FRAMEWORK FOR ENTERPRISE LOCAL AREA NETWORK DESIGN: AN OBJECT-CONNECTIVITY APPROACH

Sunil Seneviratne[1] and Rohan de Silva[2]

[1]School of Engineering and Technology Central Queensland University Melbourne, Australia
[2]School of Engineering and Technology Central Queensland University Sydney, Australia

ABSTRACT

Local Area Networks (LANs) provide necessary infrastructure and services required for organizations to conduct their businesses efficiently and securely. While a small LAN could be designed and deployed in ad-hoc fashion, an enterprise LAN should be designed systematically starting from analyzing the business and technical requirements and constraints.

The Top-down network design methodology has been an excellent way to design a new network, however it has disadvantages considering its time-consuming process of designing networks. The organizational structures change in a fast pace in these days. These changes require their networks also to be realigned at the same pace. In this climate, a time-consuming design approach such as the Top-down design approach may not be the best option.

In this paper, we propose a framework of a network design methodology that could be used for quickly designing a LAN for an organization in this landscape while satisfying their business and technical requirements.

KEYWORDS

LAN, Network design, Object-connectivity, Top- down network design.

1. INTRODUCTION

Almost all organizations, big or small, use computers to undertake their day-to-day businesses today. LANs provide necessary infrastructure and services required for organisations to carry out their businesses in the most efficient and secure manner. When designing enterprise LANs, a systematic approach starting from analysing the business and technical requirements is required. In such a design, understanding the performance expected from the network stays at the forefront. The network performance is described by several parameters, including security, scalability, availability, reliability and Quality of Service (QoS).

Larsson [1] discusses the nature and complexity of the network design process, including the theoretical concepts, problems and solutions. The author provides details on programming aspects of combinational algorithms in designing communication networks. Al-shawi and Laurent [2] describe how to perform the conceptual, intermediate, and detailed design of a network infrastructure.

David C. Wyld et al. (Eds): ITCSE, ICDIPV, NC, CBIoT, CAIML, CRYPIS, ICAIT, NLCA - 2021
pp. 37-45, 2021. CS & IT - CSCP 2021 DOI: 10.5121/csit.2021.110904

The Top-down network design methodology proposed by Oppenheimer [3], and the design and deployment methods of 802.11 wireless networks by Geier [4], are methods for designing and deploying networks recommended by Cisco Systems Inc.

The organisational structures are changing rapidly due to the market changes, restructures, mergers, forming alliances and flexible work patterns of employees. These changes demand that the organisational networks also be realigned at the same pace. When there is a need to be a merger of enterprise LANs of two different organisations, where the designer has to deal with two enterprises without disrupting the existing businesses while satisfying the evolving business and technical requirements, the success of the Top-down network design methodology is questionable. Also, the trend in modern organisations is to move the services to the cloud service providers while retaining the organisational network. In this climate, an expensive and time-consuming design approach such as the Top-down design approach may not be the best option. As such, our motivation in this research is to develop a modular design framework that can transfer the business and technical requirements into a suitable network design in the shortest possible time.

The rest of the paper is organized as follows. Section II deals with a discussion of relevant literature, including the Top-down network design methodology and Section III discusses the framework of our new modular design approach. We provide concluding remarks in Section IV.

2. BACKGROUND

Gen et al. [5] focus on the aspects of Genetic Algorithms (GAs) and their applications in design of difficult-to-resolve network design problems. In their research they consider a bicriteria LAN architecture design and apply a non-linear programming model to LAN architecture design problem. Their experimental results show that the spanning tree-based GA approach has a good performance on the bicriteria LAN architecture design problem. However, their research focus is limited to an architecture design rather than a complete network design framework or methodology.

Lima et al. [6] compare three Multiobjective Evolutionary Algorithms (NSGA-II, GDE3, and MOEA/D-DE) on Wireless Local Area Networks (WLANs). The authors identify several problem characteristics that need to be addressed in current WLAN configurations (location and coverage, channel assignment, and load balance) and how to mitigate them in practice. Testing is then undertaken to determine which one of the three algorithms performs most efficiently. This research is only concerned about WLAN configuration and not network design. The configurations are only a minor aspect that happen at a lower level in network design. As such, though this information may be useful to be considered in developing a new network design methodology, our focus is on the entire process of network design and not just the configuration part of it.

Giovanni and Surantha [7] utilise the top down network design methodology in order to create a converged network design suitable for business requirements in a government related enterprise. The research identifies the benefits of converged networks over traditional separated networks and examines previously proposed converged network designs. Moreover, the authors detail the methodology used to design the proposed converged network, including details of the testing performed and final results. Their research focuses primarily on converged networks for large-scale enterprises as opposed to smaller consumer networks.

This research is limited in designing a converged network for a single large-scale government enterprise, whereas our research topic requires coverage of enterprise LANs in different business sectors. Further in their research they do not consider enterprise merges and there was no attempt made to understand the connection between the performance of the designed network and its architecture and components.

Sung et al [8] propose the use of a systematic approach to design enterprise networks which is time consuming and complex in nature. Their research suggests that the complexity of some enterprise networks exceed those of carrier networks, resulting in the need for more efficient and effective approaches for designing these networks. The authors analyse the viability of using a systematic design approach for enterprise networks, with a focus on VLAN design and reachability control through placement of packet filters as two design tasks in their systematic approach in designing enterprise networks. The feasibility of this design approach on large-scale enterprise networks is evaluated using an existing large-scale campus network.

As the authors point out one limitation in their work is, they have validated the performance in their heuristics only on a single network. Furthermore, as mentioned earlier, VLANs belong to the configuration part of a designed network, and hence, are only a very small part in the network design process. As such, their work is also not about a network design methodology but about network configuration.

Rozenblit et al. [9] in their design framework for designing LANs, discuss about an application of knowledge-based system design concepts to design LANs. They propose activities, which include, organizing a family of possible design configurations of the system being designed, inducing appropriate generic experimental frames, pruning the generic frames with respect to system entity structure, use of pruned substructures as skeletons to generate production rules for design models. These design models are evaluated via simulations studies. They further discuss about applying this framework to design LANs.

The authors describe four types of knowledge is needed to construct a design model of a LAN architecture. They propose to apply those details to generate all model structures that satisfy design constraints proceeded by the model construction process in hierarchical manner. Then the final design will be selected after evaluating the simulation studies. An advantage of this method as claimed by the authors is its objectives driven nature. It is arguable that this is an iterative and time-consuming approach. It has its limitations in applying for rapid LAN designs in dynamic environments.

Raza et al. [10] provide an analysis of the implications of network implementation choices on healthcare applications. The authors cite existing applications of network implementations in medical institutions in order to determine how different implementations have impacted on healthcare applications. Their research focuses on medical institutions that have recently implemented network technology for which updated enterprise performance statistics are available.

This research is limited to network implementation choices, and it does not consider network design choices. Further, the research focus is on healthcare applications only. Though implementation is not a part of network design, the network designer should foresee the implementation choices. This research findings may be useful to consider when we investigate the network design requirements of medical enterprise LANs. Furthermore, they analyse several different network applications and the challenges and benefits of each. Among the analysed options in their research is the use of Cisco Medical Grade Network solution which has many network design options for health institutions.

Oppenheimer's Top-down network design methodology [3] is a methodology for designing networks starting from the upper layers of the Open Systems Interconnection (OSI) reference model and then moving to the lower layers. This methodology focuses on applications, sessions, and data transport before the selection of routers, switches, and media that operate at the lower layers. It takes a systems analysis approach and starts the design process with requirements gathering. This design methodology goes through in sequence of analysing business goals, business constraints, and technical goals and trade-offs to create a logical network design. Addressing and numbering for the network and the security strategies are designed at this stage along with selecting routing and switching protocols for the designed network. According to this methodology, the next step is to design the physical network by selecting the technologies and devices for the network followed up with testing, optimising and documenting the designed network. Not only is this methodology time consuming, but it also appears that the biggest problem in this methodology is that there is no clear approach to map the requirements to the devices and the architecture of the network. The phases and the processes a network designer has to go through to design a network using the Top-down network design methodology are as shown in Figure 1 below.

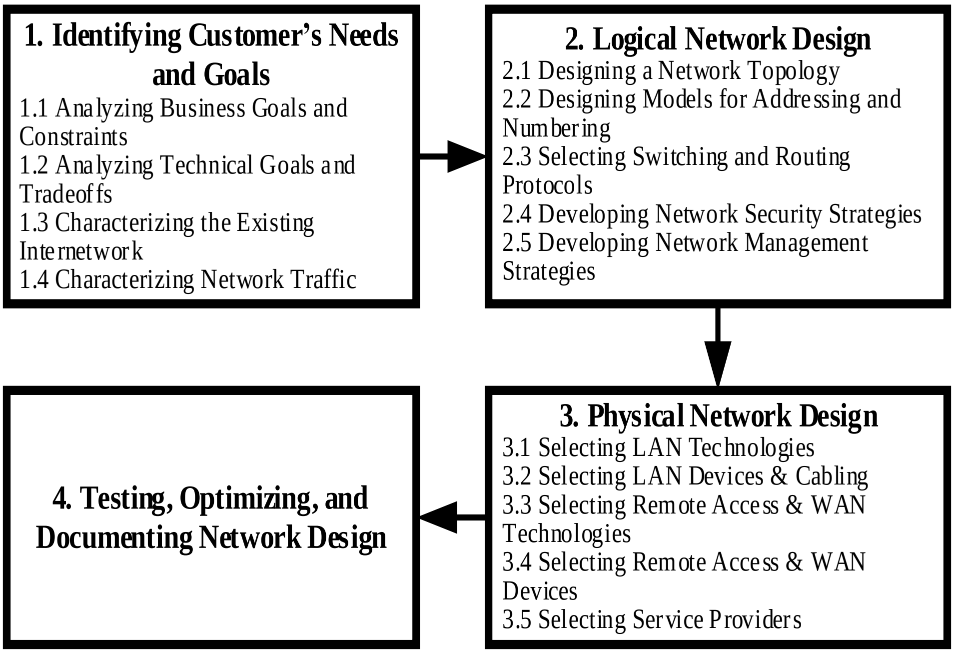

Figure 1. Top-down network design methodology. (Source: extracted from Oppenheimer [3])

As shown in Figure 1, the design process starts with requirement gathering, analysing goals and trade-offs, then designing the logical network followed by the physical architecture. Network designers who follow this methodology may come up with various design options and then need to select the suitable devices that meet the design criteria. It can be seen that the Top-down network design methodology is a tedious and time-consuming process, even though most of the design is undertaken systematically, at the end, the designer is not provided with a specific way of selecting the network components, including the software and hardware for the physical design. At this point, the design can become ad hoc as it is based on the experience, prejudice and perception of the network designer.

Object Oriented Design (OOD) is an approach used in other areas such as software design to solve software design problems. It is possible that OOD could be helpful in designing the new network design methodology to design a LAN in the shortest possible time.

Huda et al. [11] assess the effectiveness factor of OOD and develop an efficient model for effectiveness quantification using OOD constructs. The authors initially describe and analyse effectiveness factor, then use this information to develop a model for effectiveness quantification using OOD constructs.

The OOD constructs used in their analysis are encapsulation (correlated to Data Access Metrics), inheritance (correlated to Measure of functional Abstraction), coupling (correlated to Direct class Coupling), and cohesion (correlated to Cohesion among method), all of which together can be used to quantify the effectiveness of OOD. Their research focuses solely on evaluating the effectiveness factor of OOD using a testability approach. This research finding would be beneficial to our research in investigating the possibility of using OOD approaches to develop a framework of a modular network design methodology.

Georgatsos et al. [12] propose a new networking framework based on object-oriented programming (OOP), dubbed object- oriented networking (OON) in Internet technology and mobility integration. The authors describe the possibility of abstracting network layer resources as objects with attributes and methods, akin to data storage in objects using OOP applications, in order to avoid compatibility issues and create more sustainable and scalable network infrastructures. Their research focuses on the existing Information-centric networking (ICN) approach to network infrastructure, and the benefits of OON in comparison to it. Furthermore, significant documentation is provided explaining the operation of OON and its use of data and information networking layers to seamlessly transfer data.

The literature survey shows that there are no previous design methods or frameworks that can match the business and technical requirements to the finished design in a few days.

3. PROPOSED FRAMEWORK

Therefore, in this paper we propose a framework as to how categories, types and objects could be used in creating a new network design methodology to transfer the business and technical requirements into a suitable LAN design in the shortest possible time. As opposed to previous work, our approach is to use objects mapping in the entire design process.

We see the entire network design task as a transformation of a problem to a solution. Here, the problem is the set of requirements and the solution is a functioning network that satisfies the requirements. In our approach, the business and technical requirements as well as the network technology are categories. The designer may not be able to specify the network technology through requirements gathering as the business heads and users, or the system engineers or technologists may not have any special inclination for a particular technology. Thus, it becomes a designer’s choice, but we still call it a requirement as it is required for the design. As such business and technical requirements as well as network technology can be called just requirements. Each category contains types, and each type has several objects. Individual requirements can then be converted to objects that have various attributes.

Through the design, we convert the requirements to a number of categories that belong to the network (the solution). These categories are hardware, software, network technology, configuration and policy. Each of these categories contains types. For example, hardware category has switches as one type, and each design of switch is an object that has certain attributes. Each object has the connectivity as a compulsory attribute. The connectivity attribute indicates the list of other objects to which the object was connected in the design. Examples of categories, types and objects involved in our network design are shown in Figure 2. Note that network technology is a category in the problem as well as in the solution. rules must be followed strictly.

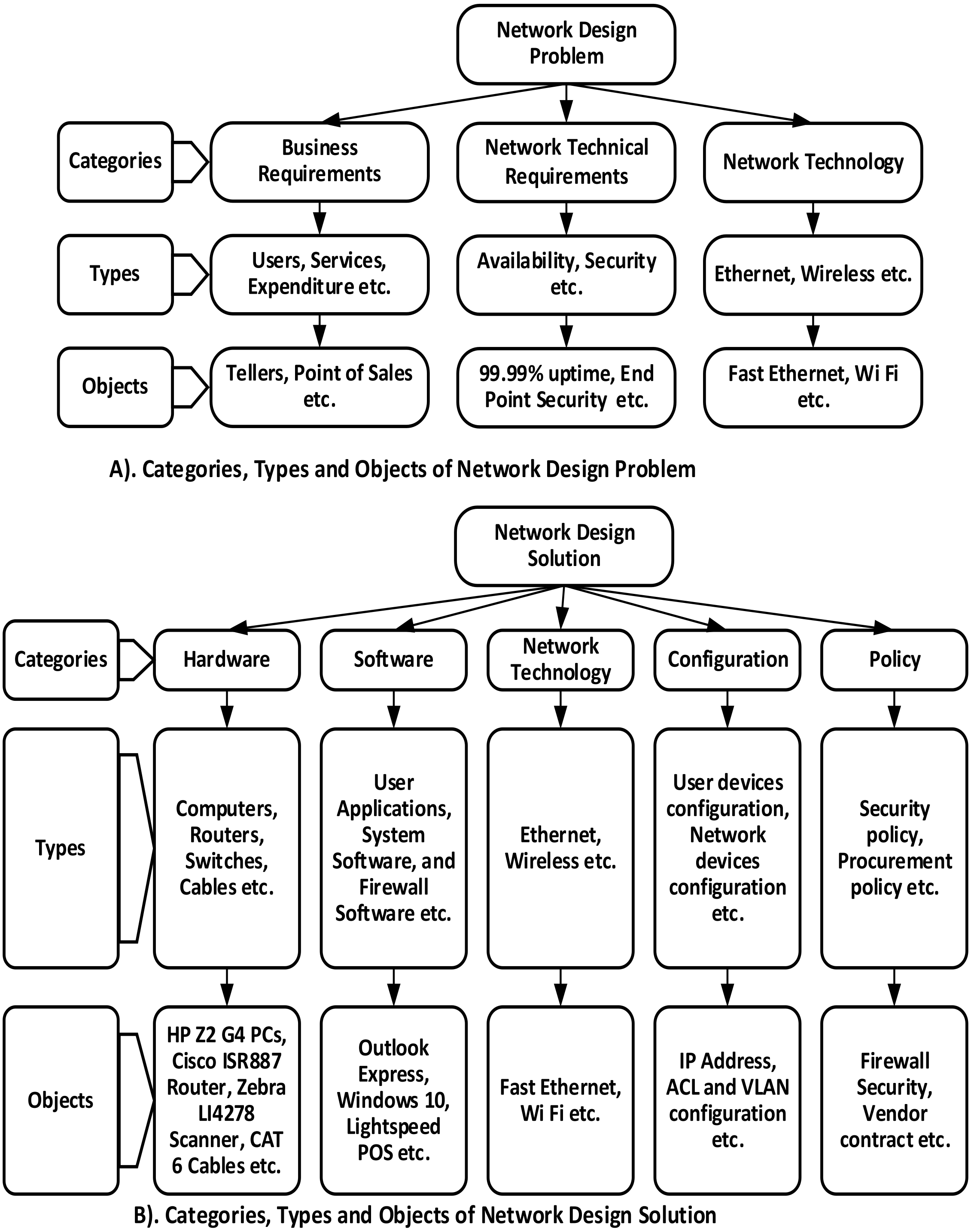

Figure 2. Example of Categories, Types and Objects of the Proposed Framework.

Now, assume that we have a set of requirements for an enterprise LAN design and a completed network design that satisfy these requirements. The network may have been designed using Top-down network design methodology. Since the network satisfies the requirements, the objects in the types falling under the technical and business requirements categories must have been matched to the objects in the types that fall under hardware, software, network technology, configuration and policy categories (Figure 3). These mappings would be many to many. We can repeat this process for a number of different pairs of requirements and finished network designs. Then, we can create a dataset by selecting each object that belongs to the finished design in turn and the corresponding objects that belong to the problem (Table 1). We call an object that belong to the finished design as a network object (NO) and an object that belong to a requirement as a requirement object (RO).

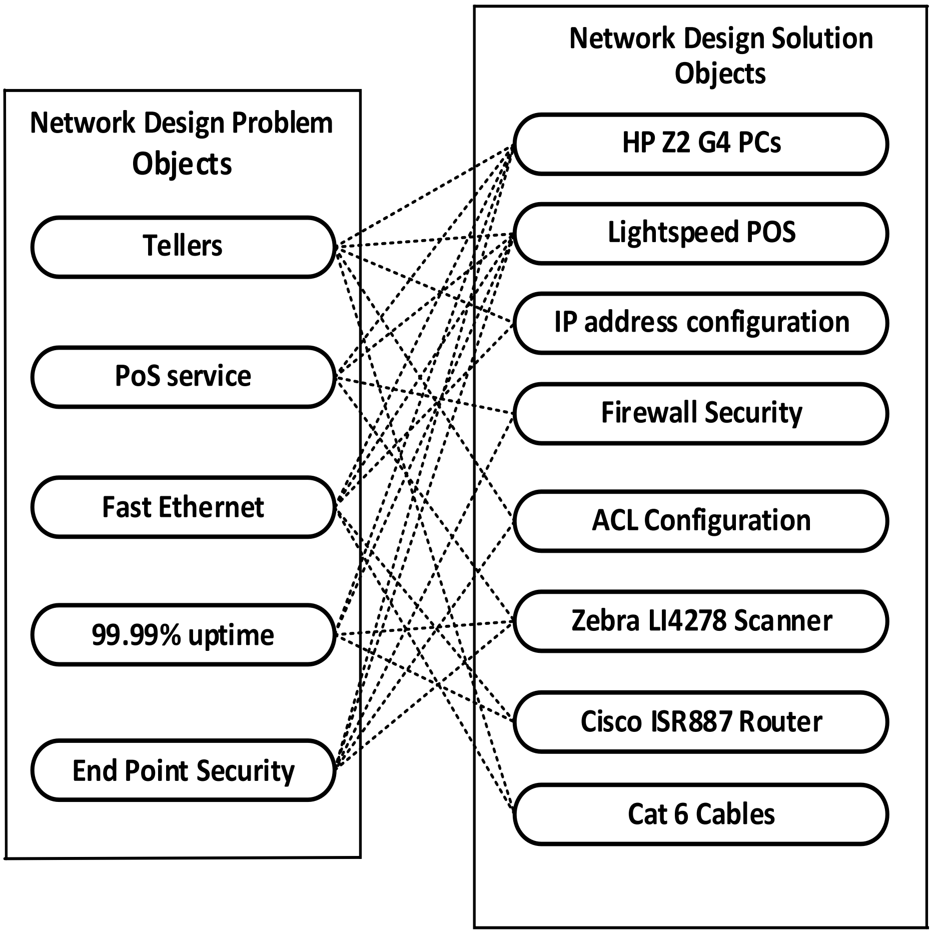

Figure 3. Mapping of Design Problem Objects to Design Solution Objects.

When we have a new network design problem, we can first extract the RO objects and using data mining techniques find NO objects in the finished design corresponding to each of these objects. Due to errors in data mining tools, it may happen that the designed network needs to be tweaked a little. But we hope that we can create a network much faster by this approach.

Instead of using objects, we may undertake the design at a higher level by mapping the classes. In this case, we need to identify recurring modules or patterns using a data mining tool.

Table 1. Sample Dataset.

NO	RO1	RO2	RO3	RO4	RO5
HP Z2 G4 PCs	Tellers	PoS service	Fast Ethernet	99.99% uptime	End Point Security
Lightspeed POS	Tellers	PoS service	Fast Ethernet	99.99% uptime	End Point Security
IP address configuration	Tellers		Fast Ethernet		
Firewall Security		PoS service			End Point Security
ACL Configuration	Tellers				End Point Security
Zebra LI4278 Scanner	Tellers	PoS service		99.99% uptime	End Point Security
Cisco ISR887 Router			Fast Ethernet	99.99% uptime	
Cat 6 Cables	Tellers		Fast Ethernet		

4. CONCLUSIONS

In today's business climate, change of business processes, restructuring of departments, mergers and acquisitions of businesses are inevitable. These changes demand that the networks are designed and implemented quickly to cater for the new business requirements. In general, a well-developed network design methodology such as Top-down network design methodology can be used for designing a new network or upgrading an existing network. However, the design process takes much time and may not be suitable for environments mentioned above.

As such, we have proposed a framework to design a network rapidly. Our approach is to convert the requirements into objects and find the connections or relationships between them, and the objects in the designed network. By repeating this process for many networks, we can construct a dataset or a table containing these relationships. Then, given the requirements of a new network design problem, we would be able to quickly find the corresponding objects of the new network using this dataset. Thus, we can complete the network design task very quickly.

As future work, we will develop this methodology further and create an actual dataset. After testing it on various new design cases, we will report our results in a future paper. We also hope to investigate the possibility of creating modules or design patterns and report our outcomes as well.

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