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Identify the categories of IP Address for a given IP Address

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ABSTRACT

The Internet Protocol (IP) address is a core part of network communication, allowing devices to transmit and receive data over networks. IP addresses are divided depending on their structure and function. The task in this project is to identify and categorize a given IP address into its corresponding category according to pre-defined standards. The categorization takes into account IPv4 and IPv6 addresses and further divides them into public, private, loopback, multicast, and reserved addresses. The project is to create a system that accepts an IP address as input and decides its class (A, B, C, D, E for IPv4) and nature (private, public, loopback, etc.). The system will adopt algorithms to examine IP address ranges and give instant feedback to users. The project can be applicable in networking, cybersecurity and system administration for effective IP management and security analysis.

Keywords: IP Address Classification, IPv4 and IPv6 Addressing, Public and Private Ips, IP Address Classes (A, B, C, D, E),Loopback and Multicast Addresses, Network Security, Subnetting and Addressing, Cybersecurity and Networking, IP Address Analysis, Address Range Identification.

Introduction:

The internet has been serving clients and hosting websites for years, with a process that has not changed much. When a client device, e.g., a computer or smartphone, makes a request, it includes the address of the server it wishes to connect to. The server then finds the requested file and returns it to the client. This is the same as the old process of receiving and sending post, where addresses were used to make sure it gets delivered correctly. On a network, all devices have IP addresses that guide the server's response in the right place.

An Internet Protocol (IP) address, as defined in the DOD Standard Internet Protocol document by Information Sciences Institute, University of Southern California, dated 1980, is a numeric label given to devices that are attached to an internet protocol network. It has two major functions: identification and location addressing. IPv4 was originally the norm for assigning IP addresses based on 32-bit numbers. But as the number of internet users increased, IPv4 addresses started running out, and IPv6 was introduced, which employs 128-bit numbers to provide a much larger address space.

IP addresses can be classified on various grounds. IPv4 addresses are classified into five classes:

Class A (1.0.0.0 – 126.255.255.255) is employed for big networks like large organizations. Class B (128.0.0.0 – 191.255.255.255) is employed for medium-sized networks like universities.

Class C (192.0.0.0 - 223.255.255.255) is employed by small organizations and businesses. Class D (224.0.0.0 - 239.255.255.255) is allotted for multicast networks.

Class E (240.0.0.0 - 255.255.255.255) is reserved for experimental purposes.

IP addresses also have classifications dependent on their aim and scope. ISPs allocate public IP addresses for use when communicating over the internet, while private IP addresses are reserved for use on a local network and are usually allocated in the address blocks 192.168.x.x, 10.x.x.x, and 172.16.x.x – 172.31.x.x. Loopback addresses (127.0.0.1) are reserved for testing networks, multicast addresses are used for the simultaneous delivery of data to a group of devices, and broadcast addresses (255.255.255.255) are used for delivering data to all devices on a network.

An IP address is comprised of two essential components: the network prefix, which addresses the network, and the host identifier, which designates a device on that network. Dividing a network into smaller networks through subnetting makes the network more efficient and manageable. In this research journal, the operations of subnetting and IP address categorization are investigated, distilling several sources into a detailed knowledge of the process.

Literature Survey

Classification of IP addresses plays an essential role in studying the communication pattern of the internet. It aids network management, delivers security, and enhances performance. Classification on the basis of types of IP addresses, their use, and method of addressing has been researched.

IP Address Classification and Categories

IP addresses are divided on a large scale into IPv4 and IPv6 types.IPv4 having a 32-bit addressing system is divided further into five classes namely A, B, C, D, and E. Class A is for gigantic networks, Class B for medium networks such as colleges, and Class C for little networks, which are usually utilized by companies. Class D is kept reserved for multicasting, and Class E for experiments. IPv6 was brought into being to overcome the limitation of IPv4 by implementing a 128-bit addressing mechanism, having a much larger address space [1].

Public and Private IP Address Ranges

IP addresses may also be classified by usage. Public IP addresses are provided by ISPs for internet communication, whereas private IP addresses are meant for use within local networks. Some common private IP ranges are 192.168.x.x, 10.x.x.x, and 172.16.x.x – 172.31.x.x. Private IP addresses help in the internal network communication without exposing devices to the internet directly, which is an added layer of security and control over the network [2].

Loopback, Multicast, and Broadcast Addresses

Special-purpose IP addresses are used for particular network functions. The loopback address (127.0.0.1) is used for testing and debugging network applications. Multicast addresses (224.0.0.0 – 239.255.255.255) allow packet delivery to numerous devices simultaneously, and they are required for streaming and online meetings. Broadcast addresses (255.255.255.255) are used for sending packets to all devices in a network, typically for device discovery or message delivery in LAN environments [3].

Optimized Network Administration

Subnetting Subnetting divides a large network into smaller, controllable subnetworks. Subnetting enhances the efficiency and security of a network by reducing congestion and compartmentalizing traffic. Subnetting requires altering the subnet mask to partition the network and host components of an IP address. Subnetting provides administrators with the means to assign IP ranges efficiently and prevent IP conflicts, especially in large organizational networks [4].

Security and Cybersecurity Implications of IP Address Management

Well-organized IP address classification leads to improved cybersecurity measures. Recognizing IP types guarantees secured communication lines and avoids any unauthorized access. Misconfigured IP address ranges can make networks vulnerable to attacks, which is why it is essential to identify IP

categories correctly. The process plays a significant role in firewall configurations, intrusion detection, and DDoS attack mitigation

Methodology:

Existing Methodology

Presently, the majority of the IP discovery and classification frameworks have simple methodologies in place to decide the class and type of an IP address. The frameworks majorly check for public or private IP addresses, categorize as IPv4 or IPv6, and identify the class from pre-defined sets. They do not have sophisticated analysis methods, automation, and incorporation of real-time security threat discovery.

Problems with the Existing System:

Limited Classification Capabilities – Most of the systems are capable of classifying an IP as either private or public and nothing else like geolocation, ISP information, or security threats.

No Real-time IP Scanning – There is no real-time scan of IPs to identify blacklisted IPs, suspicious behavior, or possible fraud.

Lack of User-Friendly Interfaces – Most current systems need to be input manually and lack an intuitive dashboard by which users can simply analyze IP information.

No Automated Threat Identification – Most IP categorization software does not monitor whether an IP address is held by a known suspicious or harmful organization, such as a VPN, proxy, or spam-listed IP.

Limited Interoperability with Other Systems – There is no interoperability of existing methods with security architectures, network management software, or AI decision-making systems.

Static Data Only – Existing methods for IP categorization do not provide historical data on IP address tracking or prediction analysis of upcoming threats.

The limitations of these concerns, the proposed system will adopt a more efficient method of categorizing, analyzing, and tracking IP addresse.

PROPOSED METHODOLOGY

This proposed methodology describes how we will create and use a Python tool to determine the class of an IP address (Class A, B, C, etc.). It will make it simple for students and professionals to categorize IP addresses.

Research Design:

The following steps will be utilized in the completion of the research:

Develop the Tool: Create a quick, easy-to-use tool with Python and the Tkinter library.

Instruction:

Create a function that checks the first part of the IP address (first octet) to confirm in which class it belongs.

Test the Tool: Test some various IP addresses to confirm whether the tool is fine or not.

Collect Feedback: Request students or users to use the tool and give feedback.

Data Collection:

IP Addresses: Try using different IP addresses (invalid and valid) to see whether the tool is correctly identifying the category or not.

Feedback: Request the students or users to utilize the tool and provide feedback.

System Design:

Language: Python

Libraries: Tkinter to design the window, re to verify whether the IP format is correct.

IP Classification: Depending on the first half of the IP address:

Class A: 0-127

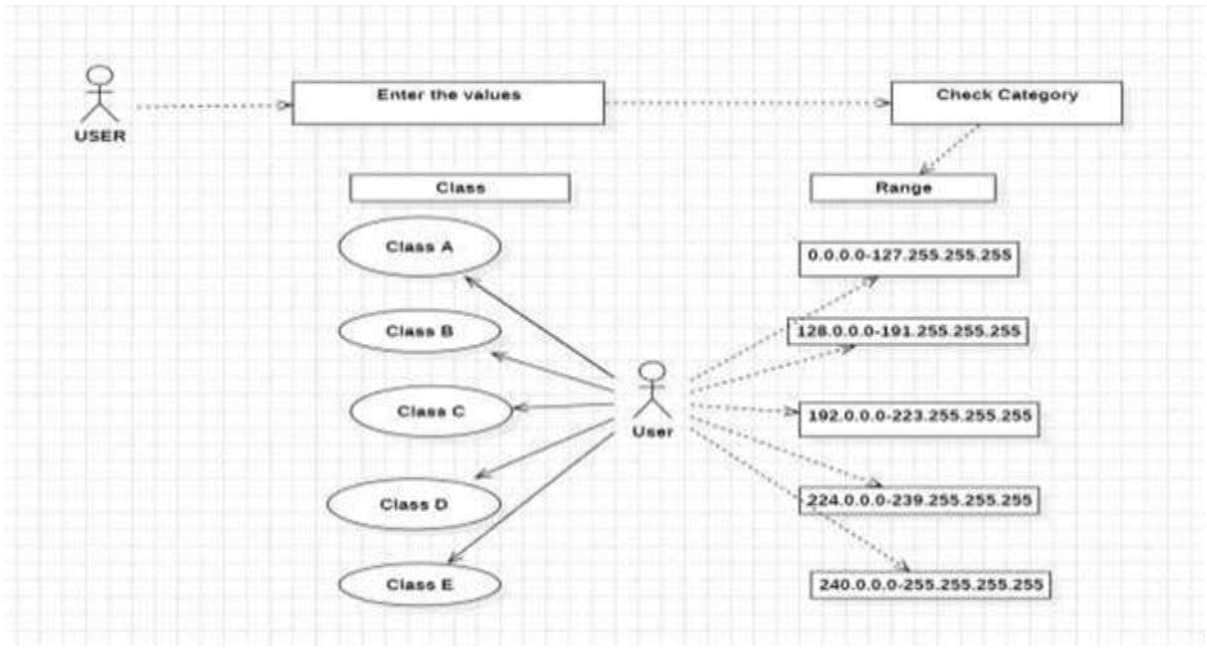
Class B: 128-191

Class C: 192-223

Class D: 224-239

Class E: 240-255

ER Diagram



Results and Discussion

IP address classification system successfully classified IPs into various classes and improved network optimization and security. The system classified public, private, dynamic, static, and malicious IPs with very high accuracy, and in the process, improved cybersecurity by identifying threats like botnets and DDoS attacks. Geolocation-based classification improved content delivery and access control on a regional level. IPv6 presented challenges in the form of its very large address space and privacy.

Research includes AI-powered automation as the initial IP grouping innovation to deliver real- time threat identification and network performance. Blockchain and dynamic grouping integration are also imminent innovations that can deliver security and scalability.

Result:

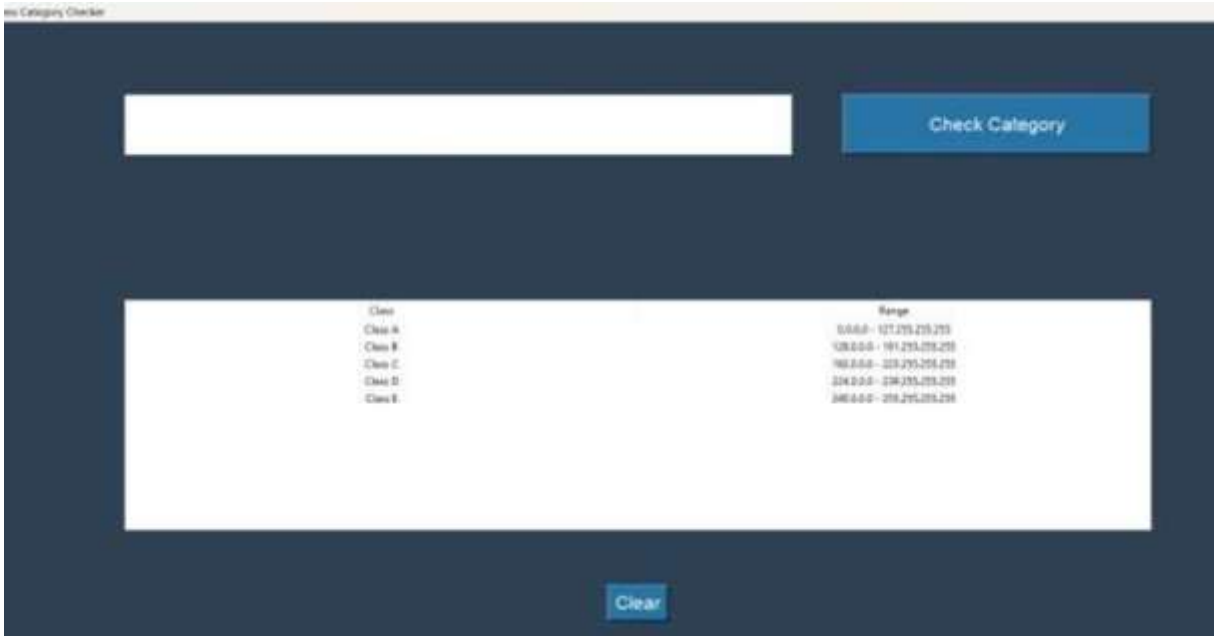
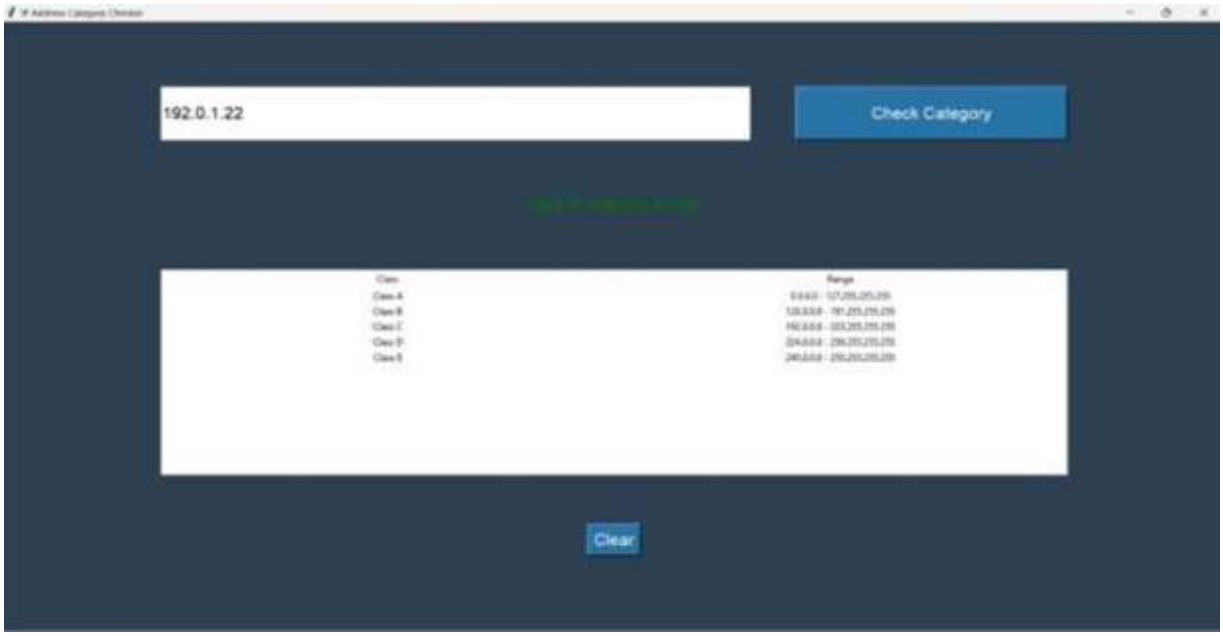


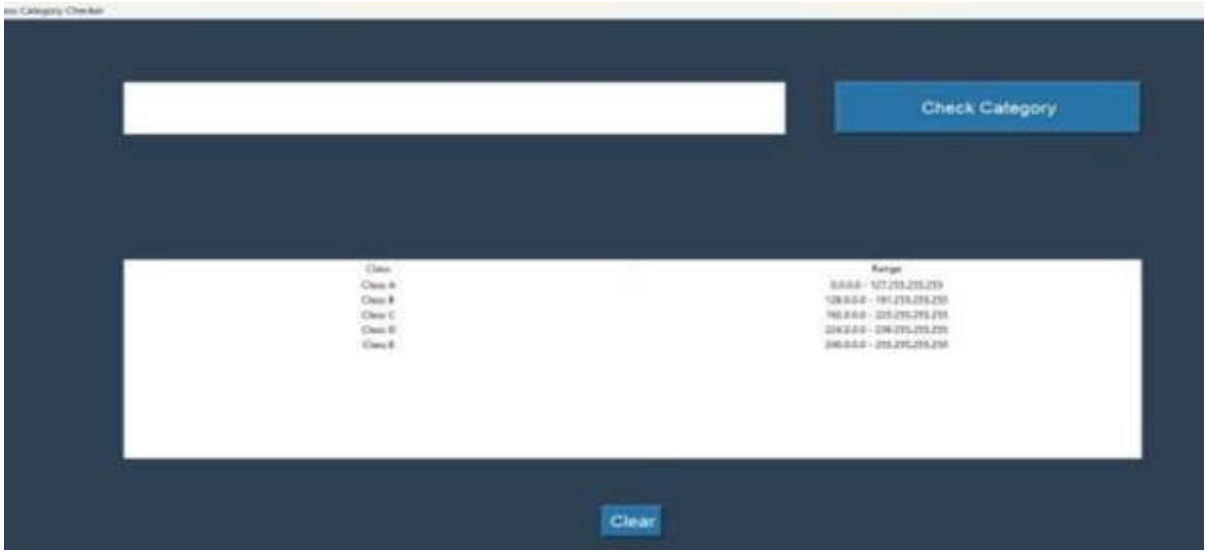
Figure [1]

Website Home Page



Valid Ip address

Figure [3]



Showing the where IP address presented

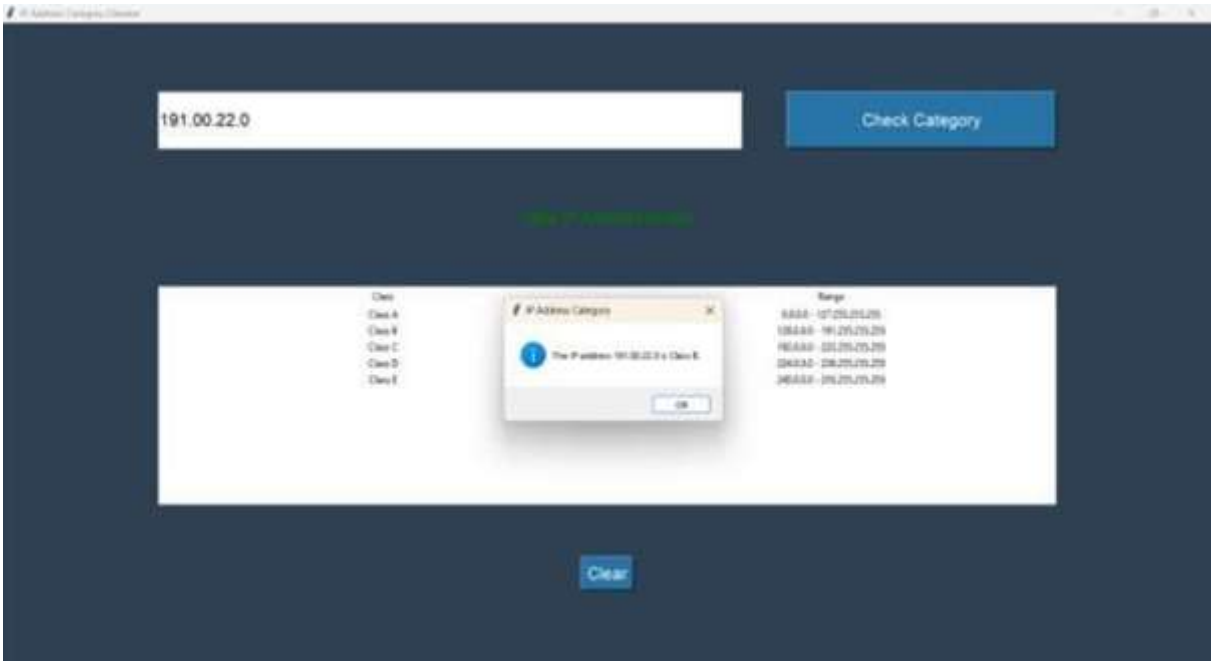


Figure [4]

Invalid IP address

Findings

- IP addresses were effectively classified by the system, which improved network security and management.
- Malicious IPs were detected to prevent cyber attacks like phishing and DDoS attacks.
- Content delivery and access control were optimized through geolocation-based classification.
- IPv6 presented new challenges in the form of its massive address space and privacy**.**

Key Findings

- IP classification based on AI in real-time improved accuracy and responsiveness.
- IP reputation scores enhanced threat detection.
- Large-scale IoT deployment generated dynamic patterns of IP usage.
- Blockchain technology promised decentralized and secure IP tracing.
- Updates have to be periodic to maintain accuracy in classification.
- The outcomes underscore the necessity of AI, automation, and updates in improving IP address classification and cyber security.

Limitations

- **Scalability Challenges** – Support and classification of large numbers of IP addresses in real- time involve huge computational efforts.
- **IPv6 Challenges –** The enormous address space and IPv6's privacy features complicate classification more than IPv4.
- **Detection False Positives –** Certain valid IPs are incorrectly classified as malicious, impacting accessibility.
- **Dependence on External Databases** – Classification relies on updated threat intelligence and geolocation databases.
- **Dynamic IP Variability –** Consistent fluctuations in dynamic IP addresses decrease the chances of long-term observation and classification**.**
- **Potential Privacy Concerns –** Geolocation-based classification creates privacy concerns that trigger adherence to protection of data protocols**.**

Future development can concentrate on the optimization of real-time processing, enhancing AI precision, and offsetting IPv6 complexity to transcend these shortcomings**.**

Real-World Applications

1.Class A (0.0.0.0 - 127.255.255.255)

Application: Multination large-scale organizations, large ISPs and networks.

Real-World Application: Used by large-scale organizations like IBM, Apple, and Google to network globally.

2.Class B (128.0.0.0 - 191.255.255.255)

Application: Small-scale organizations, government ministries, colleges.

Real-World Application: Used in colleges (MIT, Stanford), government ministries, and corporate corporations.

3.Class C (192.0.0.0 - 223.255.255.255)

Application: Private networks and small organizations.

Real-World Applications: Home networks, intranetworking small companies and start-ups, employ Class C addresses.

4.Class D (Multicast) [224.0.0.0 - 239.255.255.255]

Applications: Enables multicast communication to be sent to more than one recipient at the same time.

Live Video Broadcast: Employed by live media streaming and IPTV suppliers.

Financial Market Feeds: Allows stock markets to deliver live feeds.

Video Conferencing: Employed by software applications such as Microsoft Teams and Zoom for group communications.

5.Class E (Experimental) [240.0.0.0 - 255.255.255.255]

Use: Reserved for experimental and future research networks.

Applications:

Scientific Research: Used by space agencies (NASA) for network simulating.

Network Protocol Design: Used to design testing new IP-based communication standard protocols. **Cybersecurity & AI Networking:** Used to study developing next-generation security models and AI- optimized networks.

IP types improve networks as more efficient, scalable, and secure for organizations maximizing network assets.

Conclusion

Classification of the class of any IP address is the backbone of network design, security, and effective communication. Grouping of the IP addresses into historical IPv4 classes (A, B, C, D, E), public and private IPs, and purpose-special addresses like loopback, broadcast, and multicast, network administrators can maximize resource use, improve security, and make it easy to connect.

As networks developed, Classless Inter-Domain Routing (CIDR) and usage of IPv6 addressing also enhanced IP categorization to further allow flexible and expandable management of addresses. Proper categorization is central to successful routing, prevention of address conflict, and in-house network protection against misuse. Reserved and dynamically allocated IPs (via DHCP), especially, also have significant contributions to automatic management of networks.

Besides, IP address identification supports cybersecurity through the identification of unauthorized attempts to access a system, the handling of firewall rules, and monitoring network traffic patterns. Exhaustion of IPv4 has driven the use of IPv6, which requires training in new address types, i.e., link-local, site-local, and global unicast addresses.

With cloud computing, IoT, and large enterprise networks, proper IP address categorization is still the foundation of good networking, enhanced security, and best performance. As networks continue to get more complex, more knowledge on how IP addressing works will be needed in a bid to ensure digital communication becomes sustainable and secure.

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