# Quantum Communications for Wireless

The goal is to build a baseline proficiency in quantum wireless communications, deliver two reproducible mini-experiments based on the works of Q. Duong and propose a scoped project by the end of week 4.

There are 3 main topics to be studied: full-duplex quantum communication, SCAPE protocol, Quantum Anonymous Networking. These three concepts provide pillars of my Week-1 orientation: efficiency (full-duplex), robustness under noise (SCAPE), and security/privacy (QAN).

## Quantum Full-Duplex Communication

Full-duplex systems allow remote parties to transfer information in both directions simultaneously. By allowing simultaneous uplink and downlink operations full-duplex systems improve the spectral efficiency by a factor of two compared to half-duplex systems.

The paper proposes two new full-duplex quantum communication protocols to exchange information simultaneously without transferring any physical particles. The first protocol, called quantum duplex coding, enables the exchange of classical bit by using entangled pair of qubits. The second protocol, quantum telexchanging, enables the exchange of quantum information without using preshared entanglement. Both protocols rely on counterfactual operations to exchange information without exchanging a physical particle.

## Simultaneous communication and parameter estimation (SCAPE) for time-varying Pauli channels

The noise in quantum devices limits the size of circuits that can be executed reliably. Accurate identification of noise is important for designing appropriate countermeasures. SCAPE protocol allows simultaneous communication and the noise parameters estimation based on the usage of error correction codes (ECC). Original SCAPE assumes the noise level of the quantum channel to be constant in time. However, real quantum devices can have significant time-variations in their noise level due to fluctuations in circuitry or changing environment. Original SCAPE protocol fails to reliably measure the noise level in cases when

1. The noise level is too high and ECC is not strong enough
2. The noise level is varying in time

The paper proposes an adaptive SCAPE framework that can dynamically adjust to the noise level. The new framework makes use of codeword reliability index (CRI) which can be used to measure reliability of received codewords. The feedback loop is formed, in which in the case of insufficient CRI the code rates are changed to make error correction process easier.

## Quantum Anonymous Networking

The development of quantum computing poses critical threads to classical anonymous networks (CAN). CAN systems rely on computational complexity and trusted relays, which makes them vulnerable to traffic analysis, deanonymization, and quantum attacks.

Quantum anonymous communication (QAN) on the other hand ensures complete anonymity and untraceability, as well as the unconditional security ensured by the principles of quantum mechanics, such as quantum entanglement, superposition, and no-cloning theorem.

The central primitive is Quantum Anonymous Communication (QAC), which supports protocols:

1. Anonymous Data Disseminating, allows sender to broadcast classical symbol to all the other users.
2. Anonymous Multiparty Entangling, allows a subgroup inside the network to anonymously share entangled state.
3. Anonymous Qudit Teleporting, allows sender to anonymously teleport arbitrary qubit.
4. Anonymous Dichotomous Voting, allows voting parties to anonymously cast their binary (yes or no) votes.
5. Anonymous Information Retrieving, allows anonymously retrieve private binary information at the certain index from the database.

There are challenges: fragility of quantum states, decoherence, entanglement distribution, and integrating quantum protocols with classical network stacks.