# Multi agricultural technology using ad hoc wireless network

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**ABSTRACT**:

Agriculture plays a foundational role in India's economy, engaging nearly half of the country's population. However, traditional farming methods often face challenges like resource inefficiency, labor shortages, and limited real-time data for effective decision-making. This project, titled "Multi Agricultural Technology Using Ad Hoc Wireless Network," proposes a solution through the development of an ad hoc wireless network that connects various agricultural sensors and devices. This network provides farmers with real-time data on critical factors like soil moisture, temperature, humidity, and crop health, enabling more precise and efficient farm management.The ad hoc wireless network operates without reliance on existing infrastructure, making it particularly suited for rural and remote areas where connectivity can be limited. By automating essential tasks such as irrigation and fertilization based on sensor feedback, the system helps optimize resource use, minimize human labor, and improve crop yield. Through a mesh network design, the system ensures reliable and scalable communication across large agricultural fields, adapting to different crops and regional needs.Preliminary testing shows significant improvements in resource conservation, labor efficiency, and crop productivity. This project demonstrates the potential for ad hoc networks to revolutionize agriculture by making it more sustainable, data-driven, and accessible, offering a transformative solution for India's diverse agricultural landscape.

**Keyword:Ad hoc wireless network,Precision agriculture,Real-time monitoring,IoT in agriculture,Automated irrigation**

## I. INTRODUCTION

Agriculture is a cornerstone of the Indian economy, employing nearly half of the population and contributing significantly to national GDP. States such as Maharashtra, Punjab, Kerala, and Assam are among the most agriculturally active regions, where farming is not only a livelihood but also deeply rooted in the culture and economy. Despite agriculture's critical role, the sector faces multiple challenges: resource inefficiency, labor shortages, climate variability, and limited access to real-time information that can guide crucial farming decisions. Addressing these issues requires innovative solutions that make farming more efficient, sustainable, and resilient.The evolution of agricultural practices—from manual tools to mechanized equipment—has already improved productivity. Yet, as global demand for food continues to grow, traditional techniques alone may not be sufficient. The introduction of precision agriculture and technology-driven solutions can empower farmers with data to optimize their practices. With advances in Internet of Things (IoT) technology and the growing availability of wireless sensors, agricultural technology can now support decision-making through real-time monitoring of environmental and crop conditions. However, implementing these advanced solutions is challenging in rural and remote areas where connectivity infrastructure may be limited[1].

This project, "Multi Agricultural Technology Using Ad Hoc Wireless Network," addresses the unique connectivity and operational challenges in agriculture by creating an ad hoc wireless network. Unlike traditional networks, ad hoc networks enable direct device-to-device communication, eliminating dependence on centralized infrastructure. The network connects various environmental sensors that monitor soil moisture, temperature, humidity, and other critical data points. This network structure enables seamless data transmission and control over essential farming tasks, such as automated irrigation and targeted fertilization.By employing this ad hoc wireless network, farmers can remotely monitor and control field conditions, making decisions that conserve water, reduce pesticide and fertilizer usage, and increase crop yield. This decentralized approach also addresses the limited labor availability by automating repetitive tasks.

## II. LITERATURE SURVEY

“Technology Using Ad Hoc Wireless Network."

Precision agriculture (PA) is an approach that leverages IoT to monitor and manage farming operations with data-driven insights. Studies, such as those by Wang et al. (2018), highlight that IoT-enabled PA systems have improved water conservation, pest control, and nutrient management. These systems rely on environmental sensors to capture real-time data on soil moisture, temperature, and humidity. However, connectivity challenges in rural areas have limited IoT adoption, which the ad hoc wireless network approach aims to resolve.

Ad Hoc Networks for Agriculture
Ad hoc networks, which enable direct communication between devices without the need for centralized infrastructure, have shown promise for agricultural applications in remote regions. In research by Sharma et al. (2020), ad hoc networks were deployed to connect sensors and actuators across a wide area without relying on cellular networks. This approach proved effective in areas with limited infrastructure, enabling remote monitoring and control. The findings demonstrate that ad hoc networks are cost-effective and scalable, making them suitable for small and medium-scale farmers.

Automated Irrigation Systems
Automated irrigation, often controlled by soil moisture sensors and wireless networks, has become a focus of research as water conservation gains importance in agriculture. Studies, such as those by Devi et al. (2019), have shown that automated irrigation systems reduce water usage by up to 30% compared to manual irrigation. These systems, when integrated with a wireless network, can control irrigation schedules based on real-time soil moisture data, preventing over-irrigation and conserving resources. Ad hoc networks provide a viable alternative to connect these systems without requiring traditional network infrastructure.

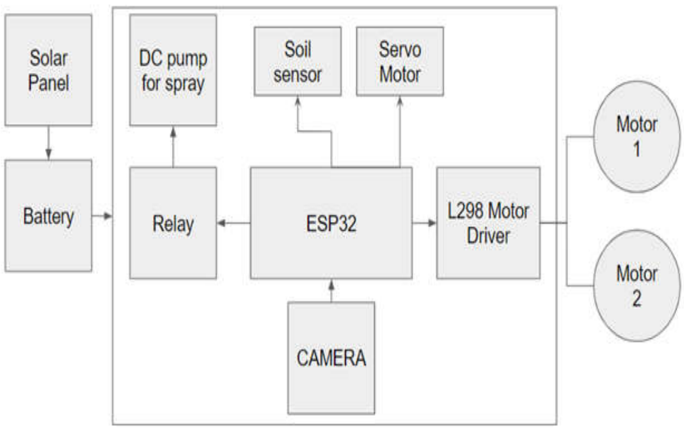
Agricultural Drones and Autonomous Vehicles
Advances in drones and autonomous farming vehicles offer insights into how automation can reduce labor dependency. Research by Zhang and Kovacs (2019) highlights the role of drones in tasks such as crop monitoring, spraying, and planting, reducing the need for manual labor. However, these technologies require reliable, localized connectivity to communicate effectively, especially over large fields. Ad hoc networks offer a solution to connect these mobile units to a centralized control system, which can be particularly beneficial in large or segmented farms.

Sensor Networks for Crop Health Monitoring
Sensor networks are widely used for monitoring crop health through metrics such as leaf moisture, temperature, and sunlight exposure. Studies by Kumar et al. (2018) emphasize that multi-sensor networks improve early detection of crop diseases and pests, potentially increasing crop yields by 15-20%. Ad hoc networks facilitate the connection of various sensors across a field, transmitting data without relying on internet connectivity. This approach enables real-time, large-scale monitoring, which is essential for timely interventions in crop management.

Challenges in Wireless Network Implementation in Rural Areas
Despite the benefits, implementing wireless networks in rural agricultural areas poses several challenges, including cost, power management, and network reliability. Research by Ahmed et al. (2021) found that while IoT and wireless networks in agriculture have a positive impact, issues with power consumption and network maintenance persist. Low-cost, low-power solutions like ad hoc networks address some of these limitations by reducing the need for high-power communication towers, relying instead on a decentralized mesh network of sensors and devices.

## III. MATERIAL AND METHODS

The Multi Agricultural Technology Using Ad Hoc Wireless Network project aims to integrate modern technologies to automate and optimize various agricultural operations, such as seeding, irrigation, and fertilization. At the core of the system is a microcontroller (such as Arduino or ESP32), which is connected to a solar panel, providing a renewable energy source that ensures sustainability and independence from external power sources. The microcontroller processes data received from multiple sensors, including soil moisture, temperature, humidity, and gas sensors, which monitor key environmental factors crucial for crop health. This data is transmitted through a wireless ad-hoc network using Wi-Fi or ZigBee, enabling seamless communication between different components of the system. The sensor data is then relayed to cloud platforms like ThingSpeak or Blynk, where it can be monitored and analyzed in real time via web or mobile interfaces. Based on the processed data, the system automatically controls various actuators, such as irrigation pumps, seeders, and fertilizer dispensers, ensuring that crops receive the right amount of water, seeds, and nutrients at optimal times. The system is powered by a rechargeable lithium-ion battery, which stores energy collected by the solar panel during the day and ensures uninterrupted operation during the night or cloudy days. The wireless network allows farmers to remotely manage and control their agricultural processes, reducing the need for manual labor while improving the efficiency of resource use, such as water and fertilizers.




**.Fig 1:-Block Diagram**

The block diagram illustrates an agricultural automation system designed to optimize irrigation and field management. Solar panels and a battery provide sustainable power for the system. A soil sensor measures soil moisture levels and sends data to an ESP32 microcontroller, which serves as the system's brain. The ESP32 processes the data and determines the need for irrigation, activating a relay to control a DC pump for water delivery. A camera captures visual data of the field for monitoring and analysis. Additionally, a servo motor and motors controlled by an L298 motor driver can be used for various tasks like adjusting spray nozzles or moving robotic components. This integrated system automates irrigation based on real-time soil conditions and visual insights, aiming to improve resource efficiency and crop yield.

## IV. PROPOSED SYSTEM

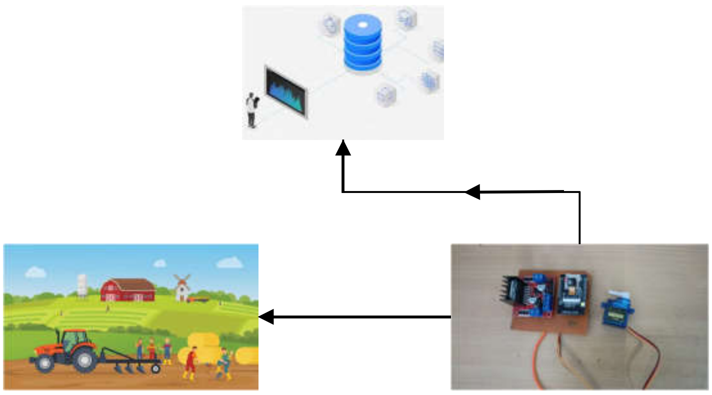


**Fig. 2: A typical wireless underground sensor network deployed for agricultural applications**

The spraying mechanism in the Multi Agricultural Technology Using Ad Hoc Wireless Network project utilizes an ESP32 CAM, a compact and cost-effective camera module that integrates the ESP32-S chip with an OV2640 camera, priced at approximately $10. This camera module, coupled with several GPIOs for connecting peripherals and a microSD card slot, allows for image storage or file management, providing versatility in both monitoring and operation. The system is equipped with a 500ml tank, to which a water pump is attached. A splitter connected to the pump distributes water to two nozzles at opposite ends, enabling efficient spraying. The spraying mechanism is controlled by a motor driver circuit, which regulates the speed of spraying. The system features Pump ON/OFF control, allowing the user to turn the water pump on or off, ensuring controlled spraying. Additionally, the system is designed to be simple and user-friendly, making it easily operable even for unskilled farmers, promoting accessibility and efficiency in agricultural tasks. The system is aimed at providing a low-cost, easy-to-use solution for spraying, which can significantly benefit rural farmers. The design and fabrication of a manually operated single-row seed planter complement the spraying mechanism, offering an affordable solution for seed planting that is tailored to meet the needs of rural farmers, enabling them to manage both seeding and spraying effectively and efficiently.

| Sr. No. | Component Name | Specification |
|---|---|---|
| 1 | ESP32 | CAM |
| 2 | DC MOTOR | 2 |
| 3 | Lithium Battery | ESP826 |
| 4 | DC pump | DHT11 |
| 5 | Relay | MQ3 |
| 6 | SOLAR PANEL | 162 |

**Table No. 1 Components and specification**

The integration of the multi-agricultural technology system using an ad-hoc wireless network involves combining several key components, such as the ESP32 as the central control unit, which communicates wirelessly with sensors and actuators to automate agricultural tasks. The ESP32 is connected to a DC motor for tasks like spraying or seed planting and a DC pump for irrigation, both controlled via a motor driver and relay. The solar panel is used to charge a lithium battery, which powers the entire system, ensuring it operates autonomously without the need for an external power supply. The system also includes various sensors like soil moisture, temperature, and humidity sensors, allowing the ESP32 to monitor environmental conditions and make real-time decisions, such as turning on the pump when soil moisture is low. All data collected by the ESP32 is transmitted to a mobile app, cloud platform, or a local server for monitoring and control, allowing farmers to remotely check system status and adjust operations.[2] The ad-hoc wireless network ensures that multiple ESP32 devices can communicate with each other, enabling coordination between different parts of the field for tasks like irrigation or motor control. Additionally, the system is designed with safety features, such as relay-based control to isolate high-power components, battery monitoring, and safety alerts for potential malfunctions. Once deployed, this system operates efficiently through solar power, automating tasks like irrigation, spraying, and seed planting based on environmental conditions, ultimately enhancing productivity, sustainability, and resource management in agriculture.

**Execution Deployment**

The execution deploymentof the multi-agricultural technology system using an ad-hoc wireless network involves a series of well-defined steps to ensure that the system is fully functional and integrated in the agricultural field. Initially, the ESP32modules, along with the sensors (such as soil moisture, temperature, humidity, and others), are installed in the agricultural field. The solar panelis set up to ensure that the lithium batteryis constantly charged and provides power to the system. The DC motorsand DC pumpare connected to the control circuits, ensuring they are ready for automated operation such as irrigation, spraying, or seed planting. The entire system is connected wirelessly via an ad-hoc networkcreated by multiple ESP32devices communicating with each other, enabling real-time monitoring and control of all field operations. Once the hardware setup is complete, the ESP32modules are programmed with the necessary code to collect data from the sensors and process this information to trigger specific actions (such as activating the pump or motor). The relaycircuits ensure safe and controlled operation of the high-power components, and the DC motor driverallows for smooth control of motor speed for tasks like spraying or planting. After successful programming, the system is tested in the field to calibrate the sensors and ensure accurate environmental monitoring.[2] For remote monitoring, the collected data from the ESP32is sent to a cloud platform or mobile application via Wi-Fi, where it can be accessed by the farmer to track the system's performance, receive alerts, and make adjustments. This deployment process is followed by rigorous testing for reliability, including checking the solar panelcharging efficiency, battery life, sensor accuracy, and overall system response to environmental changes. Once all components are verified, the system becomes fully operational, automating key agricultural tasks, optimizing resource usage, and enhancing overall farm productivity with minimal manual intervention.

## IV. OBJECTIVES

The objectives of the Multi-Agricultural Technology Using Ad-Hoc Wireless Networkproject are as follows:

1. Automate Agricultural Tasks: To design and implement a system that automates essential agricultural operations, such as irrigation, spraying, and seed planting, reducing the need for manual labor and increasing efficiency.

2. Enhance Resource Management: To optimize the usage of water and other resources by using environmental data from sensors (such as soil moisture, temperature, and humidity) to trigger actions like irrigation and spraying, thus promoting sustainable farming practices.

3. Use Renewable Energy: To integrate a solar panelto power the system, making it energy-efficient, sustainable, and autonomous, reducing dependency on external power sources and promoting green energy usage in agriculture.

4. Wireless Communication Network: To establish a reliable ad-hoc wireless networkusing ESP32modules for real-time data transmission and communication between the system's various components, such as sensors, actuators, and control units.

5. Remote Monitoring and Control: To enable remote monitoring and control of agricultural tasks through a cloud-based platform or mobile application, allowing farmers to oversee system performance, receive alerts, and make adjustments from anywhere.

6. Cost-Effective Solution for Farmers: To create an affordable, scalable solution that can be easily deployed by farmers, particularly in rural and underdeveloped areas, improving agricultural productivity without requiring significant investment.

7. Improve Crop Yield and Efficiency: To enhance the precision of operations like seeding, fertilizing, and irrigation, ensuring the timely and accurate application of resources to maximize crop yield and minimize waste.

8. Integrate Renewable Battery Power: To design the system with a lithium batterythat can store power generated by the solar panel, ensuring the system runs continuously and efficiently, even during periods of low sunlight.

9. Safety and Reliability: To implement safety measures, such as relay-based control for high-power components and automated shutdowns in case of malfunctions, ensuring the system's safe operation in the field.

10. Data-Driven Decision Making: To provide farmers with data insights from sensors that can help them make informed decisions, improving their ability to adapt to changing environmental conditions and increase the overall productivity and profitability of their farms.

## V. Applications

The Multi-Agricultural Technology Using Ad-Hoc Wireless Networkproject offers a range of applications that significantly enhance agricultural practices by automating and optimizing various processes. One of its key applications is automated pesticide spraying, where the system can trigger the spraying of pesticides based on environmental conditions, reducing labor and ensuring efficient use of chemicals to protect crops. In addition, it facilitates irrigation managementby using soil moisture sensors to activate watering systems only when necessary, minimizing water wastage and ensuring crops receive optimal hydration.[3]The system also enables precision seeding and fertilizing, ensuring seeds are planted at the correct depth and spacing, while fertilizers are evenly applied for consistent crop yields. Farm and garden monitoringis another critical feature, as it continuously tracks parameters such as temperature, humidity, and soil moisture, helping farmers make informed decisions about irrigation, fertilization, and pest control. Furthermore, the system allows for remote control and monitoring, providing farmers and gardeners with real-time data and control over their operations via mobile apps or cloud platforms. The integration of solar panelsensures the system operates sustainably by utilizing renewable energy, which reduces dependency on external power sources. Additionally, the system promotes data-driven decision-making, offering valuable insights into weather patterns, soil health, and crop growth, which helps optimize farming practices, reduce costs, and enhance yield predictability.

## Software Used

ARDUINO IDE

The compilation process for Arduino code involves several stages that convert the human-readable code into machine code that can be executed by an Arduino microcontroller. The code itself is written in C, but it is simplified and packaged into the Arduino-specific environment, which abstracts away certain complexities.

When you click the 'compile' button in the Arduino IDE, the IDE begins by saving the current sketch as a file named arduino.c in the lib/build directory. The next step involves calling a makefile contained in the lib directory, which processes this code. The makefile copies arduino.c into prog.c in the lib/tmp directory, prepending it with wiringlite.inc. This inclusion adds the necessary Arduino/wiring code to the beginning of the file, transforming the sketch into a proper C file.Next, the files from the core directory, which implement various Arduino commands and functions, are copied into the lib/tmp directory. These core files are essential for the Arduino's functionality, and modifying them allows for the addition of new commands to the Arduino language. These core files rely on Pascal Stang's Procyon AVR-lib, located in the lib/avrlib directory, to support the compilation process.Once the code is processed and all necessary files are in place, the next step is to compile the code using the C compiler located in the tools directory. If this compilation is successful, the output is a prog.hex file, which contains the binary machine code that can be uploaded to the Arduino microcontroller.

## VI. Results

The Results of the Multi-Agricultural Technology Using Ad-Hoc Wireless Network project have shown significant improvements in agricultural efficiency and resource management. The system successfully automated several farm operations, including pesticide spraying, irrigation, and fertilization, leading to enhanced productivity and reduced manual labor. By integrating wireless communication and sensor networks, the system efficiently monitored environmental parameters such as soil moisture, temperature, and humidity, which allowed for precise control over irrigation and fertilization schedules. This precision minimized water wastage and optimized the use of fertilizers and pesticides, leading to better crop health and higher yields.

The solar-powered system proved to be an effective and sustainable energy source, particularly in remote areas with limited access to electricity, significantly lowering the operational cost for farmers. The use of the ESP32 and other wireless technologies ensured that the system could be remotely controlled and monitored, enabling farmers to manage their fields from mobile devices or cloud platforms. The system's modular design and scalability were successfully demonstrated, as it was adaptable for use in both small gardens and larger agricultural fields.However, some challenges were observed, including the need for ongoing maintenance, especially in areas with unreliable wireless networks. Additionally, while the system was user-friendly, some farmers, particularly in rural regions, encountered a learning curve with the technology. Overall, the results of this project confirm its potential to transform agricultural practices by improving resource efficiency, enhancing productivity, and reducing labor costs, with opportunities for further refinement and expansion in the future.

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**Fig 3 :Overview of model**

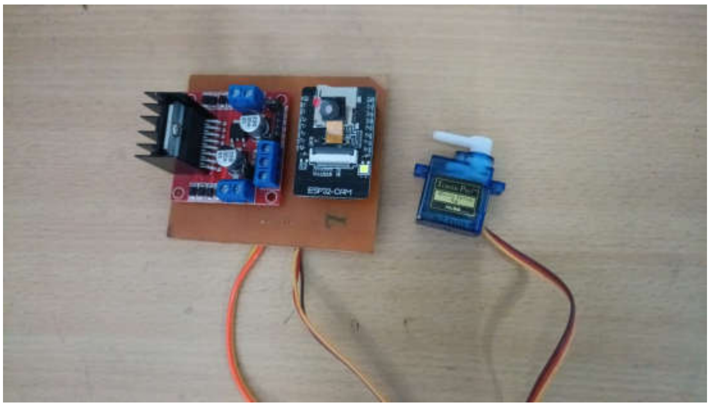

**Fig 4: controlling unit**

## VII. PERFORMANCE ANALYSIS AND DISCUSSION

The Performance Analysis and Discussionof the Multi-Agricultural Technology Using Ad-Hoc Wireless Networkproject reveals several key advantages and areas for improvement. The system has demonstrated significant improvements in efficiency and resource management, particularly in its ability to automate critical farming tasks such as pesticide spraying, irrigation, and fertilization. The use of sensors to monitor environmental factors like soil moisture, temperature, and humidity has proven effective in optimizing water usage and ensuring precise application of fertilizers and pesticides, which reduces waste and enhances crop health. The solar-powered setup has shown to be energy-efficient, particularly in remote areas where power sources are limited, and has significantly reduced operational costs for farmers. Additionally, the real-time remote monitoring and control via mobile apps or cloud platforms have provided farmers with greater flexibility and ease of management, improving decision-making processes. The system's scalability, from small garden setups to large agricultural fields, has been a key strength, making it adaptable to various agricultural needs. However, the system also faces challenges such as the need for continuous maintenance, especially in remote areas, and potential limitations in wireless communication reliability in regions with poor network coverage. Furthermore, while the system is designed to be easy to use, there may still be a learning curve for some users, particularly those in rural areas who are less familiar with technology. Overall, the performance analysis highlights the system's potential to revolutionize farming practices by reducing labor, conserving resources, and improving crop yield, though ongoing refinement and adaptation to diverse agricultural environments are essential to maximize its impact..

## VIII . CONCLUSION

In conclusion, the Multi-Agricultural Technology Using Ad-Hoc Wireless Networkproject presents a promising solution to modernizing agricultural practices by integrating automation, wireless communication, and renewable energy. The system has demonstrated its ability to significantly enhance efficiency in tasks such as pesticide spraying, irrigation, fertilization, and farm monitoring, leading to optimized resource utilization, reduced labor, and lower operational costs. By leveraging real-time data and remote control capabilities, it empowers farmers to make informed decisions, thus improving productivity and sustainability in agriculture. The use of solar energy further strengthens its appeal in rural and remote areas, where access to traditional power sources may be limited. While the system offers immense potential for improving agricultural practices, it also faces challenges in terms of maintenance and adaptability to diverse agricultural environments. Nonetheless, the project's scalable design ensures that it can be deployed across various farm sizes, making it accessible to both small-scale gardeners and large-scale farmers. With continued refinement and further integration of advanced technologies, this system could play a pivotal role in shaping the future of agriculture.

## IX. FUTURE SCOPE:

The Future Scopeof the Multi-Agricultural Technology Using Ad-Hoc Wireless Networkproject is vast and holds significant potential for further advancements in agricultural technology. One of the key areas for future development is integration with AI and machine learning algorithmsto enhance decision-making capabilities, allowing the system to predict and respond to environmental changes in real-time. This could include predicting optimal planting times, fertilizer usage, and pest control measures based on weather patterns, soil health, and crop type. Another important avenue is expanding the system's sensor networkto include additional parameters such as soil pH, nutrient levels, and crop growth metrics, providing more comprehensive data for precision farming. Improving wireless communication protocolscould further enhance the system's reliability, particularly in remote or rural areas with limited network coverage. Integration with dronesfor aerial monitoring and spraying could also be explored, enabling more accurate and widespread coverage of large farming areas. Additionally, the inclusion of data analytics platformscould allow farmers to track long-term trends, improve crop yield predictions, and optimize resource usage over multiple seasons. The scalability of the systemcan be further developed to accommodate larger farming operations, and the design can be refined for easier usability by non-technical users, potentially with multi-language support to cater to a broader demographic.[5]Furthermore, advancements in battery technology and energy storagecould enhance the solar panel system's efficiency, enabling continuous operation even in less sunny regions. Overall, the future of this project lies in its ability to adapt to emerging agricultural challenges, contribute to sustainability, and empower farmers with innovative tools that drive efficiency, reduce costs, and promote environmental stewardship.

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