# Leveraging Generative AI and Ansible Automation to Excel IPv6 Adoption

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## Background

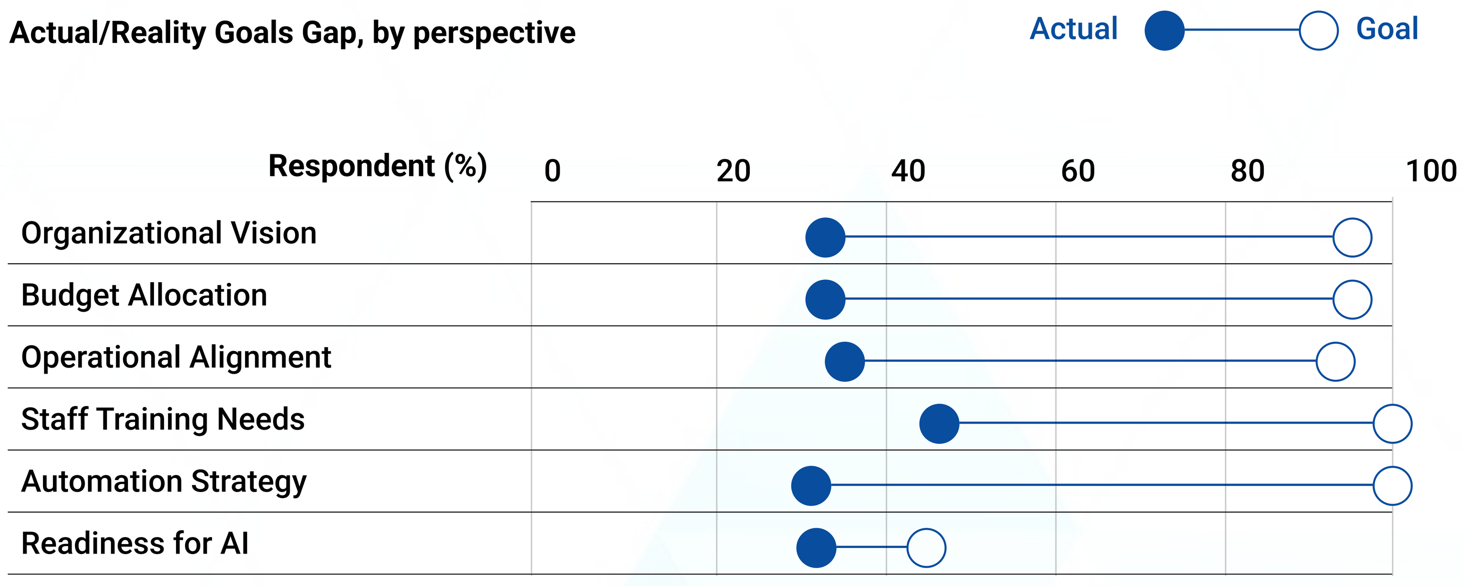
The transition from IPv4 to IPv6 is essential to address IPv4's limitations, particularly the shortage of available IP addresses; however, IPv6 adoption faces hurdles due to the complexity of its configuration, as IPv6 addresses are significantly longer and more intricate than IPv4 addresses. This complexity increases the cognitive load on network administrators, especially when renumbering static IP addresses and manually configuring devices. While the dual-stack strategy allows organizations to run IPv4 and IPv6 concurrently for a gradual migration, manual renumbering in this environment remains challenging, leading to time-consuming processes and potential errors. To overcome these issues, this research investigates the use of generative AI to automate the transformation of IPv4 configurations into IPv6 equivalents, facilitating smoother transitions within dual-stack networks. Additionally, integrating Ansible automation aims to handle static IPv6 address renumbering, reducing manual intervention and errors, thereby enhancing the efficiency and reliability of IPv6 deployment.

## Objective

This working paper aims to facilitate a seamless transition from IPv4 to IPv6 within a dual-stack network by using generative AI to automatically convert IPv4 configurations into IPv6 equivalents and employing Ansible automation to streamline the IPv6 renumbering process, thereby reducing manual intervention and enhancing the efficiency of IPv6 adoption.

## Questionnaire

This study is based on a questionnaire conducted with 16 institutions in Medan, primarily higher education institutions, along with several government organizations, involving 28 respondents. The goal was to assess organizational readiness, challenges, and the role of automation and AI in the adoption of IPv6 technology.




The study reveals significant gaps between strategic goals and actual actions regarding IPv6 adoption. Although 96.4% of organizations include IPv6 in their IT strategy, only 35.7% have allocated funds for its implementation, highlighting a 60.7% gap in financial commitment. Similarly, while most organizations face challenges with IPv6 configurations and recognize the need for automation, only 27.1% have adopted automation strategies, creating a 72.9% gap. Staff training also lags behind, with only 41.6% receiving IPv6-specific training despite the importance of preparedness, resulting in a 58.4% gap. Moreover, while nearly 95% of organizations prioritize infrastructure upgrades, only 35.7% are acting on these priorities, and only 27.1% have implemented IPv6 automation, despite 82.1% recognizing its necessity. These gaps emphasize the need for organizations to align their strategic priorities with concrete actions to ensure a successful IPv6 transition.

## Methodology

This research follows the Design Science Research (DSR) methodology to develop, test, and evaluate a web-based application that automates the transformation of IPv4 to IPv6 configurations using a generative AI engine, integrated with Ansible automation for renumbering. DSR is employed to iteratively design, build, and refine the artifact through testing and feedback, focusing on addressing the practical challenges faced in IPv6 network configuration management.

### Phase 1: Problem Identification and Objective Definition

The primary problem addressed in this research is the complexity and cognitive burden associated with transitioning from IPv4 to IPv6, particularly when manual configuration and renumbering are required. The objective is to create an automated system that simplifies this transition by using generative AI to transform configurations and Ansible to automate the renumbering process, reducing manual intervention and human error.

### Phase 2: Design and Development of the Artifact

The artifact created is a web-based application that uses the ChatGPT engine to automatically generate IPv6 configurations from IPv4 data. The application focuses on maintaining compatibility with dual-stack networks, where both IPv4 and IPv6 coexist. The AI was trained using real-world IPv4 configuration data collected from several university networks in Yogyakarta.

Additionally, Ansible was integrated into the application to automate the renumbering of IPv6 addresses across network devices. The application generates Ansible playbooks based on the AI-generated IPv6 configurations, enabling seamless deployment to various network devices. The goal was to create a system that could automate these tasks, significantly reducing the time and effort required for manual configuration updates.

### Phase 3: Demonstration and Testing in Simulated Environments

The artifact was initially tested in the GNS3 network emulator, simulating real-world network environments. The demonstration phase confirmed that the generative AI could accurately convert IPv4 to IPv6 configurations, while Ansible automation handled the renumbering process effectively.

However, limitations were observed with certain network devices, particularly older hardware or devices with non-standard firmware, which did not perform as expected. These findings highlighted the need for further refinement of the AI model and adjustments to the Ansible playbooks.

### Phase 4: Evaluation Using ISO/IEC 25010 Software Quality Model

Following the DSR cycle, the next phase involves evaluating the artifact using the ISO/IEC 25010 Software Quality Model. The evaluation focuses on the following key areas:

- **Functional Suitability**: The accuracy of the AI in generating correct IPv6 configurations.
- **Efficiency**: Measuring time savings in renumbering tasks compared to manual processes.
- **Reliability**: The system's ability to perform consistently across various network devices, brands, and firmware.
- **Usability**: Internal team feedback on the application's ease of use and learnability.
- **Maintainability**: The ease with which the Ansible playbooks and AI configurations can be modified for future use.
- Portability: Testing the system's ability to work across different environments and hardware setups.

Initial testing in GNS3 provided valuable insights but exposed certain limitations in replicating real-world conditions. Consequently, further testing in a live network environment at a neighboring university in Yogyakarta is planned to validate the artifact's scalability, reliability, and practical impact.

### Phase 5: Communication and Future Refinement

The final phase of the DSR process involves communicating the results and refining the artifact based on feedback and testing outcomes. The ongoing work includes tuning the AI model to improve compatibility with a wider range of network devices and firmware, as well as expanding the real-world testing to further validate the solution's effectiveness.

## Result

The web-based application developed for this research focuses on transforming IPv4 configurations into IPv6 using the ChatGPT engine, successfully integrating with Ansible to automate the renumbering process. Initial internal tests showed that the tool effectively reduces manual effort and configuration errors, with significant time savings in generating and deploying IPv6 configurations. However, the success rate varies depending on the brand, series, and firmware of the network devices, with older or non-standard hardware requiring manual adjustments. While GNS3 provided a testing environment, it did not always accurately reflect real-world conditions, leading to inconsistent results. As a result, further testing in live network environments is planned to fine-tune the AI model and improve the system's scalability and reliability.