SWIFT: Instantaneous Feedback-based Adaptive Communications (IFAC) and Networks

PIs: Hun-Seok Kim, Achilleas Anastasopoulos, Lei Ying

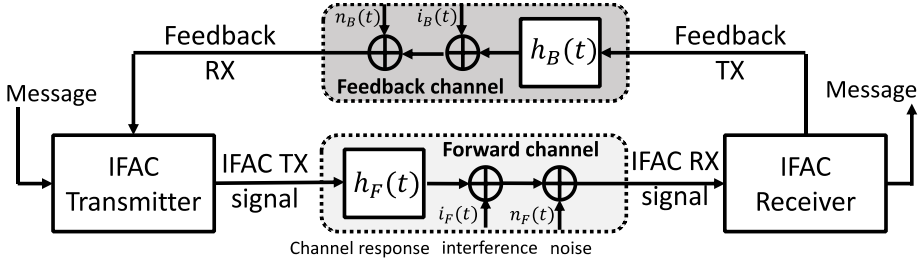
ECE, EECS, University of Michigan

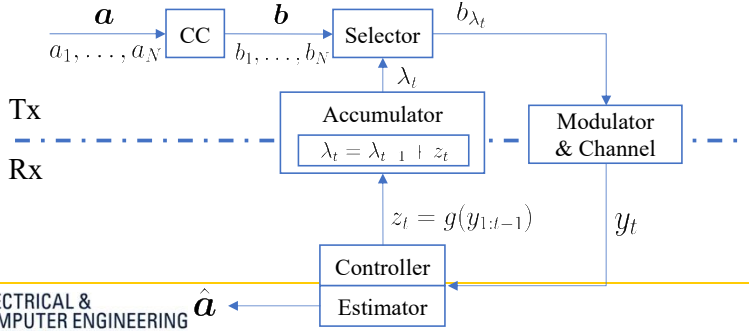
hunseok@umich.edu

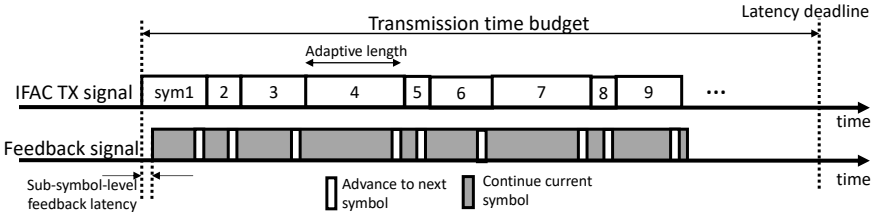
ELECTRICAL & COMPUTER ENGINEERING
UNIVERSITY OF MICHIGAN

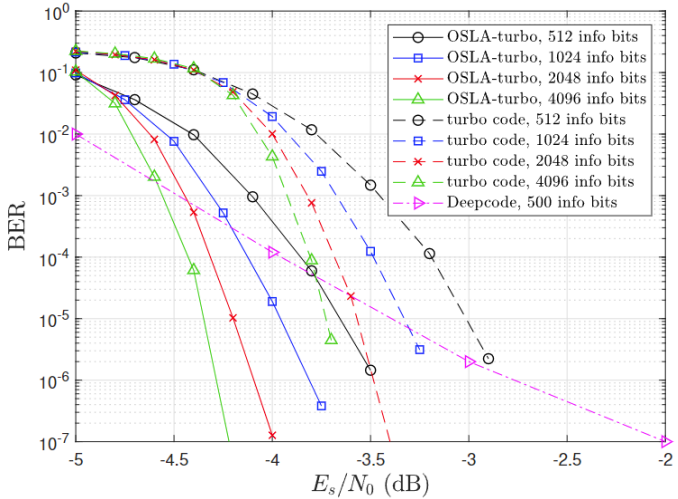
Feedback-based Wireless Communication Scheme

- **Feedback-based Opportunistic Symbol Length Adaptation** (OSLA): **[IEEE TCOM23]**
- Original concept proposed by Viterbi → uncoded case only, not practical at that time (in 1965)
- Real-time implementation feasible now thanks to advance in digital processing
- **MDP problem formulation**
- **Extended it to TBCC / Turbo-coded cases**



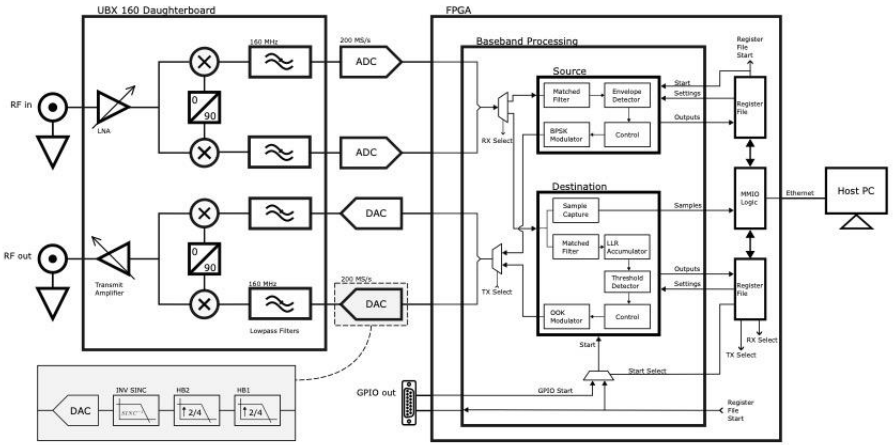


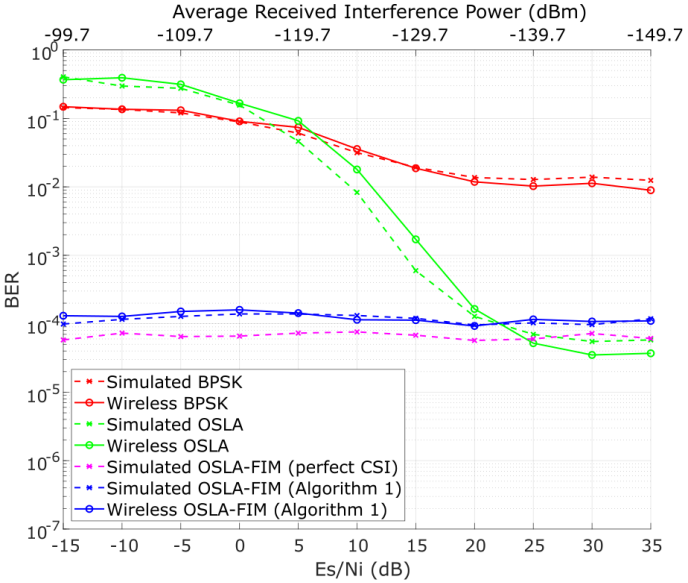




OSLA with Interference Mitigation

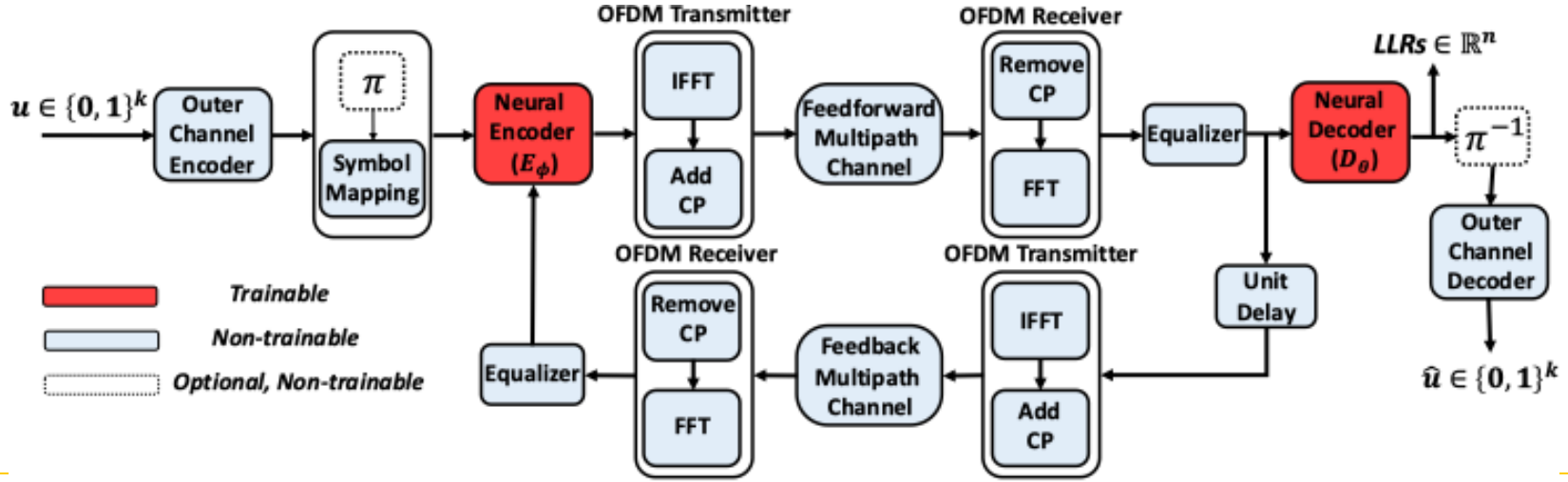
- **Real-time feedback-based communication system** implemented on USRP X310 SDR FPGA
- Feedback-scheme extended to **mitigate real-world interference** (WiFi, Bluetooth, etc.) in 2.4GHz ISM
- **Wireless experiments confirm** (almost) constant BER performance **regardless of signal-to-interference ratio [IEEE Globecom25, forthcoming]**





Deep-learning-based Feedback Coding and Modulation

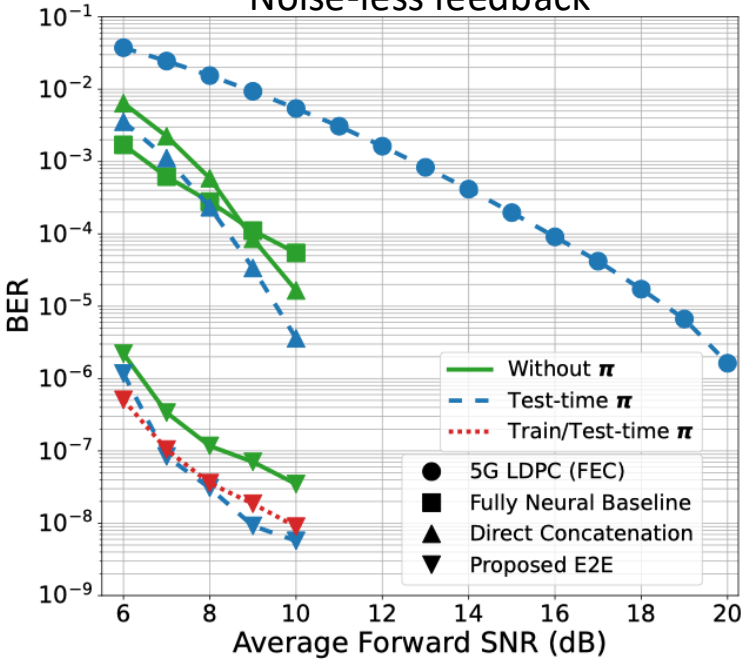
- Inner-outer BICM + OFDM structure for feedback-based communication in frequency selective channels
- **Neural network-based inner coding and modulation**, combined with classical outer code and OFDM transmission
- **'Passive' feedback** of sending received samples back to the transmitter
- **End-to-end trained (optimized) via back-propagation through LDPC decoding, OFDM and feedback**
- **Transformer-based inner neural coding and modulation**
- **[IEEE Globecom25, forthcoming]**



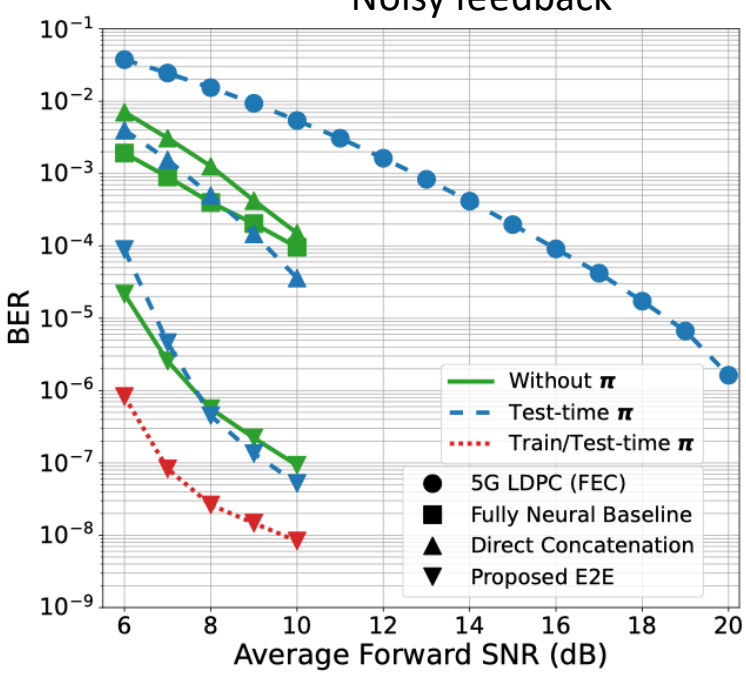
Deep-learning-based Feedback Coding and Modulation

- Remarkable performance gain in frequency selective channels vs. non-feedback scheme
- **Significantly (>5dB) outperforms the SOTA fully DNN-based feedback coding scheme** for the same rate and bandwidth
- **End-to-end training** with feedback through classical (LDPC) outer decoder and OFDM provides ~4dB gain

Noise-less feedback



Noisy feedback



SWIFT Project Summary

- Feedback provides remarkable gain compared to non-feedback case
- Practically feasible with recent advances of digital computation
- Feedback can ensure a target BER in interference heavy channels (experiments in real-world wireless channels)
- Synergy: Deep learning + classical code and OFDM to utilize feedback

- Possible applications: URLLC for V2X and industrial IoT