

Virtual versus Physical: The Future?

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Abstract

In organisational science, new organisational concepts such as business process reengineering and virtual organisations are developed. These new types of organisation have more advanced and different requirements on their information technology (IT) support, since the relation between the organisation and its IT system is much tighter for these organisation types. We discuss potential problems of traditional IT approaches in these organisations. As an alternative, we propose a different perspective on the role of IT, i.e. we view the organisation as consisting of a physical and a virtual layer that both are active, equally important and contain models of each other.

1 Introduction

Organisations have developed a long way since the beginning of the industrialisation at the end of previous century. From small home businesses where some members of a family were active in the production of a particular kind of product a century ago to the multinational conglomerates that deliver a wide range of products while employing tens of thousands of employees. The increasing size of organisations putted considerable strain on its management and during the '70s and beginning of the '80s, a large percent of the employees in these organisations were concerned with various management tasks, rather than tasks related to the primary production.

During the 80s, a countering appeared and organisations started to look for ways to improve their efficiency. The division of work tasks into several functional disciplines,

which was very common in the traditional organisations, was losing ground since it became a trend to recombine several tasks and assign them to a single person or team. One important enabling factor in this was the PC which caused, for example, many secretarial positions to disappear, since typing a letter on PC using a word processing program was cheaper and easier than writing it by hand and then having a secretary typing it. Many functions that were fully accepted during the era of bureaucratic organisations, disappeared since their tasks were integrated with other, more primary, tasks such as purchase, production and sales. At the beginning of the '90s this phenomenon was taken to an extreme by authors such as [Hammer & Champsey 93, Davenport 90] under the term 'business process re-engineering' (BPR). BPR can be defined as the fundamental reorganisation of an organisation according to its business processes rather than according to the various functions in the organisation.

After the introduction of BPR, another organisational form, i.e. the *virtual organisation* (VO) [Davidow & Malone 92], was designed. The term 'virtual' indicates that the VO is not an organisational form in the traditional sense of the word. The VO is virtual since it lacks several of the aspects that traditionally make up an organisation, such as locality, hierarchy, functional divisions etc. A virtual organisation is formed by persons or organisations with different expertise that co-operate for a particular project in order to produce a solution to the market [Goldmann et al. 94].

These new organisational forms would not have been possible without the new developments in information technology. The most important changes due to information technology are that [Scott Morton 91]:

- Distance can be shrunk to zero. This means that geographical distance becomes irrelevant for information flow, because of the interconnectedness of organisations.
- Time can shrink towards zero or to a more convenient time, e.g. by using store-and-forward databases.
- The organisational memory has changed, it can now be maintained over time, it can be contributed to form all partners of the organisation and it can be made available to a wide variety of authorised users.

The changes mentioned above allow for increased interconnectivity between partners in organisations and some examples of the use of this technology are the *mobile desk*, the *virtual office* and *hotelling*. These advances in information technology enable new forms of interorganisational relationships and alliances. Also within the market of utility providers this development can be identified. In the future, utility providers may co-operate more with providers of other products and services in order to provide integrated services.

This co-operation can result in a joint project or an alliance between several partners co-ordinating production and design of products with help of information technology. This development can already be seen in several branches and is often related to the concept of the virtual organisation.

The described, and other, organisational forms are all enabled through the (extensive) use of information technology (IT) and would not be possible without this technology. This is generally recognised and indicated by virtually all authors on these subjects, e.g. [Davidow & Malone 92, Goldmann et al. 94]. However, although everyone indicates that IT plays a central role, no author addresses the question of *how* information technology should be used except for very general statements, such as supporting information exchange in the organisation. On the other hand, the IT providers lack the organisational perspective, but provide specialised products aiming at a particular problem or aspect. Although these products may be very helpful, their integration is often very difficult, if not impossible, to achieve. In general, one can recognise a lack of an architectural perspective or overview on IT in organisations. Very often, companies base the IT support for the new organisation on the same principles as the IT systems in the traditional, functional organisations, instead of according to the BPR or virtual organisation principles. In our research, we have become convinced that serious mismatches between the organisation and its IT system will be the result of such an approach. The interaction between the IT system and the organisation is such that a fundamental organisational change needs to be accompanied with a similar change in the IT system.

In this paper, we study the relation between IT systems and organisations. The problems of traditional IT systems in new organisational forms are identified and analysed. As an alternative, we propose a different perspective on organisations and their associated IT systems and we analyse traditional and more novel organisational forms with respect to this perspective.

The remainder of this paper is organised as follows. In the next section, we discuss the notion of virtual organisation since it provides the best and most extreme example of a new, untraditional organisational form. Subsequently, in section 3, we describe and analyse the problems of traditional information systems. In section 4 we propose a fundamentally different view on IT-based organisations. This perspective is compared to related work in section 5. The paper is concluded in section 6.

2 The virtual organisation and IT

2.1 Virtual organisation

The virtual organisation is defined by [Davidow & Malone 92] as an interorganisational relationship in which independent organisations share their resources, knowledge, costs

and risks in order to produce a product. It can be seen as a novel organisational model that uses technology to dynamically link people, assets and ideas. The virtual organisation requires highly skilled, reliable and educated people. People that can work together in a team, that can make their own decisions and take responsibility. Often the participants within the virtual organisation are distributed geographically and in order to communicate with each other they are electronically connected. One form of a virtual organisation appears when several independent organisations combine their core competence for a particular project. This organisation disbands when the project is finished. One example of such a virtual organisation would be a utility supplier and a computer company create an alliance (VO) in order to investigate new market possibilities. Both parties supply competencies, and the members of the independent parties work together in a team in order to create an idea or product.

The virtual organisation has been chosen to discuss in more detail, because the relationship between IT and the organisational structure is very clear. The aforementioned interconnectivity aspect plays a large role, since most members are not situated on the same place, but still co-operate in order to produce a product or service. Since the virtual organisation is a rather new concept, not much literature has been written about *how* this relationship between IT and the organisation should be. Already some IT applications are available that support parts of the information and communication flow necessary in such a geographical distributed organisation. However, these applications can not support all IT requirements of the organisation effectively. Often the IT system used for the virtual organisation is based on the traditional division of functions, but since the virtual organisation does not have this division anymore the traditional IT systems are not suitable for the organisation's structure. Some problems with traditional IT support which can be expected in virtual organisations are discussed in more detail in the following subsections.

2.2 Current problems with information handling

2.2.1 Hierarchy versus organic structure

In a traditional, hierarchical organisation, information handling was done according to fixed structures and rules enforced by management. These structures entailed for example work-flow reports, internal and external reports per department, all on a regular basis. These reports were not only used to update management of activities within the organisation, but they were also used as a control mechanism in order to check the process of work of the employees. However, in the virtual organisation participants gain much responsibility and make their own decisions. This implicates that management has to change from being a hierarchical leader and decision-maker towards a more supportive and integrative manager. Within the organisational structure the traditional information

handling has to change, since participants in the virtual organisation see traditional information handling methods as a restriction to their freedom. However, management and stockholders would still like to control the processes in the organisation and therefore different methods for control are necessary within such a flexible and dynamic organisation. The problem is however, how to combine the loose organic structure with the traditional information handling methods in order to find a combination suitable for all participants in the organisation.

2.2.2 Information distribution

A virtual organisation, being distributed, can not dispose over the same information and communication streams as a traditional company since people do not meet in person. In the traditional organisation, people communicate with each other, among others, in the corridors and through the informal organisation. However, this is not possible in the distributed organisation where there is no single location where employees can meet and socialise. In order to counter-affect these disadvantages, it is necessary to explicitly support information exchange and personal communication within the virtual organisation. This implicates a different information distribution within the virtual organisation when compared to the hierarchical functional divided organisation. For participants it is necessary to receive all updated information about the developments and activities in the virtual organisation. Since participants receive more responsibility and make most decisions, they need access to all material available and necessary for their project.

3 Information technology problems

It is necessary that a new way of dealing with information is developed within the organisational structure and within the information system. Over the last decades, one can recognise an increasingly tight relation between the organisation and its information system. Therefore changes in, for example, the information handling methods in the organisation also implicate changes in the information handling methods in the information system. Due to this close relation between the organisation and its information system a number of difficulties can be identified. Currently available information technology suffers from a number of problems that make it hard to handle information in other than the traditional ways. The problems that we identified and discuss in this paper are related to the mismatch between the information system and the organisation structure, the lack of flexibility and the passiveness of information. In the following sections, each of the problems are discussed in more detail.

3.1 Matching IS with organisation structure

In the previous section, we recognised that the way information is organised in traditional information systems does not match a dynamic organic organisation structure. We consider it a necessary requirement of a successful information system to match the organisation structure. Especially in the virtual organisation it is important that all participants are updated on information necessary for their tasks. We have classified information within a virtual organisation in two parts. We have done this to facilitate the presented solution mentioned in section 4. The two information forms we recognise are: information to a target group and content information. Information to a target group is not information mentioned for specific people, but is information to separate roles in the organisation. With roles we mean e.g. the designer role. Since members in the virtual organisation are flexible and change when a project is finished, it is easier to have an information stream to the persons that play a certain role. This type of information can be divided into individual, global (for one group of e.g. designers) and external (for experts or roles outside the virtual organisation). Furthermore, the content information entails detailed information about e.g. products, processes (status of production or design processes), finances, logistics etc. These types of information are necessary for different groups. However, it is important that everyone in the organisation has access to this information. Often, only parts of these types of information are available and members of the organisation are dependent on others in order to receive the required information.

3.2 Lack of flexibility of the information system

The requirement of the match between the information system and the organisation structure leads to a subsequent problem: the virtual organisation develops constantly and changes partners and products regularly in response to the changing context. In the same way the organisation adapts itself to the changing context, the information system should be adapted to the organisational changes. The organisational structure of a virtual organisation in particular is very flexible and subject to change as the organisation is directed outward to the customer and the changing environment. The virtual organisation depends on the requirements of the customer and they change due to new competitors or other situational aspects. Most traditional information systems are rather static and are not able to be adjusted to rapidly changing circumstances. This is partly due to the software used for the system and partly due to opinions and ideas about the information system available in the organisation. Often the information system is only viewed as a supporting tool for some activities in the organisation. These activities are often within the administration and decision-making fields. However, we view the information system as a part of the organisation that can influence activities and processes. The dif-

difficulties of the software used for the information system are often due to the underlying paradigm used for the applications. Often a functional paradigm is used for the information system and this causes difficulties with adaptation to changing circumstances. The difficulties are caused by the fact that a change in the real-world often causes several required changes distributed throughout the information system. Incorporating these changes is generally a time-consuming and error-prone task. Due to the time-consuming and expensive nature of incorporating changes in the functional information system, the ratio between maintenance of existing systems versus the construction of new systems might be as high as 90% versus 10% in the information system departments of large organisations [Tapscott & Caston 93]. Another example is the fact that of the total cost associated with an information system, only 20% is spent during system development. The remaining 80% is spent on maintaining and updating the system [Tapscot & Caston 93]. In case of drastically organisational changes, the changes to the information system can never keep up with the changes in the organisation, which may result in various indirect organisational problems.

3.3 Passiveness of information in the IS

The current information system only stores, maintains and retrieves information in a passive way. The information system is used as a large database or a number of databases. In general, one can state that the information system is primarily used to replace physical tools like paper and filing cabinets. The information system is, only in a limited manner, used for tasks that go beyond the capabilities of the physical tools. The information system forms the passive data on which the users of the system act as active functions. Users play the active part in the information system by invoking functions stored in the system to process the passive data in order to produce output data useful for the organisation. A problem with this aspect is that the current information technology is dominated by the active user, and this often means that not all capabilities and capacity of modern technology are used within the organisation. If one would structure and model the information system in a different way in which the contents of the information system would be more active, new possibilities could arise for the operation of the organisation. The second problem with the passiveness of the information system is that the entity is not responsible for its own consistency, it is dependent on the active functions of the user.

Although the passive type of information system has proven to be very useful in improving the efficiency of the organisation, it has not nearly exploited the full capabilities of modern information technology. The presented model in this paper is partly based on developments in artificial intelligence (see also section 5), and partly based on the object oriented way of thinking. We present an alternative approach to model organisations

and their information systems. In this model a division is made between the physical organisation and a virtual layer which can be the traditional information system. The virtual layer is a copy of the physical layer, in which real-world entities are reflected in the virtual layer.

4 Virtual and Physical layer model

The use of information technology encompasses a highly promising solution to the aforementioned problems. However, to achieve the full potential of information technology, the architecture of the information system has to be such that it can replace the information exchange and communication present in a traditional organisation. There needs to be a match between the organisation and its information system, so that the information system is a reflection of the organisation and all changes in the organisation are also incorporated in the information system.

The relationship between the organisation and its information system has changed over the years. The way we view this relationship is presented in figure 1. This relationship is reproduced as consisting of two layers. The first layer is the physical layer, this implies the real-world organisation in the way we view an organisation, e.g. buildings, management hierarchy and functions. The second layer consists of the information entities and communication flows within the physical organisation that can be found in the information system. In the figure we try to emphasise on the increase of importance of the information system within an organisation. Especially in a BPR and a Virtual Organisation the information system plays a vital role. In the traditional organisation the information system only took care of parts of activities in the physical organisation, e.g. administration, accounting and some production activities. The information system could be viewed as consisting of several non related specialised applications that work upon different aspects. The physical layer shows the structure of the organisation and the virtual layer shows supporting information handling parts. The second organisation type (shown in figure 1(b)) clearly shows a change in organisational structure, but also a change in the virtual layer structure. The second organisation can be viewed as a BPR-ed organisation, where employees co-operate in teams and where the work is organised around processes. Here the organisation is much more dependent on an automated information stream since the organisation has less hierarchy and less structure. Therefore it is important that the information system takes over some co-ordination aspects between the teams and within the rest of the organisation. Since the physical layer shows less structure in the organisation compared with the hierarchical structure, the virtual layer has taken over parts of the structure forming in its layer. Only the combination of the two layers can indicate the complete organisation. The last picture (figure 1(c)) shows

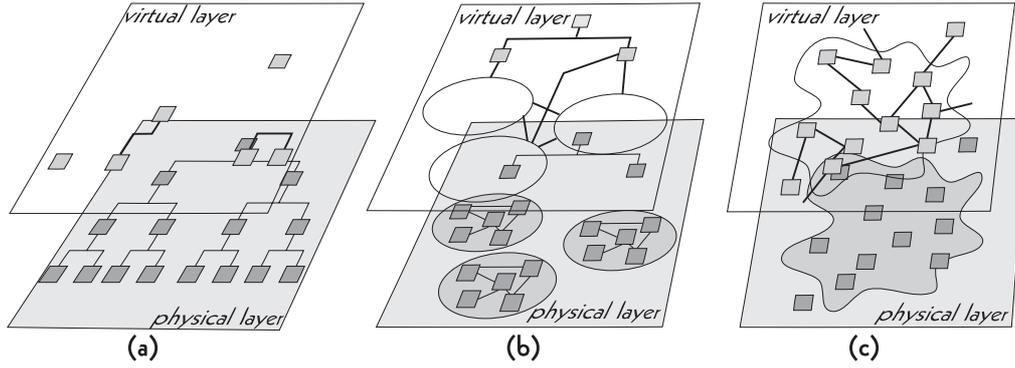


Figure 1: Virtual and physical organisational layers

the structureless physical layer of a virtual organisation. The virtual organisation is very flexible and often subject to change, therefore it is difficult to have a fixed structure in the physical layer. On the other hand, people need some structure in their life in order to feel secure and to work efficient. Therefore the virtual layer shows the structure that is left out in the physical part. The virtual layer represents the structure of the information and communication streams, necessary in order to run an organisation. This structure is relevant so that members of the organisation can communicate with each other and so that they know the activities taking place in the organisation.

4.1 Symbiosis relation

The model we present in this paper is also based on the division in a virtual and a physical layer of the organisation. However, the model is more suitable for organisations that are dependent on information technology and that are flexible and dynamic. The model we present exist of entities (entities can be humans, machines, computers but also activities) and each relevant entity in the layer exists in both the physical and the virtual dimensions. In the physical layer the real people, activities and products (i.e. physical entities) are located, whereas in the virtual layer active semantic entities, e.g. objects or agents, representing the real-world entities exist. Each active real-world entity, e.g. a person, has a corresponding active virtual entity and the two combined form a synergetic composition. It is important to stress the relation between the virtual and the physical layer, since this is the basic idea behind the presented model. We view the relationship between the physical and the virtual layer as a symbiosis relationship, the two layers belong together, co-operate together and support each other. With this model one could think that the organisation is now placed in two separate layers laying on top of each other with a connection to one another. However, we view the organisation as consisting of entities. These entities all have a virtual and a physical part necessary in order to operate in the organisation.

The term 'virtual layer' is used to refer to an artificially created reality that cannot be sensed by our traditional senses, but only through artificial created sensors converting the virtual reality into impulses that have meaning in the physical world of a human being. The physical layer consists of those entities in the real world that, in the traditional organisational view, belong to an organisation. Examples of these are the employees, machines, buildings, cars, etc., but also conceptual entities such as the hierarchical organisational structure, company culture and work schedules. The virtual layer, on the other hand, consists of all those entities in the physical layer that also have a representation within the information system.

The virtual entity can search information, make decisions, perform activities and tasks in the same way as its real-world counterpart. The virtual layer of the organisation forms a generalisation of the traditional corporate information system. Our perspective of the organisation and its information system is rather different from the traditional view where the information system is seen as a passive information provider supporting the organisation. We view both the virtual and physical layer of the organisation as equal parts that mutually depend on each other. The virtual layer exists in a 'virtual world', i.e. refers to the 'space' created by a network of integrated computer systems. This virtual world is sometimes referred to as cyber space or virtual reality. Analogous to the physical layer that exists in the physical world, one can view the virtual layer as existing in the virtual world. Necessary for this model is that the virtual entity contains a model of its activities (e.g. intelligent active objects). There are a number of ways entities can communicate with other entities: (a) communication between real world entities, (b) communication between virtual entities, (c) and communication between the virtual entity and a counterpart in the real world. In principle, one can already view existing information systems as virtual layers, but this aspect of the layer is completely dominated by the active entities in the physical layer. In these information systems, the entities represented in the virtual layer are passive and acted upon by the active entities in the real world. If one takes the viewpoint described in this paper, one can clearly identify that the virtual layer requires considerable development before it can act to the same extent as the physical layer.

Although many information systems today are passive entities, some examples of actively operating virtual layers already exist. One illustrative example is modern stock trading systems. In a stock trading organisation, the physical layer and the virtual layer co-operate interactively to maximise profit. However, the virtual layer, i.e. the stock trading system, has extended capabilities for buying and selling stocks without any human intervention. In case of unfortunate developments, the system can independently decide to sell (or dump) for enormous amounts of money. Battle field command & control systems are a second example where the virtual layer plays an (almost) equivalent role

compared to the physical layer. Offensive and defensive actions can be invoked without human intervention by the command & control system. The two examples illustrate some aspects of a virtual layer. Note that our description of a virtual layer only is one possible approach.

4.2 Virtual Layer

As mentioned in the previous section, we view the organisation as consisting of a physical and virtual layer. We view these two layers as equivalent, rather than the latter supporting the former as in the traditional view. In our approach, the virtual layer has, among others, the following three properties:

- Every relevant entity in the physical layer has a corresponding entity in the virtual layer. For example, a car that belongs to the organisation has a corresponding car object in the virtual layer. Similar, a secretary has a corresponding secretary object in the virtual layer.
- Depending on the nature of the entity in the real world, the corresponding entity in the virtual world may be an active object (or agent). An active object can search information, make decisions, perform activities and tasks.
- The virtual and real-world entity form a synergetic composition that can be viewed as a single entity at the organisation level. For example, a sales person and his/her virtual counterpart co-operate in contacting prospects and clients. This includes the possibility that the virtual object contacts the virtual layer of a prospect to determine potential interest in the products offered by the selling organisation.

The aforementioned properties of the objects in the virtual layer put the following requirements on these entities: The virtual entity requires a model of the real world entity it represents. It requires knowledge about ways to find information, decisions about processes, etc. Entities representing active real world entities also need to be active themselves.

4.3 Examples

An example of the presented model can be a designer in a virtual organisation (physical organisation). The designer, who can be defined as an entity according to object orientation, exists both in the physical world as well as in the virtual world. In the physical world the designer is a person with a specific role of designing a feature for a product. In order to do this the designer needs information about the product, material, market and production methods for this product. The virtual counterpart of the designer consists of

all information the designer has; it consists of e.g. operations and functions (functions of designer) and descriptions of what the role of the designer is. Furthermore, the virtual layer also has access to communication and information flows in and outside the organisation and the virtual part can actively (on its own) search for necessary information for the specific role, task or function of the designer. The virtual layer can also play a part in the co-operation with other members of the design team or with other roles during the process of production. For example, if the designer requires information about the market, he can search for this information himself or he directs it to his virtual counterpart and he can do other things during that time. The virtual layer searches actively for information inside and outside the organisation and facilitates communication and information channels for the designer. It is also possible that information necessary for the design is sent to the team concerned with the product, the virtual layer should be able to make decisions when and what sort of information one should obtain and for what purpose.

5 Related Work

Several authors in the domain of organisational science have indicated the importance of information technology in new organisational forms, e.g. [Barnatt 95, Birchall & Lyons 95, Davidow & Malone 92, Scott Morton 91]. However, in general, these authors do not study the particular IT needs and challenges of organisations or the relation between organisations and their IT systems. One notable exception is presented by [Jacobson et. al. 94] who studies the relation between BPR and the object-oriented paradigm.

In the object-oriented systems engineering domain [Taylor 92] one can identify certain efforts that aim at representing real-world entities as entities in the application. This is not surprising since the object-oriented paradigm aims at representing the real-world as accurately as possible. One important effort is performed by the Object Management Group on Common Business Objects [OMG 96] (CBOs). The CBOs, however, are viewed as passive entities that store the state of real-world entities and some of their reactive behaviour. CBOs fail to be active entities that actively form the virtual layer of an organisation.

Within the domain of artificial intelligence, during recent years the concept of an intelligent agent has been proposed and studied extensively. Originally proposed by [Shoham 93], the agent-oriented programming paradigm quickly became an important research field within AI. Several alternative agent models, e.g. [Hägg et al. 94], were proposed. Agents are inherently active entities that execute scripts, i.e. behaviour descriptions. One of the disadvantages of most agent approaches is that they are based on first-order logic or some variant, causing these models to be rather unintuitive and difficult to use for any but experts. Also, the agent-oriented paradigm has not yet reached the level of acceptance

required for a break-through as the object-oriented paradigm has.

Concluding, there are several promising fields of research that would be able to support the model proposed in this paper. We believe that, from the technological side, a model that extends the object-oriented paradigm with aspects from agent-oriented technology while preserving the intuitiveness of objects would be the most suitable. The main problem is that the issues discussed in this paper are very poorly understood from an organisational perspective. Much more effort needs to be spent to understand the relation between IT and these new organisational forms. This requires, we believe, that organisational scientist stop viewing IT as yet another tool, but start viewing the organisation as outlined in this paper, i.e. recognising the virtual layer of the organisation as a first-class entity.

6 Conclusion

In this paper, we discussed developments in organisational science, i.e. new organisational forms such as business process reengineered and virtual organisations. These new types of organisation have more advanced and different requirements on their information technology (IT) support. The relation between the organisation and its IT system is much tighter for these organisation types. We discussed potential problems of traditional IT approaches in these organisations, such as the match between the organisation and its IT system, the lack of flexibility of the IT systems and the passiveness of information in the information system.

As an alternative, we have introduced and discussed a different perspective on and model for the IT support in, among others, virtual organisations. The proposed model addresses the information problems in distributed and virtual organisations. The virtual entity for each member of the organisation is made responsible for the acquisition and distribution of information relevant for other members in the organisation. Members in the organisation can use their virtual entity to filter and analyse all information sent to them and, on the other hand, order their virtual entity to actively search for information in organisational and global information stores. The above mentioned solution could also improve the lack of communication, as members can now communicate with each other in a number of ways, instead of only mailing or talking through the telephone. Members in the organisation can communicate with the real-world entity, there can be communication between two virtual entities and also communication is possible between a real-world and a virtual entity. One becomes less dependent on the presence of a person, since one is always able to communicate with the entity (in person or with the virtual entity). As the virtual entities also have the possibility to communicate with each other and to distribute information between one another, the real world entity can be updated constantly. This

could be a solution to the distance problem within the distributed virtual organisation, as now participants can make use of all information available for their team and their project and their virtual entities can search actively for new prioritised information.

We have compared our proposal to related work and concluded that the object-oriented and agent-oriented paradigms provide much technological basis for the proposed model, but that much understanding is lacking at the side of organisational science. The role of IT in organisations and the relation to the organisational structure is rather poorly understood and needs to be studied in more detail.

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