NEWS FROM NEW ZEALAND

BY

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1 Scientific and Community News

0. The latest CDMTCS research reports are (http://www.cs.auckland.ac.nz/staff-cgi-bin/mjd/secondcgi.pl):

381. A.A. Abbott and C.S. Calude. Understanding the Quantum Computational Speed-up via De-quantisation. 04/2010
382. C.S. Calude, M. Cavaliere and R. Mardare. An Observer-Based De-Quantisation of Deutsch's Algorithm. 05/2010
383. E. Calude. Fermat's Last Theorem and Chaoticity. 06/2010
384. C.S. Calude, E. Calude and K. Svozil. The Complexity of Proving Chaoticity and the Church-Turing Thesis. 06/2010
385. S. Schwarz and L. Staiger. Topologies refining the CANTOR topology on X^{ω}. 06/2010
386. R. Polley and L. Staiger. The Maximal Subword Complexity of Quasiperiodic Infinite Words. 06/2010

387 A.A. Abbott. De-quantisation of the Quantum Fourier Transform. 06/2010

388. M.J. Dinneen, Y.-B. Kim and R. Nicolescu. A Faster P Solution for the Byzantine Agreement Problem. 07/2010

389. K. Tadaki. Properties of Optimal Prefix-Free Machines as Instantaneous Codes. 07/2010

390. B. Whitworth. The Light of Existence. 08/2010

391. G. Chaitin. To a Mathematical Theory of Evolution and Biological Creativity. 09/2010

2 A Dialogue about *Computer System and Network Performance Analysis* with Professor Erol Gelenbe

Erol Gelenbe, the Professor in the Dennis Gabor Chair of the Electrical and Electronic Engineering Department, Imperial College London http://www.ee.ic.ac.uk/gelenbe, is an alumnus of the Middle East Technical University in Ankara, Turkey, he received a PhD from the Polytechnic Institute of New York University (Brooklyn Poly) and the Docteur ès Sciences degree from the University of Pierre et Marie Curie (Paris VI). Professor Gelenbe, one of the founders of the field of computer system and network performance analysis, is also well known for his work on Random Neural Networks and G-networks. Two of his four books were published in English, French, Korean and Japanese. Elected to the Turkish Academy of Sciences, the Hungarian Academy of Sciences, l'Académie des Technologies (France) and Academia Europaea, he is a Fellow of IEEE (1986), Fellow ACM (2001), and has received "honoris causa" doctorates from the Universities of Liège, Boğaziçi (Istanbul), and Rome II. He has graduated more than 50 PhDs including many women computer scientists and engineers, and was awarded the ACM SIGMETRICS Life-Time Achievement Award (2008) and other awards. He is a Fellow of IEEE (1986) and a Fellow of ACM (2001).

Cristian Calude: Tell us about your experience of studying and working in so many countries.

Erol Gelenbe: No two countries and no two environments, and indeed no two institutions, are identical. There is no "best" way to do things and each institution has evolved or adapted according to the personalities of its leaders and the specific context within which it is operating. Moving from one institution to another particularly is interesting and challenging, especially from one country to another, and can be a source of fun and learning (for me, at least). However, being a foreigner almost everywhere, I can group countries and institutions into two very broad categories: those that are open to "allogens" and are willing to be inclusive, and those which have (sometimes in subtle ways) significant barriers to "foreign" penetration. It is quite different if you are a visiting professor: you are there temporarily and do not constitute a threat to others. If you are a permanent addition, matters are different, more challenging and more interesting. Similar things can be said about being a foreigner needing to acquire a residence permit and work permit.

I have held chairs in Belgium, France, the USA and UK. In several countries there can be non-explicit, but widely practiced illegal barriers to foreigners. One hears about illegal immigrants, but seldom does one hear about barriers to legally established foreigners, in matters of promotions, awards, employment, etc. Such practices can continue even when an individual acquires the nationality of the country where he/she is working, and can even happen to EU citizens with regard to another EU country, as we have seen even very recently in countries such as France. My strangest experience was in Italy with my candidacy, at the request of Italian colleagues, to become Institute Director at CNR; I am fluent in Italian. My application was eliminated from consideration because they officially stated that they could not read my signature: "firma non leggibile"! Yet I have always used my credit card in Italy without problems about accepting my signature. On that particular instance, a large number of CNR Institute directors were being appointed, and they deftly managed to avoid appointing a single foreign candidate. The CNR was reserving the positions for their local friends, and they succeeded. Even more strangely, a couple of years ago, the lady at a "Metro guichet" in Paris refused to sell discount day tickets to two of my Greek and Greek Cypriot PhD students, on the grounds that she just refused to sell discount tickets to foreigners!

CC: As a computer scientist, engineer and applied mathematician you have done a lot of theory, part of which was used in commercial products. For example, your early work was incorporated into the QNAP2 software package.

EG: I have indeed attended to theory, but my work, except for my early work on stochastic automata [1], is motivated by "practical" problems or direct physical inspiration. For instance, I got involved in performance modelling and then in queueing theory because of two main practical drivers. Shortly after defending my PhD, I spent two summers at the Phillips Research Laboratories in Eindhoven, where I was asked to work on memory management algorithms for stack oriented re-entrant programmes. I knew nothing about the subject but was annoyed by the "ad-hoc" nature of the design choices that were being made. So I felt that some theory was needed, for instance in the choice of the page and memory segment sizes, so as to optimise the overhead. Similarly, at my first job at the University of Michigan (Ann Arbor) as an Assistant Professor, they asked me to teach Computer Architecture: everyone already there had "taken over" the courses on automata theory, formal languages, etc. so I (the newcomer) was "stuck" teaching the subject that others did not wish to teach. Well, there again, I got involved in developing a more quantitative and seemingly rational (at least to me) approach to Computer Architecture and Operating Systems, which has given rise to the field of Computer and Network Performance Analysis and Evaluation. For instance, I was able to prove results on paging algorithm performance which attracted the attention of some Hungarian and Russian mathematicians and physicists, as well as on memory space optimisation which drew theoretical design conclusions from Laszlo Belady earlier measurements at IBM on "life-time functions". My development of novel "product form" networks [4, 9], which are also linked to statistical mechanics and theoretical chemistry, was motivated by listening to presentations from neuroscientists while visiting the NASA Research Centre in California, but that is yet another story to be told below.

So yes – much of my work has had a theoretical bent, but it has almost always been driven by a strong link with engineering requirements or by observations from nature. Another example inspired by engineering is the research I did on "optimum checkpointing" [6] in databases which appeared in the *Journal of the ACM*, but was motivated by a practical issue that was recounted to me by Claude Delobel in relation to the automatic storage in a database of "hits" during some fencing championships that were taking place in Grenoble, when the computer being used for this was having some intermittent failures! This work gave rise to a few PhD theses around me, and to much more work around the world. Other results were motivated by a property observed in a simpler context, and on the intuition that it actually holds in a much more general framework.

The QNAP2 (then Modline) software tool for performance evaluation was developed by my group at IRIA (now INRIA), and the specific technique that I personally contributed was on "diffusion approximations" that I first published in the *Journal of the ACM* [3]. This software tool has generated some 200 million euros of income over 20 years for the companies that commercialised it (initially SIMULOG an INRIA spin-off company). The developers and inventors themselves hardly got anything; we were naive about such things. Throughout my career I have been involved with industry, via patents, via tools such as QNAP2, via consultancies or short-term assignments inside industry, and also via contracts to my university that are directly funded by industry. Of course, many of my PhD students have gone on to work for industry, most recently in the financial sector.

CC: You are a pioneer in the adaptive control of computer systems.

EG: I am bit like the elephant in the dark room: someone comes into the room, touches the leg of the elephant and thinks it's a tree, another person feels the tail and thinks it's a rope, and yet another catches the elephant's nose and thinks it's a hose! Some people think that I am a pioneer of computer system performance evaluation (at least that's what they say on my ACM Sigmetrics Award, and on my IEEE and ACM Fellowship Awards). The French Academy in 1996 gave me the France-Telecom Prize for developing mathematical models of communication networks. The Hungarian Academy of Sciences, in its recent election, mentions both my work on system and network performance and on neural networks and learning. As you indicate, in the last six or seven years I have been involved in developing ideas on Adaptive Computer Systems and Networks such as the "Cognitive Packet Network" and this has helped generate research projects in "Autonomic Communications" in Europe. I was asked to write a paper about this work in the July 2009 issue of the *Communications of the ACM* [28]. The Internet is largely a legacy system based on principles that find their origin in the computers and data communication systems of the 1970's, and it is working pretty well. Thus it is hard to introduce new concepts and methods. Much of the current networking research only addresses tweaks to well understood aspects.

CC: Tell us about random neural networks. You developed their theory—mathematics and learning algorithms—as well as some applications to engineering and biology.

EG: Let me first tell you what the Random Neural Network (RNN) is [10], and then I will get round to telling you how it came about. Consider a system composed of N counters, and let them be numbered $i, j = 1, \ldots, N$. Each counter can have a value which is a natural number. At any instant t, only one of the following *events* can occur: the $i-th$ counter increases by one (external arrival of an excitatory spike to "neuron i), or if a counter has a positive value it may decrease by one (neuron i fires and the spike is sent out of the network), or a counter i may decrease by 1 and simultaneously some other counter increases by 1 (neuron i fires an excitatory spike which arrives instantaneously to neuron j), or i decreases by 1 and so does j if both start in a positive value (neuron i fires an inhibitory spike to j), or finally at time t nothing happens. What this is modelling is a network of N neurons which are receiving and exchanging excitatory or inhibitory spikes. The system operates in continuous time so that t is a real number, making it a continuous time network of counters. It is quite extraordinary that this very simple model has some very powerful properties including the ability to learn [14], and the ability to approximate continuous and bounded functions and also some very neat mathematical properties such as "product form".

It all started when I was visiting the RIACS Research Centre at NASA Ames, in Moffett Field, California in the summers of 1987 and 1988. This was a lot of fun because at lunch time, going out from the back of the laboratory one ended up directly on an airfield where the U2 spy aircraft was taking off. The body of this airplane is very small and thin, with just enough place for one pilot and his instruments and commands, but the wings are very long. In fact, the wings have small wheels at the edges which support them at take-off; if they did not have the wheels they would be scraping the runway because the wings are long and too heavy to stay in a horizontal position. From Moffett Field, the job of the U2s was, officially, to fly along the US Pacific Coast to try to spot and track Russian submarines. The Director of RIACS at that time was my friend Peter Denning who had just recently left Purdue University where he had been Department Head. My official job at RIACS was to work on the performance of parallel processing systems, since I had just published my small monograph on *Multiprocessor Performance*. NASA Ames had some of the largest supercomputers at that time since they were supposed to eventually replace wind tunnels (another specialty at NASA Ames) for the testing of aircraft and rockets. It is amusing to note that both supercomputers and windtunnels are “energy-vorous".

Another funny thing about my stay at NASA Ames, and these were the days before September 11, was that since it was supposed to be a very secure facility, and I was a “non-resident alien” (. . . what a funny name for a non-US citizen without a Green Card!), I was not allowed to enter the airbase officially and had to work in an external building just at the border of the base. But the funny thing is that the building’s back door was unlocked, so I could walk onto the tarmac and observe the U2s, also I could just walk over through the back door to the RIACS. Anyway, this is just to set the tone about my working environment. Peter Denning had recruited an interesting man called Penti Kanerva from Pat Suppes’ entourage at Stanford. Penti was originally a forestry engineer from Finland who had done a PhD in Philosophy with Suppes. He had invented a model of computation called “sparse distributed memory” (SDM) which is not too dissimilar from the Kohonen maps that you may know about. SDMs offer a nice adaptation or learning algorithm both for numerical and non-numerical data based on slowly modifying a data representation based on new data that is presented. As a result Penti was also interested in natural neuronal networks, as were some other people who worked at RIACS, so they had organised a series of seminars by prominent neuroscientists. My work on the Random Neural Network started in those circumstances. In the meanwhile I published a paper on the learning properties of SDM, which has remained rather obscure.

As many people of my generation, I was familiar with the McCulloch-Pitts model of neurons, and about the Minsky-Papert controversy concerning nonlinear perceptrons. I knew of John Hopfield’s model and his results concerning “optimisation through relaxation”, and of the work of the PDP Research Group at San Diego, and the contributions of Dave Rummelhart and Terry Sejnowsky, and about the backpropagation algorithm. At that time, Françoise Fogelman in Paris was a strong proponent of these techniques. My former student Andreas Stafylopatis from Athens was also quite interested in these things and we had tried our hand at some "collective stochastic models" for large numbers of neurons [11]. But I felt, after listening to several presentations by neuroscientists, that none of these models actually captured the spiking activity of natural neuronal ensembles, and furthermore (except for John Hopfield's work) the PDP Group's work did not address the important issue of feedback in natural neuronal systems, or "recurrence" as people say in that area. Filled up with all these interesting neuroscience lectures I set to work upon my return to Paris in September of 1987. Also I had the good luck of being hired by ONERA (French Aerospace Research Organisation) as a consultant in AI which was not my area, and I felt obliged to produce something significant. In six months I had developed the spiked Random Neural Network Model, and obtained its analytical solution, but the people at ONERA could not understand what I was trying to do. The following summer I was back at RIACS, and met Dave Rummelhart who had moved to the Psychology Department at Stanford. I dropped abruptly one day into his office without knowing him personally, and told him what I had done. He was very friendly and interested, and invited me to give a seminar the following week. After the seminar he told me to submit my work to the journal that Terry Sejnowski, Dave and others had started a few years back, *Neural Computation*, and the first paper was rapidly accepted and published in 1989. Several papers followed in the same venue over the years [16, 21, 26], and since the journal indicates the name of the handling editors after the papers were published I owe a debt of gratitude to Dave Cowan and Haim Sompolinsky, neither of whom I know personally. My learning algorithm [14] came later in 1993: it was the first algorithm that established that learning for an N neuron recurrent network is of time complexity $O(N^3)$, while it was well know that the backpropagation algorithm for a feed-forward network is of time complexity $O(N^2)$. In the course of this work, there were applications to imaging [13, 18], adventures and complications related to non-linear mathematics; there have been several other applications and extensions, and a return to biology while I was at Duke [20], but that would lead to an even longer story.

CC: Please describe the famous G-networks.

EG: Queueing theory has been around for at least as long as telephone systems have existed. The literature contains many tens of thousands of papers which appear either in publications related to the application domain (e.g. manufacturing systems, computer systems, the Internet, road traffic, etc.), or in more mathematical journals related to probability theory or operations research. It is a theory based on mathematical probability that considers a dynamical system composed of "service centres" and customers. The latter move around the service centres according to a designated probabilistic or deterministic behaviour, and at each service centre a customer waits in line and is then served according to a service discipline, e.g., First-in-First-Out, Round-Robin, Last-In-First-Out as in a push-down stack, or according to some priority scheme and so on. The service time of each customer in a service centre is typically given in the form of a probability density function or probability distribution, and this will typically differ in each service centre. In addition, customers may belong to "classes" so that the service time distributions and the routing of customers among different centres, may both depend on the class to which the customer belongs. Often independence assumptions are made about the service times and the routing of different customers even though they may belong to the same class. This is a very useful theory in that it is widely used in industry to design telecommunication systems, manufacturing systems, transportation, parts handling and assembly, etc. When such systems have a steady-state or long term solution in which the joint probability distribution of the number of customers in each of the queues can be expressed as the product of the marginal distributions in each of the queues, despite the fact that the distinct service centre queues are in fact coupled, then we say that the queueing network has "product form"; examples include the Jackson Networks (that Len Kleinrock used in his very early work to model packet switching networks), and the Baskett-Chandy-Muntz-Palacios (BCMP) networks. Product form is a remarkable property which in general reduces the computational complexity of using queueing networks, from an enumeration of all possible states, to a polynomial time and space complexity.

G-Networks [12] extend a network of queues, to include certain new types of customers that can modify the behaviour of others. Thus "negative" customers [12] destroy other customers; for instance they can represent external decisions that are made to reduce traffic because of congestion, or to remove packets in a network that may contain viruses. Triggers are yet another type of customer which can simply move customers from one queue to another. Multiple class G-Nets are discussed in [16, 19]. Resets are customers that replenish queues when they are empty, to represent (for instance) a situation where we wish to keep some part of the system busy, or when queue length represents the degree of reliability so that "replenishment" corresponds to repairing a component. Thus you can think of G-Networks and queueing networks that also incorporate some useful control functions: for instance the ordinary customers can be packets in a network, while these special customers can represent control signals that may travel through the network and affect the ordinary packets at certain specific nodes. The link between G-Nets and neural networks is discussed in [15]. All of these G-Network models, and other aspects discussed by my colleagues Jean-Michel Fourneau and Peter Harrison, lead to product forms. However the solutions obtained, starting with [12], differ from the earlier Jackson and BCMP networks in that they rely on non-linear "traffic equations" which describe the flow of customers of different types and classes throughout the network. Because of this non-linearity, one also has to address questions of how and when the solutions one may obtain actually exist and are unique. My first paper on G-Networks was turned down at an ACM-SIGMETRICS conference because the reviewers did not quite believe that new models in this area could be found and also solved analytically. Thus I turned to journals dealing with applied probability . . . and some of my most cited papers are in this "strange" area which has attracted much attention over the last twenty years.

CC: Tell us about the design of the first random access fibre-optics local area network.

EG: This was a very interesting experience. In the mid 1970's, thanks to Louis Pouzin who is one of the pioneers of the Internet, and an extremely sharp and amusing individual, I was put in contact with the group developing the Arpanet. In particular I met Bob Kahn in Washington. At that time, a new packet communication scheme using satellites had been devised: the ALOHA Network, which was implemented by Norman Abramson at the University of Hawaii. Of course, ALOHA is the "father" of the Ethernet. Abramson and Kahn had published papers that described the scheme and computed its maximum throughput; Leonard Kleinrock and his students were also studying the problem. I felt that the initial models were addressing steady-state analysis, in a context where the steady-state might not exist because the system was intrinsically unstable. Together with my collaborators Guy Fayolle and Jacques Labetoulle, we obtained a strong result, which after some delay managed appeared in the *Journal of the ACM* [5] proving that the slotted random access communication channel (i.e. known as "slotted ALOHA") was intrinsically unstable due to potential simultaneous transmissions between uncoordinated transmitters, and that it could be stabilised and even optimised under a "$1/n$" policy which was to retransmit previously collided packets at a rate that is inversely proportional to the number of backed-up transmitters. Strong results sometimes upset your colleagues. But Bob Metcalfe, who implemented Ethernet, was very positive about this work, as he wrote a few years ago to Jeff Buzen, his then advisor at Harvard.

This work had started while I was at the University of Liège [5], and at INRIA, and then I moved to Orsay (where I was one of the co-founders of the LRI, Laboratoire de Recherche en Informatique). At Orsay, I told Wladimir Mercouroff, a senior member of the university, that this work could have practical applications to locale area communications. He suggested funding via the DGRST (Délégation Générale à la Recherche Scientifique et Technique) jointly with a company called La Calhène, to build a fiber optics local area communication system for environments with strong electromagnetic perturbations. I would have been happier to use coaxial technology but the funding agency favoured fiber optics. So we ended up building a prototype called Xanthos, which used DEC-LSI11 processors as access nodes, and fiber optics for transport with the random access protocol using our optimal control algorithm with a clever scheme we had devised to estimate deviation from optimality based on the frequency of the fiber channel's "silent" periods. Once the system was up and running, I presented it to the French Telecommunications authority for possible commercialisation. They told me that this work was of academic interest, but because we were using random access, we could only guarantee delivery times on average and in probability, rather than with fixed maximum delays; being rather naive at the time, I believed them. So the project was set aside. A couple of years later Ethernet appeared, and I am sure that some French Telecom people were biting their nails. As I said, Bob Metcalfe knows this story. As a consolation prize, the French Telecom hired me as a consultant for a few years and I was able to do several other things for them, but they (and I) missed out on a major opportunity. What happened to Louis Pouzin and his team at INRIA, for similar reasons and regarding the Internet as a whole, is a far more tragic-comic story.

CC: You patented an admission control technique for ATM networks.

EG: This was an application of my earlier theoretical paper on diffusion approximations for queueing systems which was rejected for a prestigious French conference. My results then appeared in the *Journal of the ACM* [3] and *Acta Informatica*, motivated by the need to simplify the calculations of queue lengths, server utilisation and so on, when you have "non-exponential" assumptions. Diffusion approximations and Brownian Motion are well known, and there is a wonderful book on the subject by Albert Einstein. This approach had been suggested to approximate road traffic congestion by G.F. Newell (Berkeley), and then by Hisashi Kobayashi (IBM) for computer system performance. My original contribution introduced a mixed discrete-continuous model to address "low traffic" conditions which were ignored in earlier work. This gave rise to mixed differential and partial differential equations which I solved in "closed form". In the mid 1990's, IBM was designing its N-Way switch for ATM (Asynchronous Transfer Mode) Networks. The design was carried out at Raleigh (North Carolina) near Duke University where I was Department Head; the hardware was being designed at IBM's La Gaude Laboratory. The fashionable approach at that time to admission control was to use "large deviations", whose originator Varadhan from the Courant Institute is in 2010, like me, elected to the Hungarian Academy of Sciences, but large deviations only provide "order of magnitude" estimates of packet or cell loss, which is the primary metric of interest in ATM. I was awarded a contract by IBM-Raleigh to look at the problem and we developed an algorithm that used the predictions of my model [17] to decide whether to admit a new flow into the network, based on predictions for packet or cell loss. One of my students, Xiaowen Mang (now at AT&T Labs), performed simulations. Because it all seemed to work well we patented the technique together with IBM engineers Raif Onvural and Jerry Marin. The US Patent was awarded in 1998 or 1999. Links to these ideas can be found in my recent work on packet travel time in networks.

CC: What is the “cognitive packet network" routing protocol?

EG: Call it CPN [22, 23] to make things simpler. It is an algorithm that runs on specific network routers within an IP (Internet Protocol) or similar network (including sensor and ad hoc networks), which adaptively choses paths with desirable properties such as better delay or loss characteristics, lower energy consumption, lower economic cost, greater security, or a combination of such criteria. The combination of criteria is incorporated into a “goal” or objective function, whose instantaneous value is established based on measurements collected with the help of “smart packets”. CPN is based on on-line measurements, and responds to observations which are being made and which will in general change over time so that CPN’s choices also change. CPN offers the end user the possibility to make such choices, although the end user may delegate the decisions to an agent which manages its access to the network or which manages several end users. CPN uses two mechanisms; the first is is the use of “smart packets” which act as scouts and collect and bring back measurements. The second is the use of recurrent random neural networks (RNNs) which are installed in routers that take part in CPN’s decisions (and all routers need not do this) and which act as oracles; the excitatory and inhibitory connections of these RNNs are updated using the reinforcement learning rule based on the goal function, as a result of the measurements constantly collected by the smart packets. The RNNs are used to route the smart packets (i.e. to inform the ongoing “search”), while all the resulting measurement information concerning the goal is returned to the end-user or to its decision agent. The decision agent may then decide to follow completely or only partially, the advice it receives, so as to select the best paths in the network. For instance, the decision agent may wish to reduce the frequency with which it makes changes in paths so as to avoid needless oscillations; in that case it may only decide to change a path if the estimated benefit is very high. CPN has been implemented in several wired and wireless network test-beds. It has also been considered as a means to direct people in crowded environments, or in emergency situations.

CC: You have collaborated with the telecommunication and computer industry in various capacities. How useful/relevant are theoretical results for this industry?

EG: I think that the value of theory in our field, when it is based on realistic assumptions and sound evaluation, lies in its ability to provide tremendous shortcuts that avoid a lot of tedious work based on experimentation and testing. My first inroads into the telecommunications industry were related to the performance evaluation of the E10 electronic switch in the late 1970s. The E10 was in fact a large scale computer, together with electronic equipment, that was going to be used to establish and automatically manage large numbers of telephone calls. It was to replace the previous "dumb" electronic switching systems. The French Telecom research centre CNET had been involved in trying to evaluate whether the E10 was performing up to specification, and they were relying on simulations which were taking orders of magnitude longer than the time it took the E10 system itself to execute the corresponding task. The team studying this was at the end of their tether, and the team leader finally had a (real) nervous breakdown. Together with my PhD student Jean Vicard we stepped in and within six months we had a mathematical model based on queueing networks which was quite accurate and which could be solved in seconds of computer time, rather than in hours or days of simulation time. Thanks to this work, I continued being funded by CNET for twenty years and they hired several of my former PhD students. This also explains that many of my former PhD students teach in France at schools such as *Institut National des Télécommunications* and *École Nationale des Télécommunications*.

CC: In France in 1982 you designed and implemented a national vocational training in computer technology called the "Programme des Volontaires pour la Formation à l'Informatique."

EG: This was a very interesting experience. At the suggestion of Jacques Gualino, who was one of INRIA's managing staff, I started working with the people who had launched the "Centre Mondial pour l'Informatique" in Paris, namely Jean-Jacques Servan-Schreiber, Nicholas Negroponte and Seymour Papert. The latter two wanted to help the third world via personal computers, while Jean-Jacques was actually (I think) on a mission to transform the French bureaucracy through a greater use of Information Technology and to attain some form of political power or political role in the process. The year was 1982, soon after the elections that had brought François Mitterand and the Socialist Party to power, so there was an opportunity to make some changes – but the question was what this Centre could do. While these people aimed at lofty and global goals, I decided to tackle a relatively small project. I felt that much of vocational education in France was obsolete and essentially taking misguided teenagers and turning them into disgruntled unemployed people, simply because vocational education was essentially dispensed by obsolete technical educators in obsolete machine shops which "trained" young people to operate obsolete equipment for jobs that did not exist. On the other hand, both industry and the service sector were looking for people who had some simple computer education that could be used in technical and service jobs. However, instructors who were knowledgeable computer scientists and engineers were just too expensive to provide instruction cheaply. Furthermore computer equipment was scarce and expensive. In conversations with Jean-Jacques Servan Schreiber, Pierre Lafitte (then President of the École des Mines in Paris) and myself, we came up with the idea of using newly graduated engineers who could do a "vocational education" service for youngsters instead of their military service where they were often getting very bored. Though conceptually simple, the whole programme had to be "engineered", which I did, so that several hundred young graduate engineers could do this new form of civilian service instead of going into the military for one year. Several ministries had to be convinced. Several million francs for equipment, wiring and room security (against computer theft) were needed to get started, and the network of training centres for unemployed young people had also to be incorporated into the task. The long and short of it is that we were successful: up to seven hundred young graduating engineers and computer scientists got involved in this programme each year. Personal computers from a variety of sources were purchased and installed in small groups of ten PCs per training centre. Tens of thousands of young unemployed people were trained and many entered the job market successfully. For the first two years I ran the programme and collected detailed statistics about what was happening. Then the programme was taken over by existing social and government bodies. It came to an end towards 1989 after Jacques Chirac became Prime Minister and some things introduced by the Socialist government were abrogated.

CC: You also served as Science and Technology Advisor to the French Minister of Universities, and member of the Executive Board and of the Science and Technology Board of the Data and Information Fusion Defence Technology Centre in the UK and chaired the Technical Advisory Board of the US Army Simulation and Training Command.

EG: The VFI Programme that I discussed before attracted the attention of the then French Minister for Universities, Professor Roger-Gérard Schwartzenberg. Normally I should never have been in his group of advisers: I was a recent immigrant who had not studied at a Grande École. All of his other advisors, except the three political appointees from his party who had been to Sciences Politiques (Sciences Po in Paris) had either studied at ENA (École Nationale d'Administration) or at École Polytechnique. There was a Professor of Medicine who advised the Minister for the medical side of things, and then this strange individual: me. Some of the other people in his group of advisers and higher civil servants in the ministry obviously thought I was totally out of place. But I was a young professor from the best science campus in France, Orsay and I taught part-time at École Polytechnique, so I could not be all stupid. I spoke and wrote French well, and the Minister's parents had been immigrants, so he was open minded. I was offered the job because the VFI programme had shown that I was a "go getter", able to handle large projects and deal with the arcane administration. Sure enough I did bring together another large project. The year was 1984, and most students in French Universities and Grandes Écoles did not have an introductory course in Computer Science. The barriers were the usual ones: where to find the lecturers, where to find the computers, where to find the space with appropriate electrical and network connectivity as well as security, and what to teach. The whole funding issue needed to be dealt with because we needed to buy eight hundred PCs and install them in groups of eight or ten, and the installation itself would cost quite a bit of money. We had to open many junior faculty positions for the teaching. We set up working groups to design the material that would be taught by group of disciplines: math-physics, biology, economics, humanities, and so on. I will not dwell on the details, but it worked out well; and also made many of my colleagues unhappy because they thought they could use the equipment funds much better for CS research, without realising that we could not attract such a large investment in research alone and that the equipment and new faculty were in themselves an investment in research as well. In my role as advisor, I had several other jobs too: monitor and expand the different scientific disciplines that I was dealing with, monitor the engineering schools, deal with the transformation of the École Normale Supérieuere (a very interesting story to tell separately some day), the transformations of PhD programmes and so on. An initiative which proved very useful was the "Arrêté" which has allowed some of the Grandes Ecoles to deliver the PhD degree: it has significantly increased the research activities at many of the elite schools in France. At the end of two years of doing this job from 8am to 8pm, I was totally exhausted. I was delighted (!) when in the Spring of 1986 the Socialist Government lost the elections and I could leave this harassing activity to return to my lab. In those two years I did manage to write one or two decent papers and to graduate some PhD students, but it was tough.

You mentioned the Technical Advisory Board (TAB) of the US Army Simulation and Training Command. I spent 1993 to 1998 at Duke University as Head of Department, and then moved to Orlando, Florida. There I was the Director of the School of Electrical Engineering and Computer Science (SEECS) from 1998 to 2003, which I founded by merging several programmes at the University of Central Florida. I was in contact with the neighbouring modelling and simulation facilities for the US Army where much of the training is heavily computerised. I was asked first to sit on this TAB for a year, and then to chair it for four years until I moved to Imperial College. This offered possibilities for interaction with a sophisticated organisation in areas such as virtual and enhanced reality, games, simulation, networking and distributed computing. At UCF I was also Associate Dean of Engineering and headed an organisation with a total of 2200 students, nearly 100 instructors, three Master's and three PhD programmes, and four distinct undergraduate degree programmes in Computer Science, Computer Engineering, Electrical Engineering and Information Technology. In the five years I was there, we secured $ 15 Million for a new building, and it nice to participate in its design. I visited it in April 2010, and enjoyed seeing my "creation".

In 2003, when I joined Imperial College, the UK Government had decided to transfer much of its Defense related research (except for the top secret stuff) to Universities. I was one of the writers of a proposal to start a research centre around Imperial College joining with other universities and industry, and a budget of £10 Million per year, with half of it from three companies: BT, General Dynamics UK Ltd and QientiQ, which ran was until 2009. Since I was involved in the inception, I became a Member of the Executive and of the Science Board of this Data and Information Fusion Defence Technology Centre. It meant weekly travel around the UK, and was a good way for me to "immigrate" more rapidly. Now that it has ended I appreciate the opportunity to spend more time on own research.

CC: What gives you more pleasure in the academic work?

EG: I think that we are so lucky to have such a fun job. That's probably why we are not good at getting a decent salary in relation to the number of hours that we put into it. Exercising my curiosity and learning new things, being able to talk to experts about subjects that are new to me, being a bit of clown when I lecture, and enjoying the interest of young people, these are some of the things I really enjoy in my work.

CC: Did you ever miss a target? How did you cope?

EG: I miss targets all the time, and one reason is that I am rather dispersed as to the subjects that interest me. Right now they are Computer Networks, Gene Regulatory Networks [24], Viruses in nature and in computers , Economics [27], Synthetic Chemistry [25], and a few other things (!) .. I have given up pursuing conference deadlines. I try to publish papers on my work in the best relevant journals, and I benefit from serious refereeing and criticism: referees are my best teachers these days!

CC: Many thanks!

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