Chapter 16

Interacting with Objects in Games Through RFID Technology

Elena de la Guía, María D. Lozano and
Víctor M.R. Penichet

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1. Introduction

Interactive games aimed at educational environments are becoming increasingly important in children´s learning. At the same time, technological advances are definitely causing the arrival of new computational paradigms, such as Ubiquitous Computing or Internet of Things. Ubiquitous Computing was defined by Mark Weiser in 1988, which provides the user with advanced and implicit computing, capable of carrying out a set of services of which the user is not aware. Internet of Things is similar to the Ubiquitous Computing paradigm and was introduced by Kevin Ashton in 1999 [7]. The scenario is described as a daily life object network where all of the objects are digitalized and interconnected.

The main objective of this chapter is focused on how to exploit the evolution of technology to improve user interaction in game environments through digitalized objects with identification technology (such as RFID or Near Field Communication). Digitalized objects are used as interaction resources. They are used in conjunction with mobile devices providing the performance of tasks with a simple and intuitive gesture. In the first place, mobile devices offer sophisticated methods to provide users with services to make use of information and to interact with objects in the real world. In the second place, physical objects are associated with digital information through identification technologies such as RFID. In this context, physical mobile interactions allow users to play games through natural interaction with objects in the real world. This chapter has six sections. Section 2 describes some concepts such as: Ubiquitous Computing, the Internet of Things and the types of interaction used in games. Section 3 presents the general infrastructure of RFID systems. In section 4, we describe the development of two RFID games. In section 5 their advantages and disadvantages are presented. Finally, conclusions are set out in Section 6.

2. Related works

Ubiquitous computing involves computers and technology that blend seamlessly into day to day living. Weiser described the concept in the article [8] in 1991.

The idea of a disappearing technology can clearly be applied to the trend in RFID technology development. In recent years, RFID technology was used in retail [2] and logistics [3]. Nowadays RFID Technology is becoming such an ubiquitous technology, it has led to a particular interest in developing a system in smart spaces. The Internet of Things is similar to the Ubiquitous Computing paradigm, which was described by Kevin Ashton in 1999 [7]. This concept refers to the interconnection of everyday objects in a network. i.e., each object such as a table, a chair or a refrigerator may include integrated identification technology. In this way, the Internet evolves from traditional devices to real objects thanks to the use of technologies such as wireless sensors or RFID.

In this chapter we have focused on games as an educational tool for children's learning. A video game is a software programme created for entertainment and learning purposes in general. It is based on the interaction between one or more people and an electronic device that executes the game. Over the past decades, video games have become a mainstream form of entertainment and communication which are highly accepted and successful in the society. People like playing games for several reasons: as a pastime, as a personal challenge, to build skills, to interact with others, for fun, or as tool for learning. In recent years, the advancement of technology has allowed designs to implement intuitive and new forms of interaction between the user and the console. Some of the devices used are: Kinect, Wii, Multi-Touch Technology, Virtual Reality, and Identification technologies such as RFID, NFC. The following describes in detail the devices and ways of interacting that there are between systems and users.

Kinect is a motion sensing input device that is connected to the console and PC video. It allows the user to interact with the game through movement and voice. In order to function, it requires technologies such as sensors, multi-array microphone, RGB camera and an internal processor. Some existing games that incorporate this technology with learning games are: [4][5][6]. These games offer a new and attractive interaction technique based on movement and voice. However, the new interaction needs some getting used to, most especially for children who have either physical or cognitive disabilities, as it can be exhausting to play through movement. Another obstacle is the space requirement and the hardware, such as the camera, is more delicate and expensive. Another device developed to improve the interaction between user and console is the *Wii Remote*, which is used as a handheld pointing device and detects movement in three dimensions. This device incorporates technologies such as: accelerometers, Bluetooth...[21].The main problem is the need for battery.

In addition, there is *Virtual Reality* software using helmets, gloves and other simulators. In this way the user may feel more immersed in the game, and it is very engaging and motivating, but the problem is the high cost of devices, and the difficulty in the use of certain devices. Also, an additional person is required to control the players and devices [9][10]. *Multi-*

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touch technology for games allows the users to play on digital tabletops that provide both an embedded display and a computer to drive player interactions. Several people can thus sit around the table and play digital games together. This technology uses infrared LEDs and photodiodes, which are discretely mounted around the perimeter of the LCD. The principle of an infrared touch screen is the combination of an infrared (IR) LED and an IR-sensitive photodiode. As soon as there is an object or finger between the LED and the photodiode, the latter no longer detects the IR light from the LED. This information is the basis for the input detection. You can interact with them through multiple objects (including fingers). Some of the games implemented with touch technology for learning are:[11][12][13][14].

Identification technology such as *RFID* and *NFC* has been used to transmit the identity of an object using radio waves. In this way different types of interaction are allowed, such as touching which involves touching an object to a mobile device and enabling the user to perform the selected task. For example [15][16] show some projects using this technique.

- Scanning: the mobile device or other device is capable of scanning information and interacting with the system to provide a service to the user.
- Approach&remove: [17] this is a style of interaction which allows us to control user interfaces of a distributed nature by making a gesture with the mobile device. Interaction, as mentioned previously, may be absent or may simply consist of approaching the mobile device to digitized objects.

In this chapter we propose another kind of interaction, in which the mobile devices are stationary and the user used physical objects for interacting with the display.

Some systems that use identification technology are described as following: Smart Playing Cards [26] is a game based on RFID; this technology is integrated in cards. Augmented toys are digitalized with RFID technology simulating the real world [18] [19]. Meta-Criket is a kit developed for augmenting objects [25]. Hengeveld described in [20] the value of designing intelligent interactive games and learning environments for young children with multiple disabilities to increase their language and communication skills. In [21] we can find a proposal that digitalizes toys to help deaf children to learn sign language. This system [24] focuses on assessment and training for special children, allowing the user to store data through RFID cards data for processing daily and providing treatment advice. However, this project only focuses on monitoring the child and does not take into account activities to improve their intellectual ability. [22] describes a RFID musical table for children or people with disabilities. The table is designed for people who cannot navigate through menus or by using buttons on an iPod, and serves to enable them to select albums or songs from a music list from an iPod Touch. This system is very specific; it is more focused on entertainment. Logan Proxtalker [23] is a communication device which allows any user to communicate with symbols "PECS" System (Picture Exchange Communication), which is a device to retrieve vocabulary stored in different labels in order to play actual words. These systems provide entertainment and user interaction with the environment. The disadvantage is that are very specific and none of them has focused on the stimulation of the cognitive abilities of people with intellectual disabilities.

The advantages offered by these devices and systems are numerous. They enhance positive attitudes in users. They feel more motivated and encouraged to learn. However, the systems present the following disadvantages:

- The user needs a minimum knowledge of computer use. Not everybody can use a computer and some devices, like a mouse or a keyboard are not intuitive for people with cognitive disabilities. They need someone to help them.
- The system requires highly specialized hardware / software which can be expensive (simulators, virtual reality). In some games, impaired users may have difficulties finding specific information.

On the other hand, RFID technology has many benefits over other identification technologies because it does not require line-of-sight alignment, tags can be identified simultaneously, and the tags do not destroy the integrity or aesthetics of the original object. Due to the low cost of passive RFID tags and the fact that they operate without a battery, this technology is ideal for converting a real object in a physical interface capable of interacting with other devices

3. RFID-games proposal

The main objective of the project was to develop educational games for children that offer easy interaction based on RFID. For this purpose, the advantages offered by games developed in the pre-computer age (traditional games) were combined with the advantages and benefits of computer games.

To begin with, there are many advantages of traditional games. These were designed and carried out in the physical world with the use of real-world properties such as physical objects, our sense of space, and spatial relations.

Pre-computer games interactions consisted of two elements: user-to-physical-world interaction and user-to-user interaction. The physical objects were easily assimilated by the children, allowing users to interact intuitively with them.

There are also many benefits of computer games. These are more popular than traditional games. Some the advantages are the following:

- People create the illusion of being immersed in an imaginative virtual world with computer graphics and sound.
- Computer games are typically more interactive than traditional games, which enables the user to feel more motivated.
- Computer games allow feedback to be easily shown, as well as notifications about the game process and other important information.

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Taking advantage of real physical objects and the benefits that new technologies offer us, we have designed a new way to interact with the system. It is based on physical objects that integrate RFID technology and allow us to interact with Graphics User Interfaces.

This kind of the system functions as follows: in the main game an interface is projected on the wall. Users with physical interfaces, i.e., the objects that integrate RFID tags, can interact with the main interface; this requires the mobile device that incorporates the RFID reader to interact with the main interface, which is necessary to bring objects to the mobile device (See Figure 1).

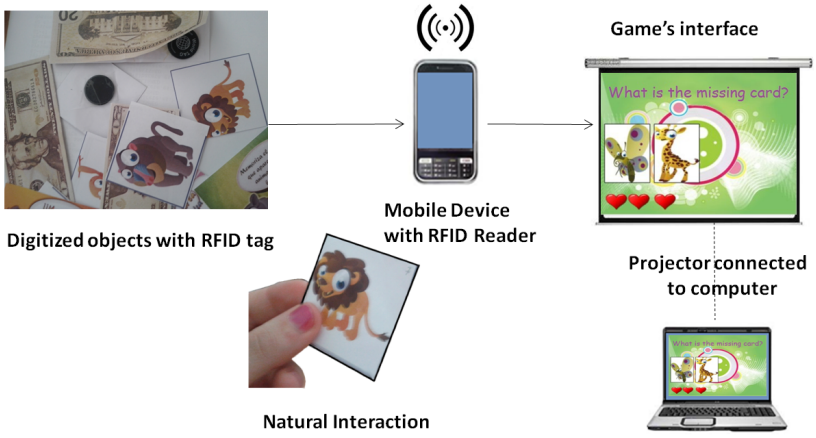

Figure 1. Digitized objects with RFID tags that communicate with the game's interface through the mobile device.

Due to the need to make a simple, accessible and intuitive system and considering the multiple technologies used to develop it, it was decided to follow an architecture based on three layers. The system infrastructure is divided in the following layers: Application Layer, Network Layer and Perception Layer. In the next section, we explain the latter in more detail (See Figure 2).

3.1. Presentation layer

This layer is the intermediary between the user and the system. Its main function is to allow the user to easily interact with the system. In our case study, the games are designed for children and users with special needs and for this reason we must focus primarily on usability and accessibility of the system. The main requirements that have been followed for the development of this type of games are:

Designing simple interfaces so that users do not have to learn to use it, acquire new skills, or need help.

Avoiding distraction and facilitating the interaction so that the user need not know and memorize how the system works.

Avoiding fear of interacting with the system, as well as providing notification of game development and the collaboration of information among players.

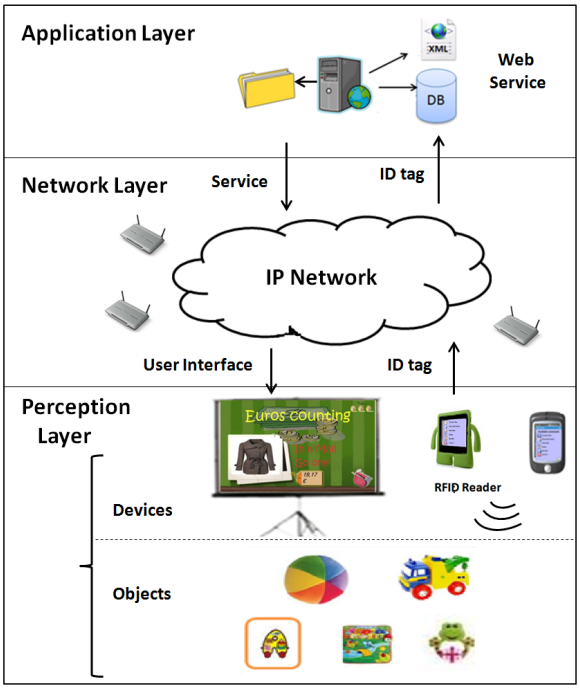

Figure 2. System architecture divided into three layers: Perception, Network and Application

This layer is divided into two parts. Firstly, there are the objects that integrate RFID technology, also called interaction resources, and secondly, there are interaction devices, through which are offered relevant services.

- Objects. Their main function is to facilitate the human-computer interaction. These resources need to have a RFID reader nearby to perform services. The main reason to use objects that interact with the environment is the following: The user uses human factors such as perception in order to interact with the environment. When an object similar to other objects with similar appearance is seen, the mind of the user automatically associates the object with its function.
- Devices. These computing devices are used as input and output of a system. They are communication channels. They are responsible for obtaining information from users

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without that them being aware of it. In this particular case, a mobile device has been camouflaged in a toy in such a way that it is more engaging and intuitive to users. The devices available in the system are described as following:

Mobiles devices: These devices internally incorporate the RFID reader, allowing users to communicate with the system through RFID technology.

Projector: This shows the game user interface, the results and feedback. The software is run on a PC or laptop. It returns the information in textual and audio format to facilitate the use of games. It works dynamically and responds to the information sent to web services (Application Layer) through the communication network (Network Layer).

The user communication style with the device is very intuitive, which is why no prior knowledge is necessary (see Figure 3), it is only necessary to move the toy, card or object, depending on the game, closer to the mobile device (hidden in an object). The interaction and the processes that occur below the system are implicitly run by the user.

In this case, the collaborative screen shows the game which is being executed. It may show some objects and to associate that object the user has to interact with it, just by moving the corresponding object closer to the mobile device. From this moment all processes are run implicitly. The collaborative screen displays the pictures, text and sounds, depending on the game executed.

Figure 3. Interaction. The user brings the digitized object closer (interaction resource) to the mobile devices that contain the RFID Reader. This is an interaction device hidden in an object [27].

The communication between interaction devices (mobile devices) and interaction resources (digitalized objects) is the following: The RFID tag (embedded in the object) is a small chip integrated circuit, adapted to a radio frequency antenna that enables communication via radio. The energy to generate communication is received from the reader´s radio waves (integrated into the mobile devices).

The device on the client´s side includes a reader and a controller that is responsible for processing information received by the physical object and transforming it into useful information, such as an XML message that is sent to the server, which will process the message and trigger an action, such as the generation of user interfaces or the information requested at that time. The network technology is then used to notify the customer with through web services, connecting the two components: the client and the server (See Figure 4).

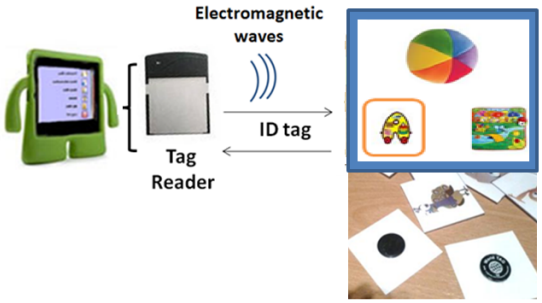

Figure 4. Communication is based on RFID technology. The mobile device has RFID reader inside. It sends electromagnetic waves when a digitalized object is close to mobile device. It processes the information contained in the object and carries out the required action.

3.2. Network layer

This layer enables the information obtained from the perception layer to be transmitted. This layer is composed by different wireless access technologies such as, Wireless Local Area Networks (WLAMs) (IEEE 802.11 variants), Bluetooth (IEEE 802.15.1). Wireless networks are a good option to establish wireless and mobile communications within the Internet of Things. We have used Wi-Fi technology because it allows connection of heterogeneous devices with the system (the computer interface that supports games and mobile devices which communicate with the objects). In addition, it allows user mobility, is highly scalable, efficient and lightweight.

3.3. Application layer

This layer provides services to support the stimulating games. It is consists of a server, which is a computer as part of a network, providing services to the devices which are connected to it. It provides important functions such as Web Services database.

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Web Services are a set of protocols and standards used to exchange data between applications in order to offer services. They facilitate interoperability and enable automated services to be offered, automatically causing the generation of user interfaces, thus allowing user consistency and transparency in use of the technology. Web services are of great importance in the trend of distributed computing on the Internet. To broaden and clarify the concept of Web services, we can quote a presentation by Dr. Marcos Escobar: "A Web Service is a software component that communicates with other applications by coding the XML message and sends this message via standard Internet protocols such as HTTP (Hypertext Transfer Protocol)". Intuitively, a Web Service is similar to a Web site that has a user interface that provides a service to applications, by receiving requests through a message formatted in XML (Extensible Markup Language) from an application, it then performs a task and sends a response message, which is also formatted in XML. The standard protocol for messages is SOAP (Simple Object Access Protocol). A SOAP message is similar to a letter: it is an envelope containing a header with the address of the recipient, a set of delivery options (data encryption), and a body with the information or data of the message. The performance of the web services is as follows: the client application sends an XML message to the server, and then the services contained provide an XML document called WSDL (Web Services Description Language). Its aim is to describe in detail the interfaces so that the user can communicate with the service. XML Web services are registered so that the user can easily find them. This is performed using UDDI (Universal Description Discovery and Integration). The response to the customer is another XML message that is capable of generating the user interface that the device in the client´s side is going to display at that moment. Figure 3 shows the communication that takes place between Web services and client applications.

Database is an organized collection of data, today typically in digital form. The data is typically organized to model relevant aspects of reality. In this case, the database is composed the idtag field. Each idtag is associated with the web service function. Among the functions are the following: execute a method, update information.

The internal operation is as follows: the web service receives the information, which is the output layer, and specifically the id tag which in this application has been read from mobile devices. The system checks the method associated with this id tag in the database. Web Service receives information about the method that it must execute. The execution of this operation depends on the following parameters: the object identifier, the executed game and the current status in the game. A common flow of actions that a user may perform could include:

- Updating the database and results internally in the system.
- The system automatically generates the corresponding game interface. The projector displays it. According to the action carried out, different messages might be shown.
- If the answer is right, a message indicates the outcome of play. This user interface congratulates and encourages the children to continue playing. A few seconds later, the interface related to the game that is running appears, but at a higher level than before.

- If the answer is wrong, a message indicates the outcome of the play. This user interface motivates and encourages them to try again. The next user interface is related to the game that is running at the time, but at the same level as before. Voices and motivating messages sound in every interface to make the user feel actively accompanied and encouraged.
- The system automatically generates the corresponding mobile user interface. It shows feedback and status of the system according to the action carried out.

4. Case studies developed by using RFID technology

In this section we describe two systems built in the University of Castilla-La Mancha (Albacete). The main objective is to take advantage of RFID technology to build systems that improve the user experience.

We used the same architecture for both games, while changing the contents and taking into account the cognitive abilities that we aimed to stimulate in each particular case.

This system functions by projecting an interface on the wall in the main game. Users with physical interfaces, i.e., the objects that integrate RFID tags, can interact with the main interface; this requires a mobile device that allows the RFID reader to interact with the main interface by bringing an object closer to the mobile device to play the game. For example, if in the game an object must be associated with another, the user only has to bring the corresponding object closer to the mobile device for the system to recognize it and display the outcome of the game.

4.1. Train InAb system

Intellectual disability, also called mental retardation, is a disability characterized by significant limitations in intellectual functioning and in adaptive behavior skills manifested in conceptual, social and practical aspects [1].

So far, this group has always had barriers imposed by society and by technology as it has often not been known how to adapt to the personal needs of each of these people.

Gradually, this situation has been improving with technological assistance and that of society. However, many of these people consider the world of technology to be strange and difficult to use.

TrainInAb (Training Intellectual Abilities) is an interactive and collaborative game designed to stimulate people with intellectual disabilities. The game is based on RFID technology; it allows a new form of human-computer interaction to be integrated. The user can interact with the system through everyday objects such as cards, toys, coins, etc. (See Figure 5). For example, if in the game an object must be associated with another, the user only has to bring the corresponding object closer to the mobile device, which the system will then recognize and display the outcome of the game (See Figure 5 and Figure 6)

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The package consists of three different types of game, each aimed at stimulating a different cognitive ability such as memory, calculation, attention and auditory discrimination.

- They are divided into different levels to motivate the child when using the game. If the child fails, s/he loses a life and if the user wins, s/he moves on to the next level. Each level is more difficult.
- It displays the external information differently, as it is different for every level.
- The information is displayed as text, voice and graphics. In addition, the game can show the status and game results when the game ends
- The feedback-state messages are motivating for the user who then feels more encouraged to continue playing.
- The user has the possibility of repeating items.

Figure 5. The first image shows the Mobile devices interfaces. The next image shows the Physical user interfaces, that is, objects that integrate the RFID inside.The first objects are cards with images from the game, and the last image shows the notes and coins used for the game.

Figure 6. Main interface of the game designed to stimulate user memory, attention and calculative abilities.

4.2. StiCap

Attention-deficit/hyperactivity disorder (ADHD) is a neurobiological disorder characterized by developmentally inappropriate impulsivity, inattention, and in some cases, hyperactivity. Children who are affected by this disorder have occasional difficulty paying attention or controlling impulsive behavior. This problem affects them in their daily lives at home, at school, at work, and in social settings.

StiCap, Stimulating Capabilities, is an interactive system to improve attention and learning in children with ADHD. It is directed towards psychological therapies, in schools, allowing supervision by professionals, parents, and teachers.

The system consists of three games: two oriented towards memory improvement and another one oriented towards vocabulary enrichment. It is composed of the following devices: cards integrating RFID tags used as interactive resources which allow a one-way transfer of information between a user and the system; mobile devices provide the necessary communication between the cards and the system and a projector or any other big display showing the game interface which is running on any PC or laptop.

Figure 7. Main interface of the game designed to stimulate user memory and attention [28]

5. Benefits and drawbacks

In this section we will discuss the advantages offered by the integration of RFID technology in the new scenarios.

The main advantages of the system are the following:

- Reduction of the cognitive load. This means that users have to rely more on recognition skills than on their memory and that they do not have to remember complicated abbreviations and codes. For this reason, it has been designed in a very graphic way and has also used common objects which can be easily assimilated.
- Flexibility. This refers to the multiple ways in which the user and the system can exchange information. The information exchanged is displayed as text, voice, cheerful

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sounds or by using graphics. The goal is to adapt to any user, regardless of any disability or limitation he/she may have.

- Flexibility in the number of users. This is a multi-player game. This allows users to share and exchange experiences with other users. The situation of each user may be complex and variable and for this reason, the game can also be used by one player.
- Flexibility in terms of space. Players can be situated anywhere in the room, the only requirement is that the mobile device is connected to the server.
- Very cheap to develop. Mobile devices will incorporate RFID technology in the short term and passive RFID tags are very inexpensive. In our case, only one mobile device is required, which is why it is low cost.
- Expandable. It offers the possibility to extend the games. The topic can be changed easily. The only requirement is that the RFID must be integrated in the object selected.
- Interaction with the system is simple and intuitive. Common items are familiar and can be easily assimilated by users, making it more predictable to use. They do not need prior knowledge of the system or device.
- The cognitive stimulation of the system can enhance mental abilities such as perception, attention, reasoning, abstraction, memory, language, orientation processes, while optimizing their performance. These games can be used as therapy for the cognitive deficit.

Thanks to this technology, the implementation of new interfaces can be developed for any mobile device, allowing system usability and user-friendly interaction, thus improving user satisfaction.

One possible limitation are that it requires connectivity to another network interconnection. The server needs to contain all the data from RFID tags, so in very complex systems we can find a lot of data, which might be difficult to manage.

6. Conclusions

Educational games are currently making a very positive impact and are extremely successful among society, especially among children.

Emerging technologies and mobility are being inserted without society realising by providing services previously unthinkable. In recent years, devices have been invented that offer new techniques for interaction between humans and game consoles. Nowadays, the user can interact through movement, voice command control, virtual reality, mobile devices, etc... However, there are still some hardware limitations for children and especially people who need special education.In recent years, RFID technology is booming and being used to digitalize spaces and objects easily, so we are getting closer to the new paradigm predicted by Weiser, ubiquitous computing.Exploiting the advantages offered by this technology, this chapter proposes a new form of interaction based on objects that integrate RFID technology.

In this way, anyone can interact with the software(in this case with the games)in an intuitive way.

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Author details

Elena de la Guía, María D. Lozano and Víctor M.R. Penichet

University of Castilla-La Mancha, Spain

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