What do you think a simulation is, anyway?

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This short paper elaborates freely on the discussions held at an ATACD workshop hosted at the CSI (Centre de Sociologie de l'Innovation), in the Ecole des Mines de Paris (Mines ParisTech), on October 30th, 2008. The workshop, titled "Stacked networks described through stochastic automata: an ANT approach to cultural dynamics", consisted of an informal discussion about the interfaces between Actor-Network Theory, network analysis and stochastic automata modelling. Participants were Ivan Tchalakov, Petar Kopanov and Donka Keskinova from Plovdiv University, and Michel Callon, Fabian Muniesa and Liliana Doganova from Mines ParisTech. The discussion built upon earlier collaborations[1] but also upon more recent work in both research institutions, considered in the light of joint reflexions prompted by the ATACD Network.

The paper takes the form of a dialogue between two human agents: A and B.

[1] These collaborations focused on the TACTICS Project (Telematics And Communications Technology Industrial Comparative Study), an INCO FP4 RTD Cooperation Project, developed from 1998 to 2000. For an overview, see: Tchalakov, I. and P. Burton (eds.), 2001, *Project TACTICS*, Sofia: LIK Publishers. Support for these collaborations has been provided also by the ACE/Phare Programme in 1994 and the NATO Science Fellowships Programme (France) in 2001.

A: What do you think a simulation is, anyway?

B: I can think of two major directions for understanding the value of a simulation. One would be a rather *sociological one,* a direction in which you start with a dataset, or a database. You don't care about things such as whether or not you are confronting a stable state – what you primarily need is to describe the dataset itself. You can then imagine a computational model that is useful or interesting in order to describe the dataset, to find an analytical vocabulary that allows making sense of the assemblage of data. The other way of understanding simulation would start with getting rid of data and just playing the game of the computational device. You might hook the device onto a dummy database, a database without data – a kind of *artificial situation* that does not correspond (does not need to correspond and could actually hardly correspond) to any empirical situation. The second option is the fashionable tendency in computation models, in financial computational modelling particularly. Just build an artificial world and play the game within – describing, at best, the behaviour of a world that you have provoked yourself.

A: Come on, that is a bit of an exaggeration. Model-based prediction of empirical behaviour is a real possibility. What about predictions based on the simulation of real empirical data, such as predictions of energy consumption which are based on established trends and which allow for a pretty accurate prospective modelling of future behaviour?

B: Of course, prediction of behaviour. But we are talking here rather about different cultures of using models. Prediction is a very fashionable issue indeed. What makes a prediction possible is the certitude or belief that you understand the initial state (and those preceding it). This is not always the case. So maybe understanding is more important. Understanding is definitely more in the line of Actor-Network Theory – not to predict anything, but just to describe, to understand what happens in a dataset. I agree that as soon as you enter into the business of computational models, there is an urge to go into 'prediction mode'. So data from the past are interesting, but what is more important is the dynamics of the model…

A: When you are trying to build a model, there is a lot of 'trade', or 'surplus' coming out of it, especially when you are modelling small, local phenomena. First, you are using not only certain variable distributions to define the optimal states and so forth, but there are also pretty good statistical tools that enable you to establish the main interdependencies between some variables, some types of interaction. Then you can base your assumptions on this specific model even if it refers only to a specific moment – it does not matter so much whether this is a moment of crisis or a stable situation. The logic is simple enough: in the economy, for instance, if a given company is on the market for long enough, it necessarily accumulates some experience. It might be on the verge of collapse, like Lehman Brothers, but you study it a few months or weeks before it collapses. Yet, even in this case your model will be viable enough, i.e. more viable than those based on pure computation, pure combinatory logic. Second, there is no need to model events in their full complexity. We have this idea of 'stacked networks', right? These are several layers of networks of different kinds that intermingle together through small ego-networks that cut across them all.

B: Ok, I see. That is your idea of heterogeneous networks as stacked networks. In the case of, say, a transitional economy, you have several kinds of networks, such as a network of corporate interlocking directorates, and then a network of capitalistic ownership, and then a network of geographical proximity, and then you have nodes that allow you to make sense of how all these networks are stacked together. All right. But then you want to 'model' that.

A: One big challenge here is to model so-called 'nonhuman agents', technologies, artefacts, money, and so forth: how to model their role, their place, their behaviour, how to consider them as *one of the actors* described within the network. If one knows how technology behaves and put some efforts to collect the relevant data – imagine for instance a study on competing telecom protocols that would care for how each protocol functions – these nonhuman agents could perfectly be modelled by a corresponding automata and added to the compound of diverse human, individual or corporate agents. Should we use the same stochastic automaton, slightly modified, that we used in order to model human agents? Should we use a separate automaton? It all depends on the identity of the nonhuman agent.

B: But what do you mean by the 'identity' of a nonhuman agent?

A: I'm not sure it's about the singular identity of one actor. I mean rather *the different identities of one and the same nonhuman actor in each of the stacked networks*. This is a big challenge – different faces of a nonhuman agency that acts simultaneously in different networks? Take money, for instance, Viviana Zelizer's money[2]. The banker's money, the farmer's money, the farmer's wife's money: all partaking of different networks, but connected in the ego-network of money. So you see, there are lots of challenges coming from this modelling.

B: Vast programme.

A: But the most important thing is related to Claude Rosental's research on demonstrations used by software developers[3]. We are in a similar situation. If we manage to make a piece of software sophisticated enough and to model this particular field, and then to model other fields, you need at least two things. First, you need data, which are specific for the given field, allowing an outline of the stable states, the distribution of variables, interdependencies, and so forth. Then, we need to introduce the corresponding scripts in the model, to change the inputs and modify the internal properties of the automata. Then you could get *the universality of the tool*, not of the model but of the tool. This is a super goal that is worth setting… If we eventually manage to build a compound of stacked networks interconnected via ego-networks, and then we build the model for this particular field, and then we model another field, all major questions about the configuring of stochastic automata will be solved. We will just need to change the software a little bit. But its skeleton, its basic properties would be already available – as result of the modelling of the initial field. We get new data, we change some parameters in the construction and we are ready to emulate the new field… Inspiring, isn't it? To achieve the universality of the tool. This is feasible and, I believe, not very complicated: layered, stacked networks, taken

[2] See: Zelizer, V. A., 2001, *The Social Meanings of Money*, Princeton: Princeton University Press.
[3] See: Rosental, C., 2007, *Les Capitalistes de la Science*, Paris: CNRS Éditions.

simultaneously… not the Parsons way, not considering social roles, *not as attributes of the agent*, but with agents taken from the point of view of Actor-Network Theory.

B: The universality of a tool is a very inspiring thing, indeed. I can understand the objectives of mathematical modelling, this notion of stacked networks and the aim of constructing models, which have different types of interactions, different patterns of networks, but I think this is *very complicated type of job you are dealing with*. And thinking that it will be possible to use this model to describe the dynamics of real situations seems to me a bit too optimistic. If you just consider mathematical questions, it is probably very hard to succeed. If your long-term objective is to use these models to describe dynamics of whatever fields you want to study, it looks much more difficult. I'm all for a far more modest use of network analysis: using networks to describe how some configurations could be born out of the roles played by some actors, in a situation that could be thought of as a network. But that's a rather limited perspective, of course, and with barely any modelling. On the one hand, there is the concern of describing, making sense of some data, which is very difficult task. On the other hand there are these computational tools, mathematical models that can mimic this kind of behaviour, in almost a game-theoretical way. These are two different directions. But maybe one interesting compromise is *to use simulations not as research devices on their own*, to produce some data, *but as a way to construct a vocabulary for understanding the database*. I'm interested in what you said. You do not have your stochastic automata yet, but the very work you performed in order to reflect about the construction of this simulation has already produce a set of useful vocabularies aiming at describing what is happening in an heterogeneous dataset. You don't have the stochastic automaton, but you do have *the personage*, you do have *the stochastic automaton as a conceptual character* that allows you to say: well, let's consider what the actor is, let's consider it as a kind of an ego-network trapped in between a number of stacked networks, and so on. And that is a key capacity in order to describe a heterogeneous database! It is fantastic to pursue the goal of building such a computational device, but it is interesting to grasp what you have already done for this computational venture in order to describe, to make sense, to find the right vocabulary to describe what is happening in data.

A: Well, we had to come up with these sorts of concepts. But our key ambition is to *accomplish the automaton*, really. We want to spot its internal simplicities and its abilities for generating interesting network behaviour. An accomplished automaton could be used to build many kinds of research. Interesting research directions would include applying the automaton to simpler datasets. You do not need to have fifteen variables… Each sub-network could be defined by a single variable, describing the basic (critical) relationship in the network. It is difficult, of course, to decide what this basic relationship is, but I think it is worth thinking in that direction – if not one, we could combine two variables into a single one, while the other variables could be built-in as properties of the automaton itself. So when such and such a script arrives at the input, it has to react in a specific manner. The crucial point is to clarify what you want, to clarify the initial design that precedes building the automata itself…

B: But you have first to define properties that characterise your dataset. Not to try to model your dataset, because your dataset is too complex!

A: There is little sense in building purely abstract models; we need *to have datasets in mind*.

B: To build a machine that mimics the 'real world', this is a hard task… But you can have machines that are simple… Then you say: well, it does not mimic a 'real world' dataset, this is a heuristic device; it is an intellectual device actually. The tradition of complex systems in general starts from some sort of mock complexity. You have, for instance, mathematicians trying to model financial markets with some complexity in it, and then you notice that what they are actually talking about is a set of idiotic robots meeting in the CPU of their computers. Nothing that would look remotely like traders working in the trading room of an investment bank! It's totally all right to have these machines working as intellectual devices in order to foster some analytical categories, but not as a depiction of practical reality.

A: One example: we have a hypothesis about different speeds of interaction within the sub-networks and between the sub-networks. This is very important question, empirically. If you consider a case of transitional economies, *it has political implications*. For example, you can consider two types of speeds, two types of devices with different speeds and try to study the effects produced on the dynamics of each sub-network. Using these results you could have some insights as to how the real situation is configured.

B: Yes, I think this would be a more *modest approach*, where the modelling should be used more as a tool for studying very limited set of questions, even if models are very complicated… Because very often simple questions are very complicated… But still I would be very reluctant to consider a model as a straight simulation of what is in your database. *The model simulates, at best, a research question*. One example of such a research question would be about the different types of relations between sub-networks, and the speed of interaction within them. Another would be about the shape of ego-networks or about the impact of the introduction of a new actor into a sub-network of firms.

A: So, for example, if we face the specific problem of how a mediator transforms into an actor, imagining a situation where the 'switch' that propagates through the network transforms itself into an actor, then we need to change the properties of the automaton. So it seems that while the script (the 'switch') is 'just travelling' through the nodes, its properties change into the property of a specific automaton and it becomes a different agent. But then you need specific data… Anyway, I get the idea of using the model as a tool for understanding some specific, peculiar situations. But in any case this will not be a modelling of 'rules' of social interactions provided by some sociological theory. Rules need to be taken from some past situation, from data describing some real phenomena.

B: If we tackle sociological theory, then maybe we should talk a little about Actor-Network Theory and the *notion of agen*cy.

A: Yes, the agency of nonhuman agents?

B: Well, I am not sure that the point of Actor-Network Theory is to say that there are some human agents, which have agency, and that there are also some nonhuman agents, which also have agency. I'm not sure that the problem is to develop some kind of network analysis where every kind of actor could be granted with agency. Is that the most relevant point of Actor-Network Theory? I would rather say that the point is that *no one and nothing have agency at all – either human agent or otherwise – unless those agents are networks*. So in some sense the challenge of Actor-Network Theory is not to discuss the notion of agent, but rather *to reassess the notion of network*.

A: Well, it's true that the whole point is to replace both the notion of actor and of network with the notion of actor-network.

B: An interestingly misleading notion, by the way. In French, an *'acteur-réseau'* refers to 'an-actor-which-is-a-network' but the English version, 'actor-network', rather suggests the idea of 'a-network-which-acts'.

A: Was this difference in meaning created on purpose?

B: Who knows? Perhaps! Anyway, the problem with the vocabulary of network analysis is that it spontaneously grants agency to the agents, to the 'dots' in the graph, and not the edges between the dots. This is not compatible with a theoretically sound Actor-Network Theory stance! So the idea would be to establish some theoretical vocabulary that would tackle this issue, because as soon as we are heading to the implementation of these models we end up with a discussion about several kinds of agents: we have human agents, persons, then firms, then tools, etc. I thing *this is a rather impoverished version, compared with the potentials of Actor-Network Theory, which is really to criticize completely this idea of agency as a property of agents*.

A: But maybe the idea of stacked networks in which the linking agents are ego-networks can work as a possible solution, right? Because the 'identities'[4] they obtain in each layer are defined both by the interactions in the corresponding sub-network, and the interactions between these 'identities' in the ego-network - a kind of 'looping', in which one starts from nowhere or rather from the entire space of ongoing interactions. I am tempted to call that a 'topological space'.

B: Yes, but in that case what you term a 'sub-network' shouldn't be taken in the sociological sense of a 'field': the field of politics, the field of business, etc. I think one of the major proposals of Actor-Network Theory is precisely *to jeopardize the notion of field and to say that there is no such thing as a 'field' in the sense of Bourdieu, or a 'system' in a Luhmannian sense. Rather, it claims that everything is completely heteronomous, that there is no such a thing as an 'autonomous field'*.

A: Yes, right. Here we do not consider autonomous fields. But we consider in a sense, autonomous sets. I mean datasets which correspond to a heteronomous empirical reality but that look autonomous because they *correspond to one kind of source*. The fields are thus autonomous only as datasets – because if you are collecting

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[4] Or rather 'hypostases', the concept coined by Byzantine orthodox philosophers to solve the problem of relationships between the 'essential properties' of an entity and its 'existence'. For a possible reinterpretation of the Latin 'static' notions of being into more dynamic ones, see: Tchalakov I. and G. Kapriev, 2005, "The Limits of Causal Action: Actor-Network Theory Notion of Translation and Aristotle's Notion of Action", in A. Bammé, G. Getzinger and B. Weiser (Eds.), *Yearbook 2005 of the Institute for Advanced Studies on Science, Technologies and Society*, Munich: Profil, pp. 389-433.

information, there are *business* databases, *legal* databases, *scientific* databases and so forth. I would like to come back to the problem of a mediator transforming itself into an actor: from the point of view of ongoing interactions in the 'topological space', databases are just mediators that stabilise and make predictable these interactions. But all of a sudden they become actors 'speaking' or 'portraying' this space in a specific manner.

B: But that is actually the only reason why you have such a thing as different 'sub-networks': because you construct them on the basis of sources, which are instituted as different, in a sense. A 'field' is just the performative result of the institutional practice of a data provider…

A: Well, the idea that we shouldn't trust the boundaries between 'fields' is particularly helpful in the study of transitional economies. The notion of 'recombination' is particularly illuminating here[5]. The existence of different sub-networks should not derive from sociological assumptions but primarily from the properties of data sources. Consider the reality of corporate mergers and acquisitions: it is a profusion of political, kinship, social, scientific networks. But if you want some empirical databases, you will go to patenting offices, then you will need to pick from several dedicated data sources. You may say that they correspond to 'stacked' networks, but it is perhaps more realistic to say that they are completely mixed up. Any attempt at developing an evolutionary approach should care about the combinatorial evolution of networks… and about the evolution of data sources as such.

B: Talking about evolution: in stochastic modelling there is also some sort of 'optimality unconscious' that is worthwhile historicising a bit.

A: You mean the pervasiveness of the *point of view of game theory*?

B: Yes, the idea à la von Neumann and Morgenstern according to which the point of any kind of game would be gain. The leitmotiv of the attainment of 'optimality': if you do not play the optimality game you are out, and this is the only possible game. I object. Look at real life. Fortunately, there are thousands of situations in which people who do not like optimality, or who do not like games altogether, are still in. I would even say that there are thousands of 'social games' in which the rules are set in a non-economic, although realistic fashion. So I think model builders should be trained to imagine worlds that are not into the 'minimax' business and be open to other ways of theorizing behaviour other than the game-theoretical, neoclassical way. Come on, they always think in terms of 'survival'. The topic of 'survival' of so-called 'abnormal behaviour' is always a surprise for neoclassical game theory. But in reality it is a rule. We are all the living proofs of the survival of abnormal behaviour.

A: I agree. The principles of game theory are built into the properties of stochastic automata implied by most existing simulations, in the very way a modelled system arrives at stability. I think the real challenge is to envision a sort of stochastic automata in which you do not make many assumptions about the rules of behaviour of

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[5] See: Stark, D. 1996, "Recombinant Property in East European Capitalism", *American Journal of Sociology*, 101(4), pp. 993-1027.

the agents, and let them fold into the agency of the networks. Well, for the sake of computation you incidentally need to start with the design of the properties of the agents of the specific sub-network. One automaton can simulate the behaviour of all other agents. In fact there is one automaton that changes its state after each iteration. To model another sub-network you could use the same automaton just changing some of its properties according to the corresponding dataset and so on, depending on the number of layers you have in mind. Then you begin thinking about the ego-network, and about how the very fact of 'being together' modifies the functioning of automata, which now become some kind of 'modules' of the larger automata which is the ego-network. Yes, indeed it's the network that has an agency, not the separate automata! But we have to care for the stability of the sub-networks, which should not start to fall apart. And this means that we have to build into the initial automata some additional properties, stemming not from the functioning of the sub-networks, but from the necessity of their mutual co-existence. And this obviously will cause changes in the properties of the initially designed automata, in each of the initial sub-networks. This is a really complex task…

B: It is surely easier to study flat, heterogeneous networks than to model these stacked networks. But you want to try… But do not try to use data in the first place, then! I think the first step is to demonstrate, to show that this is a good idea to use the notion of 'stacked networks' in order to understand the dynamics of networks… I do not understand *how* you will do that. Is this another way of saying that there are many relations between different categories of entities?

A: Well, a very interesting – and very strong – hypothesis is the one concerning a *difference in speeds of interactions between different sub-networks and in the ego-network*.

B: But it could be the same as following a single network: some relations are stable within this network, while there are others that are rapidly evolving. That would be the same assumption, but you hide this assumption behind this complicated machinery of different networks evolving simultaneously. You could make exactly the same assumption with a single network, saying for example that some relations, some sub-regions of this network are stable or not, taken into account the overall dynamics. This is exactly the same assumption from a formal point of view… Even from a mathematical point of view one could perfectly as well say that one actor in a single 'flat' network has different roles or identities depending on the type of relation in which it is engaged. It has as many identities as sub-networks in which it is engaged.

A: Talking about 'some segments of the network' and about 'some sub-networks': it is almost the same.

B: Yes, because of the assumption that fields can be translated into network descriptions. If you have agents here and here [B takes a sheet of paper and draws a network of several star-shaped nodes grouped into several regions loosely related with a few links at the crossroads of different sub-networks], well, this is a flat representation of a single network, which is exactly the counterpart of the notion of 'stacked networks'. For example, when you start to analyse the dynamics of this network, you can make the assumption that the relations between these different networks are very weak. So this is just a particular case of network shapes, and you do not need this notion of 'stacked networks'. Try to test the hypothesis that these networks are *very specific* configurations, in which the separate sub-networks are linked through one single agent. You make the assumption that the speed of exchanges between these different sub-networks, or intensity of exchange, is lower than the intensity of the exchange within the sub-networks.

A: You mean that the stacked networks are a borderline case of one of the types of flat networks…

B: This is definitely more understandable from the perspective of Actor-Network Theory. It is exactly a description of this network structure [referring to drawing in paper], which is very specific case.

A: You mean it is better not to oppose flat networks and stacked networks?

B: Yes, because otherwise you are implying a different type of topology, I think. So it seems to me it will be easier, from a mathematical point of view, to weaken the very strong assumptions of stackedness. It would be easier to introduce, for example, the possibility of some relations between sub-networks which are not going through ego-networks.

A: However, the idea of stacked networks seems to me closer to deeper assumptions of Actor-Network Theory we mentioned above. When you take the loosely related star-shaped regions of a 'flat' network and then twist them onto each other, you arrive not just at a few nodes that mediate, but at the possibility for each node to be simultaneously immersed in several layers, and hence to be considered as a 'ego-network'.[6] Otherwise it's true that, in transitional economies for instance, such configurations of 'stacked networks' or of flat networks where the separate sub-networks are linked through one single or a few agents are exceptions rather than a rule. You also should keep in mind that after almost two decades of transition in post-socialist European economies relationships are gradually settled in a more ordered way and one could admit that a kind of re-autonomisation did occur.

B: Yes. But this is an empirical matter. Not a necessity. We should avoid the obsession of considering that every situation looks for equilibrium, or at least looks for stability. This is something that is completely discussible! I insist: 'abnormal' situations are not monsters, but something that really happens very often. That is why peoples are making money, anyway: out of disequilibrium. In a sense, there are no gains, no profits, without disequilibrium. More generally, disorder is something quite productive. It is possible to tackle disorder or dis-optimality as a situation that is stable. It is funny that in financial mathematics top traders are now more into Mandelbrot than into plain neoclassical economics[7].

A: Maybe we should refrain from assessing stability and instability and limit ourselves to descriptions of the state of networks, at best of kaleidoscopically changing states. And to attempting to trace and visualise the *continuity* in their

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[6] Maybe the very term of 'ego' is misleading here, since there is no 'center' in the 'ego-network' – it is rather 'heterarchical' and not hierarchical, like the good old 'dialectical' notion of self, develop by George H. Mead (as composed by 'I' and 'Me', none of which is superior).

[7] See: Mandelbrot, B and R. L. Hudson, 2004, *The (Mis)Behavior of Markets*, New York, Basic Books.

evolution as networks. From a mathematical topological point of view, the continuity between a circle and a square is not a big deal…

B: In a sense, maybe Actor-Network Theory is more topological than we thought: I mean in the sense of mathematical topology, not of network topology. It is precisely a point of view for which there are no dimensions, no coordinated space. Everything is self-contained in the networks, including their metrics.

[End of discussion.]