Slowing light to speed data: USC Viterbi School wins $4.3M photonics IT contract

Two prize-winning USC specialists hope to break a bottleneck that has long limited communication systems from using light - photons - instead of electronics for data information processing.

Alan Willner and Robert Hellwarth, both professors in the USC Ming Hsieh Department of Electrical Engineering, have received $4.3 million in DARPA funding to develop "continuously tunable optical delays," which they hope will change the rules of manipulating photonic data at ultra high speeds.

"The technical community is missing a simple way to tune the time delay of one photonic data stream relative to another, which is a key building block for many types of data-processing functions," said Willner. "We think we've found it."

According to Willner, 2006 President of the Institute of Electrical and Electronic Engineers' (IEEE) Lasers and Electro-Optics Society (LEOS), optical fibers can carry enormous volumes of information coded in photonic form, with far greater bandwidths than metal electrical cables.

Still, "photonics usually can't compete with electronics when it comes to processing data," says Willner, "because silicon transistors are extremely cheap and can perform processing operations that have long been very difficult to do with light. With electronic systems, it is easy to temporarily store information. "

"Therefore," he continued, "we are left with a significant mismatch - data transmission is performed optically but data processing is done electronically. Normally, transmitted photonic data would need to be turned into electronic data for processing and then turned back into photonic data for further transmission."

Willner says that if such photonic-electronic conversions can be avoided, great savings in expense and energy are possible.

For example: numerous low-speed branch data streams can feed into larger trunk lines. While the trunk cable has more than sufficient capacity to carry all the information, before it can do so, the information has to be 'multiplexed' - i.e., the data bits and packets must be collated in such a way that different channels don't interfere with each other within the same time slot.

To do this now, the laser-coded information has to be converted into electronic form, multiplexed, and then reconverted to laser pulses. "This is energy inefficient, cumbersome, and takes away system capacity," says the scientist.

But Willner says the new optical system he and Hellwarth are building will provide another way, in which data can stay photonic and pass through at extremely high speed.

Their technique is to convert the photonic information from one color to another one, and then pass the data through an element that has a speed of light which is dependent on the color of the light - i.e., red photons could travel slower than blue photons. Each photonic data stream is given its own "color," or delay value, and then seamlessly woven together and sent on their common way without ever going through an electronic interface.

Willner has already succeeded in efficiently delaying a single 80-Gigabit/s data stream and multiplexing two separate 40-Gigabit/sec data streams. His plans call for upping capacity to the 100's-of-Gigabit/sec range.

Multiplexing is only part of the suite of applications. Another is buffering. A complete rundown of the benefits of a tunable system from the proposal: it could allow "accurate synchronization for bit-level interleaving, time-slot interchange, multiplexing and demultiplexing, time switching, and data packet synchronization."

The system that the USC team proposes comes out of recent research by Willner and others worldwide in creating systems that use new techniques to slow light down. For all these applications, a high degree of delay control is needed in the ability to continuously tune the timing of the high-speed-data flow.

The design goal is a system that can tunably slow light from 0 up to 5 microseconds - that is, a slowed stream can arrive up to 5 microseconds later than an untreated on; the 5 microsecond delay would require a roughly 50 fold improvement on their current published value of 100 nanoseconds.

To put this in perspective, a delay of 5 microseconds for a 500-Gbit/sec data stream is the same as delaying a data stream by millions of bits, an amount that could open up many possible applications.

Source: University of Southern California