Accepted to The First International Workshop on Activity Theory Based Practical Methods for IT Design (ATIT2004), Copenhagen, Denmark, September 2-3, 2004

IS Design as Domain Construction

Lars Taxén
Campus Norrköping, Linköping University
Department of Science and Technology
SE - 601 74 Norrköping, Sweden
{lars.taxen@telia.com}

ABSTRACT
In this paper we describe a method for IS design which focus on constructing the social reality in which the IS is used. This reality is structured as a particular form of work practice – the activity domain – which is the main construct in the Activity Domain Theory. The gist of this theory is to integrate coordinating elements of a practice into a coherent whole in which the IS is one of these elements. The theory originated in the Ericsson telecommunication company where it has been gradually refined over more than a decade by the author. It has profoundly influenced the coordination of the development of the 3rd generation of mobile systems.

Keywords
IS design, coordination, praxis, construction of social reality, shared meaning.

MOTIVATION (initial reflection)
Product developing organizations are facing a turbulent reality today due to increased product complexity, diversification of organizational functions and an ever increasing rate of change. An example of this from Ericsson is the "anatomy" shown in Figure 1. The anatomy shows the coordination of development tasks (square white boxes) in one of the nodes in the 3rd generation of the mobile system network. Each task, which is called a 'work package', develops a specific functionality. The thin lines mark dependencies between the packages, indicating which packages must be ready in order for other packages to function properly. The development is carried out in the same order as the actual system 'comes alive', hence the term anatomy. Thick arrows show the datum for a particular integration and verification of the packages. Small dots indicate the status of a package such as 'in

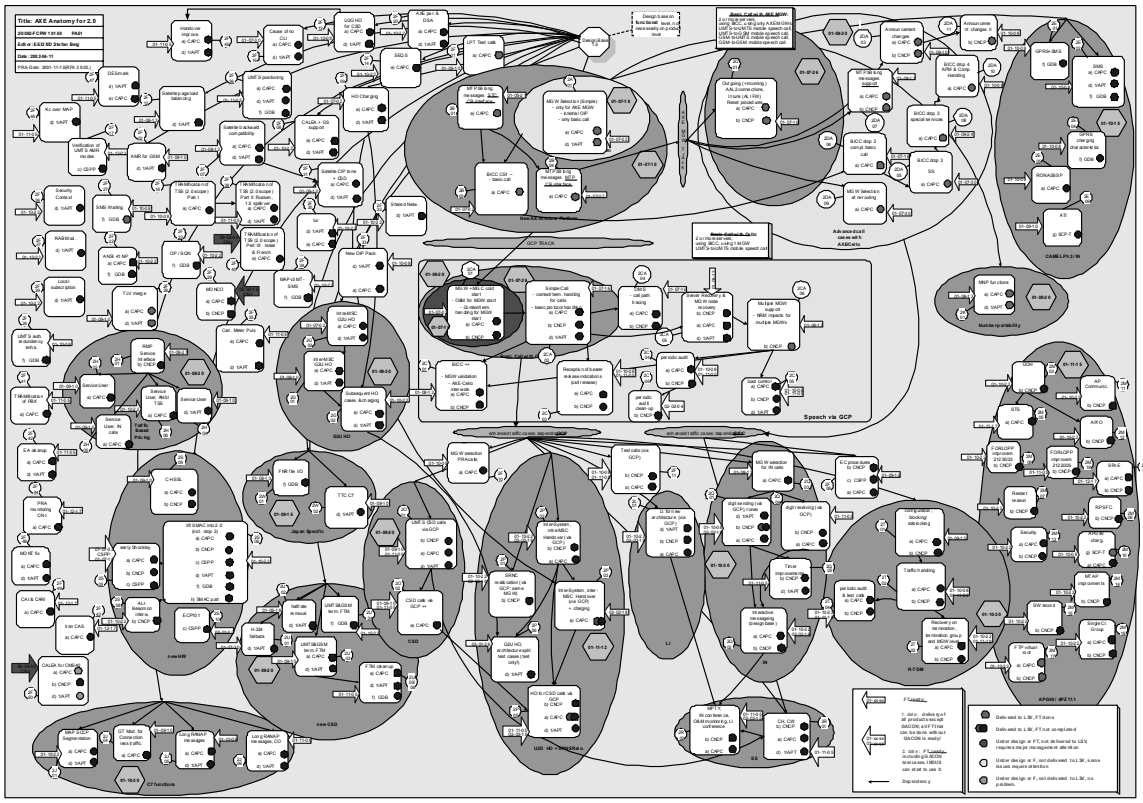

Figure 1 The anatomy of a node in the 3rd generation of mobile systems

design', 'in test', 'delayed', 'ready', etc. The ovals signify basic services like registering the location of the mobile, calling to the mobile, answering a mobile call, etc. The work packages are developed by teams distributed all over the world. In most cases the functionality is provided by software, where the total number of source code lines may be in the order of millions.

The coordination of a development task like this requires information system (IS) support. A product in a telecom system may consist of several hundreds of sub-products, each one described by a number of product related documents. In addition, other types of items such as requirements, engineering change orders, baselines, milestones, etc. must be considered. All in one, between 5,000 to 10,000 items must be tracked with respect to their revisions, states, dependencies, etc. Moreover, the development task is constantly revised due to changed customer requirements, new insights, errors discovered, available resources, etc. Thus, the technical challenges of developing IS support for this kind of application are indeed considerable.

However, the most arduous task in these circumstances is to establish a workable consensus among the actors concerning the nature of the coordination (Taxén, 2003). First, there must be a sufficient level of shared meaning about what should be coordinated and how. This concerns the identification of which items are crucial for coordination, how to characterize them and how to relate them to each other. Often, new abstract concepts are introduced, something which is particularly difficult to acquire a shared meaning about (March & Simon, 1958). Second, the actors may be geographically dispersed, have different roles, come from different traditions, speak different languages, etc. Third, the contents and structure of coordination will change according to new insights, new demands from the market, new tools and methods supporting coordination, etc. Finally, cues in models and diagrams such as those in Figure 1 must make sense to the actors.

In this contribution we describe an IS design method which addresses both the technical and social issues as described above. The gist of the method is to construct *the entire work practice* in which the IS is used. This means that the IS is but one element being constructed. The most important result is the construction of a social reality in which shared meaning is one of the outcomes. Thus, rather than focusing on the core of the IT artifact as Benbasat & Zmud (2003) suggest, we move in the opposite direction. Our focus in not the core of the IT artifact, nor the IS in its context, but rather the context in which the IS is immersed.

In order to achieve this, the work practice is structured as an *activity domain* (Taxén, 2004). An activity domain may be regarded as particular perspective of a work practice where its coordinating elements are emphasized. The activity domain is the central construct in a new theory for coordinating human activity – the Activity Domain Theory (ADT). The ADT has many features in common with the Activity Theory (AT) (e.g. Engeström, 1987; Bedny et al., 2000). However, ADT also differs in essential aspects from AT. The experiences show that the proposed method derived from ADT enables the design of ISs which can support the coordination of very complex system development tasks while taking individual, social and technical aspects into consideration.

The paper is outlined as follows. In the next sections we describe the method and its outcome in detail. This is followed by some practical experiences. Next we describe the ADT and compare it with AT. We finish up with some reflections about the transferability of the method to other settings beside Ericsson.

METHOD (practical)

In this section we describe the main features of the method, which is called "domain construction strategy". The reason why we call it 'strategy' rather than 'method' is that the fine graded steps have to be defined for each individual application.

Result

The result of the method is a constructed social reality – the activity domain – in which the IS supporting the coordination of tasks is one of its elements.

Form of result

The intangible form of the result is a shared meaning among the actors about what constitutes coordination and how it should be carried out.

The tangible forms of the result in terms of tools and artifacts are as follows.

The context model

This model signifies the structure and extension of the activity domain. It shows what types of phenomenon are considered relevant in the domain, their relations and their characterization in terms of attributes, state sets, revision rules, etc.

In order to facilitate the signification process it is important that the model notation is easily understandable. One such notation is based on the Object Modeling Technique (OMT) (e.g. Rumbaugh et al., 1991). The Universal Modeling Language (UML) notation is less useful since it has a rich repertoire of constructs which usually are familiar only to specialists. Standard drawing tools like PowerPoint may be used to describe the model (see the example in Figure 3).

The coordination model

The coordination model signifies the dependencies between the tasks in the domain. This model has the same purpose as ordinary process models. The notation used is called Information Flow Diagrams (IFD) (see the example

in Figure 8). Again, the signifying properties of the model are the prime concern.

The transition model
The transition model signifies how different activity domains interact. This model is an elaboration of the Specification Based Data Model suggested by Gandhi & Robertsson (1992). The main influence from this model is to direct the attention to the transition between domain borders. For example, the status of a work package in Figure 1 is assigned according to the states of work package internal items such as documents, etc.

The domain core
The purpose of this result is to be a place-holder for various items which provide stability to the domain. Examples of such items are identification rules, notations, cues, etc.

The running application: the IS supporting coordination
Typical features implemented are support for requirement management, configuration management, test management, project planning and control, etc.

Phase of the design process
The basic mode of design in the method is an ongoing interaction between reflection and action. Tentative models are implemented in the IS and tried out in the development practice which is to be coordinated. Thus, the method, which may be characterized as an experiential learning based method (Kolb, 1984), does not follow the traditional phases of requirement analysis, design, implementation, testing and deployment. As described below, the method rather seek to achieve a sufficient level of shared meaning about the work practice in which the IS is used. This means that the IS is gradually being shaped by the actors in the practice alongside the emergence of shared meaning. Therefore, requirements are not detailed in advance. Rather, they are stated on a high level such as "There shall be support for requirement management and engineering change order management".

Type of systems
In the applications so far the IS platform has been Matrix (Matrix-One, 2004). This system is targeted as a backbone for managing product related data in large, globally distributed organizations. It can be characterized as a high performance, complex system of its own.

In Matrix the domain models are implemented without programming in the type definition module (called the Business Modeler). The instances (objects) are managed in another module of Matrix. Besides these two modules there is a module for administration of the system and a module for communicating directly with the database.

Type of design process
Since the method aims at the construction of an activity domain, it might be characterized as inherently in-house. Due to situational circumstances such as historical influences, actor's knowledge, available resources, norms, values, etc., activity domains will be constructed differently regardless of the whether the domains provide the same type of result. Moreover, the issue of re-design is not relevant since a continuous modification of the IS is a deliberate feature of the method. Also, the method presupposes that the major stakeholders are participating in the design. Thus, the method can be characterized as a participatory design type of method.

Who is performing the method?
Since the method aims at the coordination of development task such as projects, the main stakeholders in projects are participating. Typically, these are project managers, requirement managers, configuration managers, product managers, etc., who can be characterized as users. In addition, IS platform specialists are participating. Finally, actors with an expertise in domain modeling are involved to provide a bridge between the users and the IS platform specialists. This means that users, IS specialists and domain expertise are all participating in the system design. The borders between these competences are blurred. Rather, the actors bring their expert knowledge into a common playground where they together construct the activity domain.

Competences needed
No particular competence is needed besides understanding and accepting the ideas and concepts in the ADT. However, this is not trivial. For example, an organization used to develop systems in a linear fashion might not accept the constant modifications strategy inherent in the method.

Procedure
The construction of the activity domain requires certain prerequisites. Besides the usual ones of personal and financial resources, management approval, etc., the most important prerequisite is the availability of the IS platform. The capacity of the platform and the communication network must be secured. This is especially important if the IS is to be used globally. Also, strategies for replication and synchronizing data exchange must be defined and tried out.

The construction of the domain is carried out in three phases: *exploration*, *trust boosting* and *expansion* (see Figure 2). In the first two phases the focus is on establishing the activity domain as a 'bridgehead' in one project before expanding it to other projects in the third phase. This means that the gist of the strategy is to quickly establish a relatively stable core of shared meaning in a small group of actors which is then propagated to other actors in an ongoing domain construction process.

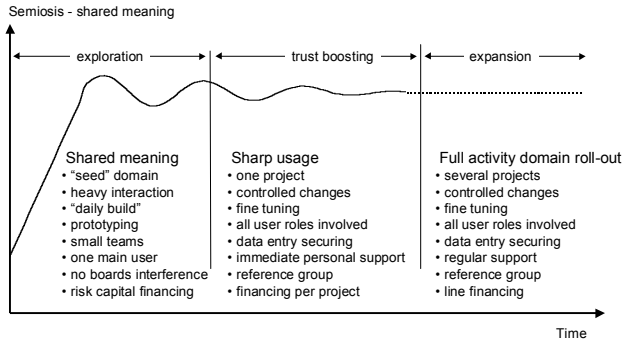

Figure 2. The domain construction method

Exploration

In this phase the initial construction of the domain is carried out. The main purpose is to rapidly achieve a tentative consensus about the content and structure of the domain. The work is carried out in a 'daily build' manner in close interaction among the actors. The work is financed on a risk capital basis. Detailed return on investment analysis is not required since the reliability of such analysis will be low.

The following tasks are carried out in this phase:

1. State the coordination requirements on an overall level, for example, "There shall be support for engineering change order management, requirement management (RM) and work package based software development". These different areas are called *coordination areas* and might be considered as domains on their own.
2. Define a 'task force' for each coordination area. For example, for RM this force may consist of the project manager, the requirement manager, the domain modeler and the IS specialist.
3. The established methods for, say RM, may be used as a point of departure. From these a first version of the context model is proposed by identifying the relevant phenomena and how these are related to each other. Define attributes, cardinalities, revision stepping rules, state sets, etc. In Figure 3 an example from Ericsson of a context model for RM is shown.
4. Implement the context model in the IS. In the IS used at Ericsson, Matrix, no programming is needed to do this. The boxes are implemented as types, the links as relations, state sets as 'policies', etc.
5. Instantiate object of the types, for example, a number of requirements and requirement issuers, and relate them to each other. Create reports. Evaluate the information: What is missing? Is this correct? Etc.
6. Make changes to the context model and implement these anew. Continue in this manner until the actors agree that the constructed domain is useful.

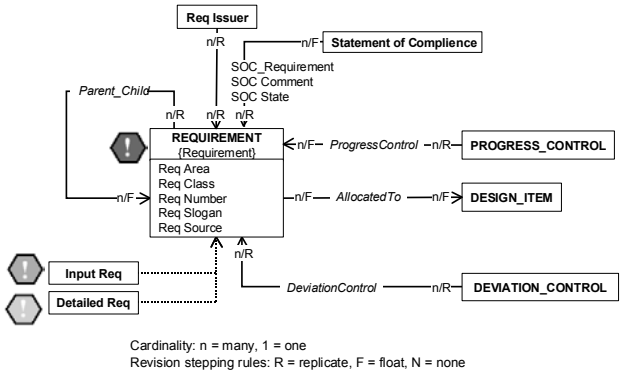

Figure 3. An example of a context model for RM

Trust boosting

The purpose of this phase is to boost the trust about the feasibility of the domain as constructed in the exploration phase. Key issues are getting all actors in the project to trust the data in the IS and to make sure that the performance of the IS is acceptable at all units world-wide. This is done in one sharp project, that is, a project which develops a product for some client. The task force is still driving the construction. All user roles around the project are involved and immediate, personalized support is provided. The development of the domain progresses by controlled changes and consists of fine tuning steps. No major reconstruction of the domain is allowed. Reference groups and steering boards are consulted and the financing is done on a project basis.

The following tasks are carried out in this phase:

1. Transfer data from previous sources into the IS. For example, requirements previously kept as text in requirement specification documents are translated into requirement objects which can be individually managed and related to other items according to the context model.
2. Set a date when the project shall start using the data in the IS as their primary source for planning and monitoring the project. The reason for this is that the data otherwise may be inconsistent.
3. Take measures to make the actors use the IS, i.e. enter data into and retrieve data from the IS. This can, for example, be done by requiring that the only source for progress reports is the data in the IS.
4. Keep a list of issues that need to be attended to. Any such issue needs to be agreed upon by the task force before it is implemented in the IS.

Expansion

In this phase several projects are included in the domain. As in the trust boosting phase, the construction is done by controlled changes, however now in a formalized way. The financing is done by the line organization rather than the project organization to keep the domain intact between projects.

The following tasks are carried out in this phase:

1. Changes in the models must be agreed upon by a change control board before it is implemented in the IS. This means that an incoming issue is sent out to an analysis group where its impact is estimated in terms of cost and implementation effort. A formal decision to go ahead is taken and the issue is followed up until it is fully implemented.
2. If the domain has to cooperate with other domains a work must be initialized to coordinate these domains. When doing so, a balance must be struck between what is absolutely necessary to coordinate and what can be left to each individual domain to decide independently.

EXAMPLE (practical)

The example is taken from Ericsson. During the late 1990s Ericsson was in a process of replacing the so far dominant 'waterfall' software development method. It had become painfully clear that this method was unable to cope with issues such as increased turbulence of the market, more complex systems and organizational upheaval.

The aim of the replacement was to come up with some kind of incremental development method which enabled the system to be implemented and tested in small steps in contrast to the 'big bang' approach in the waterfall method. Before 1996 some projects had attempted to use various incrementally flavored methods, but there was no shared meaning on the essence of this approach.

A project was initiated with the purpose of defining a methods package for the incremental development of large software projects. This project, in which this author participated, had severe problems in agreeing on what constituted incremental development. Only when the strategy suggested in this paper was applied, shared meaning began to emerge. In Figure 4 an example from 1997 of the context model is shown. It can be seen that the focus on incremental development brings about several new categories in the domain (the grayish boxes).

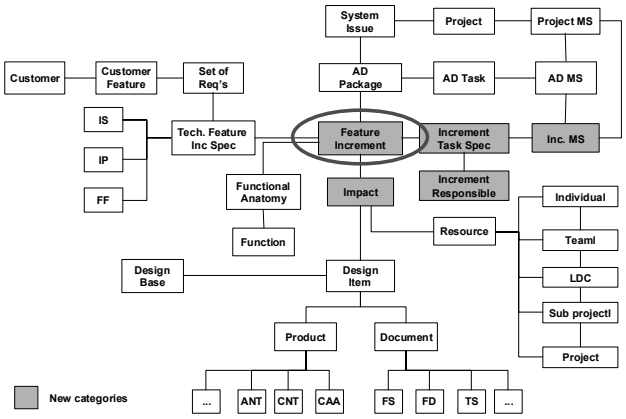

Figure 4. A context model

In Figure 5 the associated coordination model is shown:

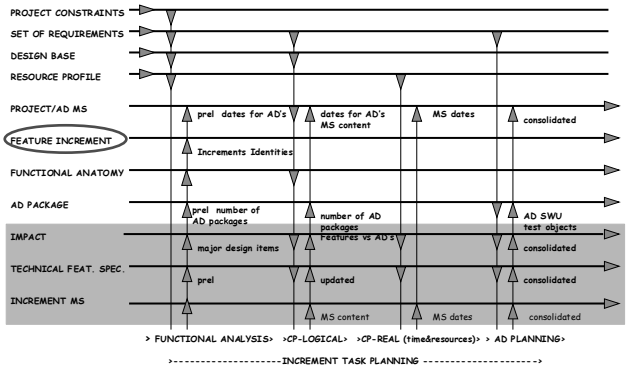

Figure 5. A coordination model

The implementation of the context and coordination models is shown in Figure 6.

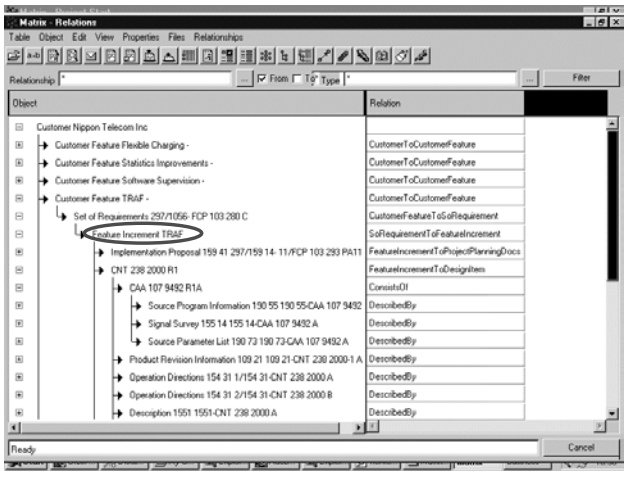

Figure 6. An implementation of the context and coordination models in the IS.

As can be seen, the same type of entities appears in the context and coordination model. In the IS, instances of these types are shown. The entity type in focus, the 'Feature Increment', is indicated by an oval.

By a continuous interplay between these three elements the domain for coordinating the incremental development of software was gradually constructed. This process was going on as long as the domain existed. As an example, in 1998 the context model was modified several hundred times. More details about this can be found in Taxén (2003).

Experiences

The domain construction strategy began to influence the Ericsson practice around 1996 with the introduction of the method package for incremental development of large software systems. The first sharp project to use Matrix was carried out in 1998. Between May 1999 and mid 2002 the number of projects using the strategy rose to around 140 distributed over more than 20 development sites worldwide. During this period four coordination domains were constructed. As indicated in the following statement the impacts on the Ericsson practice were profound:

> "Especially for the execution part I think we would not have been able to run this project without the tool. I think if you simply look at the number of work packages, the number of products that we have delivered, the number of deliveries that we have had, if we would have had to maintain that manually, that would have been a sheer disaster. [...] we had some, only in my part of the project, some 200 work packages or work packages groups or whatever you want to call them, deliveries, on the average 2-5 subprojects within them 5-10 blocks being delivered, just keeping track of that [...] would have been a hell of a job." (Project manager, 3G development)

Other identified effects are reported in Taxén (2003).

THE ACTIVITY DOMAIN THEORY (reflection)

The ADT was developed by the author in his professional work at the Ericsson telecommunication company over a period of more than 10 years (for details, see Taxén, 2003). Usually a certain element in the theory was triggered by a need in the Ericsson practice.

For example, in the early 1990s Information Flow Diagrams appeared as an alternative way of modeling processes. One example of such a diagram from 1994 is given in Figure 8. The process model was printed on a large sheet of paper and put on the wall in the project room. This meant that all actors involved had the same picture of the task and could easily orient themselves by this picture.

A striking insight was that a very complicated design process could be coordinated by a comprehensive picture. No sophisticated tools were needed. What mattered was that the actors involved had some shared meaning of the picture. Thus, its signifying and coordinating qualities were of prime importance. These observations gradually matured over the years. They were eventually incorporated in the ADT as the temporalization modality and a focus on signs and their mediating roles in the coordination of human activity.

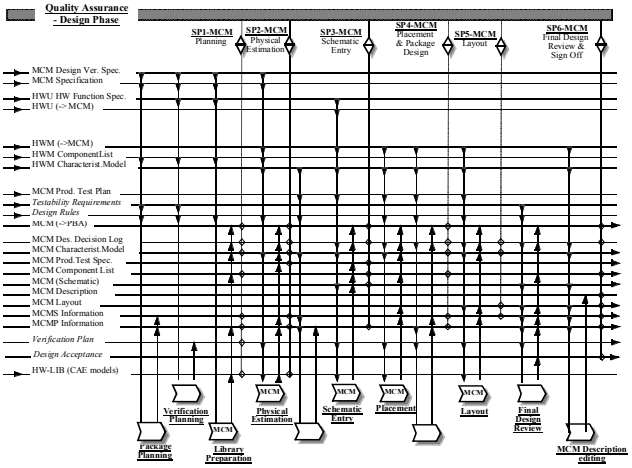

Figure 8. Information Flow Diagram for Multi-Chip Module design

This pattern was repeated for other elements of the ADT. Between 1990 and 1998 these elements were gradually shaped by practical experiences. Between 1998 and 2003 the ADT was theoretically grounded in the author's Ph.D. studies alongside with further empirical grounding in the Ericsson practice. Thus, the ADT was developed in close interaction between theory and practice.

At present, the theory has been applied in the Ericsson setting only. However, the aim of the ADT is bold: to provide an integrating framework for coordination that can be utilized for analytical and constructive purposes, including IS design. It is also our ambition that the theory will open up new lines of research in organizational studies.

When reflecting on human activity, usually an individual or a systemic perspective is taken as the Unit of Analysis (UoA). However, as a long discourse has shown, neither of these approaches is entirely satisfactory (e.g. Vološinov, 1929/1986). The individual perspective tends to ignore trans-individual phenomena such as social institutions and the structural properties of language. On the other hand, the systemic perspective easily downplays individual phenomenon such as cognition, meaning and everyday utterances.

To overcome this dilemma the *practice* has been suggested as a proper UoA where the individual and systemic may be reconciled. In this approach, the practice is regarded as the primary generical social thing (Schatzki, 2001:1). This reflects an ontology where the "… social is a field of embodied, materially interwoven practices cen-

trally organized around shared practical understandings." (ibid.3). Practices are considered to be a materially mediated nexus of activity where the "… forms of individual activity depend on the practices in which people participate." (ibid.11). Thus, both the individual human mind and social order are to a significant extent considered to be constituted within practices.

In order to make the notion of practice operational we will start from a Marxist perspective. Here, socially organized labor is seen as the basic form of human activity. "By thus acting on the external world and changing it, he at the same time changes his own nature" (Marx, 1867/1967:177). In particular, the ADT uses the theoretical perspectives of *praxis* as developed by the praxis philosophers in the former Yugoslavia. In this school, praxis permeates the whole of man and determines him in his totality:

> "In its essence and generality, praxis is the exposure of the mystery of man as an onto-formative being, as a being that *forms* the (socio – human) reality and *therefore* also grasps and interprets it (i.e. reality both human and extra-human, reality in its totality). Man's praxis is not practical activity as opposed to theorizing; it is the determination of human being as the process of *forming* reality." (Kosík, 1976:137)

Epistemologically ADT accepts "… that we can have no objective, observer-independent, access to reality but ... there is an independent external world constituted by structures or entities with causal powers…" (Mingers, 2001:118). In interaction with this reality man constructs a social reality (e.g. Searle, 1995). The meaning of any relevant phenomena in a practice is the result of social interaction processes among the actors in the practice. As in pragmatism, *usefulness* is the most important criterion by which a certain action is considered valid or not (Wicks & Freeman, 1998). For example, it may be suggested to use a certain concept like 'increment' in a software development practice. If this leads to successful results, 'increment' will be recognized as useful in that practice.

It is possible to conceive of practices as the concrete, everyday manifestations of praxis. The praxis perspective emphasizes certain qualities of human activity such as historicity, dialectical interaction, contradictions as the drivers of change, etc. By introducing the construct of *activity domains* in the ADT we strive to maintain these qualities while simultaneously giving practice a structure which is suitable for analytical and constructive purposes. This means that both the practice and its constituting elements may be taken as units of analysis.

The constitution of activity domains

When characterizing human activity at least the following aspects should be considered:

- The activity is a systemic entity which is in constant development. Its elements as well as the activity as a whole are in constant motion.
- The elements and the whole are dialectically related to each other. The whole is given its properties from the parts and, equally important, the parts are given their properties from the whole.
- The characterization of the activity should be grounded in the individual cognitive system as well as in the social practice where the individual acts.

Usually, the characterization of systemic entities proceeds from a structural perspective, that is, from an analysis of entity elements and how they relate to each other. For example, Bedny & Karwowski propose a structure consisting of subject, task, tools, methods, object and result (Bedny & Karwowski, 2004b:140).

However, since the basic feature of activity is development and motion, we propose to proceed from this perspective. To this end we will characterize the activity in terms of *activity modalities*, where 'modality' is apprehended as "a modal relation or quality; a mode or point of view under which an object presents itself to the mind." (Webster's 1913 Dictionary). The modalities can be apprehended as types of dynamic, inner processes within the activity which are dialectically interrelated.

During the socio-historical development of the activity domain two forms of objectivizing emerge (Kosík, 1976): *objectification* and *objectivation*. Objectification ("Vergegenständlichung") concerns the transformation of the world into objects such as tools, institutions, organizations, etc. Objectivation ("Objektivierung") refers to the integration of man in a trans-individual whole as one of its components. This incorporation transforms the subject: "The subject abstracts from his subjectivity and becomes an object and an element of the system." (ibid. 50).

This means that each modality will be manifested in two ways: as objectified, "external" objects and objectivated, "internal" modes of cognition. From this we conjecture that activity modalities are suitable candidates for the grounding of activity in both individual cognition and social practice. Thus, we assume that human activity systems are constructed in resonance with the cognitive apparatus of humans. For example, with the emergence of symbolic thinking it became possible to conceive of a temporal dimension besides the immediate here and now. This is reflected in ordinary practices by plans, processes, calendars, etc. but also in the neural system of humans as in the following example:

> "It was demonstrated that some *neurons* in the cerebral cortex could react to several stimuli from different modalities at the same time, processing light, sound and sense by touch, pain, etc. These neurons react not only to stimuli from different modalities, but are also able to *select stimuli important to the temporal needs of the organism* [our emphasis] from many external and internal influences." (Bedny & Karwowski, 2004:263).

These considerations are reflected in the construct of activity domains, which are characterized as follows. In the activity domain, *actors* come together in order to produce a *result*. As actors they participate in socially organized labor where individual-psychological goals, motives, ambitions, etc. are aligned and transformed into trans-individual goals and motives. In this sense, the activity domain has a *motive*, which is the reason why the activity domain exists. Likewise, the domain has a *goal* which adheres to the motive of the domain. Starting from certain *prerequisites* the actors modifies an *object* according to the goal of the domain. The result is the actual *outcome* of the activity. This result may in turn become a prerequisite for other activity domains.

These elements are influenced by the Activity Theory (Engeström, 1999; Bedny & Harris, 2004). Next, we propose that the activity domain can be characterized by the following activity modalities:

- *Stabilization*: Over time, actors in the domain develop a common ideology, by which we understand any wide-ranging systems of beliefs or ways of thought. The ideology stabilizes the activity domain and is manifested as norms, values, routines, rules, etc. The coherence to domain ideologies may destabilize the cooperation between domains if shared ideological elements are not developed.
- *Contextualization*: In the activity domain, the actions are focused and situated. This means, for example, that a particular phenomenon will be apprehended and characterized differently depending on the context in which it is considered relevant.
- *Transition*: Activity domains interact with each other. The outcome of one domain is the prerequisite of other domains. Since the stabilization brings about partly different domain ideologies, the result may be characterized differently. If so, there is a need for a translation and interpretation of the result in the transition between the domains.
- *Spatialization*: In the domain actors orient themselves spatially. This orientation concerns which phenomena actors perceive as relevant and how these are related.
- *Temporalization*: In the activity domain actors orient themselves temporarily. This orientation concerns the dependencies between the tasks in the domain.
- *Mediation*: In the activity domain the actions are mediated by instruments which can be essentially material or symbolic in character, like a hammer and a law.
- *Communication*: Communicative acts are performed by actors in order to reinforce their coordination (e.g. Goldkuhl & Röstlinger, 2002).
- *Interaction:* Interaction is fundamental for meaning creation (semiosis). During interaction, human mental processes evolve. The specificity of this interaction is determined by the socio-cultural development of the activity (e.g. Bedny & Karwowski, 2004b:138).

The reason why precisely these modalities have been included in the ADT is that they have been identified as strongly influential in the practice of complex systems development (Taxén, 2003).

Objectification

The objectified forms of the modalities are collected in a Framework as follows (ibid. 2003):

- A *context model* which emanates from the contextualization and spatialization modalities.
- A *coordination model* which emanates from the temporalization modality.
- A *transition model* which emanates from the transition modality.
- A *stabilizing core* which emanates from the stabilization modality.
- *Information systems* which emanates from the mediation modality.
- *Communicative acts* which emanates from the communication modality. Such acts may be assignments, agreements, commitments, requests, etc.
- A *domain construction strategy* which emanates from the interaction modality.

Most of these elements have been discussed in detail in previous sections. Together these elements constitute the activity domain (see Figure 7).

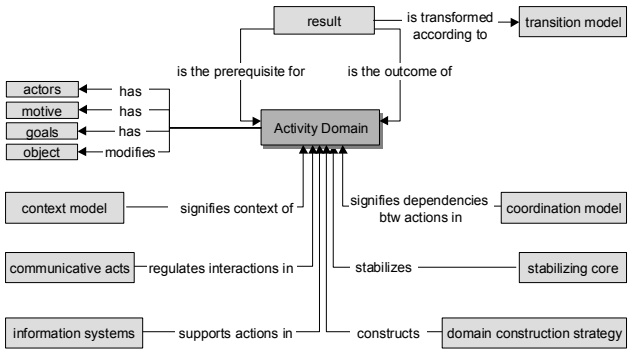

Figure 7. The constitution of the activity domain

It can be noted that the activity domain is a recursive construct. The transition model makes it possible to regard the activity domain as embedded in a larger context where other activity domains provide prerequisites for and uses the outcome of the activity domain.

Objectivation

Objectivation implies that the individual actor has acquired an understanding of the meaning of the elements in the activity domain. Otherwise she cannot perform meaningful actions in concert with other actors.

According to Bedny & Karwowski (2004c) it is important to distinguish between meaning and sense. Meaning has an objective character and is referred to as "objective meaning" while sense has an individual, subjective character and is referred to as "subjective sense". When acting in a particular situation the "… system of subjective representations of the situations unfolds in the form of dynamic models…" (ibid. 136). These dynamic models allow the actor "… to quickly orient in the current situation and adequately regulate his/her actions." (ibid. 137). The dynamic model is continuously transformed and adjusted by reflection and self-regulation. What makes the dynamic reflection of the situation in the mental model possible is the "transformation of objective meanings into subjective senses and their integration into [a] holistic framework." (ibid. 137). This in turn enables further action which may impact the objective meaning. In accordance with the previous discussion, the meaning and sense making processes may be called objectivation and 'subjectivation' respectively.

We argue that objective meaning is a *shared* meaning concerning the objectified elements at a particular moment in the socio-cultural development of the domain. The shared meaning has an external manifestation outside the heads of the individual actors. For example, the context model in Figure 3 may be regarded as the objective meaning about the spatial structure and extension of the activity domain.

The purpose of the domain construction strategy is thus to construct shared, or objective, meaning which simultaneously is transformed into subjective senses in such a way that coordinated action is possible. In the first phase, exploration, a 'seed' of objective meaning is constructed in a small group of actors. In the next phase, trust boosting, this seed is diffused and transformed to the ensemble of actors. The viability of the meaning is probed in one particular elaboration of the activity, such as a single project. In the final phase, expansion, the objective meaning is established through repeated elaborations of the activity, for example, in several projects.

A COMPARISON BETWEEN THE ADT AND AT (reflection)

In this section we will discuss the relation between the ADT and the cultural-historical variant of AT, also known as CHAT (e.g. Engeström, 1987; Nardi, 1996; Engeström, 1999). As pointed out by Harris (this publication), this variant differs in essential aspects from the original AT, which was developed by psychologists in the former Soviet Union from the beginning of the 1930s. Other variants rooted in the original AT, such as the systemic-structural theory of activity (e.g. Bedny et al., 2000) may be more apt for informing practical applications. A comparison with this variant has not been performed so far.

Stabilization

The stabilization modality is present in both theories. In AT the actions can be transformed into operations which may be seen as an objectivation process. Also, rules, norms, conventions, etc., which mediate between the subject and the community in AT, would be derived from this modality.

Contextualization

Contextuality is salient in both theories. In AT cognitive processes are not independent and unchanging 'abilities' - "they are processes occurring in concrete, practical activity and are formed within the limits of this activity" (Kuutti, 1996:33).

Transition

The transition modality in ADT does not appear to be emphasized in AT. The element "division of labor" could possibly be elaborated to include this aspect if the mapping and interpretation between the activities are taken into account.

A transition element is traceable in the discussion of "boundary objects" (Bertelsen, 1999). These are objects that can be interpreted differently by different groups (say users and designers) but still maintain some commonly understood feature which tie different praxes together.

Spatialization and temporalization

In AT actions are composed of operations and may participate in activities with different motives and objects. Thus, AT has a strong temporal orientation. However, the objectified outcome of spatialization in terms of struc-

tures, relations between phenomenon, characterization of phenomenon, etc. is not stressed.

Moreover, there is no clear indication of interdependency between spatialization and temporalization in the AT. Engeström (1999) touches on this when he classifies the mediating artifacts into what, how, why and where types. In ADT, this interdependence is emphasized. In the Framework the context model (spatialization) and the coordination model (temporalization) are strongly interdependent.

Mediation

In AT the concept of mediation plays a key role. Human activity is directed towards an object and mediated by signs (semiotic activity) and tools (instrumental activity) (Engeström, 1999:23 ff.). However, the distinction between semiotic and instrumental activity is problematic (Bødker & Bøgh Andersen, 2004). Even if these two types of activities differ with respect to their material and social effects they should not be regarded as belonging to different realms of reality (ibid. 6). Bødker & Bøgh Andersen propose a model in which the semiotic triangle is combined with the AT triangle into a combined model where "… instrumental and semiotic activities are variants of the same pattern but with different kinds of emphasis. This predicts a smooth transition between the two." (ibid.10).

This is also the approach taken in ADT. Signs are considered as fundamental mediating elements which comprises both semiotic and instrumental mediation: ""Signs (...) are particular, material things; and (...) any item of nature, technology or consumption can become a sign, acquiring in the process a meaning that goes beyond its given particularity. A sign does not simply exist as part of a reality - it reflects and refracts another reality (...)." (Vološinov, 1929/1986:10). Leiman has also pointed out the need for an articulation of the sign concept in AT (Leiman, 1999).

Interaction

The position taken in ADT is that representations are formed in dialectical interaction (Bickhard & Terveen, 1995). Representations are seen as *interaction potentials* (ibid.), regardless of whether that potential is semiotic or instrumental in character. These potentials may be regarded as *affordances*: "The *affordances* of the environment are what it *offers* the animal, what it *provides* or *furnishes*, either for good or ill." (Gibson, 1986:127). However, the affordances offered to humans are nested in the cultural-historical activity: "Direct perception of the affordances (…) is based on the perceiving observer's *inclusion* in adequate *societal forms of praxis*." "(Bærentsen & Trettvik, 2002:8). This means that intersubjectivity is considered a prerequisite for individual understanding. Moreover, the interaction perspective may be further articulated by the experiential learning model (Kolb, 1984).

In AT, the object, which can be material or intangible, is shared for manipulation into the outcome. Engeström describes an 'expansive learning' cycle in AT consisting of seven steps which has an experiential learning touch (Engeström, 1999b). However, interactivity and experiential learning do not appear to have a central position in AT.

Communication

Communication is emphasized in the ADT. This is mainly due to its focus on coordination. Language is not only used for describing and expressing the world but also for acting in it (Austin, 1962; Searle, 1969). Obviously, communicative acts such as directives and commitments are powerful coordinating mechanisms. In AT, communication does not seem to play a significant role.

Practical impacts

The ADT has clearly demonstrated its constructive capabilities in designing ISs for demanding practical tasks such as coordinating development tasks in the telecommunication area. The main impact of AT seems to be analytical.

However, Korpela et al. (2004) has used a modified version of cultural-historical AT called Activity Analysis and Development (ActAD) for constructive purposes. Like ADT, ActAD "zooms out" from the IT-artifact to include work activities in organizational, economical, social, cultural and political contexts. From this, methodological guidelines for IS design are derived. So far, these are in a "prototyping phase" and have not been tried in practice.

A major difference between ADT and ActAD seems to be the type of design process. While ADT suggests an ongoing iterative process ActAD is based on a linear process. The first phase is to define a work activity model which is then translated into process diagram which is further elaborated using UML. There is no indication of a feedback from the later phases to the work activity model. Thus, the interaction modality in the sense of ADT is not salient in ActAD. This modality has been absolutely decisive for the practical impacts achieved in applying the ADT.

General reflection

It is evident that ADT and AT have many features in common. Both acknowledge the dialectics between the individual cognition and the social praxis where the individual acts. It appears that the modalities of spatialization, transition and interactivity are more emphasized in ADT than in AT. On the other hand temporalization is more accentuated in AT. From and ADT perspective this creates an unbalance between the modalities which may conceal vital interdependencies between the modalities.

AT has strong roots in the Soviet cultural-historical psychology founded by Vygotsky, Leont'ev and Luria. The key problem for Vygotsky was "the establishment of a

cultural-historical science about humans." (Hedegaard *et al*., 1999:13). It appears that the overall trajectory of CHAT has been from a focus on the individual towards praxis. For example, the notions of operations, conscious and unconscious, zone of proximal development, etc. indicate a focus on the individual. Engeström added the elements of rules, community, division of labor, etc., (Engeström. 1987). Recently there has been a surging interest in the interrelationships between activity systems (e.g. Virkkunen, 2004). However, it seems that the main influence of AT in the IS community has been to re-focus the Unit of Analysis from an individual, cognitive oriented one to a social oriented activity (Virkkunen & Kuutti, 2000; Kuutti, 1996).

The trajectory of the ADT is rather the opposite. It began in industrial settings as an attempt to coordinate various practices, such as software and hardware design. Thus, the focus was on the praxis rather than the individual. This brought into focus problems like how to structure a practice, how to manage the transitions between practices, etc. Individual cognition became more in focus with the insight that semiotic problems, such as achieving shared meaning, are of major concern.

It can also be noted that the concept of contradiction, which is fundamental to AT, is not emphasized in ADT in its present appearance. Contradictions have not been operationalized in the Framework so far. In the future dialectical interaction between theory and practice, it might be fruitful to exploit the contradictions between the activity modalities. This will however be depending on the practical impacts of including contradictions in the theory.

Thus, CHAT and ADT have moved towards the dialectical centre of activity from two different directions, much like a thesis and anti-thesis. Whether there is a viable synthesis between the theories remains to be investigated.

TRANSFERABILITY OF THE RESULTS (reflection)

So far, the method has been applied in one target area only, that of the development practice at Ericsson. This means that the transferability of the method to other target areas has not been demonstrated. However, the method is not specific for the Ericsson organization. On the contrary, the ADT is a general theory which should be applicable to any constellation of cooperating practices whether these are internal inside an organization or external between organizations. The operationalization of the theory may take different forms. For example, a practice which does not use ISs obviously will not contain that element.

CONCLUSION (reflection)

In this paper, we have described the Activity Domain Theory and its relation to the cultural-historical Activity Theory. These theories share many features and are grounded in the same philosophical perspective. However, there are significant differences. The ADT emphasizes interactivity, signs and domain transition which are more peripheral in AT. Also, the ADT has proven capable of influencing the design of ISs supporting the coordination of exceptionally complex system development tasks. To the best of our knowledge, there is no similar achievement reported for AT.

REFERENCES

Austin JL (1962) *How to do things with words*, Oxford, University Press.

Bærentsen K, Trettvik J (2002). An Activity Theory Approach to Affordance, the *Second Nordic Conference on Human-Computer Interaction*. NORDICHI 2002. Tradition and Transcendence. Aarhus, Denmark, October 19-23.

Bedny G, Seglin M, Meister D (2000) Activity Theory: history, research and application, *Theoretical Issues in Ergonomic Sciences,* Vol. 1, No. 2, pp. 168 – 206.

Bedny G, Harris S (2004) The Systemic-Structural Theory of Activity: Applications to the Study of Human Work, forthcoming in *Mind, Culture and Activity*.

Bedny G, Karwowski W (2004) A functional model of the human orienting activity, *Theoretical Issues in Ergonomic Sciences*, Vol. 5, No. 4, pp. 255 - 274.

Bedny G, Karwowski W (2004b) Activity theory as a basis for the study of work, *Ergonomics,* Vol. 47, No. 5, pp. 134 - 153.

Bedny G, Karwowski W (2004c) Meaning and sense in activity theory and their role in study of human performance, *Ergonomia IJE&HF,* Vol. 26, No. 2, pp. 121 – 140.

Benbasat I, Zmud, R (2003) The Identity Crisis within the IS Discipline: Defining and Communicating the Discipline's Core Properties, *MIS Quarterly* (27:2), pp. 183 - 193.

Bertelsen O (1999) Mediation and Heterogeneity in Design. In *Social Thinking - Software Practice* (Dittrich Y, Floyd C, Jayaratna N, Kensing F, Klischewski R, Eds.), Dagstuhl-Seminar-Report; 250, 05.09.1999 - 10.09.1999 (99361). Wadern: IBFI gem. GmbH. pp.16-20.

Bickhard MH, Terveen L (1995) *Foundational Issues in Artificial Intelligence and Cognitive Science: Impasse and Solution*. Elsevier Scientific, Amsterdam.

Bødker S, Bøgh Andersen P (2004) Complex Mediation (*draft*).

Engeström, Y (1987) *Learning by expanding: An activity-theoretical approach to developmental research*. Helsinki: Orienta-Konsultit.

Engeström Y (1999) Activity theory and individual and social transformation. In *Perspectives on Activity Theory* (Engeström Y, Miettinen R, Punamäki RL, Eds.), Cambridge University Press, Cambridge UK. pp. 19 - 38.

Engeström Y (1999b) Innovative learning in work teams: Analyzing cycles of knowledge creations in practice. In *Perspectives on Activity Theory* (Engeström Y, Miettinen R, Punamäki RL, Eds.), Cambridge University Press, Cambridge UK, pp. 377 - 404.

Gandhi M, Robertson E L (1992) A Specification-based Data Model. *Indiana University Computer Science Department Technical Report TR344*, Indiana University, Indiana. Available at http://www.cs.indiana.edu/ftp/techreports/index.html (accessed Oct 2002).

Gibson JJ (1986) *The Ecological Approach to Visual Perception*. Lawrence Erlbaum, Hillsdale.

Goldkuhl G, Röstlinger A (2002) Towards an integral understanding of organisations and information systems: Convergence of three theories, accepted to the *5th International Workshop on Organisational Semiotics*, Delft.

Harris S (2004) Systemic-Structural Activity Analysis of Video Data, this publication.

Hedegaard M, Chaiklin S, Juul Jensen U (1999). Activity Theory and Social Practice: An Introduction. In *Activity Theory and Social Practice: Cultural-Historical Approaches* (Seth Chaiklin, Mariane Hedegaard and Uffe Juul Jensen, Eds.), Aarhus University Press, Aarhus.

Kolb D A (1984) *Experiential Learning: Experience as the Source of Learning and Development*. Prentice Hall, Englewood Cliffs, New Jersey.

Korpela M (2004) ActAD in Information Systems Analysis and Design, this publication.

Kosík K (1976) *Dialectics of the concrete. A Study on Problems of Man and World*, Reidel, Dordrecht.

Kuutti K (1996) Activity theory as a potential framework for human-computer interaction research, in Nardi B A (Ed, 1996) *Context and consciousness*. Activity theory and human-computer interaction, MIT Press, Cambridge.

Leiman M (1999) The concept of sign in the work of Vygotsky, Winnicott, and Bakhtin: Further integration of object relations theory and activity theory. In *Perspectives on Activity Theory* (Engeström Y, Miettinen R, Punamäki RL, Eds.), Cambridge University Press, Cambridge UK, pp. 419 - 434.

Mingers J (2001) Embodying information systems: the contribution of phenomenology, *Information and Organization,* Vol. 11, pp. 103-128.

March J G, Simon H A (1958) *Organizations.* Second edition, Blackwell Publishers, Cambridge, Massachusetts, USA.

Marx, K (1867/1967) *Capital, I.* New York: International Publishers. Available at (Chapter 7): http://www.ecn.bris.ac.uk/het/marx/cap1/index.htm (accessed Sept 2004)

Matrix-One (2004) http://www.matrixone.com/ (accessed Oct. 2004).

Nardi B (1996) *Context and Consciousness: Activity Theory and Human-Computer Interaction*, (Bonnie A. Nardi, Ed.), Cambridge, MA: MIT Press.

Rumbaugh J, Blaha M, Premerlani W, Eddy F, Lorensen W (1991) *Object-Oriented Modeling and Design*, Prentice-Hall International, Inc., New Jersey.

Schatzki TR (2001) Introduction: Practice theory. In *The practice turn in contemporary theory* (Schatzki TR, Knorr Cetina K, von Savigny E, Eds.), Routledge, London.

Searle J R (1969) *Speech acts. An essay in the philosophy of language*, Cambridge University, Press, London

Searle J R (1995) *The construction of social reality*. London: Allen Lane.

Taxén L (2003) *A Framework for the Coordination of Complex Systems' Development*. Dissertation No. 800. Linköping University, Dep. of Computer &Information Science, 2003. Available at http://www.ep.liu.se/diss/science_technology/08/00/index.html (accessed Sept 2004).

Taxén L (2004) Articulating Coordination of Human Activity - the Activity Domain Theory. In *Proceedings of the 2nd International workshop on Action in Language, Organisations and Information Systems (ALOIS-2004)*, Linköping University. Available at http://www.vits.org/konferenser/alois2004/proceedings.asp (accessed March 2004).

Webster's 1913 Dictionary. Available at http://humanities.uchicago.edu/orgs/ARTFL/forms_unrest/webster.form.html (accessed Sept 2004).

Wicks AC, Freeman RE (1998) Organization Studies and the New Pragmatism: Positivism, Anti-positivism, and the Search for Ethics. *Organization Science*, Vol. 9. No. 2. March-April 1998, pp. 123-140.

Virkkunen J, Kuutti K (2000) Understanding organizational learning by focusing on "activity systems", *Accting., Mgmt. & Info*. Tech. 10 (2000), pp. 291-319.

Virkkunen J (2004) Hybrid agency in co-configuration work, *3rd Nordic conference on Cultural and Activity Research*, 3-5 September, Copenhagen, Denmark.

Vološinov, V N (1929/1986) *Marxism and the Language of Philosophy*. Harvard University Press, London. (originally published in 1929).