TECHNISCHE UNIVERSITÄT DRESDEN

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Deutsche Telekom Chair of Communication Networks

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Identification System Evaluation

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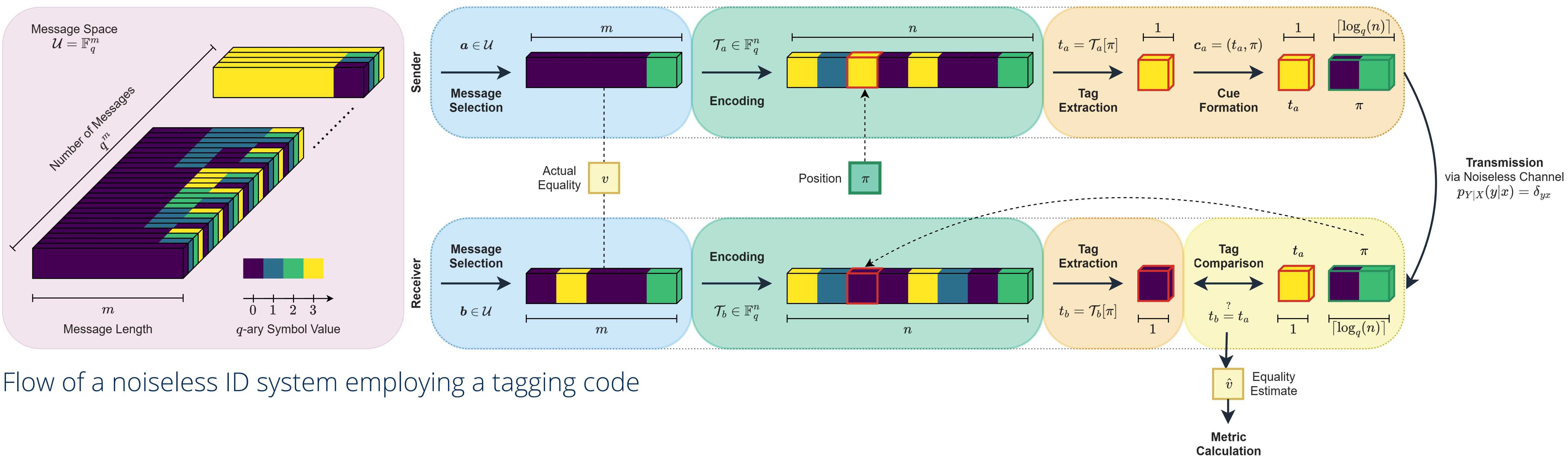
Abstract

This project evaluates noiseless identification (ID) systems, a method of goal-oriented communication, with a focus on ID tagging codes. These systems determine if a sender's and receiver's selected messages match by transmitting only a short tag, which reduces bandwidth at the cost of potential errors. Using a modular test framework developed in Python, we analyze various ID coding schemes and additional scenarios like k-Identification and multi-tag transmission, and assess system encoder performance under non-uniform message distributions.

Explore our findings via the QR code.
We present an interactive dashboard, revealing key trade-offs between system reliability, computational complexity, code rate and encoder performance for different system configurations.



Flow of a noiseless ID system employing a tagging code

Message Space

Both sender and receiver operate on a shared, predefined message space, embedded in a Galois Field $\mathbb{F}$. This space contains q^m unique messages, each of length m.

Message Selection

The sender selects the message it intends to send. Concurrently, the receiver chooses a candidate message, forming a hypothesis about the sender's choice.

Encoding

The sender's chosen message is transformed into a longer codeword. This step often uses an FEC code or hash function to improve the system's error resilience.

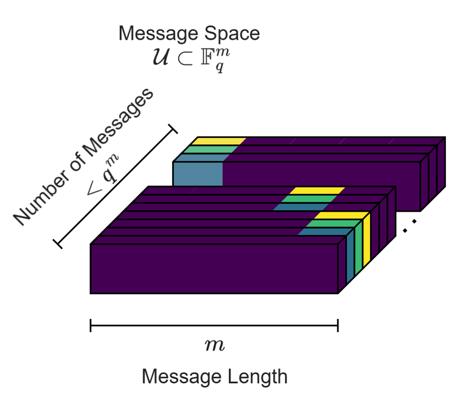
Tag Extraction and Cue Formation

A single symbol, the tag, and its position are extracted from the codeword. Together, these two pieces of information form the cue to be transmitted.

Transmission and Tag Comparison

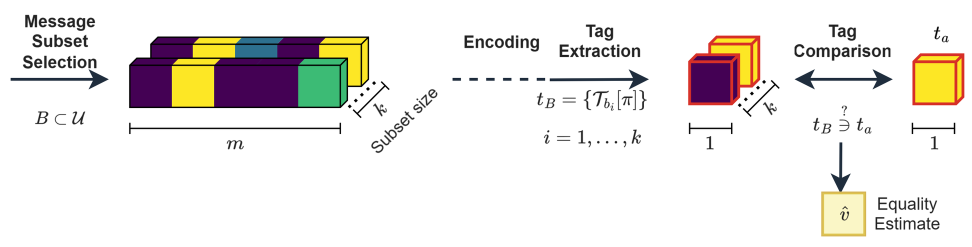
The compact cue is sent over a noiseless channel. The receiver then compares the received tag with one generated from its own message to check for a match.

Message Patterns



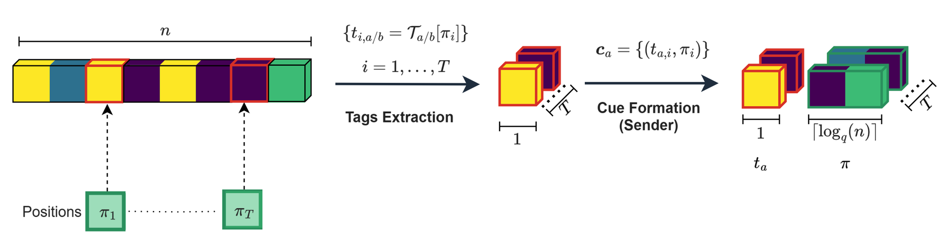
Not in any case, the whole message space is used. The encoding process should be able to convert a narrow message distribution to a uniform tag distribution since this is beneficial with regard to system reliability. Reed-Solomon encoding performs very well whereas Reed-Muller does not achieve this objective.

k-Identification



In k-Identification, the receiver groups messages into subsets and tries to determine whether the received tag matches to at least one of the tags in this subset. This gives the system more tolerance, which is expressed in an increased success probability $\mathbb{P}(\boldsymbol{a} \in B)$. However, error probability is increased if the right message is not in the subset. Thus, an appropriate partitioning of messages into subsets is crucial.

Multiple Tag Transmission



An approach to improve system reliability is the transmission of multiple tags. This exponentially decreases error probability while also decreasing code rate. To address this problem, we propose a protocol of subsequent tag transmission. A follow-up tag is only transmitted if the previous all yielded a positive equality estimate, reducing the average number of tags at the cost of a feedback channel and additional processing.

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