



Comparative evaluation of Top-Down and Cisco PPDIOO Methodologies for Campus Network Design

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التقييم المقارن لمنهجية التصميم من أعلى إلى أسفل *Top-Down* ومنهجية *Cisco PPDIOO* لتصميم شبكات الحرم الجامعي

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Abstract:

This paper is a comparative evaluation of two network design methodologies, namely the Top-Down Network design Methodology and Cisco's PPDIOO methodology, for designing a campus network. The study addresses the need for a systematic methodology for designing reliable, scalable, and manageable campus networks while considering technical requirements and the network lifecycle. The campus network is designed using each methodology under identical structural requirements and environmental parameters. By systematically analyzing both methodology processes, the study aims to identify the strengths, limitations, and practical difference between the two methodologies. The comparative analysis indicates that both methodologies effectively produce a functional network architecture; however, the key distinction lies in their primary focus. The Top-Down methodology is more closely aligned with organizational and user requirements, facilitating higher stakeholder satisfaction during initial phases. In contrast, the PPDIOO methodology emphasizes the broader network lifecycle, providing a more structured framework for long-term operation, scalability, and maintenance. The comparative findings were further validated through an empirical survey of 30 network design experts. Results indicate that 90% of experts affirm Top-Down's efficacy in initial stakeholder requirements alignment, whereas 93.3% emphasize PPDIOO's dominance in long-term lifecycle operation and maintenance. Significantly, 60% of field experts recommended a hybrid framework combining Top-down for requirement gathering with PPDIOO for operational management in campus network deployments.

Keywords: PPDIOO, Top-Down Methodology, Campus Network Design, Three-Tier Architecture, Network Lifecycle.

المخلص:

تعد هذه الورقة تقييمًا مقارنًا بين منهجيتين لتصميم الشبكات وهما: منهجية Top-Down Network Design ومنهجية PPDIOO من شركة Cisco وذلك لتصميم شبكة جامعية. حيث تهتم الدراسة بالنظر للحاجة إلى منهجية منظمة لتصميم شبكات جامعية موثوقة، مع سهولة إدارتها وقابليتها للتوسع، واخذ المتطلبات الفنية ودورة حياة الشبكة

بعين الاعتبار. حيث تم تصميم الشبكة باستخدام كل منهجية تحت نفس المتطلبات الهيكلية والمعايير البيئية. ومن خلال التحليل المنهجي للعمليات في كلا المنهجتين، هدفت الدراسة إلى تحديد نقاط القوة، والقيود، والفروق العملية بينهما. وتشير نتائج التحليل المقارن إلى أن كلا من المنهجتين ينتج عنهما بنية شبكية وظيفية ذات قيمة، ونجد أن الاختلاف الرئيسي يكمن في التركيز الأساسي لكل منهما. إذ تعد منهجية Top-Down أكثر توافقاً مع متطلبات المؤسسة والمستخدمين مما يحقق مستويات أعلى من الرضا وبشكل خاص في المرحلة الأولى، في المقابل نجد أن منهجية PPDIOO تركز على دورة حياة الشبكة بشكل أوسع، مما يوفر إطاراً أكثر تنظيمًا للتشغيل وإمكانية التوسع والصيانة على المدى الطويل. وقد تم تعزيز نتائج التقييم المقارن عبر دراسة ميدانية استهدفت 30 خبيراً ومهندساً في مجال الشبكات. وأظهرت النتائج أن 90% من المشاركين يؤكدون تفوق منهجية Top-Down في مرحلة تحديد متطلبات المؤسسة، بينما أجمع 93.3% على تميز منهجية PPDIOO في إدارة دورة حياة الشبكة والصيانة على المدى الطويل. كما أوصى 60% من الخبراء بتطبيق نهج هجين يجمع بين المنهجتين لتصميم وتدشين شبكات الحرم الجامعي.

الكلمات المفتاحية: تصميم شبكات الجامعة، البنية ثلاثية الطبقات، دورة حياة الشبكة.

Introduction:

Campus networks play an important role in modern educational institutions. They support academic and administrative activities as well as communication and various information technology services. As the number of users, connected devices, and network-based applications continues to increase, the requirements placed on campus network infrastructure also become greater. Therefore, an effective campus network should provide reliable connectivity, good performance, scalability, security, and ease of management. Designing a network involves more than selecting routers, switches, cables, and IP addressing schemes. The design process should first consider the organization's objectives, user requirements, applications, traffic characteristics, security needs, and expected future expansion. The methodology used to organize these requirements and translate them into a network architecture can affect the suitability and overall quality of the final design.

Top-Down Network Design is a structured approach that starts by identifying and analyzing the organization's requirements before developing the logical and physical network design. Instead of selecting network devices at the beginning, the methodology gives priority to applications, services, users, network architecture, and performance requirements. This approach is useful when the network needs to be designed according to current requirements while also allowing for future expansion.

Cisco's PPDIOO methodology considers not only how the network is designed and implemented, but also how it can be operated, monitored, and improved after deployment.

Although both methodologies provide a structured way of developing network solutions, they differ in their focus and scope. Top-Down places greater emphasis on understanding requirements and developing the network design accordingly, whereas PPDIOO covers a wider network lifecycle that extends from preparation to optimization. These differences raise the question of whether the choice of methodology produces measurable differences in the resulting network.

Previous studies have examined the use of different network design methodologies in educational environments. (Mulyawan,2011) applied the top-Down approach to the design and enhancement of the campus network at Tarumanagara University. The study focused on analyzing user and network requirements and resulted in a hierarchical network design with core, distribution, and access layers, together with a high-availability backbone and user segmentation. (Yuliana and Mogi,2020) applied the PPDIOO methodology to the design of a computer network at SMA Negeri. Their study used the PPDIOO phases to guide the network design and considered different network topologies to support educational activities. In another study, (Elrashdi et al.,2024) investigated the PPDIOO in network-related graduation projects and reported positive results regarding its effectiveness, as well as its ability to help students organize their projects and reduce the time and effort required to complete them. Although these studies demonstrate the usefulness of both Top-Down and PPDIOO in network design, they mainly focus on applying one methodology to a particular network or project. A direct Comparison between the two methodologies under the same network requirements and structural conditions is still limited. Therefore, this study seeks to address this gap by applying both methodologies to the design of the same campus network and evaluating the resulting designs using common architecture and operational criteria.

Empirical Survey Methodology:

To evaluate the practical applicability and expert perceptions of the Top-Down and Cisco PPDIOO methodologies, a structured survey was conducted among 30 network professionals, system engineers, academics, and graduate students. The survey incorporated a 5-point Likert scale (1= Strongly Disagree to 5 = Strongly Agree) assessing organizational alignment, lifecycle management, effort complexity, and campus network design preferences.

Top-Down vs. PPDIOO: methodological comparison:

The Top-Down Network Design approach is based on four main phases: Top-level definition, Decomposition and structural analysis, Detailed design and implementation, Integration and testing of the network design. The approach mainly begins with understanding the users' requirements and needs, as well as the current network environment. This may involve conducting interviews with the person in charge, the technical team, and reviewing the documentation of the existing network, if available (Giovanni & Surantha,2018).

In contrast, the PPDIOO methodology consists of six main phases: Prepare, Plan, Design, Implementation, Operate, and optimize (Odom & Hucaby,2012). the first step is to identify the organization's requirements, objectives and develop a network strategy. The network requirements are then defined in greater detail, followed by an assessment of the site and the existing network and a gap analysis to identify the difference between the current situation and the target requirements. these requirements and the resulting plan are then translated into a detailed technical design, taking into consideration reliability, availability, security, and scalability (Correa & Ticona,2025).

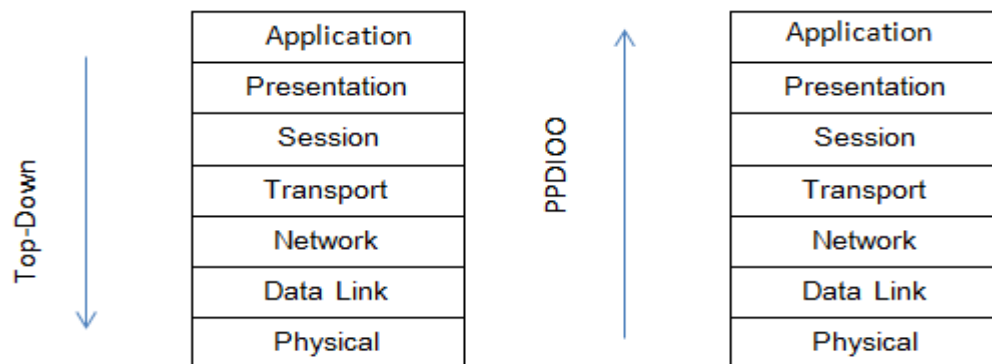


Figure (1): Cisco PPDIOO and Top-Down approach network design (Odom,2012)

Table (1): Advantages and Disadvantages of Top-Down and PPDIOO Methodologies

Methodology	Advantages	Disadvantages
Top-Down	-Requirements-driven. -Better alignment with organizational needs. -Supports scalability. -Provides an overall network view. -Reduces unnecessary hardware decisions.	-Time-consuming. -Requires accurate requirements. -Less suitable for rapidly changing requirements. -Requires planning expertise.
PPDIOO	-Covers the complete network lifecycle. -Improves reliability and availability. -Supports continuous optimization. -Helps reduce implementation risks.	-more complex. -Time consuming. -resource intensive. - Requires continuous monitoring.

Current Network Infrastructure:

The current campus network consists of three separated LANs, serving three main buildings: the Administration Building, the Registration Building, and the Lecture Halls and Laboratories Building. The Administration Building consists of a ground floor only, while the Registration Building and the Lecture Halls and Laboratories Building each have a ground floor and a first floor.

Each Building currently uses switches to connect computers and printers. there are no routers, access points, or servers in the current network infrastructure. The three buildings are not interconnected, and there is currently no Internet connection.

The network uses wired Ethernet connections and static IP addressing (Cisco Systems, Inc,2025). It also follows a flat network structure, with no separate VLANs or subnets. As a result, the devices within each building belong to a single broadcast domain. The current network allows computers within each building to communicate with one another, and printers are also connected to the network. However, there are currently no advanced mechanisms for network segmentation or access control, such as VLANs or firewall. This makes communication between devices within the same broadcast domain relatively unrestricted.

Overall, the current infrastructure represents simple and independent LAN environment for each building. It mainly provides internal connectivity between computers and printers, without an integrated network connecting the campus buildings or providing Internet access and centralized network management.

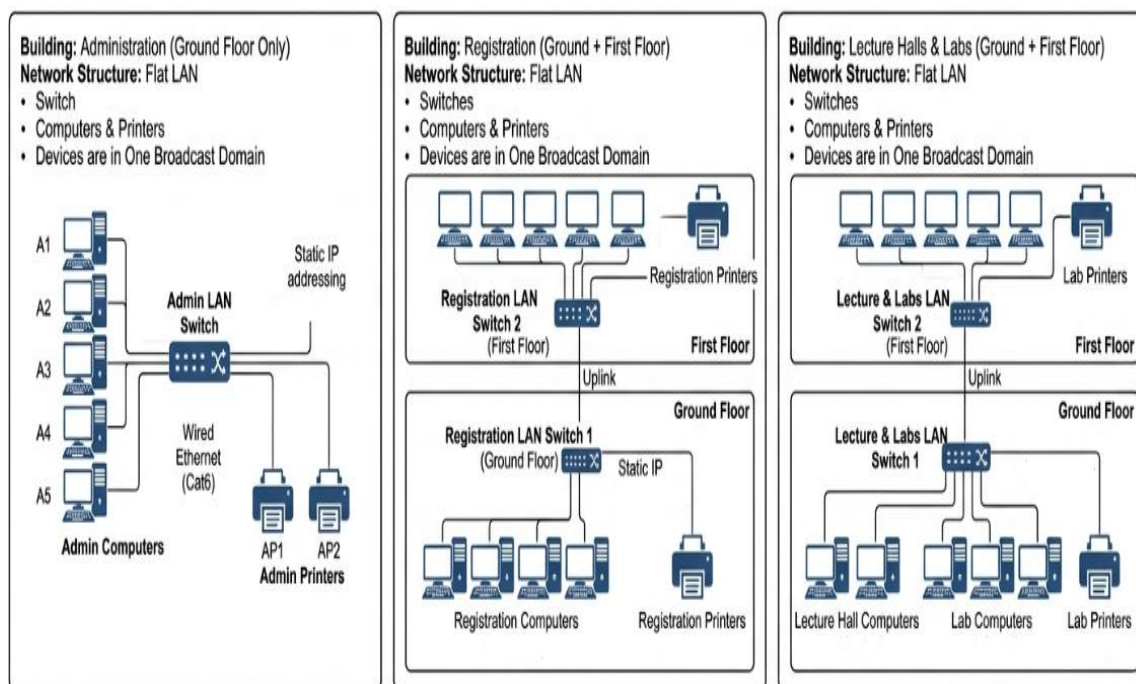


Figure (2): Illustrate current network infrastructure

Proposed Network Design:

The proposed campus network is designed to address the limitations of the current network infrastructure and provide a more reliable, scalable, secure and manageable network environment. The design follows the Three-Tier Hierarchical Network Design approach, which organizes the network into three functional layers: Core, Distribution, and Access (Cisco System, Inc.,2008). In addition, VLAN and IP addressing are used to logically segment the network and organize the devices within the three campus buildings. The proposed design also provides interconnection between the buildings and internet connectivity through a dedicated router (Odom et al.,2024).

Table (2): Proposed VLAN and IP Addressing Plan

VLAN ID	Building	Network Address	Subnet Mask	Default Gateway	Usable Host Range
VLAN 10	Administrative	10.10.10.0/24	255.255.255.0	10.10.10.1	10.10.10.2-10.10.10.254
VLAN 20	Registration	10.20.20.0/24	255.255.255.0	10.20.20.1	10.20.20.2-10.20.20.254
VLAN 30	Lecture & Labs	10.30.30.0/24	255.255.255.0	10.30.30.1	10.30.30.2-10.30.30.254
VLAN 99	Network Management	10.99.99.0/24	255.255.255.0	10.99.99.1	10.99.99.2-10.99.99.254

As mentioned earlier the proposed campus network is designed to overcome the limitations of the existing network by interconnecting the three campus buildings into a unified network. The design follows the three-tier Hierarchical Network Design approach and incorporates VLAN segmentation, inter-building connectivity, and Internet access.

The technical implementation and functional role of each layer are detailed below:

- **Access Layer (Edge Tier):** Connects end-user devices (PCs and printers) via Cat6 cabling, implementing VLANs and structured subnets to eliminate flat-network limitation, isolate broadcast domains, and reduce congestion.
- **Distribution Layer (Aggregation Tier):** Aggregation traffic from access switches within each building, manages Inter-VLAN routing, and enforces security policies via Access control Lists (ACLs) and redundant links to prevent single points of failure.
- **Core Layer (Backbone Tier):** Acts as the high-speed backbone connecting all three campus buildings, a dedicated server DMZ, and a Campus Edge Router for secure internet via Network Address Translation (NAT) with minimal Latency.

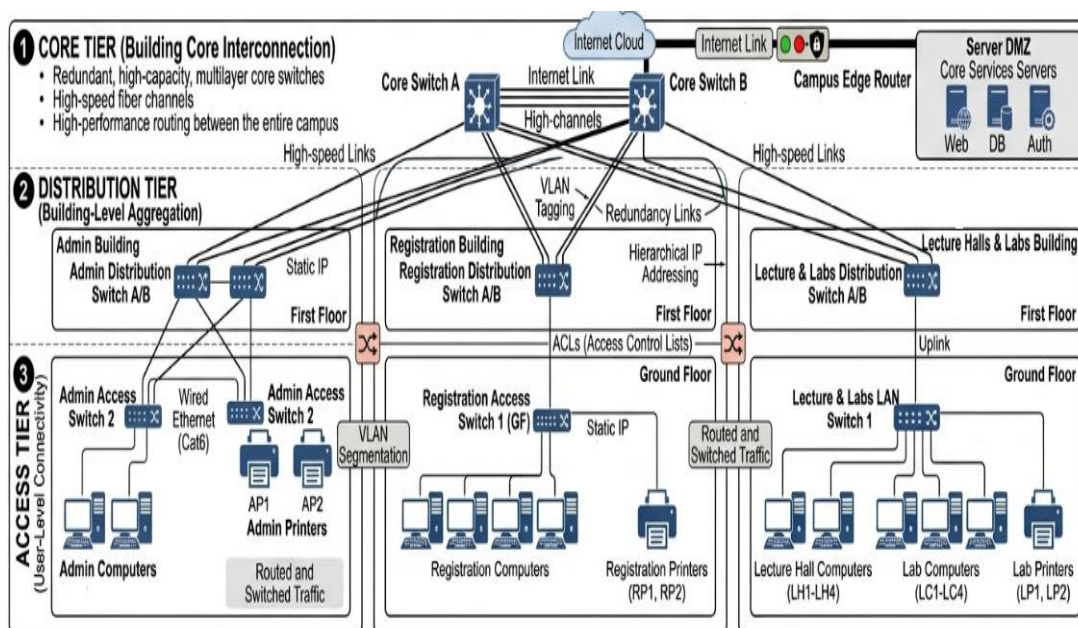


Figure (3): Physical network design.

It should be noted that a unified network diagram, incorporating both the logical and physical designs, was adopted as the final output of this study. This choice is based on the fact that applying both the Top-Down approach and the Cisco PPDIOO methodology to the same network does not necessarily result in a different physical design. The fundamental difference between the two approaches lies in the stages of the network design life cycle, the methodology used for requirements gathering, risk analysis, and implementation and operational strategies, rather than necessarily in the final form of the network's logical and physical architecture. Accordingly, the comparison in this study focuses on the design methodology and the process followed to arrive at the design, rather than on differences in the final network diagram itself.

Discussion:

Based on the comparative design analysis conducted in the study, it cannot be concluded that one methodology is universally better than the other. Both Top-Down and PPDIOO provide structured approaches for developing a campus network, but they differ in their focus and scope. The comparison indicates that Top-Down is primarily focused on requirements analysis and network design, while PPDIOO provides a broader lifecycle approach that includes preparation, planning, design, implementation, operation, and optimization. Therefore, the suitability of each methodology depends on the requirements, size, and operational needs of the network.

The main differences between the two methodologies are summarized in table (3).

Table (3): Summary of the differences between Top-Down and PPDIOO methodologies.

Comparison Criterion	Top-Down Methodology	PPDIOO Methodology
Primary focus	Requirements-driven network design	Complete network lifecycle
Starting point	Requirements analysis	Preparation and planning
Design process	Logical design – physical design	Detailed design within the design phase
Implementation	After completing the design	Separate implementation phase
Network operation	Not a separate phase	Separate operate phase
Optimization	Testing and optimization	Continuous optimization
Main strength	Focuses on user and organization requirements	Covers the network from preparation to continuous improvement
Main limitation	May require detailed and time-consuming requirements analysis	May require more time and resources due to its broader scope

The empirical feedback gathered from 30 network experts provided strong statistical validation for the theoretical comparison between the two methodologies:

- **Alignment with Organizational Goals:** An overwhelming majority of respondents (90%, n = 27) agreed or strongly agreed (M = 4.53) that the Top-Down approach effectively aligns network

design with organizational requirements. Furthermore, 90% (n = 27) confirmed that Top-Down mitigates premature and unnecessary hardware decisions early in the process (m = 4.43)

Table (4): Dataset 1: Alignment with Organizational Goals

Option	Count	Percentage
Strongly Agree	21	70%
Agree	6	20%
Neutral	1.5	5%
Disagree	0.5	1.7%
Strongly Disagree	1	3.3%

- **Lifecycle Management and Complexity:** Regarding Cisco PPDIOO, 90% (n = 27) of respondents strongly supported its superiority in long-term network lifecycle management, maintenance, and optimization (m = 4.70). Conversely, 86.7% (n = 26) acknowledged that PPDIOO incurs higher initial complexity and resource demands compared to Top-Down (m = 4.40).

Table (5): Dataset 2: Alignment with Organizational Goals

Option	Count	Percentage
Strongly Agree	22.5	75%
Agree	4.5	15%
Neutral	1.5	5%
Disagree	1.5	5%
Strongly Disagree	0	0%

- **Optimal Campus Network Strategy:** When evaluating the deployment of a new campus network, 60% of experts (n = 18) explicitly favored a Hybrid approach (combining Top-Down for initial requirements gathering and design with PPDIOO for operational lifecycle management). Meanwhile, 23.3% (n = 7) preferred a pure PPDIOO framework, and 16.7% (n = 5) preferred a pure Top-Down approach.

Table (6): Dataset 3: Alignment with Organizational Goals

Option	Count	Percentage
Hybrid	18	60%
Pure Cisco PPDIOO	7	23.3%
Pure Top-Down	5	16.7%

Conclusion:

This paper presented comparative evaluation between the Top-Down network design methodology and Cisco's PPDIOO framework applied to a campus network environment. While both approaches propositions address different stages of network engineering. Top-Down excels in aligning network capabilities with initial organizational requirements and user expectations, effectively preventing early hardware over-provisioning. On the other hand, Cisco's PPDIOO offers a robust, structured lifecycle framework that guarantees operational sustainability, continuous performance optimization, and long-term maintenance. Based on theoretical comparison and empirical validation from field experts, this study concludes that relying solely on a single methodology may present limitations during either the initial requirement phase or the subsequent operational phase. Consequently, adopting a Hybrid Framework (utilizing Top-Down for requirement analysis and logical/physical design, integrated with PPDIOO for deployment, operational management, and lifecycle optimization) represents the optimal strategic roadmap for designing reliable and scalable campus networks.

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