UNIVERSIDAD DISTRITAL
FRANCISCO JOSÉ DE CALDAS
Acreditación Institucional de Alta Calidad

Network architecture proposal for the new engineering building of the Universidad Distrital

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***Abstract*— To implement the network architecture in the new engineering building of the Universidad Distrital, a process will be followed that encompasses requirement planning, architecture design, equipment selection and installation, configuration, and continuous maintenance. This approach will ensure a robust, secure, and scalable network infrastructure to meet the connectivity needs of staff and students, promoting an efficient and modern learning and working environment on campus.**

I. INTRODUCTION

The implementation of an efficient and robust network architecture is fundamental to ensuring the optimal functioning of any educational institution in the digital age. The network infrastructure must be capable of providing reliable, secure, and high-speed connectivity to support not only administrative operations but also research, learning, and innovation in the field of engineering, as proposed at the time of designing this new building.

Careful selection of network equipment and proper installation of the physical infrastructure are critical steps in the implementation process. Special attention must be paid to configuring devices such as switches, repeaters, or routers to ensure optimal performance and solid security. Ultimately, the long term success of the network architecture largely depends on staff training and the establishment of continuous monitoring and maintenance procedures to ensure smooth operation and prompt response to any issues that may arise. Together, these efforts will ensure that the new engineering building of the Universidad Distrital has an innovative network infrastructure that meets the technological demands of both the current and future world.

II. OBJECTIVES

General:

- *The general objective of this project is to design the network for the new engineering building by analyzing it and relying on network design theory in order to improve and optimize the connectivity of this space, reducing costs in the process. This objective It can be achieved through the following specific objectives:*

Specifics:

1. *Gather information: A complete analysis of the scope of the building construction project will be carried out, determining what areas will be built, how they will be connected and what spaces will need specialized software in the networking area.*
2. *Define and refine requirements: The necessary requirements for the network project will be defined, considering the areas that require specialized connectivity software. This list of requirements will be refined later to meet the priority needs of the project.*
3. *Create a design prototype: A prototype of the building network design will be made, meeting the identified requirements and considering each of the specific spaces that will be part of the construction. To do this, a specific model will be designed for each space, which will allow the design process to be more efficient.*
4. *Simulate the design: Simulate the proposed design in specialized software for networks, where we can see the efficiency of the design and find possible points of improvement*

III. SCHEDULE

A schedule was created detailing the activities carried out during the project, which had an estimated duration of four months. Throughout this period, weekly tasks were carried out to ensure compliance with the proposed objectives. Each week was dedicated to specific activities that contributed significantly to the progress and success of the project. Below we can see a breakdown of the activities carried out

A. Review of Plans and Architectural Design

A detailed review of the architectural and design plans of the building construction project was carried out with the intention of identifying all the areas that will be built, as well as the general layout of the spaces.

B. Identification and Distribution of Spaces

It was determined how the different areas within the building are connected with the objective of mapping the physical and functional connections between the different areas of the building.

C. *Evaluation of Specialized Network Software*

The possible software needs for the management and operation of networks in the building were reviewed with the objective of determining which spaces in the building will require specialized network software.

D. *Initial Requirements Gathering*

The initial network project requirements were identified and defined in order to obtain a clear understanding of the needs and expectations of the building users.

E. *Technical Analysis of Requirements*

A technical analysis was done on the identified requirements to evaluate their feasibility and technical specificity to ensure that all requirements are technically feasible.

F. *Requirements Prioritization*

Network project requirements were prioritized based on the importance and urgency of each to ensure that the most critical requirements are addressed first.

G. *Continuous Requirements Refinement*

Created a continuous process to review and refine requirements as the project progresses in order to adapt and improve them according to the changing needs of the project.

H. *Development of the Conceptual Network Model*

A conceptual model of the building network was created, based on the identified requirements, to visualize the overall network layout and define the key components and basic structure.

I. *Design of Specific Models for Each Space*

A detailed network model was created for each specific space within the building to ensure that each space has an optimized network design that meets its particular requirements.

J. *Integration of Specific Models into a General Prototype*

All models are integrated into a general prototype of the building network design with the objective of having cohesiveness and a functional and efficient design.

K. *Simulation Software Selection*

The most appropriate network simulation software was selected for the project so that it has the necessary capabilities to simulate the proposed design.

L. *Network Model Configuration in the Software*

The proposed network model was configured within the selected software by creating a replica of the network design in the simulation environment.

M. *Running Simulations*

Detailed simulations of the network model were run to evaluate its performance and functionality, identifying the efficiency of the design and detecting possible problems or areas for improvement.

Below is a diagram that summarizes the time that the activities mentioned above took:

TABLE I
ASSIGNMENT OF THE MONTH IN WHICH THE ACTIVITIES TAKE PLACE

Activity	March	April	May	June
Review of Plans and Architectural Design	X			
Identification and Distribution of Spaces	X			
Evaluation of Specialized Network Software	X			
Initial Requirements Gathering	X	X		
Technical Analysis of Requirements		X		
Requirements Prioritization		X		
Continuous Requirements Refinement		X	X	
Development of the Conceptual Network Model			X	
Design of Specific Models for Each Space			X	
Integration of Specific Models into a General Prototype			X	X
Simulation Software Selection				X
Network Model Configuration in the Software				X
Running Simulations				X

IV. SCOPE

The following task intends to preliminarily describe a network architecture capable of meeting the connectivity demand for the new engineering building. This includes connectivity for the 11 software labs specified in the contract with the San Javier consortium (Contract No. 001057), serving the 8,400 students who will benefit from this infrastructure, and finally, for the specialized laboratories that will be available.

One factor to take into consideration when developing the design is the total area of the new building, which will be approximately 12,800 m^2, spread across 15 floors, 1 mezzanine, and 2 basements, in addition to having an observatory[1].

The budget for this project, in which both the district and the university participated, has a total value of $112,333,623,297 Colombian pesos. Within this amount, the Sistema general de regalias (SGR) contributed $100,487,000,000, while the Universidad distrital invested $11,846,623,297. Taking into account the total investment cost, we will seek to create a reasonable budget that considers expenses associated with equipment and installation personnel [2].

V. NETWORK DESIGN

A. *Cost Estimate*

Initially, the intention is to describe the costs associated with the development of this infrastructure. Therefore, it is necessary to know the market price of the equipment (routers, switches, and repeaters) as well as the necessary cabling for proper and optimal functioning.

Initially, the methodology for identifying costs was based on conducting a search for the various models offered by manufacturers and selecting those belonging to a mid range category. The next tables show different prices in common brands recognized in this area allowing to select the better option:

TABLE II
COMPARATIVE FROM DIFFERENT BRANDS FOR ROUTERS IN SAME PRICE RANGE

Routers			
Brand	**Model**	**Price (US)**	**Price (COP)**
Cisco	ISR4431/K9	$6,975.00	$27,900,000
Hewlett Packard Enterprise	JM044A HPE FlexNetwork MSR3620-DP	$4,528.08	$18,112,320
Huawei	AR 2200 Series	$3,262.00	$13,048,000
Juniper Networks	Juniper Networks SRX340	$3,256.23	$13,024,920

If we look at the prices presented, the two viable options are the Huawei router and the Juniper Networks router because both are in the same category with respect to their competitors in the market and offer the lowest purchase price, around 13,000. 000 Colombian pesos

TABLE III
COMPARATIVE FROM DIFFERENT BRANDS FOR SWITCHES IN SAME PRICE RANGE

Switches			
Brand	**Model**	**Price (US)**	**Price (COP)**
Cisco	CBS250-24P-4G Smart Switch	$484.00	$1,936,000
NetGear	GS724TP	$420.00	$1,680,000
HP	1930 Series	$449.99	$1,799,960
TP-Link	TL-SG3428MP	$388.00	$1,552,000

On the other hand, when we look for the best mid-range switch, we find that the best alternative is the one offered by TP-Link, which costs around 1,550,000 COP with 24 ports, while the most expensive alternative is the one from Cisco, which reaches almost 2,000,000 Colombian pesos.

TABLE IV
COMPARATIVE FROM DIFFERENT BRANDS FOR REPEATERS IN SAME PRICE RANGE

Repeaters			
Brand	**Model**	**Price (US)**	**Price (COP)**
Ruckus	9U1-T300-US01	$299.99	$1,199,960
NetGear	WAX625PA	$289.00	$1,156,000
Ubiquiti	UAP-AC-LITE	$130.00	$520,000
TP-Link	EAP660 HD	$199.99	$799,960

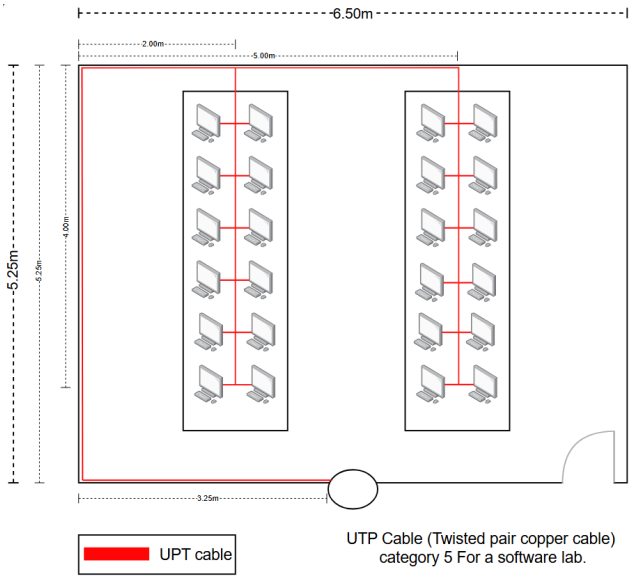
Finally, the repeater that minimizes the price is the one from the company Ubiquiti with a price of 520,000 COP while the one from Ruckus is the most expensive alternative.

TABLE V
COMPARATIVE FOR RACK PATCH PANEL WITH 24 AND 48 PORTS

Rack patch panel		
Ports	**Price (US)**	**Price (COP)**
24	$47.40	$189,600.00
48	$86.99	$347,960.00

The Rack patch panels help us distribute the signal to different end devices, and are quite useful for distributing connections in software laboratories. The alternatives found only vary in the number of ports: there are 24 or 48 ports as shown in the figure. table IV. Given that each room would be contemplated for 24 computers, it would be a viable alternative to consider that each room has its 24-port Rack patch panel.

The UTP cable estimate was made from the plans of the old Suarez Copete building [3], taking the average measurements of the rooms in that facility and the distribution of the computers in the Sabio Caldas building. With this data it was possible to create a small graph that would allow us to estimate how much cable would be used in each software laboratory, reaching the conclusion that each room must use 384 meters of category 7 UTP cable.



UTP Cable (Twisted pair copper cable) category 5 For a software lab.

TABLE VI
COST FOR TWISTED PAIR COPPER CATEGORY 7 CABLE IN 11 SOFTWARE LABS

Twisted pair copper cable quantity (meters per lab)	Price (1 meter US)	Software Labs
384	$2.00	11

Total Meters	Total Cost (US)	Total Cost (COP)
4224	$8,448.00	$33,792,000.00

Now, for the hallways that the new faculty building will have, it is important to estimate the amount of twisted pair cable and coaxial cable that will connect to each computer room. In addition to accounting for the fact that each floor will have at least 4 repeaters that provide wireless signaling to the rooms that will be around this hall and a switch that connects with the central router that must be available for the entire building.

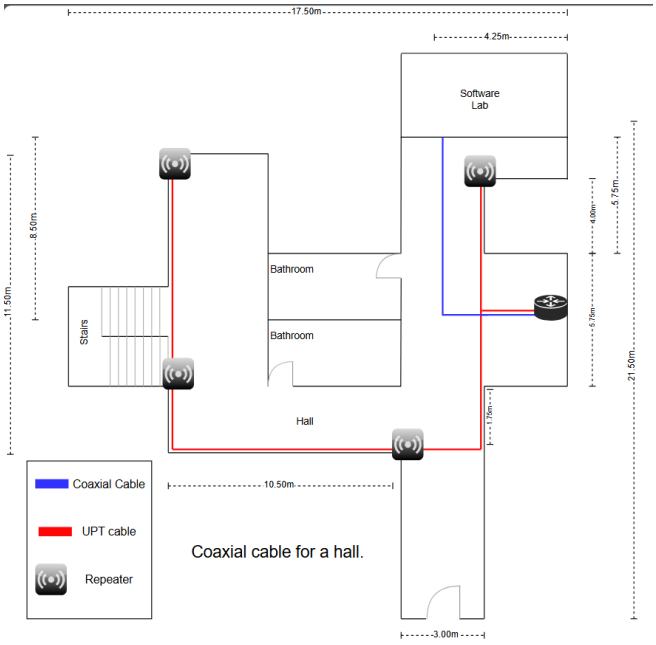


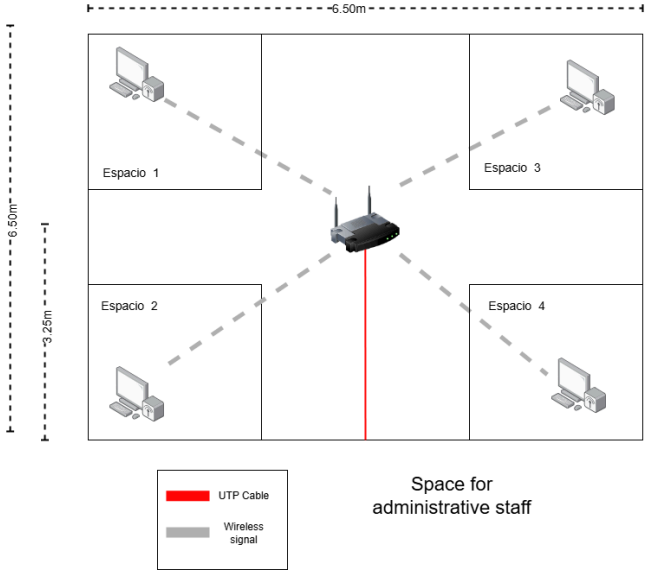
TABLE VII
COST FOR TWISTED PAIR COPPER CATEGORY 7 CABLE

Cable type	Meters per floor	Price (1 meter US)
Coaxial cable	13	$2.77
Twisted pair copper cable	36.5	$2.00

Cable type	Total Meters	Total Cost (US)	Total Cost (COP)
Coaxial cable	195	$540.15	$2,160,600.00
Twisted pair copper cable	547.5	$1,095.00	$4,380,000.00

For the administrative area, wireless connection will be used as it does not have to have high browsing speed and because it mainly uses office software. In order to have a connection, it is necessary to have a Cisco-Linksys WRT300N router that will provide a signal to the entire area. Network implementation with this feature gives us the advantage of saving on twisted pair cable because we only need one cable that connects to the router.

According to the estimate made from the graph that corresponds to this space, each administrative area would only require around 3.25m of twisted pair cable.



The following table presents the equipment to be used along with their typical prices in some national and foreign e-commerce platforms, the quantity presented in this table is the product of having basic information such as: the number of specialized rooms, the number of floors and basic information provided by the RenoBo company:

TABLE VIII
EQUIPMENT AND CABLE PRICE

Device	Model	Quantity	Unitary Cost (US$)	Total (US$)	Price in Colombian Pesos
Router	Juniper Networks SRX340	1	$3,256.23	$3,256.23	$13,024,920
Switch	TL-SG3428MP	26	$388.00	$10,088.00	$40,352,000
Repeater	UAP-AC-LITE	68	$130.00	$8,840.00	$35,360,000
Cable Coaxial	Cable Coaxial Rg6 1 Blanco D-90182	195	$2.77	$540.15	$2,160,600
Cable UTP	Cable Utp Cat 7 Ethernet	4785	$2.00	$9,570.00	$38,280,000
Rack patch panel	Rapink	11	$47.40	$521.40	$2,085,600
Wireless router	Cisco-Linksys WRT300N	4	$159.95	$639.80	$2,559,200

The selected models for routers, switches, and repeaters are mid range, and the estimation of the optimal quantity was based on some manufacturer specifications, such as switches, which feature 24 connection ports to be linked with computing devices or with repeaters on various floors within the building. Using the information provided in the table in Table VII we can conclude that the final price of

equipment and wiring is $133,822,320 Colombian pesos.

Finally, if we hire a team of network and telecommunications engineers, we must take into account the average salary of each one. Based on information extracted from different websites such as: indeed [6] or talent.com [7] that allows us to know the average salary of the different roles that are essential when carrying out the design and installation process of the entire network infrastructure. . The following table shows us what these roles are and what the average salary is for each one.

TABLE IX
ROLES AND AVERAGE SALARY

Role Name	Salary (COP)	Quantity	Contracted Months	Total Salary
Network architect	$8,349,927	1	1	$8,349,927
Network engineer	$5,768,478	1	4	$23,073,912
Network Security Specialist	$3,500,000	2	1	$7,000,000
Network Support Technician	$1,320,232	5	4	$26,404,640
Specialist in telecommunications	$3,491,160	1	2	$6,982,320

Responsibility for each role

1. Network architect: Design the network topology, select the appropriate components (routers, switches, firewalls, etc.), and plan the integration with existing infrastructures.
2. Network engineer: Deploy and configure network devices according to design, troubleshoot technical issues, and optimize network performance.
3. Network Security Specialist: Implement security measures to protect the network against threats, conduct security audits, and respond to security incidents.
4. Network Support Technician: Provide technical support, resolve connectivity issues, and perform preventive maintenance tasks
5. Specialist in telecommunications: Manage and configure telecommunications services, such as WAN links, internet connections, and voice over IP (VoIP) services.

With this we can obtain an estimate of the total cost involved in the installation of the new engineering building, therefore obtaining that the total cost is $205,633,119 Colombian pesos, including trained personnel, equipment and wiring.

B. Network Security

Designing a network security framework for the new building is crucial for several reasons. Firstly, it protects the university's digital assets and confidential information, such as student data, research, and patents, against more and more sophisticated cyber threats. Additionally, it ensures the availability and reliability of essential digital services for academic and administrative operations. Some indispensable security measures in the network project would include [5].

Firewall and Intrusion Prevention Systems (IPS):

Critical Defense Line: In the new engineering building at the Universidad Distrital, the implementation of firewalls and Intrusion Prevention Systems (IPS) is positioned as a cornerstone to ensure network security. These solutions act as robust defensive barriers, safeguarding the network against illicit access and various outside threats, thus providing a secure environment for information exchange and the smooth operation of academic and research activities.

Regular Security Audits:

Proactive Vulnerability Identification: In the new engineering building at Universidad Distrital, performing regular security audits is basic to recognize potential vulnerabilities inside the network. These audits involve panoramic examinations that enable the detection and addressing of any security gaps that may compromise the integrity of systems and data. By performing these audits periodically, a constant assessment and enhancement of network security are ensured.

Access Control:

1. Restriction of Unauthorized Access: Within the context of the new engineering building at Universidad Distrital, it is crucial to implement strict access control measures to secure that only authorized personnel can access the network. This requires carefully managing user permissions and employing robust authentication mechanisms, thus ensuring the integrity and security of digital resources, as well as protecting the privacy and confidentiality of sensitive information.
2. Role-Based Access Control: Implementing strategies based in Roles also named like RBAC is important because it allows for more efficient and granular management of user permissions within the network of the new engineering building at Universidad Distrital. By assigning specific access based on the roles and responsibilities of each user, the risk of other types of access is reduced, thereby improving the overall security of the system.

C. Topology

The logical topology was developed using the Cisco Packet Tracer software tool, taking into account the distribution of a floor that has the central router (only one would exist throughout the building) and two switches on each floor, one that would deliver connectivity to the rooms of computer that require some standard of connection quality that allow comfortable work in these spaces while on

the other hand there would be the switch that would deliver connectivity in Wireless way through 4 repeater, this would be focused on people who use devices such as laptops and smartphones .

On the other hand, administrative personnel would use Wireless connection by not requiring high data transfer and reception speeds, in addition to the use of alternatives such as UPT wiring Category 7 would mean an additional cost that does not represent so many benefits.

VI. CONCLUSIONS

The cost evaluation for the development of the infrastructure involved meticulous research and selection of mid-range equipment, considering the large price variations within the brands. Estimating the necessary cabling, based on the building layout, highlighted the importance of accurate planning. The detailed breakdown in Table VII provided information on equipment costs, while considerations for hiring a team of engineers ensured a complete budget overview. With a final estimate of $205,633,119 Colombian pesos, including trained personnel, equipment and wiring.

Even with the little public information for the new building, a schedule was established with the basic activities that satisfies the needs (requirements) that a building of this type must have. Achieving that in 4 months the design stage is carried out by the network architect and the implementation by the team of network engineers, telecommunications specialists and other related positions.

VII. ANNEXES

TABLE X
POSSIBLE PROVIDERS

URL	
ISR4431/K9 - Cisco Routers	NetGear punto de acceso inalámbrico
Hewlett Packard Enterprise JM044A HPE	Amazon.com: Ubiquiti UAP-AC-LITE UniFi AP AC LITE 802.11ac Gigabit Dual-Radio PoE : Electrónica
router-switch.com/Price-ar2200-series-enterprise-routers_c245	Ultra-High Performing AX3600
Juniper Networks SRX340 Services Gateway | NetworkScreen.com	UPT-cat-7-mercado-libre
Amazon.com: Cisco Business CBS250-24P-4G Smart Switch | 24 ports	coaxial-HomeCenter
NETGEAR GS724TP	Amazon.com: RaPpink anel de conexión de 48 puertos Cat6A con soporte Keystone
HPE Networking Instant On 1930 24-Port PoE+ Compliant JL683B#ABA (bhphotovideo.com)	Ruckus 9U1-T300-US01 ZoneFlex T300 Unleashed Entry-Level 802.11ac Outdoor AP | eBay
Amazon.com: TP-Link TL-SG3452P	

VIII. REFERENCES

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