ACN Master project proposal

# Multi-channel SI and UI protocol sequences for IoT MAC and D2D

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## Context

Many research activities have been conducted in the context of multiple access communications in which several users access a shared channel. In communication systems such as impulse radio, wireless sensor networks and ad hoc mobile networks, devices have constrained resource, limited communication power and need a flexible transmission scheme. Collision-free protocols such as TDMA may not be practical for these systems, since it requires stringent time synchronization. These systems require simple multiple access protocol with no stringent time synchronization, frequent channel monitoring and feedback link. Such a **collision channel without feedback model** was introduced by Massey and Mathys in [1]. In this model, senders cannot synchronize their transmission schedule and starting time, implying that relative time offsets among users are unavoidable and imperceptible for them. They also proposed the idea of using **protocol sequences** as medium access control (MAC) schemes. Each user transmission schedule follows their protocol sequences designed according to desirable cross-correlation and Hamming distance properties.

Important criteria of protocol sequences include their sequence length (which should be as short as possible, e.g. for devices with memory limitations) and the resulting throughput performance. Some sequences guarantee non-zero throughput for each user regardless of their relative delay, this property is studied in [2] as **user unsuppressibility** (UI). Moreover, an important sub-class of UI protocol sequences called **shift-invariant protocol sequences** (SI) ensures constant throughputs independent of any relative delay offsets. They have been introduced in [1] and studied in [3-6]. Even if this class enjoys a zero-variance shift-invariant throughput, its main disadvantage is that the sequence length grows exponentially with the number of users.

## Objective

UI and SI protocol sequences in a single shared channel have been extensively studied in the literature [1-6]. Nevertheless, allowing users to communicate on multiple frequency channels could improve

throughput and reduce the sequence length. The aim of this project is to study UI and SI protocol sequences in a multi-channel model and complete the following tasks.

## Tasks

- Calculate the achievable throughput.
- Derive lower and upper bound on the sequence length.
- Design a construction algorithm which generates the minimum necessary length for UI and/or SI protocol sequences.
- Perform simulations (e.g., using Matlab or Python) and evaluations.
- Other open challenges:
    - Design other performance criteria (delivery delay, etc.)
    - Find applications (IoT MAC, D2D, M2M, etc.)
    - Consider Unicast, broadcast, and multicast scenarios.

## Reference


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