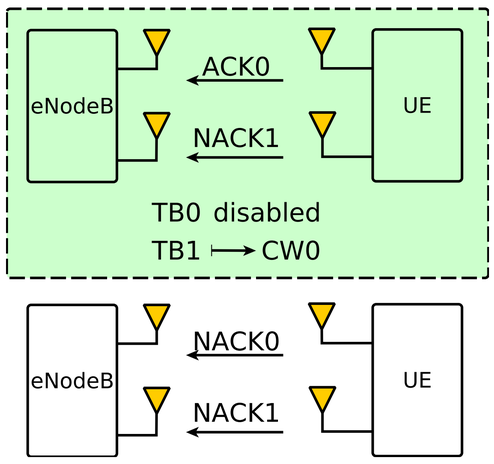


ML Parallel Interference Aware Detection (PIA)

Scenarios for the single CW retransmissions in TM4



- Tx Diversity
- CLSM rank 1
  - actual CSI
  - no or outdated CSI



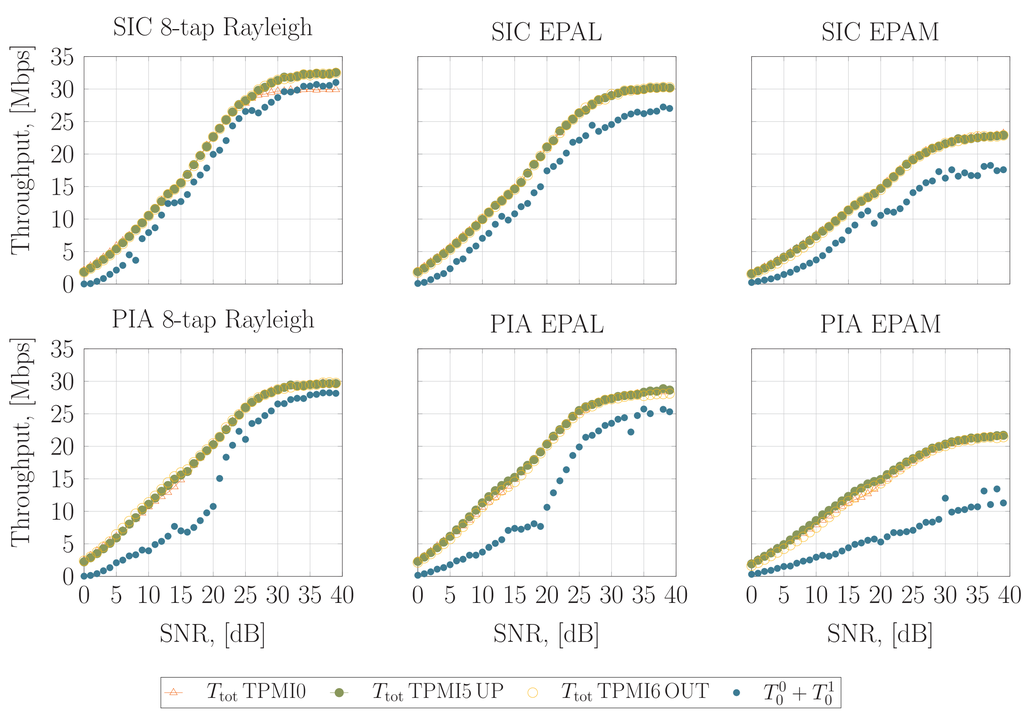
Tx scheme and precoding are signaled through TPMI filed in DCI:

Bit field	TPMI interpretation
0	Tx diversity
1	$\frac{1}{\sqrt{2}}\begin{bmatrix}1 & 1\end{bmatrix}^T$
2	$\frac{1}{\sqrt{2}}\begin{bmatrix}1 & -1\end{bmatrix}^T$
3	$\frac{1}{\sqrt{2}}\begin{bmatrix}1 & j\end{bmatrix}^T$
4	$\frac{1}{\sqrt{2}}\begin{bmatrix}1 & -j\end{bmatrix}^T$
5	1st column of the last PMI on PUSCH
6	2nd column of the last PMI on PUSCH

- Let TB^0 be decoded on the round $r = r_{\mathrm{dec}}$.
- For $\mathbf{r} \leq \mathbf{r}_{\mathrm{dec}}$: $\mathrm{TB}^0 \longmapsto \mathrm{CW}^0, \mathrm{TB}^1 \longmapsto \mathrm{CW}^1$, the MF outputs and the correlation coefficients are stored.
- For $\mathbf{r}_{\mathrm{dec}} < \mathbf{r} \leq (\mathbf{r}_{\mathrm{max}} - \mathbf{1})$: $\mathrm{TB}^1 \longmapsto \mathrm{CW}^0, \mathrm{TB}^0$ is disabled.
- **Multi-round SIC**: the UE reconstructs CW^0 for a current and previous HARQ rounds, multiplies the signal with the channel coefficients and subtracts it from the MF outputs, performing multi-round LLRs combining for TB^1.

Throughput Analysis: does TPMI have an influence?

SIC(top) and PIA (bottom) $\mathbf{T_{tot}}$ and $\mathbf{T_0^0 + T_0^1}$



The total throughput of the MIMO system with 2 TBs and $r_{\max}$ HARQ rounds:

$$T_{\mathrm{tot}} = \sum_{r=0}^{r_{\max}-1} (T_r^0 + T_r^1),$$

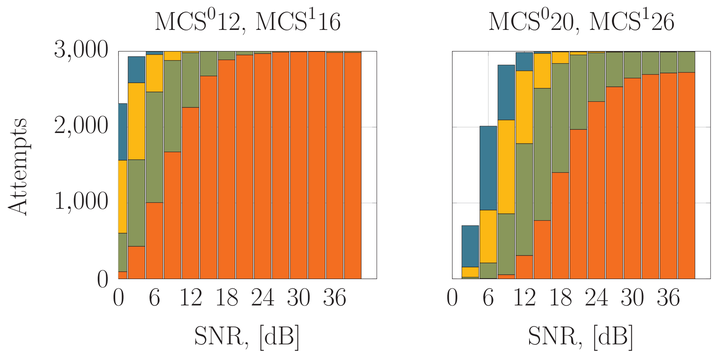
$$T_r^0 = \frac{1}{r+1} R^0 (1 - BLER_r^0), \quad T_r^1 = \frac{1}{r+1} R^1 (1 - BLER_r^1).$$

- Channel Models: 8-tap Rayleigh channel, and EPA channel with low (EPAL) and moderate (EPAM) correlation matrix.
- Signaled TPMI: TPMI0, TPMI5 based on actual CSI, TPMI6 based on outdated CSI.
- For $\mathbf{r} = \mathbf{0}$: this round contributes to the throughput the most. Throughput $T_0^0 + T_0^1$ is independent from the TPMI used during the retransmissions of single TB^1. The SIC receiver outperforms the PIA receiver in all the channel models with the gains up to 7 Mbps.
- For $\mathbf{r} > \mathbf{0}$: Multiple retransmission rounds reduce the throughput gap, but the SIC receiver still performs better at high SNR (up to $2 - 3$ Mbps).
- The TPMI during single TB retransmission does not have a noticeable impact on the throughput. There is a slight preference to TPMI5 and TPMI6 in updated and outdated CSI scenarios over Alamouti coding in the frequency-selective Rayleigh channel, while in EPA channels there is no visible difference.

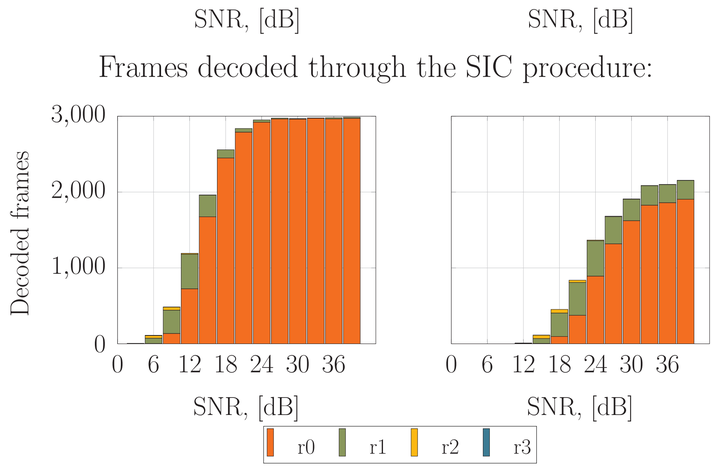
Reliability: the contribution of the multiple HARQ rounds in the MIMO system with PIA and SIC detection

Multi-round SIC procedure

Frames passed to the SIC procedure:

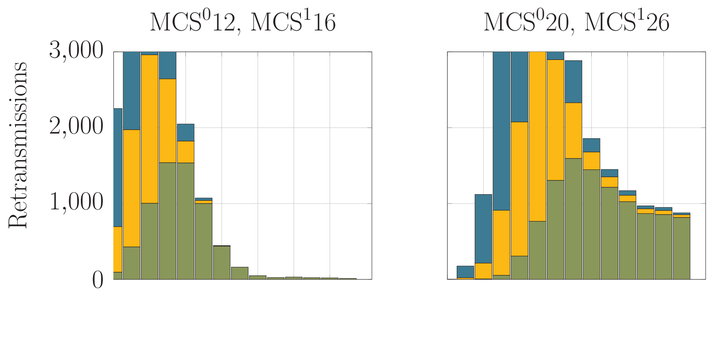


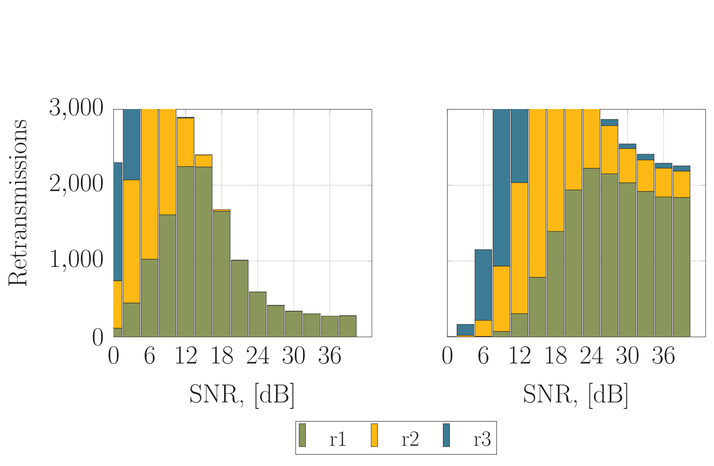
Frames decoded through the SIC procedure:



- For **low SNR**, $\mathbf{r = 0}$: a small amount of SIC attempts due to the to the high BLER of TB^0.
- For **low SNR**, $\mathbf{r > 0}$: more SIC attempts due to the to the lower BLER of TB^0, but mostly failure to decode.
- For **moderate and high SNR**: about 50% and 100% of the attempts are decoded.

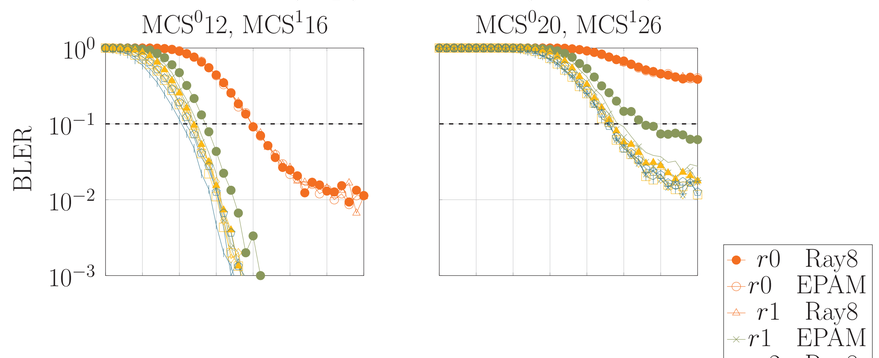
Retransmissions of TB^1 in EPAM channel for SIC (top) and PIA (bottom)

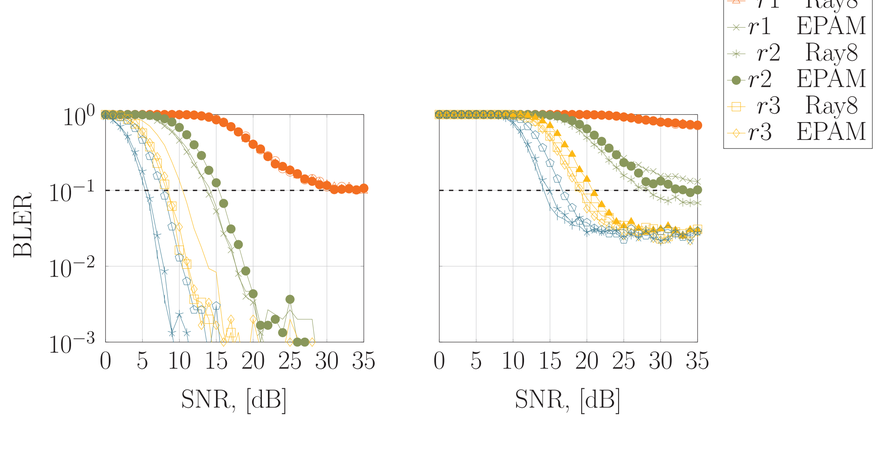




- For **low SNR**: amount of ret_r^{single} is almost identical
- For **moderate and high SNR**: SIC receiver has about 50% less of ret_r^{single} thanks to the benefits of multi-round SIC.
- the main benefits of SIC receiver are achieved during the first two rounds.

BLER of TB^1 in EPAM channel for SIC (top) and PIA (bottom)





- For $\mathbf{r = 0}$: SIC receiver significantly outperforms PIA detection. It achieves BLER of 10^{-1} at 10 dB lower for $12 - 16$MCS.
- For $\mathbf{r > 0}$: HARQ rounds bring significant benefits to the PIA receiver, for the SIC detection gain between the 3rd and 4th round is not remarkable.
- both receivers show **slight preference for the Alamouti**