1 Plastic Optical Fibre

Plastic optical fibre gets car makers out of a jam.
With nearly 20 million cars manufactured worldwide every year, the automotive industry is set to become the next high-volume consumer of fibre optic components.
Richard Sietmann reports.

Drive time: the new S-series Mercedes relies on a POF network to link up the radio, CD player, mobile phone and navigation system. DaimlerChrysler is pioneering the use of fibre-optics in the car industry.

BACK IN 1997 the Daimler-Benz (now DaimlerChrysler) research centre in Palo Alto, Califomia, presented its “Internet-on-wheels“ car concept, an experimental study of how multimedia — including navigational assistance, mobile communications and entertainment — might change user habits and add value to automobiles. The work, though significant, was by no means unique. In truth, rival manufacturers have already jumped on the bandwagon, and it‘s only a matter of time before multimedia vehicles make the transition out of the luxury end of the market.
But as cars turn into computers-on-wheels, the electronic technology, most of it invisible to the driver, is reaching almost biological levels of complexity. Tlie biggest headache is the copper wiring, which is hampering manufacturers‘ efforts to cut vehicle costs, simplify servicing, and deliver lighter vehicles with better fuel efficiency. Enter plastic optical fibre (POF), which guarantees higher transmission capacity, insensitivity to electromagnetic interference (EMI), minimal cross-talk and light weight.
“For short-distance interconnection inside passenger cabins, commercially available step-index POF already fulfils the current requirements of bandwidth—length product, attenuation, operating temperatures and cost,“ says Eberhard Zeeb of Daimler-Chrysler‘s research centre in Ulm, Germany. In the middle of last year, his company started to install POF data links in its 1999 high-end S-series Mercedes cars. The C-, E-and A-class models are about to follow suit.

Leaner, faster, smarter

The emergence of POF technology is a result of the mounting costs of in-car electronics. "Today, electronics already accounts for up to 30% of our cars' value — 10 years ago the figure was just 20%," says Wolfgang Vöhringer, Daimler's chief R&D technology officer. "If one takes into account the well known price decline in the electronics industry, up to 50% annually, it becomes obvious how much electronics has extended [the car's] functionality."

It's inevitable that the continuous addition of in-car electronics and copper wiring will soon become untenable. Air conditioning, engine management, anti-lock brakes, automatic traction adjustment, central locking and theft protection — each comfort or safety feature contributes at least one extra pair of wires to the wiring harness. And there just isn't enough space among the hundred or so cable plugs already branching out from behind the dashboard.

The bottom line is that automotive engineers have for some time been battling to simplify the masses of "spaghetti wiring" inside the modern car. The first big break through came in 1991, with the introduction of the Controller Area Network (CAN). Developed by Bosch of Germany, the CAN put a data bus in place of the traditional 2.5—3 1cm long star-wiring for the electronic controls. Daimler-Benz quickly recognized the benefits and from 1993 built the CAN bus into its S- and C-class cars. Similar systems were introduced by Volkswagen of Germany and General Motors of the US, but CAN eventually won approval as an ISO world standard.

Technically speaking, the CAN bus substitutes time division multiplexing (a dedicated time slot for each component on the shared communication bus) for space division multiplexing (one separate physical link for each data channel). However, to protect the CAN bus from electromagnetic interference, the copper wires and controls have to be carefully shielded. Even then, the theoretical maximum capacity of 1 Mbit/s was never exploited. There's a direct correlation between bit-error rates and speed, so to be on the safe side car designers operated the bus at data rates of 125 kbit/s (the star-wiring was even retained as a back-up in early applications).

It soon became apparent that CAN technology and copper wiring did not offer a suitable long-term strategy for in-car data networking — the data rates were insufficient and the EMI problems appeared to be unmanageable. The answer had to lie elsewhere.

In the late 1980s, Philips Consumer Electronics of the Netherlands, in partnership with Matsushita and Sony of Japan, developed the Domestic Digital Bus (D2B), an audio-visual control system for the home-entertainment market. The first automotive application appeared in 1992, when Honda used D2B to wire up the navigation unit, radio and CD player in its Legend and Accord prototype vehicles.

The technology was subsequently picked up by a group of three automotive-equipment manufacturers — Becker Automotive Systems, Germany, Philips Car Systems, the Netherlands, and C&C Electronics, UK. Together they developed the POF-based D2B Optical Bus, a set of protocols for the transport of digital audio, compressed video and other data over a local-area network.

This synchronous bus, which provides a bandwidth of 5.6 Mbit/s, employs a ring structure that allows any two devices to form a point-to-point link. Each D2B device is equipped with a network transceiver chip (based on 660 nm LEDs) that connects to the physical layer, while the protocol handles the routing of the source data via dedicated ports to the appropriate device. One of the technology's big attractions is that it permits new devices tobe added to the network over time. "The life-cycle of audio-visual equipment is getting shorter, and the best choice to adapt to that is a self-configuring bus system," says Michael Becker of Becker Automotive Systems.

As it tumed out, specifying the transceivers and the plastic fibre for the D2B Optical Bus was fairly straightforward. The connectors, however, were more troublesome. Not only do the connectors have to withstand extremes of temperature, humidity and vibration — to provide a

reliable optical coupling throughout an automobile‘s 12-year lifetime — but they must also endure rough handling during harness assembly, manufacturing and service checks.
One product that addresses all of these requirements, as weil as ensuring water- and dust-proof interconnection, is the thread-crimp plug (TCP) developed by FCI Auto-motive of Nu-remberg, Germany. With the TCP, the 2.2 mm diameter fibre jacket (surrounding the 1 mm POF core) slots into a custom-designed plastic inner thread, which is then crimped to the plug to provide a fixture with a maximum attenuation of 0.1 dB. The design — which also ex-ceeds the extraction force (at least 60 N) specified for automobile applications — is available for single and paired fibres, for in-line connectors, or for hybrid interfaces combining duplex optical and electrical contacts.

Weight watchers

In-car POF networks provide an order-of-magnitude weight reduction compared with copper wiring. “A few years ago we made a comparison in a specific application, where the conven-tional 2.3 kg harness was replaced by an equivalent D2B Optical Bus,“ says Becker. “The latter weighed only 260 g, including the electrical device connectors.“
This was welcome news, particularly for Daimler‘s engineers. When the previous S-class ge-neration was launched, the company‘s flagship luxury vehicles were on the wrong end of so-me derisive press coverage. Independent test drivers discovered that, with any more than three occupants in the five-seat car, models with all the available comfort features were regu-larly pushed beyond their admissible weight limit. Germany‘s top car manufacturer became a laughing stock, and in the wake of the fiasco its chief engineer was forced to resign.
After learning its lesson the hard way, Daimler is now setting the pace with its uptake of POP technology. In the new S-class models, a three-bus system controls the exchange of signals at speeds roughly 40 times faster than the state-of-the-art CAN bus. The in-car POP net-works link up to 40 non-safety-critical devices, including the car radio, the CD player, the na-vigation system COMAND, the car phone, and the emergency call system Tele-Aid.
Other German car makers have not gone as far. “Optical fibres are absolutely future use — we have barely introduced the CAN bus,“ says Harald Hoffmann, a spokesman for Volkswa-gen in Wolfsburg. BMW has a similar strategy and will deploy POF in its next 7xx series of luxury cars, scheduled for launch in 2002. For the time being, though, the company remains tight-lipped about its plans for POP. Nevertheless, in spite of their cautious approaches, both Volkswagen and BMW have signed up to an initiative working on D2B‘s successor, the Me-dia-Oriented Systems Transport (MOST).
MOST, which was pioneered by Becker Automotive Systems, DaimlerChrysler and OASIS Silicon Systems, operates at network speeds up to 21.2 Mbit/s. Because the technology is frame-based, packet-oriented transmission is possible by reserving some frames for asynch-ronous data (very much like the transport of Asynchronous Transfer Mode cells over Syn-chronous Digital Hierarchy in a traditional telecoms network).
Along with Daimler, BMW and Volkswagen, the initiative has won the backing of automotive giants like Ford, Opel, Saab, Porsche, Renault and Fiat. However, MOST is not the only way forward. The Universal Serial Bus (USB) or IEEE 1394 (“FireWire“) bus — originally develo-ped for PC and home networking — offer data rates of 200 and 400 Mbit/s. Why not use the-se technologies for in-car networks?
According to Becker, these options bave been discussed but were subsequently discarded. “While D2B and MOST are synchronous buses,“ he explains, “USB and FireWire are isoch-ronous transmission protocols that require expensive buffer memories in each transceiver.“ Another factor is that FireWire-equipped devices have not yet made inroads into the consu-mer market (and those that .have do not meet automobile specifications). “Ordinary consu-

mer electronics operate in a controlled office or home environment,“ Becker adds. “In cars they have to work reliably over a temperature range of—40 to +85 °C.“
Even so, several Japanese car manufacturers are known to favour the FireWire option, while one of the leading automotive equipment suppliers, Bosch, has not committed itself to any technology at this point. One thing at least seems certain: whatever technology prevails, plastic optical fibres will provide the physical medium of choice.

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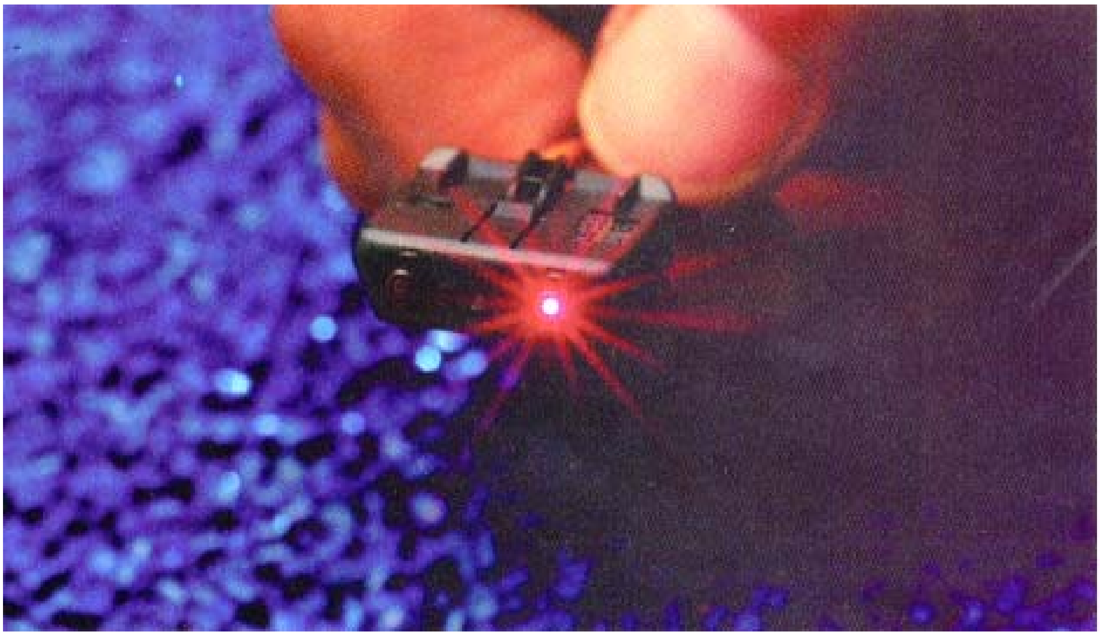
DRIVE - BY – WIRE: THE FUTURE BECKONS



Light work: each device on the S-series POF network uses a transceiver chip based on 660 nm LEDs. Specialized TCP connectors are designed to handle extremes ot temperature, shock and vibration.

DaimlerChrysler is now installing POF to support some of the non-safety-critical systems in its highend vehicles. In the tonger term, however, the automotive applications of POF technology are tikely to be much more extensive.
Car rnakers are already working towards a “drive-by-wire“ future, where the steering wheel, accelerator or brake pedals no longer need mechanics or hydraulics to couple to the wheels. carburettor or brakes. Instead optical fibres will transmit commands to a series of actuators that adjust the direction and speed of the car.
There has already been significant progress. Researchers at Daimler for example, have implemented what they call a Time-Triggered Protocol (TTP), which acts like a „central nervous system“ for an experimental car that has no hydraulics in its brake system. The prototype is currently beingtested in real-traffic mode.
Extending the brake-by-wire concept to drive-by-wire will require all safety-critical systems to be linked via the TTP bus so that they can exchange information about the car´s driving state. “Drive-by-wire is bound to come, in minor as well as in major steps,“ says Helmut Petri, who is responsible for the development of passenger vehicles at Daimler. “Over the next 15 years, the car will develop much faster than in the previous 50 years.“

POP DEMAND IS ON THE RISE

- The worldwide market tor POF and its associatect technologies – including cables, transceivers and Connectors – is set to grow from a 1998 value of USD 50 million tomore than USD 220 million by 2003.
- At present, the biggest market for POF is in factory automation systems. But this will soon change as the technology establishes itself in consumer electronics and automotive applications.
- POF-based automotive data networks will experience a compound annual growth rate of 109% over the next four years. Hands-free communications, audio, Internet access and video will be some of the initial functions connected by POF networks.
- The latest industry data suggest that by 2005, in-car POF networks will have an 8% penetration rate. This equates to a market size of USD 100 million, more than twice the size of the entire POF-market today.

Source: Ccommunications Over Plastic Optical Fibre, a new market study by the US fibre-optics consultancy KMI. Price is USD 6450. Fax: +1 401 847 5866

2 Soliton Fibre Upgrades

Soliton pulses facilitate fibre upgrades to 40 Gbit/s

Solitons are picosecond optical pulses which, because of their high peak powers, can counteract the effects of chromatic dispersion. Now, British researchers have leveraged these favourable properties to establish a new distance record — more than 1000 km for single-channel 40 Gbitls transmission over standard, non-dispersion-shifted optical fibre.
Nick Doran and his colleagues at the University of Aston believe their laboratory demonstration points the way to a straightforward upgrade of the installed singlemode base to 40 Gbit/s line speeds. “Our approach requires no complex in-line control and relies instead on simple, passive dispersion-management techniques,“ Doran told *FibreSystems.* “The secret is to employ both pre- and post-transmission chirping of pulses, or, as in this experiment, to start and end the transmission at an intermediate point in the dispersion-compensation cycle.“
The Aston team used a specialized distributed-feedback laser (to generate 7.2 ps soliton pulses), a lithium-niobate amplitude modulator (to impose a 10 Gbit/s data pattern onto the pulse stream) and a fibre delay-line multiplexer (to multiplex the bit stream up to 40 Gbit/s). The experiment was carried out using a recirculating loop containing 32.3 km of standard fibre, 6.8 km of dispersion-compensating fibre (DCF), as well as an erbium-doped fibre amplifier and a 2.3 nm optical bandpass filter.
Writing in the journal *Electronics Letters,* the researchers point out that “although the fibre amplifier span (39 km) was limited by the DCF available, the fact that the system was not noise-limited is an indication that a larger amplifier spacing may be possible“.
Doran says that the next step is to combine the dispersion-management technique with multi-channel transmission. “Our approach is suitable for real-world implementation and can handle a large number of wavelength division multiplexing channels,“ he explained. “Within the next year we hope to begin soliton field trials in collaboration with a number of European partners.“

• The University of Aston‘s work on dispersion-managed solitons received a boost earlier this summer. Doran and his team in the photonics group received a £1 million grant from the UK government‘s Engineering and Physical Science Research Council.

3 DWDM in the Sky

DWDM in the sky is ideal for metro networks
By Joe McEntee

Earlier this year, scientists from Bell Labs, the research arm of the US telecoms equipment maker Lucent Technologies, unveiled a prototype dense wavelength division multiplexing (DWDM) System capabie of sending 10 Gbit/s of voice, video or data traffic from point to point through the air *(FibreSystems* April 1999 p14).
Since then, engineers have been working overtime to get the technology ready for the transition into real-world networks. The international telecoms operator Global Crossing plans to carry out field trials by the end of the year, while Lucent itself reckons that the first commercial models will be available by March 2000.
The system, called WaveStar OpticAir, is being touted as a nononsense capacity-fix for metropolitan or campus-area networks where fibre connections are impractical. “OpticAir“ is ideal for local operators who need to move fast when delivering broadband connections into businesses,“ said Jim Auborn of Lucent‘s Government Solutions R&D division.
“The system will be particularly attractive in areas where there are no spare fibres or where it‘s prohibitively expensive, or even forbidden, to dig up the streets. Another potential application is at major sporting events, like the Olympics or the Superbowl, where OpticAir could be set up on a temporary basis to provide high-efficiency video feeds for TV companies.“

In the picture: TV companies will use Lucent‘s OpticAir to provide high-efficiency video feeds from major sports events.

But what about the quality of service? Auborn acknowledges that availability is greater for shorter spans. “As long as you can see the receiver you can close the link,“ he added, “though low-lying mist or smog will affect transmissions?“
Atmospheric turbulence is another possible source of signal degradation. “An automatic beamtracking system tackles the beam wander caused by movements of air-pockets larger than the diameter of the light path,“ explained Auborn. “In addition, the system sends four separate beams to counteract the effects of scintillation, which is the same atmospheric process that causes stars to twinkle.“
At the component level, the optical transmitters and modulators in OpticAir are similar to those used in Lucent‘s fixed-line DWDM system (WaveStar OLS400G). The big difference is the optical—air interface, where a high-power fibre amplifier is installed to generate the launch power of 1 W per channel.
The telescope on the transmitter has four apertures, each of which emits an expanded beam (at 1550 nm) to ensure eye-safe operation. As the beams travel through the air they undergo a transition from singlemode to multimode. “We need a multimode optical demultiplexer in the receiver,“ said Auborn. “Otherwise it‘s the same receiver that we use in our fixedline DWDM system.“
The first commercial release of WaveStar OpticAir will support one wavelength at speeds up to 2.5 Gbit/s. The four-wavelength version, with a capacity of 10 Gbit/s and a range up to 5 km, will be available by summer 2000. Lucent is thought to be keen to test the system at a high-profile sports event early next year.

4 SIEMENS WDM

Weltrekord: 32 Tbit/s über 1 Glasfaser

(tC, München) Siemens-Entwickler erzielten einen neuen Geschwindigkeitsweltrekord bei der optischen Datenübertragung. In den Transport System Laboratories des Siemens-Bereichs Information and Communication Networks (ICN) in München wurden mit Hilfe der WDM-Technik (Wavelength Division Multiplexing) Übertragungsraten von 3,2 Tbit/s demonstriert. Bei dieser Vorführung wurden gleichzeitig 80 Kanäle mit jeweils 40 Gbit/s fehlerfrei auf einer 40km langen Glasfaser übertragen. Die 40-Gbit/s-Kanäle wurden mit dem von Siemens entwickelten elektronischen Zeitmultiplexverfahren (ETDM - Electronic Time Division Multiplexing) erzeugt. Mit dieser Technik konnte die weltweit höchste Datenrate, die bislang über eine einzige Glasfaser übertragen wurde, erreicht werden. Mit einer Kapazität von 3,2 Tbit/s lassen sich 50 Mio. simultane Telefongespräche oder 100 Mio. Schreibmaschinenseiten pro Sekunde über eine Glasfaser übertragen. WDM ist die Schlüsseltechnologie für integrierte Telekommunikations- und Datennetze mit extrem hohen Übertragungsraten. Siemens entwickelt die nächste Generation optischer Übertragungssysteme, die das “Internet der Zukunft“ ermöglichen sollen. Das sogenannte “40G/System“ will Siemens live auf der Telecom ‘99 vorstellen, die 10. bis 17. Oktober in Genf stattfinden wird.

5 Petabit Netz

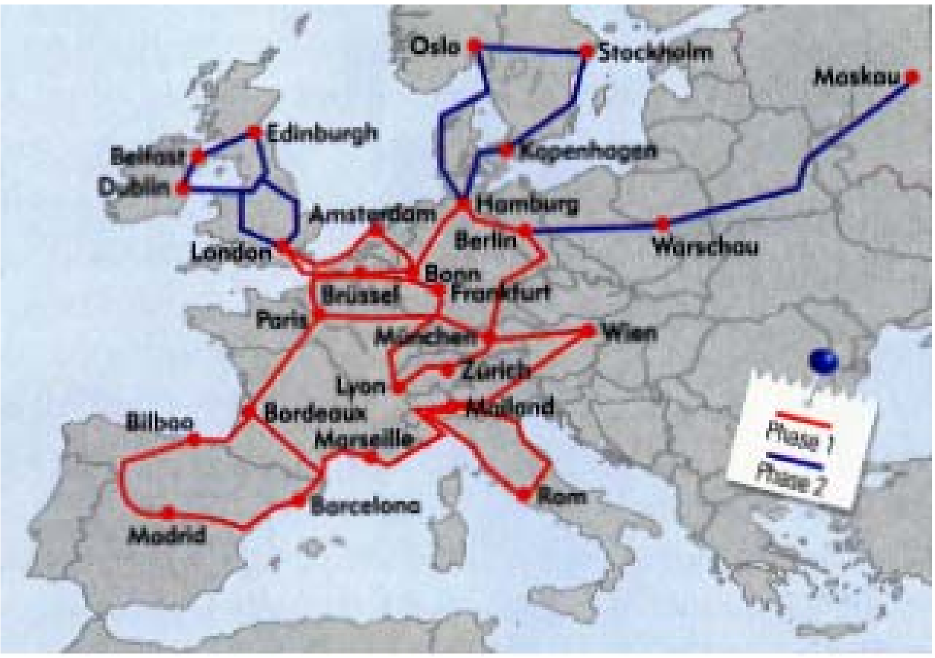
Gateway 11/99 vom 22. Juli 1999, Seite 9

Glasfaser

Petabit-Netz

Das Breitbandnetzwerk »I-21 « von Interoute (http://www.interoute.de) soll bereits im Mai kommenden Jahres den Betrieb für IP-Dienste aufnehmen. Bei einer geplanten Transferrate von 1000 TBit/s verbindet das Netzwerk nach Fertigstellung 17 europäische Länder. Insgesamt werde es über 200 »Points of Presence« sowie eine Gesamtlänge von rund 21000 Kilometern verfügen. Die Zielgruppe sind Carrier und Internet-Serviceprovider. Das Hochgeschwindigkeitsnetz offeriert Zugänge zu anderen IP-Carriern und Internet-Serviceprovidern in Europa und den USA sowie Gateway-Dienste zwischen herkömmlichen leitungs- sowie paketvermittelten IP-Netzwerken. Hosting-Dienste für Web-basierende E-Commerce- und andere Lösungen für End- und Geschäftskunden sind ein weiterer Bestandteil des Angebots. Experten erwarten einen dramatischen Fall der Bandbreitenpreise in Europa, die derzeit bis zu zehnmal höher sind als in den USA. Generalunternehmer für das Netzwerk ist der französische TK-Konzern Alcatel (http://www.alcatel.com), während die Kabel von Corning (htp://www.corningom) stammen.

(afi)



Strukturplan: Das paneuropäische Netzwerk von Interoute wird in zwei Phasen fertiggestellt.

6 Glasfieber Solitonen als Datentransporter

Nikolaus Ebbinghaus

Auf dem Forschungsgebiet der Hochgeschwindigkeits-Glasfasernetze, nimmt Japan eine Spitzenstellung ein. Ein kürzlich durchgeführtes Experiment könnte der japanischen Industrie nun auch den Weg zur kommerziellen Nutzung ebnen.

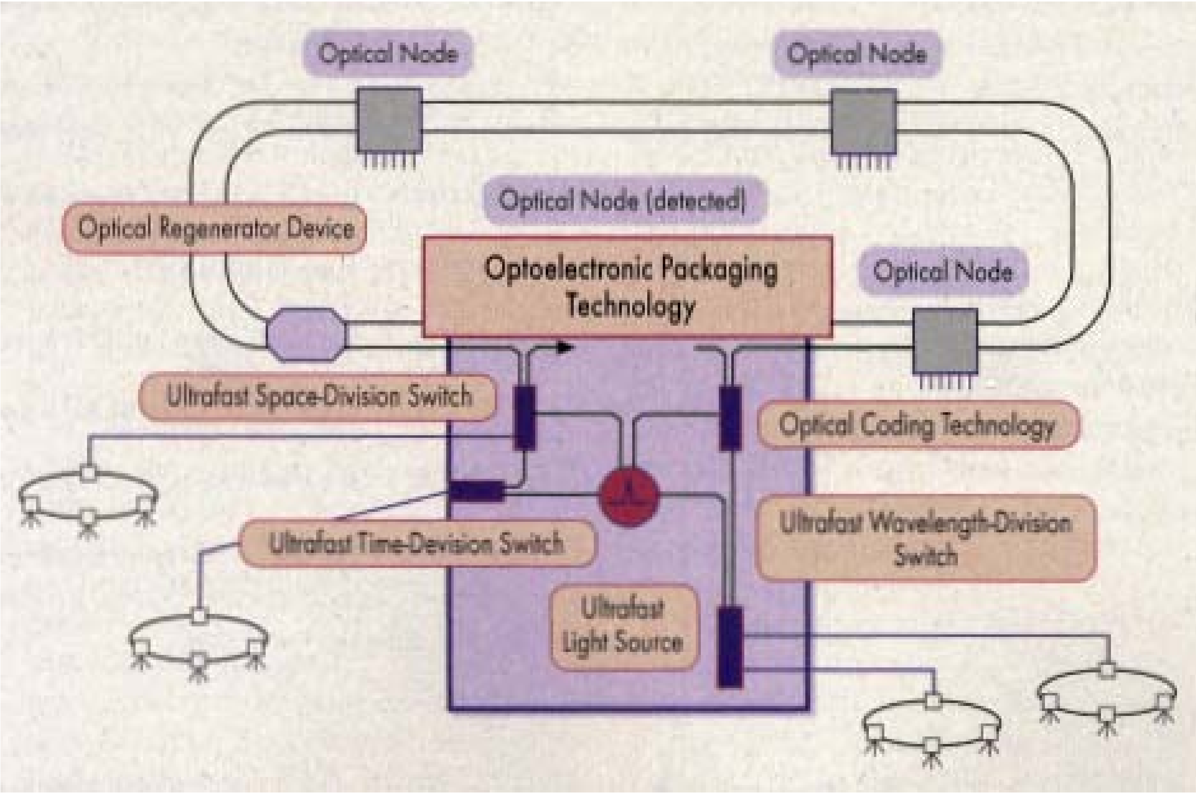
Soshiro Yoshikawa, geschäftsführender Direktor der japanischen Femtosecond Technology Research Association (FESTA), sieht dieses Jahr als schicksalhaft für seine Organisation an: „Dies ist das Jahr des Hasen!“, eröffnete er seine Neujahrsansprache, und nicht umsonst laute eine bekannte Redensart: „Schnell wie ein flüchtender Hase.“
Tatsächlich hat Yoshikawas Institution, ein unter der Schirmherrschaft der japanischen Regierung stehender Zusammenschluß führender Elektronikkonzerne, viel mit Schnelligkeit zu tun. Eine Femtosekunde (10^{-15} Sekunden) benötigt ein Lichtstrahl, um gerade einmal 0,3 Mikrometer ($3 \, . \, 10^{-7}$ m) zurückzulegen. Prozesse in diesen Größenordnungen gilt es zu beherrschen, um Photonen und Elektronen für extrem schnelle Datenübertragungen zu nutzen. So müssen etwa Lichtimpulse in solch extrem kurzen Intervallen abgefeuert werden, damit sie in Gestalt ideal geformter Soliton-Wellen (siehe Kasten und Bild) durch die Glasfasernetze huschen können. Langfristig soll diese Technik bis zu 5 Terabit/s in Backbone-Glasfasern ermöglichen, so daß private Internet-Zugänge mit 100 Megabit/s keine Utopie mehr wären.
Seit 1995 fördert das japanische Ministerium für Handel und Industrie (MITI) das ehrgeizige Femtosecond Project, an dem neben den elf Mitgliedern der FESTA, darunter Fujitsu, Hitachi

und Toshiba, auch verschiedene Hochschulen beteiligt sind. Ziel ist es, den Yoshikawa zufolge „objektiv wahrnehmbaren“ Vorsprung der japanischen Forschung auf diesem Gebiet zu festigen und auszubauen. So hält der japanische Telekommunikationskonzern KDD mit 40 Gigabyte/s, die verlustier über 10000 Kilometer gesendet werden konnten, derzeit den Durchsatz- und Streckenrekord. Den amerikanischen Bell Laboratories (alias Lucent) gelangen vor wenigen Monaten sogar 1,6 Terabit/s, doch wurden dabei 40 Kanäle zu je 40 Gigabit/s gebündelt, und die überbrückte Entfernung betrug lediglich 100 Kilometer. Für 400 km waren optische Verstärker nötig.

Herausforderung

LAN -Ankoppelung

Bis vor kurzem gab es ein gewichtiges Hindernis, das der Nutzung von Soliton-Netzen für allgemeine Zwecke wie Internet, Video on Demand und Videokonferenzen im Wege stand. Seit langem ist bekannt, daß die Verknüpfung von Highspeed-Backbone-Netzen mit gewöhnlichen LANs mit Schwierigkeiten verbunden ist. Denn selbstverständlich werden auch die künftigen Soliton-Netze in erster Linie für herkömmliche Telefonverbindungen konstruiert, und deren Architektur weicht nun einmal erheblich von der Konstruktion heutiger Datennetze wie LAN, ATM oder Internet ab., Die Highspeed-Glasfasernetze eignen sich eben mehr für breitbandige analoge Datenströme wie Telefonate oder Videoübertragungen als für die handlichen Datenpakete, wie sie im Internet oder im LAN unterwegs sind.



Die Ankoppelung langsamer lokaler Netze an schnelle optische Netze gelingt mit einer optoelektronischen Schleuse für die Kompression und das Entpacken der Signale.

Dies gilt insbesondere für den hohen Durchsatz zukünftiger Glasfasernetze. Spätestens ab 100 Gigabit/s, so eine Faustregel, schien eine direkte Koppelung an herkömmliche lokale Netze nicht realisierbar. Eine weitere Schwierigkeit bestand darin, daß „gewöhnliche“ Elektronik mit dem Tempo optischer Netze noch nicht mithalten kann. Auf der anderen Seite war bis vor kurzem kein Verfahren bekannt, mit dem optische Signale komprimiert und wieder ausgepackt werden können. Ohne Anbindung an Datennetze ergibt aber die Soliton-Technik wenig Sinn, schließlich werden die zusätzlichen Übertragungskapazitäten vor allem wegen des besonders schnell wachsenden Datenverkehrs benötigt. Schon jetzt übersteigt beispielsweise zwischen den USA und Japan der Umfang der Datenkommunikation den der herkömmlichen Telefonie.
Einen Ausweg aus diesem Dilemma eröffneten erst die gemeinsamen Forschungen von dem mittlerweile an die Kochi-Universität nach Japan zurückgekehrten Akira Hasegawa (siehe Kasten) und Hiroyuki Toda von der Osaka-Universität. Die beiden Wissenschaftler entwickelten eine Art optisches Schleusensystem aus einer Doppelschleife, die die Signale zunächst verstärkt und anschließend komprimiert.

Schleuse zur Glasfaser

In umgekehrter Richtung. funktioniert dies in erster Linie für TDM-Netze (Time Division Multiplexing) konzipierte Prinzip ebenfalls, so daß die Daten auf Empfangsseite wieder entpackt werden können. Der einzige Nachteil dieses Verfahrens besteht darin, daß etwa 10 Prozent des LAN-Durchsatzes verloren gehen, da die einzelnen LAN-Datenpakete umgruppiert und mit zusätzlichen Headern versehen werden müssen. Dafür ermöglicht es aber auch, daß praktisch beliebig viele Betriebe oder Haushalte unmittelbar von der Leistung künftiger Hochgeschwindigkeitsnetze profitieren können. Zu guter Letzt lassen sich die Gateways mit konventioneller Technik konstruieren.
Seit Ende Juni ist dieses Verfahren nun auch praktisch erprobt: In einem Experiment, an dem neben FESTA auch die Universitäten Kochi und Osaka beteiligt waren, gelang es erstmals, ein solches Highspeed-Glasfasemetz mit einem gewöhnlichen LAN zu verknüpfen. Dabei wurden die optischen Signale um den Faktor 16 von 155 Megabit/s auf 2,5 Gigabit/s komprimiert, ehe sie auf umgekehrtem Wege wieder ausgepackt wurden. Mit einer Art „Gangschaltung“ wurden die Signale dabei von optischen in elektronische verwandelt und umgekehrt. Zur technischen Realisierung trugen maßgeblich die Unternehmen Oki und NEC bei.
Gegenüber ***iX*** erklärte Akira Hasegawa zufrieden, das Experiment habe bewiesen, daß sein und Todas Konzept geeignet sei, Highspeed-Soliton-Netzwerke mit LANs zu verknüpfen. Allerdings befinde sich die gesamte Technologie noch im Forschungsstadium, der optische Kompressor etwa erfordere noch weitere Designverbesserungen und eine geeignete Management-Software. Dennoch kann aber wohl kein Zweifel daran bestehen, daß mit diesem Experiment ein wichtiger Eckstein für die praktische Nutzung der Solitonen gelegt wurde.

Keine Begrenzung in Sicht

Andererseits, so Hasegawa weiter, arbeite man aber auch an der weiteren Steigerung der Bandbreiten, schließlich sei das Ende der Fahnenstange hier noch lange nicht erreicht. So

zeigten theoretische Berechnungen und Simulationen, daß etwa das DDMS-Verfahren (Densely Dispersion Managed Soliton, eine vom idealen Soliton abweichende Wellenform, die noch effizienter ist) bis zu 160 Gigabit/s über Entfernungen von bis zu 2000 Kilometern ohne zusätzliche Verstärkung realisieren könnte. Außerdem, so Hasegawa weiter, beschäftige man sich intensiv an der Entwicklung kombinierter DDMS-Übertragungsverfahren, die gleichzeitig von TDM und WDM (Wave Division Multiplexing) Gebrauch machen, und sich dabei auch noch besonders an die Erfordernisse von IP anpassen lassen. Zum gegenwärtigen Zeitpunkt ließen sich hierüber aber noch keine näheren Aussagen machen.
Vieles spricht dafür, daß Japan auch weiterhin eine führende Rolle in der Soliton-Technologie einnehmen wird. Und zu Beginn des kommenden Jahrtausends, wenn die derzeit noch in der Erprobung befindlichen Technologien erstmals kommerziell eingesetzt werden, dürften demnach vor allem japanische Unternehmen von diesem Vorsprung profitieren.

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Nikolaus Ebinghaus ist Japanologe und arbeitet seit seiner Ausbildung zum DV-Spezialisten als freier Journalist.

John 5. Russell und die „einsame Welle“

Anno 1834 führte der schottische Schiffsbauingenieur John Scott Russell (1808 bis 1882) in einem Vorort von Edinburgh Experimente mit Kanalbooten durch und machte dabei eine ungewöhnliche Entdeckung: Als ein Boot. das von zwei Pferden durch einen schmalen Kanal gezogen wurde, abrupt bremste, nahm eine stattliche Welle Gestalt an, die sich vom Bug her vorwärts gerichtet fortbewegte, ohne ihre Form oder Geschwindigkeit zu ändern. Auf einem Pferd reitend konnte Russel diese wohlgeformte Welle ein oder zwei Meilen weiterverfolgen, erst dann verlor sie sich in den Windungen des Kanals. Das Aufmacherfoto zeigt die Soliton—Entdeckung, nachgestellt von einem Team der Heriot-Watt University, Edinburgh.
Russell war von dieser Erscheinung so beeindruckt. daß er sie in zahlreichen Experimenten eingehend untersuchte. Seine Forschungen über die „Wave of Translation“ blieben allerdings lange unbeachtet. so daß Russell es allein seinem Können als Konstrukteur zu verdanken hat. daß er schon zu Lebzeiten Ruhm erntete. Erst über ein Jahrhundert später in den Sechzigern erfaßten Techniker und Naturwissenschaftler die Bedeutung von Russells Erkenntnissen für die Hydrodynamik, Optik und die Plasmaforschung. Da sich bei diesem Phänomen im Idealfall eine allein stehende Welle (SOLITary Wave) nahezu wie ein unwandelbares Elementarteilchen (wie ein ElektrON, ein ProtON oder ein PhotON) verhält, erhielt es die wohlklingende Bezeichnung Soliton.
Im Jahre 1973 war es der damals noch in den Diensten der AT&T Bell Laboratories (heute als Lucent firmierend) stehende Japaner Akira Hasegawa. der die Existez von Solitonen in optischen Glasfasern vorhersagte. Demnach sollte sich eine Glasfaser grundsätzlich wie Russells Kanal auswirken. das heißt Streuungen und nichtlineare Eigenschaften der Lichtimpulse so kanalisieren. daß sie einander ausgleichen. so daß die Signale über weite Strecken ohne Verluste transportiert werden können. Damit eröffnete sich die Möglichkeit. noch größere Datenmengen als bisher über riesige Entfernungen zu übertragen.

7 Light Bullets

'Light bullets' will make mass surfing a reality

- a natural phenomenon discovered on a canal in 1834 will underpin the 21st-century's 'information age'
- light bullets allow 16 million phone calls on one fibre! – making video-on-demand, video phones, e-commerce, web, TV... possible

Lannion - France, July 27, 1999 - A new company, Algety Telecom, has been set up to introduce a revolutionary technology that will help turn the vision of the smart consumer society into a practical reality. Using a technique known as 'light bullets', it is developing equipment to remove a major communications bottleneck and allow existing national telephone systems to deliver new digital services such as video phones and web shopping to billions of homes.
"Digital technology can already offer us an amazing range of services – a major hold-up in making these available via low-cost gadgets for consumers is the practical problem of delivering vast amounts of information to tens of millions of individuals," says Thierry Georges of Algety Telecom. "We have started Algety to provide the solution in the form of a new kind of light transmission technology known as a soliton."
Modern phone communications relies on multiplexing - interleaving different voice calls or data traffic on the same line - in order to save space. But even the fibre optic cables that are used on the main highways of the telecommunications network can only carry so much traffic, and new developments such as web, TV, video phones and video-on-demand will generate enormous amounts of data traffic.
"Using light bullets we can transmit much more information on existing fibre-optic cable networks," explains Thierry Georges. "Just to give you an idea, each strand of fibre in a telephone network will be able to carry over 16 million simultaneous phone calls!". Light bullets are an exceptionally fast and stable type of light wave known as a soliton. They have only been developed in last 30 years, but they're based on a natural phenomenon first identified in 1834. Riding alongside a canal, John Scott-Russel noticed a special kind of wave that travels, fast, for exceptionally long distances without changing shape or speed. Today, this wave form is known as a soliton, and it can be used in light, air and water.
Algety is the brainchild of a team of engineers from France Telecom's research centre, and set up specifically to develop commercial light bullet solutions. The team has worked on solitons for more than six years, and is responsible for numerous breakthroughs, including the current record for terrestrial soliton transmission of one terabit per second (that's 1,000,000,000,000 bits of digital data a second!) over a distance of 1000km. This technology is ideal for improving the capacity of the inter-city links of telephone networks. In conjunction with faster phone connections to homes, via ISDN and other emerging technologies, users will be able surf the web at enormous speed, to watch movies exactly when they want to, and to buy goods and services from the comfort of their armchair. "In five years time, we will be sending hundreds -- probably thousands – of times more data down our phone lines. Solitons will underpin that future 'information society'", adds Thierry Georges.

What are solitons?
Solitons are a naturally occurring wave that will travel for long distances, with very small losses. They were first identified in 1834, by John Scott-Russel, who was riding alongside Union Canal in Edinburgh, and happened to notice when a barge came to a sudden halt, it generated a single, large wave. Unlike a normal water ripple, it continued to travel down

the canal without apparently losing shape or speed. He followed it for a couple of miles until it was lost in the twists and turns of the channel. In recent years, this type of wave has been applied to the light-based communications links that telecommunications networks use. It allows telecommunications operators to squeeze more 'channels' (which might be a conversation between two people or someone accessing a web site) into a single cable. (Today, phone communications - even voice information - travels down the main highways of the network in digital form. A technique called time division multiplexing allows multiple phone connections on one line - several different conversations can take place using the same line, at the same time.) Solitons also allow phone operators to send signals much further without reamplifying them, or rebuilding the signal, allowing long distance links between cites and countries, under oceans etc, to be built much more economically.
Engineers at France Telecom's research centre have led the world in applying soliton theory to optical data transmission, and now the team that has performed this work has started a company under the name of Algety Telecom, to make commercial systems.

Optoelectronic start-up targets world's first soliton for long-haul telecoms

- new transmission technology dramatically boosts fiber datarate & distance
- lets carriers prepare for bandwidth demand of internet2, e-commerce, web, TV...

A start-up called Algety Telecom has been formed to bring soliton dense wave division multiplexing (DWDM) systems to market, a new breed of optical transmission equipment which will revolutionize the performance of long-haul telecommunications. Algety is the brainchild of a team of engineers out of CNET, the R&D arm of France Telecom. The team has worked on soliton technology for more than six years, and has been responsible for numerous pioneering developments, including the current record for terrestrial soliton transmission of 1 terabits/sec over a distance of 1000km.

Backed by US and European venture capitalists and governmental grants, with seed capital of over $7.5m, Algety will deliver prototypes by the end of 1999, and full commercial systems by mid-2000. Based on its long experience of fiber optic transmission, Algety is developing a new generation of solitons for DWDM and Sonet/SDH long-haul transmission. Algety expects these solitons to enable carriers to substantially increase system lengths between regeneration sites, and to improve the spectral efficiency of their network. This will eliminate millions of dollars of equipment from every link, decreasing long-haul costs typically by a factor of between two and three --providing carriers with an economic upgrade to manage the huge increases in traffic expected in the next decade.

The company's edge lies in its unique and proven knowledge of soliton pulse shaping and correction required to achieve ultra-long distance transmission. Algety is managed by Chairman and CEO Thierry Georges, previously the head of optical transmission development at CNET, with Jérôme Faul and Roland Leners as joint executive officers.

The Algety team has worked together for many years on the practical implementation of transmission systems and management software for network operators. Soliton development started in 1992, and the team has an impressive track record of achievements in this field, the latest being the terrestrial record for optical solitons of 1000km at 1 terabits/sec -- established in March 1999. "The demand for bandwidth, and the best way to cope with it, has become a major concern for telecommunications carriers, and yet we are still at the very beginning of the explosion in demand", says Thierry Georges of Algety. "Soliton-based DWDM will give long haul carriers the means to economically upgrade their backbone networks to all-optical technology with virtually limitless capacity." He noted that this new technology provides the means to multiply capacity regardless of whether installations have single-mode or advanced non-zero dispersion-shifted fiber, and that solitons could effectively level the playing field between small carriers and large organizations with their investments in dark fiber.

Algety was incorporated in France during the second quarter of 1999, and has raised 4.4 million euros (approximately US $4.7 million) in its first round of funding. The seed capital has come from private sources and four European and US companies: Banexi Venture Partners, Crescendo Ventures, Newbury Ventures and Technocom Ventures. Algety has also received funding amounting to a further 2.74 million euros(approximately US $2.9 million) from French governmental agencies including ANVAR (Agence National de l'Innovation).

BACKGROUND INFORMATION:

What is a soliton?
Solitons were first discovered in 1834, by John Scott-Russel, who was riding alongside Union Canal in Edinburgh, and happened to notice after a barge came to a sudden halt that a large solitary wave was generated, and that it continued to travel down the canal without noticeable deformation of shape or variation in speed. He followed it for a couple of miles until it was lost in the twists and turns of the channel. Scott-Russel noticed that waves of higher amplitude travel faster than smaller waves - a non-linear propagating effect. Scott-Russel didn't notice that after a collision between solitary waves of different amplitudes, the two waves return to their original shape. These highly stable solitary waves have become known as solitons. Soliton waves occur in numerous areas, including light. It took more than 50 years to mathematically model the phenomenon, and until the 1960s to obtain a detailed theoretical study. Since 1973, the idea of using solitons to transmit data on fiber optics gained currency and led to experiments, and recently, to practical products.

What is WDM?
To further increase the capacity that can be transmitted over a single fiber, wavelength division multiplexing (WDM) is used. WDM divides light into multiple wavelengths (or colours). Using different wavelengths for different solitons allows Algety to insert (or multiplex) them on the same fiber with no risk of interference and loss a data as they propagate and interact. The term dense WDM (DWDM) is used when the number of different wavelengths is typically 16 or more.

What is capacity?
The amount of information carried by a single fiber or a whole network is measured in terms of binary information (bits) per second. For example, voice, once converted into a digital signal, will need 64,000 bits/second capacity. If a fiber is able to carry 1 terabits/sec, it will have the capacity of transmitting 15,625,000 phone calls simultaneously because 1 terabit is 1,000 billion bits.