The European Researchers' Network

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In the middle of the 1980s, most European countries did not dispose of any operational network. Whilst Governments (States) and the major computer manufacturers negotiate, public research computer scientists adopt the Internet technology. Without explicit mandates from their organisations, they deploy it, spreading it out all over, and ten years later, the door is opened to the private sector.

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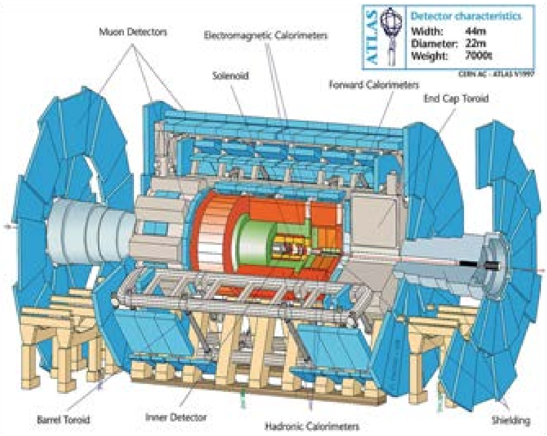
In spite of what has often been said, the Internet is not a positive product of unconstrained liberalism, nor a product of the imagination of private enterprise which is free of the straightjacket of autocratic policy; neither could have accomplished something that both Governments and major institutions had failed to achieve.

No, the setting up of a world-wide information network, based on universal standards, is truly the result of public research: the Internet is the indirect product of universities and laboratories that not only invented the technology but – a rare fact – used it as a world-wide operational network, at the researchers' service.

Our narrative begins in 1980. What facilities did universities and researchers have at their disposal then to communicate between themselves or to accede, at a distance, to computer science resources? In the United States, the Arpanet network, set up in 1969, links universities and laboratories that collaborate in research projects of the Department of Defense. (See article by Jean-Claude Guédon p. 16.) But the technology used at that time to transport data is not the one we know today – "TCP/IP" technology will be introduced into Arpanet only in 1983. What can researchers do with this network? Exchange electronic messages, transfer files from one computer to another and connect at long distance to another computer. Moreover, the USENet network, since 1979, allows any university who so wishes to exchange any news item, the famous *Internet news*, between any computer that has the Unix operating system installed, thanks to a technique developed by Bell Laboratories (UUCP: Unix to Unix Copy Protocol).

What's happening in Europe?

Research into computer network technology remains active. It splits into two schools of thought: that of the telecommunications operators, who



To conceive, construct and use complex instruments (here the ATLAS detector), particle physics as practiced at CERN requires the participation of hundreds of researchers, engineers and computer scientists: this culture of collaboration promoted the development of the Internet.

develop standards based on telephone network principles – this approach culminates in the X.25 standard, largely due to the work of the Centre National *d'Etudes des* Telecommunications (CNET) – and that of computer scientists, illustrated in France by the Institut National de Recherche en Informatique et Automatique (INRIA). The latter, led by Louis Pouzin, had worked on solutions similar to those of their American colleagues Bob Khan and Vint Cerf (see article by Louis Pouzin p.32 in this magazine). If experimental networks have been put in place with success in Europe, such as the French INRIA Cyclades network, no ambitious plan exists for the deployment of either national or multi-disciplinary infrastructures, i.e., open to all universities and researchers. Except for two countries: in Norway and in Great Britain, work has begun on the one hand on the development of the required technology – in fact, everyone is inspired by the Arpanet technology, but nobody thinks to use it directly - and on the other hand its implementation in a national network (UNINETT in Norway and JANET in Great Britain). During the period 1980-1983, the situation becomes more complicated in the United States, and, in Europe, awareness slowly dawns. On the other side of the Atlantic, university computer centres, most of which are not connected to the Arpanet network, can no longer wait. Under the impetus of Ira Fuchs who is in charge of the computer centre of the City University of New York, they decide, on their own initiative, to interconnect themselves and to offer an electronic mail and news broadcasting service to their users. The name of the network is evocative: BITNet, Because It's Time Network. Its method of financing is very simple: each new centre starts to seek a centre that is not too far away and already connected, and connects itself at its own expense. BITNet becomes operational at the beginning of 1981. Most of these centres use IBM computers, and it is without surprise that one sees IBM actively supporting this initiative. In parallel, American university computer science research departments interconnect themselves as well, by setting up the CSNet (Computer Science Network), under the initiative of Professor Larry Landweber of the University of Wisconsin. In Europe, the British initiative, JANET – which starts to offer its first services – is echoed. Germany creates a structure baptized DFN (Deutsches ForschungsNetz), SUENet and FUNet greet the day in Sweden and in Finland, soon to be followed by SURFNet in the Netherlands. They are, above all, development structures, not yet operational networks.

The year 1983 is a turning point for what will become the world-wide Internet. Whilst most European countries do not yet have a network, the first efforts at world-wide coordination start. Curiously, the very first meeting ever to be held to envisage a general world-wide research network is not held in the United States. It is held in Oslo, in July 1983 (see box "First Steps"), at the initiative of Larry Landweber, that exceptional visionary. Oslo inaugurates a series of events that Larry will organize – the 1984 edition is held in Paris – and which will be transformed, in 1991, into official conferences of the Internet Society (ISOC). Once again, the impetus came from universities and public sector researchers who, without any explicit mandate from their institute, meet to lay down together the base of a global initiative. The Oslo meeting allowed not only to verify a common desire to create a trans-national network, and not just national islets, but also brought to light one of the major difficulties that this enterprise would encounter: the deep divide concerning the choice of technologies. Now the most painful phase begins: the protocol war.

In July 1983, the first meeting where the future world-wide research network is elaborated is held in Oslo

The history of the Internet cannot be dissociated from that of its technology. Communication between computers requires the use common rules and a common language. These rules are called communication protocols. They broadly divide into two types. The first type is designed to ensure the transport of raw information data between two network points, independent of their significance or of their use: These rules are implemented by "transport protocols". The second type of rule offers to the end user a tangible service which is called an "application", e.g. electronic mail and is implemented by "application protocols". As of 1983, the Arpanet network, the ancestor of the American Internet, will use protocols called TCP/IP for their transport technology. Their success was such that, for a number of years, their name will replace that of the network. One talks of the "TCP/IP Network".

In fact, TCP/IP contains two distinct protocols: The IP (Internet Protocol), on the one hand, which specifies that the data flow sent out by one computer to another must be split beforehand by the source computer into individual blocks, known as packets, and on the other hand, TCP (Transport Control Protocol) which allows the two communicating computers to detect if any packets are lost and if retransmission is required. The specificity of IP is essential: packets are independent of each other, as a letter that is posted is independent, even if it is part of a more global correspondence. Since packets are independent - just like letters sent via the postal service – they must each carry the address of the remote computer. Inside the network, packets are forwarded by relays known as routers, connected one to the other, just like the mesh of Post Offices and Sorting Offices. It can thus happen that an Internet packet, following a different route, arrives at its destination before another that preceded it at the time of emission. It is this principle, known as the principle of *connectionless* communication, that gave rise to the liveliest confrontations between a fraction of Europe and the United States

During this epoch there are three types of Internet application protocols and this will remain so until 1991: SMTP for electronic mail, FTP for the exchange of files and Telnet for the connection from a terminal to a computer at long distance. Thus, no Web! These Internet protocols have two properties: they are open, i.e. they do not belong to any particular manufacturer and can thus operate on any type of computer; they are public, i.e. everyone has access to their specifications. In fact they are delivered via a light, informal structure, open to all: the IETF (Internet Engineering Task Force. The Internet designers set up this structure so as to benefit from contributions from all over the world, from universities, researchers and engineers in the public or private sector. There is no need to belong to a Standards Organisation in order to propose an idea, an improvement or a new norm: any individual or group of individuals, at whatever rank or qualification, from a mere student to a group of experts, can propose an idea: it will be analysed by volunteers from the IETF and will be retained if it's considered pertinent. This work method, focused on the individual and, by extension, based upon a certain notion of individualism – the author's name remains attached to his/her contribution – is fundamentally different from the hierarchical procedures in force in official Standards Organisations such as ISO (International Standard Organisation) or ITU (International Telecommunications Union) which, historically, promulgate the rules for telephony, television and radio communication.

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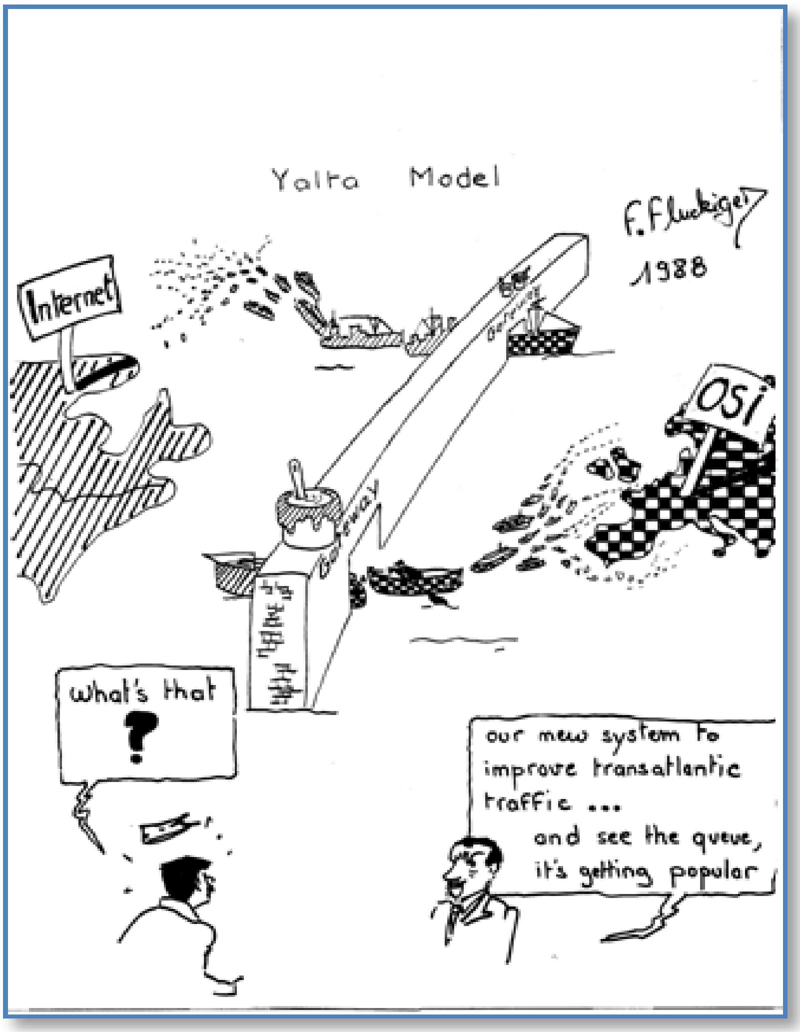

At the time when this drawing was sketched (1988) some people foresaw a division between world technologies: Internet in the United States, OSI in Europe. In this model, the two sides would have communicated via gateways.

While the American Internet refines its protocols, at the beginning of 1980 ISO and then UIT elaborate a set of rules baptized OSI protocols (Open Systems Interconnection). The objective is to promulgate rules that are open, i.e. compatible with any type of computer, and covering the whole spectrum of protocols, from transport to application protocols. Finally, the same objective as that of the Internet! The technological divergence is at its greatest at the level of transport protocols. Influenced by telecommunication operators, who see the future computer-based communication services as an extension of the telephone service, ISO and UIT opt, in priority, for a connection-oriented technology, as opposed to the Internet's connectionless approach: thus, before an information packet can be sent, the two computers must have established a connection beforehand, i.e. the equivalent of a telephone call. If necessary, the invoicing will be based of the duration of this call. The proposed standard, known as X.25, has already been in existence for ten years,. At the applications level, ISO and ITU also promulgate standards that are different from those of the Internet: X.400 for electronic mail, FTAM for the transfer of files. A difficulty arises due to the fact that at this epoch no implementation of these protocols exists in the form of operational software. Some, such as FTAM, will never see the day in the shape of a product!

Very rapidly, a significant fraction of the budding European networks chooses OSI technology as their strategic direction. This is notably the case in Germany and in Great Britain. As products do not exist, apart from the X.25 transport system, temporary protocols are developed: Great Britain, for example, designs and develops a set of software, called Colored Books, on the JANET network. This strategy in favour of the OSI standards is encouraged both by the European Commission and by a majority of European Governments. They perceive here a technological domain where European industry is deemed to be significantly ahead. In fact, if the computing and telecommunications industry adopts the OSI approach without too much soul-searching, even sometimes with enthusiasm, the reaction of American industry is more tempered. They

If European industry adopts the OSI approach, without any soul-searching, American industry is more circumspect

First steps

The very first meeting about the idea of creating a universal network was held in Oslo at the beginning of July 1983. The initiative was due to Larry Landweber of the University of Wisconsin who directed the American network CSNet. The local host was Professor Rolf Nordhagen of the University of Oslo, a wise and resolute giant. In total a dozen representatives from varying horizons participated, such as the American Ira Fuchs, Chairman of the BITNet network, and the Englishman Peter Kirstein of University College London. I represented CERN, the European laboratory for Particle Physics, a great consumer of computer science and telecommunications resources.

The idyllic frame of the hotel Holmenkollen (photo) overlooking the fjord of Oslo will see a common resolution emerge but technological divergences will also be brought to light, some Europeans insisting that any solution should use the so-called OSI technology from the International Standards Organisation (ISO).

Sixteen years later, the participants' most marked souvenir is the garden of Rolf Nordhagen where discussions carried long into the evening, late, very late, in the Norwegian summer, waiting for a night that did not come.

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support it (like the computer manufacturer Digital Equipment) but often with reserve. What worries the Americans is first of all the complexity of the OSI standards: they abound in options, to such an extent that so-called functional standards are invented, specifying which part of the standard must be used and under what circumstances. The development costs do not leave them indifferent. On top of this the delay between two consecutive versions of the standards, from two to four years, is thought to be ill suited to the dynamics of their industry.

At the end of 1983 reaction to an impromptu event of crucial importance will crystallize the gathering together of effort in Europe towards promoting OSI technology. Following the undisputed success of the BITNet network in the United States, IBM proposes the creation of a similar network, based like BITNet on IBM's own communication protocols, to the major European academic computer centres. IBM proposes to finance the connections between centres for a period of three years. Herb Budd, on IBM's side, is the initiator and overseer of this project. A foundation meeting is held at CERN (European Laboratory for Particle Physics) in Geneva, during which the Englishman, David Lord, responsible at this time for the CERN network, is elected Chairman of the Management Committee of the new Organisation: EARN (European Academic and Research Network).

The network starts operating in the beginning of 1984 and covers most European countries. For the first time, universities and researchers have a trans-national communication tool. Although limited to electronic mail and news broadcasting, EARN's success is immediate. However, the initiative is ill perceived by a lot of organisations responsible for the setting up of national research networks. On one side, the EARN network often precedes them in their own country, in particular in those which, having opted for a complete OSI strategy, must wait for product availability. On the other side, EARN has appropriated the only name in English that perfectly describes what national networks would have liked to establish together: a European Academic and Research Network. But the major reservation concerns the technology and its industrial implications: on the one hand, EARN uses proprietary protocols and, on the other, the firm that supports these protocols is not European. It will take 18 months before reaction sets in.

1984 and 1985 see both the strengthening of the EARN network as a true trans-national communication tool and the multiplication of national research network initiatives, apart from a notable exception, France. With the support of the European Commission, the first informal conference of national research network representatives is held on 14 May 1985. It is coordinated by James Hutton and Paul Bryant both of whom are British and is chaired by Peter Linnington, the Director of JANET. The outcome is a two-stage plan. In a first phase the objective is to harmonize the technologies that are used by various national networks and, in a second phase, to interconnect them. The problem is that in a number of countries the national network's existence is not yet tangible, apart from an administrative structure: to be truthful, often only the EARN national branch exists! Above all, the technological orientation is clear: national networks are converging towards the use of OSI standards, and their interconnection will also use these standards. A decision is taken to create a common organisation that will assemble national networks to pursue this goal. The most appropriate acronym in English is no longer available and a French acronym is chosen: the new organisation will be called RARE (Réseaux Associés pour la Recherche Européenne). It will take a year to legally set up the organisation, and RARE will see the day on 13 June 1986. It's a Dutch association based in Amsterdam. Its initial financing is ensured by the Dutch Government, and then by the European Commission's Directorate General XIII. Peter Linnington is its first Chairman.

The period 1986-1988 is still marked by the confrontation between technological strategies. Indeed two distinct fronts will be active. On the first, EARN's IBM protocols confront OSI protocols whose products are starting to become available (especially X.400 for electronic mail). In a gesture of conciliation the Irishman Dennis Jennings who has replaced David Lord at the head of EARN, proposes to replace the EARN transport infrastructure by an OSI technology infrastructure. This solution is needed to obtain the support of a new sponsor, Digital Equipment, who takes over from IBM. In fact, the international EARN network will remain the major method of international communication between European universities and researchers until the end of the decade.

Arriving from nowhere, a research network appears on the international scene and converts to Internet in 1988

In the meantime, another network, arriving from nowhere, appears on the international scene, without being invited by any official body. Its role will be decisive. This is known as EUNet (European UNIX Network) and is a replica of the American USENet created in 1979. Its birth is due to the needs of computer scientists in European public research centres who use the UNIX operating system and who need to use a trans-national network. Moreover, at this epoch EARN is centred on IBM and DEC systems and RARE does not yet have an international network. The main EUNet partners are the Royal Institute of Technology (KTH), Stockholm, and the National Research Institute for Mathematics and Computer Science (CWI) in the Netherlands, where Daniel Karrenberg works and who will become the network coordinator, and INRIA which in France will play a major role in the national network. The network supplies message and news services and is connected to its American parent. In 1988 EUNet announces its conversion to Internet technology.

A second front in the technology conflict has been open in Europe since 1986. This time the OSI and Internet protocols are in opposition. That year, RARE proposes to the European Commission that an ambitious project to establish an OSI network infrastructure for European research be financed. The project is known as COSINE (Cooperation for OSI Networking in Europe). The task is immense as nothing exists, neither products nor certain protocols. A long specification phase begins and is finalized in the autumn of 1988. The project endorses a new Yalta. It implicitly recognises that the USA will no doubt use Internet protocols, while Europe intends to use OSI protocols. Two worlds would exist, side-by-side, with different network languages, and obliged to communicate via gateways - a kind of automatic translation system. Ever since the use of different norms for, amongst others, television, technological schisms are considered a normal part of life. The implementation phase of COSINE begins in 1989 and will be consolidated by the setting up of an international transport network, IXI, based on X.25 technology. It will never be finalized, stopped in its tracks by the surging wave of Internet technology in Europe!

In effect, Internet technologies (TCP/IP together with file transfer and Internet messaging) have, in the meantime, made a violent entry onto university campuses. The technology is simple, efficient, is integrated into UNIX-type operating systems and costs nothing for the users' computers. The first companies that commercialise routers, such as Cisco, seem healthy and supply good products. Above all, the technology used for local campus networks and research centres can also be used to interconnect remote centers in a simple way. The fundamental difference with the previous systems lies in the fact that from now on, users exchange messages or transfer files without having to worry about the different makes and types of computer. Certain national networks do not hesitate and adopt Internet technology very early on, not only for their domestic communications but also for their interconnections with other European countries or the United States. In this way, the Scandinavian countries set up infrastructures based entirely on Internet, forming a federation thanks to the NORDUNet organization, and interconnecting themselves to form the first regional Internet network in Europe. On top of this, they connect directly to NSFNet (National Science Foundation Network), the central Internet network in the United States. The Dutch network SURFnet is also one of the first in Europe to convert to Internet protocols.

The European networks that continue to use the OSI strategy are now confronted by a strong internal demand for Internet technology. It becomes difficult to refuse this demand as the criticisms aimed at EARN concerning the use of a "proprietary" technology cannot be levied against the Internet, an open technology if ever there was one. Only the industrial argument remains: Europe is perhaps better armed in OSI technology than the United States. Events will show that this is not true. More and more it appears that the heavy OSI technology favours major firms able to invest in battalions of engineers so as to be ready to offer a product if necessary. However in this domain this is not a characteristic of European industry which on the contrary seems more likely to develop lighter Internet products that require lower investment for the creation of expertise. As a matter of fact, the firms that win the Internet market, like Cisco, are small. Simply, they possess the Internet culture, are interested in it and, notably, participate in IETF.

Towards the end of 1980, changes in opinion will be felt in the national networks that are the most reticent towards Internet. In Great Britain JANET starts to convert. It is time for RARE, that made OSI technology its strategic guide, to react. Three experts, the Finn Lars Backstrom, the Englishman Brian Carpenter and the Frenchman Guy Pujolle receive a mandate to audit the situation. The three sages hand in their paper on 22 January 1990. They recommend that RARE accepts the TCP/IP technology. At its conference in Vienna on the 1st of February RARE adopt a resolution that has remained famous. It is an historic revision, painful for some: "*RARE, without putting into question its OSI policy, recognizes the TCP/IP family of protocols as an open multi-vendor suite, well adapted to scientific and technical applications*."

The political path has been freed, everything can now happen very quickly.

Before reaching this point, Europeans who believed in the Internet transport technology had to maintain credible contact with the rest of the Internet world still under construction. NORDnet and EUNet, amongst others, tackle this task. A world-wide coordination structure had also seen the day in 1988: CCIRN (Coordinating Committee for Intercontinental Research Networks). This was the source of an important advance in Internet autonomy. In fact, the Americans, in the memorable meeting of this committee (see box "The Abandon of Power"), insist that Europe takes over the attribution of Internet addresses for computers that are connected. It is a well-known fact that each connected computer must have an address, a unique identifying number. Historically, the NIC (Network Information Centre), an American organization, allocated addresses for the whole world. The Americans, sometimes accused of wanting to dominate the Internet world, on this occasion showed great respect toward the Europeans. A few months later a non-profit-making European organization saw the day – it's mission was to grant Internet addresses to European computers. Its creator, Daniel Karrenberg, gave it a French name: Réseau IP Européen, whose acronym (RIPE) is a play on words in English…

Abandon of Power

The third meeting of the Intercontinental Committee for the Coordination of Research Networks (CCIRN) took place in a summer resort of Western Virginia, sad and grey in this month of October 1988. The Americans turned up in force. Bill Bostwick, of the Department of Energy was the Chairman. Barry Leiner of the Department of Defense was present, together with Dave Clark of MIT, one of the great Internet architects. The European representatives were thin on the ground: a German representative, a British representative and myself. Towards the end of the meeting the Americans became insistent: "It is essential that you, the Europeans, set up as far as possible a structure to allocate Internet addresses in Europe. It is not good that we keep doing it for you." My two colleagues did not seem too concerned, replying that they did not foresee the use of Internet rules in Europe. I thus took it upon myself to initiate this operation. On my return, I sent an electronic message to about one hundred European engineers and computer scientists whom I knew to be interested in the Internet. I asked them, if they wanted to contribute to the coordination of addresses, to contact Daniel Karrenberg at EUNet in Amsterdam, who had undertaken to coordinate everything. The number of replies outstripped our hopes!

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As of 1990 the European Internet transport infrastructure grew rapidly. An important factor in its acceleration, six years after EARN, was a second IBM initiative that, again under the impetus of Herb Budd, proposed, for a limited period of three years, to finance a set of international connections and switching equipment in order to create a major European network based-on Internet technology, with a higher transfer rate than that already in existence and to connect it at high speed to the American NSFNet network. The network was organized in the form of a great European star around one point of connection to the United States, and CERN was chosen to play this hub role. In February 1990 the first transatlantic Internet link with a transfer rate of 1.5 million bits per second, entered into service between CERN and Cornell University on the east coast of the United States.

At the beginning of the decade, the European Internet is essentially a network used by universities and researchers. Some countries have already adopted its technology: the Scandinavian countries, the Netherlands, Spain, Ireland, Switzerland, Austria; some are in a transition phase (Great Britain). International communications are made either via entirely Internet networks (EUNet, EASInet), or via the IXI network which uses X.25 technology (soon to be replaced by the Internet technology network EMPB).

In France, the situation is more confused. As yet there is no single national network, but a stack of varying types of network, generally using Internet technology (the French section of EUNet, the French part of EARN, a few disciplinary networks such as that of particle physicists). On the international side, as of 1988 INRIA at Sophia-Antipolis had put into place an Internet connection with the United States, at the initiative of Christian Huitema. NSF, one of the project's partners, will reinforce its contribution to the liaison, which will allow INRIA not only to act as a doorway for a part of France to access the United States, but also as an hub point for a number of Internet connections with Mediterranean countries. It is only at the end of 1991, notably under the impetus of Christian Michau of the CNRS, that Renater, the national network for education and research, will enter into service, catching up on lost time by the immediate setting up of a powerful infrastructure.

If the Internet is essentially an academic network at the beginning of the 1990s, the non-academic world is beginning at this epoch to take an interest, its main objective being electronic mail. As there is no commercial Internet network, European telecommunication operators continue to disdain Internet technology: which has the reputation of being unreliable and IETF meetings, where engineers in sandals and computer scientists with long hair (such as the late Jon Postel) are side-by-side, hardly inspire confidence; last and above all, the Internet connectionless principle destroys the practice of invoicing individual calls. Interested private users turn towards research networks. Then begins a transition period of three to four years where some national or international networks agree to connect non-university academic users on a temporary basis. Some will even cross the Rubicon and will become the first Internet Service Providers (ISPs) in Europe. This is the case for EUNet, renamed EurOpen - of which Glenn Kovack becomes the executive director- and is also the case for some of EUNet's national branches. In parallel new companies are created here and there to offer Internet interconnection services, offering general local or regional coverage. In Great Britain PIPEX is one of the first. The clients of these first access providers are not satisfied with just a local service, they want world-wide access, both commercial and academic – above all academic, as at this time, the great majority of information is stored on university and research sites, and there are practically no commercial servers. However, there is no European international network in existence whose statute allows it to interconnect isolated commercial access providers to give them access to the academic part of Internet. As for the private sector, it seems unable to set up such a network on its own.

The public part of the Internet, i.e. universities and research centres, will for the last time come to the aid of the private sector to set up the appropriate infrastructure: Ebone (European Backbone). In 1991 a certain number of research network managers, such as the Dane Frode Griesen, Kees Neggers, director of the Dutch network SURFNet, and the author of this article realise that the task must be achieved by establishing an international network of mixed interconnection, i.e. open to everyone, publicly financed academic networks or private commercial networks. The principle is simple: the network will consist of international links and switching nodes; each participant will connect to the nearest node; the overall cost will be divided amongst all the participants; no profit will be made. This set-up is governed by a simple Memorandum of Understanding (MOU, the first draft of which will be written by the author of this article).

The network starts up at the end of 1991 with 14 member organizations. In the autumn of 1992 ten other members join the Ebone consortium, and Frode Greisen becomes its Director General. The circle is thus closed and private Internet networks can fly on their own. Internet Service Providers will progressively develop, later on telecommunication operators will enter onto the stage, and interconnection points for access providers will bloom almost everywhere in Europe, commercial users will quit public networks which will completely rethink their mandate – to serve universities and researchers – and the British statutory entity DANTE will be created which will be mandated to supply the European transport network.

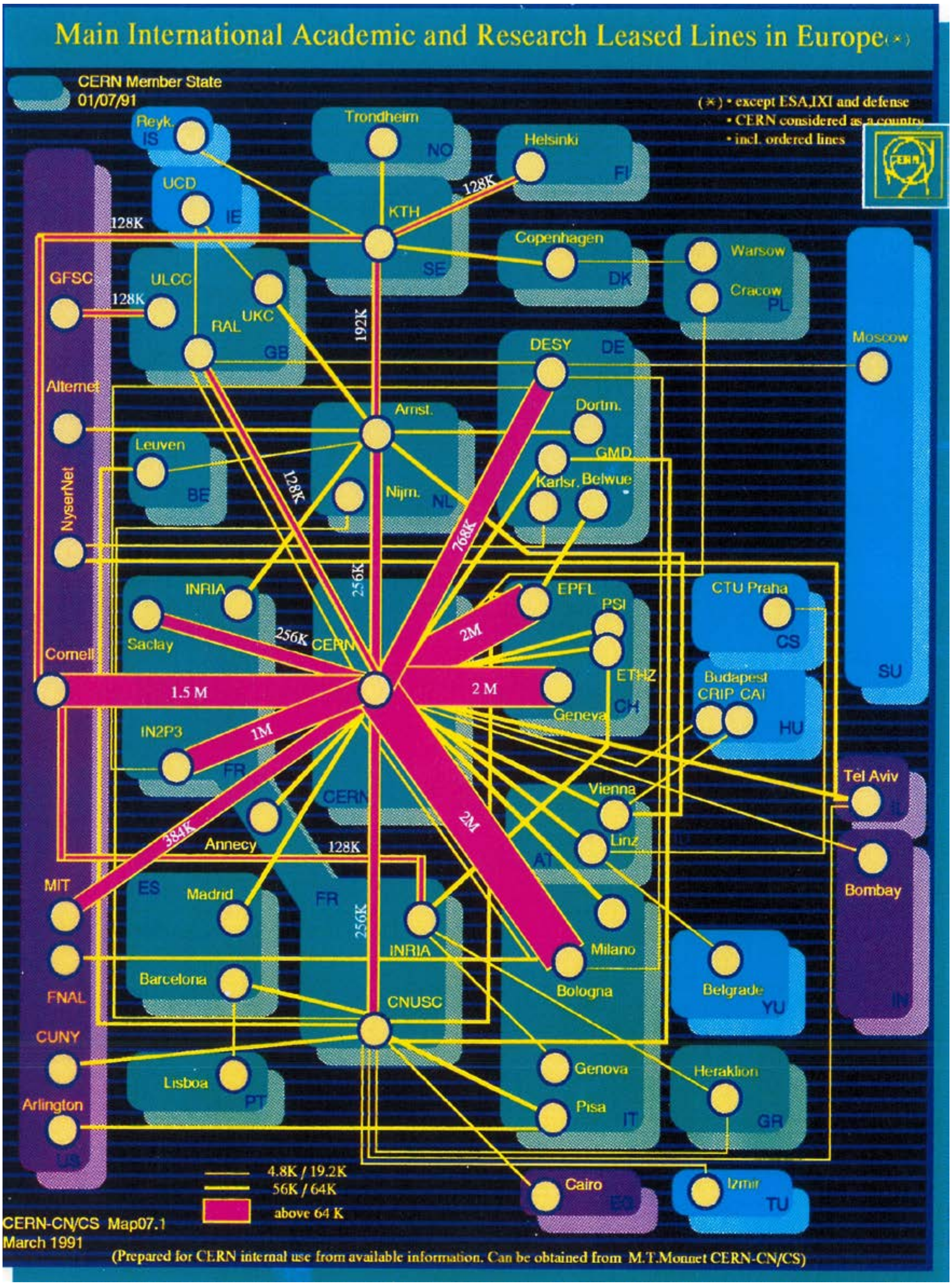
Internet technology having come out on top, the conflict between technologies, will calm down (apart from a few fits and hiccups) the most active adversaries of TCP/IP will discover a new passion and will reinvent their past as veteran defenders of Internet which will sometimes bring them honours and promotions. RARE and EARN, rival organizations in the 1980s, will even merge in 1994, and TERENA is born from this union.

However, the history of this period is not finished. Whilst Internet technology was developed by universities, politics will now enter into action. During a conference on telecommunications in Buenos Aires in 1994, Vice President Al Gore declares: “I have come here, 8000 kilometers from my home, to ask you to help create a Global Information Infrastructure”. Every country starts to frenetically produce plans for a national information infrastructure. But what exactly does it all mean, what are these information highways that everyone is talking about, in the G7 or in television studios? Is it the Internet? It doesn’t seem so. Reports talk about optical fibres in private homes, about servers providing television programmes on request, about ATM transport technology, about bi-directional satellite antennae. But not about Internet, except perhaps to mention that it is not the right solution, but is may be at best an intermediary step. And who is supposed to create and finance this new infrastructure that will cover the world, in not Internet? The private sector. Five years later, one is forced to admit that the information highways have disappeared: only Internet, which overtook as the unique world network, remains.

This narrative cannot be completed without evoking one of the essential contributions to Internet technology which came from public research: the World Wide Web. Is it necessary to remind you that this Internet application was invented by Europeans, in the heart of Europe, in its biggest scientific laboratory, CERN? In March 1989, Tim Berners-Lee proposed an information management project to CERN which did not receive much attention (see the interview with Tim Berners-Lee in this magazine). He had to re-submit his project a year later and only then did he succeed in obtaining a few resources in order to start up the development of the system. A prototype of the web-browser was demonstrated at CERN at the end of 1990, and, in 1992, the first public presentations were made. As the software was freely made available by CERN, then at the heart of the European Internet, its growth was like a flash of lightning: the number of web

Euro Internet in 1991: A gigantic star around CERN

At that time, 85% of the international bandwidth installed for the Internet in Europe terminates in the Computer Centre building 513 of CERN.



servers grew from 26 at the end of 1992 to 200 in October 1993. In the summer of 1994, Tim left CERN to create the W3 Consortium at the Massachusetts Institute of Technology (MIT), keeping a European branch, initially at CERN and then at INRIA. Mark Andreesen had just created Netscape together with Jim Clark, whilst in Europe the Web was of no interest to any industrialist…..

This way of using the Internet is today merged with the network itself. Shortcuts became necessary, the Web and the Net are become synonymous. This distortion of the initial reality which no longer differentiates between the transport of information from what is transported irritates the specialists. On the bottom line they are right – although…… The Internet has possibly simply become the Web – as practically any communication between man and machine can be made via a Web window – and the rest is just mere detail.

There are numerous reasons for the success of the World Wide Web project, whereas many other technological projects have foundered. Like a lot of births, the coming of the Web was perhaps a mix of chance and necessity. Too many projects seek their goal retrospectively. The Web fulfilled a genuine need, that of a well-defined community – the community of particle physicists. This community is made up of ten thousand researchers and technicians, spread all over the whole world. The planetary dimension was thus present right at the beginning. It was just chance that the Internet transport network developed at the same time, and that CERN, having the greatest capacity for Internet transfer in Europe, was at the heart of the network. It was also luck -or good design- that supplied the Internet with mechanisms unique in the history of telecommunication. One of these mechanisms, essential to the functioning of the Web, is the fact that any connected system, any connected object can have a unique name, independent of its real address; as well an automatic system (Domain Name System, DNS) allows the transformation of these names into addresses. It was also chance that several cutting-edge technical skills were gathered together with Tim Berners-Lee, in particular a great knowledge of telecommunications and of document structure techniques. In our more and more complex technological world, the compartmentalization of individuals into specialities is a brake on creativity and often progress is made by those who master more than one domain. The double invention by the same person of the Hypertext Markup Language (HTML) and of the Hypertext Transport Protocol (HTTP) is an illustration that will mark the history of our society.

The method should not be forgotten. Rather than just specifying the technology, which is the traditional method used by standardization bodies, Tim invented it and offered it to all. Rather than saying "this is how HTTP works, it's up to you to develop it and to test it", he said, "here's the software, download it, it works". ***And it worked!***

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