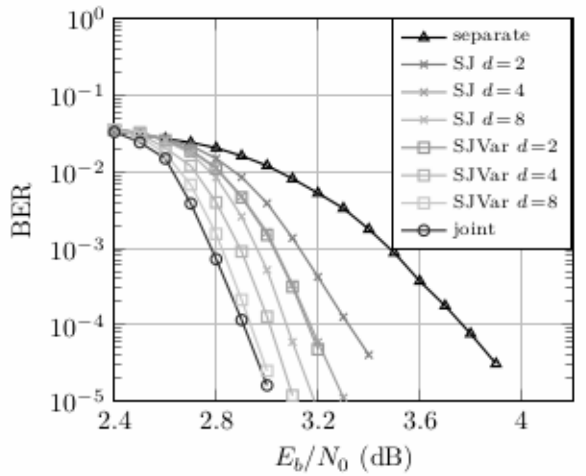

Fig. 2: Performance of $(d_v = 4, d_c = 20, t = \frac{1}{4})$ code under SJ decoding and the proposed variant

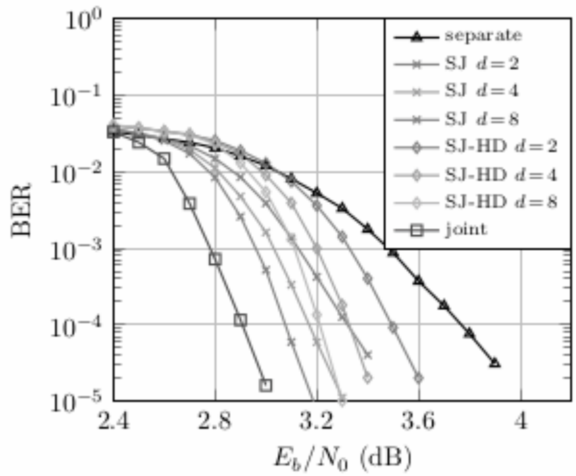

Fig. 3: Performance of $(d_v = 4, d_c = 20, t = \frac{1}{4})$ code SJ and HD-SJ decoding

is described in what follows:

1. For decoding target sub-block T, the helpers $T-\frac{d}{2}, \dots, T-1$ and $T+1, \dots, T+\frac{d}{2}$ transmit their channel information to the target.
2. Carry out BP decoding using the parity check matrix

$$\boldsymbol{B} = \underbrace{\begin{bmatrix} \boldsymbol{H}_{\text{local}} & & & & \\ \boldsymbol{H}_{\text{right}} & \boldsymbol{H}_{\text{left}} & & & \\ & \boldsymbol{H}_{\text{local}} & & & \\ & \boldsymbol{H}_{\text{right}} & & & \\ & & \ddots & & \\ & & & \boldsymbol{H}_{\text{right}} & \boldsymbol{H}_{\text{left}} \\ & & & & \boldsymbol{H}_{\text{local}} \end{bmatrix}}_{d+1 \text{ sub-blocks}}$$

and the channel information

$$[\boldsymbol{y}_{T-\frac{d}{2}}, \dots, \boldsymbol{y}_{T-1}, \boldsymbol{y}_T, \boldsymbol{y}_{T+1}, \dots, \boldsymbol{y}_{T+\frac{d}{2}}].$$

It is easy to show that the complexity of this approach is identical to the SJ decoder and the different decoders only need to exchange information before starting decoding and not during the execution of the decoder. The performance of our example code using the new decoder variant (denoted "SJVar") is shown in Fig. ??. With the same number of helpers d, our new variant provides a performance gain of approximately 0.2dB, without increasing the information flow between the sub-blocks and the complexity of the decoder.

SJ Decoding with Hard Information Exchange

In both the SJ decoder and the variant, we exchange soft information between the sub-blocks. Soft information is usually quantized using q bits (typically $q = 5, \dots, 7$). Exchanging hard information significantly reduces the information flow in the system by a factor of q. Therefore, we propose a SJ decoder variant, denoted "SJ-HD", which allows hard information exchange while degrading the performance only slightly. The idea is that after BP decoding of a helper, the hard decisions of the variable nodes are transmitted along with an estimate $\hat{\delta}_b$ of the BER. Ther BER estimate is obtained from the fraction δ_c of unfulfilled check equations through

$$\hat{\delta}_b = \frac{1}{2}\left(1 - (1-2\delta_c)^{\frac{1}{d_c}}\right). \qquad (1)$$

The hard decision of the helper $\hat{\boldsymbol{x}}$ and the corresponding BER are then used to calculate soft information (in terms of log-likelihood ratios (LLRs)) for the next stage (next helper or final decoder) via $\boldsymbol{y} = \hat{\boldsymbol{x}} \cdot \ln\left(\frac{1-\hat{\delta}_b}{\hat{\delta}_b}\right)$. We compare the the decoding performance with conventional SJ decoding Fig. ??. We observe that the reduction of information flow towards hard decision by a factor q is achieved at the cost of only around 0.1 dB in BER, which offers a reasonable trade-off between information flow and decoding performance.

Unfortunately, both variants cannot be trivially combined as the SJ decoder uses soft information to get an estimate of the local symbols, while the variant uses soft information from the beginning.

Conclusions

In this paper, we have discussed the application of SC-LDPCL ensembles for scalable optical communication systems with SDM. We have adapted the SC-LDPCL to the new application scenario and proposed the semi-joint decoder for decoders that are distributed on multiple processors together with two variants: The first variant improves the BER performance without increasing the information exchange, and the second reduces