Randomness, Interference and Freedom: A Philosophical View
Random Signaling

Shannon showed in 1940’s that optimal communication systems can be built using randomly generated signals.

However, random coding has long been regarded as genius theoretical concept, rather than a practical method.

The advent of turbo coding showed that Shannon’s is actually very “practical”, at least for binary error correction codes.

The work presented below is to extend the random coding idea to other applications, such as coded modulation, multiple-access, space-time coding and MIMO.
Randomness, Interleaving and Interference

A simple way to approximately realize Shannon’s random signaling is by interleaving. Properly interleaved signals possess the basic characteristics of random signals.

However, interference is a problem accompanied with random signaling. Therefore interference cancellation is a challenging topic for a random system.

The main difference between random and orthogonal approaches are:
- A random system allows interference and then tries to cancel it.
- An orthogonal system tries to avoid interference.
Iterative Interference Cancellation

Iterative detection is a useful technique to suppress the interference problem associated with random coding.

Interleaving at the transmitters facilitates iterative detection at the receiver. Interleaving can reduce the correlation between the adjacent signals. Its effect is very different from that provided by random spreading.

We will explain this using an example below.
A Factor Graph for a LDPC Code
A Factor Graph for a CDMA System

User 1 information bits

User 2 information bits

Note that the randomness in the spreading sequences will not change the topology of the graph.
A Factor Graph for an IDMA System

User 1 information bits

User 2 information bits
Randomness and Freedom

A random system is also a very free system. For example, we may consider an ad hoc system below. According to information theory, using a random coding strategy, each node should be able freely transmit at any time. This can lead to optimal performance even though it incurs interference.

Note that TDMA and FDMA are not free systems. Rather, they are strictly regulated systems. They may avoid interference, but they cannot achieve optimal performance.
Freedom

Life is important.

Love should be treasured.

However, nothing -

nothing is more precious than freedom.

---- by a poet

Similarly, freedom is of vital importance for communications systems. Whence we can provide basic services, we will look for freedom in space, time, speed.
Interference

The boundary of someone’s freedom is the somebody else’s freedom.

---- by a politician

In a communication system, freedom causes interference, which eventually impose a limiting factor.
Who should we listen to?

the poet, or
the politician.

(Another analogy is whether we should endorse free-market capitalism, or regulated socialism?)

We will answer this question in the following talks.
The references used in the talks can be found in the following website:

www.ee.cityu.edu.hk/~liping/research

There are also three simulation packages there for
(1) zigzag coding,
(2) un-coded IDMA system
(3) zigzag coded IDMA system
You may try them out to verify IDMA principles.