



# Evaluating Evolutionary Information Systems

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## ABSTRACT

*Most information technology evaluation research and practice is either done before the decision to invest or after it. This type of evaluation is suitable for methodological information system development, where a system is developed using business projects and methods with set budgets and time scales, and where the system is regarded as completed. However, it is now recognised that systems development is evolutionary, leading to information systems that are classified as evolutionary systems. Examples of such systems are the World Wide Web, Internet, and Extranets, as well as other software systems that are designed to evolve. We are aware of no current research into evaluating such evolutionary information systems. Current research and practice in information system evaluation is not suitable for information systems that are classified as evolutionary. Thus there is a gap in current research in evaluation of evolutionary information systems that this paper addresses. We do this by proposing a post-modernist framework for exploring the issue of assessing the benefits of such evolutionary information systems, and argue that such evaluation is necessary but could perhaps develop into a new research area within IS evaluation. We conclude that evaluation is necessary throughout the life of evolutionary systems, and that the management of benefits, risks and costs is an important aspect of IS evaluation.*

## 1. INTRODUCTION

This paper addresses the problem of evaluating evolutionary information systems. We do not know of any research in information systems evaluation that addresses this problem. Research into evaluating evolutionary information systems is relevant and pertinent when viewed in the context of recent developments in evolutionary systems development and evolutionary information systems. Examples of evolutionary systems development are prototyping (Bowen, 1994) and Rapid Application Development (Pressman, 1997), amongst others. There are also developments in evolving legacy systems (Warren, 1999) that are at present not considered. Equally, we do not know of evaluation methods that consider the improvement or enhancements made to information systems through maintenance activity. The effort spent in systems maintenance, often quoted as sixty to seventy per cent of the cost of systems (Pressman, 1997), questions the value of both ex ante and ex post evaluation. The actual information system in operation is significantly different from the one that would have been evaluated before or after it was built. We refer to the above activity in systems development and systems usage as *evolutionary information systems*.

We further distinguish evolutionary information systems from traditional ones with reference to their development method. Traditional information systems are developed using some structured method or systems development methodology, for example Structured Systems Analysis Design and Methodology used in England by government agencies and some large companies. However, research shows that, though a particular methodology may be named in systems development projects, it is often not adhered to and is used as a means of social defence (Westell, 1996). An extensive literature exists detailing methods for evaluating traditional information systems. It considers associated problems of quantifying individual or organisational, whether tangible or intangible, second order or third order benefits (Clemans, and 1991; Farbey et al., 1995)

In addressing the issue of evaluating evolutionary information systems, we take a broad perspective of the recent developments in the information systems field in terms of considering societal and human issues. We consider it necessary first to discuss recent concepts of organisations as (business) processes, their modern character of uncertainty and permanent organisational change. This is necessary to do because such characterisations in turn affect the conceptions of information systems to be used in organisations. We then deepen the discussion to take a deeper conceptual and philosophical view of organisational behaviour. We do this by considering post modernist views of society and organisations. We contend that post modernism is a cause of the need for evolutionary information systems. We introduce the work of the German philosopher Martin Heidegger on *Dasein* as offering a philosophical explanation for the need for evolutionary information systems. Having thus set the conceptual ground, we then begin to consider evolutionary information systems per

se and how to evaluate them. We do not propose any new technique, rather our aim is to open the debate in this increasingly pertinent area. So, we first provide some examples of evolutionary systems development and evolutionary information systems, and attempt to characterise such systems. This then enables us to consider appropriate conception of evaluating evolutionary information systems. We end the discussion by offering some conclusions and considering the implications of our discussion for further research in the area.

## 2. BUSINESS PROCESSES AND ORGANISATIONAL CHANGE

Recent characterisations of business organisations have two prominent themes, business processes and organisational change, both of which are relevant to evaluating evolutionary information systems. Hammer (1990) and Davenport (1993) argue that business processes can be changed to improve the competitive position of a company and to maximise the value that it can deliver to its customers. Changing processes, often radically, leads to improvements in performance as measured by cost, cycle time, service and techniques (Johansson et al. 1993).

The second dominant characterisation of modern companies is that they consist of permanent organisational change and uncertainty. Companies have to accept and learn to cope with uncertainty and constant change in markets and economic conditions (Handy, 1995). In manufacturing such uncertainty and changing conditions has brought about a call for 'agile' production techniques or systems (IMECH, 1999). Business processes, uncertainty and change are brought together in business process reengineering in that processes, once engineered, need to be constantly changed to remain competitive (Hammer and Champy, 1997).

The role of information technology and information systems is significant in this modern view of organisations. Its role is to enable business processes (Moreton and Chester, 1997) and even to transform significantly organisations (Venketrman, 1991). This modern view of organisations has important bearings on information systems evaluation. In it information technology is affected by environmental and organisational change and because it supports business processes that change, it too must be capable of changing or evolving.

The evaluation of information technology and information systems in organisations consisting of processes, uncertainty and constant change is problematic. Since information technology is used to change fundamentally business processes and change affects newly designed processes, quite what the benefits of the use of the technology are becomes difficult to measure. This is partly because of multiple variables such as processes changing simultaneously. Our traditional quantitative and qualitative techniques possibly are unsuitable in such an environment. For example, Aggarwal (1991) discusses procedures for assessing investments in flexible manufacturing technology, and posits that traditional capital budget-

ing procedures should be supplemented with strategic analysis and net present value. However, whilst such techniques may be used for assessing flexible information systems too, they may not be entirely useful for evaluating the real worth of information technology investments.

To attempt to understand the role of information technology and information systems in organisations consisting of processes, uncertainty and change, and to begin to think about how evolutionary information systems should be evaluated in them, requires us to take a border perspective. It is necessary to turn to the recent re-conception of society as post-modern to gain a better understanding of what is happening in society and in organisations, and in that context to begin to explore how to evaluate evolutionary information systems.

### 3. POST-MODERNISM

Post-modernist ideas of society are relevant to the issue of evaluating evolutionary information systems. Not only does post-modernism provide useful concepts to evaluate evolutionary information systems, but it is necessary to consider post modernism because, we suggest, it has brought about the very need for evolutionary information systems.

Post-modernism has its origins in art (Bjørn-Anderson, 1988). It arises from artists' concern with understanding what constitutes a "proper" piece of art, and their attempt to explore beyond traditional ideals and style. In science, the affect of post-modernism among some researchers has been to abandon the search for a grand theory that explains all physical phenomenon. In the social sciences, researchers now accept that there is no one theory or no one right theory. Rather, they argue that all perspectives are equally acceptable. Consequently, a central theme in post-modernism is relativism. Relativism is the view that there is no objective reality that can somehow be understood and accounted for and then allow us thereby to control it. Our perception of reality is unique to us and is as valid as anybody else's in the post-modern world.

The implications of this view of society, science and organisations for information systems evaluation is that such systems are not objective entities that can be measured independently of their users or contexts. Most of the evaluation techniques developed to date would be inadequate because they are based on an objective view of reality. A view in which benefits can be identified as separate from their users and quantified independently of the users' perceptions. We posit that post-modernist ideas permeate our society and organisations such that they have affected the way in which information technology is used in them. In particular, that post-modernism is the cause for evolutionary information systems in organisations.

For the purposes of evaluating evolutionary information systems, the central theme of *interpretation* in post-modernist thinking is relevant. As reality itself is understood relatively, it requires the act of interpretation of reality to act in the world. Each person or group interprets phenomena individually. Consequently, in the context of post-modernism, there can be no objective evaluation. The evaluation act itself is to be thought of as an interpretation of the value of an information system to the person or group using it.

Whilst an understanding of post-modernism enables us to set the context in which to think about evaluating evolutionary information systems, we require a philosophical basis for thinking about them generally. In particular, the work of the German philosopher Martin Heidegger is relevant (Dreyfus, 1994). Heidegger's ontological consideration of human *being* has a resonance with the notion of evolving information systems. In systems development terms, the need for system evolution arises because new information requirements arise. This commonly observed phenomenon in information systems development practice is stated in Heideggerian terms as: "Every decision...bases itself in something not mastered, something concealed, confusing; else it would never be a decision". Thus the very act of developing information systems on pre-determined systems requirements leaves the developer with having to tackle "...something not mastered, something concealed, confusing..."

The need for evolutionary information systems may be explained in Heideggerian terms too. Heidegger attempts to understand how something (person or thing) is or what it means for something to be. For Heidegger something is because of *Dasein* or being. Humans acting in the world do so because of and through *Dasein*, but they are not cognisant of it. Yet they have to act in the world to be it. It is this non-transparent being-in-the-world which gives rise for constant striving to be – or in information systems terms emergent information or evolutionary information systems. The

method, which Heidegger puts forward for understanding human being, is phenomenology.

Based on post-modernist thinking and phenomenology, Ciborra (1997) proposes a re-conception of information systems based on *improvisation*. He argues that:

"A small Copernican revolution is suggested: competent actions which seem improvised are in reality deeply rooted, while structured decisions based on abstract representations and models appear to be improvised, i.e. lacking any relationship to context." p.138.

The reference to 'deeply rooted' human actions is often supported by information that is contextually rich, and we suggest that such information is made available through evolutionary information systems. There are issues that arise from viewing organisations as post-modernists. They concern the social, contextual and situated nature of organisational activity, which evolutionary information systems cater for.

### 4. EVOLUTIONARY INFORMATION SYSTEMS

Research into evolutionary systems development and types of evolutionary information systems has been prompted by conceptions of business as processes, business uncertainties and organisational change. In this section, we provide examples of both evolutionary information systems development and evolutionary information systems *per se*.

#### 4.1 Evolutionary Systems Development

Software developers have attempted to meet the challenges of the modern organisation. The challenges are conceptual and practical. Conceptually, researchers have attempted to conceive systems development as flexible or evolvable. Practically, they have proposed or implemented such methods.

There are various systems development methods that can be categorised as evolutionary systems development. These methods attempt to develop software that is appropriate to the needs of its users, and some incorporate organisational uncertainty. The methods are prototyping (Bowen, 1994), rapid application development (Martin, 1992), component based development (Jacobson et al., 1997), and the incorporation of flexibility in development methods (Fitzgerald, 1990 and Boogaard, 1994). In addition, Pressman (1997) details the incremental model, the spiral model, the component assembly model, and the concurrent development model as evolutionary software process models.

Researchers have investigated ways to evolve software processes (Lehman 1980; 1984; Conradi, 1994). Such research has been prompted by the needs of business process re-engineering and the need to model commensurate software processes (Warboys, 1994). Some programming languages facilitate flexibility, especially on the World Wide Web. For example, the recent announcements by W3C to make an extensible mark up language for the Web in the form of XML (W3C Consortium, 1999).

Patel (1999) has proposed the spiral of change model of tailorable information systems development. It is conceived to enable contextual and situated aspects of individual and organisational work to be incorporated in an interpretative way into information systems development and usage. Patel and Irani (1999) suggest ways of evaluating tailorable information systems that evolve. On a conceptual level, Paul (1993) has suggested the development of 'living systems' and proposes various development frameworks for such systems.

We suggest that all such developments, to varying degrees, reflect the needs of modern organisations as processes that change and which have to respond to uncertainties.

#### 4.2 Examples of Evolutionary Information Systems

The examples of evolutionary information we cite in this section are reflective of modern organisations. They enable individuals or groups to tailor information to suite their purposes, and to that extent allow interpretative use of data and information. They also enable their users to react speedily to market demands. A defining characteristic of these systems is that they do not have the problematic phase of requirement definition as a prerequisite for design and development. Such systems, amongst meeting other individual and organisational needs, are designed to stay relevant in changing business environments.

For example, Pawson et. el. (1995) discuss 'expressive systems' that reduce the time to market and help tailor products and services to custom-

ers' needs, as well as be more responsive to unexpected events. The actual system, named Kapital, is used on the derivatives floor at J.P. Morgan in New York. Traders using Kapital can choose the user interface that suites them, perform financial analytical calculations using mathematical models, and use real-time data from current market conditions. As Pawson et al state:

"However, what really distinguishes Kapital from other information systems is not the technology, but the fact that it does not attempt to fulfill a specified set of user requirements – at least in the conventional sense. Rather, Kapital attempts to model the very 'language' of J.P. Morgan's trading business – not only the vocabulary, but also the grammar and, arguable, the style." p.41

Weiser (1991) presents Xerox PARC's 'ubiquitous computing' research program, and Newman et al., (1991) identify the 'Forget-me-not' application at EuroPARC. These systems capture electronically current events and occurrences in the organisation and make them available for future use. Such systems cannot be evaluated ex ante because their potential use is unspecified at the time of capture of data – location, time, document, a picture, a conversation.

Patel (1999) introduces the notion of 'tailorable information systems', which are designed to enable users to tailor systems to particular contexts and situations. Tailorable information systems are not based on predetermined systems requirements, and aim to fulfill information requirements in an emerging fashion.

Tailorable computer systems enable their users to tailor their use to individual or group needs. The "Xerox Tailorable Buttons" system is appropriately described by MacLean et al. (1990) as a user tailorable system. They devised simple models of users and utilised participatory design methods. Xerox Tailorable Buttons uses object oriented design and object implementation, and provided users with user-interfaces consisting of tailorable "Buttons". The system was interfaced with an email system so that user-tailored systems functionality designs and implementations may be shared among users. MacLean et al (1990) state that users can tailor Xerox Buttons on different levels with different systems properties and systems consequences, ranging from simple windows customisation on a desktop interface, to complex user-programming using fifth generation languages. They cite unique and idiosyncratic uses of the system, as well as uses to support co-operative work.

## 5. ISSUES IN EVALUATING EVOLUTIONARY IS

To understand how to evaluate evolutionary information systems it is necessary to identify their pertinent features. In this section we explore such features which would have to be considered when deciding on what to evaluate and how to do it.

A central issue in developing any approach to evaluating evolutionary information systems concerns requirement analysis. In evolutionary information systems there is an absence of requirement analysis as practised by current developers and advocated by researchers and academics. The Kapital (Pawson et al., 1995) and 'Forget-Me-Not' (Newman, 1991) systems we cited above were not built with a set of pre-determined requirements. Evolutionary information systems that are built in the absence of pre-determined requirements cannot be evaluated using ex ante or ex post evaluation, since there would be nothing to compare the outcome with.

Another important feature of evolutionary systems is that they are continuous and continual processes. A traditional information system is considered completed once the business project to develop it is terminated. Tailorable information systems (Patel, 1999) would not similarly be considered as completed. Users (and developers) continuously develop tailorable systems in the context of their use. It becomes problematic to decide when to evaluate systems that are being continuously developed.

Evolutionary systems are interpreted entities. Individuals and groups interpret them in the sense that changes made to them are done to reflect organisational change and context. Interpretation of information systems is closely tied to the concept of emergence (see Ali and Zimmer, 1998 for discussion on emergence in artificial systems.) As systems developers begin to design information systems that facilitate emergence, as in the case of the Kapital system, it becomes necessary to develop appropriate evaluation approaches. Emergent properties cannot be predicted and they happen in context, making ex ante evaluation unsuitable for evolutionary information systems. Other features of evolutionary information systems such

as functionality changes, relevance at a particular time, provision of contextual and situated data, and use in the future, mean that a radically alternative evaluation approach is required.

Evolutionary information systems are actively used and developed, they are ongoing, and provide utility to their users at the time of use. The notion of utility is an important feature of evolutionary information systems, especially in the context of post-modernist thinking. Measuring the utility of such systems to knowledge workers may be difficult, because as Drucker (1993) states:

"One has to assume, first, that the individual human being at work knows better than anyone else what makes him or her more productive, and what is helpful or unhelpful." p. 24

Evolutionary systems development is a processes of co-creation and co-evolution of systems. Professional developers and users develop systems, but, significantly, the power shifts to users, because as Drucker (1993) states they "know better than anyone else" what is required.

## 6. AN APPROACH TO EVALUATING EVOLUTIONARY IS

Ex ante and ex post evaluation is not suitable for evolutionary systems development and evolutionary information systems. Systems such as Kapital, Xerox Buttons, and Forget-me-not, cited above, undoubtedly contribute to individual and organisational performance. Yet it is certain that they would have been considered doubtful projects using ex ante evaluation techniques because of the unforeseen benefits. In this section we integrate the salient features of evolutionary information system discussed above, and introduce other features, to suggest aspects of an approach for evaluating evolutionary information systems. Like Bjørn-Anderson (1988) below, we do not propose our way or one way, we simply add to our communal understanding of the matter.

We suggest that evaluation of evolutionary information systems should be based around concepts that reflect post-modernism, business processes and organisational uncertainty and change. In an early paper, Bjørn-Anderson (1988), told a "number of small stories" concerning post-modernist ideas and technology assessment. In the essay, he provides an informative overview of post-modernism, and considers its influence on technology assessment and information systems evaluation. He adheres to the post-modernist style and states that

"...my presentation (in a true post-modernist sense) does not serve any utilitarian purpose. The value of it, if any, is in the experience it creates in the mind of the listener." (p.11)

However, he does offer an number of insights that post-modernism provides for information systems evaluation. One, that no single solution should be acceptable, and that a multiplicity of perspectives should be encouraged and accommodated. Two, that pure data analysis may not reveal underlying truths or patterns, simply because there are none. Three that the phenomenological experience in the mind of users of systems is equally as important as other evaluation criteria. Four, that we should explore other fields such as art to inspire us to use different, experimental evaluation approaches. Finally, that post modernist concepts such as recycling, re-user, patch-working, and borrowing may be valuable in information systems evaluation.

First, what should be evaluated? It is certain that in evolutionary systems context and value or utility is important. The Kapital system enables its users to react to market demands by enabling new products and services to be designed using it. Much of the data capture and analysis occurs at the time and in the context of its use. Context and utility are this important aspects of the evaluation process.

Second, how should evolutionary information systems be evaluated? We discussed above that the interpretations individuals and groups place on the systems they use are an important feature of evolutionary information systems, and that such interpretations occur in context and in an ongoing manner. Formative and continuous participative evaluation would be required for such systems. In art form is considered to be a style or mode of expression, opposite of content or orderly arrangement of components. As interpretations, evolutionary information systems should similarly be evaluated according to their form in the organisation.

Third, who should do the evaluation? Though participative evaluation is suited for evolutionary information systems, given the innovative and strategic nature of typical evolutionary IS and their penetration into the core of organisational functioning, one could argue that a high-level, broad



perspective is needed to assess the system’s implications for the business. Such a broad perspective can be brought into the evaluation only at a relatively high level in the organisational hierarchy. However, we would also argue that user involvement is also critical but mainly for ensuring acceptance and reducing resistance to change.

Other issues to consider in any approach to evaluating evolutionary information systems are : the involvement of all stakeholders, a focus on the wide range of benefits both tangible and intangible, and accommodate change in the evaluation parameters.

Some existing evaluation techniques that could be extended to incorporate the issues discussed above are worth mentioning. These techniques can be compared along the dimensions of complexity, communication, quantification and facilities as shown in Table 1 below.

Fisher (1995) compares traditional approaches to information technology decision-making and shows that Information Economics focuses in change. As such Information Economics would be suitable, but it would need to be re-based on interpretative grounds. Experimental evaluation techniques like prototyping and simulation would be appropriate for the continuous aspects of evolutionary information systems. The Multi-Objective Multi-Criteria technique would be accommodate the interpretative aspects of evolutionary systems, and facilitate the post-modernist notion of all perspectives being equally acceptable. Similarly, the Value Analysis technique would be suitable. However, we would add that those techniques that initially seem appropriate may need to be further enhanced to address the unique requirements of evolutionary systems.

**7. CONCLUSIONS AND FURTHER RESEARCH**

We contend that there are evolutionary information systems that are at present not evaluated. We have couched such systems in the context of post-modernist thinking. In doing so, we have identified characteristics of modern economies and companies such as processes, uncertainty and change. We have posited that information technology is used in this context and that it needs to be flexible, or in our terms, evolutionary. We have provided examples of evolutionary systems development and evolutionary information systems that are indicative of this trend.

We have identified salient features of such systems and shown how they may be used to construct an approach to evaluating them. We do not think that benchmarks can be set for evolutionary systems. On the contrary, in the context of post-modernist thinking we have suggested that individuals and groups would be best suited to decide the utility or value they derive from evolutionary systems.

Table 1: A Comparison of IS Evaluation Methods

Method	Complexity	Communication	Quantification	Facilities
DCF Methods (NPV, ROI, IRR)	<ul style="list-style-type: none"> <li>• Easy to understand</li> <li>• Large amounts of data required</li> <li>• Focus only on cash flows</li> </ul>	<ul style="list-style-type: none"> <li>• Easy to learn</li> <li>• Easy to communicate</li> </ul>	<ul style="list-style-type: none"> <li>• Precise</li> <li>• Only monetary values</li> </ul>	<ul style="list-style-type: none"> <li>• Some risk analysis (discount factor)</li> </ul>
CBA, SESAME	<ul style="list-style-type: none"> <li>• Similar to DCF</li> <li>• Intangibles taken into account</li> </ul>	<ul style="list-style-type: none"> <li>• May involve controversy &amp; discussion</li> </ul>	<ul style="list-style-type: none"> <li>• Similar to DCF</li> </ul>	<ul style="list-style-type: none"> <li>• Similar to DCF</li> </ul>
ROM	<ul style="list-style-type: none"> <li>• Low data requirements</li> </ul>	<ul style="list-style-type: none"> <li>• Difficult to learn, apply, &amp; communicate</li> </ul>	<ul style="list-style-type: none"> <li>• Precise (accounting data)</li> </ul>	<ul style="list-style-type: none"> <li>• Targeted to MIS</li> <li>• Suitable only for <i>ex post</i> evaluation</li> </ul>
IE	<ul style="list-style-type: none"> <li>• Large amounts of data required</li> <li>• Considerable expertise &amp; resources required</li> </ul>	<ul style="list-style-type: none"> <li>• Difficult to learn and apply</li> </ul>	<ul style="list-style-type: none"> <li>• Precise measurement of tangibles, as well as ranking &amp; rating of intangibles</li> </ul>	<ul style="list-style-type: none"> <li>• Considerable risk analysis at all levels</li> </ul>
MOMC methods, Value Analysis	<ul style="list-style-type: none"> <li>• Medium data requirements</li> <li>• Focus on subjective measures of utility</li> </ul>	<ul style="list-style-type: none"> <li>• Subjective and exploratory methods, involving discussion &amp; controversy</li> </ul>	<ul style="list-style-type: none"> <li>• Subjective, non-monetary measures</li> </ul>	<ul style="list-style-type: none"> <li>• Stakeholder analysis</li> </ul>
Prototyping	<ul style="list-style-type: none"> <li>• Limited-scale system development required</li> </ul>	<ul style="list-style-type: none"> <li>• Based on real data on system impacts</li> </ul>	<ul style="list-style-type: none"> <li>• Precise</li> </ul>	<ul style="list-style-type: none"> <li>• Congruent with IS development</li> </ul>
Simulation	<ul style="list-style-type: none"> <li>• Large amounts of data required</li> </ul>	<ul style="list-style-type: none"> <li>• Expertise required in applying</li> <li>• Easy to communicate</li> </ul>	<ul style="list-style-type: none"> <li>• Precise (numerical) estimates</li> </ul>	<ul style="list-style-type: none"> <li>• What-if analysis</li> <li>• Sensitivity analysis</li> <li>• Experimental control</li> </ul>

KEY: DCF = Discounted Cash Flow  
 ROI = Return on Investment  
 CBA = Cost-Benefit Analysis  
 IE = Information Economics

NPV = Net Present Value  
 IRR = Internal Rate of Return  
 ROM = Return on Management  
 MOMC = Multi-Objective, Multi-Criteria

Farbey et al (1995) state that that IS evaluation can be ex ante, ex post or throughout the life of a system. We posit that in evolutionary information systems evaluation should be done throughout the system’s life. However, we emphasis that monitoring and control is critical, and that evaluation of evolutionary IS should include the management of benefits, risks and costs.

Our discussion has implications for research. As interpretation (utility and value, context and change) is an important aspect of evolutionary information systems, we argue that interpretative notions of evaluation need to be researched. Interpretative research into evolutionary systems cannot be a simple extension of the current research in qualitative techniques. Such research in based on the modernist view of society. Rather interpretative research would need to be based on the post-modernist view of society and consider phenomenology as a method of research (Husserl, 1970).

In particular, the hermeneutic method of understanding is appropriate for evaluating evolutionary information systems. As Introna (1993) states, hermeneutic understanding is:

“Understanding that comes into being by active (in the situation) interpretation, thus based on lived experience (*Erlebnis*) not on removed contemplation;  
 Always within a context and coloured by that context;  
 Part of the history and tradition of the person and the organisation;  
 The act of appropriate, thus genuinely making one’s own what was initially alien.”

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