Modeling Paging Delay in Computer Systems

1. Introduction

Efficient memory management is essential for modern computer systems. Paging is a virtual memory technique where memory is divided into fixed-size pages and transferred between RAM and secondary storage. Paging delay represents the waiting time for required memory pages and directly affects system performance.

2. Problem Statement

In virtual memory systems, page faults and high memory load create delays known as paging delay. This behavior can be mathematically modeled using a second-order differential equation to analyze system responsiveness under varying memory loads.

3. Objectives

- Derive and solve the paging delay differential equation.
- Implement the model using MATLAB or Python.
- Plot and analyze system behavior over time.
- Validate analytical results using numerical simulation.

4. Mathematical Modeling

The paging delay w(t) is modeled using a linear second-order differential equation. The general solution is formed by combining the complementary function and particular integral. Numerical methods such as Runge–Kutta (ode45) are used to validate the analytical solution.

5. Results and Conclusion

The analytical and numerical solutions closely match, confirming the accuracy of the model. The paging delay initially increases due to external load and later stabilizes, demonstrating controlled system behavior under memory pressure.

6. Future Scope

- Integration with real-time operating system data.

- Model extension for multi-level paging and TLB delay.

- Advanced numerical solver implementation.

- Machine learning-based paging delay prediction.

7. RAM Doctor – Interactive Web Simulation

RAM Doctor is an interactive educational tool that visualizes paging delay under varying memory loads. It demonstrates how increasing RAM usage leads to higher paging delays, system lag, and reduced responsiveness. The tool bridges theoretical modeling and real-world system performance analysis.