Layered Coding Strategy for Cooperation

1) **Layered Source Coding (LS):** Compress source in layers, each layer composed of the successive refinement bits, transmit layers successively in time at different rates. Relay only important layers by amplify-and-forward.

2) **Broadcast Strategy (BS):** Compress source in layers, each layer composed of the successive refinement bits, transmit layers simultaneously at different rates by superimposing their codewords. Relay amplify-and-forwards.

3) **Uncoded Transmission (UT):** Source is only scaled and transmitted.

- **Application to direct channel can be found in [3].**

Broadcast Strategy for Cooperation

- Quasi-static fading channel thought as a Gaussian broadcast channel with continuum of receivers, one for each fading level.
- Superimpose source layers using broadcast codes:
  - Better the channel realization, the more layers decoded successfully, the less the end-to-end distortion is.
  - Power distribution among codewords of different layers.
  - Relay amplify-and-forwards all layers.

- Interference among layers is traded-off for increased multiplexing gain:

\[
\Delta = \lim_{\alpha \to \infty} \frac{\log(ED(R, SNR))}{\log(SNR)}
\]

\[
\Delta = \frac{2b - (4^k - b^k)}{(4^k - b^k)}
\]

Comparison of the Protocols

- Distortion exponent depends on bandwidth expansion ratio:
  - BS optimal for b ≥ 4
  - For b ≤ 2 BS is the best strategy. Further improve possible by 'partial cooperation'.
  - Unlike direct transmission, UT not optimal. \( \Delta \) Analog transmission cannot adapt to more complex network structures.

- Performance improvement in BS over LS comes at the expense of a more complex encoder-decoder pair, as BS requires SNR-dependent power allocation among layers, superposition of codewords and sequential decoding.

Uncoded and Upper Bound for Cooperation

- In UT, cooperation possible for b ≥ 4.
- Optimum ML estimator at the destination:

\[
\Delta = \left\{ \begin{array}{ll}
0 & \text{if } b < 1 \\
2 & \text{if } b \geq 2
\end{array} \right.
\]

- For upper bound, assume perfect S-R channel and CSI:

\[
\Delta = \left\{ \begin{array}{ll}
b & \text{if } b < 2 \\
2 & \text{if } b \geq 2
\end{array} \right.
\]

References: