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ZigBee Enabled RFID based Tracking System

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ABSTRACT: The Radio Frequency Identification (RFID) system is a widely used Auto-ID technology today to identify and track objects and people in manufacturing, inventory management, retailing, and security applications. The ZigBee technology, which is a network communication protocol based on the IEEE 802.15.4 standard, provides a self-organized mesh network topology with a power-effective, low data rate and multi hop data transmission. We can achieve more efficiency by introducing the ZigBee technology into the existing RFID architectures, such as having extended effective range, improving network flexibility and having compatibility with other ZigBee enabled environment systems. In this paper, we propose a system to track the location of a person using RFID (Radio Frequency Identification) Technology and notify it to a monitoring PC using wireless ZigBee Technology.

KEYWORDS: RFID, ZigBee, Tracking, Tag, Reader, SM125-IC.

I. INTRODUCTION

In many cases, the location from which the data is coming is equally as important as the data itself. Fields such as asset management, access control and remote monitoring all contain certain applications that would benefit from knowing the location of a reading, as well as the reading itself.

In a campus, monitoring each employee manually is very complex. Some automated applications were developed using GPS and RFID, but they are more expensive [1]. We propose an efficient method suitable to all conditions and comparatively low cost. Here usage of ZigBee also facilitates wireless transmission of data to the PC. By using RFID monitoring system, we can track the employee movements inside the office premises. The updated data from the host computer can be used to determine the effective working hours that a worker actually makes. RFID tag of each employee has a unique ID and correlates with the RFID reader placed inside the campus premises. The passive tag is activated with the help of RF energy from the antenna and it extracts information from the tag. The reader reads the information from the tag and passes to the microcontroller. The information is given to the computer through wireless ZigBee protocol. A graphical User Interface is also developed for ease of access.

The demand for wireless solutions continues to grow and with it new standards have come forward and other existing standards have strengthened their position in the marketplace. Table1 compares three popular wireless standards being used today and lists some of the design considerations that differentiate them.

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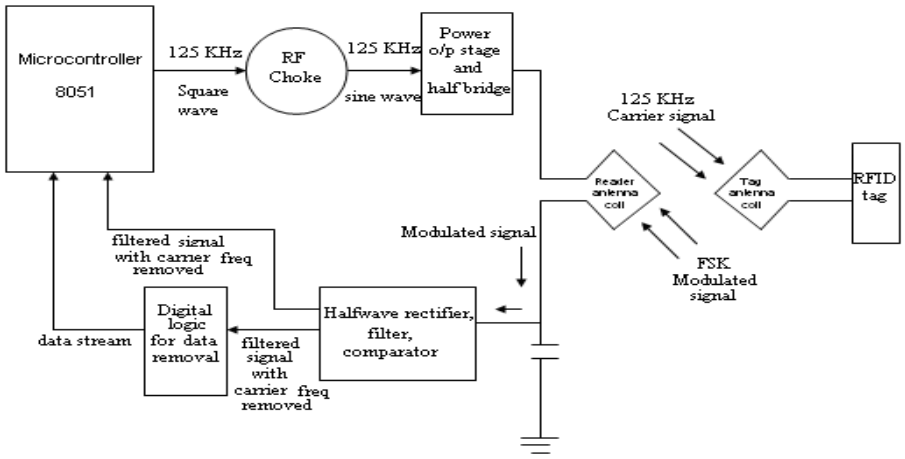
Wireless Parameter	Bluetooth	Wi-Fi	ZigBee
Frequency band	2.4 GHz	2.4 GHz	2.4 GHz
Physical/MAC layers	IEEE 802.15.1	IEEE 802.11b	IEEE 802.15.4
Range	9 m	75 to 90 m	Indoors: up to 30 m Outdoors (line of sight): up to 100 m
Current consumption	60 mA (Tx mode)	400 mA (Tx mode) 20 mA (Standby mode)	25-35 mA (Tx mode) 3 µA (Standby mode)
Raw data rate	1 Mbps	11 Mbps	250 Kbps
Typical network join time	>3 sec	variable, 1 sec typically	30 ms typically
Interference avoidance method	FHSS (frequency-hopping spread spectrum)	DSSS (direct-sequence spread spectrum)	DSSS (direct-sequence spread spectrum)
Minimum quiet bandwidth required	15 MHz (dynamic)	22 MHz (static)	3 MHz (static)
Maximum number of nodes per network	7	32 per access point	64 K
Number of channels	19	13	16

V. LITERATURE REVIEW

A. *RFID*

RFID stands for Radio Frequency Identification. **Radio-frequency identification** is an automatic identification method, relying on storing and remotely retrieving data using devices called RFID tags or transponders

Block diagram of RFID system:



Microcontroller is programmed to generate a 125 KHz square signal. This signal is given to a RF choke which converts it to sine waveform with frequency equal to 125 KHz. This is given to an amplifier stage and the amplified signal drives the reader antenna. The reader antenna produces an electromagnetic field. When tag is brought within the vicinity of the coil, inductive coupling takes place between the coil in the tag and reader antenna. The internal circuitry in the tag modulates the carrier signal. The FSK modulated signal is obtained from the tag. This signal is then filtered and demodulated by the receiver and given to the microcontroller for further processing.

The traditional RFID systems needed many components and IC‘s to form the transmitter and receiver sections of the reader as shown above. Transmitter Section comprises of the RF choke and Power amplifier. Receiver Section comprises of the Envelope Detector, RC Low Pass Filter, Twin-T filter, Butterworth filter, Comparator, D flip-flop & Decade Counter, Microcontroller.

The SM125-IC design eliminates using external amplifiers, filters, antenna driver and even microcontroller. The following diagram illustrates SM125-IC internal blocks.

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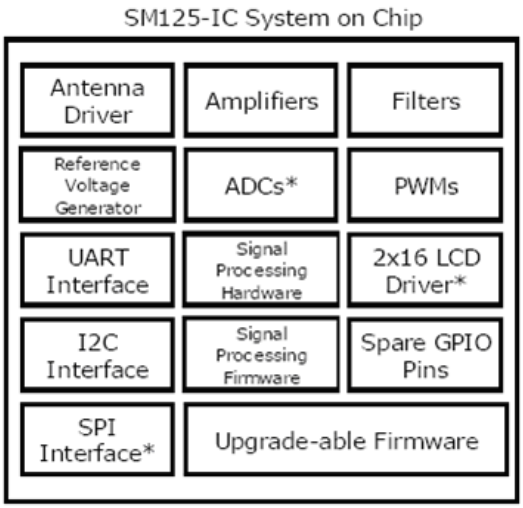

SM125-IC drives the antenna with a 125 KHz (programmable) clock frequency. The antenna supplies energy to the tag. Tag is energized and it modulates the magnetic field. The modulated signal is passed on passive analog front end components and DC signal level is adjusted. SM125-IC amplifies, filters, then demodulates the signal and converts it to digital. The digitalized signals then get decoded and the actual tag data is captured. The actual tag data is available to send to external peripheral over I2C bus, UART, Wiegand or GPIO output. 125 KHz RFID systems is not designed for data storage and mass writings. Once the tag is programmed, e.g. such as given IDs, it is rarely written again in the field in real life. SM125-IC supports Manchester modulation. The supported tags are Atmel / Temic T55xx (Q5, T5551, T5552, T5554, T5555, T5557).

Reader Antenna design:-

Reader antenna can be designed in various shape and size coil, in our project we will be using a square shaped coil. The read range of tag largely depends upon the antenna circuit and size.

We used a series LC resonant circuit.

$f = 1/2\pi\sqrt{(LC)}$ where f – resonant frequency, L – Inductance, C – Capacitance

To calculate the number of turns for the rectangular coil we use the following equation:

$$L = \frac{0.0276\left((x+y+2h)N\right)^2}{1.908(x+y+2h)+9b+10h}$$

Since f=125 KHz, C=100µF hence L=16.2nH.

RFID READER

a) Top view of RFID Reader

b) Bottom view of RFID Reader

UART communication protocol

UART communication protocol is used for communication between the SM125 IC and an interface.

The RFID Chip communicates with peripheral devices via 8-byte data packets at 19200 bps. This baud rate can be increased or decreased through firmware modification. Most commands consist of 8-byte packets but there are also 16-byte data packets. The RFID Chip sends the received data back to an external device upon receipt of the UART signal. The external device checks that the data is the same as the previously sent data. If the data is the same, it sends an acknowledgement. If not, it sends a non-acknowledgement string message.

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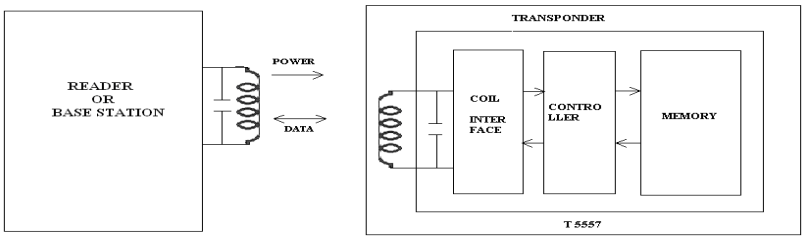
TAGS:



Interaction of reader and tag

T5557 is a contactless R/W identification IC for application in 125 KHz frequency range. Single coil, connected to the chip serves as IC's power supply. Antenna & chip together form a transponder or tag.

Reading a Tag:

For reading a tag (ISO card or keyfob or others), first send the proper string from PC side over the serial RS232C port. This turns the LED to Red color indicating that the unit is ready to read tag. Now, hold the tag at a distance not exceeding 80mmfrom the top face of the unit. Sometimes the proper orientation of the tag might be necessary to read it. This is a typical characteristic of passive tags and has nothing to do with the performance of RFID reader unit. A tag can be read any number of times after the data is written.

B. ZIGBEE

ZigBee is a technological standard, based on the IEEE 802.15.4 standard, which was created specifically for control and sensor networks. The standard for this WPAN specifies not only a low data rate but also low power consumption and low complexity, among other things. The ZigBee standard is built on top of this IEEE standard, addressing remote monitoring and control for sensory network applications. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth. ZigBee is targeted at radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking. Zigbee is generally used for energy management because it consumes less power comparing with other devices (like Blue tooth), .Hence it increases the battery life. ZigBee adopts IEEE 802.15.4 standard as its physical and MAC protocols and solves the interoperability issues from the physical layer to the application layer.

What ZigBee is designed to do is add mesh networking to the underlying 802.15.4 radio. Mesh networking is used in applications where the range between two points may be beyond the range of the two radios located at those points, but intermediate radios are in place that could forward on any messages to and from the desired radio.Another feature of ZigBee is its ability to self-heal. If the radio at a certain point was removed for some reason, a new path would be used to route messages from source to destination.

Modes of Operation

1. Idle Mode

When not receiving or transmitting data, the RF module is in Idle Mode. During Idle Mode, the RF module is also checking for valid RF data. The module shifts into the other modes of operation under the following conditions:

- Transmit Mode (Serial data in the DI Buffer is ready to be packetized)
- Receive Mode (Valid RF data is received through the antenna)
- Sleep Mode (End Devices only - not supported in this release)
- Command Mode (Command Mode Sequence is issued)

2. Transmit Mode

When serial data is received and is ready for packetization, the RF module will exit Idle Mode and attempt to transmit the data. The destination address determines which node(s) will receive the data. Prior to transmitting the data, the module ensures that a 16-bit Network Address and route to the destination node have been established. If the 16-bit

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Network Address is not known, Network Address Discovery will take place. If a route is not known, route discovery will take place for the purpose of establishing a route to the destination node. If a module with a matching Network Address is not discovered, the packet is discarded. The data will be transmitted once a route is established. If route discovery fails to establish a route, the packet will be discarded. When data is transmitted from one node to another, a network-level acknowledgement is transmitted back across the established route to the source node. This acknowledgement packet indicates to the source node that the data packet was received by the destination node. If a network acknowledgement is not received, the source node will re-transmit the data.

3. Receive Mode

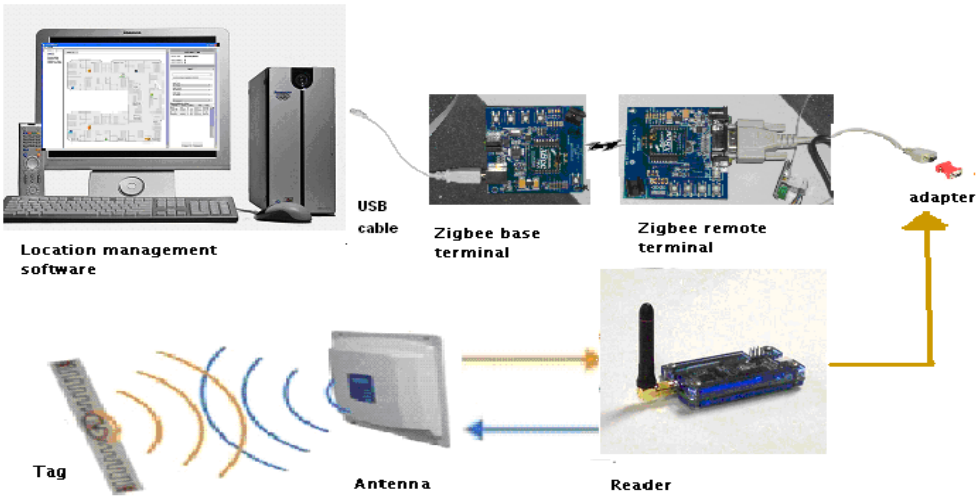
If a valid RF packet is received and its address matches the RF module's MY (16-bit Source Address) parameter, the data is transferred to the DO buffer.

4. Command Mode

To modify or read RF Module parameters, the module must first enter into Command Mode – a state in which incoming serial characters are interpreted as commands.

VI. PROPOSED SYSTEM

RFID readers are mounted at the doors. The person to be tracked will carry a passive RFID tag. The person should hold the tag in front of the reader. The readers send out an RF signal in order to identify the tag. The tag has a unique number, which is communicated to the reader as it passes by. This establishes the person's identity. This information is sent via a wireless ZigBee Network to monitoring PCs. The PCs will have access to location management software. This software will identify the person and determine his location.



In unicast mode the ZigBee base terminal has only one destination address which is the address of ZigBee remote terminal. ZigBee base terminal and ZigBee remote terminal form a wireless link. The ZigBee base terminal is connected to a PC which has the API of the RFID reader present on it. The API sends the read command to the RFID reader (which is the end device of the ZigBee remote terminal.) via the wireless link. Since it is unicast mode the read command is sent to only that ZigBee node. If the RFID tag is present at that node, the tag data is collected by the node and transmitted to base terminal (coordinator) which passes it on to the API present on PC.

In our tracking method we intend to have two (or more) ZigBee nodes (remote terminals) with RFID reader attached as end devices, to be present at two (or more) locations (say doors). Each ZigBee node has a different address. In the location management software each address corresponds to a location for e.g. address 5678 is location Door 1.

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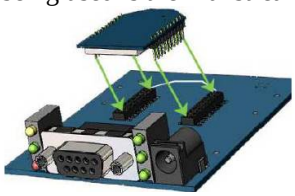
We use a method of polling all ZigBee nodes (remote terminals) by changing the destination address of the base terminal to ZigBee node addresses at gaps of small time intervals and sending the read command to each node one at a time. If the tag is present at that node the tag information is sent via wireless link to PC, thus establishing the location of the person as well as his identity. Further applications can be developed like access control.

IV. IMPLEMENTATION

1. Configuration of ZigBee Modules:

The ZigBee kit being used is the Maxstream XBee Pro 802.15.4 OEM RF Module



The XBee/XBee-PRO RF Module was designed to mount into a receptacle (as shown in fig.) (socket) and therefore does not require any soldering when mounting it to a board. The XBee Development Kits contain RS-232 and USB interface boards which use two 20-pin receptacles to receive modules.

The module was mounted onto the interface board. The board is connected via USB cable (or a RS-232 cable) to the PC. The adapter is also plugged into the board. The Modules (Transmitter and Receiver) were programmed through the XCTU software interface. USB Drivers (Hardware USB Bus & Virtual Com Port drivers) were installed on the monitoring PC. XBee-PRO Modules were mounted on the USB & RS-232 development boards. The module mounted to the USB board will be referred to as the "BASE". The module mounted to the RS-232 board will be referred to as the "REMOTE". The BASE module was connected to the PC using a standard USB cable. Power the REMOTE through the RS-232 development board's power connector using the power adapter included in the development kit. The BASE is powered through its USB connection. Both BASE and REMOTE modules are configured using AT commands. Then the RFID reader is setup by connecting the RS232C cable male side to the unit and the other end (female 9-pin) to the available null modem. After this, the RFID reader is connected as target device to ZigBee as shown

Typical wireless link between DTE and DCE devices

2. Software Installation & PC Setup

Open HyperTerminal (with settings 19200 baud, No parity, 8 data bits and 1 stop bit) on PC to check proper connections. When the power supply is switched on, the reader transmits data string WDR Reset over the serial port. Proper reception of this string on the HyperTerminal screen concludes the setup procedure. On GUI screen the message in list box shows System Initialized to indicate unit's proper initialization

Reading a Tag

The Reader reads formatted T555x series transponders. For reading a tag (ISO card or keyfob or others), first send the proper string from PC side (using GUI) over the serial RS232C port. This turns the LED to Red color indicating that the unit is ready to read tag. Now, hold the tag at a distance not exceeding 80mm from the top face of the unit. Sometimes the proper orientation of the tag might be necessary to read it. This is a typical characteristic of passive tags

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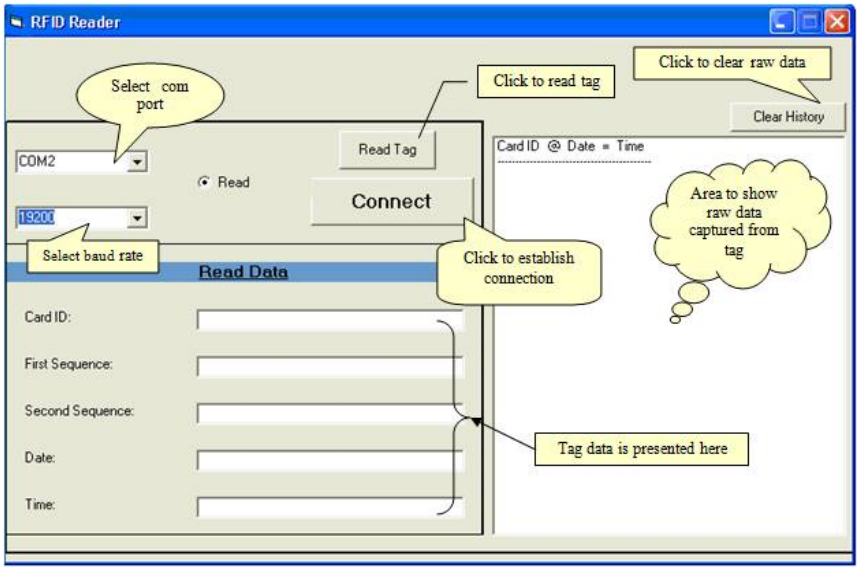
and has nothing to do with the performance of RFID reader unit. A tag can be read any number of times after the data is written.

3. Algorithm

1.Set the remote terminal address
2. Call the reader program and do
   -Select COM port
   -Select baud rate
   -Send read command to Reader
   presence or absence of tag is detected by atdb and rss command of zigbee.
   if tag data is present ie if person is present then data is received and displayed on pc.
3.Repeat step 1 and 2 for all the remote addresses to which reader is connected.

4. Graphical User Interface (GUI)



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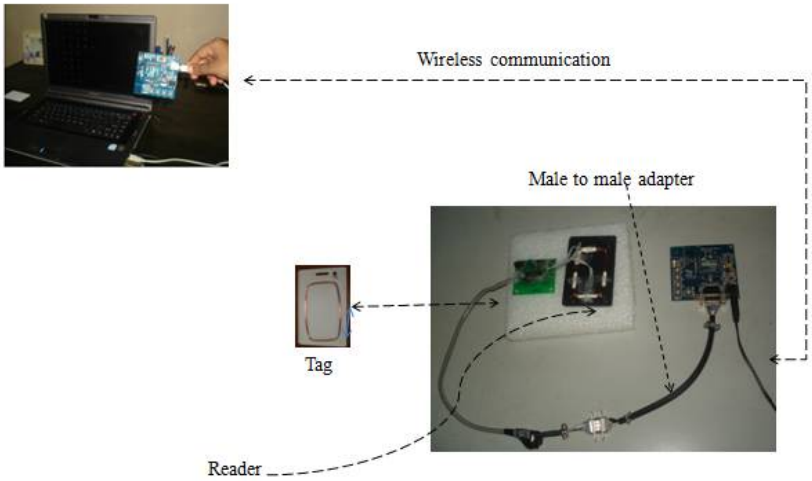
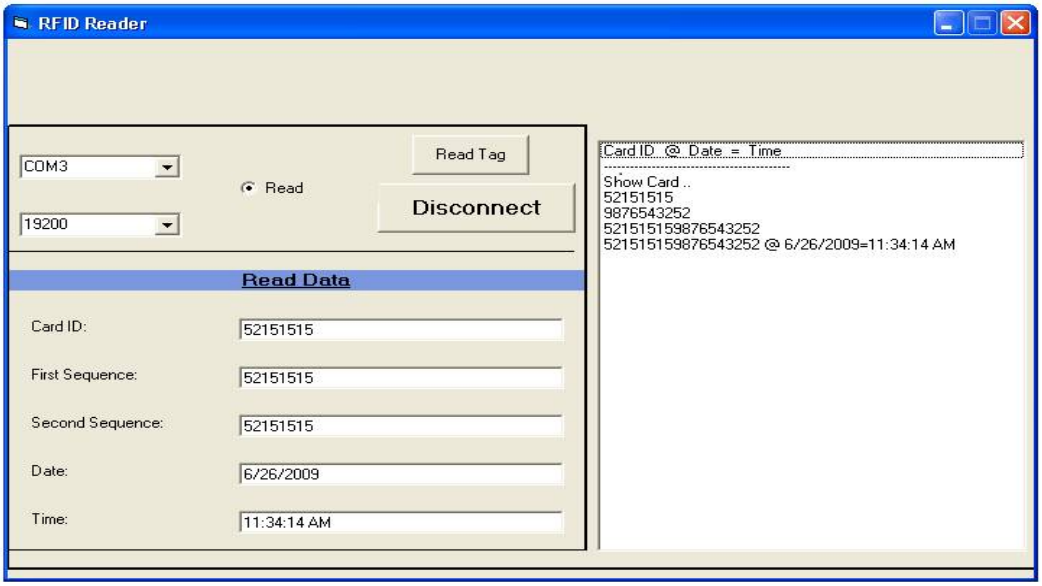
V. HARDWARE SETUP & RESULTS

The figure shows the hardware setup for the project.



The following figure shows the results obtained through the location management software on the PC interfaced to the Graphical User Interface created.



VI. ACKNOWLEDGEMENT

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VII. CONCLUSION

In this paper, we have proposed a low cost but effective monitoring system using ZigBee & RFID. It is more efficient and dynamic method and suitable for all environments. The implemented system increases the range between

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the RFID reader and PC using ZigBee wireless technology. ZigBee technology is based on IEEE 802.15.4 standard. RFID reader follows RFID protocol. As global standards are followed interoperability of the system is ensured. For ease of access at the user end ,we have also developed a graphical user interface for the monitoring PC. A system with multiple remote terminals along with RFID readers will allow more locations to be tracked. An access control system could also be developed to permit only authorized tag bearers in the allowed locations.

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BIOGRAPHY

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