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Free-space lasers light urban broadband links

Why lay fibre when you can send laser beams through the air? That's the thinking behind fSONA, a Canadian start-up that specializes in urban optical wireless for the 'last mile' of the network. Michael Kenward reports.

FEW COMPANIES in optical communications, if any, can pin down their origins to a search on the Internet. The creation of fSONA is especially intriguing given that the firm is based in Vancouver, Canada, more than 7600 km from the UK R&D centre where its chief executive found the technology she was looking for. Yet, Theresa Carbonneau's search was no random Web walk. As a former employee of the UK incumbent telco BT, she was well aware of the operator's research campus at Martlesham Heath in south-east England.

The story really begins when Carbonneau moved to Vancouver in the mid-1990s to work for a local telecommunications company called BCTel. However, bored with the opportunities that BCTel was offering, Carbonneau set about creating her own telecoms business. "I wanted to do something wireless. I wanted it to be broadband," she explains.

Her first thought was to get into millimetre-wave services. Unfortunately, there was a problem. In Canada, the main licences for this region of the radio spectrum were already allocated. Carbonneau's energy was redirected into free-space optical communication. She knew that lasers could also span the final mile, but without the need for a wavelength licence.

It was at this juncture that the BT connection came into play. The incumbent's R&D labs in Martlesham Heath, UK, had just finished a five-year project devoted to free-space laser communications, in association with researchers at Imperial College, London. The thing that really caught Carbonneau's eye was that the BT experiments were at a wavelength of 1550 nm, whereas most other free-space optics projects at the time concentrated on wavelengths around 800 nm (780 and 830 nm).

Despite being more pricey, 1550 nm technology has several advantages over shorter-wavelength systems. For starters, it supports transmission rates in excess of 1 Gbit/s, whereas 800 nm gear is currently limited to modulation rates around 622 Mbit/s. Furthermore, eye-safe power levels at 1550 nm are approximately 50 times greater than for systems operating at 800 nm – a critical feature that ensures enhanced link performance in all sorts of weather conditions.

The beginning of the affair

The next step was to contact BT's technical team and strike a deal. Timing is everything, and back towards the end of 1996 BT just happened to be seeking ways to exploit the extensive portfolio of patents and intellectual property rights that it had cooked up in its Martlesham lab over the years. "If we had not chanced upon it [the BT work on optical wireless] quite by accident, it would have got shelved, like thousands of Martlesham projects," says Carbonneau.

It took about a year to negotiate a licensing agreement, but a deal was signed with BT in April 1997 and fSONA was born. The telco is now considering whether to take up the 5% share in fSONA that it is entitled to under that original contract. The name fSONA, which stands for "free-space optical networking architecture", was supposed to be a working title until something better came up. Nothing did, so it stayed. Finding funding proved to be just as difficult as coming up with a snappy moniker.

It took two years to raise enough money to get the ball rolling. "We formed the company late February '97, but we did not get funded until June '99," says Carbonneau. She believes that fundraising was a slow process because she and her colleagues were seeking cash at a time when bucketloads of venture money was being funnelled into dot.com businesses, rather than into companies that actually manufacture something.

All the same, in its first round, fSONA raised USD 800 000 from a group of three Canadian venture-capital funds and a further USD 23 million came in last year from heavyweight American investors. On the way to raising those funds, Carbonneau approached Stephen Mecherle, an American scientist with more than 20 years experience in optics and

THE POWER AND THE GLORY

Even though fSONA is still a start-up operation, it's already thinking big. "We're trying to be the first [company] to mass-produce optical-wireless products, and we're trying to achieve lower cost per bit per second than radio systems," Stephen Mecherle, the company's chief technical officer, told delegates at a recent optical components seminar organized by US telecoms consultancy Electronicast.

There are two wavelength ranges that optical-wireless vendors can exploit: 800 nm (using 780 or 830 nm emitters) and 1550 nm. All of fSONA's last-mile solutions operate at the longer wavelength. One of the main factors behind this choice is eye-safety, says Mecherle.

"We don't want to deploy any equipment that is not safe for normal viewing," he explained. "That means safe for normal viewing at the emitting aperture, without binoculars or collecting optics. I would not think operators would want to buy kit that would give them eye-safe liability issues."

It all boils down to biophysics. Put simply, corneal and lens absorption in the eye prevents wavelengths greater than 1400 nm from focusing on the retina (the light-sensitive region of the eye). At 800 nm, however, collimated light is concentrated 10 000× on the retina. Because of this, the power budget in a 1550 nm optical-wireless system can be 50× greater than that of a comparable 800 nm link.

Another factor in favour of 1550 nm is the extensive technology base that already exists to support this wavelength in fixed-line fibre systems. "There's all kinds of technology available for the C-band window," said Mecherle, though he points out that it's not simply a matter of using the same components. "The fibre-optics industry has lots of components [at 1550 nm] that we can tweak. There's just no similar technology infrastructure at 800 nm."

He added: "We have been able to co-develop a 1550 nm telecommunications-grade laser diode with approximately the same cost per transmitted mW as for a 780 nm diode." But it isn't just the laser transmitters and receivers that are important. fSONA's patent portfolio for free-space optics also includes the gimbals (tilting support mechanisms) that keep the laser beams aligned over distances of up to 4 km.

As with any new technology,

Mecherle: aiming to achieve lower cost per bit/s than radio systems.

however, the acid test comes when it has to be deployed out in the field. With optical wireless, for example, many network operators have big concerns about possible "fog fading" (disruption of free-space communications caused by fog, smog or mist).

fSONA's priority now is to win over the doubters. In February, at the Broadband Wireless World Forum in San Francisco, the company set out to do just that by deploying a beta unit to provide 100 Mbit/s full-duplex Ethernet connectivity between two buildings approximately 800 m apart.

"We had all these things running simultaneously – 8 Mbit/s streaming video, 30 Mbit/s server downloads, 756 kbit/s full-duplex videoconferencing – but we weren't filling up the pipe," said Mecherle. "And during that conference we had some rain and fog, but we had no bit errors operating for nine hours a day."

Additional beta testing is now under way, with commercial shipments expected to start in May. fSONA has a range of optical-wireless systems under development: the SONAbeam155 delivers 155 Mbit/s over 500 m, 2 km or 4 km; the SONAbeam622 offers 622 Mbit/s over 500 m or 4 km; and the SONAbeam1G delivers 1.25 Gbit/s over 500 m or 4 km. In each case, the transceivers weigh about 15 kg.

fSONA claims that, at USD 20 000 for both ends of a link, its free-space system comes in at a quarter to a third of the cost of an equivalent radio system.

Additional reporting by Joe McEntee.

free-space laser communications, to check out BT's technology. After seeing what was on the table, Mecherle, who is based in Los Angeles, was so impressed that he decided to become fSONA's chief technical officer.

Strangely, Carbonneau is still in Vancouver, while Mecherle remains in Los Angeles. "People wonder why we aren't in the same place," she says. "[But] it isn't necessary." The company's R&D takes place in Manhattan Beach, California, near Los Angeles. Production engineering, manufacture and marketing are based in Richmond, British Columbia, near Vancouver.

The plan for the Los Angeles operation, says Carbonneau, is to turn it into "a centre of excellence for free-space communications and applications" employing around a dozen technical experts. The Vancouver operation, on the other hand, has nearer 60 people, with more joining all the time as the production operation shapes up.

A further sticking point for some investors was the fact that, as Carbonneau puts it, "there was always the issue of the weather". People feared that pointing a beam of light through rain and fog was asking for trouble. However, subsequent field trials have shown that the high transmission power of fSONA's antennae allow services to be maintained 99.95% of the time in some of the worst weather in the Pacific north-west.

Carbonneau recounts with amusement an event that despatched any worries about the reliability of free-space lasers. "We were looking for cash with one particular venture capitalist in Palo Alto [in Silicon Valley]," she says. "Right outside, on University Avenue, the fibre runs down the street." Five operators have cables there, and one company managed to cut everybody else's fibre. "So just as we were turning up, the whole street and all the businesses in that area had been without services for about two days." In that time, she says, fSONA could have installed broadband optical-wireless connections for all the affected businesses.

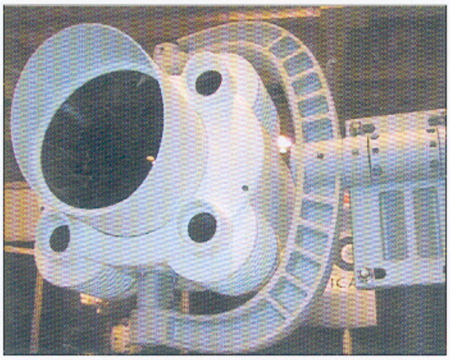
The heart of the matter

fSONA's confidence in its technology comes not just from the systems it has developed on the back of BT's R&D. "BT focused on the receiver sensitivity," says Carbonneau. "But we have added a lot of intellectual property, including the high-power laser driver."

The Martlesham lab also carried out extensive measurements of attenuation and transmission that allow fSONA to predict system performance. Network designers talk about achieving "five nines" (99.999%) availability. Optical-wireless links are not quite that good, but fSONA plans to use radio back-up alongside the laser transmitters. "We can get five nines availability with a radio back-up," claims Carbonneau.

The customers in fSONA's sights are all in the access market – incumbent local-exchange carriers, competitive local-exchange carriers, integrated access providers and Internet service providers to name just a few. Other potential users of free-space optics are operators that want to provide tenants in multi-occupancy buildings with a full range of telecoms services. Using fSONA's equipment, these building local-exchange carriers (or BLECs) can connect buildings to the public network without having to install fibre. fSONA claims that 99% of the commercial buildings in the US do not have a fibre link to the backbone network.

Here in Europe, meanwhile, the ability to connect customers without digging the streets could prove a big selling point, especially in cities where there are sites of historic or archaeological interest. fSONA also hopes to benefit from the move by wireless operators into third-generation (3G) mobile data services, with free-space lasers providing connections between base stations and the fixed-line optical network. "We simply provide additional capacity for back-haul between the base stations, without having to string fibre between them," explains Carbonneau.



Top: ease of deployment is one of the big selling points of optical-wireless technology. Bottom: fSONA's transceivers weigh just 15 kg and provide free-space links running at speeds up to 1 Gbit/s.

Another edge that free-space systems have over fibre is their speed of deployment. Transceivers are simply mounted on tripods or brackets behind windows, on the side of buildings or on roof-tops. It can be as little as half a day's work to install a system – simply a matter of putting the hardware on the stands, pointing the receivers and transmitters, and turning them on "like a computer", says Carbonneau. But fSONA does not plan to install equipment itself. "We are doing that through partners and network integrators," she says.

And when it comes to manufacturing, fSONA wants to join the trend towards subcontracting. "We have farmed out as much as we can of the subassemblies and the subcomponents," says Carbonneau. All the same, the company insists on integrating, assembling and testing systems at its manufacturing facility in Vancouver in order to ensure the quality of the final product. "Quite honestly," explains Carbonneau, "no-one has mass produced these before."

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