International Journal of Innovative Research and Scientific Studies, 8(1) 2025, pages:2752-2761

IJIRSS
International Journal of Innovative Research & Scientific Studies

**ISSN:** 2617-6548

URL: www.ijirss.com

# A simulation-based approach to automating subnetting for network efficiency

Mujahid Hamood Hilal Alzakwani[1*], Rabei Raad Ali[2], Khaldoon Ammar Al-Atrakchii[3], Estabrak Bassam Yahya[4] Ashraf Ibrahim Abdallah Qahman[5]

[1,5] *Centre for Language and Foundation Studies, A'Sharqiyah University (ASU), Ibra, 400, Oman.*
[2]*Technical Engineering College for Computer and AI, Northern Technical University, Mosul, 41000, Iraq.*
[3,4]*University Presidency, Northern Technical University, Mosul, 41000, Iraq.*

Corresponding author: Mujahid Hamood Hilal Alzakwani (*Email: m.alzakwani81@gmail.com*)

## Abstract

In many organizations, dividing networks into sub-networks can be complex and time-consuming, requiring accuracy and precision. This makes it relevant that there is an increasing requirement for an automated system that can make the subnetting process faster and easier. Moreover, companies also receive multiple static IP addresses from an ISP when they register for web hosting, which again needs to be managed and stored in a database. This manual tracking frequently results in conflicts and inefficiencies, diverting precious time in the pursuit of free addresses. In this paper, we demonstrate an automated application implementation to facilitate subnetting to help engineers allocate IP addresses according to the number of hosts. We will thus create a solution where we will automate the subnet process and then provide a mechanism to store and manage allocated IPs more effectively, as well as reduce conflicts, leading to more optimized overall system management. This tool is built in Microsoft Visual Studio 2010 and C# software. The primary contribution is an intuitive and streamlined interface for performing subnetting calculations and allocating IP addresses.

**Keywords:** Network subnetting, Network management, Automated subnetting system, IPv4, Internet Protocol (IP).

**DOI:** 10.53894/ijirss.v8i1.5051
**Funding:** This research is supported by the Centre for Language and Foundation Studies, A'Sharqiyah University (ASU).
**History: Received:** 5 January 2025 / **Revised:** 14 February 2025 / **Accepted:** 22 February 2025 / **Published:** 28 February 2025

**Competing Interests:** The authors declare that they have no competing interests.
**Authors' Contributions:** All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.
**Transparency:** The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.
**Institutional Review Board Statement:** The Ethical Committee of the Centre for Language and Foundation Studies, A'Sharqiyah University (ASU).
**Publisher:** Innovative Research Publishing

## 1. Introduction

A network is an important aspect of subnetting. It is a logical subdivision of an Internet Protocol (IP) network address. Subnetting is normally practiced by partitioning a network into two or more networks. The address space can be separated into subnets, each representing a subnet for which an administration is responsible; this can ease the administration of a large network because the effect of subnetting itself is mentioned well in networking [1]. Traditionally, the design of the Transmission Control Protocol/Internet Protocol (TCP/IP) addressing scheme doesn't allow the authorities to assign many public IP addresses for one organization because that would go far beyond our exploitation boundaries of IPv4 addresses [2].

Subnetting offers a wide range of advantages such as security, limitations, speed of network transfers, and improved performance [3]. It can enhance network performance by splitting up collision and broadcast domains. Subnets can be treated in a manner that defines administrative units and hence supports the structuring and delegating of administrative tasks [4]. The subnetting process includes a series of moderately complex mathematical steps. A major stumbling block to successful subnetting is often a lack of understanding of the underlying binary math. Its principles can be challenging to understand without a solid grasp of binary arithmetic, logic, and binary-to-decimal conversions [5]. There is always a small chance of making calculation errors, even for skilled engineers. The system begins by converting the subnet mask into binary [6]. A traditional approach to ensuring Local Area Network (LAN) redundancy involves setting up multiple LANs, each with a LAN controller connected to data communication devices. In this setup, the devices require software to switch between LAN controllers when failures occur in certain network segments. However, this method is often costly and complicated, especially when using off-the-shelf data communication devices with integrated LAN controller drivers [7]. Proper IP address assignment is crucial, as each device or user connected to a specific subnet will be assigned an IP address using the same network prefix, but each subnet will have a distinct network prefix [8]. Figure 1 shows how each subnet has its unique network prefix. Dividing a network into subnets offers several practical benefits, such as better security, easier management of network limits, cost savings, faster data transfers, clearer boundaries for broadcasts, and the ability to isolate and address performance problems.

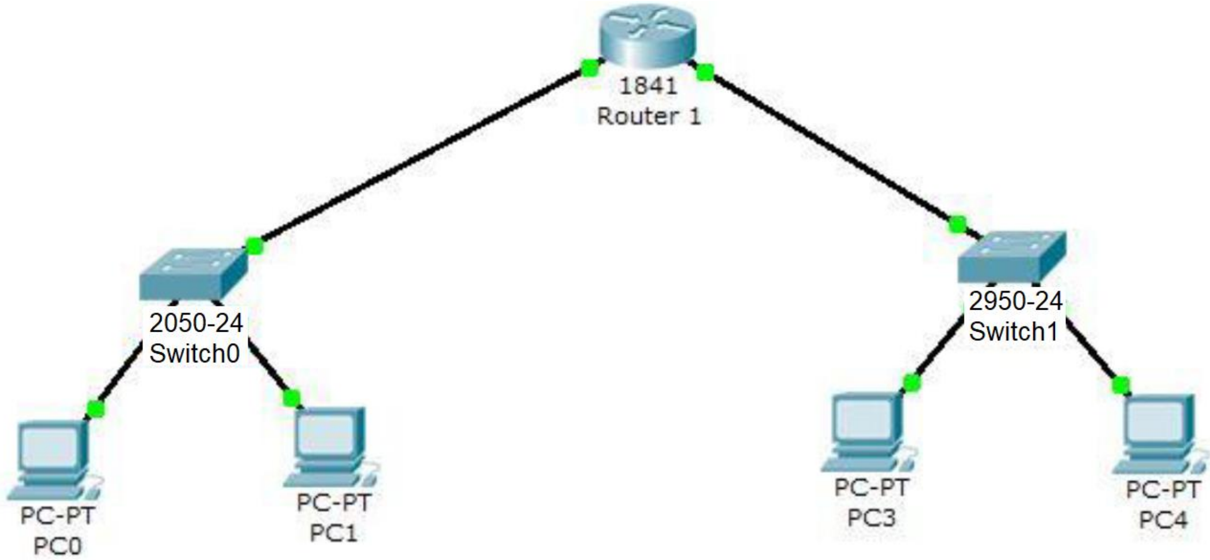



**Figure 1.**
Two LANs connected by a router [9].

As shown in the above figure, we have LAN1 and LAN2 as two sub-networks with one router to connect two different networks. In a two-network, it's not possible to assign unique public IP addresses to every subnet. Therefore, subnetting is very necessary in that case. It's very important also to first review the basics of the TCP/IP scheme before diving into the subnetting details. Cisco Networking Academy Program (CCNP) clarifies in tables each of the four octets of an IP address represents either the network portion or the host portion of the address, depending on the address class. (CCNP) presents IP address structure before and after subnetting. In Sari, et al. [10] the authors proposed tabular worksheets that can calculate address ranges and track the assignment of addresses to devices on your network. The worksheet provides a visual reference to the addresses that are valid for each subnet, regardless of the mask used. In Huang, et al. [11] the authors presented three steps to create a subnet: specify the number of required network IDs, specify the number of required host IDs per subnet, and finally, based on the above requirements. In Hunt [12] the authors develop a method for subnetting in a switched IP network, provide an amelioration communication between data and networking system, provide a method for spreading IP network layer routing functions to a switch device, and present a method. The proposed method lets host devices on a variety of subnetworks communicate speedily in a switch without the use of router devices.

In this paper, we examine the difficulty of network subnetting to divide a large network into smaller networks that are meant to produce IPs by providing Internet Service Providers (ISPs) and separating them into subnetworks. The Phase Teaching Model Subnetting IPv4 (PTMS-IP4) is applied as an automated system that calculates the subnet of a network. It is used to demonstrate step by step all the stages involved in subnetting. The PTMS-IP4 model implements the three phases that help the network encompass all the steps involved in subnetting.

*1.1. Internet Protocol (IPv4) Address*

The Internet Protocol (IP) address identifies a system's location on the network. It comes in two versions: IP version 4 consists of 32 bits, and IP version 6 consists of 128 bits [8]. Each IP address includes a network ID and a host ID. The IPv4 is a common practice to segment the 32 bits of an IP address into four 8-bit fields called octets. Figure 2. illustrates that each octet is converted to a decimal number (the Base 10 numbering system) in the range 0-255 and separated by a period (a dot). This format is called dotted decimal notation.

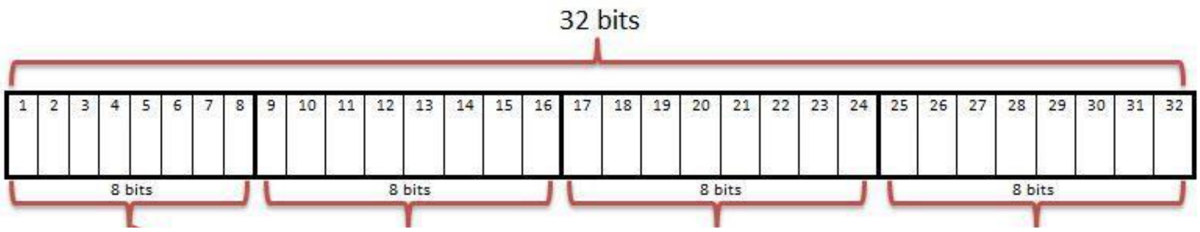



**Figure 2.**
IP address octets.

Each IP address includes a network ID and a host ID [13].

- The network ID identifies the systems that are located on the same physical network bound by some components like routers or switches. All systems on the same physical network must have the same network ID. The network ID must be unique to the internetwork.
- The host ID identifies a workstation, server, router, or other TCP/IP host within a network. The address for each host must be unique to the network ID.

Microsoft TCP/IP supports class A, B, and C addresses assigned to hosts. The class of address defines which bits are used for the network ID and which bits are used for the host ID [14-18]. It also defines the possible number of networks and the number of hosts per network.

Class A: It is assigned to networks with many hosts, as shown in Figure 3. The remaining 24 bits (the last three octets) represent the host ID. This allows for 126 networks and 16,777,214 hosts per network. The default subnet mask for class A is (255.0.0.0).

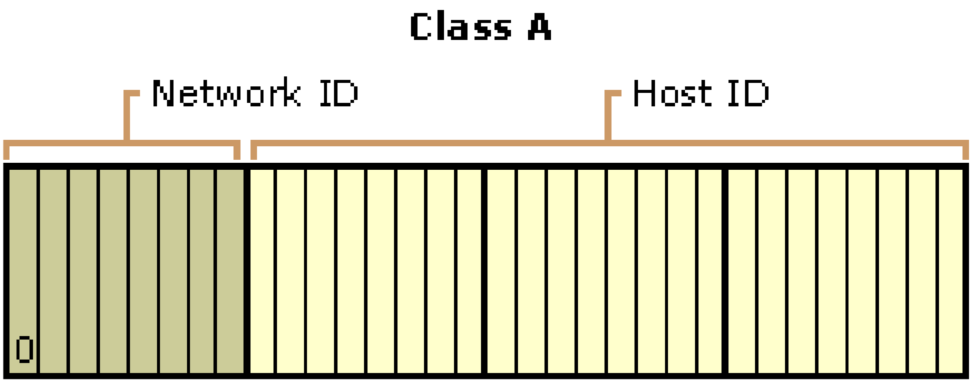



**Figure 3.**
Class A address.

Class B: It is assigned to medium-sized and large-sized networks, as shown in Figure 4. The remaining 16 bits (the last two octets) represent the host ID. This allows for 16,384 networks and 65,534 hosts per network. The default subnet mask for class B is (255.255.0.0).

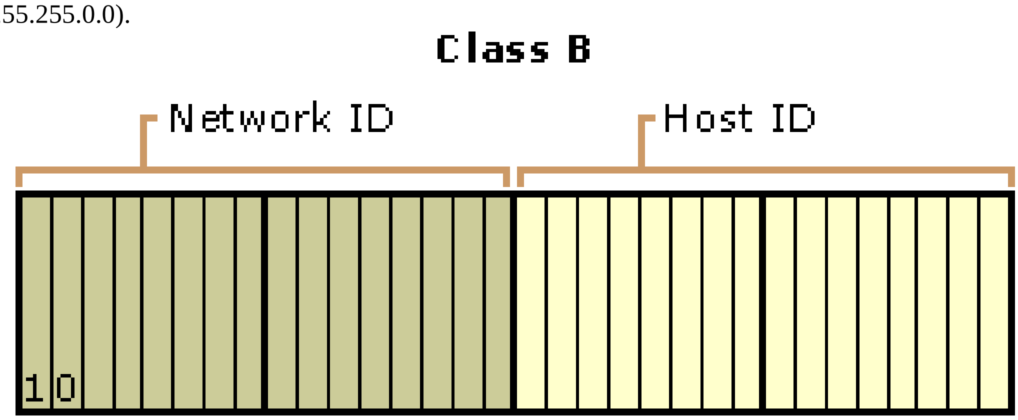



**Figure 4.**
Class B address.

Class C: It is used for small networks, as shown in Figure 5. The remaining 8 bits (last octet) represent the host ID. This allows for 2,097,152 networks and 254 hosts per network. The default subnet mask for class A is (255.255.255.0).

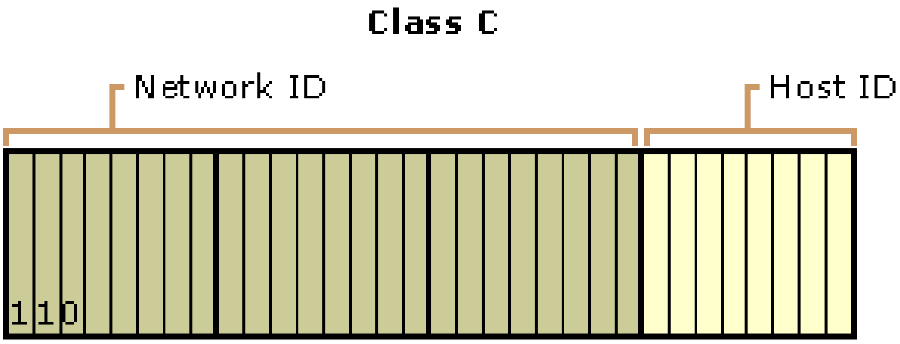



**Figure 5.**
Class C address.

## 2. Proposed Model

The proposed model aims to automate and optimize the subnetting process using a mathematical approach to calculate the appropriate number of subnets, their respective IP ranges, and the broadcast addresses. This model is based on binary mathematics for efficient subnet calculation and utilizes a stepwise procedure to minimize human error and improve accuracy. Key components of the model include:

- Determining the number of subnet bits based on required subnets.
- Calculating the host addresses within each subnet using a systematic approach.
- Using the subnet mask and network class (A, B, or C) to segment the network accurately.

### *2.1. Subnetting Procedure*

Subnetting involves a series of steps to split a network into subnets:

1. Determine Host Bits: The number of host bits determines the number of subnets and the hosts per subnet.
2. Subnet IDs: After determining the number of host bits, the new subnet IDs are derived by adding the required number of subnets.
3. Subnet Address and Broadcast Address: Each subnet has a broadcast address, and the valid host range is defined between the subnet and broadcast addresses.

### *2.2. Class C Subnetting*

This methodology is applied using a Class C subnet mask (255.255.255.224). The steps include determining the number of subnet bits, calculating the available hosts per subnet, identifying subnet addresses, and calculating broadcast addresses.

Subnetting Algorithm:

This is used to determine how to divide the given IP address range into smaller subnets in class C.

1. *Formula for X:*

X= (2y / 2560) + given subnet mask address - 1

Where:

- X the required octet needed to calculate the broadcast address.
- y refers to the number of zeros in the last subnet mask octet.
- The power (0) indicates there is no remaining octet in the last section, with each having a value of 256.

2. *Broadcast Address Calculation:* The broadcast address is obtained by taking the first three octets from the given IP address and appending X as the last octet:
3. *Broadcast Address* = (1st octet given IP address. 2nd octet given IP address. 3rd octet given IP address. X)

Broadcast Address Calculation Algorithm:

This algorithm helps to calculate the broadcast address for each subnet.

1. *Formula for X:*

X= (3d octet given IP address/subnet address)

2. *Round X:*

X=round (X * subnet address, 0)

3. *Broadcast Address:*

Broadcast Address= (2y / 2560) +X - 1

Where: y refers to the number of zeros in the last subnet mask octet.

### *2.3. Class B Subnetting*

Class B follows similar principles but with different subnetting and host allocation rules. The methodology for subnetting Class B networks is based on the number of bits in the subnet mask and the total number of subnets and hosts required.

Subnetting Algorithm:

This is used to determine how to divide the given IP address range into smaller subnets in class B.

1. *Formula for X:*

X= (2y / 2561) + given subnet mask address - 1

Where:

- X the required octet needed to calculate the broadcast address.
- Power (1) refers to the last octet in the formula, where the value is 256.
- Power (y) refers to the number of zeros in the last two octets of the subnet mask.

2. *Broadcast Address Calculation:* The broadcast address is formed by taking the first two octets from the given IP address, appending X for the 3rd octet, and setting the 4th octet to 255.
3. *Broadcast Address* = (1st octet given IP address. 2nd octet given IP address. X.255)

Broadcast Address Calculation Algorithm:

This algorithm helps to calculate the broadcast address for each subnet.

1. *Formula for X:*

X= (3d octet given IP address/subnet address)

2. *Round X:*

X=round (X * subnet address, 0)

3. *Broadcast Address:*

Broadcast Address= (2y / 2561) +X - 1

Where:

- X the required octet needed to calculate the broadcast address.
- Power (1) refers to the last subnet octet (which is 256 in this case).
- Power (y) refers to the number of zeros in the last two subnet mask octets.

*2.4. Class A Subnetting*

Class A follows similar principles but with different subnetting and host allocation rules. The methodology for subnetting Class A networks is based on the number of bits in the subnet mask and the total number of subnets and hosts required.

Subnetting Algorithm:

This is used to determine how to divide the given IP address range into smaller subnets in class A.

1. *Formula for X:*

X= (2y / 2562) + given subnet mask address - 1

Where:

- X the required octet needed to calculate the broadcast address.
- Power (2) refers to the last two octets of the subnet mask, each of which will be 256.
- Power (y) refers to the number of zeros in the last three subnet mask octets.

2. *Broadcast Address Calculation:* The broadcast address is derived by taking the 1st octet from the given IP address and appending X for the 2nd octet, followed by 255 for the last two octets.
3. *Broadcast Address* = (1st octet given IP address. X. 255. 255)

Broadcast Address Calculation Algorithm:

This algorithm helps to calculate the broadcast address for each subnet.

1. *Formula for X:*

X= (3d octet given IP address/subnet address)

2. *Round X:*

X=round (X * subnet address, 0)

3. *Broadcast Address:*

Broadcast Address= (2y / 2562) +X - 1

Where:

- X the required octet needed to calculate the broadcast address.
- Power (2) refers to the last two octets of the subnet mask, each of which will be 256.
- Power (y) refers to the number of zeros in the last three subnet mask octets.

## 3. Implementation and Results

The implementation was created in C# using Microsoft Visual Studio to automate subnet calculations. It offers a user interface for input, calculates subnets, and stores the results for future use.

*3.1. Key Aspects of the Implementation of Automated Subnetting System*

The automated subnetting system includes:

i. ISP Interface: Allows the ISP to input network details and generates subnetting results. Using this interface, the ISP can determine the optimized IP based on the customer's request. Before selecting the best IP, the ISP must choose a method of calculation. Figure 6 presents two options:

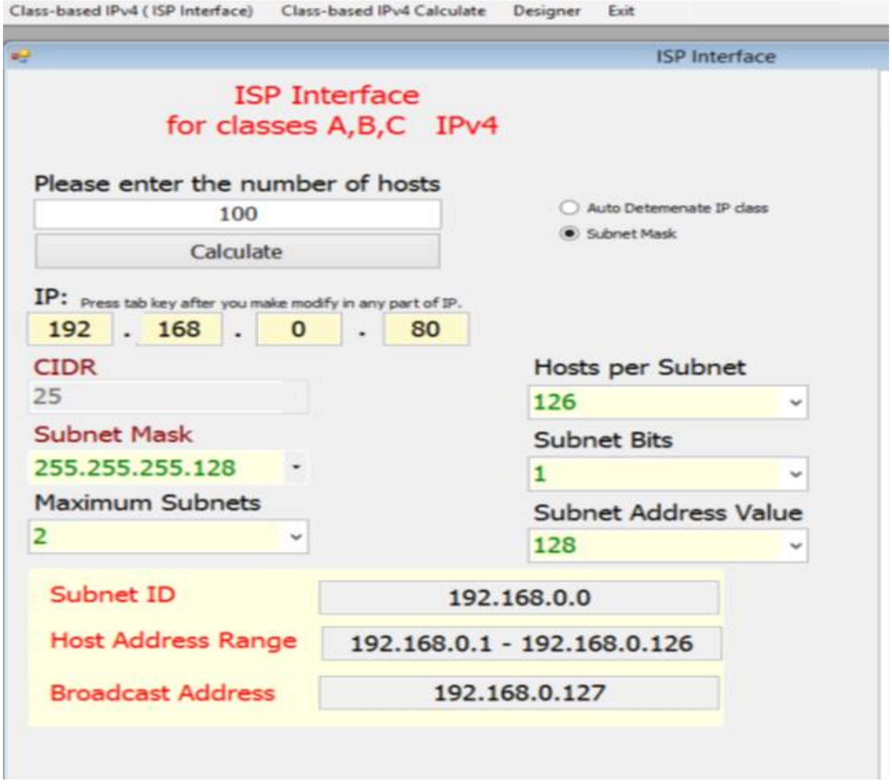
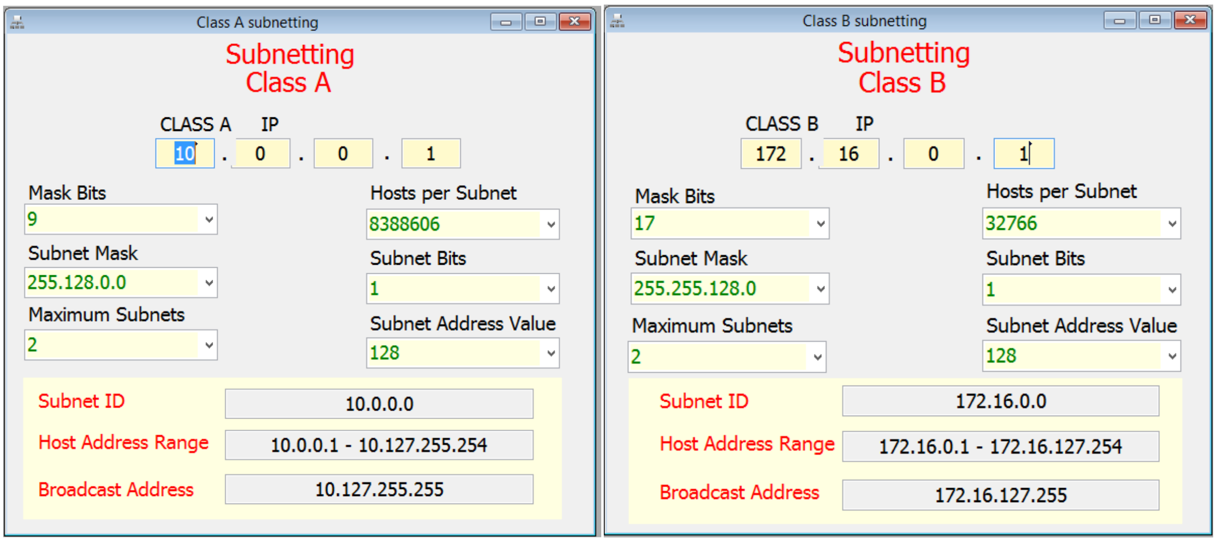



**Figure 6.**
ISP interface.

- Auto Determine IP Class: This option automatically selects the appropriate IP class (A, B, C, etc.) based on the required number of hosts.
- Subnet Mask: This option allows the ISP to divide the address space into subnets, each containing the required number of hosts, without altering the original IP class.

ii. Customer Interface: This window is very helpful for customers. Customers can input an IP address from classes A, B, or C and receive accurate results, including subnet ID, host range, and broadcast address, as shown in Figure 7.



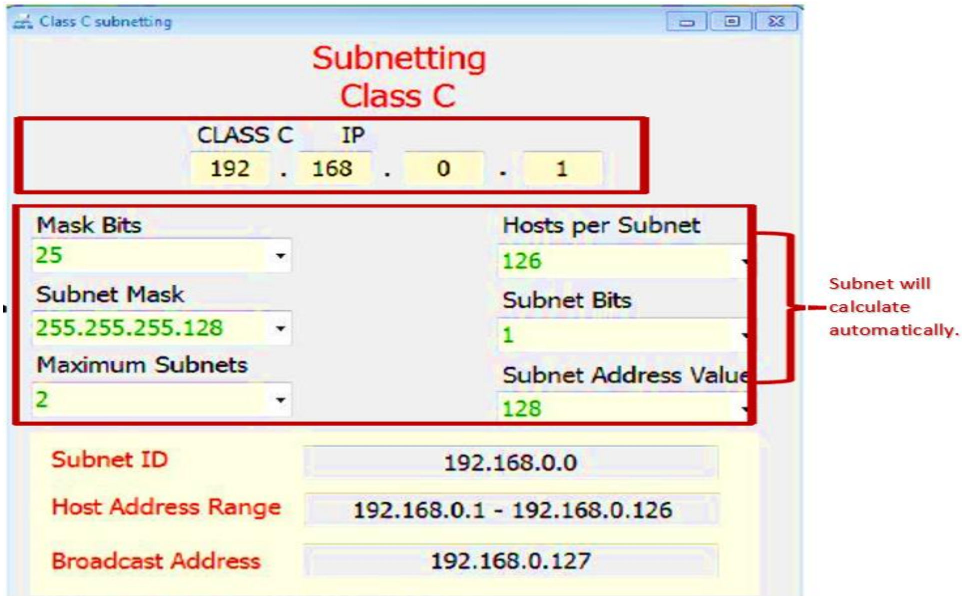



**Figure 7.**
Customer interface.

iii. IP Database Management: The implementation includes a feature to store reserved IPs, ensuring that no IP addresses are re-assigned once they have been allocated to a User. This database functionality reduces time wastage and improves operational efficiency for ISPs. The data table contains the following fields, as shown in Figure 8.

- Saved IP ID: This field gives the stored IP a serial number.
- IP Address: This field is used to input the reserved IP.
- Customer Name: This field is used to input the beneficiary (customer) name.

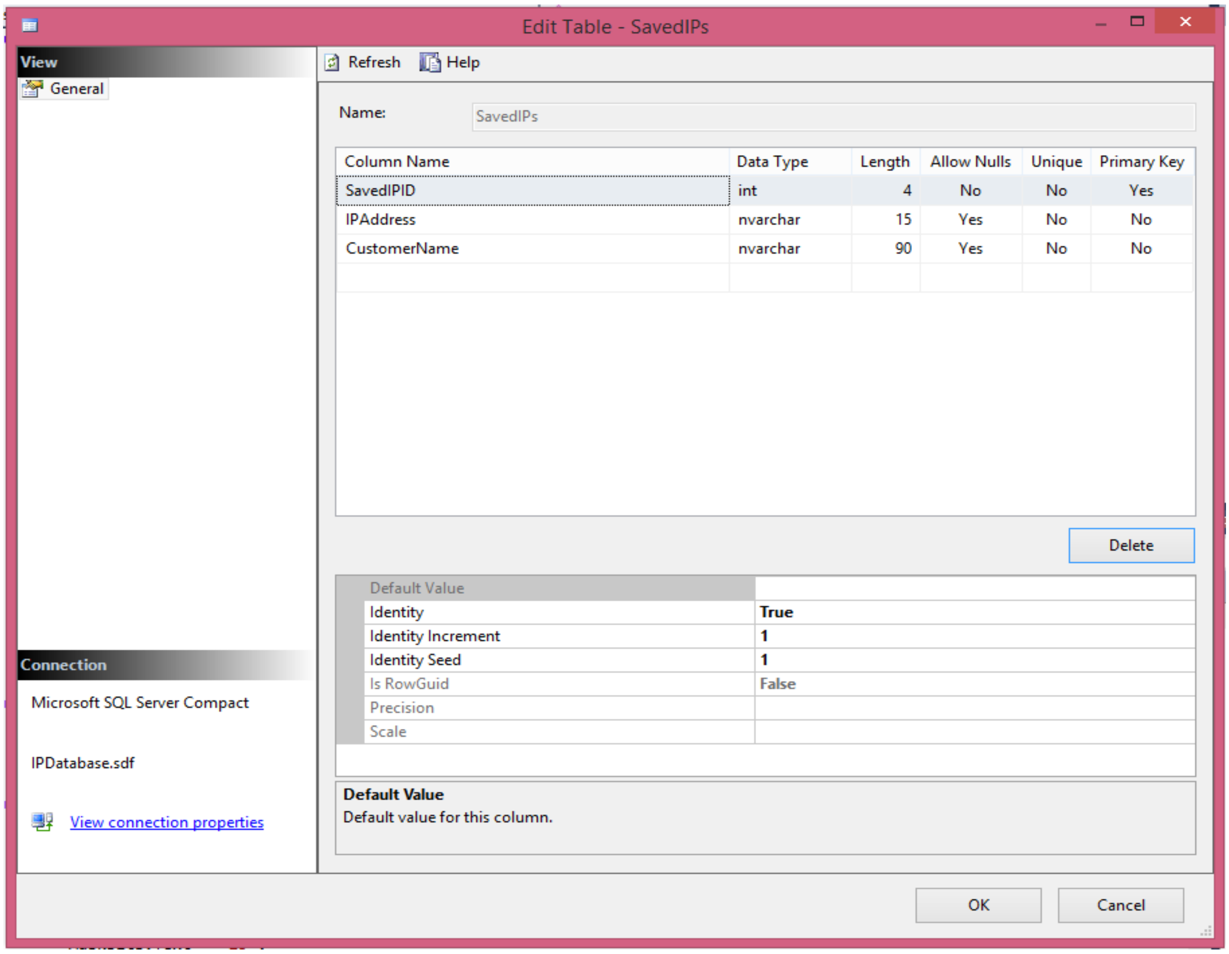



**Figure 8.**
Data table fields

When executing the application and saving IP, as shown in Figure 9.

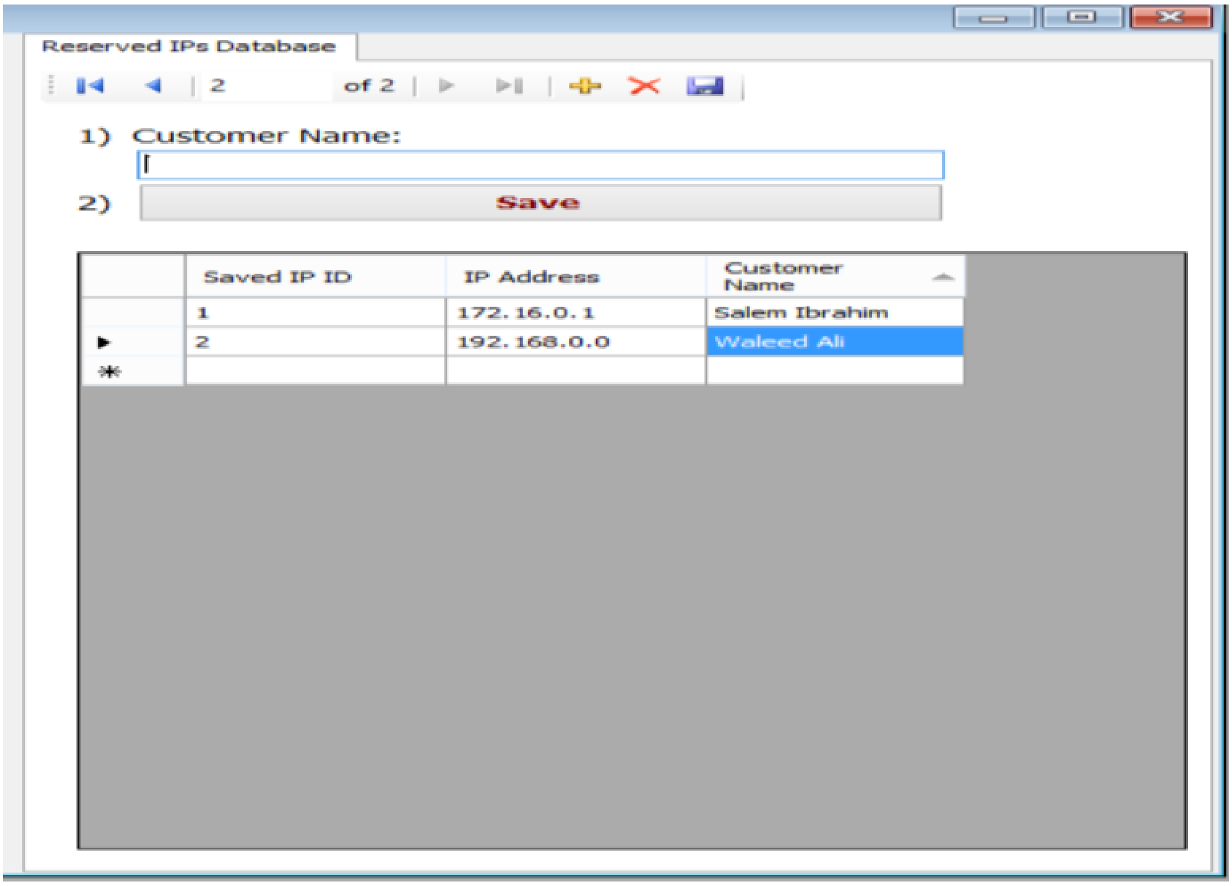



**Figure 9.**
Reserved IP Addresses Ips.

*3.2. Results of Automated Subnetting System*

Using the automated subnetting system leads to better results by saving time and reducing complexity. The ISP interface provides an optimized IP selection with two modes. The first mode automatically selects the IP class based on the required number of hosts, while the second mode allows each subnet to contain the required number of hosts without changing the IP class. Therefore, by using these two options, the user can choose the method when inputting the IP address. For example, if the number of hosts required is 100 and the IP address is 192.168.1.0, the result would appear as shown in Table 1 and illustrated in Figure 10 Auto Determinate IP class Mode and Subnet Mask class Mode.

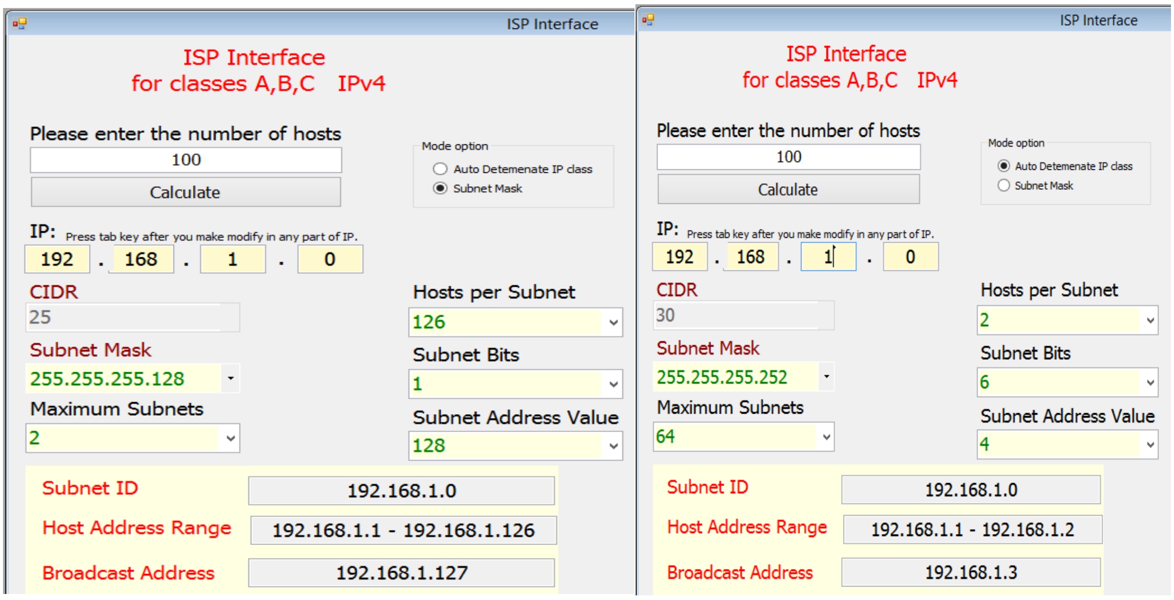



**Figure 10.**
Auto determinate IP class mode and subnet mask class mode.

Additionally, the difference is noticeable when comparing the subnetting calculation using the manual method. In the automated system, there are no lengthy steps, no binary figures, and no mental calculations required. By incorporating Classless Inter-Domain Routing (CIDR), the router table growth is reduced, and IP address wastage is minimized. Adding this concept to the automated system significantly enhances its efficiency. Instead of using the manual method to calculate any IP class, the automated system simplifies the process, making it much easier, as shown in Figure 11.

**Table 1.**
IP address calculating mode option.

| **Auto Determinate IP class Mode** | **Subnet mask mode** |
|---|---|
| Subnet ID: 192.168.1.0 | subnet ID: 192.168.1.0 |
| The subnet mask still appears not to change. | The subnet mask will change automatically depending on the host's number. |
| Subnet mask: 255.255.255.252 | Subnet mask: 255.255.255.192 |
| Host address range: 192.168.1.1 to 192.168.1.2 | Host address range: 192.168.1.1 to 192.168.1.126 |
| Broadcast address: 192.168.1.3 | Broadcast address: 192.168.1.127 |

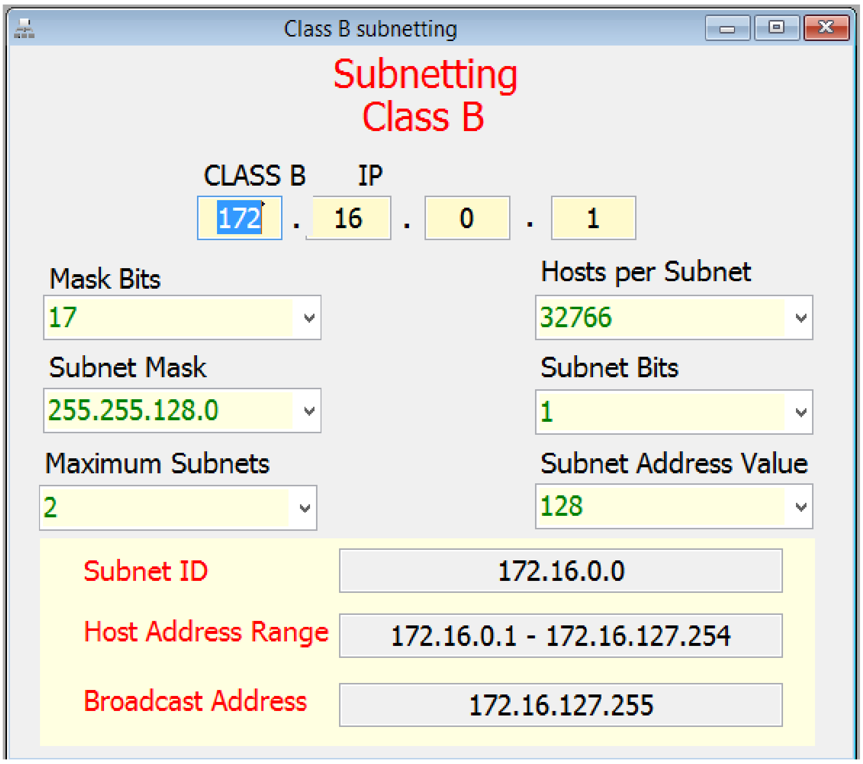



**Figure 11.**
Subnetting class B.

## 4. Conclusion

Nowadays, speed and simplicity are required in most organizations, such as ISPs, to achieve frequent business. Therefore, using a subnetting automated system is very useful, and this software can be utilized in fields of study such as computer science and higher education. Students can use it to verify their answers resulting from manual subnetting calculations. When we return to the manual method of calculating subnetting, we can see the challenges and difficulties until we obtain the result, which may carry errors and result in a loss of time as well. Through this paper, researchers can refer to it to take advantage, such as building equations that support programmers in their software.

## References

[1] Y. C. Tian and J. Gao, *Network addressing architecture," in Network Analysis and Architecture*. Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-99-5648-7_6 2023.

[2] W. Khalid, M. Jamil, A. A. Khan, and Q. Awais, "Open-source internet of things-based supervisory control and data acquisition system for photovoltaic monitoring and control using HTTP and TCP/IP protocols," *Energies*, vol. 17, no. 16, p. 4083, 2024. https://doi.org/10.3390/en17164083

[3] C. A. Sari, I. P. Sari, E. H. Rachmawanto, E. Proborini, R. R. Ali, and I. Rizqa, " Papaya fruit type classification using LBP features extraction and naive bayes classifier," presented at the 2020 International Seminar on Application For Technology of Information And Communication (iSemantic) , IEEE, 2020.

[4] A. Siddiqui, B. P. Rimal, M. Reisslein, and Y. Wang, "Survey on unified threat management (UTM) systems for home networks," *IEEE Communications Surveys & Tutorials*, 2024. https://doi.org/10.1109/COMST.2024.3382470

[5] S. K. Das and N. Pahari, "Binary to hexadecimal decoder using pockels' effect guided mach-zehnder interferometer (MZI) and optical tree architecture," *Brazilian Journal of Physics*, vol. 54, no. 1, p. 26, 2024. https://doi.org/10.1007/s13538-023-01389-4

[6] A. Siddiqui, B. P. Rimal, M. Reisslein, G. Deepak, and Y. Wang, "SUTMS: Designing a unified threat management system for home networks," *IEEE Access*, vol. 12, pp. 80930-80949, 2024. https://doi.org/10.1109/ACCESS.2024.3410111

[7] T. Adiono *et al.*, "A scalable design of a full-stack real-time OFDM baseband processor for network-enabled VLC systems," *IEEE Access*, vol. 12, pp. 94527-94542, 2024. https://doi.org/10.1109/ACCESS.2024.3425720

[8] C. Okoh, W. N. Theophilus, P. Dawkins, and S. Paheerathan, "Enhancing data security through VLSM subnetting and TCP/IP model in an ENT," *Applied Sciences*, vol. 14, no. 23, p. 10968, 2024. https://doi.org/10.3390/app142310968

[9] M. H. H. Al-Zakwani, S. Basha, N. A. Khan, and M. J. Hashmi, "Automation of sub-netting problems using mathematical modeling and simulation," *Asian Journal of Computer Science and Technology*, vol. 3, no. 2, pp. 18-27, 2014. https://doi.org/10.51983/ajcst-2014.3.2.1739

[10] C. A. Sari, M. H. Dzaki, E. H. Rachmawanto, R. R. Ali, and M. Doheir, "High PSNR using fibonacci sequences in classical cryptography and steganography using LSB," *International Journal of Intelligent Engineering & Systems*, vol. 16, no. 4, pp. 1-13, 2023. https://doi.org/10.22266/ijies2023.0831.46

[11] Y. M. Huang, C. H. Yeh, T. I. Wang, and H. C. Chao, "Constructing secure group communication over wireless ad hoc networks based on a virtual subnet model," *IEEE Wireless Communications*, vol. 14, no. 5, pp. 70-75, 2007. https://doi.org/10.1109/MWC.2007.4396940

[12] C. Hunt, *TCP/IP network administration*, 2nd ed. United States: O'Reilly Media, Inc, 2002.

[13] M. K. Tiwari *et al.*, "The comprehensive review: Internet Protocol (IP) address a primer for digital connectivity," *Asian Journal of Research in Computer Science*, vol. 17, no. 7, pp. 178-189, 2024. https://doi.org/10.9734/ajrcos/2024/v17i7488

[14] M. Nallakaruppan, S. R. K. Somayaji, S. Fuladi, F. Benedetto, S. K. Ulaganathan, and G. Yenduri, "Enhancing security of host-based intrusion detection systems for the internet of things," *IEEE Access*, vol. 12, pp. 31788-31797, 2024. https://doi.org/10.1109/ACCESS.2024.3355794

[15] A. Babakian, G. Huston, R. Braun, and J. Lipman, "Internet identifiers: A survey of history, challenges, and future perspectives," *IEEE Access*, vol. 12, pp. 51919-51941, 2024. https://doi.org/10.1109/ACCESS.2024.3382115

[16] R. R. Ali, S. A. Mostafa, H. Mahdin, A. Mustapha, and S. S. Gunasekaran, "Incorporating the Markov Chain model in WBSN for improving patients' remote monitoring systems," presented at the Recent Advances on Soft Computing and Data Mining: Proceedings of the Fourth International Conference on Soft Computing and Data Mining (SCDM 2020), Melaka, Malaysia, January 22– 23, 2020, Springer International Publishing. , 2020.

[17] F. Al-Dolaimy *et al.*, "Hybrid optimization with enhanced qos-based path selection in VANETs," *International Journal of Intelligent Engineering & Systems*, vol. 16, no. 4, pp. 69-80, 2023. https://doi.org/10.22266/ijies2023.0831.06

[18] R. R. Ali, K. M. B. Mohamad, S. A. Mostafa, D. A. Zebari, M. A. Jubair, and M. T.-H. Alouane, "A meta-heuristic method for reassemble bifragmented intertwined JPEG image files in digital forensic investigation," *IEEE Access*, vol. 11, pp. 111789-111800, 2023. https://doi.org/r10.1109/ACCESS.2023.3321680