On information, information technology and the development of society: an information science perspective

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Abstract

Information technology (IT) is being considered one of the current key factors shaping the present societies. The paper presents an outline of the research on its impacts on society and focuses on its impacts on professional/scientific communication, information seeking and use, and information systems design which are most relevant to traditional information science. The complex relations between information and professional/scientific work are discussed as well as factors contributing to this complexity. Secondly, a typology of (work-internal) impacts of IT on work is presented and contrasted to the external impacts (e.g. efficiency, job satisfaction). It is argued that the current contradictory research results concerned with the external impacts can be resolved (in part) by carefully recognizing the underlying internal impacts in each study. It is further argued that each technology has its typical possible impacts on work. Thirdly, the author presents an abstract internal-factors model as a conceptual framework for research on the relations between information, IT and professional/scientific work. Understanding the factors of this model and their potential interaction is crucial for any rational attempt to investigate information services, systems, use or seeking for professional/scientific work.

1. INTRODUCTION

The development of the present-day societies is leading to post-industrial societies, information societies or paperless societies. Although the concept of the future information society is very ambiguous, vague, technology-centred and also ideological, there is a general agreement that information and information technology (IT) are essential both as phenomena in the information society and as factors shaping the present-day societies toward the information society. During the past two decades the impact of IT on society has been analyzed in many studies concerning individual or worker-level changes in work, changes in organizations and society-wide changes in employment, democracy and power structures. Yet it seems fair to say that a well-developed body of knowledge on
this area is missing - the results seem fragmented, superficial and/or contradictory.

1.1 Previous studies

In the social sciences there have been many studies on job satisfaction, job design, the deskilling vs. upgrading and related impacts of IT on the individual level (reviewed in (1)). These have been augmented by more information systems design motivated studies on the individual level (2,3). In both study areas clerical or office workers have received most attention. The latter was traditionally quite technology-centred, e.g. viewing jobs as what remains outside edp-systems. However, since the mid-seventies much has happened in this respect. Management decision-makers in their semistructured tasks have been studied in the decision support systems (DSS) area (4,5). In all these areas the human side of the man-machine interface is difficult and poorly understood - as put by Jacques Vallee, "there ain't no user science" (6). The evidence acquired in the studies has been quite contradictory (1).

On the organizational level changes in the organization structures, power structures, management, and customer relations due to IT have been studied. For example, some studies have indicated that IT weakens the position of middle management while other studies indicate the opposite. Such contradictions are true of the whole organizational level study area (1).

On the society-wide level issues like the information occupations and their development, unemployment, the balance of the national economy, the vulnerability of the society, democracy, participation, privacy, and power have been debated. There are optimists and pessimists, utopians and anti-utopians - and statistics supporting all of the views. For example, although many definitions of the information society are related to the proportion of information occupations in the labour structure, this concept has been found to be very ambiguous and difficult to classify reliably (7). Moreover, from an information science point-of-view it is at least problematic to consider only information producing occupations as opposed to information consuming occupations (e.g. dentists) in the statistics.

The traditional interest areas of information science have been (in broad terms) scientific or professional communication; information needs, seeking and utilization; and the design and operation of information systems or services in order to enhance scientific or professional communication. Although some definitions have been more general with respect to the types of communication of interest (8) this (elitist) concentration on scientific/professional communication characterizes information science well. From this point of view the social science, economic and man-machine studies have very little to offer because of the focus on non-professional work and/or information production as opposed to its use. Let us make a short review of the contributions of information science itself on the relations of information, IT and professional/scientific work.

Information needs and seeking of scientists and professionals of various types have received much attention in information science since the fifties (for reviews see e.g. 9,10,11). The vast majority of this research has focused on the use of various channels of information supply, and even here mainly on the library/information service institution. This study area has suffered from conceptual and methodological problems, lack of cumulation of results and has been useless for the analysis and design of information services/systems (9,12,13). In information science, relatively little work has been done on understanding/modelling of scientific/professional work (e.g. 14,15) or the impacts of IT on it (e.g. 12). In summary, many contributions by this area to the research on information, IT and professional/scientific work should not be expected.

The information service/system design research in information science is not much better off. The main effort has been in the enhancement of existing (mainly bibliographic) services/systems, and their relevance and (lack of) importance to scientific/professional work has not been analyzed. Rather, the user's work has been treated as a black box that, for some irrational reason, all too rarely produces queries for documents or references (16,17). Systems analysis (13,15) and action research (18,19) have provided usable novel approaches to the design and evolution of information services/systems. However, there is no firm knowledge base on the relations of information, IT and professional/scientific work.

Knowledge utilization and innovations have also been studied in information science using social science approaches (e.g. 20, 21,22,23,24). According to Caplan's recent review (22) too much of this research has concentrated on "factors affecting" utilization with irrelevant or misleading results. Utilization should be investigated as a phenomenon in its own right. Progress in this area requires a new level of scientific maturity accompanied by an understanding that utilization does not happen in a vacuum, that work itself is not a steady-state process (leading to steady-state utilization), and that manifest utilization is just one part of the phenomenon (22). In summary, this research is not likely to clarify the relations of information, IT and professional/scientific work.
1.2 Framework of the present analysis

Our problem in this study is the impact of information and IT on professional/scientific work which is motivated from the information science point-of-view and represents one area of social development, which we call micro-level social development. Work-specific, micro-level research is necessary in order to understand the phenomena (e.g. 16,25). Concentration on professional/scientific work does not mean concentration on fringe areas of social development: the statistics (e.g. 26) show that about one third of the information producing occupations consist of non-routine work - that is, generally ten to twenty per cent of the total labour force. By taking the non-routine information-consuming occupations into account the figures would grow larger. Moreover, it is obvious that the non-routine occupations are essential objects of study in any research on social development (in general).

Our review (above) on the study areas potentially contributing to the analysis of the relations of information, IT and professional/scientific work indicate that the phenomenon is now well understood. Much of the research is irrelevant and/or of no use, although there are some relatively recent positive developments: DSS-research, action research and systems analysis, and an understanding that the present situation is unsatisfactory. It is clear that nobody can change this situation in one study. Therefore, our aim in this paper is to contribute a better understanding of the problem, the complexity of the potential interactions of information, IT and professional/scientific work, and to contrast it to previous approaches. We try to decompose work, information, IT and their effects into unlike components, types and or phases, and to point out these as sources of variation in the problem area, sources which must not be mixed and treated as a whole. We argue strongly that different types of information can be supported to different degrees by different types of IT and that different types of information have different types of relevance to, and impacts on, different types of work. We shall present an abstract understanding model on the relations of information, IT and professional/scientific work. Understanding the components of this model and their interaction is crucial for any rational attempt to investigate information use, seeking or services/systems for professional/scientific work.

We base our arguments and analyses on relating the findings, problems and approaches of the above-mentioned study areas from a problem-solving point-of-view. We have not conducted empirical studies to support our arguments. Some empirical studies by other researchers can be used to some degree. However, we mainly try to convince the reader by logical, obvious arguments. This is sufficient for outlining an approach or defining a problem. It is obvious that we can only hypothesize empirical impacts on this basis.

We shall not consider the future of scientific/professional publishing and communication - we concentrate on the information seeking/receiving end of the communication process. The electronic publishing studies provide scenario's for the future of communication (e.g. 27,28). In Section 2 we shall consider the relations of information and work and sources of variation in these relations. These are analyzed in the context of planning and decision making. In Section 3 we shall typologize the internal impacts of IT on work with examples from the library and information service work and compare them to the external impacts of IT (e.g. efficiency, job satisfaction). The complexity of the impacts is pointed out. The abstract understanding model on the relations of information, IT and professional/scientific work is presented in Section 4. Section 5 contains the conclusions.

2. INFORMATION AND WORK: SOURCES OF VARIATION IN THEIR RELATIONS

Our thesis in this section is that the traditional approaches of information science, and more generally of social science, to the relations of information and work have been insufficient, have been concerned with the external relations rather than internal impacts: both have been treated largely as steady-state phenomena. This is not a totally new thesis: Caplan (22) and Rich (29) have complained of this in the context of knowledge utilization research, and ourselves in the context of information-seeking research (16). We shall consider this thesis with respect to information in planning and decision-making, and restructure and complete earlier arguments on the sources of variation in their relations. Information technology as a source is discussed in Section 3.

Management planning and decision-making were chosen to be the sample context of our analysis for the following reasons:

- generality: many types of professional/scientific work can be seen as planning and decision-making (or roughly equivalently, as problem-solving);
- relevance: information science is oriented toward persons who have problems in their work rather than toward clerks performing routines; planning and decision-making are inherently non-routine;
- fruitfulness: planning and decision-making reflect all the difficulties in work upon which information and IT may have an effect.
Rich (29) argues that each manager has a personal problem-solving style in planning and decision-making. The following five factors were identified as contributing to the formation of this style:

1. Manager's background, education and experience,
2. His information-processing style,
3. His responsibilities,
4. His level within the organization, and
5. Types of information.

Rich discusses these factors at some length and gives somewhat unstructured and sketch, although relevant, examples on each of them. We shall reconsider the last four factors, or sources of variation, in more detail. At the same time we rename the items three and four to be 'the types of tasks of the manager' and 'problem complexity', respectively. We shall consider these factors in reverse order.

2.1 Types of information

The concept of information is a swampland for anybody trying to define it unless he considers the Shannon-Weaver model solely for message transmission purposes. There are approaches from those considering structural aspects to those considering knowledge, messages, meaning, effects and process (8). The following three conceptualizations are relevant from the decision-making point-of-view no matter whether one considers information as representations on some media or as interpretations of these representations in somebody's mind. The conceptualizations are also relevant in the knowledge, effects and process approaches as defined in (8).

Hard vs. soft information (knowledge). Factual information, statistics and simple statistical analyses represent hard information, generally couched in quantitative terms and in scientific language. Soft information contains qualitative data, non-research based information, common sense, and general knowledge, expressed in non-scientific language. The use of the former in decision-making is a lot easier to observe; decision-makers seek for hard information when their initial soft information is not sufficient to push them through the decision-making situation. On the contrary, the use of soft information is difficult to observe, although its impact on decision-making is more all-encompassing than that of the hard information. Hard information may have an impact, but not necessarily an essential one - it may be used only to check the preconviction of the decision-maker (21,29).

Neutral vs. persuasive information. Objective research that seeks the truth provides the most neutral information. It is not sufficient in decision-making. Persuasive information has many degrees of persuasion: the decision-maker's own, and his organization's values, goals and perspective; public opinion, information supplied by pressure groups and information on the political consequences and usability of alternative courses of action (pressure groups and political should be understood broadly, i.e., not covering only national level party politics but also similar phenomena in enterprises etc.). Obviously decision makers are sensitive in different degrees to various sources of persuasive information (adapted and structured from (21,29).

Problem information vs. domain information vs. problem-solving information (or knowledge, respectively). This conceptualization has its roots in the literature on problem-solving and artificial intelligence. The three concepts are orthogonal, the first one representing information on the structure and requirements of the problem to be solved, the second one the facts, relations, theories and laws known about the domain of the problem, and the third, methodological knowledge on problem-solving or problem treatment. It is obvious that they have sharply differing roles in, and impact on, decision-making.

Further conceptualizations could be given, e.g. on the basis of domains of operation (marketing information vs. budgeting information vs. ... (29)). However, even the three given above are sufficient to demonstrate that:
- there are many different types of information associated with decision-making;
- different types of information have different roles in, and impacts on, decision-making;
- different types of information quite probably have different sources and require different means of supply;
- all types of information are probably not amenable to systematic treatment.

2.2 Types of problems

Problems may differ from each other with respect to many dimensions. Perhaps the most common conceptualization is concerned with characterising genuine, proper problems (or wicked problems (13)) as opposed to routines. Genuine problems are typically complex, and the goal or result of problem-solving the problem treatment procedure, and the starting point of problem treatment (i.e. the current situation) are typically ill-defined or undefined, whereas routine problems are characterized by the opposite properties. (The term problem treatment is used to reflect the fact that problems are not always solved.) This dimension correlates to the organizational level of the decision-makers so that top managers deal regularly with genuine problems while low level managers deal more with routines. The
The following outline of different types of tasks in decisionmaking is based on characterization of the result of various tasks. We have extended and restructured the outline in (29):
the relations of information and work. In all cases we ended up with propositions stressing differences, e.g. that different types of information are relevant to different degrees in different types of problem situations which occur differently in different types of tasks and for different types of decision-makers. These sources of variation are internal to the decision-making process as opposed to external factors e.g. organizational climate or bureaucratic policies, which indirectly affect the process. The latter are analogous to the (external) factors affecting information needs in, for example, (21).

Caplan calls for more scientific maturity in knowledge utilization research in (22), where he presents a matrix for structuring the studies in the area. The dimensions of the matrix are task type (three classes) and uncertainty (four classes) which roughly corresponds to the problems in our terms. We want to join the call with our more complex set of dimensions, to which we still have to add one dimension: IT.

3 INFORMATION TECHNOLOGY AND WORK: INTERNAL AND EXTERNAL IMPACTS, AND RECOMMENDATIONS

In this section we shall present a typology of the impacts of IT on work processes, that is, a typology of the internal impacts of IT on work. The presentation is an extension of (16), and will be given with illustrations from library and information service work. Thereafter we shall review some of the literature concerning the external impacts of IT on work, e.g. efficiency and job satisfaction impacts. The section is concluded with a discussion on the complexity of the impacts and design recommendations.

3.1 Internal impacts of IT: changes in the work process

It is obvious that IT changes work processes in many ways. By recognizing different types of change one might be able to analyze and explain different types of external impacts. In order to typologize the internal changes we shall first distinguish the primary sub-processes of work from the logistic ones. The latter are often called administrative tasks: they are necessary to ensure resources (e.g. money, information, food) for the work, while the former are immediately responsible for the end-products or the achievement of goals. Among the primary sub-processes we have identified five types of possible change. In the order of increasing thoroughness:

- change of implementation,
- change of method or content,
- change of the level of optimality,
- change of the criteria of goodness,
- change of the ultimate goal.
Change of implementation. Essentially, the same method of performing the work is here implemented in a new way, thereby replacing perhaps an old manual procedure with a computerized one. The functions performed are essentially the same. Instead of doing the job himself, the worker controls an automatic process for at least some of his time. There are numerous examples in the library and information service area, e.g. computerized catalogue production.

Change of method or content. This type of change brings new methods to the work process and/or deletes old ones; that is, the old goal is aimed at with new methods. The new methods may be employed by the worker or by the IT-based tools, or both. The prevailing ideology of developing EDI-systems has been that old routines should not be automated plainly as such; things can be done in a new way and new by-products can be produced. Automatic indexing is a new method of assigning index terms to documents - it is logically different from manual indexing. Possible new by-products are exemplified by the statistics available from computerized catalogues.

Change of the level of optimality. Insufficient resources or time may mean that the work process has essentially been 'muddling through' to reach some solution or result. IT may increase the worker's capacity so that he can create and evaluate more candidate solutions and even try to identify the optimal one. This means that the emphasis of the worker's tasks shifts toward creation of relevant alternatives. On-line Boolean search systems have provided a new possibility of optimizing recall and precision in bibliographic retrieval.

Change of the criteria of goodness. Increased capabilities may mean that formerly unrecognized or impossible criteria for the evaluation of candidate solutions emerge. Good cars are nowadays aerodynamic and have a good mileage per gallon of gas. It wasn't so in the sixties! Such changes may cause changes also in the implementation, methods and optimality levels of work. As an example, consider citation indexing. It would be quite impossible without computers. These indices introduce a new criterion of relevance: citation, instead of matching keywords.

The final change type is the change of the ultimate goals. Some technological innovations may provide final or total solutions to former critical problems of work, thereby fostering the evolution of problems. Technology has caused such changes throughout history. For example, 'number crunching' programs are effective tools in finding the zeroes of complex functions. Such change types are common in research. I have no specific library example here.

Among the logistic sub-processes of work we shall concentrate on information-seeking. We have identified two types of changes, namely:
- change of the organization of the information sources, and
- change of the means of accessing (distributed) sources of information.
These changes are necessarily more technical than those of the primary processes. They have a direct impact on information-seeking.

Change of the organization of the sources. Some formerly manually accessible and/or distributed sources are assembled into a new whole. The whereabouts in information-seeking become different. Obvious examples are the large bibliographic databases and database systems/services, e.g. the Dialog retrieval service.

Change of means of accessing sources of information. The developments in communication technologies cause these changes. Computer telecommunication networks are relatively recent developments, and so are teleconferences. New means to access information are used and so they presumably serve some useful purpose.

We have argued elsewhere (12, 33) that different types of IT-based tools support in different ways the seeking of different types of information and that different types of tools are likely to cause different types of information needs due to different types of changes in the primary sub-processes. For example, implementation changes require knowledge for operating/controlling the tools; that is, only minor changes in problem-solving information. Other types of change alter the needs for all types of information more thoroughly.

It is probable that different types of change in work processes also have different external impacts. For example, implementation changes may improve efficiency but not effectiveness, and they may cause the 'deskilling' effect discussed in the next section. In general, implementation changes are relatively simple, whereas the work processes before and after a change of goals may have little in common.

3.2. External impacts of IT: the necessity of an analytic and holistic view

Proponents of IT see many positive external impacts attainable via the application of IT. For example, Alter has listed the following outcomes due to using decision support systems (5):
- increased personal efficiency,
- speedier problem solving,
- better or easier communication,
- better learning and training, and
- increased possibilities for planning and controlling the work process.

These are the potentials or promises which should lead to increased effectiveness. There is, however, no guarantee of reaching these outcomes. DSS-systems are really meant for semistructured decisions (non-routine but not genuine, either) so these promises may not be wholly relevant to other types of decisions (or problems). Moreover, these outcomes reflect only two dimensions of external effects, namely the quality and cost dimensions. There are other dimensions, e.g. skill requirements, stress, job satisfaction, and achievements in one dimension may be coupled by surprises in other dimensions. This was shown lucidly by Turner in a study of a large group of social workers (34).

In Turner's study the social workers all had a similar task to perform and the only difference between them was the type of computer interface they were using: one half of them were using a tedious time-sharing interface, with response times varying from eight minutes to ten hours, while the other half was using a fast and well-designed on-line interface. The hypothesis was that the on-line users would be more satisfied than the other group, solely due to the better interface which required less effort and speeded up their work. The findings were quite the opposite: the on-line users had more symptoms of stress and less job satisfaction than the other group. In addition, the on-line group made different decisions: they were more likely to reject their client's application for monetary support. The explanation is that the client interview was much more stressing than the tedious time-sharing interface which, in fact, provided an opportunity to relax a little. The two groups perceived their work and its environment in markedly different ways. Although the work process was quite structured, this example emphasizes the necessity of taking a holistic view on the impacts of IT: in this case the restructuring of work had more profound impacts than the cute on-line interface.

The necessity of an analytical approach is emphasized by the generally contradictory research results concerning the IT impacts on skill requirements (deskilling vs. upgrading), stress, job satisfaction and autonomy of workers (for a review, see (1)). These results may be due to insufficient analysis and comparison of the types of change IT has caused (or has been used to cause) in the particular situations under study. Our analysis of the relations of information and work and of the types of change IT may cause suggests that internal determinants like task type, problem type, information type, change type, etc., should be analyzed carefully. Concentration on the external impacts alone cannot increase our understanding on the impacts.

Generally the external impacts of IT on professional or scientific work, including non-routine decision-making, may be more positive than the impacts on routine work. The following reasons contribute to this:
- professionals or scientists have enough power and status to keep the application of IT under their own control;
- they cannot be forced to use tools they do not want;
- they are immediately responsible for, and their rewards depend directly on, their personal efficiency and effectiveness;
- they do not wish job enrichment nor enlargement; rather quite the opposite - they have more than enough problems;
- they are more receptive to learning even complicated procedures if the results are good.

3.3 IT and work: summary and recommendations

We have analyzed the types of change that IT may cause in work processes, and argued that understanding the external impacts of IT and resolving the contradictory results require a holistic perspective and careful analysis of the particular determinants of the case in terms of the sources of variation reported in Section 2 and Section 3.1. The relations of the determinants and the external impacts are obviously very complex. Therefore simple models or taxonomies of the impacts (e.g. (35)) are insufficient. Also partial models, e.g. our taxonomy of IT-based tools for the analysis of the impacts on information needs and seeking (12), fall short in the present case: types of problems, tasks and information-processing styles are missing.

The design of IT-based professional or scientific tools has to cope with the following limitations and difficulties:
- the designer and the user may be unable to give a functional specification for the tool,
- the user does not know what he wants and the designer
  does not know what the user needs,
- the user's understanding of his needs if influenced by
  the tools,
- the users have different styles of performing their work,
  which inhibits standardization (36),
- some problems or tasks cannot be supported by any tools,
- only some types of information may be relevant (29),
- differences: different determinants yield different outcomes.
Therefore the design procedure should be adapted to the following conditions and requirements:

- sensitivity to the sources of variation,
- there is no single best tool for all situations and all users,
- focus must be on changes in the work, not on the tools themselves (29),
- the tools must not be optimized irrespective of the context of their use (design-non-separability) (37),
- the designer and the users should work together so that both learn the requirements and possibilities (13),
- the process must be evolutionary (36).

4. AN ABSTRACT UNDERSTANDING MODEL

In the problem-solving literature, the definition of a problem situation consists of three items, namely the definitions of the target problem, treatment procedure and treatment resources (30). The problem is defined by stating the present situation, the goals and the resources available for striving toward the goals; there must be at least some uncertainty on how the goals can be achieved with the available resources. The treatment procedure defines how this uncertainty can be removed, i.e. it defines the steps of work of the problem-solver. The treatment resources are the resources available to the problem-solver to go through the treatment procedure, e.g. money, time, information, personnel, tools. We shall use this as a definition scheme for professional/scientific tasks or work.

In the types of professional/scientific work of interest to information science the three items defining the problem situations can be, and often are, ill-defined. The problem definition may be vague with respect to goals, the current situation and/or the resources; these may also be partially interdependent. Often the treatment procedure is to a large degree unknown at the beginning of the process: the more genuine the problem is, the more there is uncertainty on the relevant steps of problem treatment and the more there is need for problem-solving knowledge. If the treatment procedure is unknown then so are the resource requirements of the procedure.

In this paper we have focused on two types of resources: information and IT, and we have also considered work as consisting of primary and logistic sub-processes. If we consider only these two types of resource and only information-seeking among the logistic processes, we can redefine problem situations for our present purposes with the five components: the target problem, primary process, logistic process, IT and information.

The neat picture is not important here; we do not just want to say that everything influences everything else. The influences are there, as represented by the arcs in the picture, but we have already discussed them quite fully in the previous sections. To recapitulate:

- different types of information must be sought in different ways from different sources,
- can be supported to different degrees by different tools,
- have different usability, role and/or effects in the primary process,
- have different roles in shaping the target problem;
- different types of tools cause different types of change, i.e. some tools are relevant only in information-seeking while other tools may cause restructuring of the primary process or of the target problems.

To cover the remaining three arcs at the bottom: the primary process, information-seeking and the target problem must be adjusted to each other so that the process is valid and the target problem manageable.

We call this model an understanding model primarily because it does not say anything specific about particular situations of the real world. It tries to cover the relevant components and characterize their possible interactions so that essential interactions are not overlooked when analyzing the relations of
information, IT and work. It also emphasizes the feature, that changes in some components/relations propagate others and lead gradually to a more or less thorough restructuring of the whole work.

The components/interactions of the model are crucial in the analysis of the relations of information, IT and professional or scientific work. However, much needs to be done to ascertain empirically the specific relations of the components. Many hypotheses on the probable types of relations can readily be drawn from the model, e.g. what kind of tools have which types of effects in a given situation (see also (12)).

5. CONCLUSIONS

We have considered the relations of information, IT and professional/scientific work as one area of social development which is especially interesting to information science. We have discussed the complexity of the relations of information and work as well as the diversity of the impacts of IT on work. These emphasize the necessity of a holistic and analytic approach to the impacts of information and IT, analytic meaning the consideration of the external impacts on the basis of carefully recognized internal changes in the work process. Some of the contradictions of recent research results might be resolved in this way. We then presented an abstract understanding model of the internal impacts on work due to information and IT. All the components and interactions of the model are crucial in investigating the relations of information, IT and work. We have complicated the picture but think that the definition of the problem is better in this way.

Our general conclusion is that there is no single general impact of information or IT on work. IT provides technical alternatives - the impacts depend largely on the social choices which need to be made. However, the design of information services and systems is ineffective, and an understanding of the relevant design principles is unlikely to develop, unless a holistic and analytic approach to their impacts is assumed. The model is also applicable to information needs/seeking studies, service use (or non-use) studies, utilization research and, to some degree, to phenomena related to more routine work.

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