Trustworthy Communications across Parallel Asynchronous Channels with Glitches

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***Abstract*—Transmission across asynchronous communication channels is subject to laser injection attacks which cause glitches – pulses that are added to the transmitted signal at arbitrary times. This paper presents self-synchronizing zero-latency or near zero-latency coding schemes that require no acknowledge and can perfectly decode any transmission distorted by glitches (as long as the percentage of glitches is not too large).**

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I. Extended Abstract

Most block-coding schemes are designed under the assumption that the decoder knows (or can synchronize on) the transmission rate: They assume that the time is "slotted." Such channels are said to be *synchronous*. Channels that do not have this property are said to be *asynchronous*. The error mechanisms and models in such channels differ significantly from those of a synchronous channel.

Synchronous channels may suffer from synchronization errors, i.e. insertions, deletions or substitution of *symbols* [1], which change the block boundaries. For example, the channel input may be a sequence of, say, n bits and the output a sequence of m bits, m being a random variable depending on the number of insertions/deletions. The positions of insertions, deletions, and substitutions are random and unknown to either transmitter and receiver. Capacity bounds and coding schemes are available in the literature [2], [3], [4]. Synchronous channels may suffer from delays that change the arrival time of symbols by a random (yet, bounded) number of time slots. Consider, for example, the parallel indistinguishable channels in which the information is conveyed via the number of "particles" transmitted in each time slot studied in [5].

Synchronous channels have a common property, the receiver "sees" both zeros and ones. This is not the case in communication over asynchronous channel where the sender and receiver have different clock frequencies. A parallel asynchronous channel consists of N wires connecting two units. When transmitting a zero, the transmitter leaves a wire in its default state, and when transmitting a one, the transmitter sends a (positive) pulse down the wire. Transmissions on all wires take place simultaneously, however the arrival times may vary. This implies that, unless a properly crafted code is used, the receiver will not be able to distinguish between a single transmission over k wires, and k (or fewer) transmissions over the same wires. In this work, all channels are taken to be asychronous.

We assume that each wire in our asynchronous channel has a delay that can be different for each transmission, and that the lengths of the delays are variable and not known to either unit. Upon detecting the rising edge of a pulse on a wire, the receiver determines that it has seen a pulse on that wire.

In some cases the propagation time over the parallel wires way cause a *skew*. That is, pulses from different transmissions may mix with one another. In a skew-less channel, the pulses sent in any transmission can be received in any order but all the pulses from the i^{th} transmission arrive at the receiver before any from the $(i+1)^{\mathrm{th}}$ transmission arrives. In a noiseless skew-less channel, unordered codes *are* zero-error codes.

Even in the presence of skew it is often possible to maintain reliable communications. It is common to assume that no transmission is delayed or advanced by as much as a single transmission period (with respect to the average delay). This assumption, implies that every pulse from the i^{th} transmission is detected before any pulse from the $(i+2)^{\mathrm{th}}$ transmission is detected. Codes to detect and correct small numbers of skews are known, and zero-error codes for channels that suffer from arbitrarily many skews have also been developed.

Some asynchronous channels suffer from glitches – informally, unwanted signals that are erroneously identified by the receiver as valid pulses. Our contribution is the construction of zero-error, zero-latency (instantaneously decodable) or near zero-latency codes for asynchronous channels that suffer from glitches. We use these codes to provide lower bounds for the maximal error-free transmission rate attainable on such channels.

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References

[1] R. Gallager, *Sequential decoding for binary channels with noise and synchronization errors*, 1961.

[2] M. C. Davey and D. J. C. MacKay, "Reliable communication over channels with insertions, deletions, and substitutions", *IEEE Trans. Inf. Theory*, vol. 47, pp.687 -698, 2001.

[3] R. L. Dobrushin "Shannon's theorems for channels with synchronization errors", Problems Inf. Transmission, vol. 3, no. 4, pp.11 -26 1967.

[4] D. Fertonani, T.M. Duman, M.F. Erden, "Bounds on the Capacity of Channels with Insertions, Deletions and Substitutions," *IEEE Transactions on Communications*, vol.59, no.1, pp.2,6, January 2011.

[5] M. Kovacevic, P. Popovski (2014), "Zero-error capacity of a class of timing channels," *IEEE. Trans. Inform. Theory*, Vol. 60, No. 11, pp. 6796-6800, 2014.