Quality of Service and Availability in a Full Mesh WAN using IP/MPLS. Case Study: The Network at the Department of Justice in Argentina

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Abstract. At the Argentine Department of Justice (Ministerio Público Fiscal de la República Argentina), a project is developed to set up a WAN with national coverage, quality of service, and IP/MPLS/VPN links. The project focuses on quality of service, a direct result from the selected technology. In previous work, studies explored these issues. Hence, the project enabled the implementation of the examined theory. The advantages of MPLS technology are evaluated to determine quality standards in VoIP, videoconference, mission critical applications, e-mail, web access, and others. Other aspects of LANs are analyzed to obtain an availability level compatible to the required needs. The Project include practical recommendations to adequate the LAN to the desired availability levels.

1 Design and Implementation of the Network at the Argentine Department of Justice (MPF).[1] Background

The Project to organize communications adequately at the Argentine Department of Justice (MPF) began in 2006. Its purpose is to link through a WAN all of its offices, taking into account that the District Attorney's Offices and their administration are nodes of this Department.

The MPF is an institution incorporated in the National Constitution[2] in its last reform. Organically, it consists of the Department of Justice and the Office of the Attorney General.

[1] MPF stands for Ministerio Público Fiscal (Argentine Department of Justice)

[2] The 1994 Reform established that the Department of Justice become one of the authorities of the Argentine Government – along with the Executive, Legislative, and Judiciary Powers– as an independent entity with functional autonomy and financial autarchy (art. 120).

The MFP is divided in 16 jurisdictions distributed along the entire country: Bahía Blanca, Buenos Aires, Comodoro Rivadavia, Córdoba, Corrientes, General Roca, La Plata, Mar del Plata, Mendoza, Paraná, Posadas, Resistencia, Rosario, San Martín, Santa Fe, and Tucumán.

The Project is carried out with its own personnel, from the Department of Computer Engineering and Communications under the Department's Technological Accessibility and Upgrade Plan

Its main objective consists of linking 350 District Attorney Offices and other dependencies of the MPF around the country with its own network, providing VoIP, data and video transmission, and institutional applications with an adequate level of information security.

After a preliminary survey carried out in 2007, the following assumptions are established for the network design:

- Ensure that the chosen technologies could remain current in the long run.
- Use Category 6 LAN Ethernet Networks.
- Divide the development areas in two: AMBA[3] and the rest of the territory.
- Implement LANs with local companies.
- Select computer technicians by jurisdiction for maintenance and follow-up.
- Implement a Network Operations Center: Secure Room.
- Provide the LANs with analogous equipment: switches, servers and UPS.
- Use a public transmission network for the WAN, working with IP/MPLS links; thus ensuring quality of service.
- Monitor and control the network in a centralized manner.
- Implement an effective and centralized security policy.
- Minimize maintenance costs and decrease reparation times.
- Maximize reliability and network availability.

The Project involves hiring specialized human resources and technical personnel as well as the purchase of technology, hardware, and the contracting of services from telecommunications vendors through open bids and current purchase regulation.

In 2008, the MPF Network Implementation Plan was launched. By March 2009, the Plan consists of:

- 350 linked D.A. Offices.
- 130 links through IP/MPLS/VPN networks.
- 3.500 network terminals.
- 130 LANs.
- 17 Videoconference equipment sets.

[3] Área Múltiple Buenos Aires (AMBA): Consists of the City of Buenos Aires and a significant part of its suburban area, called Gran Buenos Aires.

- 150 Servers.
- VoIP service in all D.A. Offices.
- Central Operations Control Room and "storage" system: located in Avenida de Mayo 760, including a Backup Processing Center.
- Massive storage system with a backup processing center.
- User support for institutional applications, network, and telephone services.
- Institutional applications for the management of the Judiciary Power in Criminal Law.

2 MPF Network Architecture

MPF WAN[4] architecture is based on protocols IP-MPLS [1] [2][5].

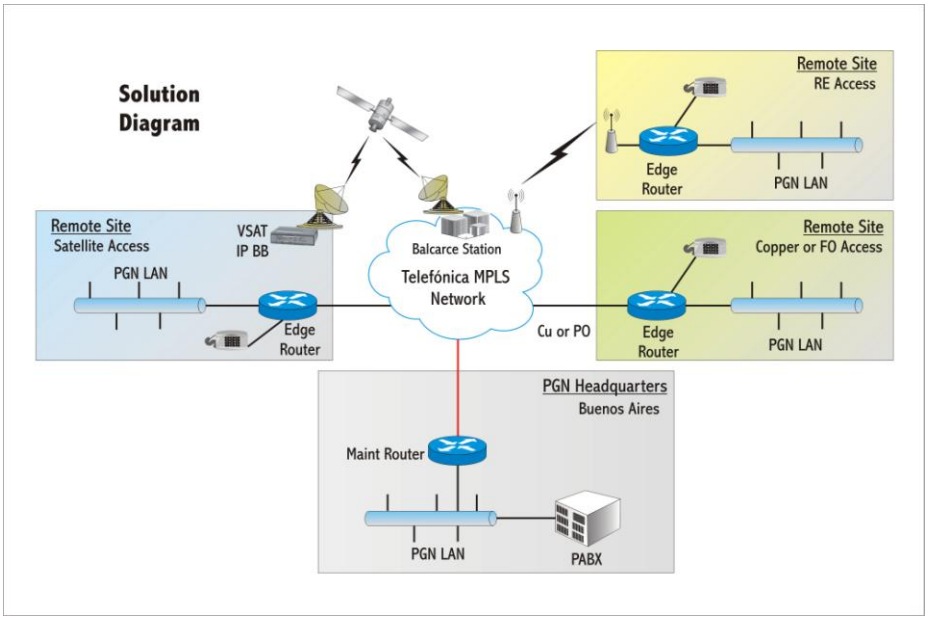

Figure 1 MPF Network Architecture

LAN is designed with protocols 802.3 for 100 Mbps, with structured wiring following norm ANSI/EIA/TIA 568, category 6. In the future, this design enables upgrades, up to 1 Gbps. Figure 1 shows the network architecture.
Internet connection is centralized in the MPF Central Office,[6] and is distributed through the MPF network to 130 destinations.

[4] Wide Area Network.
[5] Internet Protocol - Multiprotocol Label Switching.
[6] Located in Avenida de Mayo 760, Buenos Aires.

The network enables VoIP communication among all MPF offices using three voice channels per office.

Data and voice transmission is full mesh for the network nodes, as well as videoconference among the head offices and the sixteen Prosecutor offices.

The network has a structure of terrestrial physical fiber optic links, copper and/or digital microwave, linking the different nodes and following transmission speeds ranging from 512 Kbps to 4 Mbps. The link between the Buenos Aires central node with the IP/MPLS network of the Internet provider is 100 Mbps.

The basis for this architecture relies on MPLS [3] performance, granting:

- An adequate security level.
- Bandwidth on demand.
- Access to the network from any place with Internet access.

Furthermore, the architecture also offers the following convenient features:

- "Full mesh" architecture.
- Quality of Service: Using MPLS the network controls the quality of service.
- Voice, data, video, and mission critical application transmission capabilities.
- Cost reduction in telephone services, videoconferences, and others.

Among the main services provided, we can mention:

- Multimedia: voice and video, and video streaming.
- VoIP.
- Reliable safeguarding of MPF information.
- Secure Access to internet through firewalls.
- Access to databases and applications from other government offices.
- Videoconference
- Institutional electronic mail

Given the required characteristics for the network traffic, the services provided are:

- Multimedia Traffic. Minimum delay and jitter. In addition, delayed packets are deleted.
- Videoconference Traffic. Similar to multimedia traffic but with less priority.
- High Priority Traffic. Sensitive to Time Out, for critical applications.
- Normal Priority Traffic. For the transmission of files, databases, and systems in general.
- Low Priority Traffic. Used in electronic mail and internet.

3 Features of the Network Level of Service with Internet Access.

Service provides Internet access with a transmission speed of 40 Mbps and upgrading capabilities. Transmission is digital, with no tolerance for analog lines.

Internet access is through the Central Office. From that point, service is granted to all other offices through the WAN of the MPF.

Total bandwidth is distributed between domestic and international access, assigning it dynamically to ensure a "Committed Information Rate" (CIR %) for both cases, according to the following ratios:

$$CIR_{NAC}(\%) \geq CIR_{NAC(\min imum)} = \frac{BW_{NAC(\min imum)}}{BW_{TOTAL}};$$

$$CIR_{INT}(\%) \geq CIR_{INT(\min imum)} = \frac{BW_{INT(\min imum)}}{BW_{TOTAL}}$$

$BW_{TOTAL:}$ Transmission speed of each link

$BW_{NAC(minimum)}$ and $BW_{INT(minimum)}$: Desired Domestic and International bandwidth. Their sum never exceeds the total bandwidth (BW_{TOTAL}).

The Network guarantees a $CIR_{NAC(minimum)}$ (%) = 95% and $CIR_{INT(minimum)}$ (%) = 95%.

The network also complies with the following features to provide an adequate quality of service:

- Minimum link availability of 99,7 % -- measured annually – and 99,5 % if measured per trimester.
- BER = 10^{-7}.

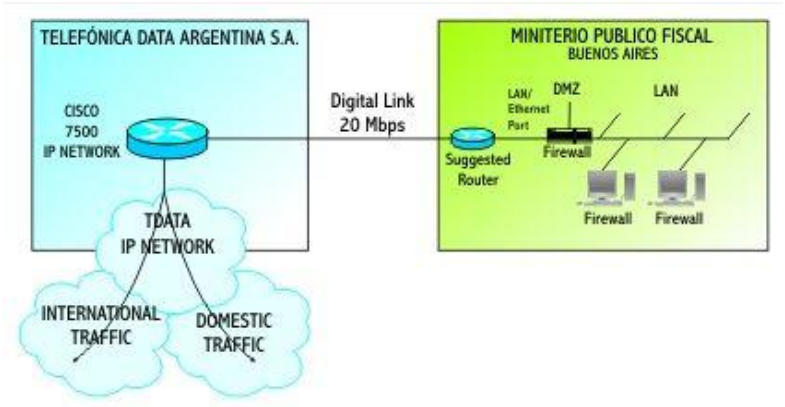

Figure 2

- Average Minimum Time between Failures – MTmBF, maximum per month: 30 hours.
- Minimum Time between Failures – TmBF, maximum per month: 15 hours.
- Maximum Time for Restoration of Service – TMRS, less than 2 hours per month.

Parameters used in the estimation:

- Average Minimum Time between Failures- MTmBF:
  Constant defining the average tolerance between two successive failures. MTBF > MTmBF must hold
  Where:
  Minimum Time between Failures– MTBF is defined as

$$MTBF = \frac{\sum_{1}^{n} TBF_i}{n}$$

  n = occurrence of failures in a month.

  TBFi = Time elapsed between failure (i) and failure (i-1).

- Time between failures - TBF:
  Constant defining the time between two consecutive failures. TBFi > TmBF must hold, where:

$$TBF_i = \left(FT_i - FT_{(i-1)}\right)$$

- Minimum Time between failures (TmBF).
  Constant defining the minimum tolerance between two consecutive failures.
- Maximum Time for Restoration of Service – TMRS.
  Constant defining the maximum tolerance for the restoration of service.

4 Performance Trials

4.1 Connectivity Test

Round trip times between a single station connected to the router at the Central Office and the sites detailed in Table 1 are tested. The resulting times are under 700 [ms] for international sites and 300 [ms] for domestic sites.

List of Sites	
uc.cache.nlanr.net	www.cisco.com
ns.uu.net	www.vend.org
www.fedworld.gov	www.presidencia.gov.ar
www.mre.gov.br	www.ibge.gov.br
www.sebrae.com.br	www.presidencia.cl

Table 1

Tests run through ICMP (PING) with packets 1024-byte long, sent in three separate opportunities, ten packets each.

4.2 Bandwidth Test

The following test is required:

The sum of FTP transmission rates between a single station connected to the access router at the Central Office and the sites detailed in Table 2.

List of Sites	
ftp.netscape.com	ftp.oracle.com
ftp.sco.com	ftp.freebsd.org
ftp.openbsd.org	ftp.sun.com
ftp.hp.com	ftp.cheyenne.com
ftp.conexion.com	

Table 2

The sum should are not less than 90% of the nominal available bandwidth in the channel setup by the provider, transferring files of at least 7 MB.

4.3 Level of Service

The following features are considered to determine Quality of Service [4] [5]:

- Guaranteed Delivery.
- Transmission Error Recovery.
- Congestion Control.
- Guaranteed bandwidth.
- Flow control.

These basic principles vary when facing the need to implement mail, chat, VoIP, and multimedia. The latter require other control parameters. Thus, the following features are considered:

- Delay: Period of time in transit through a path, where the amount of jumps involved becomes a significant parameter.
- Jitter: Difference in the delay through a path, originated by network instability.
- Packet Loss: Should be restricted.
- Priority: To ensure further the adequate delivery of critical traffic.
- Availability: Percentage of time in which service is operative.

The MPLS Network has three levels for quality of service:

- Level 1: Best Effort type for Internet and e-mail traffic.
- Level 2: Reliable data traffic, for MPF institutional applications.
- Level 3: Multimedia, voice, and video traffic.

Guaranteed values in the following parameters are determined to achieve the desired quality of service:

- Packet Loss.
- Delay or Latency.
- Jitter.

Based on these criteria, the parameters listed below are established:

- WAN IP/MPLS/VPN link availability of 99,5 % measured annually and 99.2% monthly.
- BER = 10^{-7}
- Average Minimum Time between Failures – MTmBF, per month: 40 hours.
- Minimum Time between Failures – TmBF, per month: 30 hours.
- Maximum Time for Restoration of Service – TMRS, per month: less than 4 hours in AMBA and less than 6 hours in the rest of the country.

Real time reporting is available to accomplish effective control. The system reports:

- Services (use of service graphs, traffic)
- Failures: list of failures, beginning date and time, final date and time, affected service (link), date and time of failure notice, failure origin, comments.
- Line use: line use percentage in bps, incoming and outgoing frames, compared to the total available bandwidth.
- Availability: Percentage of time in service, disaggregated per service.
  tTS = Total time of Service.
  tSE = Total time of Effective Service.
  tTI = *tTS* - *tSE* (Total Unavailability Time).

$$\text{Availability}(\%) = \frac{tSE}{tTS} * 100$$

5 Concluding Remarks.

Based on the study of the network architecture developed at the Argentine Ministry of Justice, the following key features are determined for network quality of service:

- Full Mesh design in the architecture, IP / VPN / MPLS, enabling the delivery of a wide range of service based on IP, in theoretical range of 56 Kbps to 40 Gbps.

- Precise parameter definition to require the most adequate service for the variety of traffic and formats transmitted in the network, and to guarantee service availability to all offices around the country.
- Quality of Traffic ensured to critical mission applications with a WAN packet loss of less than 1%, called "Gold Traffic" by the company providing the services.
- Best Effort non priority data traffic, called "Bronze Traffic" by the service provider, with a packet loss level higher than 1%. The services provided on this quality level are internet surfing and electronic mail.
- Multimedia Traffic with two main services: VoIP and Videoconferencing. The services use the traffic called "Multimedia" by the provider which should guarantee isochrone signal transmission. Thus, packet loss, jitter, and delay need consideration. A packet loss lower than 0.5% is provided. Domestic traffic maximum delay is 200 mseg and jitter less than 30 seconds. International Traffic has a delay up to 300 mseg, and maintains the same value for jitter as the domestic case.
- Quality of service complemented with an appropriate definition of security policies, following standards and norms and their implementation. These policies are available to all network users to better visualize and understand the network.
- Central control room infrastructure with modern security features and equipment protection to permanently guarantee operations at the data processing center of the MPF.
- Availability of the network adequate to the operative needs of the organizations. TMBF availability qualifies the level of failure of the equipment and associated software, The TMRS expresses the average time for each failure reparation.

Based on quality of service, the network at the MPF ensures:

- Efficient and reliable transmission of voice, video, and data.
- MPF data transmission and safe storage.
- Resource optimization based on savings in communications, personnel, and information costs.
- Implementation of management systems which optimize MPF operations in real time.

Finally, this network is the practical implementation supported in previous work developed by this Research Group [6] [7] which focuses on achievable advantages in class and quality of service

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