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The OSI and TCP/ IP Reference Models in the Era of Industry 4.0

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Abstract

The research aims to evaluate the integration and relevance of the Open Systems Interconnection (OSI) and TCP/IP (Transmission Control Protocol/Internet Protocol) Reference Models in the context of Industry 4.0. This study seeks to analyze the suitability of these models with the complex and dynamic networking environment of the present era and to propose modifications or strategies to enhance their performance and security within the context of Industry 4.0. The research method employed is descriptive research with a literature study design. This descriptive research method with a literature study design will aid in depicting and analyzing the OSI and TCP/IP reference models in the Industry 4.0 era. Primary data sources are derived from scholarly journals, reference books, and other relevant publications. Data analysis is conducted using a qualitative approach, wherein information from various sources will be thoroughly analyzed to identify patterns, trends, and relationships among the studied concepts. The research findings indicate that the difference between the OSI and TCP/IP models lies in their approaches and characteristics in regulating the process of data communication within networks. OSI emphasizes reliability at each layer, while TCP/IP views reliability as an end-to-end issue. Structure, application layer grouping, and the level of standardization also serve as points of differentiation between the two.

Keyword: Critical Foundation, Function Separation, Industry 4.0 Relevance, Networks

1. INTRODUCTION

A network is a collection of computers that can communicate with each other and share accessible equipment collectively. Communication topologies connected to other computers are divided into four types: star topology, ring topology, bus topology [1]. To enable communication between computers, a network protocol is required. A protocol is a set of rules and standards that allow computers to communicate with each other [2]. The benefits gained from connecting computers to each other in a network using the Transmission Control Protocol/Internet Protocol (TCP/IP) protocol are significant. TCP/IP, besides being a layered protocol, also adheres to International Organization for Standardization (ISO) and Open Systems Interconnection (OSI) standards, enabling communication worldwide even if different platforms are used [3]. The OSI Reference Model for Open Networking is an architectural network model developed by the International Organization for Standardization (ISO) in Europe in 1977 [4]. This model is also referred to as the "OSI Seven Layer Model." This paper will discuss OSI Layers and TCP/IP.

In the world of computer networking, there are two reference models that are crucial for understanding and developing complex communication systems: the OSI Reference Model and the TCP/IP Model [5]. Both of these models remain critical foundations in the development of computer networks in the Industry 4.0 era. The OSI Reference Model, developed by the ISO, consists of seven layers [6]. Each layer has a specific function in the network communication process, ranging from governing the transmission of data bits to providing an interface for user applications. This model aids in understanding the fundamental concepts of network communication and separates network functions into smaller units [7].

On the other hand, the TCP/IP model is the model used in designing network protocols utilized on the Internet [8]. Although comprising only four layers, this model is highly effective in managing end-to-end connectivity and data delivery between devices in the network. The TCP/IP protocol also adheres to ISO and OSI standards, enabling smooth communication between various platforms worldwide [9]. In the era of Industry 4.0, marked by the adoption of technologies such as the Internet of Things (IoT), cloud computing, and big data, a good understanding of both models is crucial [10]. They assist in the design, implementation, and management of efficient and secure networks, enabling smooth communication between various devices and systems in an increasingly connected environment. By using these models as guides, organizations can develop robust and adaptable network infrastructures in line with the technological changes occurring in the Industry 4.0 era [11].

In the context of computer networks, the OSI and TCP/IP reference models remain crucial foundations in the development of complex communication systems, especially in the era of Industry 4.0. Although both have been around since before this era began, their relevance and necessity remain high in understanding the basic principles of network communication. The OSI model consists of seven layers, each with a specific role in the network communication process. Starting from the physical layer, which governs the transmission of data bits, to the application layer, which provides an interface for user applications, this model aids in understanding the fundamental concepts of network communication and segregates network functions into smaller units. Meanwhile, the TCP/IP model, despite comprising only four layers, is effective in managing end-to-end connectivity and data delivery between devices in the network. This protocol also adheres to ISO and OSI standards, enabling seamless communication between various platforms worldwide. Transmission Control Protocol (TCP) is a protocol used for all nodes connected to the internet so that they can communicate with each other reliably. It is a connection-oriented protocol that, along with the IP protocol, has served as the foundation for the TCP/IP model, used since before the OSI model was established, and therefore the TCP/IP model has been compared to the OSI model [12]. The OSI model aids in the installation, configuration, maintenance, and troubleshooting of networks, particularly in the context of the TCP/IP protocol, which is one of many protocol suites used [13]. The TCP-based intranet network system provides several significant benefits. Firstly, it efficiently resolves constraints in data exchange among departments, saving time, cost, and effort. Secondly, data can be transferred quickly and accurately as needed. Thirdly, direct communication without using telephones accelerates collaboration. Fourthly, simultaneous printer usage enhances resource utilization efficiency. Fifthly, high-level data security prevents unauthorized access. Finally, accessing applications from the server without installation on clients speeds up overall application usage [14]. In an era where technologies like the IoT, cloud computing, and big data are becoming increasingly important, a solid understanding of both models is paramount [15]. They aid in the design, implementation, and management of efficient and secure networks, facilitating smooth communication between various devices and systems in an increasingly interconnected environment. By utilizing these models as guides, organizations can develop resilient network infrastructures that can evolve alongside the technological changes occurring in the Industry 4.0 era [10]. The research aims to evaluate the integration and relevance of the OSI and TCP/IP Reference Models in the context of Industry 4.0. This study seeks to analyze the suitability of these models with the complex and dynamic networking environment of the present era and to propose modifications or strategies to enhance their performance and security within the context of Industry 4.0.

2. MATERIALS AND METHOD

In researching the OSI and TCP/IP reference models in the Industry 4.0 era, the methodology employed will play a crucial role. The descriptive research method will aid in portraying and analyzing both models and their relevance within the context of Industry 4.0. A fitting research design is literature review and content analysis. Literature review will facilitate gathering up-to-date information regarding the utilization of both models in Industry 4.0, while content analysis will systematically dissect this information. Primary data sources will stem from scholarly journals, reference books, and other related publications. Secondary data can also be used to bolster research arguments and findings. Data analysis will be approached qualitatively, wherein information from various sources will be deeply scrutinized to identify patterns, trends, and relationships between the concepts under scrutiny. The research findings will offer a better understanding of the OSI and TCP/IP reference models and their relevance in the Industry 4.0 era. These findings can be employed to provide fresh insights and recommendations for further development in the field of computer networking. By employing the appropriate research methodology, this study is expected to provide valuable contributions to understanding and further development in this domain. The right research methodology will ensure that the research on the OSI and TCP/IP reference models in the Industry 4.0 era is conducted systematically and accountably. Utilizing descriptive methods, this research will yield a better understanding of the fundamental concepts of both models and their application in the Industry 4.0 environment.

Literature review will serve as the primary foundation for this research, allowing researchers to gather relevant and current information about the utilization of OSI and TCP/IP reference models in Industry 4.0. Content analysis will assist in thorough analysis of this information, identifying potential patterns and trends, and connecting interrelated concepts. Data sources from scholarly journals, reference books, and other related publications will serve as the primary sources of information. Secondary data can also be used to support the findings and arguments generated in the research. Qualitative data analysis will enable researchers to gain a deep understanding of the OSI and TCP/IP reference models and their relevance in the Industry 4.0 era. The results of this research are expected to provide fresh insights and valuable recommendations for further development in the field of computer networking. By using the appropriate research methodology, this research is expected to make a significant contribution to understanding and developing the OSI and TCP/IP reference models in the context of Industry 4.0.

3. RESULTS AND DISCUSSION

3.1 Definition of Open Systems Interconnection (OSI)

The OSI reference model is a globally accepted framework for the development of complete and open standards. The OSI model helps create open standards for systems to interconnect and communicate, particularly in the field of information technology. The OSI reference model is conceptually divided into 7 layers, each layer having specific network functions. This model was created based on a proposal by the ISO as an initial step towards standardizing international protocols used across different layers.

The OSI Reference Model outlines a layered approach to networking. Each layer of the model represents a different portion of the communication process. By separating the communication process into layers, the OSI model simplifies how software and hardware collaborate, thereby facilitating troubleshooting efforts by providing a specific method for understanding how components function [16].

3.2 Seven OSI Layers

The OSI reference model was created with the aim of enabling data communication to proceed through clear steps, commonly referred to as "layers." The OSI model consists of seven layers. The principles used for these seven layers are:

1. A layer should be created if a different level of abstraction is required.
2. Each layer must have specific functions.
3. The functions of the lower layers serve to support the functions of the layers above.
4. The functions of each layer must be carefully selected in accordance with international protocol standards.
5. Layer boundaries should be designed to minimize the flow of information passing through interfaces.
6. The number of layers should be sufficient so that different functions do not need to be combined into a single layer unnecessarily. However, the number of layers should also be kept as small as possible so that network architecture is not overly complicated.

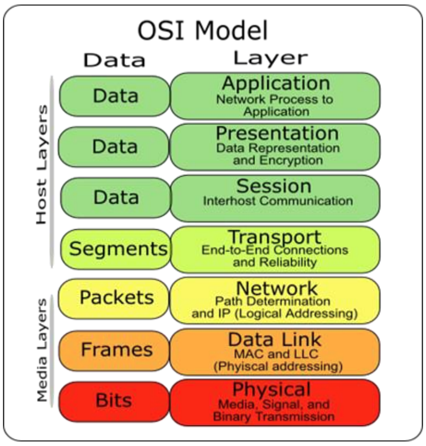

Figure1. Image 1. OSI Seven-Layer Model

The OSI reference model is conceptually divided into 7 layers, each layer having specific network functions, as explained below, among others [17]:

1. Physical Layer

   The Physical Layer functions as the transmission of raw bits over the communication channel. Design issues to be considered here include ensuring that when one side sends a data bit of 1, it is received by the other side as a 1 bit as well, and not a 0 bit. Generally, the design issues found here relate to mechanical, electrical, and procedural interface issues, as well as the physical media beneath the physical layer [18].

2. Data Link Layer

   The primary task of the data link layer is to serve as a facility for transmitting raw data and transforming it into a transmission channel free from transmission errors. Before being forwarded to the Network Layer, the data link layer accomplishes this task by allowing the sender to group input data into a number of data frames (usually hundreds or thousands of bytes). Then, the data link layer sequentially transmits these frames and processes acknowledgment frames sent back by the receiver. Issues that arise in the data link layer involve ensuring the smooth delivery of data from fast senders to slow receivers. Traffic control mechanisms must allow the sender to know the amount of buffer space available to the receiver at any given time.

In general, the main tasks of the data link layer in the data communication process encompass several key functions. Firstly, there's framing, where the data link divides the bit stream received from the network layer into data units called frames. Additionally, there's physical addressing, involving the definition of the sender's and/or receiver's identities added in the header. Furthermore, flow control is implemented to maintain the stability of the bit rate if the bit stream rate is excessive or diminished. Error control includes the addition of mechanisms for detecting and retransmitting failed frames. Finally, communication control determines which device should be controlled when there are two similar connections. All of these functions together form the crucial role of the data link layer in facilitating efficient and reliable data communication processes.

3. Network Layer

The network layer functions to control subnet operations. Issues that arise in the network layer involve determining the route for packet delivery from the source to the destination. When multiple packets exist simultaneously within a subnet, there is a possibility that these packets may arrive simultaneously [19]. This can lead to bottleneck occurrences. Managing congestion like this is also a task of the network layer, enabling different networks, with different protocols, addressing, and network architectures, to interconnect with each other.

In general, the main tasks of the network layer in the data communication process include several important functions. Firstly, there is logical addressing, where logical addressing is added to the network layer header. In TCP/IP networks, this logical addressing is known as the IP Address. Next, there's routing, which involves the relationship between networks forming an internet-work and requires a method of addressing routes so that packets can be transferred from one device originating from one network to another device on another network. Routing functionality is supported by routing protocols, which aim to find the best path to the destination and exchange information about network topology with other routers. These two functions work together to ensure efficient and accurate data delivery across the network [20].

4. Transport Layer

The transport layer functions to segment data into data packets and assigns sequence numbers to these packets so they can be reassembled at the destination side after being received. Additionally, at this layer, acknowledgments are generated to indicate successful packet reception, and retransmissions are initiated for packets lost in transit. All these tasks must be executed efficiently and aim to shield the upper layers from inevitable hardware technology changes.

5. Session Layer

The session layer controls the "dialogue" during communication, responsible for establishing connections, managing their use, and terminating connections after a communication session ends. It adds control headers to data packets during data exchange and allows users to establish sessions with each other. Besides enabling regular data transport like the transport layer, sessions also provide special services for specific applications, such as logging into remote timesharing systems or transferring files between machines.

6. Presentation Layer

The main task of the presentation layer is to ensure that data or information is transmitted in a language or syntax understandable by the destination host. Protocols at the presentation layer can translate data into a understandable language or syntax, and compress data before delivering it to the session layer. It performs specific functions requested to find a general solution to certain problems, focusing on the syntax and information being transmitted. One example service of the presentation layer is data encoding.

7. Application Layer

The application layer functions as the interface between applications and network functionality, managing how applications can access the network and handling error messages. It determines an abstract virtual network terminal, enabling editors and other programs to be written to match each other. To handle each type of terminal, a software component must be written to map virtual network terminal functions to the actual terminal. Another function of the application layer is file transfer. Different file systems have different naming conventions and ways of representing text lines. File transfer between different systems requires handling to address inconsistencies. Tasks of the application layer include email, remote job entry, directory lookup, and various other general-purpose and specific-purpose facilities. Protocols found in this application layer include FTP, SMTP, and HTTP [21].

The seven layers of the OSI reference model can be divided into two categories: the upper layers and the lower layers. The upper layers of the OSI model, consisting of the Application layer, Presentation Layer, Session Layer, and Transport Layer, deal with application-related issues and are generally implemented only in software. The Application layer is the top layer before reaching the user. Users and the application layer interact with each other through application software containing a communication component.

The lower layers of the OSI model, consisting of the Network Layer, Data Link Layer, and Physical Layer, control data transmission issues. These lower layers are implemented in hardware. The bottom layer, the Physical layer, acts as the interface to the physical network media (such as cable networks) and is responsible for placing information on the network media.

3.3 The operation of the OSI Reference

Model begins at the top layer, which is the Application layer. Data is sent from this layer to the layer below, which is the Presentation layer. In the Presentation layer, data is provided with headers or trailers and then transmitted to the layer below it. This process continues to the layers below, where each layer adds headers or trailers before passing it down to the layer below it again, until it reaches the Physical layer. In the Physical layer, data is transmitted through the media to the destination host. Thus, each layer handles specific processes in the formation and transmission of data packets.

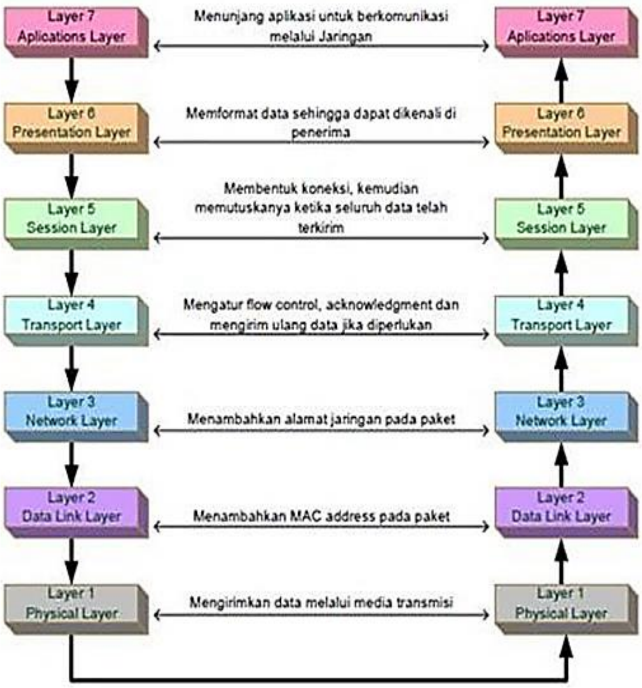

Figure 2. Structure of the OSI Model's Operation

At the destination host, the data packet flows in the opposite direction, from the bottom layer to the top layer. The protocol at the physical layer in the destination host retrieves the data packet from the transmission media and then sends it to the data link layer. The data link layer examines the data link layer header added by the sending host to the packet. If the host is not the intended recipient of the packet, it will be discarded. However, if the host is the intended recipient, the packet will be forwarded to the network layer. This process continues until it reaches the application layer at the destination host. The process of sending packets from layer to layer is called "peer layer communication."

4. CONCLUSION

The analysis of the research findings regarding the differences between the OSI model and the TCP/IP model reveals significant distinctions in their approaches and characteristics in regulating data communication processes within networks. The OSI model emphasizes reliability in data transfer services at each layer, whereas TCP/IP views reliability as an end-to-end issue. This indicates that OSI places emphasis on reliability at every stage of the communication process, while TCP/IP addresses this issue at the end-to-end level. Furthermore, OSI distributes responsibilities for detecting and handling errors in data across each layer, whereas TCP/IP centralizes reliability control at the Transport Layer. Additionally, TCP/IP employs mechanisms such as checksums, acknowledgments, and timeouts at the Transport Layer to control transmission and provide end-to-end verification. Another difference lies in the grouping of application layers, where OSI separates the application, presentation, and session layers, while TCP/IP consolidates them into one layer (the Application Layer). TCP/IP also combines the physical and data link layers into one layer (the Network/Access Layer), while OSI separates them into distinct layers. Structurally, OSI comprises seven layers that describe the data communication process within networks, whereas TCP/IP has five layers. Finally, while OSI functions as a standard model used as a reference for explaining data communication processes, TCP/IP is a standardized data communication protocol with established protocols. This indicates a difference in the level of standardization between the two.

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