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Aprenda Token Ring: An Interactive Learning Tool for Token Ring Networks

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ABSTRACT

In this paper we present *Aprenda Token Ring*, an interactive learning tool for Token Ring networks. The goal of this application is to be used as a practice tool in the undergraduate program of Computer Sciences at *Universidad Central de Venezuela* where Token Ring is included in the curriculum. *Aprenda Token Ring* is based on the IEEE 802.5 standard and allows users to understand Token Ring network operation through a set of simulations. Unlike other existing applications, *Aprenda Token Ring* covers important Token Ring processes, such as Monitor Contention, Ring Poll, Station Insertion, Station Removal and transmission of LLC frames, including detailed explanations of the frames transmitted in each case. *Aprenda Token Ring* also incorporates a glossary, a help section, and a test section, where users can reinforce the knowledge acquired with the tool.

Keywords: Token Ring, Simulation, Learning Tool, Networking.

1. INTRODUCTION

Token Ring network was originally developed in the 1970s by IBM. The formal definitions of this network technology are specified in the IEEE 802.5 standard (Love et al., 1998a). Token Ring connects workstations in a closed ring, and implements Token Passing as a medium access control method which moves a small frame, called token, around the network. Possession of the token grants the right to transmit. There are other important concepts, such as a priority reservation system at the data link layer, which make out of Token Ring an interesting technology that should be covered in computer network courses. In fact, Token Ring is included in several courses of different universities around the world.

In the undergraduate program of Computer Sciences at *Universidad Central de Venezuela* (in English: Central University of Venezuela), some of the courses include in their syllabus a Token Ring topic; it is the case of *Data Communications* (in Spanish: Comunicación de Datos) and *Computer Networks* (in Spanish: Redes de Computadores). In these courses, teachers had a hard time teaching Token Ring concepts, since it is a complex technology and there were no laboratories to support the learning process (the lack of Token Ring devices prevented teachers from performing experiments during classes). Despite of the interest of the academic world in teaching Token Ring, it is not always feasible due to costs and the decreasing availability of products. Hence simulators represent an attractive alternative. The existing Token Ring learning tools did not cover our expectations as they are very limited and do not cover important Token Ring processes.

So, we decided to develop a brand new interactive learning tool according to our expectations. *Aprenda Token Ring* is a Token Ring simulation environment that covers important Token Ring processes, such as Ring Poll, Monitor Contention, Station Insertion, Station Removal and transmission of LLC frames. The application incorporates useful tools to complete the learning process, such as a glossary, a help section and a test section. The rest of this paper is organized as follows: Token Ring network technology is discussed in Section 2. Related

works are presented in Section 3. The interactive learning tool is introduced and justified in Section 4 and Section 5. Conclusion and future work are discussed in Section 6.

2. TOKEN RING

Token Ring is the term used to refer to the IEEE 802.5 standard (Love et al., 1998a). It defines a logical ring network on a physical ring topology (although a physical star topology is also widely spread). Each workstation has a separate transmitter and receiver port; the transmitter port on one workstation is connected to the receiver port on the next workstation. Transmission speeds are normalized to 4, 16 and 100 Mbps, where 16 Mbps is commonly used; different transmission media are supported and include STP (Shielded Twisted Pair) and UTP (Unshielded Twisted Pair).

Token Passing is a medium access control method where a token is passed around between workstations that authorizes the node to communicate. The owner of the token is the only workstation that can transmit on the ring. In other words, the token is a control mechanism which gives authority to the workstation that owns it to access the medium. Because of this restriction, Token Ring is a deterministic network where the maximum transmission delay can be inferred (Love et al., 1998b). As data travel through the ring, each workstation receives the frame and repeats it onto the ring. Eventually the frame arrives at its destination, where the carried data are copied into system buffers. The destination workstation then repeats the frame which continues its trip around the ring, back to the source workstation, which removes it from the ring and sends a token downstream.

Token Ring networks have two types of workstations: *Active Monitor* and *Standby Monitor*. There can only be a single active monitor in a ring; all other workstations are standby monitors. The active monitor is responsible of the correct operation of the ring. When a Token Ring network is initialized, an active monitor is elected in a process called *Monitor Contention* (Love et al., 1998b); this process can also be initiated when a standby monitor detects that the active monitor is not properly working. In a Token Ring network, each workstation must know its upstream neighbor or NAUN (Nearest Active Upstream Neighbor); this is done in the *Ring Poll* process (Love et al., 1998b). Knowing its NAUN allows a workstation to identify a fault domain, which helps the network administrator to troubleshoot problems.

3. RELATED WORKS

Packet Tracer[1] is a graphic network simulator developed by Cisco Systems that is widely used to get the CCNA (Cisco Certified Network Associate) certification. It has two operation modes: real-time, where users can create a network topology and configure devices; and simulation, that allows the generation of traffic in the topology previously created to test the proper operation of the routing devices. It has a user-friendly graphical interface that includes tutorials and a full documentation. However, it requires a license for its use, and does not incorporate data link layer technologies other than Ethernet and the ones used in serial connections. *KivaNS*[2] is a free and open source Java based application to design data network schemes and simulate IP routing processes. Its main goal is the study of IP, without the necessity of real equipments. Nonetheless, it does not show a detailed description of the frames, and does not support Token Ring simulation. *Token Ring Trainer Applet*[3] is a Token Ring learning tool that offers exercises to test users' knowledge. It does not provide a documentation to explain the Token Ring operation and its processes. It represents a good practice tool, but does not allow users to implement their own topology. *Token Ring Simulation*[4] is a Java applet based application, embedded on a web site, which allows simulating the configuration of a Token Ring network. The main drawbacks are the lack of configuration parameters, and the fact that a web browser and an Internet connection are needed in order to use the application.

[1] http://www.cisco.com/web/learning/netacad/course_catalog/PacketTracer.html
[2] http://www.disclab.ua.es/kiva/index.html
[3] http://www.informatik.uni-mannheim.de/pi4/animations/token_ring/index.html
[4] http://www.cs.bham.ac.uk/~gkt/Teaching/SEM335/token/simulation.html

Web LAN designer (Sakar, 2006) consists of two parts: wired LAN design and wireless LAN design. The application includes a tutorial, a quiz section to test users' knowledge, a modeling section to provide an interactive and easy way to develop a variety of LAN models, and a glossary with definitions of various topics related to both wired and wireless networking. Similarly to *Token Ring Simulation*, it is necessary to have a web browser and an Internet connection in order to use the application. *iNetwork* (Sakar, 2006) is an interactive learning tool that focuses mainly on general data communication networks. Its features include operating system emulation and user-friendly interface. The application allows users to construct customized topologies using common networking devices (workstations, switches, routers, servers, etc). Users can simulate communication between devices, allowing them to identify and troubleshoot problems. *iNetworks* lacks of documentation and does not provide a detailed description of transmitted frames.

None of the previous network simulation applications satisfied our teaching needs since they only partially cover the Token Ring processes. Therefore, we decided to develop a new learning tool from scratch.

4. APRENDA TOKEN RING: DESCRIPTION AND DEVELOPMENT

Aprenda Token Ring is a simulation environment based on the IEEE 802.5 standard that allows users to learn about the operation of Token Ring networks with a set of simulations that show some important processes of this network technology, like station insertion, station removal, transmission of LLC frames, etc. *Aprenda Token Ring* also incorporates tools for users to become familiar with this technology; these tools include a glossary, a help section, and a test section (Pirela and Lin, 2009).

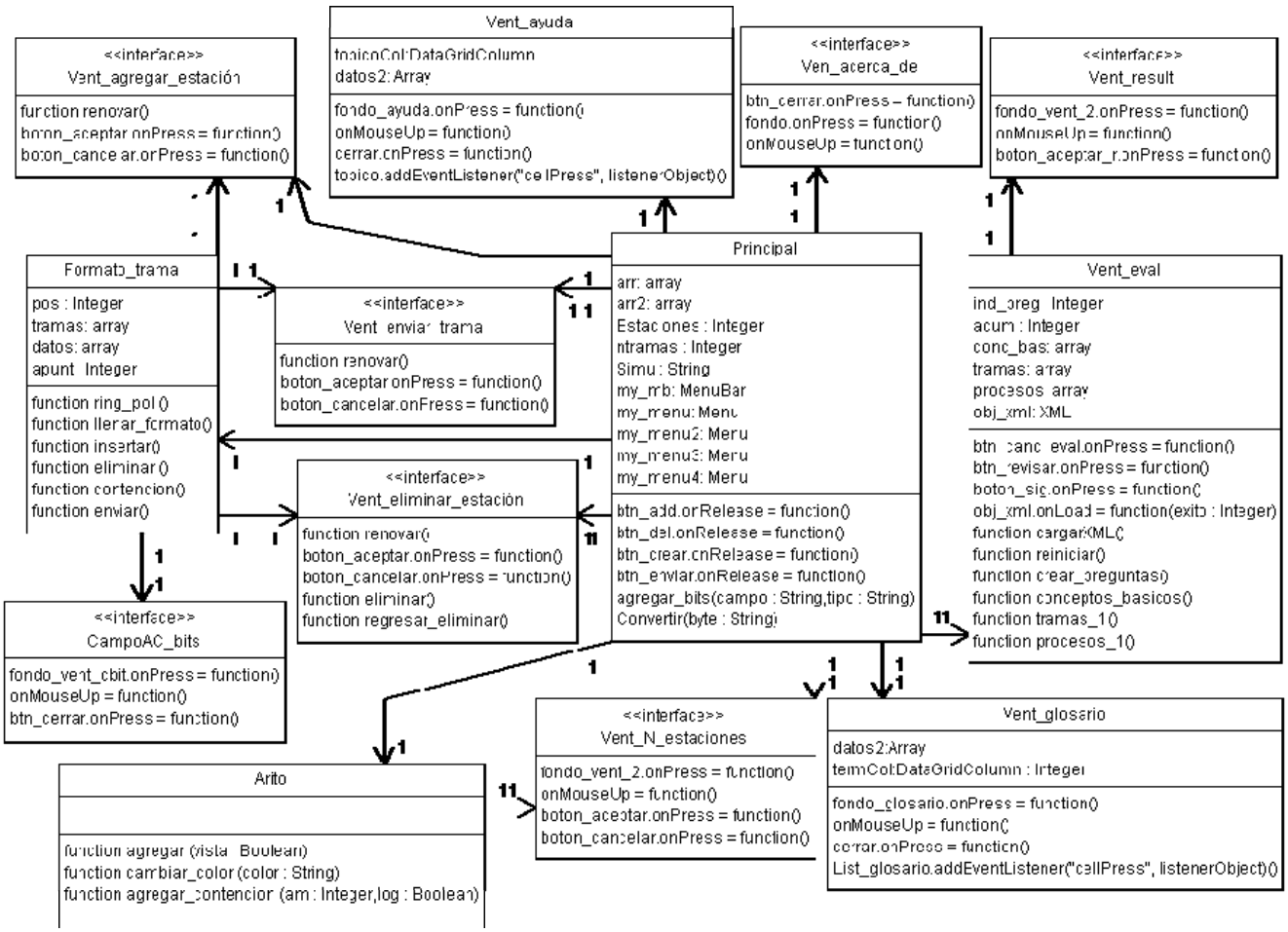

Figure 1: General Class Diagram

The development of the application was based on agile methodologies (Martin, 2002), using XP[5] (eXtreme Programming) method, where a series of iterations are defined: planning, designing, coding, and testing. In the planning iteration the functionalities are defined, specifying the interaction between users and the application. Here, use-case diagrams were employed to model the application functionality in every process simulated.

Then, in the designing iteration, the application's structure was delimited, according to functionalities defined during the previous iteration. The application's general structure consists on a main class (*Principal*) that interacts with several other classes. Figure 1 shows this structure. For instance, buttons and menus are defined in the main class, which also contains the definitions of important attributes, such as the NAUN, MAC address and name of a workstation. The frames are defined in the *Formato_trama* class, which shows the proper frame format (token, MAC frame or LLC frame) during the simulation. Interface *CampoAC_bits* shows the detailed information on AC (Access Control), FC (Frame Control), FS (Frame Status), SD (Start Delimiter) and ED (End Delimiter) fields.

The code was developed during the coding iteration, using Flash CS3 (Perkins 2007) and specifically Action Script 2.0. We defined a stage that contains a series of Movie Clips, each one containing a simulation step that is shown or not according to actions specified by users with the graphic interface. Finally, in the testing iteration, functionality tests were made in order to verify that the required results were obtained.

The final product, *Aprenda Token Ring*, consists of a main window where users can run simulations. First, users must define a topology by specifying the number of workstations in the network. Then, the *Simulations* menu becomes available, allowing users to select a process to simulate (*Monitor Contention, Ring Poll, Transmission of LLC Frames, Station Insertion,* and *Station Removal*). In each simulation, the application shows how the frame is been sent from workstation to workstation; also, a picture of the frame (including all its fields) is displayed. When users step forward in the simulation, fields that were affected by changes are shown in a different color, so users can focus on them. For commodity reasons, users can step backward the simulation. Figure 2 shows an example of a simulation.

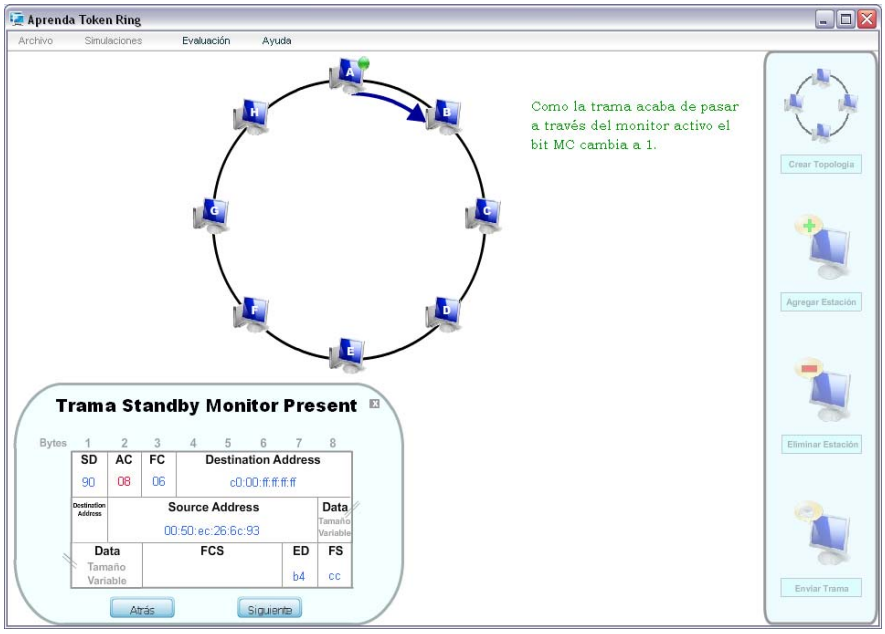

Figure 2: Simulation Window

[5] http://www.extremeprogramming.org

Some fields in the frame have subfields. It is possible to have a more detailed view of these fields, by clicking them. Figure 3 shows an example with the FS (Frame Status) field.

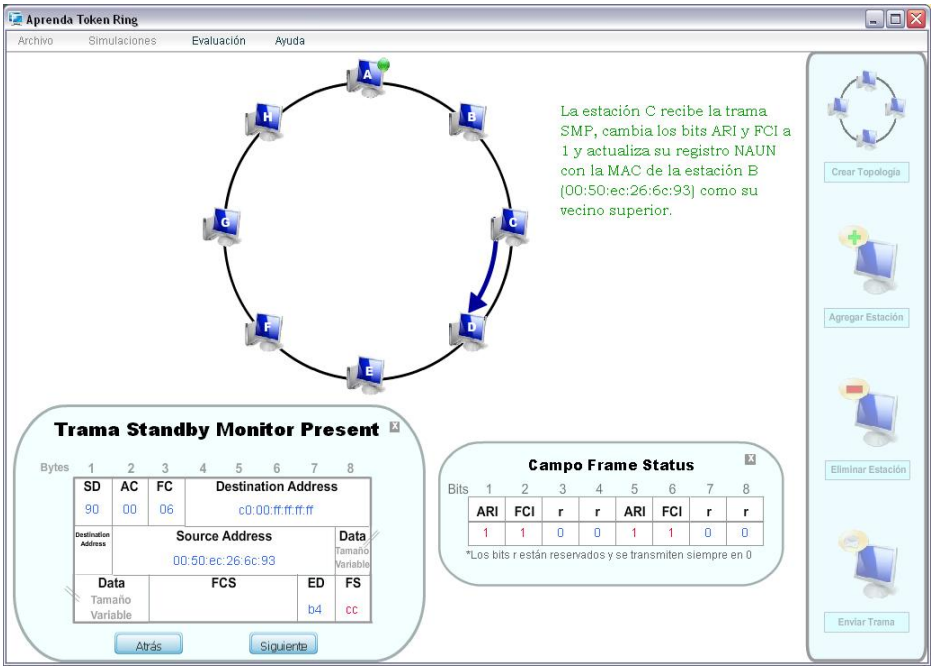

Figure 3: Details in FS Field

Aprenda Token Ring also offers a test section where users can measure the acquired knowledge. Tests include three subsections: basic concepts, frames, and processes. The test consists in a series of questions; and at the end, a grade is given as the result. Figure 4 shows the evaluation window. It is easy to add or modify questions, since they are read from an external XML file, so teachers can add their own questions.

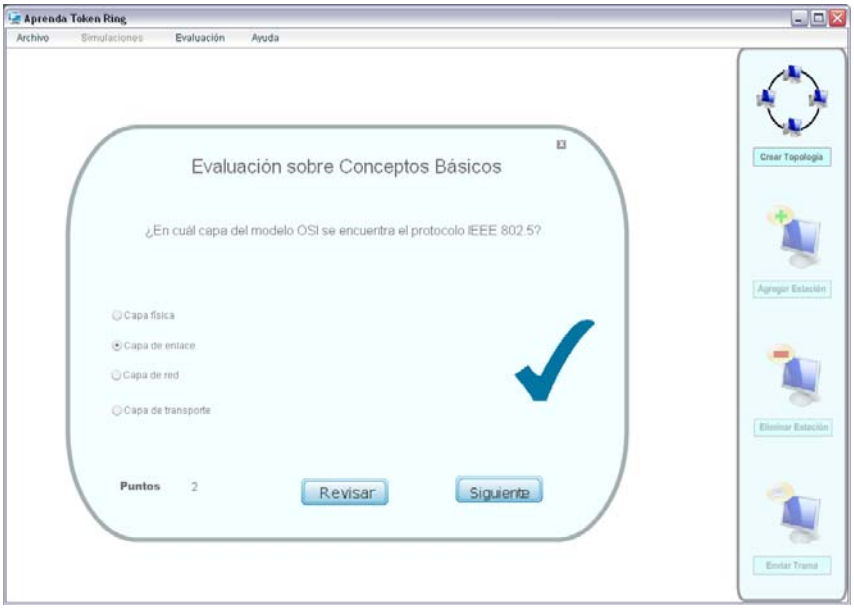

Figure 4: Evaluation Window

Finally, the application also offers a help section (see Figure 5), that includes a detailed description of the application, as well as a glossary of terms.

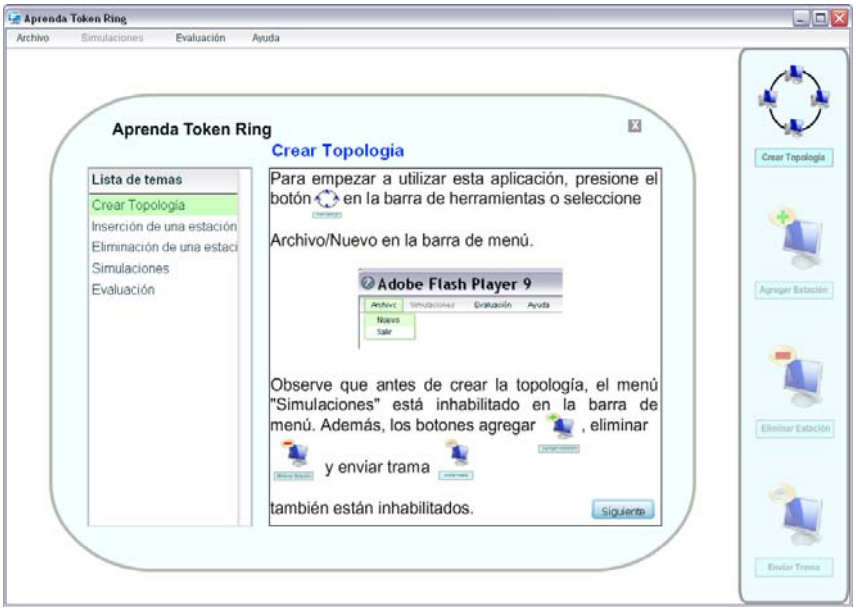

Figure 5: Help Window

5. THE NEED OF A LEARNING TOOL FOR TOKEN RING NETWORKS

Nowadays, the most widely used LAN architecture is Ethernet; this had led to the fading of Token Ring. However, Token Ring is still considered an important network technology that needs to be taught, because it involves concepts that are not covered by other network architectures, such as priority at the data link layer. As stated in Section 3, there are only a few learning tools that cover Token Ring architecture; and are limited to basic functionalities of the technology.

Due to the relevance of learning different medium access control methods, it is important to cover Token Ring networks. However, installing a Token Ring network is not always possible because of the cost of the equipments and the lack of products in the market. Simulations and learning tools are becoming more frequently used to analyze network protocols, due to the diversity of network technologies, their complexity, and their cost. This is why we decided to develop an application that shows, in a practical and easy way, the operation of Token Ring networks, specifically at the data link layer (MAC and LLC sublayers).

Several national and international universities include Token Ring in their curriculum. Examples can be found in Table 1, where the courses listed include a topic related to Token Ring networks in their syllabus. For these universities, *Aprenda Token Ring* is a solution to do laboratories.

Table 1: Universities that Include Token Ring in their Courses

University	Course Name
Universidad Central de Venezuela, Venezuela	Computer Networks
University of Mumbai, India	Networking and Internet Fundamentals
Carnegie Mellon, USA	Basic Computer Systems
Washington University in St. Louis, USA	Protocols for Computer Networks
Georgia State University, USA	Telecommunications for Business
University of Pennsylvania, USA	Introduction to Networks and Protocols
American University of Beirut, Lebanon	Computer Networks
Universidad de Antioquia, Colombia	Data Communications

Knowledge of Token Ring networks goes beyond college campuses. For instance, several certification programs include Token Ring in their evaluation exams. It is the case of CCNA (Cisco Certified Network Associate) (Odom, 2007), and CompTIA (Computer Technology Industry Association) Network+ (Meyers, 2009). In this case also, *Aprenda Token Ring* can help users in their preparation for the exam certification.

6. CONCLUSION AND FUTURE WORK

In this paper, we present *Aprenda Token Ring*, a Token Ring simulation environment. The application attempts to fill a lack in the academic community, representing a practical way to learn about Token Ring network operation. The application was developed using agile methodologies, employing the XP method. *Aprenda Token Ring* was written in Flash CS3 and Action Script 2.0, where the classes are managed through Movie Clips. It is an open source project developed under the GNU General Public License and can be downloaded at http://sourceforge.net/projects/aprendatokenrin. The animations involved in the simulations allow users a faster and easier comprehension on the network operation. *Aprenda Token Ring* also incorporates additional tools, like a glossary, a help section and a test section, that complement the user learning experience. Since it is an open source project, users can modify its source code and adapt it to specific needs. *Aprenda Token Ring* is now in use in different courses (*Data Communications* and *Computer Networks*) of the undergraduate program of the school of Computer Science at *Universidad Central de Venezuela*, and the feedback that we received from students and professors has been helpful and very positive.

For future work, we plan to incorporate other Token Ring processes, such as Ring Purge, in our learning tool. Also, we will translate the application into different languages (right now it only supports Spanish), which will permit people all over the world to use it, since Token Ring is covered by universities worldwide.

We are also interested in developing other simulators for learning purposes to cover technologies such as FDDI (Fiber Distributed Data Interface) (Albert and Jayasumana, 1994), Frame Relay (Buckwalter, 1999), ATM (Asynchronous Transfer Mode) (Kasera, 2006), MPLS (Multiprotocol Label Switching) (Davie and Farrel, 2008) and IPv6 (Internet Protocol version 6) (Deering and Hinden, 1998).

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