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Integrating an Enterprise 802.11b Wireless Solution:

Now is Not Too Late, and Not Too Soon

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Abstract

Due to its increasing feasibility for certain local area networking applications, network managers must consider implementing 802.11b wireless technology as an alternative to wired LAN's. Users benefit from a multitude of applications, strong acceptance by manufacturers, and explosive growth in the market. Its technical architecture has achieved industry certification and is a global standard. Competing protocols are not getting the same outpouring of support from manufacturers or acceptance by the market. The potential pitfalls of an 802.11b network are easily avoided if the network is properly designed and carefully implemented. Concerns voiced about 802.11b's security measures are muted when proper network management is in place. External solution providers, such as outsourced systems integration, can help guarantee a robust and secure wireless network implementation. Falling equipment prices and low implementation and operation costs make the installation of an 802.11b network attractive today, and additional applications will allow it to maintain value in the future. Though 802.11a promises more bandwidth, the world may in many ways not be ready for that protocol yet.

INTRODUCTION TO 802.11B WIRELESS NETWORKING

Applications

Businesses are becoming ever-increasingly attracted to wireless networking for its variety of advantages over wired networks. The technology frees employees from their desks to access the corporate network and business applications as they roam within a building or throughout a corporate campus (Rosenberg, 2001) . Installing a wireless network also means forgoing the tedious tasks of running and connecting cables. At some network sites, installing cabling is unfeasible either because the structure won't allow it (thick walls, limited access between rooms or floors, or historic buildings) or the spaces are too vast (warehouses, convention centers, or outdoor sites). Due to its increasing feasibility for certain local area networking applications, network managers must now consider implementing 802.11b wireless technology as an alternative to wired LAN's.

802.11 is an IEEE group who create standards for wireless LAN's. The 802.11b data link protocol uses a spread spectrum CSMA/CA signal within the 2.4-GHz Industrial, Scientific, and Medical (ISM) band. It carries data at speeds up to 11 Mbps. This protocol seems suitable for most typical wireless LAN applications, including LAN extensions, cross-building interconnects, nomadic access, and ad hoc networks. "Wireless Fidelity", or Wi-Fi, is an industry certification given to 802.11b products that

seamlessly interoperate. Wi-Fi is often used as a synonym for 802.11b products.

Wireless networking designed around universal standards open up countless potential applications. The use of notebook PC's (laptops) takes full advantage of the mobility allowed when operating without wires (Stambaugh, 2001). Laptops can be set up away from the work area without disturbing the flow of work (Iroff, 2000). That means users' computers can always be with them, increasing productivity. When authorized, visitors can bring their notebooks with them into a facility and connect anywhere. Consultants can link to clients' systems more easily. Here are several more example applications of wireless networking in business, as outlined by a wireless product manufacturer (Proxim, 1998):

- Consultant workgroups or auditing teams increase productivity with a quick wireless network setup.
- Advance teams start up a new branch office or set up a stand at a trade show can install pre-configured wireless LAN's without bringing along additional IT support.
- Senior executives in meetings make decisions more quickly with accurate information because they have real-time information at their fingertips.

- Doctors and nurses in hospitals instantly access patient information using hand-held or notebook computers with wireless LAN.

- Network managers in dynamic environments minimize the overhead caused by moves, extensions to networks, and other changes with wireless LANs.

- Training candidates at corporations and students at universities bring their own wireless devices to ad hoc classrooms to access course and research materials. Apple’s iBook Wireless Mobile Lab is an attractive instant wireless network solution utilizing 802.11b technology. It is helping schools make the move from having one computer room or center to distributing computers to the classrooms. Apple's solution is the iBook Wireless Mobile Lab. It includes 16 iBooks, a printer and an AirPort Wi-Fi access point for classroom networking and Internet access (Baard, 2001).

- Warehouses can reinvigorate their workflow. Once access points are installed throughout, forklift drivers, machine operators, and shipping clerks all have complete access to order databases. This removes the requirement for each of them to search through stacks of invoices or stop at a central terminal.

- Any enterprise in which employees need remote access to special applications or documents could benefit, says Gemma Paulo, a networking analyst with the Cahners In-Stat Group in Scottsdale, Arizona. "A wireless LAN is an extension of your computer network, enabling you to communicate with remote sites in ways not possible before. It can be an especially good solution if you have a large distributed computing enterprise but don't have IT managers on site," says Paulo (Kranz, 2001).

Acceptance

Technology leaders have known the merits of wireless networking for years now. Some of the largest active Wi-Fi networks are now installed at campuses such as Stanford, MIT, and Carnegie Mellon (Gurley, 2001).

Wireless LAN's remain a market segment that's expected to achieve its anticipated growth rate (Bucholtz, 2001). The WLAN equipment market will grow from $624 million in 1999 to $3 billion in 2002, according to Cahners In-Stat Group (Stambaugh, 2001). That means the businesses that provide 802.11b hardware will stay around and will be in position to provide continued support and upgrades.

The amount of hardware vendors and products will continue to grow, and prices will continue to drop and more vendors offer more products that are Wi-Fi compliant. Interoperability has been spurred by the Wireless Ethernet Compatibility Alliance (WECA). This organization promotes

interoperability of 802.11b products and sponsors a formal testing and certification program. It awards the Wi-Fi certification to those products that meet its stringent test conditions. Any Wi-Fi certified product will work with any other. To date, more than 44 wireless LAN products have been certified (Frenzel, 2000). The number of compliant products is growing. This indicates that vendors are interested in complying with this standard, and will not abandon it.

TECHNICAL ARCHITECTURE

Specifications

The 2.4-GHz Industrial, Scientific, and Medical (ISM) frequency bands used by 802.11b are recognized by international regulatory agencies in the United States, Europe and Japan, for unlicensed radio operations. As such, 802.11-based products do not require user licensing or special training (Rosenberg, 2001). However, congestion is inevitable because Wi-Fi uses the same unregulated frequency as microwave ovens, cordless phones and Bluetooth (Dvorak, 2001).

Under optimal (theoretical) conditions, an 802.11b access point allows connections from distances up to 1800 feet (Gomes, 2001). In real usage, wireless LAN signals have a transmission range of 80 to 1,500 feet. The variability comes from the type of equipment being used, the data exchange rate, and obstacles in the signal path (Stambaugh, 2001).

The required quantity and positioning of access points varies by the maximum number of simultaneous users. Maximum capacity ranges from 15 to 60 users per access point depending on the type of equipment. Proper positioning of access points is critical to achieve optimal communications; fortunately, several vendors bundle system survey tools to determine the best positions with their equipment (Stambaugh, 2001).

For all its promise of delivering 11 Mbps, 802.11b networking will never approach that throughput. In this respect, it is much like Ethernet, in that abundant collisions would prevent bandwidth from being saturated with successfully transmitted data. 802.11b's highest bit rate in the real world is seldom greater than 4 Mbps. Nevertheless, this is sufficient for most business applications (Vaughn-Nichols, 2001). A group of several workstations transferring small files or web browsing would not encounter slowdowns with this amount of bandwidth (Iroff, 2000).

Competing Standards

The 802.11b standard is not alone in the arena for the wireless LAN market. HomeRF uses Frequency Hopping Spread Spectrum (FHSS) modulation, with a maximum throughput of 1.6 Mbps. This throughput rate compares with the original 802.11 standard of 2 Mbps (Stambaugh, 2001). However, the cost of HomeRF's FHSS transmitter radios is nearly as much as 802.11b's 11Mbps DSSS radios (Mannion, 2000). Though HomeRF may allow connections from greater distances than 802.11b,

equal pricing and lower bandwidth in relation to Wi-Fi is failing to attract many new customers to HomeRF technology.

Initially, Bluetooth was conceived by Ericsson as a way to get multiple personal communications devices to recognize each other. That way, your PDA, cell phone, and laptop could all communicate. Later, the wireless protocol was seen to have potential as a wireless LAN protocol. Both Bluetooth and 802.11b use transmission frequencies around 2.4 GHz. The ISM band where the two protocols coexist is never licensed, so there is a potential for plenty of noise in that range. Bluetooth and 802.11b signals don't communicate with each other, but rather collide. Bluetooth's lower power signal cannot compete with the signal strength used by Wi-Fi products. One hope for a Bluetooth future was a reduction is production costs for Bluetooth transmitters. Some projections are now estimating that Bluetooth chipsets under $5, originally forecasted for 2000, will now be realized no earlier than 2005 (Mannion, 2000).

The 802.11 group has developed a faster protocol called 802.11a. This OFDM (orthogonal frequency-division multiplexing) signal travels at speeds up to 54 Mbps over distances of 50 meters. The 802.11a protocol is discussed at length later in this paper.

The competing wireless industries are confusing, scaring, and dividing their potential customers. None of the protocols used by contemporary wireless products, including Bluetooth, HiperLAN2, MMAC, 802.11,

802.11b, and 802.11a, can communicate with one another (Hiller, 2001). Inevitably, a choice may be necessary, most likely between Bluetooth and 802.11b. These two most popular standards do not often attempt to serve the same purpose; nevertheless, their two radio signals interfere with each other. Another IEEE group, 802.15, is attempting to resolve this conflict. The four task groups of 802.15 are looking at ways to allow the two protocols to cooperate within an environment, and perhaps communicate with each other.

Equipment Manufacturers

Proxim, Lucent, 3Com, Intersil, Zoom Telephonics, Symbol Technologies, and other network product makers have historically sold proprietary wireless connectivity solutions to vertical markets (Mannion, 2000). They are now well positioned to push standards-based products to broader markets. They realize the high bit rate capacity of Direct Sequence Spread Spectrum (DSSS) and understand the significance of the 802.11b standard being ratified by the IEEE and accepted by the market.

HP is committed to competing in a market for 802.11b wireless products and services. Andrew Bolwell believes that market will be worth $80 billion by 2004. As Hewlett-Packard's director of mobile e-services, he wants to see wireless capabilities put into all their products. “It needs to be a part of hardware design and software design,” Bolwell says. “In the same way that the Internet needs to be pervasive, mobility needs to be

pervasive. It needs to be a part of every product developed today" (Kwan, 2001). Oracle Chief Executive Larry Ellison has also stated that his company is committed to wireless-enabling all its products and services (Kwan, 2001).

802.11b PROJECT CONSIDERATIONS

Design Guidance

In his article in CEE News, Paul Rosenberg (2001) identified six major areas to consider when designing an 802.11b site:

- Future use. It's not enough to consider current applications. The wireless capability may, in and of itself, lend itself to additional applications that would be added at a alter date.
- Coverage. A good guideline for each office area, according to Rosenberg, is four access points, with cells overlapping by about 30% to achieve optimum coverage.
- Capacity. The access point placement and density also depends on the number of users and the required bandwidth of their applications.
- Interference. What are the potential sources of interference now and in the future? These can include sensitive equipment, previously installed wireless systems, and signals from Bluetooth mobile communications applications.

- Connectivity and power requirements. Access points will always require a cable connection to the wired Ethernet network, and they will also need cable connection to AC power.

- Cost and ease of installation. This consideration is satisfied by conducting a thorough site survey. Surprises the designer wants to avoid include unusually high interference issues to resolve, or greater-than-anticipated capacity requirements. Also, although all 802.11b-compliant products are based on a single standard, the standard offers no guarantee that access points, NIC's and other equipment from various manufacturers will interoperate (Rosenberg, 2001).

Radio signals may not travel through concrete walls or other substructures, so your IT department needs to carefully position receivers to provide overlapping service and enable routers to send the correct messages to the correct IP addresses as users roam between subnets (Kranz, 2001).

Once a wireless network is installed and configured, it doesn't take much more effort to share the network with another location. Using a directional antenna, one area using a wireless network can be connected to another area up to a city block away without too much work (Coursey, 2001).

The wireless environment is an extension of the wired environment, but the skills that are required to extend it to a wireless environment are skills

that go beyond what a typical networking expert in a wired environment has. Most firms do not have the skills to properly develop a wireless LAN solution in-house. Wireless is still new enough that most enterprises rely on outsourced experts. Wireless will be so common within the next few years, though, that many firms will have those skills in-house (Betts, 2001).

Implementation Considerations

Implementation of an 802.11b wireless LAN is potentially simpler than that of a wired LAN. The biggest implementation plus is eliminating the need to string cables around the office, providing all the advantages of a wired network with much less labor. Wireless networks are not completely wireless, though. There still has to be a wired network to bring information to access points (Betts, 2001). A potential difficulty arises in placing access points and running Ethernet cabling and power cabling to their locations.

The most common mistake in the implementation of a wireless LAN is the improper installation of cable connectors—in particular, the coaxial connections to the antennas. Improper installation of data communications interconnections is also common. This includes both making mechanical connections and using incompatible products or protocols (Rosenberg, 2001).

The capability of implementing a wireless network parallel to an operational wired network eases the transition. In an organization of several hundred employees, the 11 person IT department superimposed a wireless network onto an existing wired network. They accomplished this without disturbing any productivity at the operational wired workstations (Joch, 2001). Proxim, a leading manufacturer of 802.11b hardware, provides white papers outlining diagnostic procedures to evaluate WLAN implementations (Proxim, 1998b).

Security Concerns

The 802.11b standard includes built-in security, providing some defense against unauthorized interception and access; however, there still are weaknesses (Stambaugh, 2001). A group of researchers at the University of California at Berkeley—Nikita Borisov, David Wagner, and Ian Goldberg—discovered shortcomings in 802.11b's Wired Equivalent Privacy algorithm, or WEP (Sandberg, 2001).

Greg Ennis, technical director of the Wireless Ethernet Compatibility Alliance, suggests using virtual private networking (VPN) or other additional security enhancements to prevent unauthorized access to 802.11b networks. He notes that the IEEE is working on future versions of the protocol's security algorithm that won't be vulnerable (Sandberg, 2001). A Gartner group report estimates that implementations to correct

802.11b's security shortcomings will be available in the first quarter of 2002 (Hiller, 2001).

An example interim solution to 802.11b's security shortcomings uses a firewall between the base station and the mini-LAN that contains the VPN concentrator. Each workstation on the wireless network should also run personal firewall software (Tuesday, 2001). "You can definitely use a wireless LAN securely" if you set it up properly, says John Pescatore, an analyst at Gartner Inc. (Mitchell, 2001).

In another example of using 802.11b securely, the Connecticut Hospice has implemented special security features to prevent unauthorized access to patient data. CIO Marcel Blanchet uses a power-on password to protect handheld devices and laptops, and 128-bit encryption to protect wireless transmissions. To break into the network and communicate through the hospital's wireless hubs, a hacker would have to provide the correct service-set identifier code. A wireless user who has successfully gained access to the network still faces server and application-level authentication (Mitchell, 2001).

Some developers have implemented proprietary solutions to upgrade wireless security. Unfortunately, these features may make it impossible for equipment from different manufacturers to interoperate, limiting LAN design options (Stambaugh, 2001). One such device is Bluesocket's WG-1000 gateway. The gateway is to be placed between WLAN access points

and the corporate LAN. It provides authentication and access control, as well as IPSec security and support for quality of service (Hooper, 2001).

Whatever efforts are made to patch security on their wireless LAN's, information security staff can monitor, capture, decode, and filter 802.11b network data with Sniffer Wireless (Fisher, 2001). This network management product is the wireless member of a family of network monitoring tools from Network Associates. Similar applications from other software firms allow wireless network managers to verify the effectiveness of the security solutions they implement on their networks.

If an organization does not want the responsibility of verifying their wireless security using in-house resources, there are dozens of specialized security outsourcers—also called managed security service providers (MSSP's) (Ambrosio, 2001). When fully entrusted, MSSP's manage an enterprises' entire network security needs. They can also be contracted to be responsible for isolated aspects of security, such as wireless network security or VPN's.

Wireless Network Management

Management of a wireless network is identical to managing a wired LAN in terms of its major requirements: fault, configuration, account, performance, and security management. Wireless LAN management has the additional challenge of managing users that appear and disappear from the network randomly. Network managers need to be prepared for

this type of user by having appropriate tools and training. Other unique factors of managing a wireless LAN include transparent integration with the existing wired LAN, open systems architecture, and ease of use and maintenance. Though wireless networking presents the network manager with a clear need for a single element manager, none are available yet the market (Hiller, 2001).

COSTS

While 802.11b hardware is currently expensive relative to wired network components, prices are falling. They will continue to do so and, simultaneously, wireless LAN speed and reliability will improve. Since wireless LAN installations do not require structural work, it may be cheaper to install wireless rather than wired, sooner rather than later. Upgrading access points and network interfaces over time as wireless hardware improves is cheaper than making a substantial investment in new cables and wires (Stambaugh, 2001).

Currently, the price of 802.11b wireless access points are around $140, and each network interface card is around $50 (Gomes, 2001). The price of an 802.11b PCMCIA card, currently between $100 and $300, is expected drop to $60 in 2002 (Maarouf, 2001).

The cost of installing a wireless LAN varies considerably. Much depends on the organization's current computer equipment, the wireless hardware selected, the vendor, the distances between workstations and network

components, and the number of staff members who access the network. Another variable is the amount of outsourced assistance required to get the system up and running (Stambaugh, 2001).

Johns Hopkins University is working on its second full-scale wireless LAN upgrade. It currently has an 802.11 LAN, and is upgrading to 802.11b. The original wireless LAN cost $3000 per classroom. They had expected to spend $18,000 to install cabling and false floors (Lais, 2000). The savings from that first wireless conversion are now paying for upgrading access points and NIC's for the newer wireless LAN standard.

The following points are cost guidelines for an implementation of an 802.11b wireless LAN (Stambaugh, 2001):

- Generally, every staff person who moves around their workspace with a computer should have a quality laptop (between $2,000 and $3,500) that can accommodate a wireless NIC.
- Every laptop needs a wireless LAN PCMCIA, which costs between $100 and $300.
- Every desktop connected to the wireless LAN will require PCI or ISA adapters and a wireless NIC, which costs between $50 and $160. At least one desktop unit should act as a file and print server.

- For optimal positioning of access points, it's probably best to engage an industry consultant to conduct signal testing. A rough guide is positioning an access point for every 2,000 square feet of floor space. Access points cost between $200 and $1,500.

- An additional investment of between $200 and $1,000 may be required for a firewall and cable/DSL router.

While the initial investment required for wireless LAN hardware can be higher than the cost of wired LAN hardware, overall installation expenses and life-cycle costs can be significantly lower. Long-term cost benefits are greatest in dynamic environments requiring frequent moves and changes (Proxim, 1998).

Budgeting for outside resources also may be necessary to assist in the introduction of wireless networks. This is especially important if the IT staff lacks experience installing wireless networks. If your implementation is complex, you may need to hire a system integrator to set up the network correctly (Kranz, 2001).

So far, no figures exist to help quantify productivity gains that wireless networking adds for remote users. According to Galen Schreck, a systems analyst with Forrester Research Inc. in Cambridge, Massachusetts, "No one's really shown a productivity gain that you could put a dollar value on" (Kranz, 2001). Savings could come from the elimination of an

employee's second PC or dedicated workspace for their wired laptop at a remote location.

THE FUTURE

Growing Roles for 802.11b

Peter Beardmore of Enterasys believes the 802.11b standard will be strong for at least two to three more years (Hooper, 2001). That means PC manufacturers should plan on 802.11b as the primary wireless computing protocol through at least 2003. To meet the demand, 802.11b radios should be integrated in notebook PCs now. It is expected that more than 90 percent of laptops will ship with integrated 802.11b capability by 2005 (Maarouf, 2001).

802.11b provides wireless internet access for mobile users who would be third generation (3G) mobile services customers but can't wait for telecoms' rollout of 3G services. 802.11b is cheaper to implement than an enterprise 3G solution and can provide many of the same services when the user is within range of an 802.11b wireless access point (Carroll, 2001). However, 802.11b has competition (and conflict) with Bluetooth. As a stop-gap technology for 3G, 802.11b is a less popular runner-up than Bluetooth, which was designed with mobile handset services in mind (Carroll, 2001). GPRS (General Packet Radio Service) will provide some interim solutions between the current patchwork digital data mechanisms and 3G systems. There is currently much serious discussion within the

industry of developing a mobile communications device that can roam between GPRS and 802.11b.

More Bandwidth in the Future with 802.11a

“Wireless ATM” is coming. The 802.11 group is currently developing the faster 802.11a protocol. Its OFDM (orthogonal frequency-division multiplexing) signal travels at speeds up to 54 Mbps over distances of 50 meters.

A Gartner Group report recently showed that only 5 percent of businesses have implemented 802.11b, which means 802.11a has a chance to gain significant market share (Batista, 2001). Companies may even be waiting for 802.11a before they decide to implement a wireless LAN. However, it will likely be several years down the road before 802.11a becomes widely available. Mainstream acceptance and applications may not surface until 2005 (Rosenberg, 2001). Arguing for current implementation of 802.11b networks, the Gartner report noted that 802.11b products are available now at reasonable prices for enterprises. There were no 802.11a products available on the market other than from Enterasys at the time of the report. They noted that when 802.11a products are available, pricing will be high but expected to drop. Another argument for currently implementing 802.11b is its clear migration path to 802.11a (Hiller, 2001). Additionally, the frequencies used by 802.11a are not available globally. In Europe, the locally developed standard for the unlicensed spectrum

between 5 and 6 GHz is HiperLAN-2. In Japan, similar blocks could stall that country's 5-GHz standard, known as HisWANa (Clarke, 2001).

Current operators of 802.11b networks who nevertheless want to upgrade to 802.11a will need to buy all new equipment or upgrade their current networks. Intel plans to sell the 802.11a PC card for $179, an access point for $449, and PCI cards for $229. This compares to an enterprise 802.11b set-up costing $149 for an access point and $69 to $109 for a PC card (Batista, 2001).

Another option for enterprises upgrading from current 802.11b networks is the use of wireless LAN hardware with dual-radio modems or PC cards that accommodate both the 802.11b and 802.11a standards. Intel (INTC) and Intermec have not released prices for their dual-radio access points using both standards, which they demonstrated at the latest NetWorld + Interop tradeshow in Atlanta (Batista, 2001). An Enterasys spokesman said that their RoamAbout2 system contains one slot for an 802.11b card and another for an 802.11a card. The access point chassis is priced around $1,900 with both transceiver slots populated and was to be available in July 2001. But the 802.11a card won't ship until late this year or the first quarter of next year (Batista, 2001).

Why haven’t any 802.11a products appeared yet from Cisco? Cisco Systems Inc. issued a statement specifically addressing the Enterasys announcement and, in an article for Computerworld magazine, stated that

the company “doesn't believe 801.11a is ready for prime time” yet (Batista, 2001). Perhaps Cisco wants another strategy for 802.11a devices that will not displace a market for 802.11b products. Mike Francini, director of business development for wireless LANs at Cisco, says 802.11a was never meant to replace 802.11b. “It's a common misconception in the marketplace right now,” Francini says. “But it's not an ‘a vs. b’ kind of question. The two technologies complement each other” (Hooper, 2001). Francini says he expects that customers initially will use the faster 802.11a radios as wireless bridges to connect different buildings rather than to replace 802.11b networks within offices (Hooper, 2001).

Proxim Inc. announced that it would incorporate 802.11a into its Harmony line of 802.11b products by selling 802.11a-specific access hubs instead of dual-slot hubs that handle both specifications. Access points transmitting the 802.11a data cannot transmit as far—its maximum 54 Mbps data rate is not maintained beyond distances of 50 meters. Implementing 802.11a technology means installing four access points for every one Wi-Fi access point to achieve the maximum 54 Mbps-throughput, said Gemma Paulo, an analyst with Cahners In-Stat Group (Batista, 2001). Proxim's believes that Enterasys’ dual-slot approach could leave holes in wireless coverage (Batista, 2001).

Card Access, Intermec, and Proxim have already developed network interface cards and access points to work at the 802.11a frequency. The

products currently deliver practical speeds of about 20 to 23 Mbps (Vaughn-Nichols, 2001). Wireless LAN chip suppliers such as Intersil, Lucent, TI, and others are also working on products for this frequency band (Frenzel, 2000).

CONCLUSION

Finally, a wireless network protocol has emerged and taken hold to unite the WLAN market. 802.11b “Wi-Fi” can become an enterprises’ ubiquitous “ether” that network engineers dream of. The standard has simultaneously realized multiple and expanding uses, strong acceptance, explosive growth, industry standardization, and global standardization (Gurley, 2001). Concerns voiced about 802.11b’s security measures are muted via proper network management. Competing protocols are not getting the support from manufacturers or acceptance by the market. Though 802.11a offers more bandwidth, the world may not be ready for it yet in many ways. For organizations’ current network development cycle, 802.11b wireless offers several applications that are less expensive and more robust than ever before.

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