'Time reversal' allows wireless broadband under the sea

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Playing garbled acoustic messages backwards could take wireless broadband communication beneath the waves, boosting the speed of data transfers to submarines, undersea robots and data collection devices by up to three times. Wireless communication in the ocean is difficult because water molecules absorb radio waves very efficiently, an effect exploited by microwave ovens.

Acoustic signals travel better, but also degrade quickly due to echoes, ambient noise, swirling currents and, again, water absorbing the signals.

But a technique called acoustic time reversal can change that. The trick cleans up underwater sound signals, extending their range and capacity.

William Kuperman and colleagues at the Scripps Institution of Oceanography in La Jolla, California, US, and researchers from the NATO Undersea Research Centre in La Spezia, Italy, have been testing the technique in the Mediterranean.

Reconstructed signal

Time reversal exploits the way undersea acoustic signals typically arrive clouded by echoes that travel at different speeds. For example, a "ping" may arrive as three separate sounds - one that travelled directly, an echo from the surface and then an echo from the ocean floor.

If the receiver transmits the same sequence of sounds backwards, they will take the same routes back to the original source. But because the sound that took the longest to travel is sent first, the second-slowest next, and the fastest last, all three will arrive at about the same time at the original source.

In effect, they converge in time, reconstructing the original signal. The retransmitted sounds will create echoes of their own, but the original signal is strong enough to stand out, say the researchers.

To use this technique for communication, a person that wishes to receive a message first transmits a carrier signal. The sender time-reverses what they receive, and also alters it to carry a message before sending it back.
The receiver gets a clean enough version of the original signal to decode the added message.

Huge range

Kuperman and colleagues managed to use the technique to transmit 15 kilobits a second at a range of 4 kilometres, and 5 kilobits per second at 20 km. It even worked over 3,500 km - comparable to the distance some whales can communicate with song - although the data rate fell to only about 100 bits per second.

Conventional underwater acoustic modems achieve reliable rates of just a few kilobits per second across 5 km in shallow water.

Geoffrey Edelmann, a physicist at the US Naval Research Laboratory in Washington, DC, US, says that time reversal is acknowledged to be the best way to improve acoustic communications, and that Kuperman and colleagues have achieved the best results.

"Their work is the best. I think they are leading the charge at the moment," he told **New Scientist**.

Previous tests have not achieved such long distance, or high bandwidth links.

Kuperman and colleagues will present their work at the Acoustics 08 meeting in Paris on 1 July.