A Power Conservation Methodology for Hard Drives by Combining Prefetching Algorithms and Flash Memory

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The Problem

Computing system power consumption is a problem as it has financial and environmental implications. This problem will increase in the future due to the current trends in data growth, information availability requirements, and increases in the cost of energy. Data growth is compounded daily because of the accessibility of portable devices, increased connectivity to the Internet, and a trend toward storing information electronically. These three factors also result in an increased demand for the data to be available for access at all times which results in more electronic devices requiring power. As more electricity is required the overall cost of energy increases due to demand and limited resource availability. The environment also suffers as most electricity is generated from fossil fuels which increase emission of carbon dioxide into the atmosphere.

The Research

In order to reduce the amount of energy required while maintaining data availability researchers have focused on changing how data is accessed from hard drives. Hard drives have been found to consume 10 to 86 percent of a system's energy. Through changing the way data is accessed by implementing multi speed hard drives, algorithms that pre-fetch, cache, and batch data requests, or by implementing flash drive caches researchers have been able to reduce the energy required from hard drive operation. However, these approaches often result in reduced I/O performance or reduced data availability.

Research Questions

1) **Can a methodology be devised that reduces hard drive power consumption over previous methodologies while guaranteeing data availability?**

2) **Can this methodology also guarantee higher levels of performance over previous research?**

3) **Can the algorithms involved in the methodology be shown to have low processing overhead and thus insure system availability?**

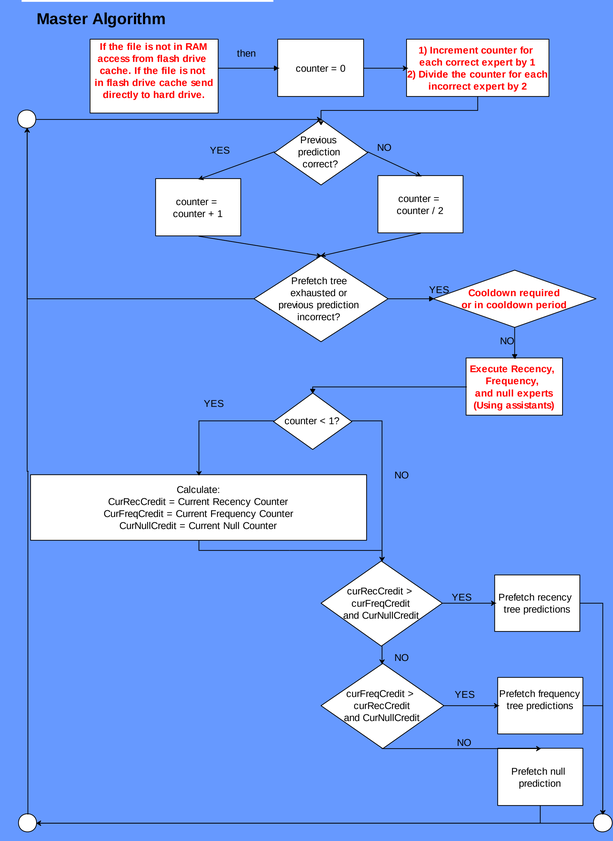
Solution Design

The dissertation provided a new method, entitled FEnSTEP (Flash Enabled Self-Tuning Energy Predictors), that reduced hard drive energy consumption by implementing a prefetching technique that predicts a chain of future requests based upon previous request observations. The files to be prefetched were given to a caching system which uses a flash memory device for caching. This caching system implemented energy sensitive algorithms to optimize the value of files stored in the flash memory device. Through prefetching files the hard drive on a system can be placed in a low power sleep state. This results in reduced power consumption while providing high I/O performance and data availability.

Results

Analysis of simulator results confirmed that this new method increased I/O performance and data availability over previous studies while also providing a higher level of energy savings. Out of 30 scenarios, the new method displayed better energy savings in 26 scenarios and better performance in all 30 scenarios over previous studies. The new method also displayed it could achieve results of 50.9 percent less time and 34.6 percent less energy for a workload over previous methodologies.

FEnSTEP Flow



Conclusions

- **Combining an adaptive caching mechanism with a flash memory buffer can result in significant energy savings while producing high levels of execution performance.**
- **The simulator constructed displayed that high data and system availability can be achieved through this methodology.**
- **This dissertation provided an energy saving methodology that decouples itself from a specific kernel which results in a widely applicable solution to address the energy needs of computing proliferation and rising energy costs.**