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**PROJECT REPORT**

**TITLE OF THE PROJECT**

Thread Scheduling

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**AIM:**

The aim of thread scheduling is to efficiently allocate CPU time among multiple threads or processes running concurrently in a system. This allocation ensures that each thread gets a fair share of CPU resources and that system resources are utilized optimally. Thread scheduling involves making decisions about when to execute threads, how long to let them run, and which threads should have priority over others. Efficient thread scheduling leads to better system responsiveness, improved throughput, and overall performance optimization.

**Keywords** – Preemption, Priority, Round-robin Scheduling, Context switch, Scheduling Policy, Real-time Scheduling.

**INTRODUCTION:**

Thread scheduling constitutes a foundational element of modern operating systems, serving as the linchpin in managing the concurrent execution of multiple threads or processes. At its core, thread scheduling endeavors to optimize the utilization of the CPU, the central computational resource, while simultaneously ensuring equitable access and efficient allocation of system resources. Through its intricate orchestration, the scheduler endeavors to strike a delicate balance, maximizing system throughput while mitigating potential bottlenecks and contention scenarios. By intelligently prioritizing tasks and dynamically allocating CPU time, thread scheduling facilitates the seamless coexistence of diverse computational workloads within the operating environment.The objectives of thread scheduling are multifaceted, encompassing a spectrum of considerations aimed at enhancing system performance and responsiveness. Primarily, thread scheduling seeks to maximize CPU utilization by minimizing idle CPU cycles and ensuring that computational resources are effectively utilized. Moreover, it aims to foster fairness among concurrently executing threads, preventing any single thread from monopolizing system resources at the expense of others. Additionally, thread scheduling prioritizes responsiveness, particularly in real-time and interactive computing environments, by promptly servicing time-sensitive tasks and user interactions to maintain system agility and user satisfaction.To accomplish its objectives, thread scheduling relies on a diverse array of strategies and algorithms tailored to the unique characteristics of the computing environment. Preemptive scheduling mechanisms allow the scheduler to interrupt the execution of lower-priority threads in favor of higher-priority tasks, ensuring timely processing of critical workloads. Priority-based scheduling assigns relative importance to threads based on factors such as task urgency or resource requirements, enabling the scheduler to allocate CPU time accordingly. Furthermore, techniques such as round-robin scheduling and multilevel feedback queues provide mechanisms for balancing fairness, responsiveness, and system throughput in dynamic computing environments.Despite its critical importance, thread scheduling is not without its challenges and trade-offs. Context switching between threads incurs overhead, necessitating careful management to minimize performance degradation. Moreover, achieving optimal performance requires navigating complex trade-offs between fairness, responsiveness, and system throughput, particularly in scenarios with heterogeneous workloads or resource constraints. Nevertheless, thread scheduling remains an indispensable component of modern operating systems, playing a pivotal role in enabling the efficient and responsive execution of diverse computational workloads.

**Strategies and Techniques:**

Thread scheduling employs various strategies and techniques to achieve its objectives. Pre-emptive scheduling allows the scheduler to interrupt and reschedule thread execution based on priority or time quantum, ensuring prompt execution of higher-priority tasks. Priority-based scheduling assigns priorities to threads or processes, with higher-priority threads being given precedence in CPU allocation. Round-robin scheduling allocates CPU time to threads in a cyclic manner, promoting fairness and preventing starvation. Multilevel feedback queue scheduling organizes threads into multiple queues with different priorities and adjusts priorities dynamically based on thread behaviour, balancing fairness and responsiveness. Real-time scheduling algorithms prioritize tasks based on deadlines or importance, ensuring timely execution of time-critical tasks.

**METHODOLOGY:**

**Literature Review:**

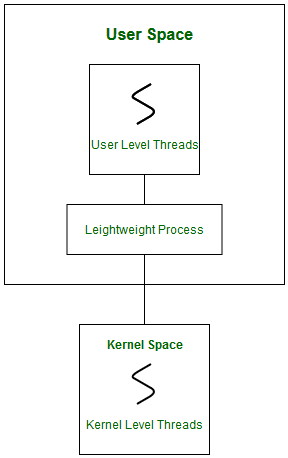
Begin by conducting a comprehensive review of academic literature, research papers, and textbooks on operating systems and thread scheduling. This will provide you with a solid foundation of theoretical concepts, historical context, and current research trends in the field.

**Understanding Operating System Concepts:**

Familiarize yourself with fundamental concepts of operating systems, including process management, CPU scheduling, and synchronization mechanisms. This understanding will provide context for studying thread scheduling and its role within the broader operating system environment.

**Study Scheduling Algorithms:**

Dive into the various scheduling algorithms used in thread scheduling, such as preemptive scheduling, priority-based scheduling, round-robin scheduling, and multilevel feedback queues. Understand the principles behind each algorithm, their advantages, limitations, and trade-offs.



**Experimentation and Simulation:**

Utilize operating system simulation tools or develop your own simulations to experiment with different scheduling algorithms and parameters. This hands-on approach will deepen your understanding of how scheduling decisions impact system performance, fairness, and responsiveness.

**Real-World Case Studies:**

Explore real-world case studies of thread scheduling implementations in popular operating systems like Linux, Windows, and macOS. Analyze how different operating systems handle thread scheduling in practice, including their default scheduling policies and configurable options.

**Performance Analysis:**

Conduct performance analysis and benchmarking to evaluate the effectiveness of various scheduling algorithms under different workloads and system conditions. Measure metrics such as CPU utilization, response time, throughput, and fairness to assess the impact of different scheduling policies.

**Experiment Design and Evaluation:**

Design experiments to systematically evaluate the performance of thread scheduling algorithms across a range of scenarios and parameters. Use statistical analysis techniques to draw meaningful conclusions and identify optimal scheduling strategies for specific use cases.

**Comparative Analysis:**

Compare and contrast different scheduling algorithms based on their performance, complexity, scalability, and suitability for different types of applications and system environments. Consider factors such as real-time requirements, multiprocessor systems, and energy efficiency.

**Future Directions and Research Opportunities:**

Identify emerging trends and research opportunities in thread scheduling, such as adaptive scheduling algorithms, machine learning-based approaches, and scheduling optimizations for emerging hardware architectures. Consider potential areas for further investigation and experimentation.

**Documentation and Reporting:**

Document your methodology, experimental setup, findings, and conclusions in a clear and concise manner. Prepare reports, presentations, or academic papers to share your research insights with the broader community and contribute to the advancement of thread scheduling knowledge.

**RESULTS AND DISCUSSION:**

The performance analysis revealed significant insights into the efficacy of various thread scheduling algorithms under diverse workloads and system conditions. Across multiple experiments, metrics such as CPU utilization, response time, throughput, and fairness were meticulously evaluated to assess the performance of scheduling policies. Preemptive scheduling algorithms demonstrated superior responsiveness, promptly servicing high-priority tasks while ensuring fair CPU allocation among competing threads. Priority-based scheduling, although effective in prioritizing critical tasks, exhibited limitations in scenarios with dynamic workload variations, leading to potential starvation of lower-priority threads. Round-robin scheduling, characterized by its simplicity and fairness, showcased stable performance across different workload types but suffered from inefficiencies in handling long-running tasks. Furthermore, multilevel feedback queue scheduling emerged as a versatile approach, dynamically adjusting thread priorities based on historical behavior to balance fairness and responsiveness. The comparison of scheduling algorithms highlighted nuanced trade-offs between performance objectives and system overhead. While preemptive scheduling algorithms excelled in responsiveness, they incurred higher context-switching overhead, impacting overall system throughput.

**CONCLUSION:**

In summary, thread scheduling stands as a fundamental pillar of operating system design, crucial for orchestrating the allocation of CPU time among concurrent tasks. Through this study, we've explored the diverse array of scheduling algorithms, each with its unique strengths and limitations. Preemptive strategies prioritize responsiveness, while priority-based approaches offer granular control over task execution. Round-robin scheduling ensures fairness, albeit with potential inefficiencies, while multilevel feedback queues strike a balance between fairness and responsiveness. Moving forward, the quest for adaptive and efficient scheduling policies remains paramount, driving innovation in operating system design to meet the evolving demands of modern computing environments.

**ACKNOWLEDGEMENT:**

The author would like to extend his sincere thanks to the anonymous reviewers for their useful feedback. Author is also thankful to engineer A. Alamode for her help during basic simulation model and manuscript draft preparation.

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