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Combining Luhmann and Actor-Network Theory to see Farm Enterprises as Self-organizing Systems*

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Abstract

From a rural, sociological point of view no social theories have so far been able to grasp the ontological complexity and special character of a farm enterprise as an entity in a really satisfying way. The contention of this paper is that a combination of Luhmann's theory of social systems and actor-network theory (ANT) of Latour, Callon, and Law offers a new and radical framework for understanding a farm as a self-organizing, heterogeneous system.

Luhmann's theory offers an approach to understand a farm as a self-organizing system (operating in meaning) that must produce and reproduce itself through demarcation from the surrounding world by selection of meaning. The meaning of the system is expressed through the goals, values, and the logic of the farming processes. His theory, however, is less useful when studying the heterogeneous character of a farm as a mixture of biology, sociology, technology, and economy.

ANT offers an approach to focus on the heterogeneous network of interactions of human and non-human actors such as knowledge, technology, money, farmland, animals, plants, etc., and as to how these interactions depend on both the quality of the actors and the network context of interaction, but the theory is weak when it comes to explaining the self-organizing character of a farm enterprise.

Keywords: Farm enterprise, self-organizing systems, actor-network theory, autopoietic social systems, semiotic.

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1 Introduction

For many reasons we strive for a more comprehensive ontological and epistemological framework for studying farm enterprises. Traditional farms, farming and agricultural production have been studied with different scientific approaches, each including its own ontological and epistemological framework, focusing on either social, economical, technical or biological processes and systems.

In particular, the growing attention to sustainability and, lately, multi-functionality of agriculture and food production calls for a shared ontological understanding of farms that can facilitate the communication of different perspectives.

Many different attempts have been made to grasp the farm as a whole system in order to provide a comprehensive ontological framework. In Noe and Alrøe (2002) we discuss several of these attempts (Ploeg 1994, Sriskandarajah et al. 1989, Conway 1987) and conclude that the existing theoretical frameworks that we know of, do not provide a such an ontology. From the foundation of phenomenological studies of farms and farm management, we have been searching for and developing a theoretical framework for understanding and observing farm enterprises and management that corresponds to empirical observations (Noe 1999). This search has followed two paths that look potentially fruitful for this purpose: the actor theory path, ending in actor-network theory (ANT), and the systems theory path, ending up in Luhmann's theory of self-referential social systems.

In Noe and Alrøe (2002) these two theories are briefly presented and their contributions to the understanding of farm enterprises are discussed. Both theories offer new and stimulating perspectives on farm enterprises, but in their present form they have some serious shortcomings. Luhmann's theory offers a theoretical understanding of autopoiesis, self-organizing and self-reference of social systems that goes beyond the limitations of Maturana and Varela's autopoietic theory of biological systems, but offers little on the relationship between social communicative systems and other kinds of self-referential systems such as enterprises with heterogeneous features. ANT offers a radical view on heterogeneous organizations or networks, consisting of both human and non-human actors, but has a weak and fuzzy understanding of how networks are organised.

In this paper we will extend the theoretical analysis of these two theories as tools for observing and understanding farm enterprises, and go into a discussion of how the two theoretical frameworks can communicate, or be combined, in a common ontological framework. But before we go into a deeper presentation and discussion of the two theories, we will outline some fundamental (interrelated) assumptions about farms that lie behind our interest in precisely these theories. The assumptions can of course be questioned, but they will not be open for discussion in the present paper.

- Farms are self-organizing systems, that is, they are (to some degree) autonomous entities with their own life, apart from the humans that are involved in them.
- Farms are social systems, that is, the workings of a farm are dependent on social, communicative processes.

We see a farm as basically a social communicative system, even though there may be only one person working on the farm. Commonly, people speak about companies as if they have their own lives. They talk about the spirit of a company - even of large multinational companies - and they say that a company can do something, e.g. operate in a market or sue other companies. The same is not the case with farm enterprises. The majority of farm enterprises are operated by one or very few persons, and here people commonly speak of a farmer or a manager when they speak about the agency of the farm. But we consider the agency of farms to be more like enterprises than like farmers. Some scholars speak about a farm as a human activity system (Bawden et al. 1985), but even from this perspective the farm agency (in our view) is still mainly limited to the notion of a farmer.

- Farms are heterogeneous systems, that is, they are composed of many different kinds of entities such as soil, machinery, animals, persons, knowledge, regulations, enterprises, etc.
- Farms involve fundamentally different kinds of relations, such as physical/non-semiotic, biological/semiotic and intellectual/self-reflexive relations.

Thus, we assume the necessity of including semiotic and self-reflexive aspects when studying farm enterprises. On a still more fundamental level, we employ semiotics (of a Peircean flavor) as an epistemological basis in our work (Alrøe 2000, Alrøe and Kristensen 2002). This basis provides a necessary standpoint from where we can compare the abilities and usefulness of different theoretical tools for studying farms.

At first sight, the two theories that we discuss, differ in almost all aspects. Luhmann speaks about operationally closed systems and ANT about never ending networks, with local summing up. Luhmann is only interested in the pure social, which in his perspective can be reduced to communication, while ANT is manly focusing on human interaction with technology and artefacts. These differences are, we would argue, mostly a matter of different interests and not indications of incompatibility. On a deeper level, the two theories show interesting similarities. Both are theories of social order that transgress the 'individual subject'-oriented action theories, and both have a semiotic perspective that goes beyond linguistic semiotics, even though the semiotic perspective is developed into quite different forms. There is no mention of semiotics in Luhmann's ground-breaking "Social Systems", but Luhmann focuses on communicative processes and develops a semiotic understanding of communication beyond "transmission" (Luhmann 1995, p 139ff). ANT has a fundamentally relationary worldview that builds explicitly on semiotics, where objects are seen as simply relational contingencies (e.g. Law 2002).

The contention of this paper is that a multidisciplinary framework for exploring a farm enterprise as an entity needs to build on a common comprehensive ontological framework that goes beyond the ontology/epistemology of the different disciplines and approaches (to look at an object from different angels wee need a shared understanding of what is the object). And that (we will argue) a combination of ANT and Luhmann's theory of autopoietic social systems could serve as such a ontological framework and platform for interdiciplinary communication. First, we will present and discuss each theory, before discussing if and how these theories can communicate with each other, and whether they can be combined.

2 A farm enterprise explored as an Actor-Network

ANT is a theory or rather a family of theories within the field of Sociology of Scientific Knowledge proposed by Bruno Latour, Michel Callon, and John Law.

The focus of the development of ANT was to study the heterogeneous character of technology and scientific knowledge. As Law puts it:

> "I simply want to note that actor-network theory may be understood as a *semiotics of materiality*. It takes the semiotic insight, that of the relationality of entities, the notion that they are produced in relations, and applies this ruthlessly to all materials - and not simply to those that are linguistic" (Law 1999, p 4).

There are a number of concepts used by the actor-network theorists to methodologically operationalize this kind of thinking. We will only highlight here a few that are necessary to understand a farm enterprise as an actor-network. The first one is the notion of an actor:

> "An 'actor' in ANT is a semiotic definition – an actant – that is, something that acts or to which activity is granted by others" (Latour 1997, p 6).

In accordance with this definition we will use the term 'actant' for the actors of ANT. The notion of an actant is not linked to the quality of the entity as such, but to the quality of the entity in the frame of the network into which the entity is mobilised:

> " …For the semiotic approach tells us that entities achieve their form as a consequence of the relations in which they are located. But this means that it also tells us that they are performed in, by, and through those relations." (Law 1999, p 4).

An actant is an entity that 'performs' in network relations with other actants. This definition also means that an actant does not need consciousness. An artefact, like a hammer, can be an actant in an actor-network, too. Another way to understand the notion of an actant is that the way a hammer performs in an actor-network is framed by the actor-network – among all the ways in which a hammer could be performed only a limited horizon of possibilities are actualised within the particular actor-network.

The second notion is 'translation', which can be characterised as the transformation of objects as they are enrolled into the network and mobilised as actants of the network.

The third notion or rather pair of notions 'local summing up' and 'framing' are linked to the concept of organizing of the network and here the discourses of ANT become very fuzzy. This is partly because they want to bypass the hierarchies and dichotomies of ordering of the social world. As Latour writes:

> "… the social is a certain type of circulation that can travel endlessly *without* ever encountering either micro level – there is never an interaction that is not framed – or the macro level - there are only local summing up[s] which

> produce either local totalities (‘oligoptica’ [structure viewed from one position. Authors' note]) or total localities (agencies)” (Latour 1999, p 19).

In our interpretation the notion of ‘summing up’ in ANT is close to a concept of self-organization. ‘Summing up’ is connected to a process of circulation and is thereby an internal process within the actor-network.

If we approach a farm as an actor-network there are a lot of elements that are translated and enrolled into the objective of farming. There are the cows, various kinds of machines and technology, the fields, sunshine, rain, computers, various kinds of plants, labour, family labour, experience, skills and knowledge, values, goals, etc. depending on the heterogeneous strategy of the enterprise. One may easily realize how important it is to the results of the farming processes that all these interactions in the actor-network are balanced in accordance with the strategy of the network.

The perspective which we get from understanding farm enterprises from an ANT approach and the relationality of entities is that the entities enrolled get their forms and performances through the relations in which they are located (Law 1999, p 4). To explore this, a particular cow on one farm will eat grass from the field and on another farm stay in the stable and eat concentrate. And, theoretically, the same cow may produce 12,000-kg milk in one system and 7,000-kg milk in another. The same kind of difference can be explored for the other entities enrolled such as wheat varieties, computers, etc.

To add to this complexity, the heterogeneous network of entities enrolled is not limited to the physical site of the farm. A lot of what we could call external entities are enrolled as, and mobilised as, actants into the farming processes: seeds, semen, advisors, capital, magazines, weather forecasts, fodder, food chains, colleagues, knowledge, labour, subsidies, etc. The kind of entities and actors that are enrolled or not enrolled into the network and how they are enrolled is characteristic of the enterprise, e.g. whether the commercial consultants or the consultants of the farmers' unions are enrolled and to what kind of performances they are enrolled.

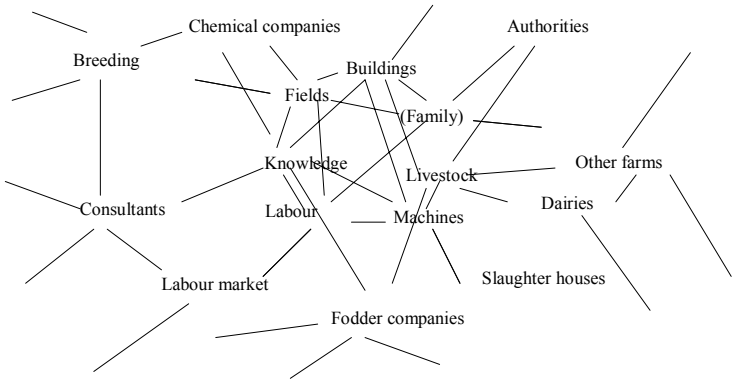

Figure 1: A farm as a network of internal and external relations

The notion of contingency is central to ANT. The accomplishment of a certain actor-network is always just one among (infinitely) many possible outcomes. Contingency then means that actor-networks are built on choices, there is no master plan prescribing the mobilisation of the network and there is no platform for making these choices rationally, because the network must establish its own schema of rationality. The trajectory of the networks is lying inside and not outside the network. But again, the network is not necessarily conscious of this matter of contingency. Only through a reflexive communicative process of the actor-network, the fact of choice becomes visible. Therefore, it is often not acknowledged by the actor-network that there has ever been any choice - as Mol puts it: "So they displace the decisive moment to places where, seen from here, it seems no decision, but a fact" (Mol 1999, p 80). If you ask a farmer why the farm is organized in the way it is, you will often get the answer that it is because it is the only rational way to do it, because of … etc. And the argument leads to a place where there was no choice.

The notion of contingency opens for exploring the diversity of farming strategies among the different farm enterprises. If we give up the idea of optimal solutions, the different strategies among the farm enterprises that are reported in numerous empirical studies (e.g. Ploeg 1994, Whatmore 1994) can be seen as contingency, as actualisation of possibilities.

It is also important to notice that actants enrolled in the network of the farm can be actor-networks themselves, e.g. in the shape of consultants offices, dairy companies, wholesalers, etc. organizing their own heterogeneous complexity. And that each of these is striving to translate the farm enterprises into their own network strategies by selling their products, etc.

There will therefore be a tension in the interactions between the actor-networks. The mobilisation and translation processes will always be connected with a negotiation process. A particular farmer's expectations from a certain consultant may differ very much from the consultant's ideas of her own role as an advisor. The same applies to technology, software, and knowledge. An artefact like a computer programme to optimize pest control is produced from a certain set of ideas of how farming is organized. The company tries to mobilise the farmers to use the programme that they produce, through advertisements, salesmen, policy, etc., and the farmer tries, if he is persuaded to buy, to translate the programme into the management processes of the farm enterprise, which may differ very much form the expectations of the company.

But how are actor-networks assembled? Or, expressed in the context of this paper, how is the farm enterprise as an actor-network organizing itself? Here we enter the weak point of the ANT (Law 1999, p 5). To our knowledge the notion of self-organization is not applied in the central literature of ANT, but as already mentioned, the ideas of summing up and circulation and the rejection of a macro master plan (Latour 1999) correspond to the concept of self-organization. How to study this entity of self-organization remains fuzzy in the discourses of ANT, however.

Several metaphors of how actor-networks are organized or assembled have been proposed in the ANT literature: "The centre of translation…. power of translation… order is an effect of generated means… centre and periphery… local processes of

patterning, social orchestration, ordering and resistance" (Law 1992). And Law concludes that: "Actor-network theory almost always approaches its tasks empirically, and this is no exception. So the empirical conclusion is that translation is contingent, local, and variable" (Law 1992, p 387). This does not provide a clear theoretical idea of the processes of self-organizing. Latour proposes a general theoretical concept of 'self-ordering' as a process of circulation, and he writes:

> "By growing each network 'binds' so to speak the explanatory resources around it and there is no way they can be detached from its growth. One does not jump outside a network to add an explanation – a cause, a set of factors, a series of co-occurrences; one simply extends to the network further. Every network surrounds itself with its own frame of reference, its own definition of growth, of referring, of framing, of explaining" (Latour 1997).

Another problem with ANT and self-organising is that ANT does no have a notion of network environment. The world become an endless web of interactions, and it does not have a notion of object independent of it relations.

To sum up, ANT provides a very fruitful framework for the exploring of the heterogeneous and complex 'nature' of a farm, both from an agronomic point of view, to study different aspects at private farm enterprises, and from a sociological point of view, to study and understand the very heterogeneous organization of a farm enterprise. But when it comes to exploring the processes of self-organization, ANT is weak and fuzzy and lacks a theoretical/ontological notion of independent objects. However, as we will argue later, the combination with Luhmann's systems theory can overcome some of these problems. The notion of contingency and Latour's notion of circulation indicates some ideas of self-organizing and may be possible links to Luhmann's theory of autopoietic, social systems.

3 A farm enterprise as an autopoietic system

Where ANT focuses on the heterogeneous openness of relations between the entities of the social, biological, and technical domains of the world, Luhmann takes the opposite position in his theory of social systems where he focuses on the operational closure necessary for any system to operate itself.

> "Autopoietic systems are systems that are defined as unities as networks of production of components that recursively, through their interactions, generate and realize the network that produces them and constitute, in the space in which they exist, the boundaries of the network as components that participate in the realization of the network" (Luhmann 1990, p 3).

Luhmann distinguishes between three kinds of autopoietic systems: biological systems operating in life, psychic systems operating in thoughts, and social systems operating in communication. Both psychic and social systems operate in meaning. None of these systems fits readily to heterogeneous social systems such as a farm enterprise. To

pursue our efforts, we need to develop and add a category of heterogeneous social system to Luhmann's systems typology. In this paper we strive to do so from a Peircian semiotic perspective by way of broadening the understanding of communication to include heterogeneous relations. This is in line with Brier (2002), who suggests semioticizing Luhmann to include communication between different levels of autopoietic systems and not only the autopoietic language games of communication. At the end of the paper we will discuss a proposition to develop such a theory. We will first extract some of the central ideas of Luhmann's theory.

Luhmann's theory of autopoietic systems provides some fruitful notions for the study of farm-enterprises as self-organizing systems. The first step to understand the self-organizing process of a farm is the selection of meaning. In Luhmann's terminology, meaning is linked to the fact of complexity that every operation enforces a selection:

> "Meaning is a representation of complexity. Meaning is not an image or a model of complexity used by a conscious or a social system, but simply a new and powerful form of coping with complexity under the unavoidable condition of enforced selectivity" (Luhmann 1990, p 84).

> "The phenomenon of meaning appears as a surplus of references to other possibilities of experience and actions. ……. Reference actualizes itself as the standpoint of reality. It refers however, not only to what is real (or presumably real), but also to what is possible (conditionally real) and what is negative (unreal, impossible). The totality of references presented by a meaningfully intended object offers more to hand that can in fact be actualized in any moment. Thus the form of meaning through its referential structure, *forces* the next step, to *selection*. This inevitability of selection enters into consciousness of meaning, and for social systems, into communication about what is meaningful (Luhmann 1995, p 60).

The selection of meaning is not to be confused with the notion of meaningfulness, but refers more to the semiotic notion that an element gets its identity through its relational position. We thereby understand Luhmann's use of meaning as semiotic, and his use of meaningfulness as normative.

Food production may be organized in numerous ways according to different goals and purposes, e.g. ecological or conventional production. The farm enterprise as a heterogeneous social system must select a meaning in the surplus of possibilities offered by each object that is mobilised into the system/network, in order to be operational at all. But the process of local summing up (withan ANT-term) into a coherent strategy is the unlikely situation. The network or system needs a kind of meaningfulness to make a situation of coherence possible and likely. According to Luhmann the production or reproduction of such system meaningfulness must be an internal process of the social system, in this case the farm enterprise. The encompassing world offers a surplus of meaningfulness, and the system has to select/develop its own in order to be operational in a coherent strategy.

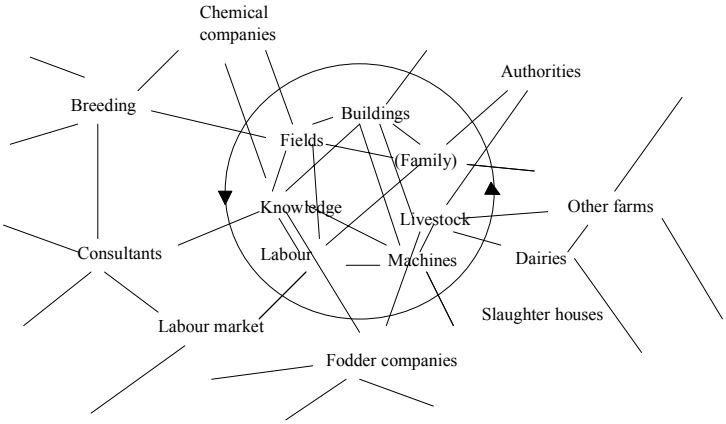

Figure 2: There needs to be a process self-reference to make the mobilisation of the farming network possible

The self-organization of social systems as autopoiesis is then a process of reducing complexity by selection of meaning. The selection of meaning must be a system-internal and self-referential operation by which the system draws its own operational boundaries. The farming styles studies are examples on how these operational boundaries can be studied (Ploeg 1994, Noe 1999). In these studies, farming systems are typologized with respect to the meaningfulness that they are organised around.

From an autopoietic understanding, the self-referential process of selection of meaning will, as a first step, be hidden to the system, because it is not a social system until a selection has been made. This corresponds to Mol's (1999) findings, presented above, that the decisive moment of an actor-network will be moved to some facts from where there seems to be no choice. Only through reflexive (re-entry) processes can these choices be made open for observation to the system.

Another characteristic of an autopoietic system is that it has its own internal system rationality or schema at its disposal. Autopoietic systems are operationally closed systems. This means that the system must produce its own input for operation. E.g. the needle does not produce the feelings of pain while the person who feels the pain does. The nerve cells are only transmitting impulses, and it is in the mind that this disturbance is translated into pain. So, it is the internal schema of the system and not the specific quality of the perturbation that defines how a system reacts to a certain perturbation.

> "Translated into the language of causality, this idea decrees that a system must control its effects on the environment by checking its repercussions upon itself if it wants to behave rationally. A system that controls its environment in the end control itself [note omitted]" (Luhmann 1995, p 475).
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> "The environment is a world horizon that corresponds to the system's internal horizon. Therefore, a system's rationality cannot be clarified by referring to a superordinate, encompassing system" (Luhmann 1995, p 474).

The notion of self-reference also leads to a general understanding of observation, namely, that it is the internal complexity of the system that is limiting the capability of the system to observe itself and the capability to observe the encompassing world.

According to Noe and Alrøe (2002), the ontological understanding of a farm enterprise as a self-referential autopoietic system is widening the possibilities for observing and understanding the complexity of farm enterprises to e.g.: observe the rationality and values around which farm enterprises are organized; explore what kind of internal and external observations are involved in the management; and observe whom and what are involved in the management processes. All these aspects are adding to the exploration of farm management based on the inner system logic (Noe 1999).

The autopoietic metaphor for a farming system seems very useful to grasp the self-organizing identity of a farm enterprise (and for other enterprises as well), but the question remains how to understand the mode of autopoietic reproduction of the farming system. To observe the self-organizing processes of a farm only as a communicative system may not be sufficient to understand the very heterogeneous character of a farm. From the system theoretical angle a farm enterprise may be perceived as a structural coupling[1] between social, psychic, biological and technical systems, but Luhmann's theory leaves no suggestion to understand the autopoiesis of such mixed socio-technical systems:

> "Therefore, to cite an extreme case, no system unity can exist between mechanical and conscious operations, between chemical operations and those that communicate meaning. There are machines, chemical systems, living systems, conscious systems, and (social) systems that communicate via meaning: but no system unities encompass all these at once. A human being may appear to himself or to an observer as a unity, but he is not a system. … The living system is inaccessible to the psychic system; it must itch, hurt, or in some other way attract attention in order to stir another level of system information – the consciousness of the psychic system – into operation" (Luhmann 1995, p 39-40).

4 Towards a concept of farm-enterprises as heterogeneous, self-organizing entities

So far, we have argued that ANT is a promising framework to observe and understand the heterogeneous features and complexity of a farm enterprise as en entity, beyond the different disciplines and approaches. But ANT has a diffuse conceptualization of the processes that order and organize this complexity. And, as a payment for its radicality and generality, ANT lacks a notion of objects outside networks. Luhmann's theory of self-referential social systems offers an interesting theoretical framework for

[1] This is further discussed in Alrøe (2000, p. 71ff). Luhmann uses 'structural coupling' as a term for the interdependence between autopoietic systems at different (emergent) levels, in the same sense as his earlier term 'interpenetration'. According to Kneer and Nassihi (1997, p. 64ff, 74f), this is different from Humberto Maturana's use of structural coupling as a term for the structural correspondence between two or more systems (e.g., cellular organisms).

understanding processes of self-organization, but he seems to reject the idea that heterogeneous social/technical entities can be self-organizing. We will now go further into the discussion on how these two theoretical bodies can communicate and be combined to a more comprehensive framework.

Based on Luhmann's systems theory every semiotic interaction in a network of actants has to build on the system/environment difference as a selection of meaning of an object against all possible meanings of the object:

> "Every communication in a social system, not just one that crosses the external boundaries, employs the system/environment difference and thereby contributes to determining or changing the system's boundaries. Conversely, representations of boundaries serve to order the constitution of elements; they make it possible to assess which elements form in the system and which communications can be risked." (Luhmann 1995, p 195).

Where actor network theory is translated into semioticized autopoietic system theory, an actant can be understood as a coupling between an object and its representation in the network or system.[2] This means that the object will never be a part of the network/system. We then maintain the radical view on actants from ANT that actants do not exist outside networks. And we combine it with Luhmann's theory of autopoietic social systems, saying that a system will reproduce its own boundaries, as a selection of possibilities (meanings) that are open for the system, selected from a surplus of possibilities offered by the environment. This also means that actants do not exist outside autopoietic networks. Only with the appearance of self-referential systems is there an ability of interpretation and thereby a semeiotic relationship between object and representation.

While ANT and the semiotic turn helps to approach heterogeneous systems as self-referential and self-organizing systems, Luhmann's systems theory could help ANT to a more stringent understanding of actor-networks. According to ANT an actant is also always a network (Law 1992, p 384), but in an actor-network the actants' own organization appears as a black box or punctualization to the network. Law explains this as a simplification necessary for the actor-network to work. To ANT everything is a network, there is nothing outside networks. This makes the distinction between actants and objects, such as artefacts, very unclear. Actor-networks are as a rhizome encompassing it all; networks never stop and begin, only "sum up". By distinguishing between actants and objects, the actants always belong to a particular (self-organizing) network as a representation of the object, which always belongs to the environment.

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[2] The concept of actant can be further analysed in Peircean terms, into the representamen, the sign as determined by the object, and the interpretant, the sign as determining some subject. Furthermore Peirce distinguishes between the immediate object, which is the object as referred to, within the sign, and the mediate or dynamical object, which is the independent object that is pointed or hinted at, outside the sign (Peirce 1998, p. 477ff). For sake of simplicity, we speak here only of the object, meaning the dynamical object in the systems environment. Similarly, Peirce distinguishes between the immediate interpretant, which is a part of the sign, and the dynamical interpretant, which is the effect produced by the sign (Ibid, p. 482). The dynamical interpretant seems an important aspect of the concept of actant in ANT.

This means that an actant cannot be actant in more than one network, but an object can be represented as an actant in several networks.

This concept of an actant helps us understand the relationship between the representation and the object. There will, as a continuous process, be a "negotiation" between the object and the representation. Let us again use a cow as an example to illustrate this relationship. The representation of a cow in a particular farming network/system could be that it is an actant that can produce 14,000 kg milk per year. The cow, as an object, will “negotiate” with this representation either by producing the amount under the present circumstances or by striking back, e.g. by not fulfilling the expectation or by getting serious health problems. On the other hand, the negotiation process also affects the object and thereby it can add to the range of possibilities of the object by e.g. selection of genetic breeds that codes for high milk production.

The breeds of cattle are then an example of what ANT labels as artefacts. As objects, artefacts will always belong to the system environment and only be part of the system as a representation within the system – as an actant. Artefacts are co-evolving objects that serve as environment (a surplus of possibilities) not only to one autopoietic system, but to a multitude of autopoietic systems. It is also interesting to notice that the negotiation processes not only add to the possibilities of an object, they can also diminish the possibilities. For instance, a horse is no longer represented within modern agriculture as a draft animal for cultivating land. This opens an understanding of the co-evolving processes of enterprises, which we will not develop further here. We will only state that a farm enterprise needs to be understood as a co-evolving system, dependent on the co-evolution of artefacts such as knowledge, food, machinery, capital, etc

One of the epistemological implications of this framework is that we cannot describe the systems only by way of knowledge about the objects, by focusing on the features of the cow, tractor, or farmer in isolation, and this applies to agronomical, economical, and sociological approaches alike – either. We need to take into account how these objects are mobilised into the network/system, as a consequence of the enforced selection of meaning. An example to illustrate this is that we cannot tell how a cow will act in a particular system from the knowledge obtained about the cow in another situation. It is possible to look at simple relationships between fodder, cow, milk and meat to se how a particular cow responds to different fodder supplies. But this description fits only as long as the other conditions are kept unchanged. When we add complexity (as it is the case when studying real farm enterprises) by taking into account other factors like stable conditions, genetic potentials, care taking, milking equipment, etc., the systematic description is drowning in complexity. This framework encourages us to approach the objects as actants, from the perspective that they are enrolled into different networks/systems with different logics. And this is a new strategy to make the reductions of complexity that are necessary for scientific investigation and description of farm enterprises.

The last aspect that we want to elaborate on, is the link between the semiotic and the self-reflexive levels of interrelation. While the physical level of interaction always belongs to the system's environment, the semiotic and self-reflexive relations only belong to autopoietic systems. While the semiotic relations are located in networks of representations, the self-reflexive relations are dependent on structural couplings

between psychic and communicative systems. It is through self-reflexive processes that the system represents itself as action, input/output borders, property, values, goals, expectations, etc.

As mentioned above in the presentation of ANT, in most cases there are many actors (human and social networks) involved in the farming processes. Therefore a cohesive farming strategy (where all objects are mobilised into the same global goals and strategies) needs a global meaningfulness of the farming system. We argue that the production and reproduction of this organizing meaningfulness is located not only in the mind of the farmer or in the communicative processes, but also in technical biological interactions in the farming processes, as a necessary self-referential process.

It is important to notice that far from all semiotic relations are open for self-reflexive processes. If we use again the example with the representation of a cow with the ability to produce 14,000 kg milk, the cow may strike back, get sick or otherwise not fulfill the expectation. But the self-reflexive processes of the system must produce their own explanations of why; and these explanations do not necessarily reflect the actual negotiation process between the object (artefact) and the representation (actant).

We would like to argue here that self-reflexivity would be a fruitful distinction and definition of (farm) management. This means that management is not defined in fixed terms, but by how the particular heterogeneous network/system observes and represents itself, and this becomes the point of departure for the farm. Self-reflexivity enables us to understand farms as potential learning systems and to understand development of farm enterprises not only as adjusting to the environment.

5 Conclusions

ANT and Luhmann's systems theory differ fundamentally in their approach and terminology, but the two theories have some deeper similarities that tempt us to seek to combine them, using Peirce's general semiotics as a platform. We have argued that both theoretical approaches add a fruitful perspective to the ontological understanding of the self-organizing entity of a farm enterprise and that they highlight different aspects.

ANT focuses on the heterogeneous character and on the entities and actors mobilised and translated into the farming processes as actants, while Luhmann's system theory focuses on the self-referential processes and the selection of meaning (values and rationality) around which the farming processes are organized. Luhmann's theory of autopoiesis does not readily provide us with the means to perceive the entity of a farm enterprise as an autopoietic system, but leads us to understand the entity as an outcome of autopoietic, social processes in structural couplings with other systems. Luhmann's theory moves us away from the heterogeneous substance of farm enterprises revealed by ANT, but it does not deny this view. On the other hand, ANT encourages us to observe a farm enterprise as a heterogeneous network of interrelations, "an actor-network".

Both "operationally closed systems" and "actor-networks" are fruitful perspectives on farms and the two perspectives are not incompatible – they can be used as complementary views. The two theories in combination open a new and radical framework for multidisciplinary studies of farm enterprises that may serve as a platform

for communication between the different disciplines and approaches. The present paper can only be seen as the very beginning of a potentially fruitful interaction between these two substantial theoretical bodies, and as an indication of how they can be translated into a methodology for studying self-organizing farm enterprises. We expect that further explorations of the semiotic basis of the two theories will provide a pathway for a closer integration of them as tools for observation and understanding.

None of the theories build on normative ideas of the ideal social order; they are theories of the processes of social ordering. This leaves the ethical and normative responsibility to the inhabitants of the social ordering processes and thereby also to the researchers. As Luhmann phrases it:

> "As a technique of scientific observation and analysis, the functional method allows its object to appear more complex that it is for itself. In this sense it overburdens its object's self-referential order. It undermines its object's intuitive evidences. It irritates, unsettles, disturbs, and possibly destroys, if the natural lethargy of its object does not adequately protect it." (Luhmann 1995, p 56).

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