FRAME LOGISTICS PROBLEMS, PROCESSES, AND TOOLS IN CLOUD-BASED DECISION-MAKING SYSTEMS FROM DESIGN TO EXECUTION

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The level of investment in disruptive technologies for future supply chain, in a worldwide approach, have received considerable huge investment in cloud computing. Despite being a leading technology, industry still has opportunities to identify in which process and where in the supply chain would adopt cloud computing technologies in order to make strategic decisions which drive digital supply network transformation. To this end, this paper proposes a framework of logistics problems, processes, and technologies by analysing the existing cloud-based decision-making approaches. A systematic review procedure based on a structured protocol was conducted to explore and analyse the research papers; then, the principles of plan-do-check-act cycle were adopted to categorise the data and propose a new framework. The resulting framework reveals that the cloud-based decision-making in supply chain can be categorised in four phases: design, development, evaluation, and execution, each one supported by a set of intelligent methods and tools, stakeholders, value-added disruptive technologies; also, the utilization of these systems are key driver for early warming decisions, on-going situations tracking and future problems prediction in uncertain supply chain environment. Green truck routing, resource allocation and logistics collaboration are among the most significant decision-making problems while transportation and warehousing are likely the logistics processes that companies would achieve digital transformation into supply chain. Research findings provide some guidelines that can allow logistics and supply chain managers to utilize potentials of cloud computing technologies in strategic decisions at the firm level. This study presents an original framework named, Design, Development Validation and Execution (DDVE) for cloud-based decision-making which can not only assist logistics managers in strategic decisions, but also cloud service providers in improving their solutions to effectively migrate customer systems to the cloud.

Keywords: Cloud Computing, Decision-making, Logistics and Supply Chain, Disruptive Technology.
1. Introduction

Cloud computing (CC) which makes applications run on the Internet rather than on local information infrastructure, has become an industry trend and, in terms of level of investment, a significant disruptive technology for supply chain strategies worldwide in recent years (STATISTA, 2018). As a leading disruptive technology, cloud computing is driving digital transformation in supply chains for industries engaged in global activities and considering their interest in integrating manufacturing processes and trading partners as well as harvesting visibility into supply chain (SAIDEEP AND ADITYA, 2014). The goal of cloud computing is to provide consistent services which share real-time data, to improve customer service, to reduce maintenance costs of hardware, and to easily upgrade software and support in decision-making (LU AND WANG, 2017).

The utilization of CC technology in operations management of dynamic nature in logistics processes has an important role in strategic decisions, which is known as cloud logistics (CL) (MATKOVIC ET AL., 2014). CL has been adopted by some firms to interact with and assist internal and external users and customers (SUGUNA AND KUMAR, 2019). Using specific applications and accessing with any web browser device anytime and anywhere, CL has improved their flow of resource information, level of information sharing and effectiveness of information systems as well as increased corporate profits (LIU ET AL., 2018; XIAOKUN ET AL., 2019). Nevertheless, cloud computing usability have been considered as next enabler of information technology platform for supply chain information systems (LIU ET AL., 2018).

There are companies disquieting about implementing information systems that assist decision-makers in managing logistics activities on strategic level (FILIP AND DUTA, 2015). One of the most elaborate information systems to solve problems of different complexity and provide timely information are decision support systems (DSS) based on cloud computing (MATKOVIC ET AL., 2014). However, when it comes to adopting a cloud-based system, logistics managers have faced some practice difficulties in deciding what supply chain processes should migrate to the cloud logistics and how to use them to obtain more value and cost savings (GIANNAKIS ET AL., 2019). Therefore, to fill this research gap, this paper proposes a framework that provides guidance for cloud computing adoption in the context of decision-making supply chain regarding specific practices. The rest of the paper is arranged as follows. Section 2 describes the research methodology Section 3 describes the resulting framework for logistics problem-solving, processes and tools. Section 3 presents the resulting...
framework and describes each one of its phases. Section 4 offers the discussions and conclusions.

2. Research methodology

The analysis of this research is based on a robust methodology, as depicted in Figure 1. In the first phase, a method called Methodi Ordinatio, proposed by Pagani et al. (2015), in which, in 9 steps, utilize criteria to select and rank relevant scientific papers taking into consideration the impact factor, number of citations, and year of publication. Also, only papers published in peer-reviewed journals written in English were included, as they were presumed to provide the most suitable coverage on the issue studied. The methodology of Methodi Ordinatio involved several steps as follows:

Step 1 - Establishing the intention of research: In this study, the scope is delimited to empirical research papers that have used cloud-based systems to support decision-making of logistics and supply chain management.

Step 2 - Preliminary exploratory search with keywords in relevant databases.

Step 3 - Definition of keyword combinations, as well as bibliographic databases, are presented in Table 1. We did not establish a temporal delimitation in order to approach the extant literature since related to the themes emerged.

Step 4 - Final search in the databases and gross results are described in Table 1.

<table>
<thead>
<tr>
<th>Database</th>
<th>Web of Science</th>
<th>Scopus</th>
<th>Science Direct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keyword combination</td>
<td>&quot;technolog* transfer*&quot; AND &quot;Sustainab* development&quot;</td>
<td>&quot;technolog* transfer*&quot; AND &quot;Sustainab* development&quot;</td>
<td>&quot;technology transfer&quot; AND &quot;Sustainable development&quot;</td>
</tr>
<tr>
<td>Total per database</td>
<td>97</td>
<td>216</td>
<td>25</td>
</tr>
<tr>
<td>Total articles</td>
<td>338</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Step 5 - Filtering procedures: were used to eliminate duplicated papers; papers not related to the theme; conference papers and books and/or book chapters. Conference papers and books or book chapters were added in another search, as complementary material.
Table 2: Filtering procedures

<table>
<thead>
<tr>
<th>Filtering Procedures</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duplicate papers; Conference papers and books and/or book chapters</td>
<td>149</td>
</tr>
<tr>
<td>Papers not related to the theme</td>
<td>154</td>
</tr>
<tr>
<td><strong>Final number of articles</strong></td>
<td><strong>35</strong></td>
</tr>
</tbody>
</table>

Source: Author

Step 6 - Identifying impact factor, year and number of citations.

Step 7 - Ranking the papers using the InOrdinatio by the equation 1.

\[
\text{InOrdinatio} = \frac{\text{IF}}{1000} + \alpha \times [10 - (\text{ResearchYear} - \text{PublishYear})] + \text{Ci} \tag{1}
\]

The elements of the equation are: IF (impact factor); \(\alpha\) (alpha value, ranging from 1 to 10); ResearchYear (year in which the research was developed); PublishYear (year in which the paper was published); and Ci (number of times the paper has been cited).

Step 8 - Finding the full papers: papers were collected and stored using the reference manager Mendeley.

Step 9 - Reading and systematizing analysis of the papers: bibliometric mapping and content analysis were used to evaluate the papers.

In the second phase, the information was structured and categorised based on the plan-do-check-action philosophy to propose a new framework. This information was placed in tables and the data were segregated at different stages of the framework. With the data collected it
was possible to analyse the combination of existing decision-making approaches and cloud computing technologies in solving problems of logistics and supply chain management.

3. Descriptive findings

Tables 1-6 showcase the full analysis of the papers after assessing and applying them into the plan-do-check-action categorisation. It is noteworthy for the reader that every paper was analysed if it addressed logistics activities and decision-making problems with cloud-based systems. Although the assignment of the categories was without much hesitation, there were also some aspects that gave equally attention such as: users interface device, analytics tools, methods, software, data management technologies and procedures; how real-time information is exchange; and which are the criteria, principles and requirements considered in the cloud-based decision-making systems. After the applicability of the plan-do-check-action, the division of four model steps, named as Design, Development, Validation and Execution (DDVE) was produced as depicted in Figure 2.

Figure 2: Frame logistics problems, process, and tools of cloud-based decision-making system – DDVE

Each phase is responsible for different stakeholders such as designers, cooperating actors, cloud service provider and decision-makers. cloud computing environment. Their involvement would enable the companies to adopt an effective information system, however, the stakeholders who could be considered in the use of cloud computing technology for supply chain management are listed and unlimited. Internal stakeholders are directly involved in the logistics operation and belong to the company’s supply chain processes. System designers, cloud service providers, decision-makers and cooperating actors are internal stakeholders who also are key in the
construction project of the cloud-based decision-making solution since they are concern about business requirements. Depending on the logistics process, cooperating actors can be unlimited. In the case of external stakeholders, were identified government, consumer, and external information service provider. Government provides rough granularity traceability data that it may demand, and consumers contributes with a querying interface for supply chain traceability information (XU ET AL., 2015).

3.1. Design
In the initiation phase, to develop an effective supply chain information system based on cloud computing technology for supporting decision-makers on strategic level, it is necessary to identify the company’s needs according to the problems that occur in managing logistics activities. Designers should therefore trace user company requirements and principles which describe the cloud-based decision-making system that is desired as a solution which are explained in Table 1.

Table 1 – Design requirements and principles

<table>
<thead>
<tr>
<th>Design requirements</th>
<th>Description</th>
<th>Author and Year</th>
<th>Design principles</th>
<th>Description</th>
<th>Author and Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessibility</td>
<td>Rapid response and accurate information retrieval of all supply chain operations are provided by such interfaces, which is necessary for the stakeholders.</td>
<td>(Chen et al., 2017); Xi (2017)</td>
<td>System Principle</td>
<td>Include the monitoring, auditing, and such viewing mechanisms, which include participants such as suppliers, distribution, chain stores, retailers, and chain enterprise headquarters, homogenize distribution routes.</td>
<td>(Chen et al., 2017)</td>
</tr>
<tr>
<td>Availability</td>
<td>System can provide historical and present information to display different views on the truth central and monitoring data, present the most location of any possible breakdown in the network and a mechanism to communicate emergency responses.</td>
<td>(Chen et al., 2017); Xi (2017)</td>
<td>Reliability Principle</td>
<td>Prevent and reduce the risk of unassumed emergencies in the retail supply chain in real time, and to identify and judge retail supply chain unassumed emergencies fall in time.</td>
<td>(Chen et al., 2017)</td>
</tr>
<tr>
<td>Stability</td>
<td>Processing power, memory, transmission, storage relations are required to satisfy neither mission or decrease in a cloud-based database system. The database is divided into the background database and storage, which interacts only for the cloud computing database and relevant period. For example, clients are added, deleted, and modified, which is possible by cooperating actors and provide variability to add future markets.</td>
<td>(Chen et al., 2017); Xi (2017)</td>
<td>Scientific Principle</td>
<td>Develop accurate judging criteria for qualitative and quantitative indicators.</td>
<td>(Chen et al., 2017)</td>
</tr>
<tr>
<td>Concurrency &amp; pricing</td>
<td>The decision-making system architecture shares cloud computing resources with the different stakeholders. In other words, each stakeholder can use its own resource of the proposed system and customize their environment.</td>
<td>(Chen et al., 2017); Xi (2017)</td>
<td>Elasticity Principle</td>
<td>The functional module in the system can run independently, no different functions, are complement each other and avoid redundancy.</td>
<td>(Chen et al., 2017)</td>
</tr>
<tr>
<td>Environments</td>
<td>The decision-making system architecture shares cloud computing resources with the different stakeholders. Each stakeholder can use its own resource of the proposed system and customize their environment.</td>
<td>(Chen et al., 2017); Xi (2017)</td>
<td>Operational Principle</td>
<td>Early warning decision-making operations should be simple, reliable and easy in the system connection process.</td>
<td>(Chen et al., 2017)</td>
</tr>
</tbody>
</table>

3.2 Development
This second phase is when the designer concentrated on accomplishing a project to build the information system that would lead a better resolution in the decision-making problem. The results of this phase will describe the characteristics of the new system as a group of layers and certain operation constraints as shown in Table 2.
3.3 Validation

In this stage, the effectiveness of the developed system is evaluated by the benefits this system provides to the user company. Prior to the execution of the system, a pilot project might be conducted to directly tested it in a real environment. The assessment of develop system can be performed by methods and software tools as Table 3.

<table>
<thead>
<tr>
<th>Methods</th>
<th>Description</th>
<th>Author and Year</th>
<th>Software tools</th>
<th>Description</th>
<th>Author and Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuzzy membership function</td>
<td>Evaluates the performance of the algorithm in terms of number of used vehicles and objective function value over scenarios with an unlimited number of available vehicles. Identifies the basic performance measures.</td>
<td>(Heidari et al., 2017)</td>
<td>MATLAB</td>
<td>Balances the load and to prevent excess of vehicles in certain areas. (Heidari et al., 2017)</td>
<td>Virtual machine</td>
</tr>
<tr>
<td>Supply Chain Reference model</td>
<td>Aims to obtain all the feasible solutions of the problem.</td>
<td>(Dev et al., 2019)</td>
<td>Java</td>
<td>Evaluates the effectiveness of wireless sensors on supply chain containers.</td>
<td>Virtual machine</td>
</tr>
<tr>
<td>Pareto front method</td>
<td>Evaluates the efficiency of the algorithm using real facilities such as empty container depots, repair stations and related value-added logistics facilities.</td>
<td>(Heidari et al., 2017)</td>
<td>MATLAB Neural Network Toolbox</td>
<td>Assess vehicle routing time forecast.</td>
<td>Virtual machine</td>
</tr>
<tr>
<td>Trade-off analysis method</td>
<td>Consists of a set of different scenarios created by choosing different values of the decision variables.</td>
<td>(Fanti et al., 2017)</td>
<td>INEJOG</td>
<td>Relies on the prompt processing of the acquired transport-related information.</td>
<td>Virtual machine</td>
</tr>
</tbody>
</table>

Source: Authors
3.4 Execution

For the cloud computing decision-making execution system are introduced the corresponding components consisting of three components: supply chain network infrastructure, back-end and front-end interface.

3.4.1 Supply chain network infrastructure

Supply chain network infrastructure comprises of all the facilities and physical data acquisition technologies required to run real-time information exchange for supply chain.

3.4.1.1 Supply chain facilities

In cloud-based decision-making system, supply chain facilities involve supplier facility buildings, manufacturing industries, distribution centres, stores, and value-added facilities such as highway, shipping agency, inland terminal, seaport facilities, truck vehicles, container loading terminals, empty container depots and repair stations (HEILIG ET AL., 2017; HILL AND BOSE, 2017).

3.4.1.3 Real-time information exchange

The individual data sets from cooperating actors are remotely stored in the cloud and can be categorized into internal and external information. In particular, the cloud-based decision-making system works by exploiting the historical and real-time information from supply chain network infrastructure (FANTI ET AL., 2017). This information is collected from physical data acquisition technologies (Table 4) and encompasses observations that originate from business and operations at the supply chain facilities (HILL AND BOSE, 2017). Internal information is given by historical data usually hosted from supply chain facilities (e.g. outbound frequency, past storage time of SKUs, and supplier performance records) (HILL AND BOSE, 2017). External information is third party data that describes the economic (e.g. from government), environmental and traffic related situation that has an influence on decision-making process.

3.4.2 Back-end interface

Back-end interface in cloud-based decision-making system, is leaded by the cloud service provider offering services such as data storage, that powers the front-end interface (JADEJA AND MODI, 2012). Data store management should exist in the supply chain network infrastructure to receive, transmit, and make critical data available in a cloud-based data
repository (LU AND WANG, 2017). Thus, the store management of technologies adopted are shown in Table 4.

Table 4 – Physical data acquisition technologies and data store management technologies

<table>
<thead>
<tr>
<th>Physical data acquisition technologies</th>
<th>Description</th>
<th>Author and Year</th>
<th>Data store management technologies</th>
<th>Description</th>
<th>Author and Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surveying equipment</td>
<td>Realizes the efficient and timely collection of the scene big data (e.g. for environmental monitoring, vehicle management, detection of the plate or object movement purpose)</td>
<td>(Yam et al., 2017)</td>
<td>Data store management</td>
<td>Realizes the efficient and timely collection of the scene big data</td>
<td>(Chen et al., 2017)</td>
</tr>
<tr>
<td>Mobile app (Global Positioning System (GPS), Google Maps)</td>
<td>They can be used for truck drivers or supervisors in their mobile phones.</td>
<td>(Yam et al., 2017)</td>
<td>OSAP (On-Orbit Analysis Processing)</td>
<td>Makes the system can adopt to the rigid change of environmental conditions, reasonably solve the heterogeneous, vague, structured decision problems</td>
<td>(Zhang et al., 2012)</td>
</tr>
<tr>
<td>Hand-held terminal, RFID (Radio-Frequency Identification reader)</td>
<td>Through these technologies, tag information can be read automatically and some basic functions such as stocktaking, goods tracking, real-time positioning of guided vehicles, field-like inspector, and rapid data collection can be automatically without manual intervention, provide real-time information on various parameters related to final stage input, support, work-in-progress inventory levels and lotting times, and also follow the data associated with the external environment like demand volume, demand volatility, order sizes, etc.</td>
<td>(Qin and Zhai, 2012)</td>
<td>GDEP (Geospatial Data Processing)</td>
<td>It is a real-time external data source and system database</td>
<td>(Zhang et al., 2014)</td>
</tr>
<tr>
<td>RFID mobile reader, RFID network, RFID technology</td>
<td>Data analytics tools</td>
<td>(Qin et al., 2019)</td>
<td>NoSQL system</td>
<td>Source: Authors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Front-end interface in cloud-based decision-making system, is what the decision-maker users interacts with the application required to access the cloud. These include web browsers, local networks and common web apps (JADEJA AND MODI, 2012).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.5.1 Front-end interface

3.5.1.1 Data analytics tools

Decision-making users and cooperating actors can access the consolidated data from the cloud-based data repository for business analysis (LEE ET AL., 2016). For instance, identifying value trends of different measures within data or classifying data according to its values (QIN AND ZHU, 2013). These data analytics tools include in this phase are demonstrated in Table 5.

3.5.1.2 Decision variable selection

Through the interface, the user can specify the range of data in terms of date, the parameters involved, and the support count, confidence, and discrepancy thresholds for rule filtering. These rules are stored into the knowledge repository to provide accurate decision variables (HUI ET AL., 2016). These decision variables include criteria, factors, and parameters.
Table 5 – Physical data acquisition technologies and data store management technologies

<table>
<thead>
<tr>
<th>Data analytics tools</th>
<th>Description</th>
<th>Author and Year</th>
<th>Decision support modules</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPC charts</td>
<td>Displays the information related to meeting operational targets of a supply chain</td>
<td>(Lee et al., 2019)</td>
<td>MSQSA method</td>
</tr>
<tr>
<td>Temporary Operating System</td>
<td>Organizes historical data from weak schedules, customer order information and forecast processes</td>
<td>Qin and Zhu, Fuzzy logic (2013)</td>
<td></td>
</tr>
<tr>
<td>Portal dashboard</td>
<td>Monitors the logistics processes</td>
<td>Krishnaverma and Chen, 2017</td>
<td></td>
</tr>
<tr>
<td>Excel VBA Macro</td>
<td>Creates various user-generated functions and speeds up manual tasks by creating automated processes</td>
<td>(Lee et al., 2019)</td>
<td></td>
</tr>
<tr>
<td>SPC, defect rules and control charts</td>
<td>Determines the variable condition by reading the continuous data</td>
<td>(Zhu et al., 2015)</td>
<td></td>
</tr>
<tr>
<td>FFT, Fuzzy Tree, analysis</td>
<td>Diagnoses supports inventory decision-making analysis</td>
<td>(Zhu et al., 2015)</td>
<td></td>
</tr>
<tr>
<td>Web service</td>
<td>Allows to provide the generated statistics</td>
<td>(Krishnaverma et al., 2019)</td>
<td></td>
</tr>
<tr>
<td>ALS, Anopheles</td>
<td>Provides functionality to plan and manage activities related to logistics</td>
<td>(Rahaj et al., 2017)</td>
<td></td>
</tr>
</tbody>
</table>

Source: Authors

3.5.1.3 Decision support module

The decision support system is generally composed of modules, algorithms, platforms and applications (as Table 5) which are run on a hosted server by a service provider and are accessible by decision-maker users via Internet (LEE ET AL., 2016). This eliminates the need to install and run the application on users’ computers, lowering the upfront costs (LEE ET AL., 2016).

3.5.1.4 Solving problems

In this step, many solving problems supported by cloud-based decision support systems in supply chain are identified based on the outcomes of the systematic review analysis as an adoption practice. On that basis, the problems which are specifically encountered by decision-making users are presented and detailed in significance order as depicted in Table 6.

Table 6 – Top 4 cloud-based decision-making problems in Logistics

<table>
<thead>
<tr>
<th>SIC problem</th>
<th>Description</th>
<th>Author and Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green vehicles routing</td>
<td>The objective of the problem is to minimize overall costs, total travel distances and travel time of each vehicle while environmental impacts are reduced.</td>
<td>(Dvorak et al., 2018) (Krishnaverma and Chen, 2017)</td>
</tr>
<tr>
<td>Resource planning and allocation</td>
<td>The main objective is to maximize the cost of logistics activity or maximize the resulting profit when the resources such as personnel, material, services, and vehicles are determined Aiming to optimize the transportation by sharing vehicle capacities and delivery tools with less-than-trucked organizations. The focus of the cloud-based decision-making system is particularly on cutting empty back loads, increasing vehicle utilization rate and adding new logistics partners.</td>
<td>(Hill and Bose, 2017) (Krishnaverma and Chen, 2017) (Hui et al., 2017) (Faust et al., 2017)</td>
</tr>
<tr>
<td>Logistics collaboration information</td>
<td>In cloud computing context, the system provides a global view of the status of transport, helps making accurate strategic decisions, and gain performance for logistics partners.</td>
<td>(Qin and Zhu, 2013).</td>
</tr>
</tbody>
</table>

Source: Authors

4. Conclusions

The present study settles the issue of adopting cloud-based decision-making systems for logistics and supply chain management. For this purpose, an original framework named Design, Development, Validation and Execution (DDVE) is proposed to provide a guide to logistics managers about where to adopt cloud computing technologies, which intelligent methods and tools should implement for supporting decision-making process in logistics and supply chain management. In addition, the proposed framework has included disruptive technologies related to IoT, big data analytics, Artificial Intelligence the execution of cloud-based decision-making systems. The findings indicated that decision-making systems based on cloud computing technologies are most used to certainly have supply chain visibility but also to track the ongoing situation of the logistics process in the supply chain, early warming decision-making and predict future problems or results (e.g., predict the sales situation of e-commerce enterprises, real-time indicators, truck numbers, temperature in cold chain, traffic problems, production forecast). Furthermore, the adoption of cloud computing most significant decision-making problems was green truck routing, resource planning allocation and logistics collaboration while transportation and warehousing are likely the logistics processes that companies would achieve digital transformation into supply chain. Thus, the authors firstly believe that to successfully adopt cloud computing technologies for supporting decision-making process in supply chains, the logistics managers may follow the adoption practices of the proposed framework and furthermore to identify the feasible logistics process they would deploy this disruptive technology. Secondly, following these guidelines combine with IoT, big data analytics and Intelligent Artificial may help the decision-makers bring more significant improvements across the company’ supply chain. Thirdly, the decision-makers should be concern about the involvement of the internal and external stakeholders since they could affect to the adoption of the practices. Finally, the value of this study could not lie only in the objective to assist companies in logistics decision, but also the practices can be applied by business partners and cloud service providers. Further research directions can apply to this proposed
framework as an adaptable study to other disruptive technologies such as machine learning, blockchain, autonomous vehicles and drones. The framework has some limitations, logistics managers and researchers might need to consider transfer technologies barriers while they are adopting cloud-based decision-making. In such case, the classification of factors of knowledge and technology transfer can be implemented together. Although supply chain network infrastructure and logistics processes vary from company to company, the proposed framework showed how they have been integrated by real companies to handle the problem of using cloud computing in decision-making, consequently obtaining a tool to design a new information system. Hence, logistics managers can assign this structure effectively to improve business benefits. The main limitation of this proposed framework is that the results of this study could have analysed with a different approach and yielded interesting outcomes.

5. Acknowledgment
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