The position fields of technology: a role-theoretical approach to socio-technical networks

Schulz-Schaeffer, Ingo

Erstveröffentlichung / Primary Publication
Arbeitspapier / working paper

Ingo Schulz-Schaeffer

The position fields of technology. A role-theoretical approach to socio-technical networks

Technical University Technology Studies

Working Papers

TUTS-WP-2-2016

The position fields of technology. A role-theoretical approach to socio-technical networks

Ingo Schulz-Schaeffer

Abstract:
This article builds on the idea of actor-network theory to use role terminology for describing the heterogeneous associations that make up technological innovations. Referring to key concepts of sociological role theory it proposes a more elaborate role-theoretical approach to socio-technical networks. It is argued that technological innovations consist of fields of positions to be occupied by human actors or techno-logical artifacts. Network-building thus is viewed as a process of establishing sets of interrelated positions. Consequently, actors and objects are relevant only in their capacity as occupants of positions. The role-theoretical approach draws attention to the fact that the human and nonhuman components of a technological innovation may hold several positions within the socio-technical network and may play functional and social roles at the same time. The conceptual approach is illustrated with two examples from the history of the automobile: the chauffeur problem and the invention of the jaywalker.

Schlüsselworte:
technological innovation – role-theory – position – role – socio-technical networks – actor-network theory

Contents

1. Introduction

It is a crucial insight, gained through the last three decades of research on the sociology and history of technology that technological innovations consist not only of technological artifacts but of sets of interrelated heterogeneous components. Accordingly, each successful innovation requires its components to become mutually adapted to each other, resulting in a sufficiently consistent and coherent behavior by the constellation as a whole. However, it seems to be difficult to arrive at a theory of technological innovation that incorporates this insight without running into conceptual difficulties. Approaches that conceive technological innovations as socio-technical systems or heterogeneous networks in one way or another face the following conceptual dilemma: Mutual adaption means that the heterogeneous elements are similar in that they may become subject to (re-)definitions, which – if successful – turn them into suitable components of the innovation. Yet they are as different as heterogeneous elements can be: Some are humans others are objects, some have been around for some time others are newly invented, some are involved in already established social, economic, political, cultural, organizational or functional arrangements others have still to find their place, and so on. Thus, the conceptual dilemma is that taking the heterogeneity of the elements seriously makes it difficult to stick with the assumption that they all are to be treated as components of a technological innovation. On the other hand, to stick with this assumption makes it difficult to take the elements heterogeneity seriously.

This article presents a role-theoretical approach to socio-technical networks that shows a way out of this dilemma. At the core of sociological role theory is the distinction between person, position, and role. As I will argue, this distinction paves the way to an approach that allows to conceptualize technological innovations as networks of mutually adapted components and to take account of these components heterogeneity. The key to the solution is that it is the positions of the components of a socio-technical network that are subject to processes of mutual adaption and not (or only derivatively) the humans or the objects occupying them. Two other notions from sociological role theory prove to be most helpful for understanding socio-technical networks: The first is that positions exist only in relation to other positions thus constituting position fields, sets of related positions. The second is that positions usually allow their occupants to hold other positions as well. This leads to an understanding of socio-technical networks as structures that consist of different position fields and of elements which may occupy positions in these different position fields. As I will argue, each successful innovation consists of at least two position fields which co-constitute socio-technical networks: an effect-related and a use-related position field. This conceptualization allows to acknowledge differences between the functional and social features of the components

of technological innovations without ignoring that functional features may be provided by human actors and social features by technological artifacts.

The article proceeds as follows. First, I will address the use of role terminology in actor-network theory. Over the last decades actor-network theory has been the most influential approach to spread the notion that technological innovations are heterogeneous networks. Therefore, it is worth noting that proponents of this approach have repeatedly employed role terminology to express their views (2.). Second, I will argue that there are several conceptual problems with how actor-network theory applies role terminology which call for a more elaborate role-theoretical approach (3.). The theoretical components of this role-theoretical approach to socio-technical networks is presented in the then following four sections (4., 5., 6., 7.). Subsequently, I will introduce the difference between the effect-related and the use-related position fields of technological innovations (8.) and point to role conflicts which may result from the fact that components of innovations may hold positions in different position fields (10.). Both aspects will be illustrated with an empirical example: the chauffeur problem (9.) and the invention of the jay walker (11.). The article will finish with some considerations about implications of the approach presented in this paper (12.) and a short conclusion (13.).

2. The use of role terminology in actor-network theory

Michel Callon uses role terminology to describe the interrelated activities of different entities required for a particular technological innovation to occur and to succeed. He refers to the everyday notion of "playing a role" as "behaving in a fixed way that is defined by others" but applies this notion not only to human actors but also to technical artifacts and other non-human entities. In his reconstruction of the failed attempt of the French electric utility company EDF to establish the electric car in the early 1970s Callon (1986a: 22) argues: "The EDF has defined the roles, and then attempts to enroll other entities into them. It binds the functions of these roles together by building a world where everyone has his own place. Up to this point, the entities are ones familiar to the sociologist. There are consumers, social movements and ministries. But it would be wrong to limit the inventory. There are also accumulators, fuel cells, electrodes, electrons, catalysts and electrolytes. For, if the electrons do not play their part or the catalysts become contaminated, the result would be no less disastrous than if the users rejected the new vehicle, the new regulations were not enforced, or Renault stubbornly decided to develop the R5."

In a similar way, Callon (1986b) employs role terminology in his reconstruction of the successful attempt of a group of scientists to realize a new technique for cultivating the great scallop in France. The cultivation technique, which was first implemented in the early 1970s at Saint-

Brieuc Bay, France, includes the larvae of the great scallop being "anchored to collectors immersed in the sea where they are sheltered from predators as they grow" (p. 202). Interpreting the process that led to the successful implementation of the new cultivation technique, Callon (1986b: 214) argues: "This example mainly shows that the definition and distribution of roles (the scallops which anchor themselves, the fishermen who are persuaded that the collectors could help restock the Bay, the colleagues who believe in the anchorage) are a result of multilateral negotiations during which the identity of the actors is determined and tested."

Callon (1986b: 211) thus characterizes a successful innovation as a result of a process "by which a set of interrelated roles is defined and attributed to actors who accept them". According to this view, innovators at first envision a scenario (cf. Akrich, 1992a: 174; Akrich, 1992b: 208; Callon, 1986a: 26), which defines roles for a set of human and nonhuman entities that are supposed to assume them. Realizing a technological innovation is a process of enrolling these entities, that is, of making sure that they accept the roles proposed for them. This does not mean that innovators are necessarily successful in enrolling the relevant entities according to their plans. Some of them may refuse to comply or come up with different role definitions. But if a successful technological innovation eventually occurs, it is because somehow a sufficiently consistent and coherent set of interrelated roles has emerged.

Madeleine Akrich (1992b: 209) elaborates on this point by distinguishing "between the user, as imagined by the designer and the real user". Similar to Callon she argues "that when technologists define the characteristics of their objects, they necessarily make hypotheses about the entities that make the world into which the object is to be inserted. Designers thus define actors with specific tastes, competences, motives, aspirations, political prejudices, and the rest, and they assume that morality, technology, science, and economy will evolve in particular ways" (p. 207-08). According to Akrich, to design technical artifacts means to inscribe "this vision of (or prediction about) the world in the technical content of the new object" (p. 208) and thereby to prescribe particular roles to users: "The technical realization of the innovator's beliefs about the relationships between an object and its surrounding actors is thus an attempt to predetermine the settings that users are asked to imagine for a particular piece of technology and the pre-scriptions (notices, contracts, advice, etc.) that accompany it" (p. 208). Akrich argues that the inscription of a particular role in a technological artifact implies the prescription of corresponding roles to human actors. Adopting Akrich's terminology, Latour (1988a) notes that prescription "is very much like 'role expectation' in sociology, except that it may be inscribed or encoded in the machine" (p. 306). For instance, "a traffic light expects that its users will watch it from the street and not sideways" (p. 306).

Consequently, a technology that works needs not only the technical artifact to function properly. It also requires that its surrounding human actors adopt the corresponding roles. And vice versa the same criterion applies to technological artifacts: To function properly means that the artifact assumes its proposed role. A technical defect, thus, is an artifact's failure to play its part within the set of interrelated roles. Akrich illustrates this point with the example of an electric meter with the property of being easily deactivated by a simple tap, thus giving customers the opportunity to consume unbilled electricity. This device, she argues, is defective because "although the contract between supplier and consumer remained in force, the meter failed in its prescribed role as the material inscription of that contract" (Akrich, 1992b: 218).

Latour describes technological artifacts as holders of roles as a result of his strategy to understand the meaning of artifacts by identifying the human activities they substitute. He states as a general descriptive rule that "every time you want to know what a nonhuman does, simply imagine what other humans or other nonhumans would have to do were this character not present. This imaginary substitution exactly sizes up the role, or function, of this little figure" (Latour, 1988a: 299). Accordingly, in his reconstruction of the mechanical door-closer, he describes door-closers with primitive spring mechanisms as entities that "play the role of a very rude, uneducated porter" and "simply slam the door shut" (p. 301). Again, the role description draws attention to the role relationship it implies: "The interesting thing with such impolite doors is this: if they slam shut so violently, it means that you, the visitor, have to be very quick in passing through and that you should not be at someone else's heels; otherwise your nose will get shorter and bloody. An unskilled nonhuman groom thus presupposes a skilled human user" (p. 301). The hydraulic door-closer, in contrast, which closes the door "slowly with a subtle variety of implacable firmness that one could expect from a well trained butler" (p. 302), prescribes quite a different role to its users.

3. Similarities between humans and technological artifacts as role holders

There are many empirical examples of technological artifacts which are designed and used to assume tasks that would otherwise be performed by humans as holders of particular roles. Sometimes the substitution is so direct, that the artifact is named after the role of the human it replaces. An example is the "dumb waiter" that came into use in the 18th century in English middle class households. The "dumb waiter" is a piece of furniture that allows presenting dishes, beverages, and cutlery in a readily accessible way so that no waiter is required to serve the company at table. Contemporary sources describe it as "a useful piece of furniture, to serve in some respects the place of a waiter" (Sheraton, 1803: 203, cited in Heyl, 2004: 217-18), and recommend its use to avoid that

intimate conversations are overheard by servants (cf. Heyl, 2004: 217-19). Such examples maybe provide the best evidence that applying role terminology to technological artifacts is not just a metaphorical embellishment, but a useful way to address similarities between technological artifacts and humans in their capacity as role occupants. Based on the considerations from the previous paragraph, the following similarities can be identified:

(1) Similar to human roles technological artifacts are relational entities. Their properties and their behavior make sense only in relation to the properties and the behavior of other entities, some of which are human actors. Such as the role of teacher presupposes the role of student, the car presupposes the car driver, and the camera presupposes the photographer.

(2) In both cases the relationships are constituted by a correspondence between the behavior of one party and the expectations of relevant other parties. Relations between humans as occupants of roles substantially rely on correspondences between role behavior and role expectations. Similarly, the car's acceleration, slowing down or change of direction are related to the car driver's expectations to cause these behaviors by operating the car in a particular way. Vice versa, there are expectations about the user's behavior inscribed in the technological artifact. Cars require particular bodily movements from car drivers in order to be operated properly.

(3) For human role occupants to play a role requires that others play their roles as well. A teacher will have a hard time in trying to fulfill his or her role if the children in the classroom do not assume their roles as students. The reason for this is that roles are relational entities and are mutually related by corresponding behaviors and expectations. The same applies to technological artifacts: They also play their part only if other entities – humans and nonhumans – play their part as well. Without persons in the driver's seat who assume the role of car driver, cars will not fulfill their role as a means of individual transportation.

(4) The character of both, human roles and technological artifacts, is defined by what they contribute to the setting of interrelated entities they are part of. Often the name of the role or the name of the artifact reflects their particular contribution: The role of the teacher is to teach that of the student to study. It is the role of the dishwasher to wash the dishes and of the word processor to process words. Human roles as well as technological artifacts are defined by (sets of) particular properties they possess and particular behaviors they show. Thus both thus are defined by behavioral stability with respect to a limited set of behaviors. The substitution of human role behavior with technological artifacts relies on this.

In general, it thus seems to make sense to conceptualize technological objects as holders or roles in a way similar to human actors. There are, however, several difficulties with how role terminology is used in actor-network theory. Callon and Akrich claim that the identity of the humans

and the nonhumans involved is defined and determined by the roles they assume. At least with respect to the human actors in the examples provided above this is somewhat of an exaggeration. Only a few of their characteristics and only a small part of their behavior is subject to redefinition. Furthermore, the effect on their identity is probably rather limited in most of the cases. How deeply will it change the identity of a man working as a fisherman in Saint-Brieuc Bay after learning to accept that his role as fisherman now includes cultivating the scallops he wants to harvest? Moderately at best, I would guess. And what impact on a person's identity will result from him or her assuming the role as a competent user of a door-closer? Interestingly, the same kind of skeptical questions can be raised with respect to the identity of the objects that serve as technological artifacts. The "dumb waiter", for instance, is being described as "a piece of furniture". Thus, the identity of the physical structure that assumes the role of a waiter is obviously not exclusively defined by this role. Additionally, and independently from this role, it can be characterized as a piece of furniture, as a kind of table to be more precise. Actor-network theory does not provide conceptual criteria that allow one to determine which (re-)definitions affect which entities how and why. As I will argue below, a cornerstone of sociological role theory, the distinction between person, position, and role is most helpful in this respect.

Another difficulty results from the problem that actor-network theory does not provide criteria for determining the boundaries of actor-networks, that is, of the heterogeneous associations that constitute a technology that works. As Latour illustrates with the example of the door-closer, each network of heterogeneous associations is part of a more extended network and thus "depends on a range of other set-ups being aligned. For instance, the groom closes the door only if there are people reaching the Sociology Department of Walla Walla. These people arrive in front of the door only if they have found maps and only if there are roads leading to it; and, of course, people will start bothering about reading the maps, getting to Washington state and pushing the door open only if they are convinced that the department is worth visiting" (Latour, 1988a: 308). Consequently, Latour (1988b: 160) suggests to analyze extended networks. But, as Akrich notes, there is no other criteria of when to stop "apart from the arbitrary one of lassitude" (Akrich, 1992b: 205, n. 1). This lack of criteria, however, cannot be tolerated, if the heterogeneous associations are to be conceptualized as sets of interrelated roles. If a role is defined by its relation to one or more other roles, then to define roles necessarily implies to define a particular set of roles and its boundaries. As I will show below, it is again the distinction between position and role that provides the conceptual tool to deal with these difficulties and makes solving the conceptual problem of the boundaries of socio-technical networks possible.

A third difficulty results from the notion of "playing a role" as "behaving in accordance with expectations of others". For the time being technological artifacts do not understand expectations of humans in the same way other humans do. Nevertheless, Latour wants to convince us that we should study role expectations whether we analyze relations among humans, among nonhumans, or between humans and nonhumans (Latour, 1988a: 308). I agree with Latour but not for the same reasons. In contrast to the symmetry between human and nonhuman actors assumed by actor-network theorists, to say that a technological artifact or a human actor conforms with certain expectations in fact does not necessarily mean the same. To deal with this problem, another aspect of sociological role theory will prove useful: The distinction between "role taking" and "role making".

4. Person, position, and role

Sociological role theory (cf. Dahrendorf, 1968 [1958]; Linton, 1936: 113-31; Merton, 1957) describes and analyzes forms of coordinated behavior that occur when the behavior of human actors is structured by patterned expectations with which they are confronted because of the social positions they occupy. In role theory, a role is "the behaviour oriented to these patterned expectations of others" (Merton, 1957: 110), while a social position is defined as a "place in a field of social relations" (Dahrendorf, 1968 [1958]: 34). According to Merton (1957: 110), the terms position (or status respectively)[1] and role serve to grasp the connection of the "culturally defined expectations with the patterned conduct and relationships which make up a social structure". Merton and Dahrendorf agree that positions are constituted and defined by the set of patterned relations within a position field. Positions are, so to speak, the nodes of the network that results from the patterned relations between theses nodes. Thus, positions are as stable as the relations between them.

As a result of occupying social positions their incumbents are required to behave in particular ways. According to role theory, these requirements of behavior result from patterned expectations placed by others on individuals in their capacity as occupants of these positions. The sets of patterned behavior which corresponds to these expectations constitute the social roles of the incumbents. Accordingly, the expectations by others on occupants of positions are called role expectations and the corresponding bundles of behavior constitute their role behavior. Role expectations and role behavior are relational phenomena. They result from relations between social positions. Role expectations are expectations on each other that individuals have because they are related to each other as occupants of positions. Role behavior is a behavior between human actors who are

[1] Linton and Merton use the term status instead of 'position'. Following Dahrendorf I prefer 'position' over 'status' because, as he argues, in 'general usage, "status" refers primarily to one particular kind of position, namely, position in a hierarchical scale of social prestige' (Dahrendorf, 1968 [1958]: 65).

occupants of interrelated social positions. Roles, therefore, are bundles of position-related behaviors where human actors react to position-related expectations of other actors. “Positions merely identify places in fields of reference; roles tell us about how people in given positions relate to people in other positions in the same field” (Dahrendorf, 1968 [1958]: 36).

A core characteristic of social positions is that they “may in principle be thought of independently of their incumbents” (p. 34). Positions “do not cease to exist when they become vacant” (p. 34) and do not depend on the personality or the existence of particular individuals. The admission to a social position may be regulated by all kinds of requirements, but whoever meets these requirements may in principle occupy the position. The same applies to social roles: “Like positions, roles are in principle conceivable without reference to particular persons” (p. 36). It may require particular properties or skills to be able to conform with the particular role expectations but whoever meets these requirements may play the role if she or he is in the position to do so.

Explaining the difference between person and position, Ralph Linton (1936: 113), the founding father of sociological role theory, uses the following analogy: “The relation between any individual and any status he holds is somewhat like that between the driver of an automobile and the driver's place in the machine. The driver's seat with its steering wheel, accelerator, and other controls is a constant with ever-present potentialities for action and control, while the driver may be any member of the family and may exercise these potentialities very well or very badly.” With this analogy Linton illustrates his notion that a position is “a collection of rights and duties” (p. 113). The duties reflect role expectations by others. The rights result from the incumbent’s role expectations on incumbents of other positions. Accordingly, these rights and duties are linked with positions and not with particular persons. They become the rights and duties of an individual only if and as long as he or she occupies the corresponding position.

5. Object, position, and role

It is perhaps no coincidence that Linton uses an example from the realm of technology to explain the difference between person and position. Though he claims to compare the relation between car, driver’s place and driving individual only by analogy with the relation between positions and their incumbents, his example in fact represents an actual application of role theory. It is not only by analogy but literally true that by occupying the driver’s seat of a car the person assumes a position which is defined by its relation to other positions and linked with particular role expectations. Most interestingly, the position field within which these positions are defined in relation to each other consists not only of positions for human incumbents but also of positions occupied by objects such as the individual car. Obviously, what constitutes “the car driver” is in many respects defined by

“the car”, and the same holds vice versa. Positions are constituted in relation to other positions. Consequently, one should not only conceive “the car driver” as a position but also “the car”.

My suggestion is to consider not only human actors as occupants of positions but objects as well. This suggestion is supported by the observation that with technological artifacts there is the same difference between individual and position as with human occupants of positions. To clarify this, it is helpful to take a closer look at the expectations that are directed at the single technological artifact, for instance, by its users: Why do we expect that the particular light bulb will emit light if the lamp is turned on? Or why do we expect that the particular car rented at the airport will react to movements of the steering wheel in a similar way than our car at home? Because the particular object in the socket of the lamp is a light bulb and the particular object rented at the airport is a car. In other words, our expectations as users of technological artifacts are based on the assumption that the individual objects we are dealing with are occupying particular positions; that the object in the socket occupies the position as a light bulb and the object obtained from the car rental clerk occupies the position as a car. Our expectations on their properties and their behavior are derived from this assumption. We expect that these objects in their property as occupants of this or that position will behave in a particular way. Thus, in a sense quite similarly to that of role theory in sociology, our expectations are role expectations while the corresponding behavior is role behavior.

The relation between the single object and the position it occupies as a particular kind of technological artifact is in some crucial respects rather similar to the relation between person and position: The positions as car, light bulb, or as whatever kind of technological artifact do not depend on individual characteristics or on the existence of particular single objects, and they also do not cease to exist when they become vacant. The same applies to the roles linked with the positions. They as well exist independently from any particular object.

6. Positional roles as subject of (re-)definitions

The lack of conceptual criteria for determining which definitions may affect which actors or objects how and why is a problem not only for actor-network theory but for socio-technical network approaches in general. The following considerations by Thomas P. Hughes from his well-known article on large technological systems strikingly illustrate the problem. Hughes (1987: 52) argues: “Because components of a technological system interact, their characteristics derive from the system.” Accordingly, “the components of technological systems are socially constructed artifacts.” However, somewhat later he argues: “Inventors, industrial scientists, engineers, managers, financiers, and workers are components of but not artifacts in the system. Not created by the system builders, individuals and groups in systems have degrees of freedom not possessed by artifacts” (p.

54). So all components are equal, but some are unequal to the others. The underlying reason for this contradiction is the same which makes proponents of actor-network theory believe in the principle of generalized symmetry (Callon, 1986b: 200). The crucial insight that technological innovations require their heterogeneous components to be adapted to each other – and thus to be defined or redefined accordingly – has led many authors to the conclusion that it is the entities serving as the components which are the subject of these (re-)definitions.

This conclusion is wrong or at least grossly misleading: It is the positions of the single components and the roles related to these positions that are subject of the (re-)definitions and not the humans or the objects occupying them. Obviously, this does not mean that the human or nonhuman incumbents remain unaffected. But as individuals they are affected only insofar as they are affected by the position they occupy and the corresponding roles they are expected to play. Consequently, the influence on the nature or identity of the individual may vary greatly. Some positions within socio-technical networks require newly inventing and constructing the objects that are able to fill them, such as the incandescent light bulb within Thomas Edison's electrical lighting system (cf. Hughes, 1985: 45-49; Schulz-Schaeffer, 2000: 96). Others, however, may be defined with reference to properties of already existing objects, thus leaving them largely unchanged. Copper in its position as conductor in Edison's lighting system provides an example. The same applies for the positions assumed by human actors: Some of them, such as the position of the car driver, impose on their incumbents requirements of conduct that may need considerable time to learn and to master. Others however, leave their human incumbents largely unchanged. But even when the position strongly affects the individual occupant, it never defines its (or his or her) nature or identity completely. Even the objects that serve as light bulbs have properties that are not derived from that position. The fragility of their glass bulbs, for instance, is a property that light bulbs have although to be fragile is obviously not desirable for objects in this position.

I suggest viewing technological innovations as networks of positional roles, that is, as networks of positions interrelated through the corresponding roles. Conceptualizing socio-technical networks this way solves the first two problems raised above as follows: The boundaries of a socio-technical network are defined by its position fields. The fields of positions are the particular sets of positions which, when placed in relation to each other and filled with suitable candidates constitute a technology that works. Thus, it is determined by the positions who or what a component of a socio-technical network is and who or what not. Consequently, to know the position fields of a socio-technical network means to know its boundaries.

Within networks of positional roles, the whole process of interrelating the components by adapting them to each other is a process of (re-)defining positions and positional roles. This provides clear criteria for determining which definitions may affect which actors or objects how and why: Subject to the (re-)definitions are positions and the corresponding roles. Actors or objects are affected when they are brought to assume particular positions within a developing socio-technical network. They are affected because occupying these positions means to conform with the related positional roles. But only the part of their identity or nature is involved that is relevant for playing these roles.

7. Role taking and role making

Playing a role in the sense of responding to expectations by others has two rather different meanings and only one of them is applicable to humans as well as artifacts. One meaning of this phrase requires that the protagonist understands what others expect from him or her as occupant of the role, has reasons to act according to these expectations and thus assumes the role. As long as technological artifacts do not understand the intentions of others the way humans may, and as long as they do not build intentions of their own, this meaning of "playing a role" applies only to humans. However, responding to expectations does not necessarily require such an understanding. It can also be achieved by defining and implementing certain patterns or sequences of behavior which are triggered in a sufficiently reliable manner by certain stimulus events. In this sense it is perfectly sound to say that the supermarket cashier responds to the customers' expectations by scanning the labels of the items appearing on the checkout counter, even if his or her scanning behavior is simply a reaction to the appearing items as stimulus events, and even if this cashier is a machine and not a human actor. Only this second meaning of "playing a role" applies both to humans and artifacts.

The reason behind these different meanings of "playing a role" is that roles exist "in varying degrees of concreteness and consistency" (Turner, 1962: 22). If roles are very well defined, then playing a role becomes a process of just enacting the prescribed behavioral patterns. On the other hand, the role expectations may be less unequivocal and consequently the role behavior may be prescribed in much less detail. If this is the case it is impossible to play the role by relying on predefined behavioral patterns. Rather, who assumes roles of this kind necessarily "is creating and modifying roles as well as merely bringing them to light; the process is not only role-taking but *role-making*" (p. 22). Since a role "cannot exist without one or more relevant other-roles toward which it is oriented" (p. 23) role-making is an interactive process which requires reflection about the expectations of others as well as on own expectations. Thus, roles which include role-making

are for the time being roles that can be fulfilled only by human actors while roles that only require role-taking can be occupied by humans as well as artifacts.

Some sociologists believe that it always includes role-making when human actors play roles. However, if this were true, it would be impossible to replace humans with technological artifacts. Yet this happens each time when positional roles once occupied by humans are delegated to machines and devices. But despite all such delegations and substitutions there is no symmetry between human and nonhuman actors as claimed by actor-network theory. The similarity between humans and objects as occupants of positions and of the related roles is based on the fact that both can act as role-takers. Humans, however, can also act as role-makers.

8. The functional and the social position field of technological artifacts

Since a positional role does not demand the whole person, human actors can hold different positions at the same time. In modern societies, a person "not only can, but as a rule must, assume a number of positions, and it may be supposed that the number grows with the complexity of the society. Moreover, the position field corresponding to a given position may consist of a multitude of distinct referents" (Dahrendorf, 1968 [1958]: 34). A teacher can also be a mother, and while as a teacher her position field includes students, parents, and colleagues, her position as mother is part of a different position field including at least the position of child and of child's father. The same, however, applies for objects as occupants of positions. A light bulb, for instance, may also be a piece of recyclable waste. In that case, the object not only occupies a position in the position field of the electrical lighting system but in the position field of the recycling system as well.

The notion that objects as well as humans may hold positions within different position fields allows to conceptually grasp a constitutive feature of technological artifacts, a feature which so far has caused a lot of trouble for sociologists and historians of technology: Technological artifacts are necessarily a part of effect-oriented functional settings and of use-oriented social settings. The meaning of technology is to produce desirable effects and to do so reliably whenever the effect is desired (cf. Schulz-Schaeffer, 2008). However, what the desired effects are, depends on the technology's context of use. Consequently, each technological artifact is part of two different settings: the setting responsible for producing the effects provided by the particular technology, and the setting within which these effects are used. These two settings are not independent from each other: Without contexts of use there would be no desire for particular technological effects. But these effects, obviously, would not exist without the settings that produce them. Moreover, both settings may overlap with each other to some degree. In empirical reality, effect-related and use-related

aspects of socio-technical networks are often intermingled. However, as I will argue, they overlap like different positions and roles of a single individual do. Consequently, I suggest conceptualizing them as two position fields that co-constitute socio-technical networks: a functional or effect-related position field and a social or use-related position field.

Accordingly, I assume that each technological artifact holds a position in a functional as well as in a social position field. The underlying structure of this double reference is implied in the following considerations by Hans Freyer (1998 [1934]: 62): "Suppose we say that I want a drink of water. I must first look for a source of water, then bend down, cup my hand, scoop up the water, and so forth. As a correlate of this action (we do not ask how it came about developmentally), a particular fragment, 'the manufacture of a cavity with a thick base' becomes objectified in form." Thus, "the fragment is separated out of mere action and is (in our case also materially) solidified. As the road sign bears a relationship to the pointing finger, so the drinking cup does to the cupped hand. And precisely because in the latter case, a mere fragment of a total action constitutes the meaningful content of the objectification, the character of the tool is a consequence of the product of the action. This is and remains according to its meaning an essential part – the tool is not sufficient unto itself […], it requires a fulfillment of its intended meaning through an accompanying act of employment. That it is usable, in fact usable in a definite direction, is for the tool neither accidental nor unessential, as it is for the work of art; rather, to be usable is present throughout the entire structure of the tool's signifying content."

Thus, a technological artifact is, in two different respects, part of a whole: As a solidified fragment of a total action it takes part in particular sequences of action which are more or less purposefully designed to bring about particular results. This is the effect-related or functional setting. These sequences of action, however, do not have their ends in themselves but are meaningful only within particular contexts of human life and work. This is the use-related or social setting. Because of their character as objectifications, the positions of technological artifacts within these two settings are fixed to some extent and their behavior is patterned. Additionally, they require patterned behavior from interacting entities. Adapting humans to such requirements is the task of "configuring the user". (Woolgar, 1991).

The minimal position field for the effect-related setting consists of the technological artifact and the operator, the operator being the position responsible for all parts of the sequence of action not delegated to the technological artifact. The minimal use-related position field consists of the artifact and the user. With many everyday technologies, the users are also the operators. In order to use them we operate our cars, coffee machines, or cameras ourselves, thus occupying two different positions at the same time. That these positions belong to different position fields becomes

obvious, when we leave these minimal constellations behind and move on to more complex settings. For instance, to the setting that constituted the chauffeur problem.

9. The chauffeur problem

A market research survey by Daimler Motors in 1901 predicted that the global demand for automobiles would not exceed one million, due to a lack of available chauffeurs (cf. Häder, 2009: 28). This prediction is often quoted as an example of failed technological forecasts – but wrongly so. At that time, the availability of chauffeurs did indeed constitute a major bottleneck for the dissemination of the automobile. According to contemporary sources, the chauffeur problem was "one of the most serious that the automobilist has to deal with" (cf. "Chauffeurs Lord it Over Their Employers", New York Times, 12. August 1906). It was, in short, the problem to find employees for operating the automobile who were able and willing to assume a position comparable to the position of coachman.

The first motor vehicles looked like carriages without horses, and that is exactly what they were called: "horseless carriages". The analogy between carriages and automobiles, however, was much more far-reaching. At the turn of the 20th century it still was a widely shared belief in the USA "that in both use and ownership, horseless carriages would occupy roughly the same roles in American life as horses; few predicted that the new machines would radically transform basic daily routines or practices" (Wells, 2007: 501). The carriage with a privately hired coachman was the usual means of individual transportation for wealthy Americans of the 19th century. "The coachman acted as a superintendent of transportation. […] He supervised the actions of underlings such as grooms and stable hands, took responsibility for the ordering and inspection of fodder and bedding, supervised the feeding, dieting, blanketing, shoeing, and grooming of the horses, inspected and maintained the condition of carriages and harness, and drove whenever the owner or his wife used the carriage" (Borg, 1999: 800). Wealthy American automobile owners simply transposed this job description to the position of chauffeur, "they hired chauffeurs, dressed them in livery, and gave them responsibility for the care and maintenance of their vehicles, transposing the rules associated with horse transportation to their new horseless carriages" (p. 803). Defining the position of chauffeur in analogy to the position of coachman was an obvious idea for many reasons: Not only were early automobiles prone to breakdowns, they "also required much more intensive routine maintenance than later models. During the motoring season […] the oil in most gasoline-powered vehicles had to be changed nearly every week. Valve seats had to be reground several times during the season and occasionally required regrinding while on road" (p. 805).

It required constant supervision, care, and maintenance to keep the early automobiles roadworthy. In the case of the carriage, where the same applies, a particular occupation had been established to cover this range of tasks, the position as hired coachman. Consequently, for wealthy American automobile owners it seemed quite natural to delegate these tasks to a similar occupational position: "a significant number of wealthy motorists employed chauffeurs, servants who would perform the duties of driver and mechanic: 'coachmen' for the automobile" (p. 806). The chauffeur's job was not only "to drive whenever the owner or his wife used the car" (p. 806) but also to maintain and repair the automobile; "he might in addition supervise a wash boy, just as the coachman has done for the groom and the stable hand" (p. 806). To be available whenever needed, "employers typically expected that he, like the coachman before him, would live on the property with the automobile, receiving board and lodging in addition to his pay" (p. 806).

However, not only was the chauffeur's range of tasks defined along the lines of the coachman's but so was his social position. The social position of the coachman was that of a servant within a strict master-servant hierarchy, a social relationship requiring from coachmen to display the proper deference and to obey orders without further comment. The coachman's livery was "a clear outward sign of servile status" (p. 801). Wealthy motorists expected their chauffeurs to occupy the same social position, to be as deferential and obedient as expected from coachmen, and "to wear servant's livery, which one fashion observer described as 'cut very nearly in the same manner as the coachman's great coat'" (p. 806).

Based on this historical reconstruction, the chauffeur problem can be described more precisely as the problem to find employees able and willing to assume the two positions that make a coachman and, accordingly, a chauffeur: the functional position with the responsibility of driving the vehicle and keeping it roadworthy, and the social position as deferential servant. At first, the previous coachmen were believed to be the ideal candidates for the new position of chauffeur. "Wealthy motorists clearly desired that their coachmen make the transition to chauffeur, because coachmen already knew their place. In the words of one editorial, the coachman 'is better fitted for the work of a chauffeur than any other class of operatives, being imbued, first of all, with some measure of comprehension of his social position'" (p. 808). Though this indeed makes a coachman the ideal candidate for the social position of chauffeur, his background is of limited use for the functional position of chauffeur: "The knowledge and skills of animal husbandry did not necessarily translate into mechanical ability. As another editor wrote, 'The only attainments that a coachman, per se, has for the position of chauffeur are his familiarity with what are called the rules of the road and his knowledge of the social relations of the driver of a vehicle to his employer […] the man who has a liking for the position of coachmen is not likely to have taste or talent for

mechanical work.'" (p. 808) Consequently, the attempts to retrain coachmen as chauffeurs mostly failed.

It required the knowledge and skills of a mechanic to be able to repair and maintain early automobiles, yet people with such abilities refused to be treated as servants; "chauffeurs developed their own ideas about their social status. Their knowledge of the new technology placed them in high demand, and this fact gave them, in their estimation, a status distinctly above the coachman's, more akin to the railroad engineer's. […] As a consequence, many chauffeurs refused to wear livery, some balked at requests to do menial jobs such as washing the car or announcing the car's arrival, and in Des Moines, Iowa, chauffeurs organized a strike against employers who required them to sleep in the same building with their machine" (p. 809-10).

The chauffeur problem was only serious in the first decade of the 20th century. From then on, cars became much more reliable and the risk of breakdowns on the road decreased significantly. Driving cars became technically less demanding. "In this changing technical climate the wealthy motorist no longer needed to have his mechanic on board at all times" (p. 821). Repair and maintenance became the job of mechanics at dealers' shops or independent repair shops (cf. McIntyre, 2000).The car production focused more and more on moderately- and low-priced cars for the broader market. They thus became available for people from less wealthy social classes which "could not afford, and did not desire, the services of a chauffeur-mechanic" (Borg, 1999: 821) but preferred to drive themselves. Many innovations such as the electric self-starter that replaced the hand crank (cf. Boyd, 1968) made driving easier, thus facilitating use by nonprofessional drivers. These developments had consequences for the functional and social position of chauffeur: "the chauffeurs of the second and third decades of the twentieth century were professional drivers, not mechanics, and their social position as servants was relatively stable and uncontested" (Borg, 1999: 822).

The chauffeur problem nicely illustrates the difference between the effect-oriented and the use-oriented position fields of technological innovations. The early automobile gains its functional meaning as a means of individual transportation by taking part in a sequence of action which requires not only a driver, but the constant maintenance and repair work from that driver as another part of this same action sequence. Thus, the early automobile with its susceptibility to damage and the driver with mechanical skills constitute two interrelated positions in the functional position field of this transportation technology. The social context within which this rather effortful way to provide individual mobility was viewed as desirable was the wealthy private household. Members of the 19th century upper classes were used to enjoy the advantages of individual transportation. They were able and willing to pay for this privilege. And they were used to servants. The use-

oriented position field of the automobile that emerged within this social context assigned to the automobile a position comparable to the carriage. This implied that the owner as a rule would not drive the vehicle himself but hire a driver who was expected to accept the social position of servant. The chauffeur problem results from tensions between the functional and the social position of chauffeur. The functional position required highly demanded skills from their occupants and thus provided them with some bargaining power. But at the same time the social position defined them as servants who should not contradict their masters.

10. Role conflicts between functional and social positions

The tension that leads to the chauffeur problem is, in the terminology of role theory, a role conflict. Role conflicts occur when occupants of positions are confronted with contradicting role expectations. Sociological role theory distinguishes between two forms of role conflicts (cf. Dahrendorf, 1968 [1958]: 71-72; Merton, 1968 [1949]: 424-38). On the one hand it may happen that the occupant of a position is confronted with different role expectations from the occupants of different other positions of the position field. A teacher who has to deal with different expectations by the students' parents and the school board members is an example of this kind of role conflict. This is called an intra-role conflict or a role conflict within the role-set. On the other hand role expectations that are related to different positions of the occupant may contradict each other (inter-role conflict or role conflict within the status-set). The chauffeur problem is caused by a role conflict of this kind. The role expectations related to the position as skilled mechanic are incompatible with the role expectations related to the position as servant. Consequently, the chauffeur problem vanished as the functional position of chauffeur no longer required professional mechanical skills. Now, enough people were available again who were able to do the job and willing to accept the social position of servant.

According to sociological role theory, a social structure can be described as a patterned arrangement of positions and positional roles. Consequently, the existence and the relative stability of a social structure at a particular time depends on the positional roles being sufficiently adjusted to each other. Role conflicts, on the other hand, are sources of instability (cf. Merton, 1968 [1949]: 424). As the example of the chauffeur problem suggests, the same applies to technological innovations. The role conflict constituting the chauffeur problem definitely was a source of instability which – as reflected by the forecast of Daimler Motors – negatively affected the dissemination of the automobile for some time.

It is not specific to this empirical case that interactions between the effect-related and the use-related position field of a technology may lead to role conflicts. Thus, the success of a technological

innovation depends not only on mutually adapted roles within the functional and social position field. Because of the persons and objects that hold positions in both position fields, it also requires adjustments between the functional and social roles of these entities. In the following section, I will take a closer look at adjustments of this kind, using as an example the struggle in American cities of the 1910s and 1920s over who belongs in the streets and who does not.

11. The invention of the jaywalker

Today it is taken for granted that city streets are for motor vehicles, if not explicitly designated otherwise. Before the advent of the automobile, however, streets served as public spaces, open to a broad range of different uses: "Private, horse-drawn vehicles and city services (such as street cars, telephones, and water supply) depended on them. Pedestrians, pushcart vendors, and children at play used them as well" (Norton, 2007: 332). This did not change immediately with the advent of the automobile. Rather, in the early years of the automobile "most – including many motorists – would have agreed that streets were not for fast driving, and that motorists who drove faster than pre-automotive vehicles were alone responsible for any harmful consequences" (p. 335). The co-existence of vehicles and pedestrians in the pre-automotive city street was facilitated by the low speed of horse-drawn vehicles. Thus, this arrangement could continue to exist only if motorists would moderate their speed accordingly. But, as Peter Norton (2007: 335) puts it, "[t]o those who bought and sold them, cars were vehicles capable of higher sustained speeds than horses […] Thus the automobile's essential attributes put it at odds with prevailing perceptions of legitimate street use. Used as intended, the car was a *misuser* of streets."

The conflict implicated in the automobile's higher speed is another example of a role conflict between effect-related and use-related positional roles. The sequence of actions providing individual transportation faster than with horse-drawn vehicles relies not only on the automobiles. Beside others, it also requires streets that are not blocked by obstacles such as pedestrians or playing children. Thus, pedestrians who can be expected not to impede the motorized traffic on the street are part of this action sequence. The then established uses of the city street, however, allowed persons in the position of pedestrian to use the streets unrestrictedly. Conversely, it was required from persons in the position of vehicle driver to take care. There are two opposite ways to solve this role conflict: Adapting the functional to the social roles, or vice versa. It is an interesting aspect of this historical case that both ways of solving the role conflict are relevant in the history of this case.

Until the early 1920s, it was commonly viewed as the right of pedestrians to use the streets and as the duty of the motorists to take care not to harm them. Accordingly, in accidents between

automobiles and pedestrians, juries "tended to favor pedestrians" and to give them "almost invariably […] the benefit of the doubt" (Norton, 2007: 337). This view of the rights and duties of motorists and pedestrians was reflected by the speed limits of that time. "In 1906 the median state-designated limit in cities was ten miles per hour, and local authorities often set limits still lower. States were slow to raise them; Indiana, which limited city speeds to eight miles per hour in 1906, had raised the limit to only ten by 1919" (p. 337). Yet the automobile's capability of faster speeds provided a constant invitation to violate the role expectations attached to the position of driver and it proved difficult to effectively enforce such low speed limits. As a consequence, it was discussed by local officials and the public to equip cars with technical devices, so called "governors", which would limit their speed. In 1923, a "letter writer to the St. Louis Star suggested this: 'Gear them down to fifteen or twenty miles per hour and quit joking about speed limit laws'" (p. 338). In a survey from 1926 with about 500 American police chiefs participating, "two of every three police chiefs agreed that their cities should require governors on automobiles. Such a plan won mass support in Cincinnati, where 42,000 people – more than 10 percent of the population – signed petitions in 1923 for a local ordinance requiring governors that would shut off automobile engines at twenty-five miles per hour" (p. 339).

All these are attempts to adapt the automobile and its use to the already established position field and its interrelated roles which until then had defined the use of the city streets. If these attempts had succeeded, the role conflict would have been resolved by adapting functional roles to social roles. Yet the opposite solution prevailed, but only after the social position of pedestrian was successfully redefined so that it fitted as a functional position into the action sequence of providing individual transportation in the city at faster-than-horse speeds.

It always depends on the envisaged contexts of use of technologies if and how the effects they provide are viewed as desired effects. In the early days of the automobile many people had a "horse-minded" (Wells, 2007: 500) view on this artifact's context of use, assuming, as cited above, that "horseless carriages would occupy roughly the same roles in American life as horses" (p. 501). According to this view, functional features of the automobile that could not be used within the context of use defined by the already existing role patterns of traffic behavior were judged as undesirable. This was the view of those fighting for the "pedestrians' rights to the pavement" (Norton, 2007: 337). However, with the increasing popularity of the car a more "motor-minded" (p. 352) or "mobility-minded" (Wells, 2007: 501-02) view grew stronger. Adherents to this view envisaged a context of use in which the superior speed and other advantages of the automobile over horse-drawn vehicles would come into effect. In the countryside a major obstacle to this envisaged use

of the automobile was the poor quality of roads (cf. Wells, 2007: 501-02, 13-14). In the city, however, the chief obstacle was the behavior of the pedestrians. Thus, establishing a mobility-minded use of the car in the city "would require streets that were redefined as places where motorists belonged and where pedestrians were responsible for their own safety" (Norton, 2007: 339). This, however, required redefining the position of pedestrian in relation to the car and the car driver.

From 1915 onwards, cities started marking crosswalks at intersections and tried to enforce their use. Yet as long as most people stuck to the "old common law rule that every person, whether on foot or driving, has equal rights in all parts of the roadway" (Norton, 2007: 351-52) these attempts to redefine the position of pedestrians was of limited success. First and foremost, the established customs had to be tackled. This is where the rhetoric of jaywalking came into play. "A *jay* was a country hayseed out of place in the city. By extension, a *jaywalker* was someone who did not know how to walk in the city" (p. 342). Originally, pedestrians were called jaywalkers who "obstructed other pedestrians by their irregular paths and their susceptibility to distraction by sidewalk vendors" (p. 343). Motorists and their advocacy groups adopted this term and started to use it as a rhetorical means of fighting the overcome traditions of street use. In this spirit, an article in the Washington Post in 1913 disparagingly described as jaywalkers people "'who are so accustomed to cutting across fields and village lots that they zigzag across city streets, scorning to keep to the crossings, ignoring their own safety' and 'impeding traffic.'" ("Jay" Walkers, Washington Post, 18 May 1913, cited in Norton, 2007: 342). It took some time and effort for the motorists and their advocates to succeed in redefining the once customary pedestrian life in the streets as jaywalking. By exerting their influence on newspapers, car manufacturers, car dealers and automobile clubs caused a change in the newspaper coverage of accidents, to the effect that accidents were more often ascribed to jaywalking rather than to reckless driving (cf. 357). "By sponsoring safety education in schools, motordom made the next generation enemies of jaywalking. By the late 1920s AAA [American Automobile Association, author's note] led the field in classroom safety instruction" (p. 358). By 1930 "jaywalking" had become a regular term used in everyday American English to designate the misuse of the street by pedestrians who obstruct automobiles. "The legitimation of *jaywalking* as a term corresponded to its fall into disrepute as a practice" (p. 359). This was the "crucial step toward the reconstruction of city streets as motor thoroughfares" (p. 358).

Vehicles, vehicle drivers, streets, pedestrians, playing children, and several other entities occupy positions in an effect-oriented field of interrelated positions that provides mobility and at the same time they occupy positions in a position field that defines the legitimate use of the mobility infrastructure. In the pre-automotive 19th century a somewhat viable balance between role requirements from both position fields had been reached. The higher speed individual transportation that

became technically feasible with the advent of the automobile, however, required these persons and objects to assume functional positions which were incompatible with their established social positions. To bring into effect the new capabilities of the automobile, these social positions had to be redefined as well. Consequently, overthrowing the overcome customs of street use was a major part of the innovation of motorized individual transportation.

12. Innovations as socio-technical networks of positional roles

To invent and to introduce a new technological artifact means to suggest a new way of producing effects for particular uses. Since the artifact constitutes only one of the interrelated positions necessary to produce the effect and only one of the positions of the context of use, a technological innovation necessarily requires defining or redefining these other positions and the corresponding roles and role relations. According to Callon and Akrich, every technological innovation is necessarily accompanied by the "delineation of a scenario" (Callon, 1986a: 26) which envisages these roles and role relations (cf. Akrich, 1992b: 208). To the degree that the role relations are inscribed in the technological artifact, the artifact itself "can be described as a scenario replete with a stage, roles, and directions governing the interactions between the actors (human and nonhuman) who are supposed to assume those roles" (Akrich, 1992a: 174). This is not to say that engineers are necessarily aware of the scenarios implied in their artifacts. Rather, the underlying assumptions, especially the assumptions about the context of use are often, to some extent, tacit assumptions. Of course, as discussed above, this does not mean that the scenarios which are explicitly envisaged or tacitly presupposed by the engineers are the same scenarios that eventually become reality. As the examples above have shown, a developing innovation may be subject to a lot of different and competing influences and thus the underlying scenario may change accordingly.

According to Callon and Akrich, the technological innovation, as it is explicitly or implicitly envisaged in such scenarios, and as it becomes reality in the case of success, consists of a network of interrelated roles to be played by heterogeneous entities. I agree with this basic picture. But, as I have tried to show, by applying a more elaborate role-theoretical view, this picture becomes much more detailed and precise. Above all, it is crucial to add the mechanism by which roles are proposed to, and assumed by the persons and objects involved: By defining positions and by occupying them. The notion that there is an essential difference between a position and the holder of a position is, as we have seen, of major importance for the analysis of socio-technical networks. Because of this difference a position usually does not demand the whole person or object so that persons and objects can occupy different positions at the same time. Only when taking this into account does it

become possible to understand how the components of a socio-technical network can play roles in producing technological effects, and in shaping social settings at the same time.

The chauffeur problem and the invention of the jaywalker show that the role requirements of social positions may lead to redefinitions of functional positions and vice versa. Analyzed with the means of role theory it turns out that these adjustments became necessary because of role conflicts resulting from the fact that the occupants of the social position in question occupied a functional position at the same time or vice versa. These observations confirm the conceptual assumption that technological innovations, insofar as they are new ways to produce effects for particular uses, consist of an effect-related and a use-related position field which are related to each other. It is because of this structure that technological artifacts, and as we have seen, other components of socio-technical networks as well, are able and are often required to occupy positions in both position fields.

The examples of the preceding sections may have given the impression that there is always a trade-off between functional and social role requirements. However, this is true only in the case of role conflicts and only if these conflicts have to be resolved and cannot be neutralized otherwise. And just as functional role requirements may prevail over social role requirements so the opposite may occur. Obviously, there is space for possible compromises between these poles. Additionally, it should be noted that the role requirements imposed by different positions are not necessarily competing requirements. Often it is perfectly possible for persons or objects to conform to the different role requirements of their different positions, since they are engaged in each of them with only some of their attributes, capabilities and resources.

It is obvious from the examples above, that human actors who assume use-related or effect-related positions in a socio-technical network at the same time occupy several other positions as well. It is important to see that the same may be true with objects as well. Cars for instance, may, in addition to their functions and uses, play a symbolic role as means of social distinction. Living room lamps may be chosen because of their aesthetic features rather than their functionality or usability. These are phenomena made possible by the positional structure of socio-technical networks, namely, by the fact that assuming effect-related or use-related positions does not per se preclude their occupants from also assuming further positions. As with functional and use-related positions, these additional positions may or may not interfere with the person's or object's other positions. For example, the streamlined design of a car that makes it look sporty and fast may in fact worsen its drag coefficient, and the artistic design of a lamp may negatively affect its ratio of light yield to energy consumption. On the other hand, these objects could have also been designed according to the design principle "form follows function." However, even a lamp with a poor light yield or a car with dysfunctional streamlining are still technological artifacts as long as they are

used because of their contributions to the production of desired effects and thus keep playing their functional and use-related roles within the socio-technical network of the respective technology.

13. Conclusion

To explain technology through social factors is, according to Latour, as wrong as to believe that the behavior of people is caused by the diffusion of technology. "Social determinism courageously fights against technical determinism, whereas *neither exist* except in the fanciful descriptions proposed by the diffusion model" (Latour, 1987: 141). According to Latour (1987: 141) this is because technological determinism and social constructivism share the wrong idea that there are distinct "spheres of Science, Technology, and Society, where the influence and impact of each of them on the other have to be studied". In contrast, he argues: "*Understanding* what facts and machines are is the same task as understanding who the people are. If you describe the controlling elements that have been gathered together you will understand the groups which are controlled. Conversely, if you observe the new groups which are tied together, you will see how machines work and what facts are hard. The only question in common is to learn *which associations are stronger and which weaker*. We are never confronted with science, technology, and society, but with a gamut of weaker and stronger associations" (p. 140).

Obviously, there are a lot of relevant scientific and non-scientific perspectives from which understanding what machines and who people are is definitely not the same task. To ignore this is to unduly stretch the principle of symmetry. On the other hand, it is not an option to return to the antagonistic distinction between social constructivism and technological determinism which leaves the observer blind to the interrelatedness of social and technical arrangements. The role-theoretical approach to socio-technical networks shows a way out of this dilemma. Understanding human actors and technological artifacts is the same task (or at least a similar task) where humans or objects act as role-taking occupants of positions within the same position field. It becomes a more different task where they occupy positions within different position fields. In both cases the task becomes even more different when the humans act as role-makers as well. Thus, the role-theoretical perspective allows to conceptually integrate similarities and differences between humans and artifacts. Accordingly, similarities between humans and artifacts are due to the fact that they both may act as occupants of positions. However, they may hold positions in different position fields, positions in use-related or other social or cultural position fields, or positions in effect-related, functional position fields. And these differences are as important for understanding socio-technical networks as those similarities.

References

Akrich M (1992a) "Beyond Social Construction of Technology: The Shaping of People and Things in the Innovation Process", in Dierkes M and Hoffmann U (eds), *New Technology at the Outset. Social Forces in the Shaping of Technological Innovations* (Frankfurt/Main: Campus): 173-90.

Akrich M (1992b) "The De-Scription of Technical Objects", in Bijker WE and Law J (eds), *Shaping Technology; Building Society. Studies in Sociotechnical Change* (Cambridge, Mass. u.a.: The MIT Press): 205-24.

Borg KL (1999) "The 'Chauffeur Problem' in the Early Auto Era: Structuration Theory and the Users of Technology", *Technology and Culture* 40(4):797-832.

Boyd TA (1968) "The Self-Starter", *Technology and Culture* 9(4):585-91.

Callon M (1986a) "The Sociology of an Actor-Network: The Case of the Electric Vehicle", in Callon M, Law J and Rip A (eds), *Mapping the Dynamics of Science and Technology. Sociology of Science in the Real World* (London u.a.: Macmillan Press): 19-34.

Callon M (1986b) "Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay", in Law J (ed), *Power, Action and Belief. A New Sociology of Knowledge?* (London u.a.: Routledge & Kegan Paul): 196-232.

Dahrendorf R (1968 [1958]) "Homo Sociologicus: On the History, Significance, and Limits of the Category of Social Role", in Dahrendorf R (ed), *Essays in the Theory of Society* (London: Routledge and Kegan Paul): 19-87.

Freyer H (1998 [1934]) *Theory of Objective Mind. An Introduction to the Philosophy of Culture. Translated and with an Introduction by Steven Grosby* (Athens, Ohio: Ohio University Press).

Häder M (2009) *Delphi-Befragungen. Ein Arbeitsbuch* (Wiesbaden: VS Verlag).

Heyl C (2004) *A Passion for Privacy. Untersuchungen zur Genese der bürgerlichen Privatsphäre in London (1660-1800)* (München: Oldenbourg).

Hughes TP (1985) "Edison and Electric Light", in MacKenzie D and Wajcman J (eds), *The Social Shaping of Technology. How the Refrigerator Got its Hum* (Milton Keynes u.a.: Open University Press): 39-52.

Hughes TP (1987) "The Evolution of Large Technological Systems", in Bijker WE, Hughes TP and Pinch TJ (eds), *The Social Construction of Technological Systems. New Directions in the Sociology and History of Technology, Cambridge* (Mass. u.a.: The MIT Press): 51-82.

Latour B (1987) *Science in Action. How to Follow Scientists and Engineers through Society* (Cambridge, Mass.: Harvard University Press).

Latour B (1988a) "Mixing Humans and Nonhumans Together. The Sociology of a Door-Closer", *Social Problems* 35(3):298-310.

Latour B (1988b) "The Politics of Explanation: An Alternative", in Woolgar S (ed), *Knowledge and Reflexivity. New Frontiers in the Sociology of Knowledge* (London u.a.: Sage Publications): 155-76.

Linton R (1936) *The Study of Man. An Introduction* (New York: Appleton-Century-Crofts).

McIntyre SL (2000) “The Failure of Fordism: Reform of the Automobile Repair Industry, 1913-1940”, *Technology and Culture* 41(2):269-99.

Merton RK (1957) “The Role-Set: Problems in Sociological Theory”, *The British Journal of Sociology* 8(2):106-20.

Merton RK (1968 [1949]) “Continuities in the Theory of Reference Groups and Social Structure”, in Merton RK (ed), *Social Theory and Social Structure* (New York, NY: The Free Press): 335-440.

Norton PD (2007) “Street Rivals: Jaywalking and the Invention of the Motor Age Street”, *Technology and Culture* 48(2):331-59.

Schulz-Schaeffer I (2000) *Sozialtheorie der Technik* (Frankfurt/Main u.a.: Campus Verlag).

Schulz-Schaeffer I (2008) “Technik”, in Baur N, Korte H, Löw M and Schroer M (eds), *Handbuch Soziologie* (Wiesbaden: VS Verlag): 445-63.

Sheraton T (1803) *The Cabinet Dictionary* (London: W. Smith).

Turner RH (1962) “Role-Taking: Process versus Conformity”, in Rose AM (ed), *Human Behavior and Social Processes. An Interactionist Approach* (London: Routledge and Kegan Paul): 20-40.

Wells CW (2007) “The Road to the Model T: Culture, Road Conditions, and Innovation at the Dawn of the American Motor Age”, *Technology and Culture* 48(3):497-523.

Woolgar S (1991) “Configuring the User: The Case of Usability Trials”, in Law J (ed), *A Sociology of Monsters: Essays on Power, Technology and Domination, Sociological Review Monograph 38* (London u.a.: Routledge): 57-99.

In der Reihe „TUTS Working Papers“ sind bisher erschienen:

01/2016	Matthias Bottel Eltje Gajewski Christoph Potempa Melike Şahinol Ingo Schulz-Schaeffer	Offshoring und Outsourcing von Arbeitstätigkeiten, insbesondere von Telearbeit und Tätigkeiten der Softwareentwicklung. Ein Literaturbericht
05/2015	Gustav Roßler	Designte Dinge und offene Objekte. Theorieskizze für ein empirisches Projekt TUTS-WP-5-2015
04/2015	Werner Rammert	Technik und Innovationen: Kerninstitutionen der modernen Wirtschaft TUTS-WP-4-2015
03/2015	Valentin Janda	The means of design work. Models, sketches, and related objects in the creation of new technologies TUTS-WP-3-2015
02/2015	Jan-Hendrik Passoth Werner Rammert	Fragmentale Differenzierung und die Praxis der Innovation: Wie immer mehr Innovationsfelder entstehen TUTS-WP-2-2015
01/2015	Werner Rammert Cornelius Schubert	Körper und Technik. Zur doppelten Verkörperung des Sozialen TUTS-WP-1-2015
03/2014	Hubert Knoblauch	Communicative Action, Reflexivity, and Innovation Society TUTS-WP-3-2014
02/2014	Cornelius Schubert	Social Innovations. Highly reflexive and multi-referential phenomena of today’s innovation society? A report on analytical concepts and a social science initiative TUTS-WP-2-2014
01/2014	Werner Rammert	Unsicherheit trotz Sicherheitstechnik? Das Kreuz mit den komplexen Konstellationen TUTS-WP-1-2014
05/2013	Michael Hutter Hubert Knoblauch Werner Rammert Arnold Windeler	Innovation Society Today: The Reflexive Creation of Novelty TUTS-WP-5-2013
04/2013	Valentin Janda	Werner Rammert – wider soziale und technische Reduktionen TUTS-WP-4-2013

03/2013	Jörg Potthast	Technik als Experiment, Technikforschung als Kritik? Eine Zwischenbilanz TUTS-WP-3-2013
02/2013	Katharina Oehme	Rahmen und Routinen der Techniknutzung. Was kann man aus Experimenten über alltägliche Techniknutzung lernen? TUTS-WP-2-2013
01/2013	Werner Rammert	Vielfalt der Innovation und gesellschaftlicher Zusammenhalt Von der ökonomischen zur gesellschaftstheoretischen Perspektive TUTS-WP-1-2013
05/2012	Valentin Janda	Usability-Experimente: Das konstruktive Experiment einer soziologischen Analyse TUTS-WP-5-2012
04/2012	Jörg Potthast	Politische Soziologie technischer Prüfungen. Das Beispiel Straßenverkehrssicherheit TUTS-WP-4-2012
03/2012	Christina Besio Robert J. Schmidt	Innovationen als spezifische Form sozialer Evolution: Ein systemtheoretischer Entwurf TUTS-WP-3-2012
02/2012	Julian Stubbe Mandy Töppel (Hrsg.)	Muster und Verläufe der Mensch-Technik-Interaktivität Band zum gleichnamigen Workshop am 17./18. Juni 2011 in Berlin TUTS-WP-2-2012
01/2012	Jochen Gläser	How does Governance change research content? On the possibility of a sociological middle-range theory linking science policy studies to the sociology of scientific knowledge* TUTS-WP-1-2012
06/2011	Anna Henkel	Die Dinge der Gesellschaft Erste Überlegungen zu einer Gesellschaftstheorie der Dinglichkeit TUTS-WP-6-2011
05/2011	Jörg Potthast	Soziologie der Kritik und Technik im Alltag TUTS-WP-5-2011
04/2011	Michael Hutter Hubert Knoblauch	Innovationsgesellschaft heute: Die reflexive Herstellung des Neuen

	Werner Rammert Arnold Windeler	TUTS-WP-4-2011
03/2011	Werner Rammert	Distributed Agency and Advanced Technology Or: How to Analyse Constellations of Collective Inter-Agency TUTS-WP-3-2011
02/2011	Jessica Stock	Eine Maschine wird Mensch? Von der Notwendigkeit, Technik als integralen Bestandteil sozialer Praktiken zu akzeptieren – Ein Theorie-Report. TUTS-WP-2-2011
01/2011	Jörg Potthast	Wetterkarten, Netzwerkdiagramme und Stammbäume: Innovationskulturanalyse in Kalifornien. TUTS-WP-1-2011
03/2010	Michael Hahne	Aktivitätstheorie. Vorstellung zentraler Konzepte und Einordnung in die perspektivistische Theorievorstellung. TUTS-WP-3-2010
02/2010	Werner Rammert	Die Innovationen der Gesellschaft TUTS-WP-2-2010
01/2010	Jörg Potthast	Following passengers/locating access On recent attempts to disrupt terrorist travel (by air) TUTS-WP-1-2010
02/2009	Cornelius Schubert	Medizinisches Körperwissen als zirkulierende Referenzen zwischen Körper und Technik TUTS-WP-2-2009
01/2009	Werner Rammert	Die Pragmatik des technischen Wissens oder: „How to do Words with things“ TUTS-WP-1-2009
05/2008	Michael Hahne Corinna Jung	Über die Entstehungsbedingungen von technisch unterstützten Gemeinschaften TUTS-WP-5-2008
04/2008	Werner Rammert	Where the action is: Distributed agency between humans, machines, and programs TUTS-WP-4-2008
03/2008	Ingo Schulz-Schaeffer	Technik als Gegenstand der Soziologie TUTS-WP-3-2008
02/2008	Holger Braun-Thürmann	Die Ökonomie der Wissenschaften und ihre Spin-offs

		TUTS-WP-2-2008
01/2008	Werner Rammert	Technik und Innovation TUTS-WP-1-2008
08/2007	Jörg Potthast	Die Bodenhaftung der Flugsicherung TUTS-WP-8-2007
07/2007	Kirstin Lenzen	Die innovationsbiographische Rekonstruktion technischer Identitäten am Beispiel der Augmented Reality-Technologie. TUTS-WP-7-2007
06/2007	Michael Hahne Martin Meister Renate Lieb Peter Biniok	Sequenzen-Routinen-Positionen – Von der Interaktion zur Struktur. Anlage und Ergebnisse des zweiten Interaktivitätsexperimentes des INKA-Projektes. TUTS-WP-6-2007
05/2007	Nico Lüdtke	Lässt sich das Problem der Intersubjektivität mit Mead lösen? – Zu aktuellen Fragen der Sozialtheorie TUTS-WP-5-2007
04/2007	Werner Rammert	Die Techniken der Gesellschaft: in Aktion, in Interaktivität und hybriden Konstellationen. TUTS-WP-4-2007
03/2007	Ingo Schulz-Schaeffer	Technik als sozialer Akteur und als soziale Institution. Sozialität von Technik statt Postsozialität TUTS-WP-3-2007
02/2007	Cornelius Schubert	Technology Roadmapping in der Halbleiterindustrie TUTS-WP-2-2007 1/2007 Werner Rammert
01/2007	Werner Rammert	Technografie trifft Theorie: Forschungsperspektiven einer Soziologie der Technik TUTS-WP-1-2007
04/2006	Esther Ruiz Ben	Timing Expertise in Software Development Environments TUTS-WP-4-2006
03/2006	Werner Rammert	Technik, Handeln und Sozialstruktur: Eine Einführung in die Soziologie der Technik TUTS-WP-3-2006
02/2006	Alexander Peine	Technological Paradigms Revisited – How They Contribute to the Understanding of Open Systems of Technology TUTS-WP-2-2006

01/2006	Michael Hahne	Identität durch Technik: Wie soziale Identität und Gruppenidentität im sozio-technischen Ensemble von Ego-Shooterclans entstehen TUTS-WP-1-2006
07/2005	Peter Biniok	Kooperationsnetz Nanotechnologie – Verkörperung eines Neuen Innovationsregimes? TUTS-WP-7-2005
06/2005	Uli Meyer Cornelius Schubert	Die Konstitution technologischer Pfade. Überlegungen jenseits der Dichotomie von Pfadabhängigkeit und Pfadkreation TUTS-WP-6-2005
05/2005	Gesa Lindemann	Beobachtung der Hirnforschung TUTS-WP-5-2005
04/2005	Gesa Lindemann	Verstehen und Erklären bei Helmuth Plessner TUTS-WP-4-2005
03/2005	Daniela Manger	Entstehung und Funktionsweise eines regionalen Innovationsnetzwerks – Eine Fallstudienanalyse TUTS-WP-3-2005
02/2005	Estrid Sørensen	Fluid design as technology in practice – Spatial description of online 3D virtual environment in primary school Bestell-Nr. TUTS-WP-2-2005
01/2005	Uli Meyer Ingo Schulz-Schaeffer	Drei Formen interpretativer Flexibilität TUTS-WP-1-2005
03/2004	Werner Rammert	Two Styles of Knowing and Knowledge Regimes: Between 'Explicitation' and 'Exploration' under Conditions of 'Functional Specialization' or 'Fragmental Distribution' TUTS-WP-3-2004
02/2004	Jörg Sydow Arnold Windeler Guido Möllering	Path-Creating Networks in the Field of Text Generation Lithography: Outline of a Research Project TUTS-WP-2-2004
01/2004	Corinna Jung	Die Erweiterung der Mensch-Prothesen-Konstellation. Eine technografische Analyse zur ‚intelligenten' Beinprothese TUTS-WP-1-2004
10/2003	Cornelius Schubert	Patient safety and the practice of anaesthesia: how hybrid networks of cooperation live and breathe

TUTS-WP-10-2003

09/2003	Holger Braun-Thürmann Christin Leube Katharina Fichtenau Steffen Motzkus Saskia Wessäly	Wissen in (Inter-)Aktion - eine technografische Studie TUTS-WP-9-2003
08/2003	Eric Lettkemann Martin Meister	Vom Flugabwehrgeschütz zum niedlichen Roboter. Zum Wandel des Kooperation stiftenden Universalismus der Kybernetik TUTS-WP-8-2003
07/2003	Klaus Scheuermann Renate Gerstl	Das Zusammenspiel von Multiagentensystem und Mensch bei der Terminkoordination im Krankenhaus: Ergebnisse der Simulationsstudie ChariTime TUTS-WP-7-2003
06/2003	Martin Meister Diemo Urbig Kay Schröter Renate Gerstl	Agents Enacting Social Roles. Balancing Formal Structure and Practical Rationality in MAS Design TUTS-WP-6-2003
05/2003	Roger Häußling	Perspektiven und Grenzen der empirischen Netzwerkanalyse für die Innovationsforschung am Fallbeispiel der Konsumgüterindustrie TUTS-WP-5-2003
04/2003	Werner Rammert	Die Zukunft der künstlichen Intelligenz: verkörpert – verteilt – hybrid TUTS-WP-4-2003
03/2003	Regula Burri	Digitalisieren, disziplinieren. Soziotechnische Anatomie und die Konstitution des Körpers in medizinischen Bildgebungsverfahren TUTS-WP-3-2003
02/2003	Werner Rammert	Technik in Aktion: Verteiltes Handeln in soziotechnischen Konstellationen TUTS-WP-2-2003
01/2003	Renate Gerstl Alexander Hanft	Modellierung der praktischen Rolle in Verhandlungen mit einem erweiterten Verfahren des fallbasierten Schließens

	Sebastian Müller Michael Hahne Martin Meister Dagmar Monett Diaz	TUTS-WP-1-2003
09/2002	Werner Rammert	Gestörter Blickwechsel durch Videoüberwachung? Ambivalenzen und Asymmetrien soziotechnischer Beobachtungsordnungen TUTS-WP-9-2002
08/2002	Werner Rammert	Zwei Paradoxien einer Wissenspolitik: Die Verknüpfung heterogenen und die Verwertung impliziten Wissens TUTS-WP-8-2002
06/2002	Martin Meister Diemo Urbig Renate Gerstl Eric Lettkemann Alexander Ostherenko Kay Schröter	Die Modellierung praktischer Rollen für Verhandlungssysteme in Organisationen. Wie die Komplexität von Multiagenten-systemen durch Rollenkonzeptionen erhöht werden kann TUTS-WP-6-2002
05/2002	Cornelius Schubert	Making interaction and interactivity visible. On the practical and analytical uses of audiovisual recordings in high-tech and high-risk work situations TUTS-WP-5-2002
04/2002	Werner Rammert Ingo Schulz-Schaeffer	Technik und Handeln - Wenn soziales Handeln sich auf menschliches Verhalten und technische Artefakte verteilt. TUTS-WP-4-2002
03/2002	Werner Rammert	Technik als verteilte Aktion. Wie technisches Wirken als Agentur in hybriden Aktionszusammenhängen gedeutet werden kann. TUTS-WP-3-2002
02/2002	Werner Rammert	Die technische Konstruktion als Teil der gesellschaftlichen Konstruktion der Wirklichkeit TUTS-WP-2-2002
01/2002	Werner Rammert	The Governance of Knowledge Limited: The rising relevance of non-explicit knowledge under a new regime of distributed knowledge production TUTS-WP-1-2002
02/2001	Ingo Schulz-Schaeffer	Technikbezogene Konzeptübertragungen und das Problem der Problemähnlichkeit. Der Rekurs der Multiagentensystem-

		Forschung auf Mechanismen sozialer Koordination TUTS-WP-2-2001
01/2001	Werner Rammert	The Cultural Shaping of Technologies and the Politics of Technodiversity TUTS-WP-1-2001
10/2000	Frank Janning Klaus Scheuermann Cornelius Schubert	Multiagentensysteme im Krankenhaus. Sozionische Gestaltung hybrider Zusammenhänge TUTS-WP-10-2000
09/2000	Holger Braun	Formen und Verfahren der Interaktivität – Soziologische Analysen einer Technik im Entwicklungsstadium. TUTS-WP-9-2000
08/2000	Werner Rammert	Nichtexplizites Wissen in Soziologie und Sozionik. Ein kursorischer Überblick TUTS-WP-8-2000
07/2000	Werner Rammert	Ritardando and Accelerando in Reflexive Innovation, or How Networks Synchronise the Tempi of Technological Innovation TUTS-WP-7-2000
05/2000	Jerold Hage Roger Hollingsworth Werner Rammert	A Strategy for Analysis of Idea Innovation, Networks and Institutions National Systems of Innovation, Idea Innovation Networks, and Comparative Innovation Biographies TUTS-WP-5-2000
04/2000	Holger Braun	Soziologie der Hybriden. Über die Handlungsfähigkeit von technischen Agenten TUTS-WP-4-2000
03/2000	Ingo Schulz-Schaeffer	Enrolling Software Agents in Human Organizations. The Exploration of Hybrid Organizations within the Socionics Research Program TUTS-WP-3-2000
02/2000	Klaus Scheuermann	Menschliche und technische ‚Agency': Soziologische Einschätzungen der Möglichkeiten und Grenzen künstlicher Intelligenz im Bereich der Multiagentensysteme TUTS-WP-2-2000
01/2000	Hans-Dieter Burkhard Werner Rammert	Integration kooperationsfähiger Agenten in komplexen Organisationen. Möglichkeiten und Grenzen der Gestaltung hybrider offener Systeme

		TUTS-WP-1-2000
01/1999	Werner Rammert	Technik Stichwort für eine Enzyklopädie TUTS-WP-1-1999