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**QUALITY SYSTEM
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Dear fans of quality,

Association for quality and standardization of Serbia in cooperation with the Center for quality of Faculty of Engineering Kragujevac, Center for Quality Faculty of Mechanical Engineering Podgorica, College of technical studies & technology Krusevac, Middle and South East European countries Quality Initiative, with support of Ministry of Education, Science and Technology, Accreditation Body of Serbia and Institute for Standardization of Serbia, continues the tradition of improvement quality infrastructure in the Republic of Serbia by organizing the 19th National and 5th international conference QUALITY SYSTEM CONDITION FOR SUCCESSFUL BUSINESS AND COMPETITIVENESS.

At this conference will be discussed about many topics, and the most significant we emphasize improvement of quality infrastructure, development and establishment of IMS - from practice to practice, path to business excellence, knowledge management, quality culture, innovation and quality, quality in the public sector, motivation and quality, audit and certification.

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- ☞ Examples of good practice - the strengths of the organization*
- ☞ Culture, Risks, Opportunities, Standards*
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On behalf of the Organizing Committee of the 19th National and 4th International scientific conference to thank to all article authors and co-authors, co-organizers, sponsors, participants from Serbia and abroad, and all who have helped to make this conference successfully.

President of the Organizing Committee

Professor Zoran Punoševac PhD

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XIX national and V international scientific conference

QUALITY SYSTEM CONDITIONS FOR SUCCESSFUL BUSINESS AND COMPETITIVENESS

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METODOLOGICAL APPROACH TO THE MEASUREMENT OF TECHNOLOGICAL COMPETENCE

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Abstract: The organization creates goods using its technology. It has emerged from the acceptance of existing technology in the market as well as the development of its own technology and technological knowledge, using them in various processes and projects. Technology is key to achieving competitive advantage on market thus is measuring of organizational technology competence and constant benchmarking with the industry's main competitors required to maintain market positions. Equally, measurement is needed to develop a technological strategy of organization and organization development strategy. Measurement is performed using developed tools to measure the current state of technological competence and organization's ability, and it also monitors accumulation and changes in organizational technology competencies over time.

Keywords: organization, technology, technological competence, measurement, accumulation of technological competence

JEL Classification: M1

1. INTRODUCTION

Organizations are struggling with their competitors at the market to sell their products to potential buyers. Those organizations that are more successful survive, and the rest disappear from the market. Technology creates competitive advantage, increases efficiency and productivity and reduces costs, and market forces displace those that do not accept the latest technology. That is why it is vital to be better than the competition. This means that a better product or a cheaper product should be delivered. Technology helps to reduce costs and produce more quality products, but it is possible to imitate or buy it, so it needs constant monitoring of technological development, comparing it with competitors, and constantly improving its own technology level to stay competitive. Technological changes triggered by the three industrial revolutions in the last two centuries have shifted the world from the Middle Ages to the modern era, entering the fourth industrial revolution. Technological changes become a generator of development and growth and a decisive factor in the long-term survival strategy in the market. Therefore, technological

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competence of companies is one of the main indicators of market survival. The aim of this paper is to present methods of measurement and monitoring of technological competence and direction of further research in order to create a generic framework for the assessment, analysis and monitoring of technological competencies of organizations.

2. ORGANISATION

The word organization comes from the Greek word *organon*, which means organ, tool, instrument, device or musical instrument. From the Greek word *organon* through Latin *organum*, it entered into all languages of the world as an internationally accepted term of organization. [16]

Organization is a business system that operates within the external and internal environment that affect the organization. The business system consists of input components (natural resources, people, capital, information), transformation (resource processing), output (goods and services) and management (planning, organization, influence, control) which manages the transformation process and responds to the challenges of internal and external environment. [5] Organization is a dynamic system with all key system elements and can be expressed as:

$S = \{E, a, r\}$, where:

- S – system,
- E- the sum of elements from E_1 to E_n provided that $E \geq 2$,
- a - attributes, system properties,
- r - relationships, links between system elements. [2]

A dominant view of the organization's position and success was, until the nineties of the twentieth century, through the structured approach of SCP (Structure-conduct-performance) from the theory of industrial organization. According to this model, competitive advantage is related to existing industry activities and the current market. The advantage to competitors in this approach is achieved through strategic positioning in the industry. The attractiveness of the industry and the relative position of the organization in that industry are measures of organization's success. [17]

Structural approach was replaced in the nineties of the twentieth century by the Resource-based view of the firm (RBV) because competitive positioning in existing industries became a secondary strategic issue due to the strong uncertainty and variability of the overall environment. Competitive struggle moves towards future markets or new activities that enable over-the-counter profits. [6] Organizations are turning to internal forces and by building their competences ensure their long-term survival in an unsafe and unpredictable environment. A resource-based approach to strategy starts with how the organization provides the necessary factors to create competencies and capabilities that are the basis for the development and maintenance of competitive advantage. In case of resource-based approach, the competitive advantage is the result of heterogeneity and immobility of resources and their asymmetric distribution in different industries. [8]

3. ORGANISATIONAL COMPETENCES

In the scope of the Resource-based view of the firm, many authors have dealt with the concept of organizational competence and technological competence, especially after Prahalad and Hamel (1990) published an article "The Core Competence of the Corporation." [13], defining their constituents and frameworks.

The organizational competence of integration is the competence of the individual and the technical, technological and organizational abilities that must adequately respond to the complex challenges of the organization's dynamic environment in a timely fashion. The particularly worth mentioning is the impact of intellectual (invisible) capital which largely covers the competence of employees, as well as technological and organizational ability of the organization. [1]

Intellectual capital is created, developed and maintained by the management of knowledge. Intellectual means that its source is in the human intellect. It has the potential to create surplus values, whose achievement depends on the success of managing it. Buntak [1] divides intellectual capital to:

- Human capital
- Structural (organizational) capital
- Relational (consumer) capital
- Intellectual property.

Today's organizations base their survival and development on intellectual capital. They turn to branding, image and good reputation. Good reputation requires from the organization a socially responsible behaviour, which will help achieve sustainable development in the environment in which the organization operates. [3]

Employee competencies are a set of knowledge, skills, attitudes, behaviours, personalities, experiences, and other personal characteristics that have a great effect on one's work. They are close to efficiency and can be measured using generally accepted standards. These are the abilities enabling successful performance of a specific task, activity or function. The organization should, through the systematization of workplaces, prescribe the necessary competences, such as the required education, the acquired knowledge and skills and personality traits for a particular job. [1]

The competence of an organization is constituted by the individual's competence as a proven ability to apply knowledge and skills, and the organization's competence to accomplish, through a process, system and organization's ability, the product or service according to the requirements set for that product or service.

The competence of an organization can be expressed as a set of competences of a human factor and the sum of key capabilities:

$Ko = \{Kljk, S, a, r\}$, where:

- Ko - the competence of an organization,
- $Kljk$ – the competence of human capital, i.e. employees,
- S – the sum of key capabilities (organizational, technical and technological) from S_1 to S_n provided that $S \geq 2$,
- a - attributes, system properties,
- r - relationships, links between system elements.

The competence of an organization reduces the coincidence or uncertainty in the process of managing in an uncertain dynamic environment. With documentation and manageability, it has become one of the three key management features for achieving sustainable success according to the concept of quality management system. [2]

4. TECHNICAL COMPETENCE

Technological competence plays a key role in maintaining competitive advantage in the turbulent industry. Technology is, as the concept of evolutionary organizational learning, based on the development of a strategy. Building, maintaining and enhancing competitive advantage is the strategic goal of every organization. Competitive advantages are associated with the ability to manage technological resources and manage various types of visible and invisible assets, such as technological knowledge. By developing a strategy, there is interaction between technological abilities and competences and the interaction of the strategy itself and the experience gained through the implementation of the strategy. Experience serves as feedback to correct skills and competences, as well as technology strategy itself in terms of creating and improving competitive

advantages. [8] Competencies include organizing the organization's specific technology and manufacturing technology while organizing skills are specific business practices, processes and cultures. [11] Malerba and Marengo, researching the Italian manufacturing sector, found a positive link between technological competence and business profitability in the high technology sector and they consider that technological competence is most relevant to achieving long-term competitiveness of the organization. [10] In relation to knowledge, which is general, the technology is specific to individual products and processes. It can become materialized in materials and people, in physical processes, in cognitive processes, in equipment and tools, in factories. It is the end result of development activities and the practical application of inventions and innovations. The key technological elements can be implicit, so they are difficult to imitate and copy. [8]

Technological competence implies the internal organizational ability to understand, use and exploit the relevant technology. They enable the organization to be a market pioneer through the development of new products or the use of new production processes. [15]

Technological competence of an organization, as part of a larger system, plays a key role in explaining different phenomena such as globalization, technological discontinuity and industrial dynamics. [4]

5. DATA SOURCES FOR MEASURING TECHNOLOGICAL COMPETENCES

In order for organizations to remain competitive on the market, they must check their technological abilities and competencies. Technological competence is not something that is visible and measurable by itself. It is measured through some indicators that can somewhat describe and give an insight into the level of technological ability of a particular organization and its competencies. Data sources based on which we perform measurements can be:

- Annual financial reports of the organization
- Patent databases
- Data collected through surveys and interviews

The annual financial reports accurately show the costs of the research and development (R&D) department that are separated from the overall financial results of the organization. Many studies carried out show a positive correlation between investing in technological competence through the R&D department and the total productivity growth of the organization and business success. Business success is viewed through net income indicators and net income growth, EBITDA growth and stock price growth, which can be seen in business reports. [14]

Patents from patent databases are used as the most common indirect measure of the Proxy Measure since they are the direct result of technological activities in the organization. Their main advantage, compared to other benchmarks of technological competence, comes from a large database that is available covering a long time period. It can be well-statistically dealt with by various categories, such as technology fields, geographical positions and companies that have patented them, including technological activities and competencies that are not included in research and development department, such as design and manufacturing engineering. Patents unfortunately do not measure the scope of the software in a satisfactory manner. [12] Likewise, they cannot show the actual level of technological competence of the organization because they only show the extent of the competence from which the patent was created. However, many different technological processes take place within the organization using someone else's patents and they are an integral part of various processes and technological knowledge of the organization.

Surveys as data sources require highly qualified staff to conduct interviews, sometimes costly top experts from certain technology areas that need to make a good estimate. They also require good co-operation with the top management of the company that is being evaluated, their time and dedication to the company's goal. This is the most affordable way for small and medium-sized

organizations, as they rarely have a special department for research and development and rarely participate in patents. The same method depends on the subjective opinion of the respondent, so it is extremely important that it be performed by the professional staff.

6. METHODS FOR MEASURING TECHNOLOGICAL COMPETANCES

Various methods for measuring technological competence have been developed which can generally be categorized in two ways:

- in the degree of performance of tasks and qualifications - as an internal review, or
- since competencies cannot be reviewed externally, they can be compared to competitors, such as whether the organizational competence in a certain area is greater than or less than the competence of competitors. [15]

6.1. Internal review - Korean Method

The data collected through surveys and interviews use some auxiliary tools for assessing technological abilities and competencies, such as The Technological Capability Audit Tool, developed by Professor John Bessant [18]. The method developed by Professor John Bessant is often referred to as the Korean Method as the World Bank has used it for the first time to evaluate the Korean economy. It can be widely applied both in small and large organizations. This tool evaluates the technological abilities of individual organizations in nine key areas of activity through 24 questions that can be answered in a range from 1- Solid disagreement to 4- Complete agreement:

(I) Awareness of the need to improve technology

1. Technology plays an important part in my company's business strategy
2. My company is well aware of the technologies most important to its business

(II) Ability to search for opportunities and threats from the environment

3. My company is well equipped to assess technological opportunities
4. My company can assess technological threats without any difficulties

(III) Building key competencies

5. My company has special technological strength it can use
6. My company knows which technologies to outsource and which to develop internally

(IV) Development of technological abilities

7. Our management is skilled in formulating business-oriented technology strategies
8. Our company knows its technological priorities
9. Our company has a well-developed technology vision

(V) Ability to evaluate and select appropriate technological solutions

10. Our company knows how to select the required technology for its business
11. Our company knows the best sources of technology needed

(VI) Acceptance and absorption of technology

12. Our company is effective in acquiring technology from external sources
13. Our company is well connected to external technology suppliers

(VII) Introduction and efficient use of technology

14. Our technological activities (R&D) are efficiently organized within the company

15. We have clear processes for carrying out technological projects

(VIII) Learning from experience to improve technology

16. Our company has a good system for assessing technological projects

17. Our company is responsible for analysing the implemented projects

18. We accumulate knowledge from implemented technology projects

(IX) Ability to connect to a network of suppliers, researchers, and partner companies

19. Government policy encourages us to invest in technology

20. We use external organizations (e.g. consultants) to assist us evaluate technology

21. We use external companies and bodies to help us develop technology

22. External organizations help us assess our technological performance

23. We work with universities in key technology projects

24. We work with state research institutes in important technology projects [18]

The results of the interviews are based on the collected points in four groups that show the current level of technological ability and competence of the organization.

Figure 1: Four categories of technological abilities and competences

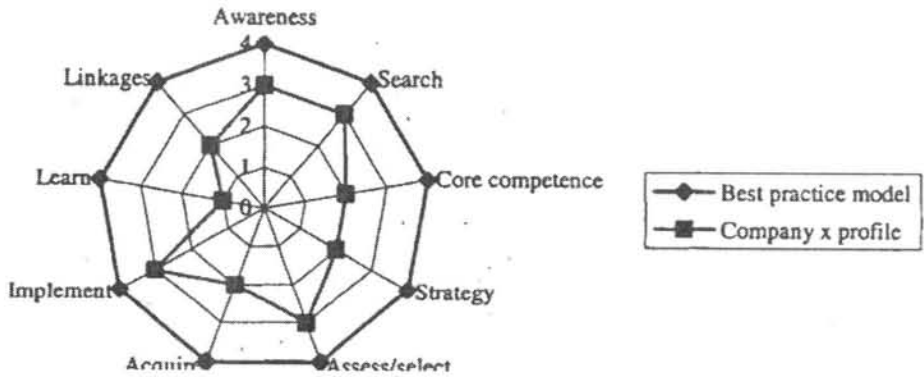
Level of technological ability (1-4)	The result of the organization	Separation by groups	Overall test result
1 (A)		0 - 24	Your organization is poorly prepared in all areas of use of technology and it is urgently needed to greatly improve its technological capabilities and competencies.
2 (B)		25 - 48	Your organization has slightly developed technological capabilities and competences in most key areas of technological activities, but there are some opportunities and strengths to build them.
3 (C)	For example: 70	49 - 72	Your organization has highly developed capabilities and competencies within the organization and strategic approach to technology. Although in some areas it is behind the leading organizations, there is power to develop them.
4 (D)		73 - 96	Your organization has fully developed technological capabilities and competencies. In many areas, it proactively approaches exploitation of technological capabilities and competences and utilizes technology as a competitive advantage.

Source: World Bank, 2003, *Korea Technology, Skills and Internet Services in Korea: Moving Towards a Knowledge-based Economy*, page 180

By further elaborating responses through nine key areas of technological activities, each area is assessed separately. Based on the obtained results a radar diagram is developed showing the current position of the company and which are the most critical areas in the organization, providing further

management guidance on improving the technological capabilities and competence to achieve the set goals and to develop a sustainable organization strategy.

Figure 2: Nine categories of technological abilities



Source: World Bank, 2003, *Korea Technology, Skills and Internet Services in Korea: Moving Towards a Knowledge-based Economy*, page 44

In this example, the organization's outstanding weakness in the learning area and the weak level of technological capability and competence in the area of connectivity with suppliers, core competencies, strategy, and adoption of new technologies are visible, and the organization's management has to focus on these areas in particular in order to improve their weaknesses.

6.2. Method of measuring accumulation of technological competencies - comparison with competitors

Achieving sustainable competitive advantage depends on both the internal competence of the organization and the accumulated competencies of competitors from the near and further environment. The current organization's position reflects the technological competence that the organization possesses, as well as changes (paths) that have led to its current position. There are constant pressures from the environment on the current position. In terms of environmental impacts and variability, the organization can respond by boosting its own technological competencies and maintain its competitive advantage in the same area or by developing new competencies in new areas, and thus differ from its competitors by building new competitive advantages. This mutual influence of the organization and the environment on the development and the persistent change of technological competence is explained by the "Red Queen evolution". According to this theory, competition between organizations is a trigger for internal processes of accumulation of technological competence, and this process generates further competitive pressure on the environment, which then becomes a self-sustaining process of continuous accumulation of competence. [8]

Forms of accumulation of technological competence

Technological competence can be measured using patent databases as indicators of technological competencies. The patent databases, as indicators for measuring technological accumulation in a particular field of technology may, to some extent, represent the accumulation of technological competence and the work of research and development departments. Knowledge that is stored in the patent includes both visible and hidden knowledge, but it is unknown in what quantity.

Measurement of technological competence is performed by RPA (relative patent advantage) index developed for the purpose of direct comparison of organizations. It shows the established level of competence and the difference between levels of competence in a given period. [8]

The RPA index is calculated based on the RTA (revealed technological advantage) index (originally developed by Soete and Wyatt in 1983) according to the equation:

$$RPA = 100 \ln(RTA) \quad (1)$$

$$RTA = \frac{P_{it} / \sum_t P_i}{\sum_t P_t / \sum_t P} \quad (2)$$

where P is the number of patents, and denotes the organization, and t denotes the technological area. The RPA index is within the range of [-100: 100] where 0 is a neutral value and the RPA value can be directly compared in such a way that the level of specialization for value 10 is twice the value level 5. [8]

Knudsen [35] defined four position states in accumulation of technological competencies in the organization:

- Competence Building
- Competence Leveraging
- Competence Erosion
- No Competence.

Competence building means that the change of competency in relation to competition is above average and growing. Competence building enables the organization to achieve its goals by creating new opportunities for future achievements. It expands the space for the diversification of knowledge and is proactive in creating new competencies as a reaction to internal needs for sustainable growth. Likewise, it is a reaction to external threats, which at the current technological competence of the organization have a disastrous effect, transforming them by the process of innovation to outdated and unnecessary. It is usual that organizations with this level of accumulation have already had a certain history in a particular field of technology. [8]

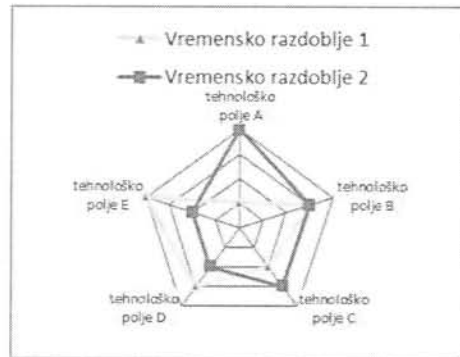
Competence leveraging means that the change of competence in relation to competition is unchanged. The competence leveraging at the same level requires organization to keep up the action, given that overall technological competence is constantly increasing. However, the increase in the technological competence of an organization in a technological field grows with the same dynamics as the increase in competency of the competition, so there is no progress or lack in accumulation of technological competence. Competence leveraging requires the organization to invest less in R&D and greater security because research takes place in a well-known field. In this way, deepening of organizational knowledge is achieved and in the short term it provides greater security in maintaining the foundation for survival of the organization. [8]

Depleting the competency level in relation to competition creates **competence erosion**. Erosion is defined as a decreasing level of competence with respect to the initial position. This can happen if the technological competence is not further developed in the organization and the competition overtakes it. This can happen for two reasons. One of the reasons is the disinvestment strategy, which abandons a strategically non-perspective technological field for the organization and relocates resources to other fields. Another reason is when an organization loses technological competence simply by forgetting them by not using them. Thus, erosion can be both intentional and unintentional. [8]

The level of **no competence** have small or highly specialized organizations that often do not enter certain technological fields or they approach it in such a minor way that in reality they do not have any technological competence in those fields. The level of no competence can also be reached after a complete erosion of competence related to strategic commitment or to technological advances of the competition. [8]

The graphical accumulation of technological competencies can be displayed using a radar diagram. In the diagram, each individual axis represents the technological competence of the organization in a particular field of technology, and the total surface shows the technological competence of the organization. As a result, the axes are graded in four levels. Number 1 indicates the level with no competence, number 2 the level of competence erosion, number 3 the competence leveraging, and number 4 the competence building. Different colours on the radar diagram indicate several time periods for which accumulation of technological competence is monitored.

Figure 3. Radar diagram of the organization's technological competence



Source: Knudsen, M. P. (2005.). *Patterns of technological competence accumulation: a proposition for empirical measurement. Industrial & Corporate Change* 14(6). 1075-1108.

Advances in the accumulation of technological competence have the following meaning:

- The shift from building level to leverage level is called **consolidation**;
- The shift from leverage level to erosion level or no competence level is called **decreasing dynamics**;
- The shift from no competence level or erosion level to building level or leverage level is called **increasing dynamics**;
- If accumulation levels remain the same, they are called **no change**. [8]

Organizational behaviour strategies

Organizations choose different strategies to meet their strategic goals. Based on the conducted research, Knudsen grouped four groups of different behavioural strategies of organizations with regard to accumulation of technological competencies during different periods [8]:

- Reorganization of competence configuration;
- Swing loss;
- Strategic reorientation;
- Impartiality or consolidation.

Reorganization of competence configuration is a strategy where, over time, the company changes the technology fields of accumulated competence and makes a change in more than two technology fields by either increasing or decreasing the accumulation of technological competencies to another type of accumulation of competence. Organizations that are blocked in problematic positions seek exit by exploring new technological opportunities in new fields. Likewise, when companies in marginal positions move forward or while well-positioned organizations seek new opportunities, they both work through a strategic manoeuvre that result in reorganization. This strategy is highly

risky and uncertain, requires substantial investment in research and development and can lead the organization to an unprecedented position. On the other hand, there are many examples of the success of this strategy, which is the only way for the organization to grow from the margin to the top and become a market leader. [8]

Swing loss is defined as consolidation or erosion at least in two technology fields. This group is characterized by total business contractions with losing dynamics. Contraction does not inevitably lead to the loss of competitiveness but will eventually lead to the erosion of the competence base. The first reason is that the organization, which has a high level of accumulation of technological competence, is difficult to maintain this level over time. After a period of intensive investment in unexplored areas that have not yet yielded economic benefits, the organization has to stop for a while and consider what are the results of those innovations and align the direction and further innovation strategy. Secondly, if investing in maintaining a level of competence is insufficient to maintain the previous level of competence accumulation, the "Red Queen" then boosts contraction and may spur some organizations out of competition. [8]

The starting point for **strategic reorientation** is consolidation or unchanging in two and more fields and focusing on stability and incremental changes rather than on change. This strategy represents focused actions in several technology fields, with higher specialization, resulting in lower costs and risks with higher expected profit. [8]

Impartiality or consolidation is the strategy those organizations that are static or aim towards consolidation. This strategy is valid for those who maintain a pattern of accumulation of past competencies and choose the strategy of keeping up with the known, better than to try something they do not understand. These are organizations that use the harvest strategy, using the current technological competency to gain competitive advantage. This group also includes organizations that do not have any competence in a particular technological field and which never even had them. [8]

7. CONCLUSION

The organization combines different resources to deliver the product or service. This process uses a certain technology. Technology also includes visible assets in the form of equipment and machines, processes and various documented rules and operational procedures, but also the invisible part that arises through the application of technology through various projects and the learning organization remains as a value that brings a competitive advantage. This hidden knowledge accumulated in the organization depends on the way the organization has gone through in its past and it is difficult to imitate it. Organizations are placed on the open market and are under constant influence of external and internal changes, especially technological, so they need to be constantly alert, follow trends, use others and develop their own technology and constantly improve themselves in order to remain competitive. For a better assessment and monitoring of the state of the company's technological abilities and competencies, various auxiliary tools for measuring technological competence have been developed. It is the wish of the authors to incorporate all the current experiences in this field and to develop a generic model in the form of a toolkit, which would in the simplest way, by means of relevant indicators, assess the technological competence of any organization. The results would help the management to simplify documenting, comparison and management of technological competence as part of the competence and ability of the organization.

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