Back to the roots of ARPANET and Internet history with Alexandre Serres

Valérie Schafer, Sarah Cooper, Camille Paloque-Bergès

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While Janet Abbate's *Inventing the Internet* (1999) and Patrice Flichy's *The Internet Imaginaire*,[1] both contemporaries of Alexandre Serres' thesis, have had a clear impact on the Anglo-American academic world and remain seminal in the historiography of the history of ARPANET and the Internet, the PhD "Aux sources d'Internet" ("The origins of the Internet"), defended in 2000, has remained less well known outside France.

Produced within the fledgling discipline of Information and Communication Sciences and supervised by Christian Le Moënne and Jean-Max Noyer,[2] this PhD research is, however, well known and recognised by specialists in France.

Alexandre Serres[3] was a lecturer in Information and Communication Sciences at URFIST[4] in Rennes, which he has co-directed from 2002 to 2018. He has focused his career on topics that are of ongoing relevance for information practices, with a particular emphasis on three areas: information cultures and transliteracy, information evaluation, and the study of researchers' information practices. After his PhD, he has tended to concentrate less on the historical field, with the exception of his production with Valérie Schafer of an online anthology entitled "Histories of the Internet and the Web.[5]" But the results and conclusion of his thesis are still valid and justify a translation that will reach a broader audience than the French-speaking community.

After a critical study of the narrative of ARPANET's alleged military origins, the thesis seeks to highlight the uncertainty that characterises innovation as well as the multiplicity of temporalities at work in the emergence of ARPANET. This study intertwines the long process of ARPANET's emergence through an examination of its diverse and multiple components (with a large part devoted to interactive computing and time-sharing) and the socio-technical networks they constitute, with a critical use of the translation model and a reflection on the history of information tools and on the difficulties of writing a "processual history.[6]"

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[1] First written and published in French by Editions La Découverte (2001), then translated and published by MIT Press (2007).

[2] Alexandre Serres notes the key role played by the latter in his choice of topic: "I would first like to thank Jean-Max Noyer, who initiated this journey and who, one day in autumn 1996, suggested that I change my destination after a false start (on a thesis topic that was quickly abandoned) and resume exploring the history of tools and information systems. This proposal resulted in a first chronology, "From Paul Otlet to the Internet," which addressed the challenge of establishing the multiple and heterogeneous intersections involved in the emergence of our information tools" (p. 5).

[3] https://perso.univ-rennes2.fr/alexandre.serres

[4] "Regional Unit Training to Scientific and Technical Information." https://www.sites.univ-rennes2.fr/urfist/

[5] "Living Books about History" collection. http://www.livingbooksabouthistory.ch/fr/book/histories-of-the-internet-and-the-web, Switzerland: InfoClio.ch, 2016.

[6] See the abstract of Serres' original thesis manuscript: Alexandre Serres. Aux sources d'Internet: l'émergence d'ARPANET. Exploration du processus d'émergence d'une infrastructure informationnelle. Description des trajectoires des acteurs et actants, des filières et des réseaux constitutifs de la naissance d'ARPANET. Problèmes critiques et épistémologiques posés par l'histoire des innovations. [The origins of the Internet: the emergence of ARPANET. Exploring the emergence process of an information infrastructure. A description of the trajectories, the actors and agents, the sectors and networks that paved the way for the creation of ARPANET. Critical and epistemological problems posed by the history of innovation], Sciences de l'Homme et Société. Université Rennes 2, 2000. Français. <tel-00312005>

We have chosen to introduce the reader to the final part of Serres' research – an inevitable choice within the 600 pages of this work[7] because it echoes other articles and interviews in this special issue by adopting a critical perspective based on the Actor-Network Theory –, within which, more specifically, the author refers to a "sociology of translation" approach. To start with, the ANT theoretical framework, based on a constructivist postulate, is key to positioning technical and scientific aspects, which are still often given a prominent place in discussions about Internet histories, in broader social contexts where people, culture and policies matter as much as machines and concepts. These concerns are explicitly conveyed by McKelvey and Driscoll in their article (in this issue) on the IMP as a boundary object, a concept in science and technology studies (STS) that resonates with ANT – extensively used by Serres himself to explain how ARPANET was at the intersection of the three worlds of science, business and the military (although opinions differed as to their relative importance). Other critical issues related to ANT and STS, such as re-assessing the role of individuals within research and innovation collectives, are raised in Morten Bay's contribution (in this issue) about the packet switching dispute, as well as in the two interviews, one with ARPANET administrator Larry Roberts and the second with the two French ARPANET contributors Michel Élie and Gérard Le Lann. The latter interview also covers Cyclades and other French computer networking innovations and contributions that are mentioned in Serres' work.

Other parts of this ample analysis could obviously have been chosen. Those relating in particular to the importance of involving actors, of which RFCs are just one example, seem to us to be as fruitful as ever, almost 20 years later. The critical historiography of the Internet and ARPANET, analysed at the beginning of the thesis, is testament to the circulation in France of many seminal writings which laid the foundations for ARPANET's official history, such as *Netizens* (1998) by Michael and Ronda Hauben, *Where Wizards Stay Up Late: The Origins of the Internet* (1998) by Katie Hafner and Matthew Lyon, and Howard Rheingold's *Virtual Communities* (1993). But it also shows how a 1993 Master's dissertation, now largely forgotten, by a student from the School of Communications at Grand Valley State University, Henry Edward Hardy, entitled *The History of the Net*, represented an important source for the first French writings on the Internet: "Thus Hardy's work served as a historical reference for the first synthetic study published in France, Arnaud Dufour's comprehensive *Internet*, in the collection *Que sais-je?*, the first edition of which was published in 1995. We will see later on just how important this bibliographical element was in disseminating the current interpretation of origins.[8]"

But the starting point for Serres' thesis was in wanting to take a stand against these commonly accepted interpretations, seen as too monolithic, and especially against the over-emphasis on military origins. In contrast with accounts along these lines by stakeholders and journalists, he recalls the first academic steps in researching the history of ARPANET, in particular the Conference on the History of the Internet organised by the *Society for Social Studies of Science* in October 1995 at the University of Virginia. Alexandre Serres had indirect access to its content thanks to the report by Geoffrey Bowker on three lectures, those by Judy O'Neill, Juan Rogers and Janet Abbate. He highlights the importance of researcher-conducted interviews, such as the interview carried out by Judy O'Neill for the Charles Babbage Institute. These interviews would come to constitute the main sources of his analysis:

[7] The full text is accessible in an open access archive: https://tel.archives-ouvertes.fr/tel-00312005.
[8] Our translation, from p. 24 of Serres' original thesis manuscript.

"Specifically concerning the emergence of ARPANET, the recording and dissemination, in paper or electronic form, of interviews with several dozen people involved in this history is one of the most crucial sources for any historical research. Unlike personal writings for the purposes of self-promotion or short interviews conducted by Internet users or journalists in a hurry, these are interviews from a long-term perspective, conducted by researchers specialised in the history of computer science (e.g. William Aspray, Artur Norberg and Judy O'Neill) […]. With this type of document, we are leaving the realm of "organised memory" and celebration to enter, finally, into that of historical intelligibility […].[9]"

Based on these sources, Alexandre Serres sought to show that the emergence of the ARPANET network was the result of a long innovation process lasting about fifteen years, involving a large number of actors from the American "military-scientific-industrial complex" and comprising various interwoven historical narratives (cybernetics, hypertext, interactive computing, packet switching transmission, time-sharing, the Cold War, etc.). By carefully following the cybernetic path, the socio-technical matrix of Whirlwind, SAGE and time-sharing, the strategic role of the MAC project and the design, mobilisation and "irreversibility" phases of ARPANET, he offered a study that goes far beyond historical causality, even considered in all its complexity.

Camille Paloque-Bergès and Valérie Schafer

Translation of part of the conclusion of Alexandre Serres' PhD on "The origins of the Internet: the emergence of ARPANET" : Lessons and unresolved questions about the history of Arpanet

At the end of this long narrative, what lessons can be drawn from the history of ARPANET? What issues does this attempt to apply the sociology of translation to the history of information infrastructures raise? What (self-)critical observations can we make about our own approach? Have we succeeded in our gamble?

This last part will attempt, if not to answer these three questions, at least to address them in all their complexity, in order to come back to our initial thoughts on the history of information systems. In the first part, we raised a difficult central question that now needs to be re-examined: how can we develop a history of an "information infrastructure" of this type? How can we write a "processual" history about something as vast as the emergence of this computer network?

First, let us note some obvious facts: the history that has been presented here is, of course, not the whole history, nor is it the only possible history, and it is certainly not the "true" history of the Internet's ancestor.

It is by no means a total history, a concept which by its very nature remains illusory. Since history is always a partition of reality, a choice of plot, the construction of a narrative, the history we have presented here, despite its apparent exhaustiveness, is no more than a selective, partial reading of a broad historical phenomenon that, by its dimensions, eludes any attempt at "totalisation." We have shown only part of a protean innovation process.

[9] Our translation, from p. 46 of Serres' original thesis manuscript.

Our history is also, it must be remembered, only one of many possible histories. Multiple "points of view" allow several kinds of histories about the emergence of ARPANET, even if they reflect pre-established and relatively conventional divisions: technical, military, economic, cultural, social, political histories, etc. However traditional and limited (at least epistemologically) these particular points of view may be, they can give rise to highly valuable narratives and histories.

We are thinking in particular of the value of a technical history of networks, which would attempt to piece together, from the point of view of tools and machines, the lengthy internal developments of the computer. A technical history of the Internet would have to get to the core of the history of computing, of which it is an essential branch, but also to explore the long history of remote communication technologies. This dual perspective is further enriched by a third dimension, that of knowledge and information tools, the development of a "technical/documentary" branch to which the Internet has been linked from Engelbart's first hypertext systems to today's search engines. The technical history of Internet technologies, which stands at the crossroads of these three long-term historical paths, could prove to be highly relevant and fruitful. It would undoubtedly find its full legitimacy and would be of great interest if it could put into perspective the various processes and technical principles at work according to the concepts developed by Gilbert Simondon. If the "concretisation process" of the networked computer, i.e. the trend towards internal coherence of its functions and integration of its interfaces, could be described and analysed with as much rigour and attention to detail as that of the internal combustion engine was under Simondon's scalpel, then our understanding and knowledge of the Internet would take a big step forward.

But such a history, which requires thorough knowledge in two areas – the philosophy of techniques, and computer science and telecommunications –, far exceeds our capabilities, and our project was quite different.

Finally, at the risk of sounding trivial, it is clear that under no circumstances have we sought to develop the "true" history of ARPANET: the search for truth or ultimate and definitive causes is not part of our approach, and while we advocate a rigorous commitment to the verification of reported facts (the most effective guarantee against all revisionism), our objective was to develop a history that is "truthful" rather than "true."

Five lessons to be drawn from this narrative of the emergence of ARPANET

[…] We have identified at least five lessons that will enable us to readdress five key questions in the history of technological innovation:

- the emergence of ARPANET cannot be reduced to one or more causes, which again raises the central question of historical causality;

- while the innovation process was eminently collective, like all technical innovation, the role of individuals was no less decisive, and the interaction between the collective and the individual may need to be re-examined;

- ARPANET trod the line between preparation and uncertainty: the entire emergence process can be seen as constantly oscillating between preparation and uncertainty, between planning and coincidence. The ambivalent nature of innovation processes seems to be a key issue;

- ARPANET stands midway between a technical approach and the impact of stakeholder associations: to what extent do internal influences, the "technical trend," come into play in innovation processes? Does the example of packet switching bring us back to technical determinism?

- ARPANET and "Americanness:" was the first network specifically American? What role does cultural determinism play in innovation?

By addressing each of these questions, we will try to critically review our approach.

The illusory search for causality

After describing the different processes that led to the emergence of the first computer network, are we in a position to answer this simple, recurring, irksome question: why ARPANET? Once we have got to grips with the *how*, are we finally able to understand the *why*, as we initially suggested?

Unfortunately, it appears that we are not. Admittedly, a number of hypotheses have been ruled out: the project was not the result of the Cold War or the product of a military plan. And if our research has served at least to destroy this myth, it has not been in vain. Other explanations, other partly known avenues have been reinforced, confirmed and demonstrated by describing the processes: ARPANET was indeed born of a desire to share computing resources between researchers under contract with ARPA. This project for sharing information and resources drew on various factors, including the financial need to rationalise ARPA's expenditures, the discourse of interactive computing and networks, the technical achievements of time-sharing, etc. But by exploring these different paths that take us to the origins of the process, have we actually been able to determine the root causes, the real reasons, which explain the birth of the network?

[…] From the perspective of the sociology of translation, which we have adopted, the ultimate explanation for innovation lies in the strength of the links and networks established by the actors. ARPANET was able to be built because of the success of the translation processes undertaken by the various actors, because sufficiently strong links, solid networks, numerous allies and the resolution of controversial issues allowed it to emerge. A successful innovation can only come about as a result of strong association and translation processes, for which there is no secret cause. Describing these processes can admittedly highlight multiple local causalities, as we have seen (time-sharing, interactive computing, rationalisation, "ARPA style," etc.). But none of these causes can claim, on its own, to encompass all the others; no explanation, however truthful, can really explain the success (or failure) of innovation, so long as it fails, as research on historical causes often does, to consider the countless mediations, platforms, processes, forces and actors, whose mobilisation and association are essential to establishing a valid, up-to-date understanding of this "causality." In other words, claiming that ARPANET was "born of a desire to share computer resources" is certainly correct and true, but this "cause" does not help us to explain why the project was successful.

[…] This almost obsessive search for "true causes" ultimately comes up against Paul Veyne's strong objection: "The choice of narrative alone determines what will be causally relevant or

not; science can make as much progress as it wants, but history will hold to its fundamental basis, according to which cause exists only through narrative."[10]

[…] Challenging the quest for origins and causality has been the cornerstone of our approach, although we have emphasised the difficulty of establishing such a postulate. But have we succeeded, in our endeavour, in overcoming this notion of causality? How far have we been able to "follow" these forces that "conspire and translate"? Not so much and not so far as we would have liked. While we believe that we have more or less succeeded in establishing the multiplicity of ARPANET's origins, it is likely that our narrative (that of time-sharing and resource-sharing) has sometimes played tricks on us, making us favour one causal path over others that were possible. The urge to search for causes is not easy to resist.

The interaction between the individual and the collective

Research on the new sociology of science and technology has long demonstrated the collective, social nature of the construction of scientific fact and technological innovation.

The myth of the genius inventor, already challenged by the deterministic vision of innovation, has not survived attacks from the other side, demonstrating the social construction of techniques and the effacement of the inventor behind his network.

And in our description of the translation processes, we have constantly stressed the collective nature of this adventure, the multiplicity of the actors and agents involved. Even without extending this notion to "non-humans," as Latour does, the "human collective," as a characteristic and condition of technological innovation, is therefore for us an asset, one which does not need revisiting.

That is, unless it needs to be balanced by refocusing on the efforts of individual actors.

Indeed, it seems to us that the role and singular nature of individuals have sometimes been overtaken by profit and loss in the social constructivist approach to innovation. While innovation is indeed a collective achievement, does this mean that individuals should be hidden in a fog where all individualities are blurred, whether by relevant social groups, social classes or even actor-networks?

We may be reproached for going too far the other way and often having given too much emphasis to the role of individuals in the overall process. It is true that we have discussed at length the figures of Licklider, Engelbart, Roberts, Taylor and many others, each time emphasising the importance, singularity and specificity of their intervention in the emergence process.

Should we see this as the (masked) return of the myth of the genius inventor? Does ARPANET owe everything to the talent of these network pioneers? Not at all, but by insisting on the role of very specific actors, we essentially wanted to emphasise a twofold conviction, both "moral" and theoretical.

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[10] Veyne, P. (1978). *Comment on écrit l'histoire. Suivi de Foucault révolutionne l'histoire.* Paris : Seuil, 117.

On a level that we will qualify as moral by simple convenience, we remain attached to a conception (inspired by Sartre) of an individual being fully and irreversibly responsible for his or her actions. And it seems to us that, in the field of scientific and technological innovation, this responsibility of specific individual actors, without necessarily having an ethical dimension, also plays a part and is ultimately decisive for the future of an event or process. […] But if we had left it at that, we would indeed have fallen back into the outdated idea of the "genius inventor."

We need to go further and, in order to fully recognise the role of a given individual actor, to try to show, beyond the usual qualifications, what made this role so important. And this is no more or less than the ability of these individuals to connect, form and interconnect (with) other entities. The key role of individuals in innovation processes is thus a strong theoretical consequence, in our opinion, of this associationist vision. It is because a given individual was able to attract the interest of others, forge alliances, neutralise opponents and mobilise allies that, at a specific moment, he or she played a more or less decisive role in the emergence process. Let us think in particular of the importance of Larry Roberts, in the crucial years 1968-69, who was active on all fronts at once and "held" in his hands all the chains of actors and translations revolving around the ARPA Network project. If another IPTO official had not been so gifted in forming associations at that time, could the network have been created (at least as quickly and as robustly)?

What makes individual actors so important in an approach based on the sociology of translation is not the "intrinsic qualities" of a particular researcher (talent, genius, audacity, etc.), but the application of these qualities to real-life situations, i.e. the ability of this researcher to associate, move and translate the collective. The "collective" should be understood here in the broad sense given by Latour and Callon, i.e. the collective of human and non-human associations. […]

The individual factor is not only involved in the ability of some people to "hold" multiple chains of translations and actors. We have also tried to highlight the importance of personal, inter-individual relationships (which cannot be reduced to processes of "capture," incentive or neutralisation). One of the pitfalls of an overly "strategic" conception of actors seems to be that it conceals the informal, personal and subjective dimension that characterises many relationships between the actors involved in innovation. On many occasions, the narrative is that of these intellectual complicities, these friendships – and also these enmities […] .[11]

In short, the interaction between individual and collective efforts and the consideration of personal relationships between researchers, of their nature and intensity, seem to us to be major elements in the elucidation of a process of technological innovation.

ARPANET treading the line between "crystal and smoke"

Preparation vs uncertainty, formalisation vs informal spontaneity, normalisation vs chance, order vs disorder: the whole long process of emergence seems to take place between these two axes. Here, too, research on the sociology of translation has shown the profound uncertainty that prevails in the processes of innovation: the uncertainty of actors, their

[11] Examples include the friendly personal relationships between Licklider and Fano, Roberts and Kleinrock, Cerf and Crocker, and the less friendly links between Teager and McCarthy, Heart and Kahn, Taylor and Fano, etc., and their impact on the development of networks of actors.

identity, their role, uncertainty about debates whose outcomes cannot be known at the outset, uncertainty about technical objects under construction which have not been stabilised. […]

In our opinion, this generalised uncertainty can be expressed in three ways:

- the role of real uncertainty, indeterminacy and chance in events, micro-processes and the trajectories of actors;

- the role of informality (which is not exactly uncertainty, but which we nevertheless place under the same heading) in encounters, decisions and relationships between actors;

- the interaction between, on the one hand, this uncertainty and informal character and, on the other hand, the aspects of preparation, organisation and planning of the process.

The role of chance in the emergence process

Whenever we have had the opportunity, we have emphasised […] the hazardous and uncertain nature of several key moments in this story: the arrival of Licklider at ARPA, the recruitment of Sutherland, the start of the MAC Project, etc. One could also consider, through the various examples we have described, that the history or future of the emergence process has more than once been played out in these unexpected encounters, in these conference feedback discussions,[12] or in decisions taken at the flip of a coin (see Licklider).

Without reducing innovation processes to a pleasant series of unpredictable events and anecdotes, it is nevertheless necessary, in order to better understand technological innovation, to fully reproduce this role of chance, as well as that of individuals. Only by patiently tracking the actors' trajectories can this element of chance, which can sometimes influence the future of the emergence process in an unexpected way, be highlighted.

The role of informality in scientific networks

Another major characteristic of the emergence of ARPANET, which we have discussed at length and often pointed out in the narrative, concerns the informal, spontaneous nature of many processes. Whether it is the functioning of ARPA and IPTO (the "ARPA style"), relationships between researchers, encounters and discussions, the technical notes themselves (formalised as RFCs), the crucial decisions taken after a brief improvised meeting (remember the Herzfeld agreement obtained by Taylor to develop the network project), the management of ARPA's Contractors or the internal functioning of the Network Working Group – the whole process is dominated by a remarkable flexibility, spontaneity, minimal organisation, even "informality." That there is a certain "Americanness" here is undeniable.

But there is nothing new under the sun, it will be said, and we have known for a long time that "science (or technology) in action" is more down to joyful disorder than the orderly arrangement of a French-style garden.

[12] Let us recall, for example, the importance of the discussion between Wes Clark and Larry Roberts after the Ann Arbor meeting, during which the idea of the IMP network was suggested.

Here again, the reconstitution of micro-processes makes it possible to restore this dimension of the innovation process, which has been buried under more large-scale and retrospective causal explanations.

One of the keys to ARPANET: the subtle interaction between spontaneity and preparation

These dimensions, which characterise all innovation processes, are particularly significant here. And the fact that uncertainty and informality lie at the heart of the American machine is all the more interesting to highlight, first of all to counter the often simplistic representations of the "military-scientific-industrial complex," but also because of this paradoxical balance between voluntarism and spontaneity that seems to characterise the entire process of ARPANET's emergence.

Because, while there is uncertainty and chance in the decisions and trajectories of actors, we are also struck by the incredible voluntarism of these same actors.

The fact that the ARPA network was not formally decided, that this project was not the subject of a preconceived political, military or scientific plan, is undeniable, and hardly surprising. But its emergence can be attributed above all to the extraordinary energy and fierce voluntarism of a few individuals (Taylor and Roberts in particular) and their ability to plan the project, once the necessary forces had been assembled.

This is perhaps what makes the difference between the emergence of ARPANET and that of other technical projects, resulting from political decisions and "plans" that were drawn up on paper even before having found the first ally.

[…] It was only when a number of allies were convinced (ARPA's Contractors), recruited (the BBN team, NWG students) and neutralised (ARPA and Pentagon leaders) that plans, schedules, contracts, deadlines and programmes could be established, then firmly organised and implemented. What would have happened if Roberts had done the opposite?

Similarly, while the implicit rule in the ARPANET actor-network was to encourage flexibility in terms of operation, it was also based on efficient organisational methods, on delegation, autonomy and compliance with collective deadlines.

In our opinion, these subtle (more or less deliberate) balances, this complex interaction between "chance and will" (rather than necessity), this combination of organisation and informality constitute one of the most plausible "causes" of the network project's success. If an explanation is to be found, we would place it there, in the collective, technical, managerial and social "intelligence" that has been demonstrated by a number of individuals who were particularly gifted at building strong links between multiple entities and who were also given decisive political and financial support. The product of a combination of spontaneity, self-organisation and proactive programming, ARPANET was soon able to benefit from a series of factors favourable to its development. The paradox between the resolute determination, even authoritarianism, of the IPTO's leaders and the openness of the project (openness of technical content, applications and actors), a paradox that we have likened to the famous

metaphor of "crystal and smoke," remains one of the most striking features, in our opinion, of this emerging process.[13]

A technical- or stakeholder-led approach? The role of technical factors

ARPANET was based on packet switching; it was the first large-scale computer network to use this mode of data transmission.

The importance of this technology and especially the conditions in which it was invented lead us to re-examine the respective roles of technical determinism and an internal, technique-based rationale.

A deterministic reading could attribute all the development processes of our current communication networks to this crucial invention of the 1960s […]

But the conditions in which this technology was invented may also lead to another possible reading of this innovation, inspired by the influence of an internal, technique-based rationale.

We have seen that several similar technical projects emerged at the same time: Paul Baran's distributed network project, the experiment of the British NPL network by Davies and Scantelbury, and ARPANET. How can these coincidences be explained? Is there a dynamic for invention that is beyond the actors' control?

According to Leroi-Gourhan, techniques obey the laws of evolution, which the anthropologist has characterised by the concepts of technical *trends* and *occurrences*. […] We can begin by speculating that the simultaneous invention of packet switching is a specific technical occurrence that is dependent and related to the circumstances and environments that surrounded it. But this technical occurrence, which should be analysed with the same meticulousness, rigour and erudition used by Leroi-Gourhan to study transport or manufacturing techniques, brings together and conveys universal components of a trend in distance communication techniques, which can be summarised by the threefold search for speed or efficiency, quantity (of both data to be transmitted and actors in communication, since packet switching transmission precisely allows several machines, therefore several people at the same time, to communicate) and accuracy (message splitting, fine packet routing, etc.).

The notions of technical trend and occurrence, which express a degree of technical determinism, thus make it possible to see the invention of this mode of communication from a long-term perspective, as related to technical progress in remote communication, of which packet transmission represented the culmination.

But how can we link this vision of the development of transmission techniques, based on internal laws and an evolutionary technique-based dynamic, with the sociology of translation, which shows us the uncertainty of innovation processes and the social construction of

[13] From this perspective, it would be interesting to compare the innovation process of Minitel with the emergence of the American network. Without a detailed knowledge of the internal processes that led to the launch of Minitel, we can summarise the major difference between the two innovation processes by referring to the terms used for their genesis: it would seem strange to speak of the "emergence" of Minitel (since this term has spontaneous connotations, implying self-organisation and natural movement), just as it would seem inappropriate to speak of the "launch" of ARPANET.

techniques? This is a recurrent question, which is the subject of much of the debate raised by the translation model and contributes to some of the criticism levelled at it. Latour and Callon have often been accused of ignoring this internal technique-based dynamic, since technicality (as well as the scientific content of inventions) often seems to be obscured when considered alongside the interactions of actors and the construction of networks. […]

Acknowledging the existence of an internal, technique-based dynamic, theorised by the notion of technical trends, does not mean that the emergence of ARPANET is the product of this dynamic. We prefer to see the simultaneous invention of packet switching transmission as the expression of a "research front," a "reverse salient" as Thomas Hughes put it, which can be summarised as follows:

- a handful of computer scientists in the 1960s "have the specific desire[14]" to make computers communicate with each other, for various reasons (ideological, technical, economic, etc.);

- the existing technology at the time (circuit transmission) is not adapted to this need;

- other modes of transmission are therefore necessary, but very few researchers and actors are convinced of this need (regardless of the innovation model, we should not lose sight of the pioneering, innovative nature of a few researchers, who were capable of identifying a problem that no one had yet seen before anyone else);

- a new "research front" then opens up, on which a few isolated and separate teams and researchers (Kleinrock, Baran, Davies, etc.) are working;

- under the effect of a complex set of translation operations, this research leads to the construction of a large-scale computer network.

A new technical occurrence thus appears, the result of a variety of methods (see the various contributions of research by Kleinrock, Baran and Scantelbury-Davies), expressing a broader, universal and more long-term trend.

While the notion of trend does not explain the emergence of an innovation, it resituates it in a broader time frame.

The "Americanness" of ARPANET

Is there such a thing as a "cultural determinism," or a "social variability of innovations"? For Marc Maurice,[15] it is impossible to isolate innovations from their societal context: workspaces that favour innovation are structured by the exchange and cooperation networks that are specific to a society. […]

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[14] To use this very accurate expression by Jean-Claude Guédon (Guedon, J-C. (2000). La force de l'intelligence distribuée. *La Recherche*, no. 328,16). There is also a dimension of desire in this whole story that we have probably not sufficiently explained.

[15] Maurice, M. (1989). *Les Bases sociales de l'innovation industrielle et du développement des produits*, Comparaisons internationales et analyse sociétale, miméo LEST, in Vinck, D, *Sociologie des sciences, op. cit.*, 239-40.

Two questions can summarise this issue of the cultural or social dimension of innovations: Is ARPANET specifically American? And does this Americanness explain its success? In other words, is the first computer network the result of American power? As much as the first question seems legitimate and well founded to us, the second seems more pernicious, because it inverts the terms of the explanation, suggesting that the result is in fact the cause.

There is little doubt about the American cultural character of ARPANET.

If all technical objects are a reflection of a world, we can suggest that this network exemplifies a broad swathe of American society in the 1960s. The complex ARPANET system, a typical "made in USA" product, seems to reflect the whole of American society in one way or another: whether through values (notably the belief in technological superiority, the importance of the "ideology of communication"), interests (political, scientific or strategic), geographical constraints (e.g. the importance of remote communication in a "continent country"), the practices of actors and management methods ("ARPA style," flexibility, etc.), this Americanness is expressed in various ways and can under no circumstances be reduced merely to the utopia of communication, often considered as the typical American factor. We would suggest that the project management methods, the types of relationships established between the actors and the combination of informal methods and planning that we have sought to highlight are just as "American" as a belief in the virtues of communication.

But what characterises "Americanness"? It is a difficult question, which we can only address in a roundabout way.

It seems to us that the practices and values, the management methods and ideology, in short all the elements of ARPANET that are undeniably American can be subsumed in the more general notions of network and relationship and in the associationist metaphor that is perhaps at the core of a certain American (or Anglo-American) vision. In the views of information technology and society developed by Licklider, we can see the modernisation of an older philosophical tradition that is typically Anglo-American and dominated by associationism. We have already pointed out the path that links Vannevar Bush and the idea of hypertext, Norbert Wiener and cybernetics as a science of relationships, and Licklider and communicational computing. But this lineage can be traced further back to Hume, the philosopher of associationism. This influence of Anglo-American associationism extends beyond philosophy to language and literature, as Deleuze so clearly demonstrated […].[16]

The "associationism" of language, literature, philosophy and cybernetics, of a certain conception of cognitive tools (Bush) and computer networks (Licklider), this primacy of relationships, associations and communication that is central to a specifically American or Anglo-American "design" was embodied in the emergence of this computer network. Whether in terms of its discourse and vulgate, impregnated with the ideology of networks, or its effective practices, based on the spontaneous efficiency of associations, the whole process of ARPANET's emergence condenses and thus expresses a profound Americanness.

Any innovation process is therefore always embedded in a given society, of which it is the expression. And while other technical networks, based on the same technological principles,

[16] Deleuze, G., Parnet, C. (1996). *Dialogues.* Paris : Flammarion, 70.

may have emerged in Europe or elsewhere, they were nevertheless very different in ideological, social, cultural and philosophical terms. Only the "technical part" escapes borders and social determinisms, being expressed in the notion of a universal "trend," as we have noted above (see again the simultaneous invention in the United Kingdom, the United States and France of packet switching transmission).

While the first question of ARPANET's Americanness is therefore easily answered by a clear "yes," the second is more complex and invites us to reconsider the different destinies of the three projects: why did the Americans succeed where the British, then the French, failed, when they had the same techniques and were virtually at the same level of conceptual advancement? […]

All our work has focused precisely on showing that the key to the success of this innovation was the multiple successful translation operations implemented by the actors. If the networking project was successful (although we saw that at the outset nothing guaranteed its success), it was because of the ability of a few researchers and organisations to capture, interest and mobilise other entities, to build closely intertwined networks. The great strength of the ARPANET process comes, as we have repeatedly pointed out, from this extremely rare combination of voluntarism and spontaneity, control and flexibility, concentration of resources and decentralisation of tasks. ARPA successfully mobilised teams of initially reluctant researchers by making them actors in their own project. This undoubtedly explains much of the "American success" of this system, of what constitutes its strength.

[…] it would be particularly interesting to be able to explore, in a "symmetrical" way, the conditions of emergence of ARPANET with those of the CYCLADES Project, another project based on packet switching transmission conducted in France at the same time. This project, launched in 1972 by the Délégation à l'Informatique, seemed destined for a future just as bright as its American cousin, but was finally shelved for socio-political reasons (the desire for hegemony of the telecoms administration, French-style centralisation, rivalry between telecoms and computing, etc.) that perhaps merely serve to demonstrate that the successful translation of an innovation process is beset with more difficulties in France. […]

Unbalanced testimonies and difficulties following both sides of debates

Finally, one last aspect of the corpus is worth noting, as it also poses a methodological and theoretical challenge.

Indeed, while a corpus exploring traces of a past innovation process is inevitably dominated by the texts, writings and testimonies of the actors, it is also characterised by a second imbalance: an under-representation of the opponents of innovation.

The actors and protagonists of innovation are, by nature and definition, easier to follow than their opponents, because they express themselves more both during the process and later on, especially when it has succeeded. As a result, recomposing the actors' verbal traces is inevitably a biased process. For example, we did not have any statements, speeches or declarations from opponents of the network project or of time-sharing. Perhaps we did not do all the in-depth research needed in this area, but even if we could have found the positions taken by IBM, ATT or ARPA's Contractors (which were initially hostile to the networking project), the imbalance between the traces of the actors and those of the opponents would still have been significant.

The reason for this is fairly simple and can be explained by the translation model: it is not the opponents of an innovation who first feel the need to express themselves, to argue and to convince, through various articles and communications. As long as an innovation does not threaten them, opponents do not have to "engage" anyone to reject that innovation. More generally, inertia and technical conservatism do not require a voice: they just need to exist *de facto* and resist the projects and arguments of innovators, who are forced to defend their approach through writings of various sorts.

What are the consequences of this imbalance in the traces of the debates that fuel the innovation process? One of them seems to us to be comparable to some extent to the case of a historian who only has access to the testimonies of a single category of actors in order to rebuild the history of an event […]. In the history of past innovations, the over-representation of the protagonists of a given innovation can lead to an equivalent dependence of the observer on these actors.

But a more problematic consequence of this inevitable emphasis on the "actors' discourse" (to the detriment of opponents or competitors) seems to us to lie in the contradiction with the third postulate of the translation model: the principle of symmetry. Set out in Bloor's "strong programme," the principle of symmetry invites the observer to consider innovations that succeed and those that fail, the supporters and opponents of a project, in a symmetrical and equal way. The study of technical debates must take into account, in equal measure, the arguments, definitions and points of view of both sides. But while this methodological principle, which has been proven to be effective, can be implemented for the study of ongoing processes, insofar as the observer can monitor all the actors involved (protagonists and opponents), what about the exploration of a finished process? Not only have many traces been lost; is there not also a strong chance that the victory cries of the "winners" will have drowned out the past arguments of those on the "losing" side?

In short, this question of traces, of their nature, of the constitution and especially the composition of the research corpus leads us to point out the following three contradictions with regard to certain methodological principles of the translation model:

- since the corpus was constituted *a posteriori*, it conflicts with or limits the principle of immanent follow-up of the process, without preconceived ideas;

- since the corpus is essentially and almost necessarily composed of written traces, of the formalised and voluntary discourses of human actors, it limits the application of the principle of generalised human/non-human symmetry;

- finally, since the corpus is mainly composed of statements by the very actors of innovation (to the detriment of those by opponents or losing competitors), the observer's viewpoint may be all the more directed, in contradiction with the principle of symmetry. […]

For other forthcoming histories

The history of information infrastructures has probably only just begun, and the exploration of the emergence and evolution of digital networks has at least three challenges ahead of it.

First of all, we need to establish a solid basis of "raw" historical knowledge. On the one hand, we are far from having finished identifying and piecing together all the actors, agents and

networks involved in ARPANET's development. Other channels need to be highlighted. And on the other hand, the story of the emergence of other networks (UseNet, BitNet, CSFNet, etc.), their progressive connection within an Internet, the invention and dissemination of protocols – in short the whole continuation of the development of ARPANET and the emergence of the Internet in the 1970s-80s – has to be continued, even if we are now familiar with the broad lines. But can the type of history we have undertaken for the period upstream of ARPANET be pursued downstream, given the diversification and proliferation of actors and agents?

We envision a second historical analysis project focusing on the long chains, the long life of information tools, particularly the intertwining of hypertext and computer network development.[17] Sylvie Fayet-Scribe's pioneering work,[18] which presents in a vast synoptic table the "chronology of media, spatial devices and information retrieval tools," shows the way forward for what could be a general, open, multiple history, integrating the diversity of historical lineages and trying to highlight the connections, interactions and relationships between histories that have been separated for too long (the history of communication techniques and that of information tools, for instance). The very development of tools and techniques related to the Internet serves as a powerful argument for this renewed historical perspective, since it has accelerated the phenomenon of convergence on all levels: convergence of techniques, tools, professions, professional sectors, challenges and, consequently, issues. We would suggest that a few decades from now, the history of methods for locating and searching for information may have been conflated with that of media and communication methods, since by that time the techniques will have merged fully.

But this history of information devices and tools should also be linked to the history of ideas. It would be useful to connect the history of Anglo-American associationism with that of its pervasive influence on the emergence of networks (for Licklider) or on the intuitions of the founders of hypertext (for Bush). Associationist philosophy, hypertext, cybernetics, networks, tools for production, research and information processing and progress in computer technology are now intertwined in the explosion of cyberspace, sometimes forcing us to disrupt well-established boundaries.

Finally, it seems inevitable that a third field of research will emerge to examine the conditions in which history is written and narrated in this era of widespread digitisation. How do digitisation processes affect the traces, documents and corpora of future histories of the present time and the tools for handling these traces? Given the increasing visibility and accessibility of a growing amount of information on the web and the emergence of a variety of tools for processing this information in detail, the very conditions of history as a narrative are changing profoundly, and it is difficult to measure this transformation.

Indeed, new information infrastructures, as embodied in digital networks, are bringing about a paradoxical twofold movement. By focusing on the present time and fragmenting the space/time of past events, digital networks seem to deny the very possibility of history as an

[17] At the beginning of our work, we had planned to deal with this last aspect of the history of the Internet and to devote a significant part of our time to it, by retracing the history of hypertext, from Paul Otlet's premonitions and Vannevar Bush's reflections to the achievements of Ted Nelson and Douglas Engelbart (which were the only ones discussed). Unfortunately, this long history of hypertext has had to be abandoned, to our great regret, for reasons of time and space.

[18] Fayet-Scribe, S.(1997). Chronologie des supports, des dispositifs spatiaux, des outils de repérage de l'information. *Solaris* [online], December no. 4.

accumulation or sedimentation of traces, distanced from analysis. With a given event, its coverage and reception now coinciding, we may be entering a new era of historicity, as Bernard Stiegler points out:

"Analogue and digital technologies are ushering in a new collective and individual experience of time that is a departure from the historical era, if it can be said that the latter is based on an essentially delayed time.[19]"

Digital technologies themselves, the permanent and rapid evolution of which defies analysis, seem to erase their traces as they progress and send their own history into oblivion.

But conversely, digitisation and the mass circulation of information of all kinds are constantly increasing the "material" nature of tomorrow's histories. Never before has access to information, to data that was previously inaccessible, been so extensive and potentially unlimited. This inflation of collective memories is, in some respects, the guarantee of a continuation of history, even if the technical problems of preserving these memories will soon become a crucial issue.

The Internet does not mark the "end of history" but certainly the renewal and transformation of its traces and the conditions of its writing. One of the most profound changes will probably concern the tools used to process these vast swathes of data. As glimpsed with the emergence of Computer-Assisted Sociology tools, the question of tools for researching, processing and displaying information is set to become a central concern in all social and human sciences.

[19] Stiegler, B. (1996). *La Technique et le temps 2: La désorientation.* Paris: Galilée, 137.