A NEW METHOD TO TRACE THE PATH OF INNOVATIONS

The "socio-technical graph" *

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Instead of deriving the rules of scientific method and the criteria of demarcation between science and non-science either from first principles or from the mythical feat of Great Scientists, some philosophers of science have recently tried to abstract them out of detailed case studies provided to them by historians or sociologists. Without abandoning their usual interest for normative rules and criteria those philosophers of science attempt to strike a middle way between a priori and a posteriori definitions of science. This is what has been termed the "naturalistic turn" in philosophy of science (Kitcher: ; Caillebaut:). What these philosophers wish to avoid is the limited, contingent, ad hoc and for them messy explanations historians too often provide. In the meantime a large body of work has been done by sociologists and economists of science to quantify in some adapted fashion the peculiar case studies provided by historians and sociologists. Like the naturalistic philosophers, "quali-quantitative" sociologists wish to avoid the limits of incommensurable and contingent case studies so as to reach out and connect with traditional concerns and types of proof in science policy, economics and general sociology without falling in the trap of quantifying only marginal aspects of science. So far it is the actor-network theory which has been able to develop the most practical tools to follow the activity of science and technology from the laboratory setting to the industrial world without losing too much of the "cognitive" components (Callon, Law, Rip, 1986; Callon, Courtial, Lavergne 1989;

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* Translated by Gabrielle Hecht. Text revised by the author.

Callon 1990 **1**). What these new brands of quantitativist and naturalistic philosophers have in common is the will to "go beyond mere description" and to find ways of circulating through case studies without being constantly hampered by the historians' request to stick to the local, idosyncratic, contingent character of the case at hand. They differ however on the metalinguistic ressources one should use. Whereas philosophers of science believe it is necessary to maintain the "classic problems" of epistemology without having too much details to absorb, sociologists of science believe that a new metalanguage may be invented that relies fully on the topology of networks and that needs <u>more</u> details not less (Callon, 1990; Teil, Akrich, Latour, 1990). Instead of abstracting out a small numbers of contingencies in order to start doing some serious modelling, the network theorists believe that the new explanatory vocabulary will come from our ability to handle large and complex data banks. More description is needed out of which the explanatory vocabulary will emerge. Network theorists believe it is possible to have the careful narrative of the historians and the generalized explanatory power of philosophy of science at the same time —or, more exactly, with the same machine...

We call something an innovation, or a discovery, or an event, when our usual methods for following, predicting, or forecasting its development fail us. Given this definition, how can we follow an innovation **2**? By devising new methods adapted to the necessary drift of research projects or paths of innovation. In the last ten years, a body of work has emerged that can be collectively grouped under the term "description of socio-technical networks." These studies have often been criticized for replacing the concepts, divisions, and tools of economics, history or sociology by non-differentiated networks. To counter this objection, analysts of socio-technical networks have turned to quantitative, computerized means of treating large masses of information on network dynamics (see Leximappe™, and Candide™ in particular). By studying the form, the deformation, and the transformation of networks, researchers have re-differentiated the networks and formulated specific hypotheses that cut through entities formerly designated by words such as "state," "market," "science," "firm," "politics," "strategy," etc. All these methods aim at bridging the gap between the statistical methods commonly found in economics and sociology and the narrative methods of anthropology, history, and field work.

The method proposed in this article aims at improving both the legibility and the narration of network analyses. Its main advantage is not to depend on the sources from which the data are coming since it can reliably construct precise, meaningful graphs based either on historical and anthropological narratives, or on the results of a Leximappe™, Lexinett™, or CANDIDE™ analysis. It can thus help to solve two of the most irritating problems encountered in both historical and contemporary science studies: first, the impossibility of <u>comparing</u> different case-studies and second, the impossibility of obtaining quantitative measures <u>adapted</u> to the local, contingent, and circumstantial characteristics of networks. As long as we lack reliable cartographical methods, the endless debates between philosophers who want to go "beyond mere descriptions" and historians who wish to maintain the local idiosyncratic character of the cases at hand will go on.

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1 See also Fujimura on problem-paths but without the adapted quantification procedures, 198-

2 We make no distinction between an innovation which has been transformed into a product, an innovation that remains a statement, a belief or an argument; in both cases it is a complex body of practices that is displaced; in other words we make no a priori distinction between science studies and technologies studies.

In the first part of this paper, we describe the principles of this cartography using a very simple example on technical artefacts. In the second, we provide justifications for the geometric shape of these maps. In the third, we apply the method to a real, more complex example - that of Eastman's camera. In the fourth, we show how our method carries us beyond the current limits of innovation studies. And finally, in the fifth, we present a detailed discussion of the different kinds of information on socio-technical networks that must be weaved together in our system of visualization.

1° From a narrative to its socio-technical recording

Consider a tiny innovation commonly found in European hotels: attaching large cumbersome weights to room keys in order to remind customers that they should leave their key at the front desk every time they leave the hotel instead of taking it along on a tour of the city. An imperative statement inscribed on a sign - "Please leave your room key at the front desk before you go out" - appears to be not enough to make customers behave according to the speaker's wishes. Our fickle customers seemingly have other concerns, and room keys disappear into thin air. But if the innovator, called to the rescue, <u>displaces</u> the incription by introducing a large metal weight, the hotel manager no longer has to rely on his customers' sense of moral obligation. Customers suddenly become only too happy to rid themselves of this annoying object which makes their pockets bulge and weighs down their handbag: they go to the front desk out of their own accord to get rid of it. Where the sign, the inscription, the imperative, discipline, or moral obligation all failed, the hotel manager, the innovator, and the metal weight succeeded. And yet, obtaining such discipline has a price: the hotel manager had to ally himself with an innovator, and the innovator had to ally herself with various metal weights and their manufacturing processes.

This minor innovation clearly illustrates the fundamental principle underlying all studies of science and technology: the <u>force</u> **3** with which a speaker makes a statement is never enough, <u>in the beginning,</u> to predict the path that the statement will follow. This path depends on what successive listeners do with the statement. If the listener - in this case the hotel customer - forgets the order inscribed on the sign, or if he doesn't speak the language, the statement is reduced to a bit of paint on a piece of board. If the scrupulous customer obeys the order, he has complied with the imperative, thereby adding reality to it. The strength of the statement thus depends in part on what is written on the sign, and in part on what each listener does with the inscription. A thousand different customers will follow a thousand different paths after reading the order. In order to be able to predict the path, the hotel manager has two choices. He can either make all the customers equal by ensuring that they all know how to read the language and that they all know that going to a hotel in Europe means that one has a private, locked room but that the key must be left at the desk upon exiting the hotel every day. Or he can <u>load</u> his statement in such a way that lots of different customers all behave in the same manner, regardless of their native language or their experience with hotels. The grammatical imperative acts as a first load - "leave your keys"; the inscription on the sign is a second load; the polite word

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3 Although we have borrowed the word "force" from Austin, but we do not yet make any distinction between locutory, illocutory, or perlocutory force.

"please," added to the imperative to win the good graces of the reader constitutes a third; the mass of the metal weight adds a fourth. The number of loads that one needs to attach to the statement depends on the customers' resistance, their carelessness, their savagery, and their mood. It also depends on how badly the hotel manager wants to control his customers. And finally, it depends on the cleverness of the customers. The <u>programs</u> of the speaker get more complicated as they respond to the <u>anti-programs</u> of the listeners. If a weird client could break the ring connecting the light key to the heavy weight, the innovator would then have to add a soldered ring to prevent such breakage. This is an anti-anti-program. If a paranoid hotel manager wanted to ensure zero key loss, he could place a guard at each door to search the customers - but then he would probably lose his customers instead. It is <u>only</u> once most of these anti-programs are countered that the path taken by the statement becomes <u>predictable</u>. The customers obey the order, with only a few exceptions, and the hotel manager accepts the loss of a few keys.

But the order that is obeyed is <u>no longer the same</u> as the initial order. It has been <u>translated</u>, not <u>transmitted</u>. In following it, we are not following a sentence through the context of its application, nor are we moving from language to the praxis. The program, "leave your key at the front desk," which is now scrupulously executed by the majority of the customers is simply not the one we started with. Its displacement has transformed it. Customers no longer leave their room keys: instead, they get rid of an unwieldy object that deforms their pockets. If they conform to the manager's wishes, it is not because they read the sign, nor because they are particularly well-mannered. It is because they cannot do otherwise. They don't even think about it. The statement is no longer the same, the customers are no longer the same, the key is no longer the same - even the hotel is no longer quite exactly the same.**4**

This little example illustrates the "first principle" of any study of innovation in science and technology: the fate of a statement is in the hands of others.**5** Any method we might adopt to follow an innovation can only aim at reconstituting both the succession of hands that <u>transport</u> a statement and the succession of <u>transformations</u> undergone by that statement. To take these successive transformations into account, the very meaning of the word "statement" must be clarified. By statement we mean anything that is thrown, sent, or delegated by an enunciator. The meaning of the statement can thus vary along the way, and it does so as a function of the load imposed by the enunciator. Sometimes it refers to a word, sometimes to a sentence, sometimes to an object, sometimes to an apparatus, and sometimes to an institution. In our example, the statement can refer to a sentence uttered by the hotel manager - but it also refers to a material apparatus which forces customers to leave their keys at the front desk. The word "statement" therefore refers not to linguistics, but to the <u>gradient</u> that carries us from words to things and from things to words.

Even with such a simple example, we can already understand that when studying science and technology, we are not to follow a given statement through a <u>context</u>. We are to follow the simultaneous production of a "text" and a "context." In other words, any division we make between society on the one hand and scientific or technical content on
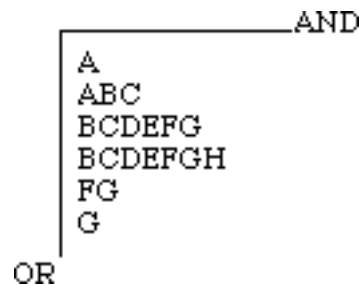

4See Akrich (1988; 1990), Akrich and Latour (1990), and Latour (1988) for the description, or verbal paraphrase of technical apparatus.

5See Latour (1987) for more on this first principle and its importance in the study of science and technology.

the other is necessarily arbitrary. The only non-arbitrary division is the succession of distinctions between "naked" and "loaded" statements. These, and only these, are the distinctions and successions which make up our world. These are the ones we must learn to document and to record, and only these.

Let us now attempt to map our little example. We wish to be able to follow both the chain of speakers and their statements and the transformation of speakers and their statements. We shall define two dimensions: association (akin to the linguist's syntagm) and substitution (or paradigm for the linguists). To simplify even further, we can think of these as the AND dimension, which will be our latitude, and the OR dimension, which will be our longitude. Any innovation can be traced both by its position on the AND-OR axes and by the recording of the AND and OR positions which have successively defined it. If we replace, by convention, all the different actors by different letters, we can always trace the path taken by an innovation using a shape such as the one below:

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                            _____AND
                      |
                      A
                      ABC
                      BCDEFG
                      BCDEFGH
                      FG
                      G
                      |
             OR
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The vertical dimension corresponds to the exploration of substitutions, and the horizontal dimension corresponds to the number of actors which have attached themselves to the innovation (by convention we read these diagrams from top to bottom).

To trace our diagram on the key example, we will pick the hotel manager's point of view as an origin. He is the speaker, or the enunciator - that is, the one who emits the statement. The track that the manager wishes his customers - the listeners - to follow we will call the program of action. We shall use numbers in parentheses to enumerate the successive versions of a program of action as seen from a single point of view. We will place all the programs to the left of the chosen point of origin, and all the anti-programs to the right. Let us also agree to enumerate the segments of the programs of action with numbers in parentheses. Finally, let us agree to draw the dividing line between programs and anti-programs in bold face; this line corresponds to the front of the tiny controversy we are following here.
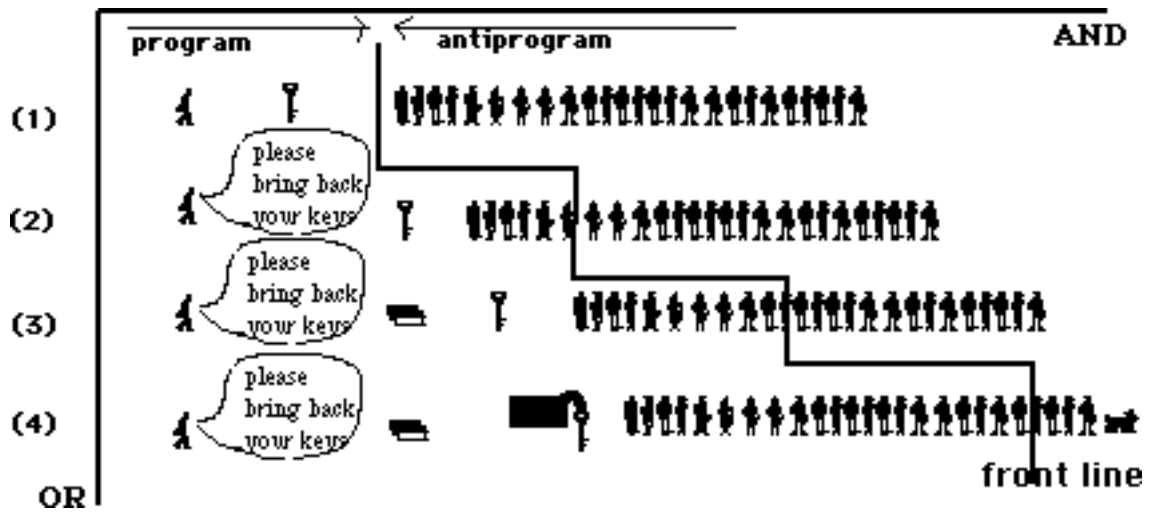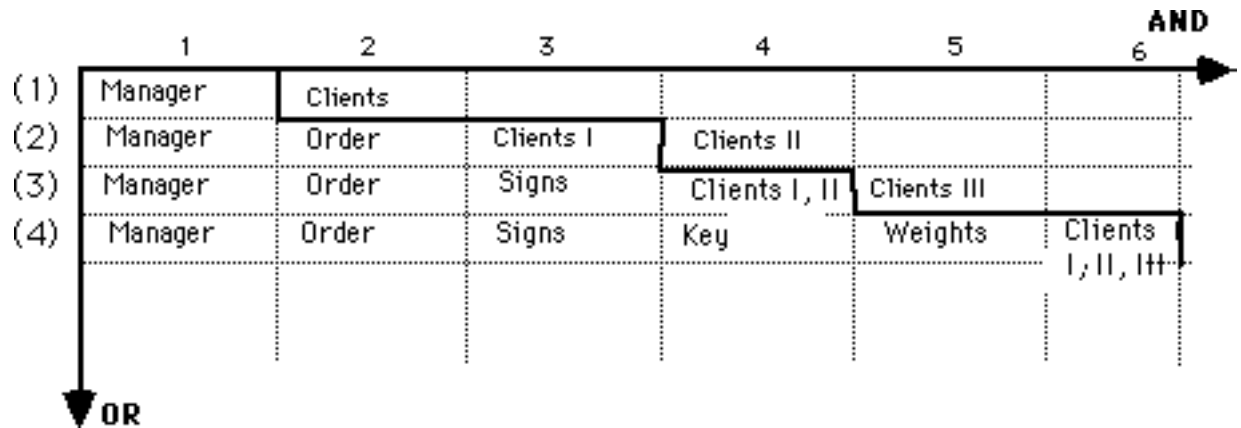
Figure 1.1: The hotel manager successively adds keys, oral notices, written notices, and finally metal weights; each time he modifies the attitude of some part of the "hotel customers" group.

In version (4), the hotel manager and almost all of his customers are in agreement, while as in version (1) the manager is the only one to wish for the return of his flighty keys. The syntagm or the association or the AND dimension have extended themselves in a lasting manner. But this extension to the right had a price: it became necessary to descend along the OR dimension by enriching the program of action with a series of subtle translations. The manager's wishes were supplemented first by a sentence in the imperative tense, then by a written sign, and finally by metal weights. The customers were nibbled away at little by little: they finally abandoned their anti-program and "surrendered" to the program. But the finances, the energy, and the intelligence of the hotel manager have also been nibbled away at! In the beginning, the wish was naked; in the end - an end which can only be provisional, as other anti-programs could always manifest themselves - it was clothed, or loaded. In the beginning it was unreal; in the end, it had gained some reality.

Such a diagram does not retrace the displacement of an immutable statement within a context of use or application. Nor does it retrace the displacement of a technical object - in this case a key weighed down by metal - within a context of use or application. Instead, it retraces a movement which is neither linguistic, nor social, nor technical, nor pragmatic. The diagram keeps track of successive changes undergone by customers, keys, hotels, and hotel managers. It does this by recording the ways in which a (syntagmatic) displacement in the associations is "paid for" by a (paradigmatic) displacement in the substitutions. It is impossible in such a diagram to move towards the right without moving downward. And, by convention, it is impossible to move back up in the OR direction, as this dimension simply records the successive versions of a program.
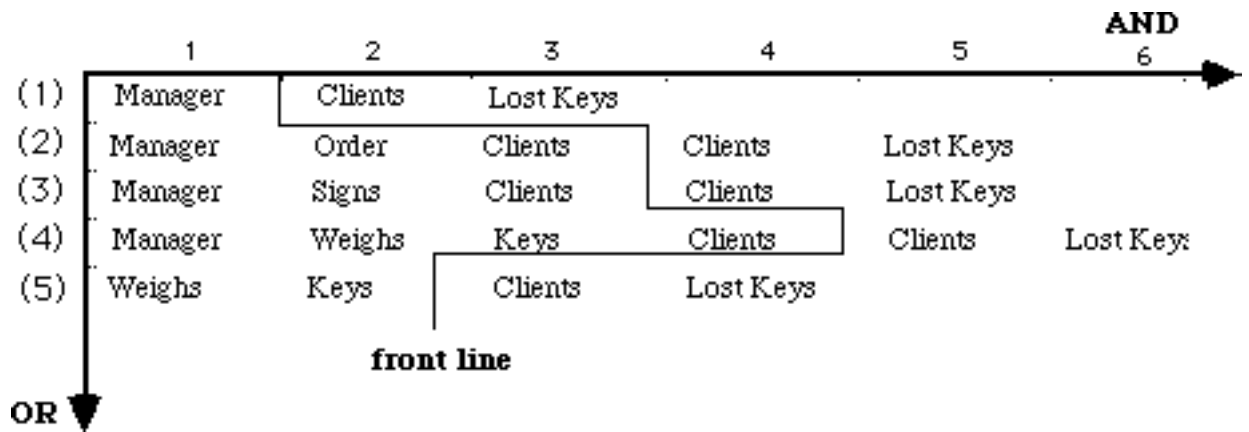
Let us now remove the figures of the hotel managers and his customers as well as the concrete symbols of the objects they mobilize in their controversy. For the time being, let us assign each actor a box and a name. The degree of attachment of an actant to a program of action vary from version to version. The terms "actant" and "degree of attachment" are symmetrical - that is, they apply indifferently to both humans and non-humans. The key is strongly attached to the weight by a ring, just as the manager is very

attached to his keys. It does not matter here that the first link is called "physical" and the second "emotional" or "financial." The problem is precisely for the hotel manager to find a way to attach his keys to the front desk when his customers go out, and he does this by attaching his customers to the front desk in a stronger and more lasting manner than that with which the keys are attached to his customers' pockets or handbags!

	1	2	3	4	5	6 (AND)
(1)	Manager	Clients				
(2)	Manager	Order	Clients I	Clients II		
(3)	Manager	Order	Signs	Clients I, II	Clients III	
(4)	Manager	Order	Signs	Key	Weights	Clients I, II, III

OR

    We notice in the diagram that the social group of the hotel customers finds itself transformed little by little. The accumulation of elements - the will of the manager, the hardness of his words, the multiplicity of his signs, the weight of his keys - ends up trying the patience of some customers, who finally give up and agree to conspire with the manager, faithfully returning their keys. The group of customers which has not been enrolled by version (4) is composed (according to the manager) either of folks of unmanageably bad faith or of exceptionally distracted professors. This gradual transformation, however, does not apply to the "hotel customers" social group alone; it also applies to the keys. Suddenly, indifferent and undifferentiated keys have become "European hotel keys" - very specific objects which we must now distinguish and isolate just as carefully as we did with clients. Herein lies the whole point of following innovations. Innovations show us that we never work in a world filled with actors to which fixed contours may be granted. It is not merely that their degree of attachment to a statement varies; their competence, and even their definition, can be transformed. These transformations undergone by actors are of crucial importance to us when we follow innovations, because they reveal that the unified actor - in this case, the hotel-customer-who-forgets-the-key - is itself an association made up of elements which can be redistributed. It is opening and closing these black boxes that, until now, have made following innovations such a delicate process.

    Note that in the case presented here the success of the innovation - that is, its extension toward the right from the manager's perspective - is only made possible by constantly maintaining the entire succession of accumulated elements. It is only because the hotel manager continues to want his keys back, reminds customers aloud, puts up signs, and weighs down the keys that he can finally manage to discipline his customers. It is this accumulation that gives the impression that we have gained some reality. But another scenario could be imagined.

	1	2	3	4	5	6 AND
(1)	Manager	Clients	Lost Keys			
(2)	Manager	Order	Clients	Clients	Lost Keys	
(3)	Manager	Signs	Clients	Clients	Lost Keys	
(4)	Manager	Weighs	Keys	Clients	Clients	Lost Keys
(5)	Weighs	Keys	Clients	Lost Keys		

front line

OR

The manager might ask his customers to leave their keys, but after putting up a few signs, he feels that he's done enough and has nothing more to say. As a result, there are just as many customers who do not follow either the oral or the written instructions. A technicist at heart, our good man choses a technical fix and proceeds to delegate all the work to the object. He weighs down all his keys without bothering to put up signs or deliver oral instructions any more. He gets a few more customers to conspire with his wishes, but soon gets disgusted and abandons his program. What is left in this case? A bunch of keys strongly attached to a bunch of metal weights by some beautiful metal rings, and customers who merrily carry the key-weight combination wherever they go. As for the hotel manager, no one knows what he wants anymore. In this scenario the final version (5) would associate fewer elements from the point of view of the original enunciator and is thus less real. But for us, observers of innovation, the only interesting reality is the <u>shape</u> of the the front line. Whereas the asymmetry between the feasible and the unfeasible, the real and the imagined, or the realistic and the idealistic dominates most studies of innovation, our cartography only recognizes <u>variations of realization and de-realization</u>. The front line traced by the exploration of what holds and what does not hold together records the compatibilities and the incompatibilities of humans and non-humans - that is, the socio-logics of the worlds in which we live.

These two possible scenarios in our example shows how easy it is, once we use our diagram, to avoid the twin pitfalls of sociologism and technologism. We are never faced with objects or social relations, we are faced with chains which are associations of human (H) and non-humans (NH). No one has ever seen a social relation by itself -or else it is that of the hotel manager unable to discipline his customers- nor a technical relations -or else it is that of the keys and the weights forgotten by everyone. We are always faced by chains which look like this

H-NH-H-NH-NH-NH-H-H-H-H-NH

Of course, a H-H-H assembly looks like social relations while a NH-NH-NH portion looks like a mechanism or a machine, but the point is that they are always integrated in longer chains. It is the chain -the syntagm- we study or its transformation -the paradigm- but it is never some of its aggregates or lumps. So instead of asking "is this social" "is this technical or scientific", or asking "is this techniques influenced by society" or is this "social relations influenced by techniques" we simply ask: has a human replaced a non-human? as a non-human replaced a human? has the competence of this actor be modified? has this actor -human or non-human- be replaced by another one?

We can see the empirical philosophy that inspires such a visualization. Instead of formulating strong hypotheses about the associations that actors may or may not be allowed to form, we let the networks deploy their own associations. Instead of being normative ion what actors do, we are only normative on the way analysts what actors do. The metalinguistic ressources we use to deploy networks is minimal; the vocabulary left to the actors to do their accounting is maximum. Not that we believe in passively recording the path and the will of the actors; we have simply shifted the point where hypotheses apply their force. We now concentrate all this force on building a space in which we will collect data. Our method resembles that of cartographers, who make <u>strong</u> hypotheses about calculating the longitude, the Mercator projection, and the definition of angles but <u>none</u> about the drawings of coastlines that navigators bring back; we make no hypotheses about the shape of a particular network but many about the the intellectual and graphic space in which we record it. This strategy is exactly the opposite of that adopted by many social sciences and philosophers of science. They impose on the data extremely constraining normative shapes with respect to what engineers, industrialists, or scientists should do, but couldn't be more lax when it comes to formulating a theory of innovation.

2°) The socio-technical graph and its indicators

We can only justify using a cartographical method if each point in the resulting geometrical distribution of data on paper means something. This is the difference between diagrams or schemas, the reading of which is necessarily subjective, and maps, which, once the reading conventions are known, establish stable relationships between the shape of the graph and its meaning. A quick glance at the literature on innovation reveals a huge number of drawings and plans. But aside from diagrams which link two or more quantitatve variables together but say very little about the peculiar contingencies of an innovation or about the specific and circumstantial network (the only thing that interests us), none of the graphs place innovation in a geometrically coherent space. And yet, this coherence is easily obtainable if we push our treatment of the two dimensions defined above, AND and OR, as far as it will go.

a) the socio-technical graph

By further simplifying and aggregating the table of actors, their associations (AND) and their substitutions (OR), we can indeed obtain information on the path of an innovation that is even more synthetic and more encoded. Let us replace actors' names by letters of the alphabet and let us eliminate, for the sake of simplicity, the actors who make up the anti-programs. Then the base diagram takes the following shape:
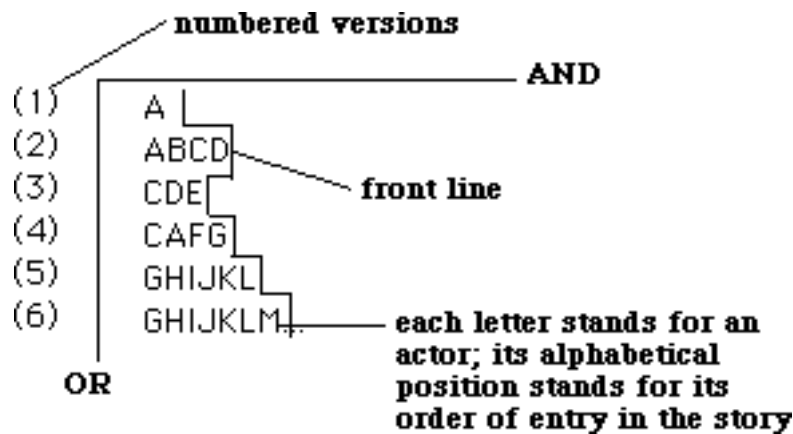
Such a diagram makes it possible to calculate a number of <u>indicators</u>, which are signatures of a statement's path. Which are the most interesting indicators for following an innovation? The first one is obviously the indicator **S** for **Size**, which gives the number of associated elements in each successive version. The second indicator of interest to us is the one that compares the number of elements <u>maintained</u> from one version to the next: we will call it **A** for **Allies**. We shall call the new actors recruited in moving from one version to another **N** for **New actors**. For each version, identified by a subscript n, we thus obtain:

$$S_{(n)} = A_{(n)} + N_{(n)}$$

(Note that, for the moment, the "seniority" of an actor is relative only to the transformations that occur <u>from version to version.</u> Thus a "lost" actor that gets recruited a second time counts as a new actor.)

Thanks to these first few indicators we can define an **Index of Negotiation IN:**

$$IN_{(n)} = N_{(n)}/S_{(n)}$$

The smaller the value of this index, the less the innovator has to negotiate to maintain his or her project in existence. Conversely, a high value of this index means that the project has to be highly renegotiated. In our fictional example, we obtain the following numbers:
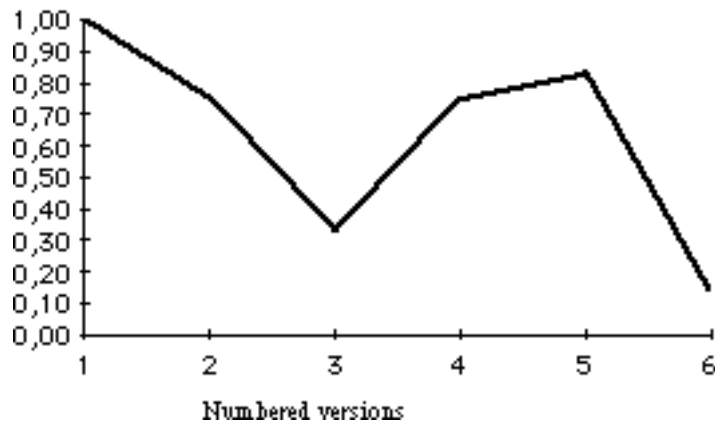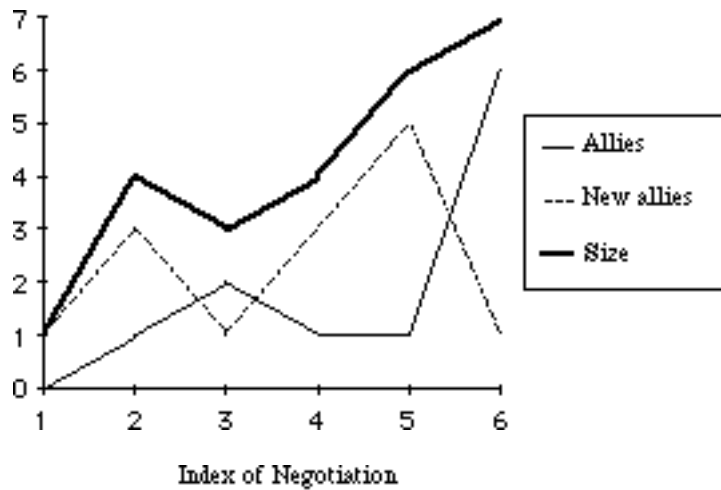

Calculating the index of negotiation IN for the fictional example

If we now draw the graph of our first three indicators, we obtain a curve specific to the innovation under examination.

Size, Allies and Index of negotiation for the fictional example above.

By using IN, the index of negotiation, and S, the index of size or of association, we can now draw the path of an innovation. We will call this map the socio-technical graph of an innovation, reserving this term for this particular type of visualization.
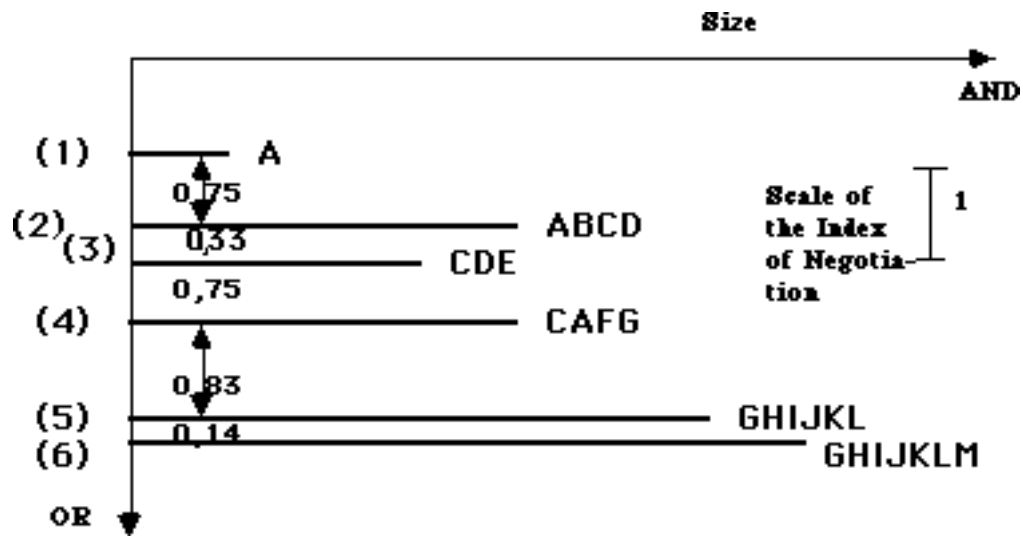
Principle of mapping the socio-technical graph of an innovation.

One advantage of this representation is that it is geometrically coherent while still remaining close to more subjective and intuitive graphic representations such as those developed to follow scientific controversies.**6** But the main advantage of such a reduction is that by summarizing the documents collected in a study, it makes possible the comparison of two completely different case studies. The socio-technical graph is an overview of the innovation, a numerical description of its successes and failures, and a reference point which then makes it possible to navigate through statistics, archives, interviews, blueprints, and narratives.

b) **Other tests and indicators allowing the comparison of different innovations**

In addition to the socio-technical graph, it is possible to produce a synthetic characterization of the paths of innovations by defining a few more indicators. Until now, we have only compared different versions one by one. It is clear, however, that new actors can be re-mobilized by a version (n) which had been already mobilized by previous versions. Thus the cumulation of new actors form version to version over a given period can be different from the total number of actors associated with the project during this same period. We will therefore distinguish between **Cumulated New Actors, CNA** and the **exploration E** of the project. **CNA** indicates the variation of the degree of attachment of the actors, while as **E** represents the size of the population of actors mobilized by the project. In the examples above, we obtain **E** by considering the rank of letters in alphabetical order. **E** is a synthetic indicator which allows us to distinguish innovations that explore a large number of new actors from those that recombine a small number of potential allies in different configurations. So for the example above:

6See the modalization studies of scientific controversies in Latour (1979) and (1987).

Cumulated New Actors and Exploration of the project.

Some projects are strongly attractive. This means that all the new actors which one day participated in the project in a version (n) find themselves associated again in the next version (n+1). These actors constitute the aggregate of new actors: they are those who move from the index $\mathbf{N}$(n) to the index $\mathbf{A}$(n+1). Conversely, some of these new actors have disappeared in the (n-1) version; these are the lost new actors. In order to measure our innovation, we calculate its **Yield Index**, $\mathbf{Y}$. This index is calculated by dividing ((the cumulative number of the aggregate of new actors) - (the cumulated number of lost new actors)) by the exploration $\mathbf{E}$. The indicator thus obtained measures either the capacity of a project to attach itself to the majority of the actors it mobilizes, or on the contrary its tendency to visit a large number of new actors without fixing itself anywhere.

$$\mathbf{Y_{(n)}} = (\textstyle\sum \mathbf{ANA}) - (\textstyle\sum \mathbf{LNA})/\mathbf{E_{(n)}}$$

where ANA = aggregate of new actors
**and   LNA = lost new actors**

This index takes values between "1" and "-1." We will show its variations below using two extreme cases.

A final synthetic index can be obtained by dividing the number of associated elements $\mathbf{A}$ which remain stable in a version (n) by the size $\mathbf{S}$ of the previous version (n - 1). This index defines the **"reality" R** of the project - that is, the "resistance" it needs to be able to move from one version to the next without putting what it already acquired into question:

$$\mathbf{R(n) = A(n)/T(n - 1)}$$

All these indicators allow us to compare trajectories whose size and content are completely dissimilar and who come from vastly distant empirical sources.

For the three indicators of negotiation (**IN**), reality (**R**), and yield (**Y**) we obtain the following profiles for the above example:
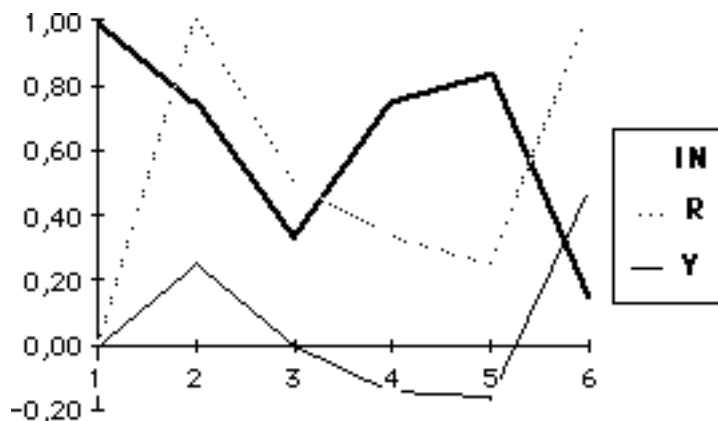

Indices of Negotiation (IN), Reality (S), and Yield (Y) in our fictional example.

Let us now take two extreme examples in order to see how these different indicators allow us to calibrate an innovation. Consider the following case:

		S	A	NCA									
(1)	2	-	2	A	B								
(2)	3	2	3	A	B	C							
(3)	4	3	4	A	B	C	D						
(4)	5	4	5	A	B	C	D	E					
(5)	6	5	6	A	B	C	D	E	F				
(6)	7	6	7	A	B	C	D	E	F	G			
(7)	8	7	8	A	B	C	D	E	F	G	H		
(8)	9	8	9	A	B	C	D	E	F	G	H	I	

In this table, each newly recruited actor remains faithfully inside the syntagm without requesting the disappearance of any other actor. For these values we obtain the following signatures:
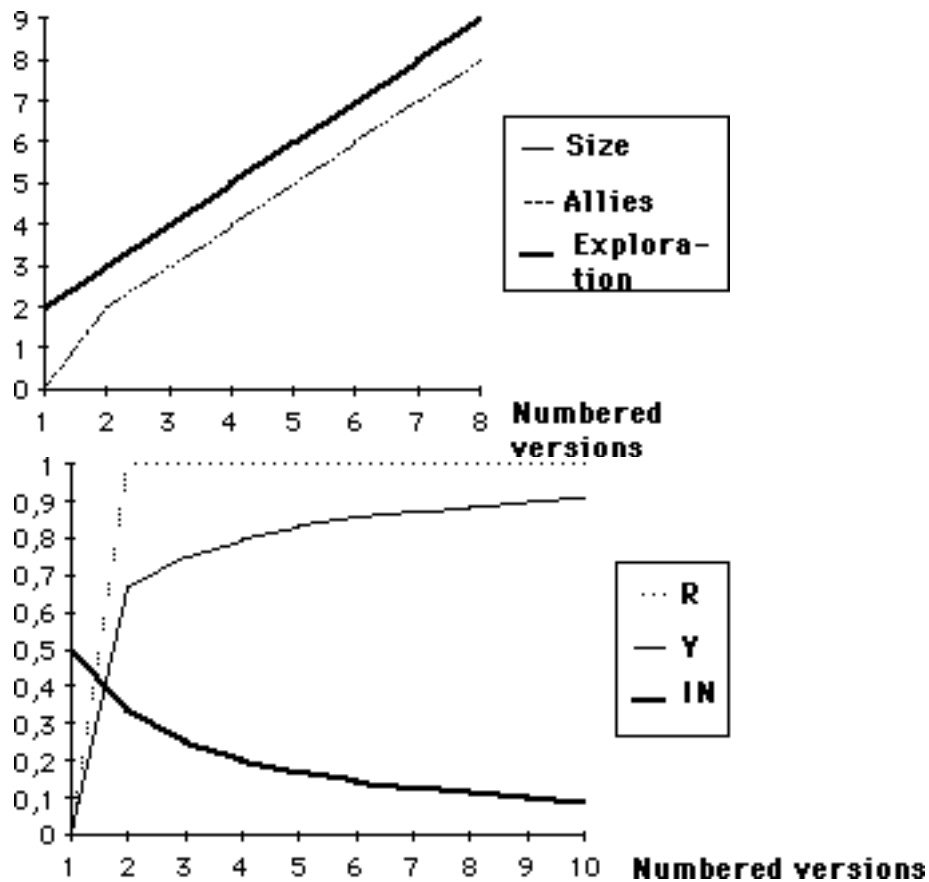
Extreme Case 1 - Indices of Reality, Yield , and Negotiation.

Such a diagram reveals the signature of an Obligatory Passage Point: every actor passing in the neighborhood of the innovation gets recruited.

This extreme case allows us to understand how we might synthesize the irreversibility or the black boxing of a syntagm. For example, the association A-G might become stable enough to think of it as a single element whose name might be, for instance, A. A has thus now become a macro-term. But we must not lose sight of the fact that this macro-term is a black box - that is, a group of actors which had been independent mediators before becoming faithful intermediaries within a syntagm. Thus we will

represent the actor in bold face, placing the "number" of actors it represents in superscript and the code number of the map picturing its construction or its deconstruction in subscript. So, in our fictional example, we would obtain $\mathbf{A_7x1}$. This information is crucial, because any renegotiation of a statement must include the reopening or the redistribution of the black boxes that make up the reserve of all the innovations .[7]

Card X1

	S	A	CNA								
(1)	2	0	2	A	B						
(2)	3	2	3	A	B	C					
(3)	4	3	4	A	B	C	D				
(4)	5	4	5	A	B	C	D	E			
(5)	6	5	6	A	B	C	D	E	F		
(6)	7	6	7	A	B	C	D	E	F	G	
(7)	8	7	8	A	B	C	D	E	F	G	H
(8)	9	8	9	A	B	C	D	E	F	G	H	I

Card X2

|	S	A	CNA		
(1)	9	0	9	$\mathbf{A_7x1}$ P	Q

Let us now look at the other extreme case, in which the same actor renegotiates each successive version without ever recruiting any stable ally, let alone constituting a black box.

|	S	A	CNA			
(1)	**4**	**0**	**3**	A	B	C	D
(2)	**4**	**1**	**6**	A	E	F	G
(3)	**4**	**1**	**9**	A	H	I	J
(4)	**4**	**1**	**12**	A	K	L	M
(5)	**4**	**1**	**15**	A	N	O	P
(6)	**4**	**1**	**18**	A	Q	R	S
(7)	**4**	**1**	**21**	A	T	U	V
(8)	**4**	**1**	**24**	A	W	X	Y

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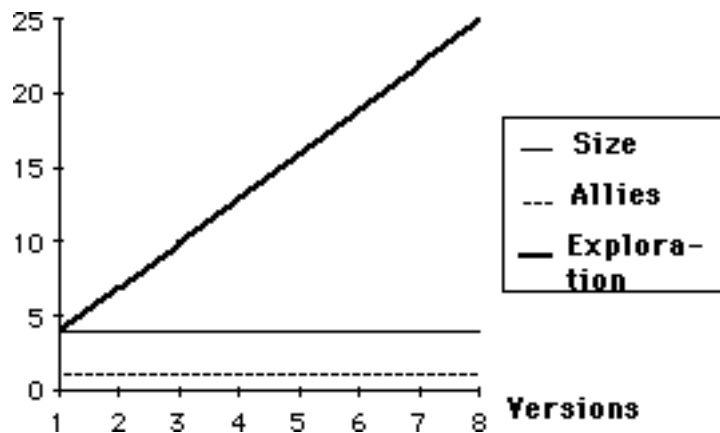
[7]Leximappe's cluster analysis now automatically designates the actor whose name is to represent the entire black box, as well as the number of associated actors. It also automatically defines the difference between a mediator and an intermediary by looking at an actor's association profile (in other words, the actor's faithfulness). For more details, see Teil and Michelet.
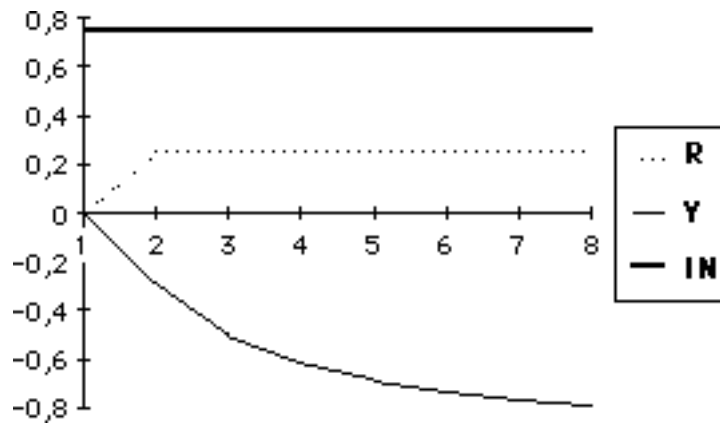
Extreme Case 2: indices of Reality, Yield, and Negotiation.

In this case we obtain a negative Yield. This single number tells use that we are dealing with an extensive exploration of the sociological universe to no use at all.

Notice that this signature of a "facultative" passage point results in two curves which can be superimposed on the previous example and which are the inverse of each other. We can now see that the real innovations, which we will map next, must probably be distributed between these two extremes. They will be characterized in a synthetic manner by both their socio-technical graph and their indicators.**8**
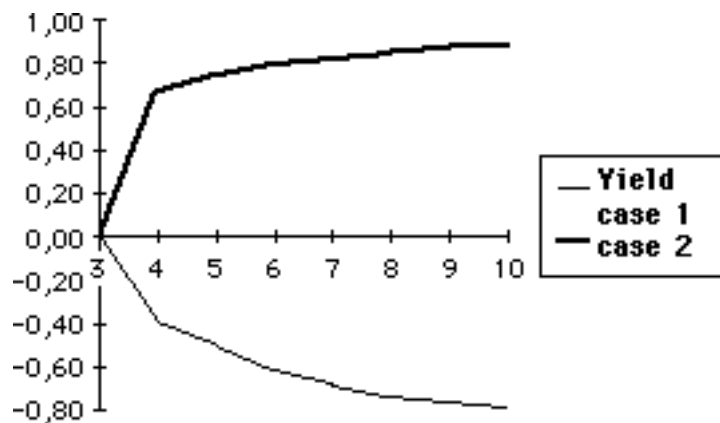
Comparison of the yield indices of the two extreme cases 1 and 2.

3°) **Applying the graphic principles: the case of Eastman's Kodak camera**

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8 The current Hypercard implementation makes it possible to obtain easy access to the databases by clicking on the name of the relevant actor. Hypertexts can thus solve previously insurmountable cartographical problems, because they are capable of both aggregating and disaggregating data. One can view the chromatograph as the "home" map of a Hypercard: it acts as the central dispatching board of a control center.

Now that we have used simple or fictional examples to define our cartographical principles, we should try these principles out on richer, more realistic examples. We shall do this slowly, taking the opportunity to clarify some of the philosophical difficulties which have limited studies of scientific or technical innovation until now. Indeed, most of these difficulties were often linked to our inability to visualize the paths of these innovations or knowledge claims.

Consider Jenkins's story of the simultaneous invention of the Kodak camera and of the mass market for amateur photography.[9] Let us abridge this story by identifying each program and anti-program and by successively recording all the new actors, be they human or non-human, single or collective.

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[9]Reese V. Jenkins, "Georges Eastman et les débuts de la photographie populaire," *Culture Technique*, n° 10 (1983): 75-87. We use this text directly without asking whether it itself is supported by archives and documents.

Abridged Script of a socio-technical path[10]

(1) professional-amateur (A)/ daguerrotype (B)

(2) professional amateur (A)/ wet collodion (C) *1850/* paper manufacturing　　　(D)**-//-** doing everything oneself right away

(3) professional amateur (A)/ paper manufacturing (D)**/ dry** collodion plates made ahead of time (E) *1860-1870* **-//-**

(4) professional amateur / paper manufacturing / more sensitive dry **gelatin** plates *1870-1880*/ companies that manufacture plates ahead of time **-//-**

(5) professional amateur / paper manufacturing / dry **gelatin** plates/ companies that manufacture plates ahead of time/ continuous plate coating machine/ Eastman **-//-**

(6) **(5)**/Strong capital/ EASTMAN DRY PLATE COMPANY *1881-1883* **-//-** low entry price/ easy competition

(7) **(6)** consortium of plate manufacturers **-//-** still limited market/ fragile plates

(8) **flexible Walker film**/Walker's Pocket Camera *1884* **-//-**

(9) roll film instead of plate film/ camera using the films **-//-** nothing other than heavy cameras using plate film exists on the market

(10) camera using the films/ Warnerke's 1870 prototype in England non-patented roll/ roll holder/ two paper rolls coated with collodion **-//-** too expensive/ difficult unloading/ uncertain markers/ distortion leading to fuzzy pictures/ not too reliable/ still for professional

(11) Eastman/ Walker/ reputed company/ commercial network/ roll holder/ flexible film in rolls/ production line manufacturing machine **-//-**

(12) **(11)** *1884* gelatin layers plus collodion **-//-** fragile

(13) **(12)** paper/ collodion **-//-** fragile

(14) **(13)** paper/ gelatin **-//-** fragile

(15) **(14)** paper/ soluble gelatin/ less slouble photosensitive gelatin "film (pelliculabe?)" **-//-** distortion

(16) **(15)** / gelatin on the back to avoid distortion/ thick gelatin layer **-//-**

(17) **(16)**/ roll holding frame/ spring against distortion/ removalble parts against lading and unloading/ measurement drum/ trigger to advance film/ puncher for exact marking **-//-**

(18) **(17)** / *early 1884* continuous paper maching for serial printing **-//-**

(19) **(18)** / patents **-//-** *1885* encroaching Houston patents inventing punch holes in roll film for exact marking, avoiding superimposed pictures

(20) **(19)** / Houston *spring 1889* sells the patent **-//-** very expensive patent

(21) **(20)** new commercial company EASTMAN DRY PLATE AND FILM COMPANY/ Strong/ Walkers/ eight stockholders // subcontrator manufactures roll holder **-//-** film cracks

(22) **(21)** / *end 1885* film available in long strips **-//-**

(23) **(22)** / seduces photography leaders/ worldwide rewards *june 1885* London **-//-**

(24) **(23)**/ Warnerke says "it's better than mine and different because of mass production" **-//-** film too delicate to develop/ doesn't appeal to professionals of lesser quality than plates

(25) Eastman printing paper very good/ professional market interested/ Eastman company does fixing and development in series/ 1887 6000 developments a day **-//-** market still limited to development

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10 The faithfulness of this script to Jenkins's narration is not in question here. We know that CANDIDE[TM] can provide a script based on regular text. Little does it matter whether the script was produced manually or automatically: only the cartography is important for now. Dates are printed in italics; their location, their proximity, and their succession is variable. Only the order of the versions numbered (1) to (n) counts--see the end of this part on the problem of time. The **-//-** sign indicates that the subsequent text describes anti-programs. If the anti-program is not known, there is still a sign to indicated the necessary existence of a controversy front. In order to simplify and lighten the writing, any version that occurs in its entirety in the next version is summarized by its number, becoming a black box. It goes without saying that the final values obtained for the indicators take into account the value of the developped version. Thus the peculiar arithmetic of the black boxes is respected: sometimes they are worth one in the syntagm which incorporates them, and sometimes they are worth the number of actors that make them up.

> (26) film not good for professional **good for amateurs** -//- abandon of amateur professional (**opening of black boxes (2) to (6)**)
>
> (27) good for amateur/ mass market -//- no (prise de vue) camera ***summer 1887***
>
> (28) mass market/ flexible film (**16**)/ existing cameras/ development fixing by the Eastman Company -//- amateurs not interested because existing camera hard to use
>
> (29) mass market/ flexible film (**16**)/ existing cameras/ development fixing by the Eastman Company/ user doesn't have to do anything -//- the Eastman company does all the work
>
> (30) mass market/ **Eastman camera**/ flexible film/ ***1887* Kodak nam**e/ 25 dollars/ 100 poses/ Eastman commercial network/ manual of use/ advertisement -//-
>
> (31) (**30**) triumphant reception -//- film still fragile
>
> (32) (**31**) then replacement of support for nitrocellulose paper displacement of rolls in front of instead of behind focal plane -//-
>
> (33) (**32**) whole world/ rewards/ mass market verified -//- celluloid problems sales go down ***1892 1893***
>
> (34) (**33**)/new support for film/market takes off -//- potential competitors and patents
>
> (35) (**34**)/ buys back all the patents -//-
>
> (36) (**35**)/*1899* large industry/ mass production/ mass market increased to amateurs from 7 to 77 years old/ hundreds of thousands of cameras sold

Let us now encode this narrative, neglecting for a moment the anti-programs. We will give a shortened name to each new actor: that is, each new actor will receive a letter of the alphabet whose position corresponds to the order in which the actors enter the scene. In this trial, we will not attempt to assess the respective weight of the actors; we will merely record the number of new actors arriving in, leaving, or returning to the narrative.

(1) AB
(2) ACD
(3) ADE
(4) ADEFG
(5) ADGHIJ
(6) ADGHIJKL
(7) ADGHIJKLM
(8) NO
(9) OQ
(10) QRST
(11) JOLUVPI
(12) JOLUVPIW
(13) JOLUVPIXY
(14) JOLUVPIZ
(15) JOLUYPIZ AA AB
(16) JOLUVPIZ AA AB AC AD
(17) JOLUVPIZ AA AB AC AD AE AF AG AH AI AJ
(18) JOLUVPIZ AA AB AC AD AE AF AG AH AI AJ AK
(19) JOLUVPIZ AA AB AC AD AE AF AG AH AI AJ AK AL
(20) JOLUVPIZ AA AB AC AD AE AF AG AH AI AJ AK AL AM
(21) JOLUVPIZ AA AB AC AD AE AF AG AH AI AJ AK AL AM AN AO AP AQ
(22) JOLUVPIZ AA AB AC AD AE AF AG AH AI AJ AK AL AM AN AO AP AQ AR
(23) JOLUVPIZ AA AB AC AD AE AF AG AH AI AJ AK AL AM AN AO AP AQ AR AS AT
(24) JOLUVPIZ AA AB AC AD AE AF AG AH AI AJ AK AL AM AN AO AP AQ AR AS AT R++
(25) AU A++ AV AW
(26) AX
(27) AX AY
(28) AY [JOLUVPIZ AA AB AC AD] AZ AW
(29) AO [JOLUVPIZ AA AB AC AD] AZ AW BA
(30) AO [JOLUVPIZ AA AB AC AD] AZ AW BA BB BC BD BE BF BG
(31) AO [JOLUVPIZ AA AB AC AD] AZ AW BA BB BC BD BE BF BG BH
(32) AO [JOLUVPIZ AA AB AC AD] AZ AW BA BB BC BD BE BF BG BH BI BJ
(33) AO [JOLUVPIZ AA AB AC AD] AZ AW BA BB BC BD BE BF BG BH BI BJ BK BL BM
(34) AO [JOLUVPIZ AA AB AC AD] AZ AW BA BB BC BD BE BF BG BH BI BJ BK BL BM BN BO
(35) AO [JOLUVPIZ AA AB AC AD] AZ AW BA BB BC BD BE BF BG BH BI BJ BK BL BM BN BO BP
(36) AO [JOLUVPIZ AA AB AC AD] AZ AW BA BB BC BD BE BF BG BH BI BJ BK BL BM BO BP BQ BR BS BT

This coding allows us to calculate the indicators and draw the diagrams that interest us.
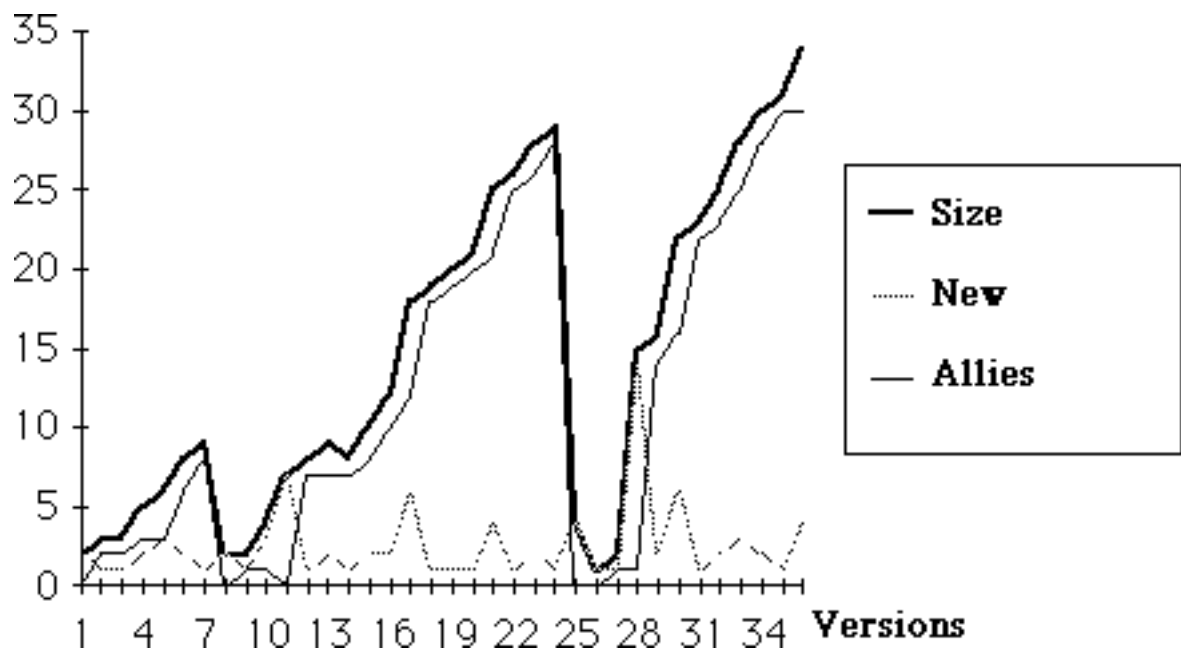
Size, Allies, and New Actors in the "Kodak" example.

In this diagram, we can recognize clearly the three different translations corresponding both to objects and to distinct interests. The variations in these translations are even clearer in the diagram of the three synthetic indicators.
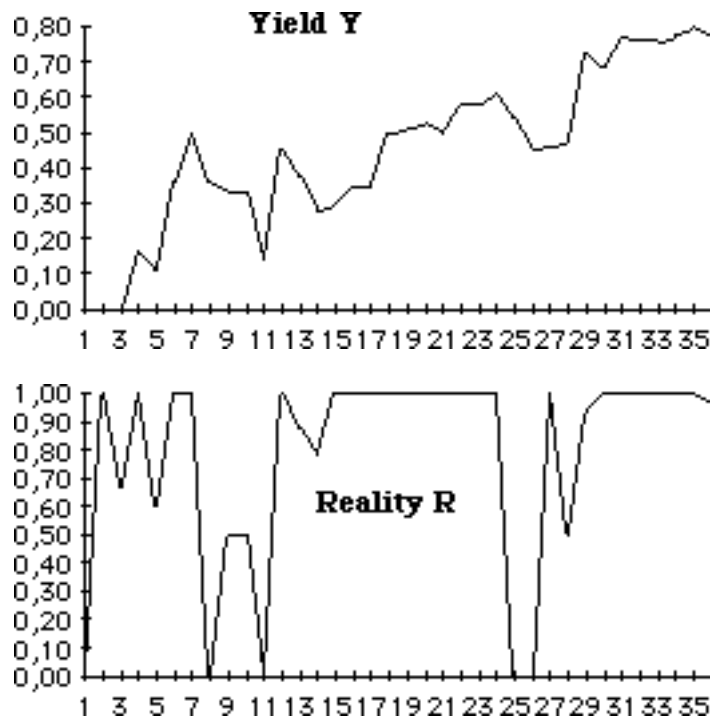
"Kodak" example: indices of yield Y, reality R, and negotiation N.

What becomes of our indicators and, more specifically, what becomes of our Yield Index when the "Kodak" camera appears "on the market"? Remember that when we encoded the narrative, the actor "market of 100,000 people" counted as one actor, as did the actors "collodion" and "eight stockholders." In part this is an artefact of our encoding scheme, but in part this results precisely from the difference between cartography and _economic tools_. What, indeed, is a sale in an expanding market? It is, in the jargon of our mapping system, the addition of a very large number of actors who do _not_ demand that the object be renegotiated in full detail. In other words, it is a displacement along the AND axis which is paid for only by an infinitesimal displacement along the OR axis. The OR displacement is never equal to 0, because the purchase, the delivery, and the usage of a Kodak camera are further translations. But users do not call directly into question the position of the film, the grain of the silver salts, or the shutter. As soon as we record these kinds of steep _slopes_, mapping innovations mapping becomes useless: market statistics, profit rates, and stocks are amply sufficient. For us economic forces are like the poles in a Mercator projection, they induce too much deformation. Economic tools can take up where chromatography leaves off as soon as the network has become stable enough to produce masses of numbers based on standardized valuemetres. But chromatography gains back its advantage as soon as the market collapses, when it becomes necessary to recruit new actors one by one by radically redesigning the object in charge of holding its world together. Thus, the tools of network analysis and those of economics are both complementary and incompatible. The second type begins to be useful when the first type becomes inapplicable.

We can now draw the socio-technical graph of Jenkins's narrative on Eastman:
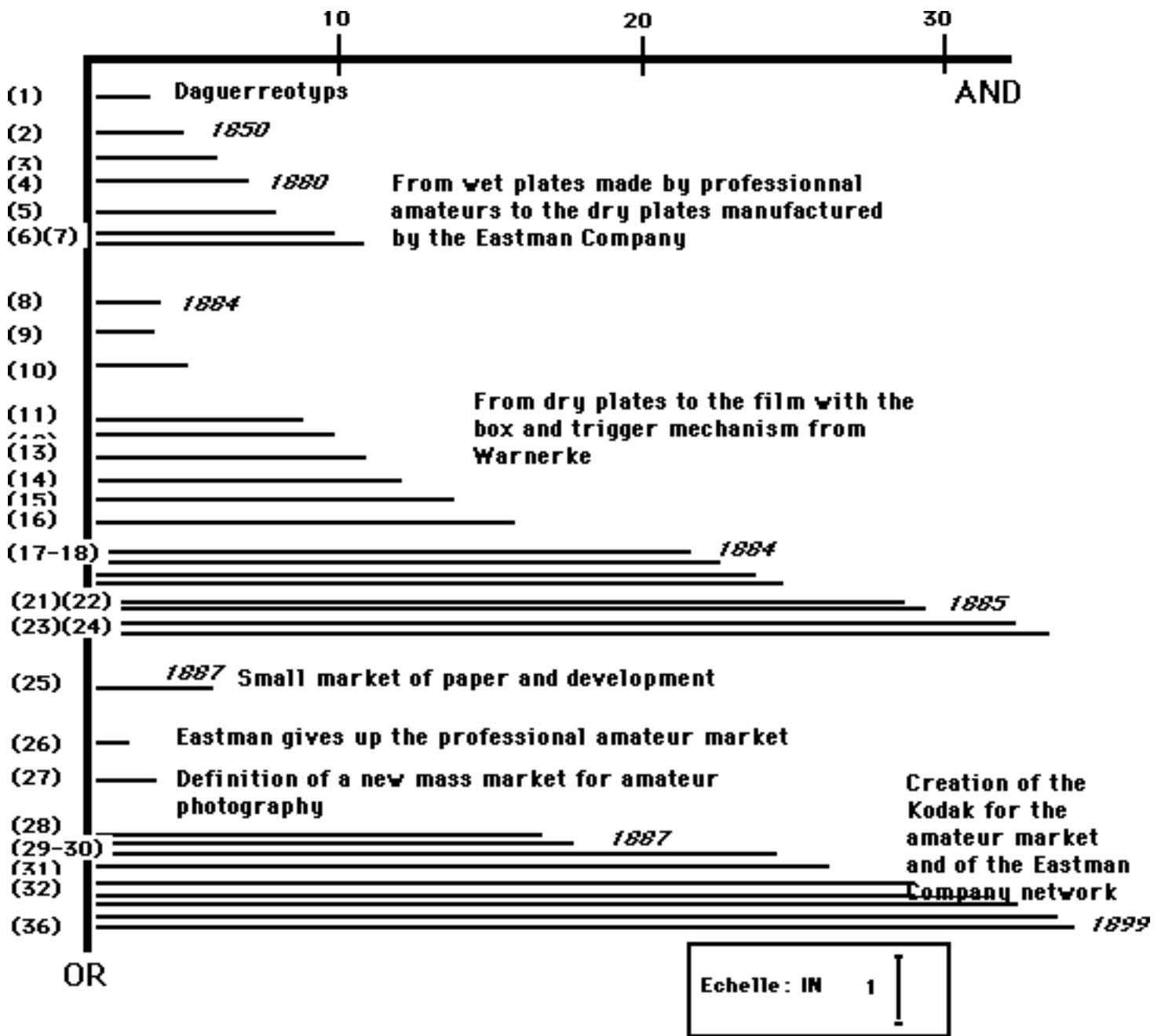
Socio-technical graph of the "Kodak camera" based on Jenkins's narrative.

Let us assume that this summary of Jenkins's work forms the basis of a Hypertext, and that we can click on any part of the diagram to obtain visual information on the shape of the cameras, the names of the actors, interviews, market statistics, or sequences in the story. We have thereby obtained a satisfactory reduction of the story while keeping the contingencies, circumstances, and alliance reversals inherent in any innovation. Thanks to the computer software now availabe, it is no longer necessary to irreversibly reduce the data in order to quantify them. It is enough to be able to navigate through data kept in coded, aggregated, and abstracted states while remaining as flexible as necessary.

4°) Different mapping, different philosophy of innovation

We will now use this Eastman example to address some enigmas that have hindered both an understanding of the mechanisms of innovation and, by extension, the following of their paths.

a) Trajectory or translation?

The first of these enigmas is the notion of <u>trajectory</u>. For example, a museum of technology curator trying to put together an exhibit on the history of photography might be tempted to link succeeding versions of cameras in a display case. These, after all, are hard, physical objects which can be easily preserved and shown. The curator does not deny the existence of the "rest" - of all the photographers, subjects, markets, and industries that surrounded the cameras. Instead, all this gets transformed into a context <u>in which</u> the technical object moved, grew, changed, or became more complex. Yet, if we compare Warnerke's invention with Eastman's first camera, we notice that they are exactly as dissimilar as Warnerke's version (10) is from his version (24) - an episode in which Warnerke most courteously recognizes Eastman's originality.

(10) QRST   ...   (24) JOLUVPIZ AA AB AC AD AE AF AG AH AI AJ AK AL AM AN AO AP AQ AR AS AT R++

From the perspective of the trajectory of a glass-and-wood object moving through society, these two innovations should no more be linked in a museum display case that a sewing meachine and an operating table. By cutting across the translations, the notion of trajectory invents surrealist "cadavres exquis". And yet, from the perspective of the flow of associations and substitutions, there does indeed exist some link, established by Warnerke and Eastman themselves. But this link is not supported by wood, reels, or glass. The two inventions do not have a single non-human in common: they only appear to do so in retrospect. Eastman's exploration work alone establishes a link between the roll holder designed for professional amateurs in England and the automatic camera mass-produced in America. Either we give this work a place in our analysis, in which case the link is not fortuitous, or we don't, in which case the link between the two is nothing but an artefact of the technical history of technology. All the questions about influences and long trends -questions in which historians relishes so much- are susceptible of a precise determination once we are able to measure the degree of sameness and otherness of a knowledge claim.[11]

b) Forms or contents?

Socio-technical graphs allows us to follow with precision their degree of similarity or dissimilarity. Rather than confusing the secondary mechanism of attribution with the

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[11] The word "path" that we use for want of a better term is in our diagram the moving front line of both the associations AND and the substitutions OR; it is not the displacement through space or time of a "thing" so a path is not a trajectory.

primary mechanism of mobilization, chromatography sticks to the latter. An innovation is a syntagmatic line (AND) containing just as many humans and non-humans as were recruited to counter the anti-programs. If even a single segment differs from one version to the next, the innovation is simply <u>no longer the same</u>. If all the segments but one are distinct, there is absolutely no reason to group two versions in the same showcase. We still have the diffusionist's[12] bad habit of considering that one particular segment of a program of action is the essence of an innovation, and that the others are merely context, packaging, history, or development. Our schema forces us to consider that the only essence of a project or of a knowledge's claims is its total <u>existence</u>. In philosophical terms, this is existentialism applied to things in themselves.

This existentialism and its visualization provides a precise content to the distinction between questions of rhetoric (or packaging) and substantive questions. Network analysis has been widely criticized for transforming scientists into washing machine salesmen, people constantly worried about rhetoric and enrollments and very little concerned about the content of their discoveries. But this objection is doubly unfair, both for washing machine salesmen, who surely exercise much more subtlety than they are usually given credit for (Hennion, Meadel 1990), and for innovators. Is the invention of the word "Kodak" important or not? Is merely deciding to build a market enough? Or is such a decision superfluous? Is the whole thing simply a marketing problem? All these questions acquire a precise meaning in our analysis: does the actor "the name Kodak" lead to a modification in the durability of the syntagm, and if so how much of a modification? In Jenkins's narrative, the actor "BB" in version (30) is an actor among twenty-three other actors, and only allows the recruitment of a single new actor in version (31). In this precise case, we can measure the exact weight of rhetorical packaging.

| (30) AO [JOLUVPIZ AA AB AC AD] AZ AW BA **BB** BC BD BE BF BG |
| (31) AO [JOLUVPIZ AA AB AC AD] AZ AW BA BB BC BD BE BF BG BH |

Consider, however, the case of the Turkish astronomer in Saint-Exupéry's *The Little Prince*. When he demonstrates the existence of asteroid XC 5890 dressed in the traditional national costume, his colleagues treat him with scorn and laughter. The next day, he makes "the same" demonstration dressed in a three-piece pin suit and wins the esteem of the colleagues. The only difference is the astronomer's clothing. Here indeed we have a case in which the weight of mere rhetoric is essential. Only a diffusionist, an essentialist, or an epistemologist would find it ridiculous that the astronomer's first demonstration was missing nothing but a tie. Those who follow innovations know perfectly well that a tie can make all the difference, and that there is no reason to <u>equate</u> the syntagm "demonstration + Turkish national costume + collegial laughter" with the syntagm "demonstration + three-piece pin suit + collegial esteem." But we do not necessarily have to conclude that the weight of a tie and a three-piece suit is in principle and for ever essential to mathematics! The analyst should never pre-determine the weight of what counts and what does not, of what is rhetoric and what is essential, of what depends on Cleopatra's nose and what resists all contingencies. The weight of these

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[12] The diffusionist model is the opposite of the translation model. The latter takes seriously the first principle defined earlier: that the fate of a statement is in the hands of others. For more on this point and on the difference between primary and secondary mechanisms, see Latour (1989).

factors must be <u>read</u> in the diagram as a function of the movement of syntagms and they will be different in each story. This is why the normative impulse of philosophers of science should shift from the description of the actors contingent's move to the quality of the framework allowing the description to be recorded.

c) Social context or technical content?

Symmetrical to the illusion of a trajectory crossing a context is that of a context crossed by innovations. The socio-technical graph allows us to dismiss this other sociological ghost as well.

Can one say that the amateur professionals of the first days of photography closed their minds to technological progress as of 1886, and that the larger public opened its mind to progress as of 1892? Can one explain the diffusion of photography by examining the nature of the social groups interested in it? In other words has the notion of interest to be stabilised in order to account for the path of the knowledge claims? No, because the social groups themselves were deeply transformed by the innovations. The professional amateurs interested in Eastman's dry-plate - versions (5) and (6) - were extermely disappointed in roll film - version (24) - whose quality was vastly inferior to that of the plates; they were interested in printing and developping pictures on Eastman's photographic paper (25), and totally disinterested in the Kodak camera. They actively sorted the proposed innovations, but they also changed, modifying their laboratories and delegating the task of plate, then paper, preparation to individual companies. What we obseve is <u>a group of variable geometry entering in a relationship with an object of variable geometry</u>.   Both get transformed We observe a process of translation - not one of reception, rejection, resistance, or acceptance.

The same applies to the amateurs. The amateur in version (36) who only has to click the Kodak camera, thereby imitating millions of other amateurs, and who does not need any laboratory since he can send the camera with the films to be developed at Eastman's factories, is no longer the same as the one in version (24), who bought intimidating cameras whose film got stuck and produced fuzzy pictures. The amateur market was explored, extracted, and constructed from heterogeneous social groups which <u>did not</u> exist before Eastman. The new amateurs and Eastman's camera <u>co-produced</u> each other. We see neither resistance to, nor opening of, nor acceptance of, nor refusal of technical progress. Instead we see millions of people, held by an innovation that they themselves hold.

And what about Eastman? Is he a fixed actor? Not at all. The contours of what Eastman can and wants to do, as well as the size and the design of his company also vary in this story - even if the perspective of our socio-technical graph still uses Eastman as a starting point.**13**   Contrary to the claims of those who want to hold either the state of technology or the that of society constant, it is possible to consider a path of an innovation in which <u>all the actors</u> co-evolve. The unity of an innovation is not given by something which would remain constant over time, but by the moving translation of what we call, with Serres, a <u>quasi-object</u>.

13We will see in the next part how we can transform the point of origin of diagrams and thus compare the degree of convergence of different narratives told by different actors.

d) Realistic or unrealistic?

By dissolving the difference between that which mutates and the surroundings in which an innovation mutates, our cartographical principle removes yet another problem: that of the asymmetry between the realizable and the unrealizable.

Reading Eastman's socio-technical graph, we can easily see that version (36) is not the realization of version (1), since none of the actors can be found at the (temporary) end of the controversy. And yet we are dealing with the progressive construction of reality. But the continuity of this story is not that of a slightly crazy idea that finally becomes reality; it is that of a translation which completely transforms that which gets transported. The real is no different from the possible, the unrealistic, the realizable, the desirable, the utopic, the absurd, the reasonable, or the costly. All these adjectives are merely ways of describing successive points along the curve. Version (24) only seems unfeasible when compared to the violent event of version (26); version (10) is not an incarnation of version (9), as the two only have a single element in common. The diagram thus allows us to use the <u>same tools</u> to treat each stage of our story without ever having to judge how "intrinsically" realistic or unrealistic an association is. The only reality that it records is socio-logical[14]: if Q is allied with O in version (9), then O retires to version (10); if Z is recruited in version (14), then AA and AB become durable allies.

A major result of this manner of recording socio-logics is that "reality" is not a final, definitive state demanding no further effort. A chain of associations is <u>more real</u> than another one if it is <u>longer</u> - from the perpective of the enunciator designated as a starting point. Maintaining reality is thus paid for by a continual extension in the syntagm (AND). Thanks to this diagram, the "inertial force" of innovations - that famous state in which they would be irreversible and would zoom through society on their own steam - is quite simply dissolved. So is the symmetrical "inertial force" of groups incapable of "accepting" an innovation. Nothing becomes real to the point of not needing a network in which to upkeep its existence. No gene pool is well adapted enough to the point that it needs not reproduce. The only possible thing to do is to diminish the margin of negotiation (the index **IN**) or to transform in black boxes the most faitfhul allies (the index of reality **R**) is as real as it gets. The only absolutely impossible thing is diminishing the number of associated actors while pretending at the same time that the existence of the innovation continues to be just as "real."

e) Local or global?

Our diagram accounts for another little mystery: the progressive passage from the microscopic scale to the macroscopic scale. Network analysis and field work have been criticized for giving interesting demonstrations of local contingencies without being able to take into account the "social structures" which influence the course of local history. Yet, as Hughes has shown in a remarkable study of electrical networks (Hughes, 198-, 198-) the macro-structure of society is made of the same stuff as the mico-structure - especially in the case of innovations which originate in a garage and end up in a world that includes all

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14The word "socio-logical" has nothing to do with the words "logic" or "sociology"; it only covers the body of associations allowed or forbidden between humans and non-humans.

garages - or, conversely, in the case of technological systems which begin as a whole world and end up in a dump. The scale change from micro to macro and from <u>macro to micro</u> is exactly what socio-technical graphs are capable of following and documenting. Consider a chain:

(1) ABCDEFGH
(2) A_7 IFJKLMNO
(3) A_7 F_8 PQRSTUV
<u>**(4)** A_7 F_8 U_7 WXYZ</u>
(5) A_7 U_7 IFJKL
(6) U_7 IF ABCD
(7) PRIBC
(8) IC

As soon as a syntagm is stable it can be summarized by a black box. We thus count it as such, but we indicate the number of actors that made up the association before black-boxing in subscript.

If version (4) does indeed represent a progressive change of scale from micro to macro with the inclusion of greater and greater numbers of black boxes (each of which counts "as one"), then we can also document, using the same tool, the progressive re-opening, dispersion, and disbanding of actors passing from the macro level to the micro level. The socio-technical world does not have a fixed, unchanging scale, and it is not the observer's job to remedy this state of affairs. The same innovation can lead us from a laboratory to a world and from a world to a laboratory. Respecting such changes of scale, induced by the actors themselves, is just as important as respecting the displacement of translations. Given the tools of network analysis that we have at our disposal, trying to dote actors with a fixed dimension as well as a fixed form is not only dangerous, but simply superfluous.

f) Slow or fast?

It is worth noting one last consequence of substituting socio-logics to asymmetric notions of the real and the possible. The passage of time becomes the consequence of alliances and no longer the fixed, regular framework within which the observer must tell a tale. The observer has no more need for a regulated time frame than for actors with fixed contours or predetermined scales. Like the relativist in physics, the relativist (or relationist) science or technologicazl studies is content with what Einstein so beautifully called "mollusc of reference" (Einstein, 19--). Just as we let actors create their respective relationships, transformations, and sizes, we also let them mark their measure of time; we even let them decide what comes before what.

The OR dimension records the order in which different version succeed one another[15] - as seen from the perspective of the observer chosen as a starting point - but it does not regularly measure time. Referring back to the Eastman example, thirty years elapse between versions (1) and (15), but only a few months go by between versions (25) and (30). Should we then conclude that the innovation "drags its feet for thirty years" and "accelerates brusquely" in 1887 as historians so often say? We could indeed reach this

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[15]This succession does not have to be temporal: it could, for example, consist of successive interviewees' versions of the same project. See later.

conclusion, but words such as "fast" or "slow", "mature" or "premature", "feasible," "utopic," "real," merely float on the surface of translation movements without explaining anything. The number and speed of events depend entirely on movements of alliance or rupture performed by the actors. If you can reconstitute these movements, you obtain the dimension of temporality as well; if you cannot reconstitute these movements, the regular passage of time won't tell you anything. What the socio-technical graph reconstitutes is the historicity of innovations ever dependent on the socio-logics of actors. This time displacement has an important consequence for map-reading: if no new actor gets recruited, literally nothing will happen. As a result, the syntagm, attacked by the anti-programs, will probably become undone. Like everything else, time must be constructed. It is not given to you. The innovator never rests a seventh day.

5°) **From description to explanation**

Admitting that we are now capable of displaying the fine variations of a socio-technical exploration, how does this ability help us <u>explain</u> the contingent shape adopted by a particular trajectory? The three Graces of Truth, Efficiency, and Profitability, so handy for providing causes in science, technology, and economics, are obviously unusable, as they are the result and not the cause of these displays. Eastman's camera in versions (8) to (29) of the socio-technical graph are neither profitable nor efficient. They will take on these qualities, but only somewhere around version (36). It is thus impossible to use the end of the story to explain its beginning or its development. The study of innovations is no more teleological than Darwinist evolution. But there is no question of substituting sociological interest for the three Graces as the motor of history. Stable Interest, like good Efficiency or sure Profitability, needs stable networks and instruments to be able to make predictions. But the amateurs do not know that they need photography before version (36). Stockholders wait twenty years to decide whether their interests are better served by plates, films, or Kodak cameras. And as for Eastman, he designs his interests little by litte as his research develops. Both economics and stable sociology arrive on the scene <u>after</u> the decisive moments in the batttle. They arrive after the points where large AND variations are paid for by large OR displacements, and they deal with states in which large AND displacements are only paid for by tiny OR displacements.**16**

Since an explanation of an innovation's path cannot be retrospective, it can only spring from the socio-logics of programs and anti-programs. Can anti-program actors be either recruited, ignored, or rebuffed? Can program actors maintain their association if such and such an actor is recruited, ignored, or rebuffed? At all times, the front line of a controversy generates such questions. It is the answers to these <u>particular</u> questions that make or break an innovation. And all these answers depend on how actors resist the proposed tests: if I add actor D to the ABC syntagm, what will A do? What will B and C do? To understand the path taken by an innovation, we must evaluate the resistance put up by the successive actors that it mobilizes or rejects. Explanation does not follow from description; it is description <u>taken that much further</u>. We do not look for a stabilized and

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16This division of labor is not a weakness of economics or sociology. It is simply linked to the problem of controlling large amounts of things: an object's ability to recruit large numbers of either masses or markets in a predictable manner depends on the stability of both the object and its network.

simplified description before we begin to propose an explanation. On the contrary, we use our mappings of innovation paths to explore the actors, and it is from them and them alone that we extract any "cause" we might need. Paradoxically our explanation are "internalist" in the sense that they all come from the inherent topography of specific networks.

a) Defining actors by the list of their trials

We define an actor or an actant only by its etymological meaning. If an innovation is defined by a diagram in which its essence is co-extensive to its existence - that is, the ever-provisional aggregate of its versions and their transformations- then these versions and transformations are in turn completely defined by the actants that constitute them. But where do we get these actants from? Where do the hotel customer, the manager, the key, and the sign come from? What would be the use of displaying innovations without reductionsim if we use a reductionist definition of actants? Luckily for us, the diagram shows us that an actant is defined exactly like an innovation. All we have to do is shift our perspective: instead of using an innovation that passes from actor to actor as a starting point, we must use one of these actors in whose "hands" successive versions of the innovation pass. Here again, the linguistic metaphor can help us. A linguist can study either a syntagm - a group of associated elements in a meaningful sentence - or the element itself in the framework of all the meaningful sentences in which it appears, that is a pradigm. This would be like moving from:

> The fisherman
> The fisherman / fishes   /
> The fisherman / fishes / a shark/
> The fisherman / fishes / a shark / with/ a gun
> The painter   /fishes / a trout / with / a knife

to

> The painter/   paints/   pictures
> The painter/   paints/   houses
> The painter/   is   /a/ substantive
> The painter/   is/   /   hyper-realistic

What changes is the point we choose to hold fixed. In the first case, our object is the length of the syntagm as well as the group of paradigms that can be substituted in each articulation. In the second case, our object is a specific articulation, and we wish to reconstitute the group of syntagms in which it occurs. Defining the essence of innovations by the existence of their successive and simultaneous actants, and then turning around to define the actants by the successive innovations in which they appear, is no more circular or contradictory here than in linguistics.

How do we visualize an actant? An actant is a list of answers to trials - a list which, once stabilized, is hooked to a name of a thing and to a substrate. This substrate acts as a subject to all the predicates - in other words, it is made the origin of actions.**17** How do we define our hotel manager of the key story? He certainly "is" the obstinate speaker who

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17This role attribution can itself be the object of a dispute if certain actors refuse to recognize others as actors. See Callon (1989) and the end of this section for more on this topic.

reminds customers to leave their keys, but he is also more than that. He "is" also the one who makes up the bills, orders clean sheets, places ads in the phone book, summons painters, etc. The key also can be defined not merely by its appearance in our innovation story, but by the list of everything it must submit to in all the innovation stories in which it appears. Its sole purpose in life is not returning to the front desk; it also throws bolts, gets stuck when a drunken customer tries to force a lock, gets imitated by a master key, etc. And as for the metal weight, it does not merely intervene as a modest attachment to a hotel key. It undergoes many other tests, which define it much more completely: it melts at 1800° in a furnace, it is made up of iron or carbon, it contains up to 4% silicon, it turns white or grey when it breaks, etc.

How do we define this list of actions based on our maps of innovations? Let us consider the following fictional example.

		1	2	3	4	5
N°2	(1)	A+	B+			
N°5	(6)	A-	C+			
N°8	(12)					
N°12	(2)	A≠	D+	F+		
N°15	(7)	A++	K+	L-		
N°17	(4)	A--	U≠	Z+		
N°9	(18)	A3	X			
N°9	(19)	A-≠	L +	M--	X	

Here we compare all the versions of the entire database in which a particular actor appears. This list defines the actor's activity and hence its essence.

To build this table, we locate all the tables in the database in which the chosen actant - in this case, A - appears. We write the numbers of these tables in bold face, and we place the numbers of the versions corresponding to the actant's appearance in parentheses. By convention, we move the actant so that it always occupies the first segment. What is the essence of A according to this list? A is an actant allied to B in version (1) of map n°6; opposed to C in version (6) of map n°18; indifferent to the DF association in version (2) of map n°4; instigator of K's attachment and L's detachment in version (7) of map n°8; and highly opposed to Z and leaving U indifferent in version (4) of map n°22. We also learn that in versions (18) and (19) of map n°9, A undergoes such a difficult trial that it bursts, leaving three elements with three different fates. The longer the vertical list, the more active the actor is inside the database. The more variations that exist among the actors to which it is linked, the more polymorphous our actor is. The more it appears as being composed of different elements from version to version, the less stable its essence. Conversely, the shorter the list the less important the actor. The more diversity it encounters among the different actors it meets, or the more difficult it is to open its black box, the more coherent and firm it is. The list of tests undergone by a given actor defines its historicity, just as a socio-technical graph defines the historicity of an innovation or knowledge claim.

Just as an innovation can become increasingly predictable by black-boxing longer and longer chains of associations, an actor can become so coherent as to be almost predictable. If A is always associated with B or dissociated from D in the succession of maps, we can safely assume that when A relates to B in a new map, it will link itself with B and unlink itself from D. We can thus begin to deduce the <u>performance</u> of actors from their <u>competence</u>. We are then, but only then allowed to be normative again, but these norms are no forced onto the data, they are extracted from the actor own's efforts at rendering each other behavioru more predictable. An essence emerges from the actor's very existence - an essence which could dissolve later. Its history becomes a nature to use Sartre's expression, perhaps to later become history again. The actor has gone from Name of Action to Name of Object.**18** The lists constructed from the joint story of innovations and actors highlight the continual variation in an actor's isotopy, i.e., in its stability over time. Its behavior becomes either more and more or less and less predictable. The list allows us to go from extremely shaky certainty to necessity, or from necessity to uncertainty. The force of habit, or of habitus (Bourdieu, 1298-), will either exert itself <u>or not</u>; it will act or not as a function of the historical records of the actor.

b) **Following the relativist variations of translation**

The socio-technical graph enables us to describe an innovation by the body of actors having adhered to or remained separate from it. The list of tests enables us to know at all moments the "essence" of the actors. Yet we are still far from providing explanations: we can only predict how long an association will last if an innovation grabs an actor or if an actor grabs an innovation. To be more precise, we can only predict such reactions in the cases that interest us the least: those in which the innovation is already a black box, in which the actors have such a stable history that it has almost become second nature. How can we manage to anticipate reactions in other cases? To do so, we must tame a third source of variation.

Since we are capable of mutually defining actants and innovations without any further essentialism we can therefore map the translation operation. This crucial operation engenders the establishment - albeit local and provisional - of social links. Thanks to translation, we do not have to begin our analysis by using actants with fixed borders and assigned interests. Instead, we can follow the way in which actant B attributes fixed border to actant A, the way in which B assigns interests or goals to A, the definition of those borders and goals shared by A and B, and finally the distribution of responsibility between A and B in their joint action.**19** In a universe of innovations solely defined by the associations and substitutions of actants, and of actants solely defined by the multiplicity of inventions in which they conspire, the translation operation becomes the essential principle of composition, of linkage, of recruitment, or of enrollment. But in order to establish the success or failure of the operation, we must be able to shift the observer's perspective.

18This distinction is crucial if we want to understand the emergence of new objects. The object starts as a list of responses to a series of trials and becomes a thing that undergoes tests. See Latour (1989), ch. II for details.

19This term belongs to Michel Serres and was introduced into sociology by Michel Callon. See Latour (1990) for a canonical presentation.

Consider a particularly elegant translation operation:

> To the Minister of Public Education
> Paris, 1 August, 1864
>
> Minister,
> Wine constitutes one of the greatest agricultural riches of France. The value of this product of our soil is increased by the commercial treaty with England. Thus in all wine-growing countries, there is interest in improving methods with a view to increasing both in number and in quality those wines that can be profitably exported.
>
> Unfortunately, our knowledge of this precious beverage leaves much to be desired. Studies of its composition are so incomplete that only in the past two years have two of its main components - glycerine and succinic [?] acid - been identified. Despite the progress of modern chemistry, there is no more knowledgeable and precise treatise on wines than that of Chaptal, which came out more than sixty years ago. This is sufficient to indicate how much remains to be done.
>
> For the past five years, I have been working on the problem of fermentation. I have taken particular interest in the fermentation of alcohol at the heart of the wine-making process. The very progress of my research has led me to want to continue it *in situ* and in countries known for the production of those wines that are most valued in France. I wish to study the fermentation processes there, and in particular to examine the microscopic vegetable matter that is the sole cause of this great and mysterious phenomenon.
>
> I intend to carry out this work during my next leave. There will be about six weeks of traveling and of study, with one assistant and a few necessary items of equipment and chemical products. I estimate the outlay to be 2500 francs.
>
> The aim of this letter is to put this project before your Excellency, and to ask for a grant to cover the cost of its execution. This is not to be the end of my interest in the matter. I will follow it up with work in future years, at the same period.
>
> Further, I am the first to admit that there may be no immediate practical consequences of my studies. The application of the results of science to industry is always slow. My present goals are very modest. I should like to arrive at a better knowledge of the cryptogamic plant that is the sole cause of fermentation in grape juice.

Successive layers of actants - the Minister, Chemistry, my research, my trip to the Arbois - get goals and borders attributed to them. Each of these layers is characterized by incompatible vocabulary: 2500F, the trade treaty with England, succinic acid, the cryptogamic plant. (Hence the word translation). An anti-program gets attributed to each of these programs of action: it would be nice to sell wine to England, but these wines are diseased; it would be nice to know the origins of these diseases, but wine chemistry is sixty years old; I would like to pursue my research, but I lack money and assistants. On the one hand, the translation operation consists of defining successive layers of vocabulary, of attributing goals, and of defining impossibilities; on the other hand, it consists of displacing - hence the other meaning of translation - one program of action into another program of action. The overall movement of the translation is defined by a <u>detour</u> and by a <u>return</u>. In the end, by giving Pasteur 2500F, the Minister is supposed to restore the balance of payments and thereby attains his goal.

But the translation operation is always risky. Indeed, nothing guarantees that the detour will, in the end, be paid for a a return. In fact, Pasteur, alwxays careful, gives a good indication of this in his last paragraph. The only goal that must be attained, he said, is that of pure knowledge of the cryptogamic plant: applying this knowledge - i.e., the return - is always problematic. One can imagine many other possible scenarios: the Minister could be uninterested in wine trade, wine diseases could be due solely to chemical

phenomena, the 2500F could never materialize, or Pasteur could change his research project. Those things composed and linked by the translation operation could disperse themselves like a flight of birds. This is precisely the possibility we must predict if we want to explain and produce some reasonably normative commentaries. And how else could we do this, except by submittting Pasteur's version of the goals and desires of all the human and non-human actors to a <u>test</u> by <u>comparing</u> them to the goals and desires they give themselves or attribute to Pasteur? Indeed, nothing guarantees that the operation Pasteur proposed corresponded to the version held by the actants named Minister, chemistry, cryptogamic plant, England, or ferment. In order to measure the potential success or failure of the translation operations - relative, of course, to an enunciator and to an observer - we must verify whether or not they occupy the position expected by Pasteur.

	1	2	3	4	5	6	AND
X1 (4)	Minister	Commerce	Diseases	Chemistry	Fermentation	2500F and aid	
X2 (6)	Minister	Silk	Commerce	Japan			
X1 (4)	Minister	Commerce	Diseases	Chemistry	Fermentation	2500F and aid	
X3 (2)	Diseases	Chemistry	Vitalism	Pasteur			
X1 (4)	Minister	Commerce	Diseases	Chemistry	Fermentation	2500F and aid	
X8 (7)	Ferment	Culture	Air	Destruction of cultures			
OR							

Here we compare on actor's verison of those it enrolls with the ideas held by enrolled actors on themselves and on it.

In this figure, for example, we compare Pasteur's version to version (6) of the Minister's map, to version (2) the chemists' map X3, and to the version (7) or the ferment's map X8 (our example is partly fictional). We notice that as far as the Minister is concerned, the problem of balancing payments has for him nothing to do with wine and its diseases. His problem lies with silk, whose trade is hampered by Japan. As for the chemists, they certainly do not occupy the position predicted in version (4). Their tragedy has nothing to do with the archaism of their discipline; on the contrary, they're concerned about the dramatic return to vitalism, which is slowing down progress in chemistry. In fact, Pasteur and his ferments figure prominently in their anti-programs! And finally, the ferments: they're beginning to die from lack of air, thereby annihilating Pasteur's efforts to cultivate them. Glancing at the table, one can easily conceive of Pasteur having a few problems getting his funds, because those mobilized in his version <u>do not occupy</u> the position he assigned them, at least, not yet. Such a diagram shows the actants' state of alignment or dispersion and predicts the complexity of future negotiations. If by normative we mean thess sort of predictions then actor-network theory is as normative as one can wish.

This example shows us that it is not merely statements which vary as a function of innovations. Both also vary <u>as a function of the perspective </u>of the observer or of the informant.

Until now, the starting points of all the narratives, diagrams, or socio-technical graphs have remained stable. We told the story of the hotel keys from the manager's perspective, and we told the Kodak story from the perspective of Eastman and Jenkins.

Yet a program's capability to counter an anti-program obviously depends on how well an actor's conception of others corresponds to their conceptions of themselves or of said actor. If this convergence is weak, the actor will populate his world with other beings; but these beings will behave in an unpredictable fashion, attaching or detaching themselves to the program from version to version. If, on the other hand, this convergence is strong, the actor can begin to make predictions - or, in any case, to guarantee the consistent behavior of the beings constituting his world.

We can use our diagrams and sociotechnical graphs to do more than follow the sequence of events surrounding an innovation: we can compare the different versions given by successive informants of the "same" syntagm. More specifically, the database can ask informants what is the same and what is different in a given statement: we can then use the succession of the OR dimension to compare the degree of agreement or disagreement found among these informants. The diagrams are constructed exactly like those in the first two parts, except that now they test the degree of coherence of a statement against the body of statements produced by the actors it refers to. We only have to replace the series of successive versions by the succession of tests that various informants (labelled X1 to Xn) apply to the same version - here (1) in italics. Let us use a classic example to demonstrate this process.

Consider a sentence often cited by language philosophers: "the present king of France is bald." This sentence has launched endless discussion in the philosophy of language, because it is both grammatically correct and completely devoid of meaning, as it does not "correspond" to any real state of affairs. It is said that this sentence has a signified but no referent. Now, if we construct a convergence diagram, we can give both the significance and the absence of meaning of this statement a specific graphic content - without, of course, having to take refuge in the notion of "referent.

(1)		**The Present**	**King**	**France**	**is Bald**
(2)X1	Charles	Bald	King	France	
(1)		**The Present**	**King**	**France**	**is Bald**
(3)X2	Bald		Hairdresser Lotion	Scalps	Creams
(1)		**The Present**	**King**	**France**	**is Bald**
(4) X6	Present	Berlin	King Sihanouk Mrs Thatcher		
(1)		**The Present**	**King**	**France**	**is Bald**
(5)X4	France	Hat	President	Mitterand	
(1)		**The Present**	**King**	**France**	**is Bald**
(6) X5	Present	Linguists	Strawson	Russell	Cambridge

Historians know Charles the Bald, but not the present king of France. Hairdressers know a few bald people, but no kings, not to mention kings of France; they do, however, hold scalps, creams, and hair lotions close to their hearts. Much is presently happening in Berlin and in Cambodia, but none of it has anything to do with the king of France. There are indeed people who run France, but they call themselves Presidents, and not kings. The only people who take this sentence into consideration are linguists and philosophers, who use it as a cliché! Based on this script, we can calculate our usual indicators, which will now represent the degree of convergence or of divergence between the actors mobilized by version (1) and what the actors say about themselves when questioned.
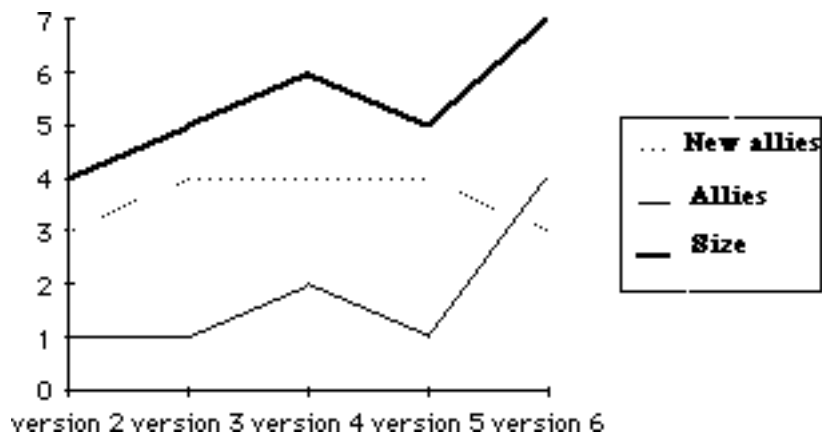
Size, New, and Allies for each version relative to version 1.

This diagram indicates the degree of convergence. In the present case, none of the actors who have been mobilized can take up the statement without adding other, completely disparate statements. There are thus very few allies and many new actors, except in the last version. For the only version that adopts (1) is that of the linguists, who stabilize it by turning it into a classic puzzle in the philosophy of language. If we turn now to the two indices of Negotiation and of Reality, we find the same striking signature.
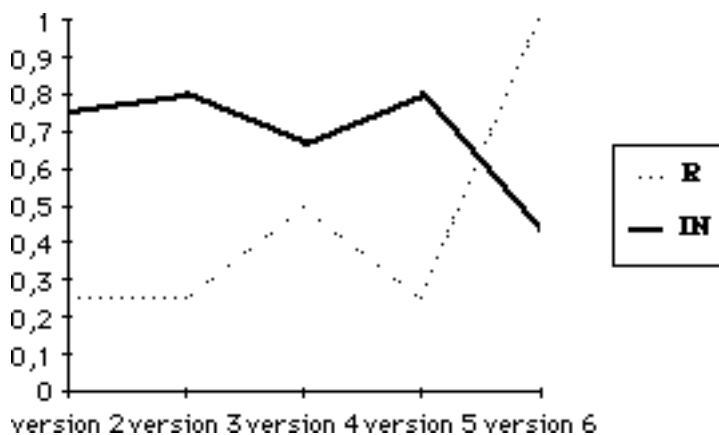
Indices of Negotiation and of Solidity for each version with reference to version 1.

The index of reality is worth "1" only in the last version, indicating that the linguists are the only ones to fully adopt this statement. In the last version, the index of negotiation is fairly weak, but it is never equal to "0" because the statement "the king of France is bald" is never completely isolated. Outside the linguistic world, each informant dismembers the statement, keeping only one or two elements. As a result, the index of negotiation **IN** remains close to 0.75.

These convergence diagram and this classic example allow us to loop network analysis back on itself. There is never any need to leave our networks, even if we are talking about defining the truth, the exactitude, the coherence, the absurdity, or the reality of a statement. The judgement of reality is immanent in, and not transcendant to, the the path of a statement. To put this the other way around, forbidding oneself to exit a

network does not entail forbidding oneself to judge. In this example, we can correctly judge the degree of truth of the statement "the present king of France is bald" without ever appealing to the notion of referent; in fact, this notion is the only mythical element in the whole bald king story. Indeed, all statements have a reality, and this reality can be evaluated precisely by comparing, each time, what an actor says about another actor with what this other actor says about itself. This comparison delineates a network which is both the existence and the essence of the statement. Unicorns, bald kings of France, black holes, flying saucers, appearances of the Virgin, chromosomes, atoms, Roger Rabbit, and utopian technological projects all possess, without excess or residue, the degree of realism delineated by their networks. This point is not relativist: all statements are not equal. It is relationist: showing the relationships between the points of view held by mobilized and by mobilizing actors gives judgements as fine a degree of precision as one could wish for. The philosophy of language, science, or technology do not know how to reconstruct or calculate these judgement with any finesse; they are content with coarse, hasty judgements on the manifest absurdity or the inevitable reality of such and such a statement or project.[20]

Conclusion

Regardless of the conventions chosen to make such a diagram, and regardless of the achievements of these computerized tools for network analysis, our present, provsional conclusion will be of a methodological nature.

The <u>description</u> of socio-technical networks is often opposed to their <u>explanation</u>, which is supposed to come afterwards. If we listen to numerous critics of the sociology of science and technology, even the most meticulous description of a case-study would not suffice to give an explanation of its development. This kind of criticism borrows from epistemology the difference between the empirical and the theoretical, between how and why, between stamp-collecting - a contemptible occupation - and the search for causality - the only activity worthy of attention. Yet nothing proves that this this intellectual ressource is necessary. If we display a socio-technical network - by which we mean something that includes the three types of diagrams defined until now (innovations, their actants, and translation operations) - we have no need to look for any additional causes. The explanation emerges once the description is saturated. We can certainly continue to follow actants, innovations, and translation operations through <u>other networks</u>, but we will never abandon the task of description to take up that of explanation. The impression that one can sometimes offer an explanation in the exact sciences like in the social sciences is due precisely to the stabilization of networks, a stabilization that the notion of explanation simply does not "explain"! In our hands, "explanation" goes back to its etymological origin, taking on the meaning of unfolding. There is no more need to go searching for mysterious or global causes outside networks. If something is missing it is because the description is not complete. Period. Conversely, if one is capable of explaining effects by causes, it is because a stabilized network is already in place. We hope

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[20]For the best treatment of ontological varieties of fictional beings, see Thomas Pavel, *Univers de la Fiction*, Paris (Le Seuil): 198?.

that the cartography of socio-technical networks will help in making this description, this deployment, this explanation that we are is such desperate need of.

Our second conclusion relates to relativism and the heterogeneity of networks. Criticisms of studies of controversy insist on the local, soft, and inconsistent nature of the results. They have the impression that network analysis recreates "that night when all the cows are grey" that Hegel ridiculed. Yet the tendency of networks analyses is exactly the opposite. Eliminating the great divides between science/society, technology/science, macro/micro, economics/research, humans/non-humans, and rational/irrational does not immerse us in relativism and indifferentiation. Networks are not amorphous. They are highly differentiated, but their differences are fine, cirumstantial, and small; to be identified and analysed, they thus require new tools. Instead of "sinking into relativism" we can float on it.

Finally, we are left with an accusation of immorality, apoliticism, or moral relativism directed against socio-technical description. But this accusation does not make any more sense than the other two. Refusing to explain the closure of a controversy by its consequences does not mean that we are indifferent to judgement but but only that we refuse to accept any judgement that transcends the situation. Network analysis does not prevent judgement any more than it prevents differentiation. Efficiency, truth, profitability, and interest are simply properties of networks, not of statements. In order to make a diagnosis or a decision about the absurdity, the danger, or the unrealism of an innovation, one must first describe the network; furthermore, this description should be the sole basis for finding contradictions or extracting predictable norms. By engaging in this exercise, we will see that if the capability to make judgements loses its vain appeals to transcendance, it loses none of its acuity.