TOPIC SELECTION RATIONALE

The topic Wireless Internet has been selected due to the increasing importance, reliance, and popularity of Wireless Internet and its various applications. Wireless Internet is becoming to be preferred amongst every people due to the increasing mobility of people, demands of more information, the advances of high-speed wireless access, the availability of more wireless applications and technology such as Wireless LAN, WAP, and 3G Cellular Systems.

ABSTRACT

The wireless internet access has been made possible by the technologies in this few years. This report discusses the technologies that are used, wireless LAN and cellular internet access. The architecture and standard will be discussed here. The applications and current products will be discussed further. Finally, the future challenges and direction of wireless internet will be presented.

INTRODUCTION

The purpose of this report is to provide a discussion of the available applications and technologies that underlay wireless internet. There are a number of different definitions of wireless internet. We consider that wireless internet is access to the Internet applications over a wireless media and use some forms of internet protocol. Some of the internet applications are email, World Wide Web, file transfer, multimedia applications such as video, internet radio, IP telephony, and various application made possible by internetworking.

The current available technology for wireless internet includes wireless LAN and internet access via cellular network. Both technologies used different devices, protocol, and serve for different purposes.

Wireless LAN is primarily used as LAN extension and based on IEEE 802.11 architecture. It provides the wireless access to TCP/IP networks for laptop computers. It operates in the unlicensed frequency bands. It is designed to work in short distance between stations. IEEE 802.11 protocol concerns with link layer and physical layer in the internet protocol stack. From the IP layer's point of view, wireless networking with IEEE 802.11 is the same with networking with wired networking.

Internet access via cellular network is technology provided by second generation (2G) and third generation (3G) cellular standard and based on protocols optimized for wireless environment. It operates in licensed frequency bands assigned specifically for cellular communication. Wireless Application Protocol (WAP) enables the cellular phone and other mobile devices to access internet. WAP enabled devices connect to the Internet by means of WAP proxy.

While Wireless LAN and WAP are parts of different technologies and works with different protocol stack, these technologies are very important for providing access to the internet in different situation and with different devices. Due to their importance, these technologies will be discussed in further detail in this report.

WIRELESS LAN

History of Wireless LAN

Wireless LAN products appeared in late 1980s. They were initially marketed as a means of replacing wired LANs. At that time, the installation of LAN cabling for a building was consider costly and wireless LAN was considered to replace it. However, as data transmission technology advanced, the cost of cabling for LAN became less expensive. Wireless LAN could not match the speed of wired LAN and security is more manageable in wired environment. For these reasons, wireless LAN never replaced wired LAN.

As more organizations and personals become more rely on Internet applications, it is found that wireless LAN can provide mobility and portability. Wireless LAN is normally used as LAN extension. Early wireless LAN products were lack of interoperability among different vendors. In order to solve this problem, a wireless LAN standard known as IEEE 802.11 was published. In 1999, two additional physical layers standard known as IEEE 802.11a and IEEE 802.11b were issued.

IEEE 802.11 Standards

Figure 1 [11] shows the layered protocol architecture of IEEE 802.11. Logical link control (LLC) is a common link protocol for all the LANs. LLC specifies mechanisms for addressing and data link control. It works seamlessly of the topology, transmission medium, and media access control (MAC) chosen. From the TCP/IP layer's point of view, wireless networking with IEEE 802.11 is the same with networking with other data link, such as Ethernet (IEEE 802.3), Token Ring (IEEE 802.5), or Fiber Optic (IEEE 802.8).

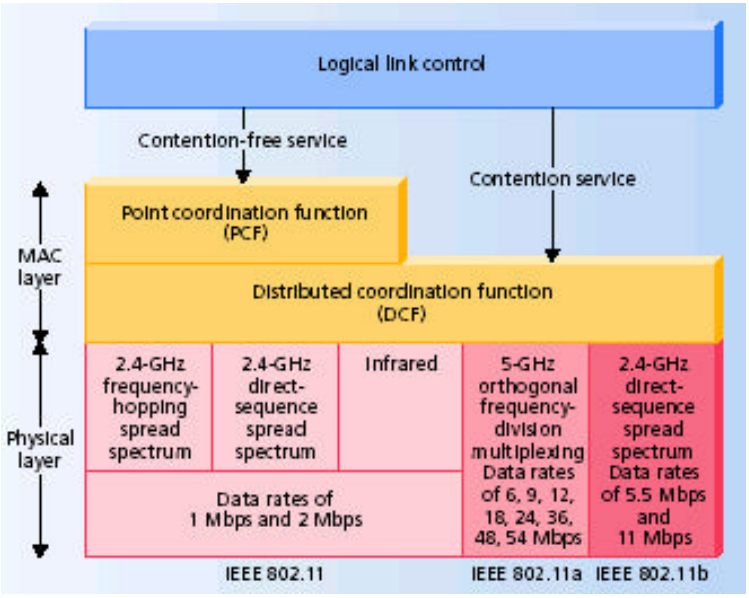

Figure 1. ***IEEE 802.11's layered protocol architecture***

MAC specifies the mechanism of controlling access to the transmission medium. It requires that only one station can transmit at one time. It also specifies the transmission of data in blocks of MAC frames. Each MAC frame consists of MAC control bits, destination address, source address, LLC PDU, and CRC. LLC PDU is data from LLC layer, which includes the user data plus the source and destination service access point (SAPs) which indicate the user of LLC. For wireless networking, the MAC layer regulates access to the shared frequency band so that the transmissions of each station do not interfere with each other. The MAC layer consists of two sub-layers. Point coordination function (PCF), which is implemented in a central controller, provides priority function. Distributed Coordination Function (DCF) provides access to all traffic using a kind of Ethernet contention algorithm.

Physical layer specifies the transmission method. There are three transmission methods supported by IEEE 802.11 [10]:

- Direct-sequence spread spectrum (DSSS), operating in the 2.4 GHz ISM (Industrial, Scientific, and Medical) band at data rates of 1 Mbps and 2 Mbps.
- Frequency-hopping spread spectrum (FHSS), operating in the 2.4 GHz ISM band at data rates of 1 Mbps and 2 Mbps.
- Infrared, operating at wavelength between 850 and 950 nm at data rates of 1 Mbps and 2 Mbps.

The second and third physical layers, IEEE 802.11a and IEEE 802.11b, were issued in 1999. IEEE 802.11a operates in the 5 GHz band at data rates of 6, 9, 12, 18, 24, 36, 48, 54 Mbps. IEEE 802.11b operates in 2.4 GHz band at data rates of 5.5 Mbps and 11 Mbps.

IEEE 802.11 Services

IEEE 802.11 defines some services that must be provided by wireless LAN to match the functionality of wired LAN. These services are [10]:

1. Association
   Before a station transmits or receives frame, it must establish an association with an access point. By doing this, the station makes its identity and address known. An access point communicates with other access points to route and deliver frames.
2. Reassociation
   Reassociation means that an established association can be transferred from one access point to other access points. This will allow a station to move.
3. Disassociation
   Disassociation service requires a station to notify other access points that an existing association is terminated.
4. Authentication
   A station must use authentication service to establish their identity with other stations. IEEE 802.11 does not specify any authentication schema but specify two authentication algorithms. It is left to vendors to decide which authentication schema they want to use.
5. Privacy
   Privacy service is used to prevent eavesdropping. IEEE 802.11 provides optional use of 40-bit encryption. For stronger protection, 128-bit encryption can be used.

Wireless LAN Configurations

There are various possible configurations for wireless LANs [7]. Some of the configurations are single cell configuration, multiple cell configuration, cross-building interconnection, nomadic access, and Ad Hoc network.

In single cell configuration, all the wireless end systems are within range of a single control module. Figure 2 shows a typical single cell configuration [11]. In multiple cell configuration, there are multiple control modules interconnected by a wired LAN. The control module acts as an interface to wireless LAN. It receives, buffers, and transmits data between the wireless LAN and wired network. End users access wireless LAN through wireless adapters. The wireless adapters are implemented as PC Cards for laptops and internal ISA/PCI for desktop computers.

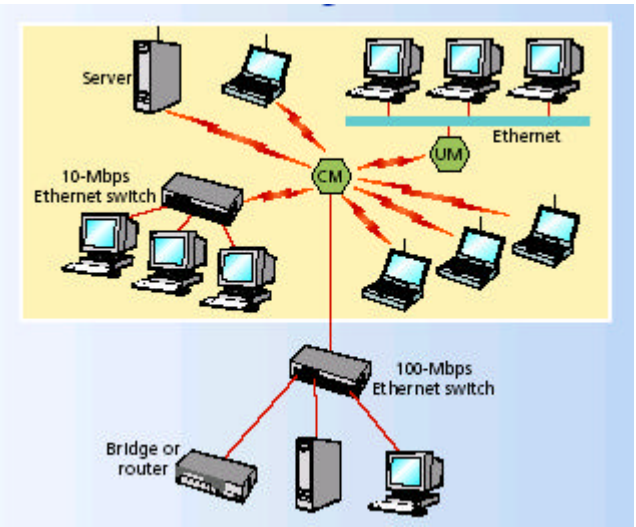

Figure 2. ***Single Cell Wireless LAN Configuration***

Cross-building interconnect is a configuration that connect LANs in nearby buildings using point to point wireless link. In nomadic access configuration, the wireless LAN links a LAN hub and a mobile terminal such as laptop. Ad hoc network is a peer-to-peer network that is set up temporarily for some immediate need such as conference room for business.

Wireless LAN Applications

The use of wireless LAN has increased the productivity of personal, business and other organization. The following list shows the applications made possible by Wireless LAN [12]:

- Home Networks
  Wireless networks provides alternative for computer networking and internet appliances at home.
- Small Business Networks
  Wireless networks can be installed easily and reduce the cost of planning and implementing for the wired network. Dynamic moves, additions, and changes to network are easy to implement.
- Public Access

Wireless access at public locations provides convenient internet connection for mobile workers, travelers, and customers. Typical public locations are airports, conference center, hotels, restaurants and university. Users can use their laptops or PDAs to access the Internet at the locations.

- Enterprise Networks
  Wireless access provides real-time information to business people and worker. Business peoples in conference rooms can have real-time information in their fingertips. Training sites at corporations use wireless connectivity to facilitate learning and information exchanges. Warehouse workers can use wireless LAN to exchange information with central inventory database. Groups meeting can easily setup in a wireless LAN networks.

Current Wireless LAN Products

Most Wireless LAN products in the market now are based on IEEE 802.11b specification. Table 1 lists some of the products including chip sets, PC Cards, access points, and systems.

Table 1. IEEE 80211.b Products

Company	Product	Company	Product
3 **Com**	AirConnect 11Mbps Wireless LAN PCI Card AirConnect 11Mbps Wireless Wireless LAN Access Point Home Wireless Gateway	**Cisco**	Aironet 340 Series Access Point Aironet 340 Series PCI Card Aironet 340 Series Wireless PC Card
Apple Computer	AirPort Base Station AirPort Client Card	**Nokia**	A032 WLAN Access Point A040 Ethernet WLAN Adapter C110 Wireless LAN Card

CELLULAR INTERNET ACCESS

The Evolution of Cellular System toward 3G and Beyond

Figure 3 illustrates the evolution of cellular systems [6]. The first generation (1G) systems appeared in the 1980s. The systems are based on analog voice communication. Networks operate in 450 and 800 MHz frequency bands. The standards for 1G [5] include Nordic Mobile Telephone (NMT), Total Access Communications System (TACS), and Advanced Mobile Phone Service (AMPS). Internetworking between different networks was not implemented.

The second generation (2G) systems include Global System for Mobile Communications (GSM), IS-136 (TDMA), IS-95 (CDMA), and Personal Digital Cellular (PDC). The 2G systems [5] use digital radio transmission. The 2G systems support data transmission at 14.4 Kbps or lower and use circuit switching. Launched in 1991, GSM is the most popular 2G system in Europe. Short Message Service (SMS) feature was incorporated into GSM standard. SMS is a service that enables users to send and receive text messages from cellular phone.

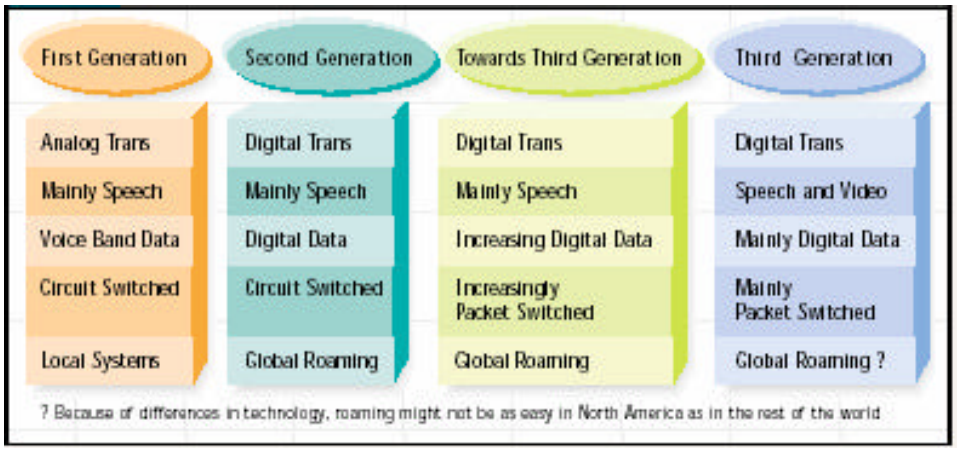

Figure 3. *Evolution of Cellular System*

WAP Forum [14] was established in 1997 by four telecommunication companies. The forum developed Wireless Application Protocol (WAP). WAP is an open standard designed for wireless phones and other wireless terminal such as pagers, personal digital assistants (PDAs) to access the Internet. The WAP is based on existing Internet standard such as TCP/IP, XML, HTTP, and optimizes them for the wireless environment.

Other wireless internet service is iMode, a wireless internet service introduced by NTT DoCoMo Japan in 1999. The iMode [4] offers service such as messaging, e-mail, and web access to thousands of partner companies. The iMode uses packet switching technology and Compact HTML (a subset of HTML that focuses on text and simple graphics) as its markup language [8].

The third generation (3G) systems were specified by ITU's International Mobile Telecommunications for the year 2000 (IMT-2000) initiative. The 3G systems use Wideband Code Division Multiple Access (WCDMA) technology and support circuit mode speech as well as packet-mode data transmission. The data rate of 144 kbps, 384 kbps, and 2 Mbps will be made available by 3G systems.

While 3G systems are not fully deployed, the 2G systems are upgraded to support more advance services. The term 2.5G [1] is often used for such technology. General Packet Radio Service (GPRS) provides packet based data transmission, higher data rate, and "always-on" connection.

Overview of WAP

WAP is an open standard designed for wireless phones and other wireless terminal such as pagers and personal digital assistants (PDAs) to access the Internet. WAP specification is published by WAP Forum, an industry group that works together to enable sophisticated information service on handheld wireless devices. WAP is an evolving standard. The latest WAP specification was WAP version 1.2.1 [13] released in 2000. Due to their availability, the WAP version 1.1 will be discussed more in detail.

The key elements of WAP specification include [14]:

- A programming model which is based on WWW Programming Model

Adopting WWW Programming model provides several benefits for programmer such as familiar programming model, proven architecture, and the ability to leverage existing tools. A typical WAP programming model is based on three elements: web server, web proxy, and web client (See Figure 4)

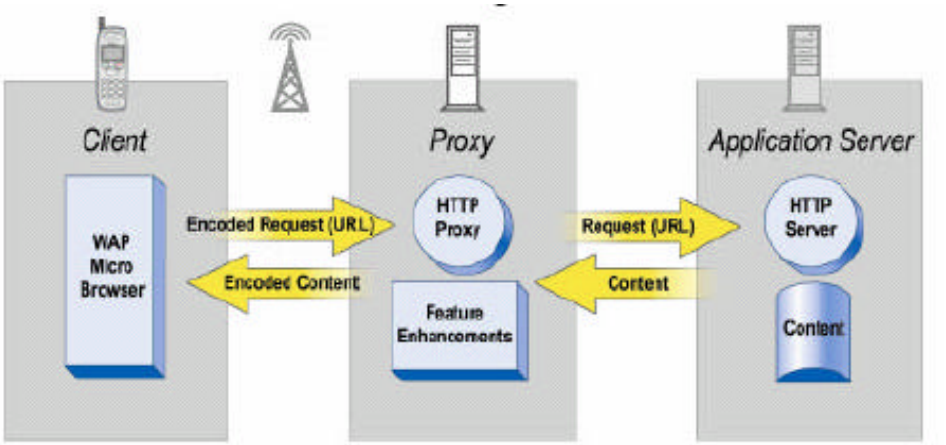

Figure 4. ***The WAP Programming Model***

The WAP proxy provides several functions, including [13]:

1. Protocol Gateway
   The function of protocol gateway is to translate requests from wireless protocol stacks to WWW protocol stacks (HTTP and TCP/IP).
2. Content Encoders and Decoders
   The function of content encoder is to translate information from the Web into more compact format. The function of content decoder is to decode the compacted form from WAP into standard WWW format.
3. User Agent Profile Management
   The function of user agent profile is to describe client capabilities and personal preferences.
4. Catching Proxy
   The function of catching proxy is to improve performance and network utilization by maintaining a cache of frequently accessed resources.

- A markup language adhering to XML
  Wireless Markup Language (WML) is designed for small-screen display. WML documents are divided into a set of well-defined units of user interaction called cards. Users navigate by moving the cards from one to another WML document.
- A specification for microbrowser that works in wireless terminal
  The specification for a microbrowser is analogous to standard web browser. The microbrowser for wireless terminal should be efficient and compact.
- A lightweighted communications protocol stack
  WAP protocol stack optimizes the Web protocol for the environment of wireless communication.

- A framework for wireless telephony applications (WTAs)
  A framework for WTA allows access to telephony functionality.

WAP Protocol Stack

WAP protocol stack is implemented via a layered approach. Figure 5 shows the WAP Protocol Stack. Wireless Application Environment (WAE) contains WML, WMLScript-a scripting for WML similar to JavaScript, and WTA. The WAP-based applications are developed using these tools.

Wireless Session Protocol (WSP) implements session service. The session services that WSP provides are [9]: a) establish a reliable session from client to server and release that session in an orderly manner; b) agree on a common level of protocol functionality using capability negotiation; c) exchange content between client and server using compact encoding; d) suspend and resume the session. WSP links WAE to two session services: connection-oriented service operating above Wireless Transaction Protocol and connectionless service operating above Wireless Datagram Protocol.

Wireless Transaction Protocol (WTP) supports three classes of transaction service [9]: unreliable one way request, reliable one way request, and reliable two way request. WTP supports Protocol Data Unit (PDU) concatenation and delayed acknowledgement to help reduce the number of messages sent.

Wireless Transport Layer Security (WTLS) uses security features that are based upon the Internet Transport Layer Security standard (formerly known as Secure Sockets Layer) such as encryption, decryption, user authentications and data integrity checking.

Wireless Datagram Protocol (WDP) works as the transport layer of WAP. It processes PDU from upper layers to formats required by specific bearer and provides consistent data format to upper layers. It allows WAP to be bearer independent.

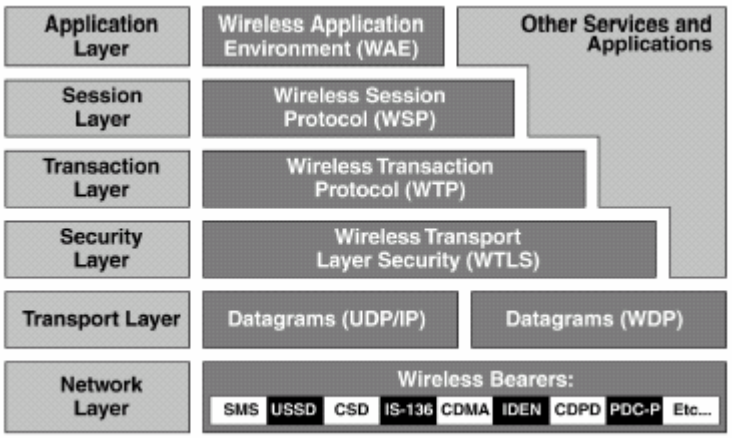

Figure 5. *WAP Protocol Stack*

WAP Applications

WAP can be used to enhance existing internet applications or provide new applications. There are hundreds of WAP content providers on the internet either providing business application or personal site.

The following list shows some of the corporate applications being enhanced and enable by WAP [2]: job dispatch, remote point of sale, customer service, remote monitoring such as meter reading, vehicle positioning, corporate email, remote LAN access, file transfer, web browsing, document sharing, collaborative working, audio, still images, moving images, and home automation. Some of personal applications that are being enhanced and enabled with WAP include [2]: simple person-to-person messaging, voice and fax mail notifications, unified messaging, internet email, prepayment, ring-tones, mobile commerce, affinity programs, mobile banking, chat, information services.

Current WAP Products

Currently, WAP enabled devices can be easily found in the market. Most mobile phones and PDAs are WAP enabled. WAP services can be accessed by devices using different bearer and microbrowser. Nokia 7110 uses GSM 900/1800 bearer and Nokia WAP 1.1 microbrowser. Motorola R320 uses CDMA bearer and use UP.Browser 3.1 microbrowser. Most PDAs such as Motorola Timeport P930/P935, RIM Blackberry 957, Palm are WAP-enabled.

There are several suppliers of WAP gateways include Nokia, Phone.com, Motorola, CMG, Ericsson, and Materna.

FUTURE TECHNOLOGIES AND CHALLANGES

The deployment of 3G cellular systems begin this year, starting in Japan and Europe. The 3G systems support different services class by an advanced quality-of-service (QoS) supports. The transmission speed of 2 Mbps for stationary users, 384 kbps for slow-moving users, and 128 kbps for vehicles are provided. Meanwhile, several wireless service providers have already offered 2.5G systems. 2.5G offers more bandwidth than 2G but less than 2G.

Another important wireless technology available recently is Bluetooth. Bluetooth can work together with 3G systems. Bluetooth is a protocol for short-range wireless links. It enables devices to communicate over short distances. Bluetooth can be integrated with cellular phones, PDAs, laptops, and other devices. Current version of Bluetooth supports data rate up to 700 kbps. Higher data rates up to 10 Mbps are currently being standardized.

Wireless LAN products based on IEEE 802.11a will also be around this year. These products will support data rates up to 54 Mbps.

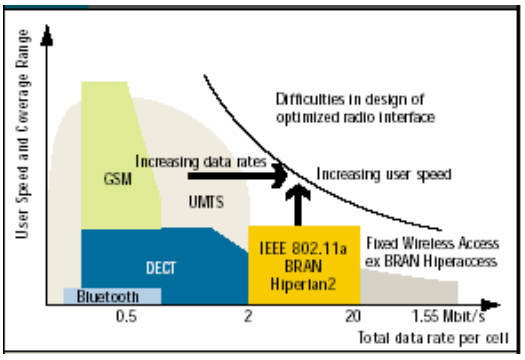

Figure 6. ***Bit Rate vs Mobility and Coverage***

3G Cellular Systems, Bluetooth, Wireless LAN provide internet access over a particular range of service bit rate, user speed of mobility, and coverage (see Figure 6) [6]. The next challenge is to provide ubiquitous internet connectivity over slow and fast moving users and different environment. The solution for this challenge is all-IP network, where IP protocols are used in every node from the user terminals to the internet servers. IPv6 is being developed in order to accommodate the needs of more IP address and improved version of IP protocol. Some of the key features of IPv6 are [3]:

- Expanded addressing capability
  IPv6 uses 128 bits of address space
- Neighbor discovery and autoconfiguration
  Neighbor discovery protocol is proposed to dynamically determines information about the directly attached network
- Quality of Service (QoS)
  QoS is used to provide real time services (IP voice, video, etc)
- IP Security (IPsec)
  IPv6 implements IP security architecture
- Mobile IPv6
  With mobile IPv6, a mobile node has one home address that remains the same regardless of its location.

The transition from IPv4 to IPv6 will need a long period. The evolution of 3G systems toward full-IP network also need a smooth network evolution strategy. There are several issues need to be solved for the future wireless internet systems:

- Security
  Mechanisms need to be designed for user authentication, call privacy, and non-repudiation guarantees.
- Handover
  Implementation of horizontal and vertical handover is essential to provide seamless connectivity for multi-mode mobile devices.
- Devices
  Multi-mode devices will have to implement software-configurable hardware architectures.
- Power requirements
  Efficient and cost-effective solutions for power generation in portable devices are essential

CONCLUSION

Each of the technologies, wireless LAN and cellular systems will continue to evolve to provide higher bit rate. The cellular systems will eventually evolve to all-IP based network. The current WAP system can be enhanced with GPRS but new protocol should be used in the 3G systems. There will be a convergence between the technologies currently used toward ubiquitous connection. However, several issues require further research and development.

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