Optical fibre: secure in all the chaos

January 17 2008

Secure messages hidden in chaotic waveforms, transmitted at up to 10 gigabits per second, is the vision behind a group of dedicated European researchers. Now they are prototyping the equipment that could make the vision a reality.

Hiding a message within a chaotic transmission offers a way of securing information exchange – provided the message can be distinguished from the chaos by the receiver.

Two years ago, members of OCCULT, a European research project, showed that messages could be sent at gigabit per second rates over 100km of the standard fibre-optic network of the city of Athens, using a chaotic mix of light frequencies with massive variation in amplitudes.

And the message was received with low bit error rates. Yet, anyone tapping into the fibre-optic cable, attempting to intercept the message without highly specialised knowledge and equipment, would have been unable to distinguish it from the chaotic light 'noise' that surrounded it.

Now researchers in a follow-on project (Photonic Integrated Components Applied to Secure chaoS encoded Optical communications systems – PICASSO) that is also funded by the European Commission are designing and testing two integrated and stable chaotic sources. In effect, these are the first prototypes for a kit that will allow chaotic transmissions to be used as a standard security measure by organisations, such as banks and governments.

They are also researching techniques that will enable chaotic transmissions to be made and received at tens of gigabits per second.

Synchronisation delivers communication

The key to sending signals using chaotic light sources is synchronisation. Chaotic systems are unpredictable because they are affected by many – often millions – of tiny events. The potential effect on the weather of the beat of a butterfly's wing is the most famous example of this.

But the fact that they are not predictable does not mean that they are random. In fact, the little events are interdependent and generate discernible patterns in the chaos. A couple of decades ago it was discovered that if, under the right conditions, two chaotic systems start to affect each other, they will synchronise their chaotic motions.

Laboratory experiments soon confirmed that lasers transmitting light in patterns that were chaotic in time and space would synchronise when they received light from one another through space or optical fibre.

The next step was to 'fold' a message into the chaotic waveform. The receiver is able to discern the message by subtracting the (synchronised) chaotic waveform he is generating from the chaotic waveform, plus message, that he is receiving.

The OCCULT team (Optical chaos Communications Using Laser-Diodes Transmitters) took the principles of synchronised chaotic transmissions out into the real world. While the signal transmitted over the Athens network was less than one second long, it proved that the technique worked.

Stable chaotic sources

PICASSO's first challenge was to build integrated devices incorporating laser diodes that were capable of acting as stable chaotic sources. They have come up with two devices. The first is a single chip about 1cm in length which is being prototyped in a Berlin laboratory. The second is a hybrid device about 15cm long consisting of a laser and a small piece of fibre, using an oil coating to maintain temperature and feedback strength.

"We expect both to work well quite soon," says Claudio Mirasso, project coordinator on the OCCULT project and a member of the PICASSO team.

Consistency is a key goal for the mechanical parts. Sending longer signals is dependent on maintaining synchronisation between the two chaotic light sources for long periods, enabling data transmission at 10 gigabits per second.

"One of the main problems could be temperature," says Mirasso. "Changes in temperature lead to deviations in wavelength and you can lose synchronisation easily. We are working on mechanisms that could offer better stabilisation, but at this stage we don't know how much our new devices will drift with temperature."

During a second phase of PICASSO, the research team will investigate increasing the rate of transmission using wavelength division multiplexing, where a number of signals are transmitted together at clearly separated wavelengths.

"You have to define the width of the channels very well," comments Mirasso. "But in many ways it is not very different from normal wavelength division multiplexing. Perhaps ten or more channels would be possible."

The security offered by chaotic waveforms does not match the complete security of quantum cryptography. But the rate of transmission is far higher – a security protection in itself. And attempts to break into the optical fibre and interpret the signal would be extremely difficult – if not impossible at the moment.

Source: ICT Results