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Developing A Model of Technology Appropriation : A Marxian Perspective

Développement d’un Modèle D'appropriation de la Technologie : Une Perspective Marxiste

Completed Research Paper

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Abstract

This paper explores the philosophical origins of appropriation of Information Systems (IS) using Marxian and other socio-cultural theory. It provides an in-depth examination of appropriation and its application in extant IS theory. We develop a three-tier model using Marx’s foundational concepts and from this generate four propositions that we test in an empirical example of IS in anesthesia. Using Marxian theory, this paper seeks common ground among existing theories of technology appropriation in IS research. This work contributes to IS research by (1) opening philosophical discussions on appropriation and the human ↔ technology nexus, (2) drawing on these varying perspectives to propose a general conceptualization of technology appropriation and (3) providing a starting point towards a general causal model of technology appropriation.

Keywords: Marx, Technology Appropriation, Information Systems
Résumé

Cette étude explore les origines philosophiques de l’appropriation des systèmes d’information (SI) à travers la théorie Marxiste et d’autres théories socioculturelles. L’étude contribue à la recherche en SI : 1) en lançant un débat philosophique sur l’appropriation, 2) en proposant une conceptualisation générale de l’appropriation de la technologie et 3) en fournissant un point de départ vers un modèle causal général d'appropriation de la technologie.

Introduction

The interplay between human behavior and technology is a central theme in contemporary information systems (IS) research (Cousins and Robey 2005; Beaudry and Pinsonneault 2005; Jones and Karsten 2008). Its interdisciplinary nature, drawing from referent disciplines such as information technology studies and sociology, provides a rich field of research challenges. A range of research areas address this human ↔ technology interplay including studies of acceptance and use (Davis 1989, 1993; DeSanctis and Poole 1994; Orlikowski 1992, 2000) and adoption (Venkatesh et al. 2003; Ahuja and Thatcher 2005; Davis and Hufnagel 2007). One socio-cultural concept linked to these research areas is the notion of ‘appropriation’

‘Appropriation’ has been a central concept in the Social Constructivist School of Information Systems, which examines the relationships between human agency, technology and social structures. Early proponents of social structures as an influence on appropriation were DeSanctis and Poole (1994). Their Adaptive Structuration Theory combined the notions of appropriation and Gidden’s (1979, 1984) social structures to examine the relationship between human behavior and information technology. Another view of this relationship is Duality of Technology (Orlikowski 1992, 2000). While Orlikowski (1992) initially supported DeSanctis and Poole’s view that social structures could be embedded in technology (and were appropriated by users), she later refined this view, “complementing the notion of embodied structure with that of emergent structure, and the notion of appropriation with that of enactment” (Orlikowski 2000, p.405).

In adopting the notion of appropriation, both DeSanctis and Poole and Orlikowski drew on the work of the philosopher Marx (and ultimately Hegel), predominantly through its interpretation by Ollman (1971). This paper deeply explores these philosophical roots seeking to better explain the process of appropriation and discover common ground across these complementary viewpoints. Like DeSanctis and Poole and Orlikowski, we also draw on Gidden’s Structuration Theory to explain the link between determinism (structures) and voluntarism (agency) in human interaction with information systems.

The purpose of this paper is to open a philosophical discussion within the information systems community about the notion of appropriation as a foundational conception in the human ↔ technology relationship. It first explores Marx’s dichotomous view of human nature as natural being and species being, and introduces social being as a way to integrate structurational concepts into Marx’s paradigm. A discussion of Structuration Theory follows to explain the various structural influences on social being. We return to Marx to introduce the important concepts of perception, orientation and appropriation, which leads into a review of the latter’s socio-cultural development. From this, we review the major theoretical works on appropriation in the information systems literature: Adaptive Structuration Theory (DeSanctis and Poole 1994), Model of Technology Appropriation (Carroll et al. 2002, 2003) and the Structurational Model of Technology (Orlikowski 1992, 2000). Following this discussion, we derive our Marxist technology appropriation model, including its various constructs and four associated propositions. We test this model with the empirical example of anesthesia. Finally, we conclude with implications for IS research and our model’s future potential impact on existing theories of technology adoption, appropriation, and use and disappropriation.

This paper contributes to IS research by making the following contributions: (1) it demonstrates how the various conceptions of technology have a common ground in Marx’s philosophy, and in doing so opens up philosophical discussion on a fundamental concept in the human ↔ technology nexus, (2) it proposes a general conceptualization of technology appropriation that encompasses varying appropriation behaviors, and (3) provides a starting point towards a general causal model of technology appropriation.
The Dichotomy of Human Nature

We begin by exploring Marx’s conception of human nature, specifically the dichotomy of natural being and species being. Adding to this dichotomy is the notion of social being, which situates humans within their social context. A critical conception in Marx’s philosophy is that of dialectics. This suggests that the way to view the world is as an evolving process rather than a collection of things (Sowell 1985). Marx sees the basic unit of reality as relations - fact-value, cause-effect or nature-society, or, in our case, human-IS. He emphasizes the idea of development or the “transition from one form to another” (Marx 1959, p. 44), an idea that resonates in his views on the subject-object relation(ship) and the transformation of work into products during the process of labor.

Describing labor, Marx states that it is “a process in which both man and nature participate, and in which man of his own accord starts, regulates and controls the material reactions between himself and nature…by thus acting on the external world and changing it, he at the same time changes his own nature” (McLellan 1980, p. 164). The dialectic approach harbors the distinction between inner, inherent forces within humans and the outward, external appearance of objects. Humans themselves can be an object, but only in interaction with other humans. The development or transition that occurs between inner forces and external appearance is the freeing of the inner senses, or the unraveling or unfolding of human essence, which allows us to realize our essential powers (Ollman 1971).

Human beings possess powers and needs, with natural needs (e.g. procreation) and powers (e.g. the senses) shared with all living entities, and species needs and powers that are possessed by humans alone (e.g. creative expression). Ollman (1971) makes clearer the distinction between needs and powers, with needs simply being the desire one feels toward an object that is not always immediately available, and powers equating to the faculty, ability, function and capacity that relate to these powers being fulfilled by the future forms of an object (its potential) and the object’s current forms. All of these needs and powers comprise the essential powers of humans. These essential powers are realized in nature by Marx’s dichotomous natural being and species being.

Natural Being – Species Being – Social Being

Natural being can be equated to animal functions or physical needs. Ollman (1977, p. 77-78) identifies two outstanding characteristics of natural being: (1) natural powers exist in humans as tendencies, abilities or impulses; and (2) natural powers seek fulfillment in objects outside of the body. At the level of natural being, humans are suffering and limited, albeit objective and sensuous, unable to distinguish themselves from their acts through imagination, are without ability or self-awareness, and are spontaneously controlled by the availability and qualities of objects in nature (Marx, 1977). Natural being is guided by senses and basic functions, with behavior driven by unconscious use of senses. It is through relation with objects that humans define their higher powers and needs.

When Marx speaks of objects, he does not specifically refer to material things. For Marx, objects are ‘the object of a subject’, and can be real or potential. Natural powers manifest in and through objects, and in turn humans require objects to express their powers. Realization is the fulfillment of powers and the objectification of these powers in nature. Through realization, humans are established by objects and objects in turn “reside in the very nature of [our] being” (Marx 1977, p. 156). Thus, objects can be understood as either material or ethereal. In the case of the latter, the virtual existence of objects equates to the idea of structures (see Giddens 1979). Structures can only be wholly realized through the perspective of social being.

Because humans create a world of objects through activity, we prove ourselves as conscious species being (Marx, 1977). The conscious life activity of species being is separate from the animal life activity of natural being. Where the animal does not distinguish itself from its life activity, humans are self-conscious, self-aware and able to confirm themselves through knowing. Ollman (1971, p. 82) identifies two characteristics of species being: (1) the peculiar physicality that establishes us as human; and (2) the way we manifest ourselves as a species through activity of quality and pace that is unique to human beings.

The species powers are driven by the same ‘physical’ senses that drive natural powers but have the added facet of the ‘mental senses’ unique to humans. Although we have explored the difference between natural and species being, the two are not necessarily opposing contrasts in the dialectic of human nature. Because humans also possess animal functions (i.e. sight, touch, smell), natural being is subsumed within the species being. Natural being is driven by instinctive behavior, and species being employs senses and functions in a reflexive human fashion as part of species life activity. This species life activity places the individual (natural being and species being) into the social system as social being (Marx, 1977).
It is through social relations that humans confirm their existence and establish themselves as species being within the sphere of human interaction (Marx and Engels 1942). Marx conceives of society as the cooperation of individuals through which humans relate to one another; relations in society can be external to humans as the product of reciprocal activities, and sometimes society exists within an individual through social relations. Importantly, humans are not only related to each other through direct contact, but are also related to one another through their objects (Ollman 1971).

Beyond the dichotomy of natural and species being, a social being has social needs (Ollman 1971). These social needs reflect the powers of other humans that have developed – through similar experience – to similar wants, demands and utility of society. Giddens (1979) holds a similar view of social systems as being emergent properties of interaction and shaped by the mutual recursiveness of structure and agency. Social beings are the product of their context, while at the same time contribute to their environment through interacting with one another, or as Ollman (1971, p. 106) says “…man’s consciousness of himself and of his relations with others and with nature are that of a social being, since the manner in which he conceives of anything is a function of his society.” Figure 1 summarizes the hierarchical but integrated nature of natural, species and social being:

![Figure 1. Conception of Human Nature](image)

Species being is the individual conscious actor, subsuming the powers and needs of natural being, and acting as social being in relation to others in society. To further consider social being and its relationship with species and natural being, we now briefly describe Giddens’ Structuration Theory.

**Social Structures – Giddens’ Structuration Theory**

The work of Giddens (1979, 1984) helps explain social being acting within the virtual, ethereal structures that comprise social systems. Structuration Theory (ST) is a way to explore the mutuality between virtual structures and the human agency that creates them. As a framework of unification, ST sought to bridge the divide between determinism (those who consider social phenomena as objective social structures) and voluntarism (those who see social phenomena as products of human agents subjectively interpreting the world) that had existed in sociology prior to its construction (Timbrell et al. 2005). Giddens saw social systems as comprised of day-to-day social interactions involving ‘situated activities’ of human agents existing in time-space, and are constituted by regular, reproduced relations of ‘interdependence’ between either individual agents or a collective group. Giddens (1979) also refers to this as ‘recurrent social practices’, or the mutual dependence of structure and agency.

In ST, structure refers to ‘patterns’ of social relationships and only exists as structural properties. These structural properties exist virtually as rules and resources that in social reproduction bind time (Giddens 1979, p. 63) and result in enduring practices in social systems (reproduced relations between actors or groups, organized as regular social practices that occur in time and space). To regard structure as a ‘virtual order’ implies recognizing the existence of:

- (a) knowledge –as memory traces – of ‘how things are to be done (said, written) on the part of social actors; (b) social practices organized through the recursive mobilization of that knowledge; (c) capabilities that the production of those social practices presupposes (p.64) (see also Becker et al. 2002).

Giddens emphasizes that structures, rather than being a physical entity, are “traces in the mind” – rules and resources – that exist only at the moment of enactment (see also Orlikowski 2000). Structural properties of social systems then are both “the medium and outcome of practices constituting those systems” (Giddens 1979, p. 69) and institutions are a product of human agency but are an “outcome of action only in so far as they are also involved
recursively as the medium of its production” (op. cit. p. 95). Structuration refers to ‘the dynamic process whereby structures come into being’ (King 2004, p.121) and structures only manifest from social interaction.

Structures (Giddens 1979) are understood as systems of semantic rules (structures of signification), as systems of resources (structures of domination) and as systems of moral rules (structures of legitimation). These three modes of structure are in turn related to three moments of interaction, summarizing the relationships as signification-communication, domination-power and legitimation-sanction. Across communication of meaning, operation of power relations and the enactment of normative sanctions, actors draw upon what Giddens refers to as ‘modalities’ in the production of social interaction. These modalities are interpretative schemes used in the communication of meaning, facilities used in the exercise of power relations, and norms applied to the sanction of social behavior. The modalities are not only the factors of social production but also its media and output.

Although Marx does not directly address the notion of structures, the idea of human actors as comprising of and shaped by these structures resonates within his work. Social being for instance can be thought of as a socially influenced actor whose cognitive behaviours are both shaped by instinct and consciousness and guided by external social influences as per Giddens’ (1984) conception of recursiveness. These referent social frameworks influence the perception, orientation and appropriation of an object or artefact by an individual. We now discuss these three Marxian processes.

Marx: Perception – Orientation – Appropriation

To piece together the fragments of Marx’s theoretical lattice, we begin with natural and species powers and how they are realized or manifested in the objects that humans produce or to which they relate. There are three interconnected processes that establish the link between the essential powers of humans and the world around them: perception, orientation and appropriation (Ollman 1971; Marx 1977). Defining the first two concepts (Ollman 1971, p. 85):

- **Perception** is the immediate contact a human (natural being) has with nature through the instinctive senses; and
- **Orientation** is the way that humans (species being) relate to things by establishing patterns, places and worth, and cognitively construct the framework for subsequent actions within the social world.

Thus, perception is the exercise of natural being powers while orientation is the exercise of powers by species being. Humans exercise perception and orientation in an integrated fashion, just as they employ structures in an integrated way. Marx links these two concepts with realization: an object is realized as ‘fulfilling of the natural senses’ or an object is realized as ‘attributive or enhancing of the species powers’. In the act of realization, humans see an object as an ‘instance of themselves’ and residing within their natural or species being (Marx, 1977).

In Marx’s philosophy, the two concepts of perception and orientation link together irrevocably. Perception leads immediately to orientation, with the latter establishing the meaning, structure and the future goals of perception. However, orientation can also be present before perception since man chooses objects that he realizes or deems irrelevant before he perceives it directly (for e.g. based on a colleague’s description). Both of these concepts carry the act of appropriation. The most general definition of appropriation is “to utilize constructively; to build by incorporating: the subject is man’s essential powers” (Ollman 1971, p. 89). In Marx’s view, appropriation is the way that humans relate to nature. Perception is appropriation through the exercise of the natural needs and powers of the individual, while orientation is appropriation since the individual makes this nature part of him or herself through the effect it has on his senses and the conscious potential it harbours.

We note at this point that Marx applied his concept of appropriation to his work on alienation. For Marx, labour is seen as external to the worker and not belonging to his intrinsic nature. The product of the worker’s labour is an object. It is the objectification or realization of labour to which humans become alienated or estranged (Marx, 1977). It is not the intention of this paper to pursue the notion of appropriation into such mainstream and previously well-covered political discussions, but rather focus on its applicability to the field of IS.

In this paper we see appropriation as humans realizing essential powers as fulfilled by objects in nature, and in the context of this research, the objects of interest are technology. Pomeroy (2004) notes that the fundamental condition for all human activity is the existence of an objective world. The activity of a subject cannot operate in isolation from the objective world, and all perception requires both the senses and the object sensed. Pomeroy (2004) refers to Marx (1959, p.106) who describes this subject-object relationship as being “each human relation to the
world...seeing, hearing, smelling, feeling, thinking, [awareness], sensing, writing – in short, all the organs of the individual being, like those organs which are directly social in their form, are in their objective orientation or in their orientation to the object, the appropriation of that object, the appropriation of the human world.”

Objects such as technology are an instance for which a human, either as natural or species being, can realize his or her needs for the expression of essential powers. When an object matches the level and development of the essential powers, the development of the human is fulfilled. Ollman (1971, p. 137) states: “Appropriation is Marx’s most general expression for the fact that man incorporates the nature he comes into contact with into himself. Activity enters this account as the chief means by which man appropriates objects and becomes the most effective medium between the individual and the outer world.”

Marx gives three moments of activities as having special relations to human powers: (1) activity is the foremost example of the combined operation of humans’ [natural and species] powers and needs (or essential powers); (2) activity establishes new possibilities for the fulfillment of needs and powers by transforming nature and the nature-imposed limitations; and (3) activity is the main means by which the potential of powers are developed.

Ollman (1971) states that appropriation occupies the most prominent space in Marx’s works, and in his later writings, perception and orientation are “wholly subsumed under it” (p.86). Appropriation is the relation between human senses and nature, but appropriation can be a changing state, with the potential to affect future perception and orientation through the effect it has on humans and objects. This changing state recognizes the complex, emergent nature of human relations within the complex environments in which these human relations operate, or, as we conceive it, a complex world. In contrast, technology, and information technology in particular, is a much more linear world in nature. The interaction between the complex and emergent world of human agency and the linear world of technology such as information systems is mediated by both individual and group behaviour and beliefs. This is consistent with other usage theories such as the Theory of Reasoned Action (see Fishbein and Azjen 1975).

The notion of appropriation has been further developed and discussed in literature pertaining to socio-cultural learning and information systems. In the next section we briefly review this literature before describing our Marxian model in detail.

**Appropriation**

A key motivation of socio-cultural studies is the relationship between human mental processes and the cultural, historical and institutional settings in which they situate (Wertsch 1995). Appropriation in the socio-cultural field is often used to refer to cultural learning, or the appropriation of cultural tools (Overdijk and van Diggelen 2006). Wertsch (1998) refers to appropriation as the act of taking something that belongs to another and making it one’s own, a notion stemming from Bakthin (1981) who uses it to describe the process of a speaker adopting a word from another system of language and adapting it to their own semantic meaning and expression. The appropriation of cultural tools (or resources) such as systems of communication occur through the involvement of individuals in cultural activities in which the tool plays a role (Newman et al. 1989).

In her study of personal, interpersonal and community development, Rogoff (1995) identifies three uses of the term appropriation. The first equates simply to the *internalization* (Berger and Luckmann 1966), whereby something external is imported. The second use, taken from Harre (1983) who sees appropriation as a process preceding transformation, extends *internalization* recognizing that what is imported is also transformed to fit the purposes of the new owner. Rogoff’s third use is participatory *appropriation*. This refers to the way in which people, by participating in an activity, adopt and change its meaning through ongoing communication, and in turn change themselves and are prepared to engage in subsequent similar activities. Her view deviates from Harre’s (1983) concept of appropriation as a *precondition* for transformation, instead focusing on appropriation as a *process* of transformation. She calls appropriation a “process of becoming rather than acquisition” (Rogoff 1995, p. 142), and that change is a result of activity and not the internalization of an external instantiation. Rogoff’s (1995) idea of appropriation by assimilation harbours strong similarities to Marx’s *realization*: a human, by applying senses and consciousness, recognizes the usefulness or potential of an external object and incorporates it through species and social activity. This accords with the view of IS potential and use (Orlikowski 2000; Bia and Kalika 2005).

Rogoff’s (1995) conceptualization of appropriation by activity, as a process of transformation, also resonates with Marx’s view. *Realization* is not only the *perception* of an object by a human, but also the *orientation* toward it - the fulfilment and ratification of essential powers by use. The object undergoes transformation from something external
to something ‘naturalized’ to the inherent senses of the natural being and ‘embedded’ within the cognitive processes of the species being.

MacKay and Gillespie (1992) posit that appropriation of technology is a subjective and actively social process, stating that “people are not merely malleable subjects who submit to the dictates of a technology…they are active, creative and expressive – albeit socially situated – subjects” (p. 698). They allude to the way in which people are not conceptualized entities that predicatively lend themselves to rigid theories, but are social beings part of a cultured, institutional setting wherein ‘complex’ interactions take place. Consequently, appropriation is not always a linear process, since “people may reject technologies, redefine their functional purpose, customize or even invest symbolic meanings to them. Indeed, they may redefine technology in a way that defies its original designed and intended purpose” (p.699). This view of customization or change in the symbolic meaning of technology shares the spirit and faithfulness of DeSanctis and Poole in AST (1994), the reinforcement of evaluative criteria regarding technology by Carroll et al. (2003, 2004) and the notion of interpretive flexibility by Orlikowski (1992). The fundamental notions of socio-cultural appropriation by Bakthin (1981), Wertsch (1998) and Rogoff (1995) hold across the IS frameworks, yet their applicability in the IS field has not been fully explored.

Appropriation as acquisition and appropriation as activity accord with the AST view of appropriating structural elements of technology and the view of enactment by Orlikowski (2000) respectively. Orlikowski’s idea of enactment aligns with Rogoff’s (1995) appropriation by participation, the act of an object being transformed through activity involving the individuals within the social institution that engaged it. Both these perspectives entail the idea that an object is first realized as useful to the purposes of the group, by means of perception and orientation; and subsequently, the object is realized by activity or enactment through the mediated interactions of social being(s).

The MacKay and Gillespie (1992) and Orlikowski (2000) views of technology as interpretive and flexible do not necessarily relate to the features of technology but the emergent structures of people’s interactions with it. So, if a newly developed system is built for one occupational group but another recognizes its potential, the perception and orientation of the second group both realizes and transforms the potential of this new technology toward fulfilling their essential powers (realization), and the technology is appropriated into their activities.

On the other hand, a technology designed rigidly for a specific purpose or task may be seen as inflexible. This is because the structural properties of the technology have already been realized. Using Marx’s terminology, the technology “has already been subsumed into the life activity of a species being” i.e. their routines and practices. The technology is already realized and confirmed. In the socio-cultural literature then, appropriation of technology has two meanings. Firstly, technology is perceived and oriented to by the species being or the institutional member, matches the inherent senses and cognitive processes, and is realized as a fulfillment of the needs and powers and appropriated for this use. Secondly, technology becomes appropriated through the process of transformation as it becomes utilized by social being within the dynamic ‘world’ of the institution.

The IS field considers the notion of appropriation as not simply adopting a technology but the mutual interplay between technology and user. Information Systems theories embracing appropriation have also employed the work of Giddens (1979) as a framework to consider the group activities that influence and affect technology appropriation and use. We now look at three of these IS theories: Adaptive Structuration Theory (Poole and DeSanctis 1989, 1990, 1992; DeSanctis and Poole 1994), the Structurational Model of Technology (Orlikowski and Robey 1991; Orlikowski 1992, 2000), and the Model of Technology Appropriation (Carroll et al. 2002, 2003; Carroll, 2004).

**Adaptive Structuration Theory**

Adaptive Structuration Theory (AST) represents a techno-centric extension of Structuration Theory that aims to analyze the interactive and social dynamics of technology within organizational settings. It has proved a popular lens in IS studies across the last decade (e.g. Gopal et al. 1992; Chin et al. 1997; Salisbury et al. 2002).

The context of AST is Group Decision Support Systems (GDSS). Initially, Poole and DeSanctis (1990, p.150) defined appropriation as the process of “how users alter systems, thereby enacting socio-technical change within the group”. Later, DeSanctis and Poole (1994, p. 128) called “the immediate, visible actions that evidence deeper structuration processes, appropriations of the technology” and cited Ollman’s (1971) work as a source in this definition. DeSanctis and Poole (1994) propose AST as a framework for studying the organizational effects of technology appropriation. When users appropriate a technology, they in turn appropriate the ‘structures’ that are embedded within the technological artefact. AST contains four ‘modes’ of appropriation: (1) appropriation moves,
otherwise known as consensus on appropriation; (2) faithfulness of appropriation, being the way an Advanced Information Technology (AIT) is used with respect to its original intent; (3) instrumental uses that incorporate what features are used by the group to understand why the AIT has been employed; and (4) attitudes toward appropriation, representing the beliefs and views work group members have toward an AIT.

In contrast to AST, Orlikowski’s model moved away from the idea of appropriation of technology structures to a complementary notion of enactment; appropriation, in her view is a social process.

**Structurational Model of Technology**

Orlikowski and Robey (1991) were among the pioneer IS scholars who recognized the potential of Structuration Theory in IS research. Using Giddens’ (1979, 1984) concepts of recursiveness, mediation and duality of structure, they developed the Structurational Model of Technology. This framework attributes a recursive notion to technology, or a duality of technology (Orlikowski 1992) in which technology is regarded as a product of human action and a consequence of human interaction. In this model, she proposes that (Orlikowski 1992, p.410): (a) technology is a product of human action e.g. design, development, appropriation and modification; (b) technology is a medium of human action, facilitating and constraining it through provision of interpretive schemes, facilities and norms; (c) institutional conditions of interaction with technology influence humans in their interaction with it; and (d) institutional consequences of interaction with technology influence the institutional properties of an organization through reinforcing or transforming structures of signification, domination and legitimation.

Her duality of technology view consists of technology physically built by designers and the product of a particular temporal and organizational context. This idea is enhanced by the notion of interpretive flexibility (Orlikowski 1992), which considers two modes of interaction in technology: the design mode and the use mode. In the former, designers impart certain interpretive schemes, facilities and norms into technology, while in the latter, agents appropriate technology through assigned meaning and are influenced by it through execution. She emphasizes however that any constraining structures are institutional and not within the technology itself.

Other proponents of technology-in-use as a building block of appropriation in the human ↔ IS relationship are Carroll et al. (2002, 2003).

**Model of Technology Appropriation**

The Model of Technology Appropriation (MTA) as proposed by Carroll et al. (2002, 2003) depicts the appropriation process as entailing the transformation of a Technology-as-Designed into a Technology-in-Use. A technology-as-designed embodies the views of designers, marketers and requirements of users as captured throughout the design process; a technology-in-use captures the needs of users as they are expressed through the action undertaken as the technology is utilized in everyday activities.

The context of the MTA was single-user appropriation, unlike the group level appropriations of AST. The MTA attempts to capture the process or act of appropriation from filtering of initial attractors, to the establishment of evaluative criteria and their subsequent reinforcement through use (Carroll et al. 2003). Carroll (2004) later extended the model to present a Technology Appropriation Cycle, purporting that developers first construct the technology and users close the cycle in their use of it.

The MTA involves a systematic evaluation by users as they progress through three levels. Level 1 is when initial judgments occur. Here, the user first encounters a technology as designed and makes an initial evaluation based on its innovation and expectations of its value (Carroll 2004). The user enters a filtering process, recognizing certain attractors that will encourage appropriation. Conversely, a lack of attractors will result in non-appropriation. During Level 2, users begin to fashion criteria through continued evaluation of the technology - they explore, adopt and adapt to it. In this process, the technology will afford some activities or constrain others, and in turn, users may configure or personalize technology to either find new uses or combine it with other resources in innovative ways.

Level 3 is what Carroll (2004) calls appropriation. Users persist with the technology over time, developing reinforcers that fortify the technology as part of their activities and practice. The technology becomes ‘stabilized’ during this period; alternatively, changes in the reinforcers may lead to re-evaluation of the technology and possibly disappropriation. In extending the MTA as a technology appropriation cycle, Carroll (2004) suggests that a technology as designed reaches its final stage of transformation through the appropriation of it by users.
Our review of the IS frameworks that explore the concept of technology appropriation in light of the philosophical Marxian underpinning of the concept of technology in general suggest the following issues:

- While the existing literature generally recognizes the interplay and interaction between human and technology, the process that leads to how the interaction might play out is neither well understood nor incorporated into these theories. Carroll (2004) has made an attempt in this direction but her description still focuses on the behavioural outcome rather than the integral processes underlying those outcomes. In order to fully understand and account for technology appropriation, we propose that a model that considers the entire appropriation process is imperative.

- While literature appears to rely on various elements from the social studies literature, e.g. the ideas of structures, subject-object distinction, appropriation, object-as-artefact vs object-in-use, etc., all of which, as we pointed out, could be traced back to the Marxian root, they have not been considered in a holistic manner. We believe that by using ideas piecemeal, emphasizing on one component while neglecting the other would result in only a piecemeal understanding of technology appropriation. 

- The transition of the state of relationships between an individual and technology: from perception to orientation, realization to appropriation, and then to disappropriation; is not well understood. We argue that a clear understanding of this transition is critical to the development of a theory for understanding not only appropriation but also adoption and rejection of technology.

To address the above issues, we present an integrated three-tier model of information systems appropriation constructed from Marx’s conceptual building blocks.

THREE-TIER MODEL OF TECHNOLOGY APPROPRIATION

Our technology appropriation model is derived from the literature, building upon the concepts of Marx (1977) as reiterated by Ollman (1971). Major concepts that form the building blocks are natural being, species being, social being, perception, orientation and realization (Marx 1977; Ollman 1971); appropriation (Marx 1977; Ollman 1971; Rogoff 1995); technology as artefact (Orlikowski 2000) and technology in use (Carroll et al. 2002, 2003; Orlikowski 2000). The model as presented in Figure 2 defines three levels of interaction with technology: the intrinsic behaviour and senses of natural being, the consciousness of species being and the structurational modalities of social being. The model is presented below in Figure 2.

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1 We recognize that the authors may have started with a different ontological base, rather than the Marxian paradigm, and thus this comment may not be entirely fair, we also argue that as much as these concepts do have its roots in Marxian paradigm, such comparison is reasonable and could be fruitful.
We now describe this model from the inside out.

**Perception of Technology**

*Natural being* perceives a technology in its artefact state; that is, technology in its static form without prior observations or established patterns of use for that technology. An individual encounters this artefact through physical senses, predominantly sight, hearing and touch, through which the tangible immediacy of the object, its function and form, is considered. Judgments are formed of the essential needs or powers that this artefact will fulfill purely through instinct. In perception, *natural being* intuitively forecasts the *sensory enablement* a technology-as-artefact might offer.

It is through perception that our senses find essentiality (see Marx 1977) in the technology. *Natural being* intuits that when the technology is placed into use, it will provide an *enhancement of senses* that enables essential powers or fulfils essential needs. This instinctual recognition occurs either prior to or simultaneously with the conscious orientation to the technological artefact by *species being*.

**Orientation of Technology**

Where *natural being* employs intrinsic senses to seek physical fulfillment of essential powers and needs in a technology, *species being* employs the unique human characteristics and the faculty, ability, function and capacity of conscious behaviour to assess the species powers and needs (see also Maslow (1943) for a discussion of human needs). During orientation, *species being* projects future behaviour, envisioning the subject-object relationship between the user and the artefact. *Species being* forecasts the transformation of work arising from the human ↔ technology interplay into products and services during the labour process. *Species being* may orient to a technology in a presumptive or pre-supposed manner (a socially ‘intended’ use) or engage unique creativity and expressiveness to exploit uses of a technology-as-artefact in an innovative manner. Orientation is thus the future *imagined use* of the artefact by *species being*.

In the orientation process, *species being* relates to technology through cognition. This subject-object relationship manifests through experientially developed or consciously held routines, guidelines and behaviours driven by occupational or cultural practice. Additional frameworks or meanings held in abstract social structures may be employed in the individual’s connection with the technology-as-artefact. One may socially associate intended use patterns with an artefact or an individual may assign new meanings or uses to the artefact. Orientation towards a specific technology, therefore, may be guided by individual choice (voluntarism) or socially-based structurationist modalities (determinism). The notion of use-as-intended vs. innovative use is merely an outcome of orientation by *species being*.

We reaffirm at this point that perception and orientation occur simultaneously and iteratively, depending on the context. Both are at the individual level and combine as the process of realization (Ollman 1971). The technology-as-artefact is realized through the natural and species needs and powers, respectively fulfilled through the sensory enablement or enhancement of cognition arising from the technology-in-use.

**Realization**

It is at the point of realization when the technology-as-artefact becomes technology-in-use that the desired needs and powers of the individual begin to manifest through preliminary engagement with the technology. This is the beginning of the appropriation process. Realization is the active fulfillment of natural (intuitive) and species (imagined) needs and powers, which are confirmed through use. For the purposes of this discussion, let us assume that the human ↔ technology interaction has some positive outcome and is not immediately disappropriated.

The effects of the adoption and application of the artefact can be seen firstly at the level of *species being*. As the individual discovers that the technology presents an *enhancement of the senses* and/or an *enhancement of cognition*, the technology might begin fulfilling needs and powers not previously anticipated. As the individual (subject) realizes the technology (object), the individual also realizes themself through the technology-in-use. This process of reflexivity yields the patterns of behaviours and meanings that a person ascribes to the technology. The use patterns as recognized by *species being* are reiterated by *social being*. These uses of the technology proliferate throughout the organizational system to result in social activity that both shapes and is shaped by technology-in-use (Giddens
In example, when a technology is marketed to consumers as an artefact, the technology may be associated with similar characteristics or perform similar functionalities to another technology that the user has previously realized. Marketing then may draw on past behaviours, making it easier for an individual to perceive the new technology, for example, by pictorially demonstrating possible enhancement of senses, or inferring enhancement of cognition. Such a marketing approach is necessary, given the intangible nature of certain technologies such as software.

If one individual verbally describes a potential technology and draws on referent frameworks or behaviours in their description, another user is able to orient to a technology without necessarily perceiving it. In light of this, we posit three propositions:

P1: Regardless of the intended use of a technology (be it for individual or group purposes), one could influence the orientation of an individual towards the technology either by directly appealing to the senses or cognition of the individual (natural being) or indirectly through the social being (or both).

P2: An individual will orient positively towards a technology if the technology is presented to be able to enhance the individual’s senses or cognition (or both).

P3: While an individual’s orientation towards a technology could be influenced socially, the ultimate realization of a technology, however, is dependent on the individual being able to perceive and orient to it directly.

What this leads to is the conception that species being, while retaining unique creativity and expressiveness of self, also patterns behaviours off their social environment. Species being performs the specific sets of behaviours that result in technology-in-use not only enhancing his or her own senses and cognition, but also contributes to the ethereal structures of their social system (Giddens 1979). Ongoing behaviours, either predetermined or new, are socially constructed and recursively executed.

**Appropriation**

Full appropriation yields the notion that a technology-as-artefact is taken possession of by an individual, for that individual’s ownership and use (Marx, 1977). Social being is the principal subject in the appropriation process post-realization. Appropriation connects humans at the level of species being to the technology by a process of objectification, or as Marx (1977, p. 102) states: “it is only when the objective world becomes everywhere for man in society the world of man’s essential powers…that all objects become for him the objectification of himself, become objects which confirm and realize his individuality, become his objects: that is, man himself becomes the object.”

From this, we can consider the interplay of human ↔ technology-as-realized as an essential feature of the appropriation process. Using the Marxian approach, the technology user himself become an object. The user is oriented and perceives the technology and realizes it, allowing it to be appropriated by higher level ethereal concepts such as an organization. The organization is an ethereal object that may seek fulfilment of essential needs and powers through the appropriation of technology-in-use and the user.

At the core of appropriation is the concept that a technology, whether as artefact or in-use, does not itself embody a structure or behaviour but represents guides to certain actions that manifest through use and engagement. Additionally, engagement with the technology might stimulate previously unrealized new needs and powers. The process of re-orientation is when new uses for the technology are found by a social group as a result of social structures being changed or reshaped or individuals in the group changing or being replaced.

This reflects Ollman’s (1971) idea of social needs being drawn from other humans who have developed essential powers through similar experience; hence, technology-in-use behaviours can mimic prior human experiences as they are actively defined by them. These technology-in-use behaviours draw on the structuration the triumvirate of legitimation, domination and signification (Giddens 1979).

This mechanism is consistent with Orlikowski’s (2000) view that technology does not embody structures but structures are instead embodied in ancillary social activities. This is also similar to Rogoff’s (1995) participatory appropriation whereby users engage in activities that are similar to ones they have previously experience. Thus, technology-in-use is guided by behaviours external to the artefact and, from time-to-time, species being may orient differently to a technology artefact, producing alternative technology-in-use behaviours to those that were socially intended. DeSanctis and Poole (1994) refer to these phenomena as appropriation moves.
This leads us to different social groups appropriating technologies differently. Differentiations may be a result of different orientations – that is, behaviours and intended uses for one group may not be the same as those for another. These differing behaviours might result from an individual within the group finding an unintended realization of essential powers. Different cultural or occupational groups possessing certain expectations for behaviour will appropriate technology-in-use in different ways. These differences support the notion of social being, with the individual drawing on referent frameworks for behaviour or the structures of their social setting to create meanings for a technology-in-use according to the rules of the group. A resultant use of the technology that is radically different or beyond the bounds of the system rules may occur when several individuals begin to invent new technology applications. These new appropriations can change the behaviours of the social group, a process Giddens (1979) describes as recursiveness.

Behaviours within cultural or occupational groupings, driven by structurational modalities (interpretive schemes, rules and resources and norms) drive perception and orientation (realization) in natural and species being, and maintain the appropriation process in social being. This leads us to our fourth proposition:

**P4:** It is easier to perceive and orient towards a technology-in-use already previously realized and socially appropriated than one that has not been realized and socially appropriated (even though it might actually enhance senses and cognitions).

As shown in our model, social being appropriates a technology-in-use, meaning that appropriation is a constant re-orientation and re-perception and therefore, an ongoing realization of the technology-in-use. Social being appropriates in accordance with how others within their cultural or occupational group are using the technology. As long as a technology fulfils the senses of natural being and enables the cognition of species being, the process of appropriation is ongoing, subject to continued social appeasement. Resultantly, when a new technology is to be adopted at the beginning point of realization, perception and orientation draw on the established expectations and patterns of use that an individual has embedded within their active species consciousness.

Having introduced our model and these four propositions, we now turn to an empirical example of Anesthesia.

**Anesthetic Information Systems: An Empirical Example**

To illustrate our model and test our propositions, we turn to the empirical example of information systems in anesthesia. We focus specifically on Anesthetic Information Systems (AIS), the class of computer-based monitoring that integrates the capture and storage of data from technology such as heart rate, respiratory and temperature monitors. These systems enable anesthetists to input drug dosages and event notes while recording data from operating procedures for electronic anesthetic records (Feldman 2004). The acceptance of computer-based monitoring in anesthesia was slow (Tremper 2005), but the introduction of this technology into the practice has significantly reshaped it by facilitating and improving information exchange and access, decision support, mitigation and tracking of adverse effects and error prevention (Bates et al. 2003).

Anesthesia represents an interesting empirical example, since a long history of appropriation exists in the field, from the early mechanical apparatus to the current sophisticated digital systems. For example, early oxygen ventilators were appropriated from pressurized cylinders in beer manufacturing (Thompson and Wilkinson 1985). In more recent times, the last two decades have seen computer technology such as electrocardiograms for heart monitoring being adapted from other domains such as critical care.

This example is brief and limited by paper length, but we use it to briefly demonstrate our model in the information systems context and explore our four propositions. We have restricted it to this particular technology due to access to data and evidence we are able to access at this time. Data is gathered from fieldwork, consisting of interviews with eleven anesthetists across two major hospitals. Interviews were semi-structured with participants interviewed one-to-one or in groups. Some participants were interviewed multiple times to clarify data and confirm emerging concepts. After data collection, we used the constructs of our model to analyze transcripts, and used observations and literature to cross-check results and enrich discussion. We begin by making mappings of themes into our model, as shown below in Figure 3.
We refer to the model in our following discussions, which are based on the four propositions introduced in the previous section.

P1: Regardless of the intended use of a technology (be it for individual or group purposes), one could influence the orientation of an individual towards the technology either by directly appealing to the senses of the individual (natural being) or indirectly through the social being (or both).

In Figure 3, clinical intuition represents the natural senses. The conscious behaviour of the anesthetist built through education and training is still driven by innate physical senses, particularly in their contact with a patient under anesthetic. Their natural senses must be attuned to the breathing, temperature and colour of the patient, so a particular technology that brings an enhancement of the senses (i.e., extends physical attunement through direct sensory inputs of conditions like breathing and temperature) influences orientation through this appeal. This technology mediated interaction with the patient is significant, as one respondent told us:

"Prior to these machines, the only way you could tell if something wrong is when the patient starts to turn blue. Monitoring gives me that extra time for quicker decisions. I don’t have to wait until the patient changes color before I can act….the monitors give me a better indication of what is going on”

Although much technology in anesthesia is designed for single or individual use in the operating theatre, the group influence of technology appropriation resides in their community of practice. Several respondents reported that overarching social structures of the anesthetic work group are not entirely instantiated by external administration, but by collectives such as the Australian and New Zealand College of Anesthetists who are comprised of anesthetists themselves. Returning to P1, this might account for the ‘indirect appeal’ upon the social being – referent frameworks such as guidelines, shared values and mutual stocks of knowledge are drawn upon, and this recursiveness between the individual and the social structures results in rationalized realization process in perception and orientation towards technology.

P2: An individual will orient positively towards a technology if the technology is presented to be able to enhance the individual’s senses or cognition (or both).

This direct impact on the perception of and orientation to a technology is also influenced by the way in which these systems complement the conscious behaviour (species being) of the anesthetist. Another respondent described monitoring technology and AIS as “inputs to our senses” (natural being) that provide early warning of physical reactions in a patient. This information is filtered by conscious behaviour to mitigate uncertainty. Their human-technology interplay is a systematic fulfillment and enablement of sensory and cognitive essential powers, an interplay described by one respondent as:

“...looking at color of the patient, listening to the sounds of the machines...those inputs are instinctive and then they feed into your ability to work out uncertainty...we have a system to work from the machine, to tube, to patient, so a systematic approach to find out what any uncertainty is.”
In this example, the orientation toward the technology is positive. The anesthetist is alerted by changing conditions via audio alarms while events during surgery are depicted by the graphical displays of the AIS. In Figure 3, we observe that the alignment between clinical intuition and anesthetist is the recognition that not only does technology enhance the natural senses, but also enhances cognition. In our example, a term that arose in interviews was mental models – the cognitive processes of the anesthetist. Mental models are experientially built algorithms, procedures and actions they take, based on patient physiology in confirmation with judgment. AIS serve as enhancement of mental models because clinicians are influenced by the visual displays of patient information. Smith et al. (2003, p. 1071) state that electronic monitoring “…extends the anesthetist’s own senses and allows continuous assessment of the patient’s physiological condition”. In terms of human-machine interaction, AIS provide information that can be cross-checked against the mental model, as “data displays that organize and present data in a format that matches the cognitive interpretation performed by the clinician should enhance the speed and accuracy of decision making” (Blike et al. 1999, p. 38).

This conscious behavior draws on both their cognitive ability and the structures of anesthetic practice to find realization with a technology. With the electrocardiogram for instance, the anesthetist is able to extend their awareness of the patient’s heart rate, giving them senses beyond conventional boundaries, and from resultant graphical displays are able to cognitively interpret conditions in the underlying physiology. The dual enhancement is not simply a matter of safety critical necessity, but an enhancement of essential needs and powers.

P3: While an individual’s orientation towards a technology could be influenced socially, the ultimate realization of a technology, however, is dependent on the individual being able to perceive it directly.

In the contemporary context of AIS, the first instances of AIS appeared in the 1970’s, roughly the same time as when digital computing was making inroads. One anesthetist we interviewed stated he saw AIS emerge in the early 1980s and adoption of these systems was not driven by external groups (i.e. hospital administration) but by anesthetists themselves. Electronic monitoring technology such as the electrocardiogram was observed in sister specialties like critical care and heart surgery and was perceived as useful to the anesthetic domain. The social influence on an anesthetist’s realization of AIS occurs in conjunction with the individual’s own perception. This is the view of enactment (Orlikowski 2000), or participatory appropriation (Rogoff 1995), where the transformation of technology confirms both the active species life of the anesthetist and the structures of anesthetic practice itself. One respondent stated:

“With regard to computers, there’s a great deal of computer-oriented monitoring in anesthesia. You need to be intuitive, know how to follow menus. There are different monitors in different private hospitals, so you need to be able to walk up to a system and not get lost.”

As a social being, the anesthetist constantly calls into action institutional structures to rationalize use of technology. Anesthetists as a community reflexively account for technology use based on the modalities of their group structure. The complexity of the operating environment can be demanding, and the alignment between inherent senses and conscious behavior is mediated by the capabilities provided by the AIS. For appropriation by realization, we can see that the coalition of sense-perception and cognition-orientation of anesthesiology is consistent with our model. The technology firstly aligns with the structures of anesthesia through the natural being and species being levels and are realized and internalized before undergoing the process of ‘becoming’.

P4: It is easier to perceive and orient towards a technology-in-use already previously realized and socially appropriated than one that has not been realized and socially appropriated (even though it might enhance senses and cognitions better).

In anesthesia, the proliferation of technology has impacted upon routines and practices. The specialty has a history of appropriation of tools, equipment and machines, dating back to the early ether inhalers and gradual accumulation of additional apparatus that eventually forged the contemporary anesthetic workstation (Thompson and Wilkinson 1985). Among the medical specialties, we find that anesthesia utilizes advanced monitoring technology more than any other medical specialty (Smith et al. 2003). Over time anesthetists have both reshaped appropriated technology to fit new or intended uses and have in turn been shaped by technology, involving interactions with it in education and training. A respondent referred to this as a transmission by diffusion:

“…we’re a collection of individual professionals who see someone else with something or see another part of the hospital with something and say that will be useful. It’s much more been a transmission by diffusion than anything else. There are some things that people bring up and say it’s going to be a standard, but it’s usually already widespread in the anesthetic workplace before it gets to that stage anyway.”
If we consider gradual upgrades or additional features, these do not necessarily entail renewed realization. Because these features align with the inherent senses and mental models, they are assimilated under previous patterns of practice and interpretation (Barley 1988). The slow proliferation of AIS could potentially be seen as an incremental process of realization, transformation and enactment. Structures or patterns of practice were slowly shaped to match the technology and the technology in turn changed to fulfill the structures, but it was only through recurrent social practices or activity involving the technology that this incremental matching could occur. If we consider the gradual addition of ventilators and pulse oxymetry, they did not all happen simultaneously. These systems were assimilated because the clinical practice of anesthesia had already appropriated their structural properties.

With regard to the second part of Proposition 4, one should not assume that just because an AIS will ‘logically’ (signification) improve critical care that a practice group such as anesthetists will adopt it. Applying Giddens’ structuration process as an explanation of activity by social being, domination and legitimation also affect appropriation. For example, the Australian and New Zealand College of Anesthetists are currently in the process of introducing a national database of anesthetic incidents. Technically, the database could have been built many years ago, because from a practice perspective, it is a logical extension to the existing local reporting mechanisms and will markedly improve patient care, giving practitioners real-time access to incidents and their resolution. However, anesthetists who are spearheading this initiative recognize that these attributes alone do not necessarily guarantee the appropriation of this technology. A longitudinal study is examining the appropriation of this database.

Summary and Future Research

In this paper, we explored the philosophical roots of appropriation within Marx and socio-cultural studies in an attempt to seek common ground among existing theories of technology appropriation in IS research. By drawing on these perspectives, our contributions were to (1) open philosophical discussions on this concept with regard to the human ↔ technology nexus, (2) draw on these varying appropriation perspectives to propose a general conceptualization of technology appropriation and (3) provide a starting point towards a general causal model of technology appropriation. In terms of implications for IS research, several areas we can significantly contribute to with future studies include:

- Using our model to examine extant technology adoption theories such as Resistance to IT (LaPoint and Rivard 2005), Adoption Intention (Venkatesh et al. 2003) and Trying and Appropriation (Ahuja and Thatcher 2005). By examining these extant theories with our model, we could potentially integrate further varying perspectives on technology adoption and use and further strengthen the generability of our Marxian technology appropriation model.

- Advancing current IS understanding of appropriation to consider both the individual and group or organizational level. While Adaptive Structuration Theory is the only theory that attempts to directly develop the construct of appropriation, this construct is developed in the context of a group support system and thus assumes as its underlying concept and measures such notion as group consensus. A more general construct of individualistic appropriation that accounts for the species and natural being as well as the social influence is therefore essential for further research in technology appropriation.

- Bringing consideration to the understanding of technology use and disappropriation. It is critical that we understand not only the initial adoption behaviours but also the continued use behaviours and, as a result of both technology pull and vendor push, the disappropriation behaviours. Our model suggests that while there is indeed a barrier to the introduction of new technology, the disappropriation of an existing technology could indeed be achieved readily. This could be done through a combination of ensuring continuity with the existing technology use, by highlighting the signal to the natural being through ensuring that enhancements to senses and cognitions are easily perceived, and through incremental buy-in by starting with small social groups. We propose therefore that future research in new technology adoption also consider models of disappropriation (of existing technology) and take into consideration aspects such as the use behaviour of existing technology.

Our conceptual model represents a starting point toward a theory of technology appropriation that encompasses philosophical foundations in Marx and contemporary IS thinking. We have briefly described an application of our model in the empirical example of anesthesiology, a domain that has demonstrated proliferation of technology over the course of its institutionalization. In closing the paper, our aim is to call further attention toward the philosophical roots of these theories to pinpoint commonalities, and potentially unify the elements of appropriation and related behaviors in existing theory.
References


Marx, K. *Economic and Philosophical Manuscripts of 1844*, Progress Publishers, Moscow, Russia, 1977.


