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Abstract

Co-ordination is seen as a fundamental aspect of organisational activity where computers can help. This is motivated by the need to reconcile the conflicts that arise from the division of labour that characterises any organisational structure and that is present in almost all business processes. We discuss the main approaches that have been proposed to address this problem and present the Theory of Organized Activity as an alternative approach. This approach, unlike most of the other computer-based approaches to coordination, focuses on the human side of activity support and sees the computer as a tool for organizing human activities instead of a way to automate these activities. In our research we have confirmed that this theory can be applied to several organisational structures, and can be used for the analysis and design of information systems that support coordination of human social activities using information technology. An example of application to the coordination of e-learning activities is provided.

1. Introduction

An organisation may be defined as a social group where a functional division of work exists, aimed at obtaining common goals and whose members are individuals who are intentionally co-operating to obtain those goals but who also have their own private goals. This definition has the virtue of emphasising two aspects of organisations: (i) the need to have a functional division within the organisation, which derives from the goals that are to be obtained; and (ii) the need to keep in mind the existence of organisational actors that are intentionally and permanently trying to fulfil their own private goals, constrained by the goals of the organisation. As a consequence, the organisation structure depends on the organisational goals and functionalities and also on the co-ordination mechanisms that are used to integrate the work of their members.

Every organised human activity gives rise to these two fundamental and opposing requirements: the division of labour into the various tasks to be performed and the co-ordination of these tasks to accomplish the activity (Mintzberg 1979). Organisation theory points out three main co-ordination mechanisms that seem to explain the fundamental ways in which organisations co-ordinate their work: mutual adjustment, direct supervision, and standardisation (of work processes, of work outputs or of work skills). This typology, described in detail by Mintzberg, reflects the conclusions of Simon (1957), March and Simon (1958) and Galbraith (1973).

Max Weber used the word bureaucracy, more than one hundred years ago, to designate a particular type of organisational structure, characterised by a primary reliance on the formalisation of behaviour to achieve co-ordination. Weber described bureaucracy as an ideal type of structure in a prescriptive way, clearly identifying and describing the set of regular activities, the hierarchical authority structure, and the documents that would support business activities.

Other types of organisation exist though. For example, Burns and Stalker (1966) found that bureaucratic-type structures worked well for organisations operating in stable circumstances but that others requiring innovation or adaptation to changing environments needed a very different type of structure, which they labelled organic. They have identified a number of characteristics of organic organisations, but the main characteristics are (i) the adjustment and continual re-definition of the individual tasks through interaction with others and (ii) the shedding of responsibility as a limited field of rights, obligations and methods. In organic organisations, commitment to an adaptive attitude that promotes efficiency and efficacy is more highly valued than loyalty and obedience.

Whereas the main co-ordinating mechanism of bureaucracies is standardisation, organic structures as described by Burns and Stalker co-ordinate using mainly the mutual adjustment mechanism, although direct supervision is also possible.

2. Organizational Coordination Background

Coordination is a broad, ill-defined, concept. However, any social organisation (either natural or artificial) needs to use different forms of coordination, which can be either mainly co-operative or mainly competitive, although both forms are usually present simultaneously.

Coordination is a constituent of co-operation, the latter involving several aspects such as: goal-oriented action, mutual benefits for the agents, division of labour, factual coordination (referring to the tool level of work processes), and social coordination (referring to agent interaction).

Coordination is necessary because specialisation, which usually leads to interdependent activities, performed by agents in different business units, breaks organisational coherence and produces new boundaries and discontinuities. Coordination enables the recovery of organisational coherence, also designated in management theory as integration.

2.1. Bunge's Ontological Framework

The vagueness of the coordination concept is due to its high order semantics: coordination refers to special properties of processes, not of objects. Müller (1997) presents a simplified analysis, based on a systemic view of organisations, specifically on Bunge's ontological framework (Bunge 1979), which reveals the following semantic structure of coordination:

Event = change (property (thing))

Process = time sequence (events)

Coordination = special property (process).

The structure would be more complicated if the system nature of 'thing' is taken into account. Using the same ontological framework, Dietz (1999) describes an organisation as a social discrete dynamic system, having the following properties:

- *Composition*, i.e. a non-empty set of elements of a particular kind.
- *Effect*, i.e. the elements performs actions that change the object world.
- *Boundary*: kernel + environment
- *Structure*, i.e. the elements influences each other (no isolated sub-systems).

In an organisation, the elements are social persons with particular authority to bring about effects and a corresponding responsibility to abide by appropriate norms.

'the structure of organisation consists of social interaction, i.e. the elements enter into and comply with commitments, regarding the bringing about of effects, towards each other. This interaction is exerted through communication.' (Dietz 1999).

Although co-operation and coordination are usually associated with communication, it is possible to achieve coherent social behaviour without explicit communication: agents can rationally infer other agents' intentions, instead of querying them. This is possible only when the various agents share the same information field, thus sharing expectations about each other's behaviour, either using an informal system based on culture, or using a formal, normative, system of externally regulated behaviour.

2.2. Malone and Crowston Coordination Theory

Another attempt to define the concept more exactly is the 'coordination theoretic' approach of Malone and Crowston (1994). Coordination Theory is classified by them as an interdisciplinary research area and defined as the *study of processes of managing dependencies between activities* and they identify four components of coordination, and their associated coordination processes:

- goals: identifying goals,
- activities: mapping goals to activities,
- actors: mapping activities to goals,
- interdependencies: "managing" interdependencies (e.g. resource allocation, sequencing, synchronizing).

2.3. Coordination Technology

Computer science is using the coordination concept in at least two different perspectives:

- One, where coordination refers mainly to using computers to support human systems. This is the perspective of the Computer-Supported Co-operative Work (CSCW) and the Language-Action Perspective communities, both strongly inspired in the work of Winograd and Flores (1986), as well as the Theory of Organized Activity (Holt 1997) which is described below.

- Another one, more technology-oriented, commonly adopted by the multi-agent systems community and the DAI community, focus on the development of intelligent software agents, virtual organisations and on the automation of coordination.

Although this paper focuses essentially on the first approach, it is worth noting that the two perspectives can be combined. Some work has been done in this direction: Abbas and O'Hare (1997) have discussed how findings in Organisational Theory can be used to effectively design multi-agent systems. The two fields are also relevant in understanding organisations where human and semi-autonomous artificial agents interact to solve business problems, and thus need to co-ordinate their activities.

In 1979, Holt together with Cashman developed the world's first "coordination system", which ran on the ARPANET to support military software development (Holt and Cashman 1981). Contrary to Malone, Holt claims that *Coordination* is not an interdisciplinary field but a first class research field, specific enough and important enough to be considered on its own, with specific theories and methods (Holt 1997).

Winograd and Flores (1986) introduced the term "Coordination Technology" in connection with the work of Holt and Cashman, which is a term that must not be confused with "Communication Technology". While coordination technology tools tend to be highly customised, and typically need to be rewritten for different organisations, communication technology tools are more unstructured and general purpose.

3. The Theory of Organized Activity

3.1. Introduction

The Theory of Organized Activity (TOA) provides a particular view into human activities, which is the basis for a systematic analysis of human organization(s). According to TOA, human actions performed inside an (organized) activity are the key element for structuring and planning all processes, which occur within any organization. From this human centred perspective, all information systems are human information systems and information technology is just seen as a collection of supporting tools for human activities.

From a theoretical point of view, TOA is based on a general **theory** about organized activity, which is independent from technological support, and from a practical point of view it shows a **vision** of its application using computers. Next section will describe and reproduce some of the main theoretical concepts of TOA. The section after it will present a view of TOA practical application using computer support – the *vision.*

3.2. Theory – Elements

TOA is build up on a metatheory named Theory of Units (TU). This theory defines the concept of a *unit* that is associated with every action or thing. A *unit* is something that the members of a group (or community) bound together by an organized activity identify in common. For example: most programmers will *agree* about what means inheritance, or what is a compiler. For this group 'inheritance' and 'compiler' are *units*. To achieve this common understanding there is a *criterion* (explicit or not) behind each *unit* that is maintained by the community and that can be used to identify realizations of that *unit*. So, the meaning of any *unit* is a collective achievement. In this sense technical terms of a theory are *units* to the experts of that theory. TOA is expressed through its own units, but also any and all activities

are carried out in terms of units being special terms, or actions or things. These ideas are introduced in the following statements[1]:

> **1.** Every social group (or community) bound together by organized activities has its UNITS.
>
> **2.** Associated with every UNIT of a community is a CRITERION which this community maintains – a CRITERION by which its members decide whether a given something is, or is not, a REALIZATION of the UNIT.

TOA is formalized through *basis statements* as those showed in 1 and 2. The main elements of an Organized Activity (OA) will be presented in the next *basis statements.*

In TOA the human act or *action* plays a central role as part of any and all organized activities. Statement 3 introduces the (human) *action* as the unit of human effort. It should be noted that *all* actions are necessarily units of human effort and conversely any unit of human effort is an action.

> **3.** An ACTION is the UNIT of (human) effort.

All actions have a performer, who is *always* a person. However any action is doubly performed, because by performing an action a person acts individually and in the role of an organizational entity (OE). As an example, an action performed by a President of a department is performed by the President (an OE) and by the person that plays that role. These notions are presented in statements 4 and 5.

> **4.** Every ACTION is doubly performed – ORGANIZATIONALLY and PERSONALLY. Correspondingly, there are two types of ACTION PERFORMERS: ORGANIZATIONAL ENTITIES, and PERSONS.
>
> **5.** A PERSON assumes a RESPONSIBILITY by becoming an ACTOR, (…) who plays a role in an ORGANIZATIONAL ENTITY.

As previously mentioned, in TOA human action has a special relevance and is the object of particular reflections. Actions are driven by the *interests* of their performers, whom carry also the *responsibility* for those actions. In this logic machines do not perform actions because neither responsibility nor interest can be attributed to a machine.

> **6.** ACTIONS are driven by the INTERESTS of their PERFORMERS. PERSONS have PERSONAL INTERESTS; ORGANIZATIONAL ENTITIES have ORGANIZATIONAL INTERESTS.
>
> **7.** To make an organized activity efficient and effective requires bringing all INTERESTS involved – PERSONAL as well as ORGANIZATIONAL – into proper alignment with one another, in every imaginable combination.

Besides actions also materials should be considered as key elements of an OA. This concept is identified in TOA by the term *body*. A *body* represents any physical thing related to the OA. A person is also a *body* in an OA.

> **8.** BODIES are material UNITS

The next statements 9 to 11, establishes the relations between *action* and *bodies*, defining also the related spatial and temporal dimensions of any activity.

> **9.** Every ACTION INVOLVES at least one BODY; every BODY is ENVOLVED in at least one ACTION.

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[1] Statements 1 to 11 where transcribed from (Holt, 1997)

10. BODIES extend in space; ACTIONS extend in time.

11. The BODIES which an ACTION INVOLVES are, together, called the THEATER of the ACTION; the ACTIONS which INVOLVE a particular BODY are, together, called the LIFE of the BODY.

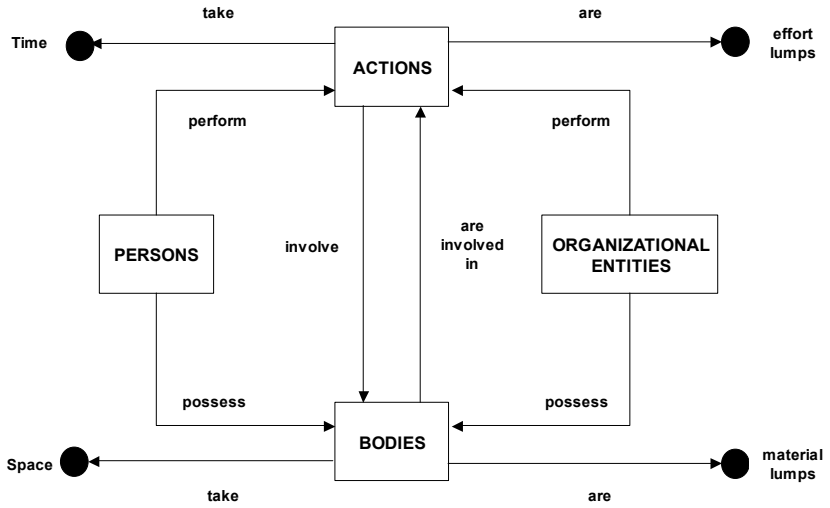

Figure 1 – Organized Activity Kernel

All mentioned concepts and elements are summarized in figure 1. This figure defines the OA kernel which relies in two dichotomies: persons/OE and actions/bodies. The grand hypothesis is that: "all organized activities, no matter how complex and subtle, can be *usefully* represented in this terms…" (Holt 1997, p.56).

TOA also defines a graphical language – *DIPLAN* language – to express action plans. Plans are used to describe OAs in an organized artefactual setting. An example of a DIPLAN graphic is presented in figure 2.

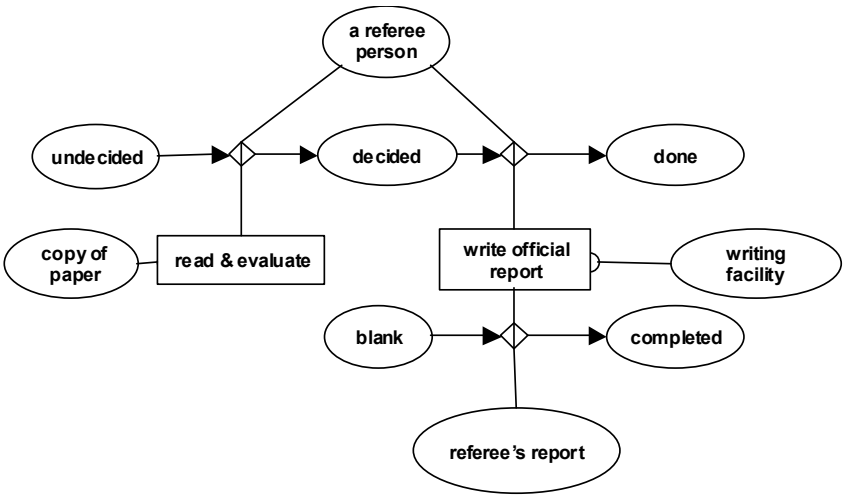

Figure 2 – DIPLAN graphic of a scientific paper revision process

3.3. Vision – Pulsar and Igo

In section 3.2 some of the main theoretical ideas of TOA were stated. However in TOA there is also a view of its application: '**the vision'.** Within this view computers are used to support activities and their coordination inside an organization. Next sections 3.3.1. and 3.3.2. will present two applications of computers or software package models - *Pulsar* and *Igo* – that can be used to support the coordination of groups and individuals.

3.3.1 PULSAR

Pulsar can be seen as a software package which aim is to coordinate the interaction of a group of people (or community) engaged on an organized activity. This application is based on a pattern of communicative interaction among a group of people. It is based on the simple observation that when two persons are having a conversation a *pattern of interaction* appears where we can see both intervenient expressing alternately. Other patterns emerge when more people are added to the conversation, as in a meeting. *Pulsar* defines exactly one of those patterns, where are present a *manager* and N *contributors*. The *Pulsar* interaction process evolves in two steps: 1 – the *manager* prepares and broadcasts a *stimulus* to each of the *contributors*. 2 – Each of the *contributors* produces and returns a *response* to the *stimulus*. From all responses received the manager prepares a new *stimulus* and the process is repeated until the objectives are fulfilled.

Some *extras* can be added to *Pulsar* to improve the system, namely:

- an auxiliary communication tool – an electronic message system, where the address of all messages will include the organizational entity and may include the name of the communicating person
- a stimulus specialization – where different stimulus can be sent dependent on the addressed contributor
- a result-to-date repository of data – to which all members have access and where it is stored the common data.

Pulsar can be usefully used in several activities, for example in conducting an electronic meeting, in a share document production, in auctions, etc.

3.3.2 IGO

Igo is a software system oriented towards computer support of individual activities, with emphasis in what the user see, does and experiences with the system. This package defines the notion of a *center* that would be associated with each activity in which someone is involved. This *center* groups and maintains all the information and all the coordination aspects related to the activity and it would be possible to transfer the *center* to other persons. In a *center* we can find:

- Current status information (CSI) – information about the state of the activity: time spent, things to be done, time to expend, time left to a particular work, etc.
- Mail to and from the centers – a messaging system, with a mailbox per center where message addresses include the originating center, and the organizational entity.
- Current managerial information (CMI) – optional information accessible from higher hierarchical centers that would permit to control the activity.

With *Igo* computer could change the way it relates to people. We could see *centers* (instead of folders) in which the state of the activity would be reflected. As an example a different colouring, a blinking, an added text, or any other interface element could be used to call the user attention to an incoming message, an urgent work, etc. This idea goes with an effective support and help to human activities.

4. A perspective of TOA in Information Systems Development

The Theory of Organized Activity proposes a way to look to Information Systems, based on (human) activities. Although the activity based approach to information systems analysis it is not new, e.g. Activity Theory formulated by Lev Vygotsky (1896-1934), its general approach build up on the Theory of Units and based on human actions it is new.

In this section we would like to emphasize some aspects of TOA and to present a particular view of its understanding and usefulness. In this sense we start by saying that since its appearance humans had always been involved in activities, individually and socially. Organized activities emerged from activities as a management necessity. Before computers, the organization of an activity was mainly the definition, coordination and execution of actions by the members of an organization. As material support to that organization there documents were produced with rules, contracts, business data, etc. Computer brought a new range of possibilities not only to the support of the organization of activities but also to the activities itself. However, we should emphasize that not all activities need organization, and even those that need it some of them doesn't need computer support. It would be necessary to take into account all costs and benefits involved in a computer solution.

TOA uses the activity concept as a main element that bounds together people, actions and materials and form the basis of any information system supported or not by computers. Inside each activity community members communicate using their own terms, or *units* as defined by TU. From this perspective each activity will define and have a special context that will be understood and maintained by its members. Any change of these members will have effect in the context. This will happen because the associated criterion of a unit, can achieve a different (common) understanding, changing the unit original meaning and consequently the context.

Another remark about activities is that they can be found in practice as structural elements of organizations. For example, an enterprise is an activity where we can find people working in a particular environment. Also, a department, a commission, or even a simple report production can be understood as an activity. Their common characteristic is that it joins actions, materials and, people (as individuals and as organizational entities) within some context (explicit or not). From this point of view it will be possible to state that each activity represents an Organizational Entity.

Regarding the main component of an OA, the human action, when we look to information system analysis and design (ISAD) it seems that it's really true that not much attention was spent in this concept. In most approaches to ISAD we try to find out what the system should do, not what we would do with the system. A simple example regarding an interface could be *having a link* to a particular site and performing *a button click* that will lead us to a presentation of that site. This will raise many other questions such as 'in what ways and what can be done with computers?'

TOA provides some useful hints. Actual software applications seem to ignore what it should be its main goal: to support human realization of tasks. In this sense, they omit communication, coordination and cooperation capabilities to their users. TOA proposes communication patterns such as *Pulsar* and *Igo* that could be used as coordination elements of an activity. Communication, in all its forms, is the link that bounds people together. Its importance is fundamental on performing an activity. So, to find out and to define new patterns of communication, and/or interaction could bring useful solutions to the activity success.

To conclude this view of IS development using TOA, we would like to point out another important feature of TOA: its capability to integrate with other theories. In our studies we found that would be feasible to integrate TOA with other theories such as the normative approach proposed by organisational semiotics (Stamper 1996; Stamper 2000) and Language/Action Perspective initiated by Winograd and Flores (1986). In these cases the most relevant connection point would be the human action. But also other theories are candidate to this integration for example Coordination Theory and the Activity Theory.

5. E-Learning Based on Coordination Using TOA

5.1. TOA and e-Learning

With TOA we can *design* and *plan* activities, and define the necessary computer support. TOA also provides some of the necessary coordination mechanisms implicit in its *vision* examples. E-learning is an activity which relies on the concepts of organic organizations where planning and change are present all the time. Applying TOA to e-learning will benefit this activity by supplying the necessary coordination mechanism, and planning support. Next sections will show a new vision for an e-learning environment and a real application of TOA.

5.2. A new *vision* based on Yahoo Groups

We would like to present here a new *vision* of a TOA application. This *vision* was originated by realizing the presence of some of TOA concepts in a popular web application, the Yahoo Groups (Yahoo Groups, 2002). Unfortunately another similar web application with special interest to the e-learning community, the Yahoo courses (Yahoo Courses, 2002) it was converted to a Yahoo Group and is no longer available.

Yahoo groups can be seen as an example of an application that implements the concept of a TOA *center*. As in a *center,* a Yahoo group is like an activity, bounding together people, actions (messages, management procedures, etc) and *bodies* (files). In this sense to create a Yahoo group, is just as to create an activity *center*. But there are other similarities:

- There is a messaging system where messages carry the Yahoo group identification as messages to and from the center carries the originating center.
- Recorded information about people and performed actions (messages sent, members management, etc.) functions as the CMI information of a center.
- Transferring of a center for another person is just to integrate and make that person the moderator of the group.

In a first analysis the expansion and adaptation of a Yahoo group can lead to an effective implementation of the ideas presented by TOA.

In order to transform and to adapt a Yahoo group to become an e-learning platform it would be necessary to add other coordination mechanisms, namely to add the possibility to create dependent activities (or groups) and to add the coordination mechanism supplied by *Igo* and *Pulsar*. Also the Yahoo group should talk the language of its members, as stated by the TU. Just as an example a 'file' could be named 'an assignment', 'a tutorial', etc.

5.3. An e-learning platform based on TOA

In order to test, experiment and explore the applicability of TOA an e-learning software platform (e-learning-Setúbal, 2002) was specified and developed by Gamboa et all (2001). This project was a first attempt to model an organizational activity based on TOA ideas and concepts. In the developed model disciplines were defined as the main activities. Other components present in the TOA kernel were also defined:

- OE - identified actors were students, teachers (and maintainers).
- Actions - appear in two main forms: as tasks and as available actions. Tasks could be an assignment to a student, to read a document, to do some work, etc, available actions were to send a message, to chat, etc
- Bodies - Bodies were mostly files and software tools.

To support this package other coordination mechanism were added. To mention the main ones: to create sub-activities (e.g. work group assignments, individual tasks), to assign tasks with time constraints, to dynamically plan an activity by defining sub-activities/tasks/actions. This platform however misses some other coordination mechanism such as the *Pulsar*.

6. Conclusion and future work

The Theory of Organized Activity was presented and proposed as an alternative approach to coordination of social information systems. Particular perspectives of its main ideas including some new point of views were used to show its relevance to information system development.

We believe that using TOA we can improve information systems flexibility and ease of change. We also claim that this theory provides natural mechanisms for supporting the coordination of individual and organizational activities. In this sense a new *vision* for TOA was introduced and an e-learning platform based on TOA was presented.

As current research work, we are studying the integration of TOA with the normative approach proposed by Organisational Semiotics (Stamper, 1996; Stamper, 2000). We are also exploring the development of activity coordination models using the Language/Action Perspective initiated by Winograd and Flores (1986).

The future work includes the application of these ideas to the development of a new e-learning system for the School of Technology of Setúbal. Another research area is the development of a new diagrammatic language to support the Theory that is envisaged as an UML extension for designing activity models of organizational activities and their support by computer.

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