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Comparison of efficiency, security and stability between RouterOS from MikroTik and Cisco IOS, in network engineering environments

Comparativa de eficiencia, seguridad y estabilidad entre RouterOS de MikroTik y Cisco IOS, en entornos de ingeniería en redes

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Abstract

The comparative study between Cisco and MikroTik devices for internet service providers (ISPs) in Ecuador sought to evaluate the efficiency, security and stability of MikroTik's RouterOS and Cisco IOS operating systems in network environments. A methodology combining theoretical and exploratory analysis was employed, using data from the ISP company "JEAPC". Aspects such as geography, static and dynamic routing, IP address translation, Google Cache network segregation and bandwidth limitation were evaluated. JEAPC" was found to have a robust data transfer capacity, serving 2800 customers, mainly in the Triunfo-Troncal region. Significant differences were identified between Cisco and MikroTik devices. For example, the Cisco ASR920 showed routing versatility, but lacked IP address translation and bandwidth limitation features for individual clients. In contrast, the MikroTik CCR2004-16G stood out for its routing stability, IP address translation capability and bandwidth limitation at the client level, being scalable and efficient for medium-

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sized environments. The findings highlighted the importance of considering current needs and future scalability when choosing between MikroTik and Cisco devices. MikroTik was identified as an efficient solution, especially beneficial for businesses with tight budgets and moderate growth, while Cisco was positioned as a solid choice for businesses with ambitions for expansion. The right choice will depend on the long-term strategy of each ISP in Ecuador.

Keywords: Device comparison, Network efficiency, Strategic equipment choice.

Resumen

El estudio comparativo entre dispositivos de Cisco y MikroTik para proveedores de servicios de internet (ISP) en Ecuador buscó evaluar la eficiencia, seguridad y estabilidad de los sistemas operativos RouterOS de MikroTik y Cisco IOS en entornos de redes. Se empleó una metodología que combinó análisis teóricos y exploratorios, utilizando datos de la empresa ISP "JEAPC". Se evaluaron aspectos como geografía, enrutamiento estático y dinámico, traducción de direcciones IP, segregación de redes Google Cache y limitación de ancho de banda. Se encontró que "JEAPC" tiene una sólida capacidad de transferencia de datos, sirviendo a 2800 clientes, principalmente en la región de Triunfo-Troncal. Se identificaron diferencias significativas entre los dispositivos Cisco y MikroTik. Por ejemplo, el Cisco ASR920 mostró versatilidad en enrutamiento, pero carecía de funciones de traducción de direcciones IP y limitación de ancho de banda para clientes individuales. En contraste, el MikroTik CCR2004-16G sobresalió por su estabilidad de rutas, capacidad de traducción de direcciones IP y limitación de ancho de banda a nivel de cliente, siendo escalable y eficiente para entornos medianos. Las conclusiones resaltaron la importancia de considerar las necesidades actuales y la escalabilidad futura al elegir entre dispositivos MikroTik y Cisco. MikroTik se identificó como una solución eficiente,

especialmente beneficiosa para empresas con presupuestos ajustados y crecimiento moderado, mientras que Cisco se posicionó como una opción sólida para empresas con ambiciones de expansión. La elección adecuada dependerá de la estrategia a largo plazo de cada ISP en Ecuador.

Palabras clave: Comparativa de dispositivos, Eficiencia en redes, Elección estratégica de equipos.

Introduction

The accelerated advancement of ICTs, further fuelled by the impact of the pandemic, at the national level has led to a remarkable increase in demand for internet services. This rapid growth has led the country's internet service providers (ISPs), including ISP JEAPC, to deploy network devices provided by two industry giants: MikroTik and Cisco. The choice between these two manufacturers has been based on economic considerations and the promise of efficient performance, but despite the widespread adoption of MikroTik and Cisco devices by ISPs, the comparative evaluation of the operating systems embedded in these devices, in terms of efficiency, security and stability, still lacks clarity. This lack of clarity drives the need for an informed analysis that provides a detailed and comparative view between MikroTik RouterOS and Cisco IOS. This research arises in response to this need, seeking to fill the existing gap in technical and strategic knowledge in ISP networks in Ecuador. The objective is to enable ISPs to respond effectively to the growing demand for internet services in the country, considering factors such as efficiency, security and stability in the MikroTik and Cisco operating systems.

Network architecture represents the most cost-effective and efficient way to conceive and implement a coherent set of products that can be interconnected. It serves as the end-to-end design that ties

together protocols and other software, this strategy is advantageous for both the customers using the network and the technology solution and platform providers (Caiza Caizabuano, Tintín Perdomo , & Caicedo Altamirano, 2018).

In a network architecture there is:

- Broad connectivity: A network, in its essence, must guarantee an effective connection between any number of network entities, taking into account the necessary degrees of protection.

- Resource sharing: Through network structures, it is possible to share resources such as printers, databases and disk drives, which optimises the network's operability in terms of cost and efficiency.

- Network management: The architecture defines the appropriate permissions for the user to define, operate, modify, protect and maintain the network.

For the purpose of singling out the numerous informational devices in existence, the IP address, a numerical representation composed of four sets of values, ranging from 0 to 255, is used.

The numerical label is uniquely assigned to each device, be it a computer, smartphone or other connected element, thus enabling efficient identification and location in the network.

. This IP address is configured as a 32-bit code, essential to facilitate communication between two computer terminals or hosts within a network. This mechanism, based on a unique numerical structure, makes it possible to identify and establish connections between devices in the vast digital landscape (GIL, 2017).

There are five different classes of IP addresses, each characterised by the corresponding network configuration.

- Class A addresses: Identified by the first network bit at 0, with a length of 8 bits for the network and 24 bits for the node address. These addresses range from 0.0.0.0 to 127.255.255.255. Network 10 is reserved for internal networking in organisations, not visible on the Internet.

- Class B addresses: Characterised by the first two network bits with the sequence 10, with 16 bits in length for both the network and node address, ranging from 128.0.0.0.0 to 191.255.255.255.255. Addresses in the range 172.16.0.0.0 to 172.31.0.0.0 are reserved for private networks.

- Class C addresses: Distinguished by a 24-bit network field starting with 110, with 8 corresponding bits, and addresses from 912.168.0.0.0 to 192.168.255.0 are reserved for hidden networks. There are a total of 2,097,152 Class C networks.

- Class D addresses: Begin with the sequence 1110 and range from 244.0.0.0.0 to 239.255.255.255.255. These addresses, known as "multicast", do not assign to individual nodes, but to groups of nodes. They allow packets to be delivered to all members of the group.

- Class E Addresses: Begin with the sequence 1111 and range from 240.0.0.0.0 to 255.255.255.255.255. Reserved by IANA, these addresses are special, being assigned only 255.255.255.255.255 to represent all machines connected to a physical medium (Corona, 2004).

Routers play a fundamental role in network configuration and management, offering advanced functionalities such as Network Address Translation (NAT) and Port Address Translation (PAT). These methods allow bidirectional translation between official and private IP addresses, transparently to end users. In addition to operating on

routers, this configuration can be implemented on firewalls (security systems that control network traffic), such as firehol (A configuration interface for iptables on Linux systems), extending the address mapping possibilities, for example, by converting the IP address 201.222.244.232 to private IP addresses such as 192.168.1.0.

Routers, in addition to facilitating connectivity, act as a firewall by discarding potentially harmful network traffic. The configuration of Access Control Lists (ACLs) on these devices allows for more precise control over the flow of data.

These devices can also act as DHCP (Dynamic Host Configuration Protocol) servers, allowing the dynamic assignment of IP addresses to network devices.

Depending on the traffic handled, they are classified into core routers and non-core or gateway routers. Core routers, operated by the Internet Operation Center (IOC), connect local networks to the Internet backbone, while non-core routers handle routing between local networks. This segmentation allows for efficient organisation of network traffic, ensuring seamless and secure connectivity (Maturel, 2013).

There are several types of networks, classified mainly by their scope in terms of size and the number of devices they cover:

- LAN: Local Area Network, usually small networks such as home or business networks, where each device is directly connected to each other.

- WAN: Wide Area Network, covering national or even continental networks, interconnecting entire countries.

- MAN: Metropolitan Area Network, larger than a LAN, covering a city or a specific population (Valencia Ayala & Risueño Benítez, 2017).

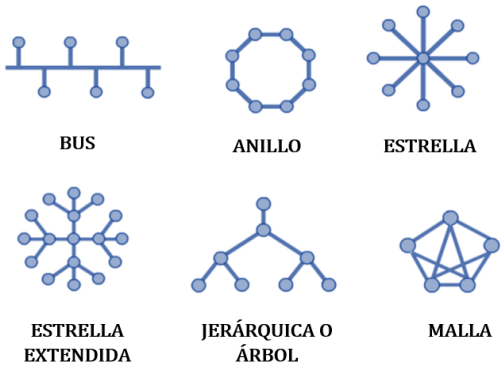
Likewise, networks are also classified according to their physical medium:

- Wired networks: They send information through the use of cables.

- Wireless networks: They use electromagnetic waves for the transmission and reception of information.

- Mixed networks: Combine wired and wireless connections in different network areas.

Fig. 1. Network topology (Garcia Palma, 2018).



The TCP/IP transmission control protocol represents a hierarchical set of protocols that facilitate effective communication between devices in computer networks. It is composed of four main layers:

- The application layer: refers to the applications and services used by end users, such as HTTP, web pages and SMTP.

- The transport layer: Ensures the correct delivery of data, ensuring the integrity and reliability of the transmitted data. The TCP protocol operates at this layer.

- The Internet layer: Facilitates the routing of data within the network, identifying the most efficient route for packets of information to reach their target.

- The Link layer: Allows the management of all the elements necessary for an IP data packet to physically connect on the media (Hernández, et al., 2017).

This model establishes the way in which data is transmitted, received and managed through a network, ensuring the integrity and correct transmission of information between connected systems on the INTERNET.

The relevance of the IP protocol lies in its essential function at the network level, where it adds a fundamental structure to the data packet or datagram to enable its transit along the network to its final destination. This process involves the packet passing through several routers on its way, following the most efficient route. This identifier element, known as the IP header, encapsulates crucial information, including the source and destination IP addresses, among other relevant data.

The importance of the IP protocol to the common user is manifested in its ability to uniquely identify hosts on the network by IP addresses. This mechanism makes it easier and faster to find and communicate between devices on the network. It is essential to note that IP addresses can be of IPv4 or IPv6 type (Castillo, 2020).

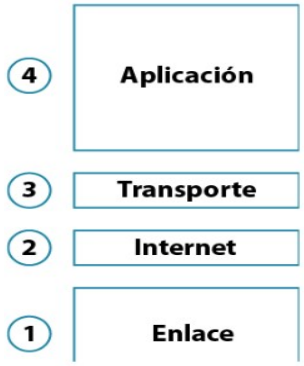


Fig. 2. Layers of the TCP/IP model.

An ISP is an entity, either public or private, whose purpose is to offer and market access to the internet network, serving both residential and corporate customers. ISPs provide access to the internet using various means of connection for end users. Among the most common at the national level are xDSL technologies, which use conventional telephone lines as a means of connection, and FTTH (Fiber to the home), which uses fibre optics, has gained popularity in recent years in the country due to its remarkable advantages in terms of peak performance, availability and speed.

The main functions of an ISP include:

- Internet connection: Providing access to the internet network to residential and corporate customers, ensuring a reliable and stable connection.

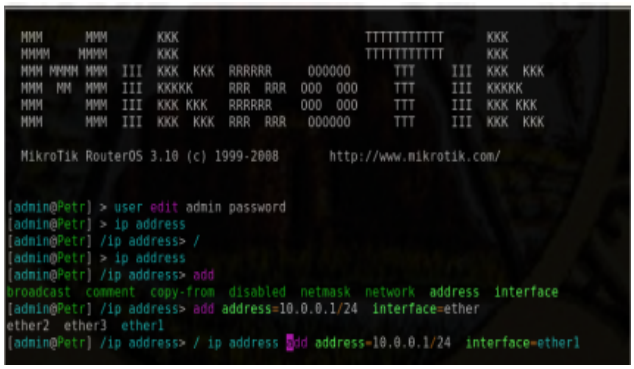
- Service provisioning: Providing various services, such as data connectivity, email, web hosting, among others, tailored to the needs of users.

- Technical support: Providing technical assistance and support to customers, solving connection problems and offering advice to

maximise the performance of the internet connection (Marcela, Altamirano, González, & Alexander, 2018).

It is an operating system rooted in the Linux 2.6 kernel, it is used in the MikroTik RouterBoard hardware, belonging to the MikroTik line of branded hardware. Renowned for its easy-to-configure proprietary system, these devices offer a remarkable cost/benefit ratio. Benefit. The fascinating thing about RouterOS is its ability to be installed on a computer, transforming it into a full-fledged router with functionalities such as firewall, routing, wireless access point, bandwidth management, VPN server and more (Llimpe & Tilio, 2019).

Fig. 3. MikroTik x86 interface.



RouterOS features include:

Configuration methods.

- Local access via keyboard and monitor: Allows direct configuration by connecting a keyboard and monitor to the device.

- Serial console and terminal: Access via a serial connection and terminal for remote configuration.

Firewall.

- Packet filtering and security: Implements security and controls data flow.

- NAT access prevention: Prevents unauthorised access to directly connected networks.

Routing.

- Static routes and dynamic protocols: Allows configuring static routes and working with dynamic protocols for IPv4 (RIP v1 and v2, OSPF v2, BGP v4) and IPv6 (RIPng, OSPFv3, BGP).

The IOS, known as the Network Interconnection Operating System, is a Cisco Systems creation designed for the management and programming of network devices, such as switches and routers. To configure a Cisco switch or router, you need to access the device's user interface using a terminal or remote connections such as telnet or SSH. When logging into the device, it is necessary to authenticate before executing any commands (Jimenez, 2017).

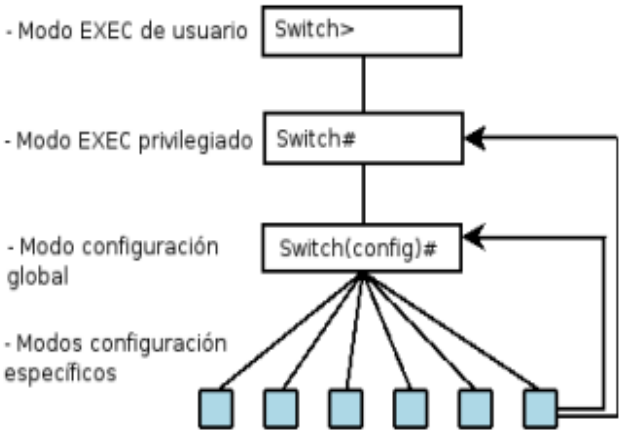


Fig. 4. Cisco IOS configuration modes. (IT)

For security reasons, these devices have two levels of access to their commands:

- User mode: intended for basic functions such as checking the status of the equipment. In this level it is not allowed to alter the device configuration.
- Privileged Mode: Reserved for tasks that involve modifying the configuration of the equipment, in addition to the common functions.
- The internal architecture of cisco routers/switches has crucial components for the boot process, these components are:
    - RAM/DRAM: This memory stores routing tables, ARP and switching caches, in addition to managing the packet queue. It also provides temporary memory for configuration while the device is running.
    - NVRAM: A non-volatile memory that stores a backup copy of the router's startup configuration, its contents are maintained even in the event of a power outage or reboot.
    - Flash: This reprogrammable memory retains an image and the operating system code. It allows software upgrades without replacing components and retains its contents before power outages or reboots. It can also store multiple versions of the operating system.
    - ROM: Contains power-on diagnostics, the Bootstrap program, and critical operating system software. Upgrading the software in ROM requires replacing chips in the CPU.
    - Interfaces: These are the network connections, either on the backplane or in separate modules, that manage packets into and out of the device.

Cisco 4000 Routers belong to the Integrated Service Router (ISR) category and are designed for enterprises with multiple branch offices and remote sites. These routers excel in providing comprehensive services through various cloud applications, mobile multimedia devices. Their main function is to facilitate more efficient and direct

communication between branch offices and private cough centres, as well as with public clouds through the use of VPN and internet (Barrero Lasso, Cortes Muñoz, & Moya Correa, 2023).

The Cisco 4000 series offers higher bandwidth in a physically more compact form factor. In addition, it incorporates advanced WAN traffic management to adapt to new applications and usage patterns. These routers also stand out for their performance-on-demand capability and server consolidation, which contributes to a more efficient and agile infrastructure.

The Cisco 4000 Series Routers incorporate the advanced Cisco IOS XE software, which shares similarities with the operating system found on the larger ASR 1000 Series platforms. While retaining the design and user interface characteristic of traditional Cisco IOS, Cisco IOS XE introduces the ability to leverage the efficient separation of the data and control planes, allocating dedicated CPUs to services (IT).

For services such as CUBE, you experience significantly improved stability without incurring additional per-port costs. Improved performance without incurring additional per-port costs. Performance remains robust in most typical branch office deployments, providing performance on par with dedicated ICs on a reliable alternate platform.

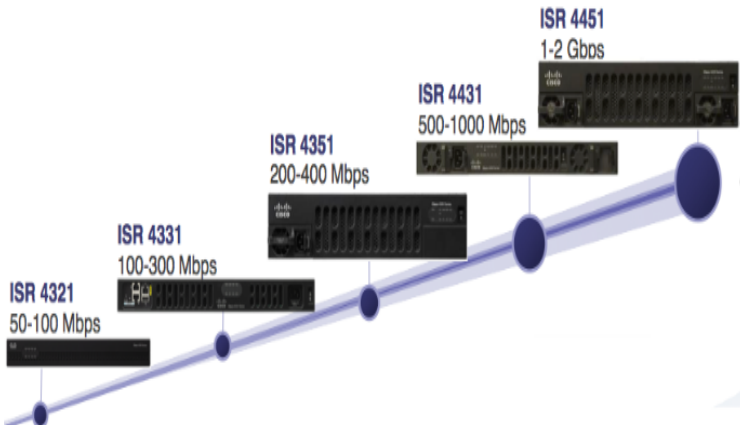


Fig. 4. cisco 4000 Router models. [12]

Cisco 4451-X ISR.

It is recommended as a natural evolution from the 3925E and 3945E Routers. Offers 1 Gbps throughput, with an option to upgrade to 2 Gbps, in a 2RU form factor that includes three NIM slots and two slots for enhanced service modules

- 10 cores in the data plane.

- Support for single- or double-wide Cisco UCS E-series.

- Control and service memory up to 16 GB.

Cisco 4431 ISR.

A suggested migration from the 9325 and 3945 Routers. Provides 500 Mbps throughput, with an option to upgrade to 1 Gbps, in a 1RU form factor with three NIM slots.

- 4-core processor (one control core, and three service processors).
- 6 cores in data plane.
- Up to 16GB of control and services memory.

Cisco 4351 ISR

It is designed to provide a robust, high-performance platform, especially suitable for enterprise and service provider environments.

Key features and functions:

- Agility and Scalability: The ASR 4351 provides a modular and scalable architecture, allowing additional modules to be added to suit specific network needs.

- High Performance Processing: Equipped with a powerful multicore processor, the router is capable of handling intensive workloads and providing exceptional performance for critical applications and services.
- Integrated Services: Offers a wide range of integrated services, such as security services, application services and advanced connectivity services, all on a single platform (Cahuana, 2020).

Mikrotik RouterBOARD router

A series of router hardware manufactured by the Latvian company MikroTik. These devices are designed to provide routing, security and network management solutions.

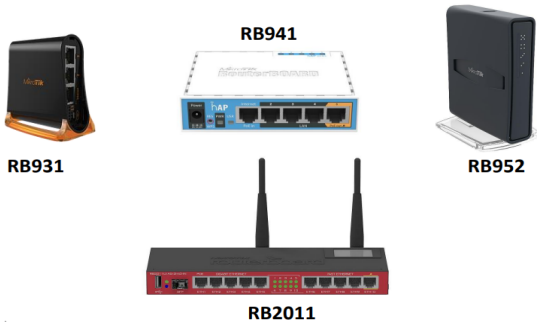


Fig. 5. MikroTik RouterBOARD models. [13]

Methodology

This research follows an exploratory and applicative approach. An exploratory perspective is adopted by identifying and addressing the existing gap in the technical and strategic knowledge of ISP networks in Ecuador, in addition to carrying out a detailed analysis of the equipment: "Cisco ASR920", "MIKROTIK CCR2004-16G", "MikroTik CCR1036-12G" and thus having a deeper understanding. The necessary data was collected through the ISP company "JEAPC".

The evaluation of geographical and routing parameters, such as static and dynamic routing, IP address translation, Google Cache network segregation, bandwidth limitation at the interface, as well as client capacity, was carried out using specific measurements and indicators. For example, the efficiency of route management, the effectiveness of IP address translation, and the ability to control bandwidth both at the interface level and for individual users were measured.

The applicability of this research lies in the delivery of a solution to meet the identified need in the field of ISP networks in Ecuador. The results provide an informed analysis that offers a detailed and comparative view between MikroTik RouterOS and Cisco IOS, enabling ISPs to make informed decisions to optimise their infrastructures and address the growing demands for internet services in the nation.

Results

The results obtained are as follows:

"JEAPC, has a total capacity of 6 Gigas, the company's infrastructure ensures a solid data transfer capacity to meet the needs of its customers. An interesting detail is the Google Cache of 2.5 Gigabytes, indicating that the company optimises the loading speed of Google-related services. This suggests a strategy to improve the browsing experience of its customers.

In terms of user base, JEAPC serves a number of 2800 customers. The geography of operation, concentrated in the Triunfo - Troncal region, suggests a strategic focus on specific areas. This may indicate a specialised attention to the needs and demands of that particular region.

It is evident that the Cisco ASR920 (equipment selected for comparison) is used for the Triunfo-Troncal cantons, offering outstanding versatility in terms of routing. Its ability to implement

both static and dynamic routing makes it a robust component to adapt to different network needs.

This device, however, does not incorporate IP address translation capabilities. On the other hand, it is notable for its network segregation capability specifically designed for Google cache optimisation. In terms of bandwidth management, the ASR920 has no limiting functionalities on interfaces or for individual clients, allowing for unrestricted data flow.

In terms of capacity, the ASR920 demonstrates its potential to manage up to 2,800 clients, which can be critical in larger network environments. In summary, the Cisco ASR920 stands as a solid choice for efficient network management in the specific Triunfo-Troncal location.

Shows that the equipment used strategically for the Triunfo canton, the MikroTik CCR2004-16G distinguishes itself as a comprehensive network solution. With a focus on route stability, this device is especially adept at managing static routing, providing a solid foundation for predictable network structures.

The IP address translation capability provides flexibility by enabling dynamic address management in the network. This is combined with the network segregation capability, designed to optimise Google's cache efficiency and improve overall performance.In terms of bandwidth, the MikroTik CCR2004-16G takes a balanced approach. While dispensing with interface limitations to facilitate unrestricted data flow, it provides the ability to limit bandwidth at the client level, giving precise control over resource allocation. With an impressive capacity to manage up to 1200 clients, the MikroTik CCR2004-16G emerges as a scalable and efficient solution for medium-sized environments, highlighting its suitability for professional networks in Triumph.

It is evident that the IP address translation capability adds an additional layer of versatility by allowing dynamic address management in the network. The network segregation functionality, specifically aimed at optimising Google's cache, highlights its commitment to data management efficiency. In terms of bandwidth,

the CCR1036-12G takes a balanced approach. While it imposes no limitations on interfaces to facilitate unrestricted data flow, it provides the ability to limit bandwidth at the client level, giving fine-grained control over resource allocation.

With a capacity to manage up to 550 clients, the MikroTik CCR1036-12G is positioned as a scalable and efficient option, particularly suitable for medium-sized environments looking for robust Trunking performance.

Conclusions

At the conclusion of this comprehensive research, key conclusions are distilled that shed light on the strategic choice between Cisco and MikroTik devices for ISPs in Ecuador.

Both vendors present options, and the choice between them must be a careful reflection on current needs and vision for future scalability. MikroTik is an efficient solution, especially beneficial for companies with tighter budgets. Its ability to manage an appropriate number of clients, as evidenced by the 1200 client base on the MikroTik CCR2004-16G, is a key strength for enterprises looking for an affordable and robust deployment.

In contrast, Cisco offers additional power and resources that are ideal for businesses that aspire to expand and adapt to growing connectivity demands. The Cisco ASR920, with a capacity of up to 2,800 clients, underlines its suitability for environments looking for a larger infrastructure or more clients.

In conclusion, MikroTik provides an efficient solution for moderate growth, while Cisco positions itself as a solid choice for companies with expansive ambitions. The right choice will ultimately depend on the long-term strategy of each ISP in Ecuador.

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