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NCAR

Simulating the NCAR Mass Storage System to Improve Performance

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Introduction

- NCAR has a 1.9 PB Mass Storage System.
- The size and complexity of the hardware and software can make it difficult to estimate the effects of system configuration changes on performance.
- A trace-driven performance simulator was built to aid us in ranking design and configuration alternatives.

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Overview

- NCAR & the NCAR MSS
- High Level View of the Simulator
- Lower Level View of the Simulator
- Validation
- Limitations
- Example of Simulator Use
- Future Uses

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The NCAR MSS

- 1.9 PBs total, 1.1 PBs of unique data (as of 1 June 2004)
- 23 M files
- Average net growth rate ~1.7 TB per day
- Average 16,000 reads per day and 22,000 writes per day
- Average 4500 tape mounts per day (mostly robotic)

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The NCAR MSS

- 5 StorageTek 9310 Tape Silos plus an offline (manual mount) archive
- 20 9940B FC tape drives, 38 9940A Escon tape drives and 24 9840A Escon tape drives
- 7 TB of disk cache
- rcp model – moves entire files to/from host at user request
- IP and Hippi are used for the data paths.
- In the future, all data transfers will occur over IP networks through custom software to FC devices.

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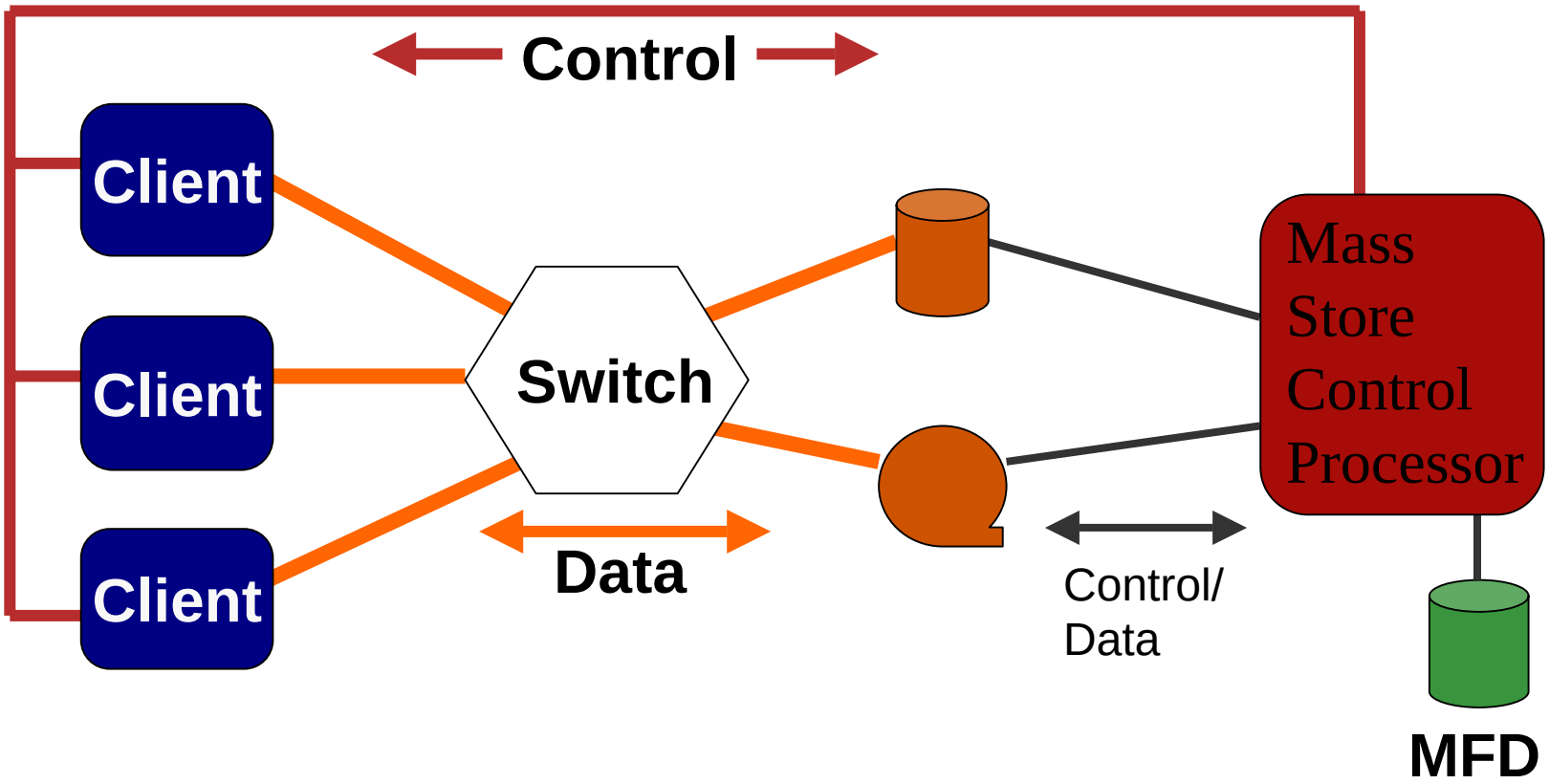
Data Flow in the NCAR MSS



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Configuring the MSS

- System complexity and component interdependence can make it hard to estimate the effects of system changes.
- Can be difficult and expensive to experiment with a production MSS.
- Analytic approaches (e.g., queueing theory) often have low accuracy.
- Simulations are generally more accurate than analytic approaches and easier than experimenting with a production MSS.

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Goal of Simulator

- main goal: estimate the ***average*** response time and other metrics for user file transfers over time periods of a month or more to within about 15% percent of the true values.
- Of the set of performance metrics, users are probably most aware of response time.
- Simulator only provides information about performance related metrics.

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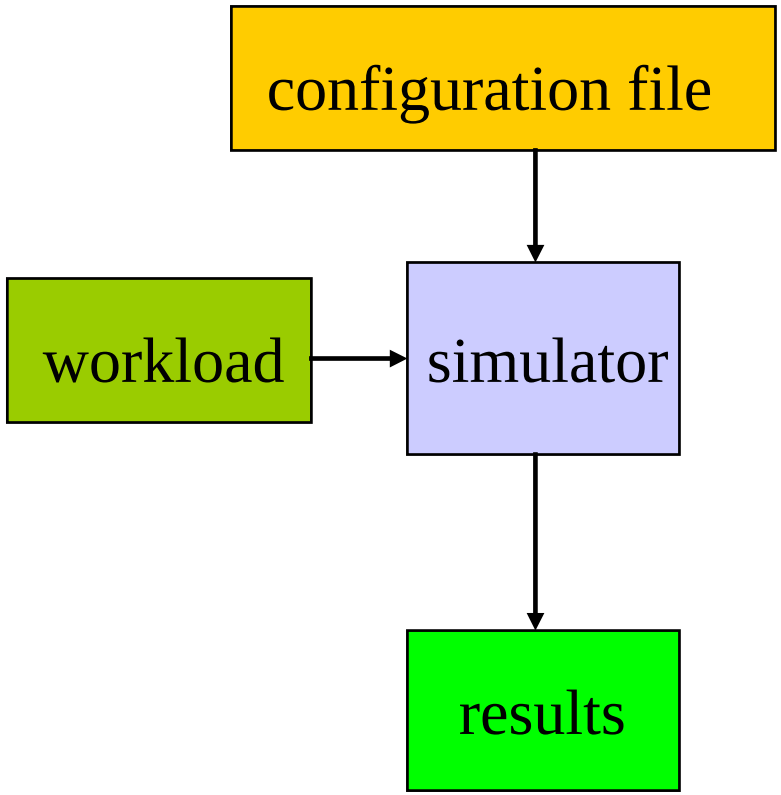
High Level View of Simulator



- Trace driven using logs
- discrete-event simulator
- Hardware & software components are simulated
- Simulator written in Java
- ASCII configuration file used
- Calculates metrics such as response time, # of tape mounts, device utilization

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Components in the Simulator

- Tape drives
- Silos
- Disk subsystems
- Numerous software components

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Simulating a Component

- First, build a conceptual model of a component such as a tape drive.
- Information was obtained by talking with other group members and vendors, by reading documentation and source code and by running tests.
- Components are modeled with the least amount of detail consistent with the desired accuracy.
- Many details can be ignored.
- Next, implement the model in software.

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Simulating a Component

- Test
- Refine and add more detail as necessary to achieve desired accuracy
- Each component that takes time to perform operations is modeled using a separate thread.
- Example…

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Silo Example

- Consider a single silo.
- It primarily receives requests to mount or dismount tapes and can queue up requests.
- If a request arrives while a silo is currently mounting or dismounting a tape, the request waits in a queue.
- The time to actually service a mount request is a function of drive location, cell location and robot speed.
- Average service times can be measured and obtained from vendor.

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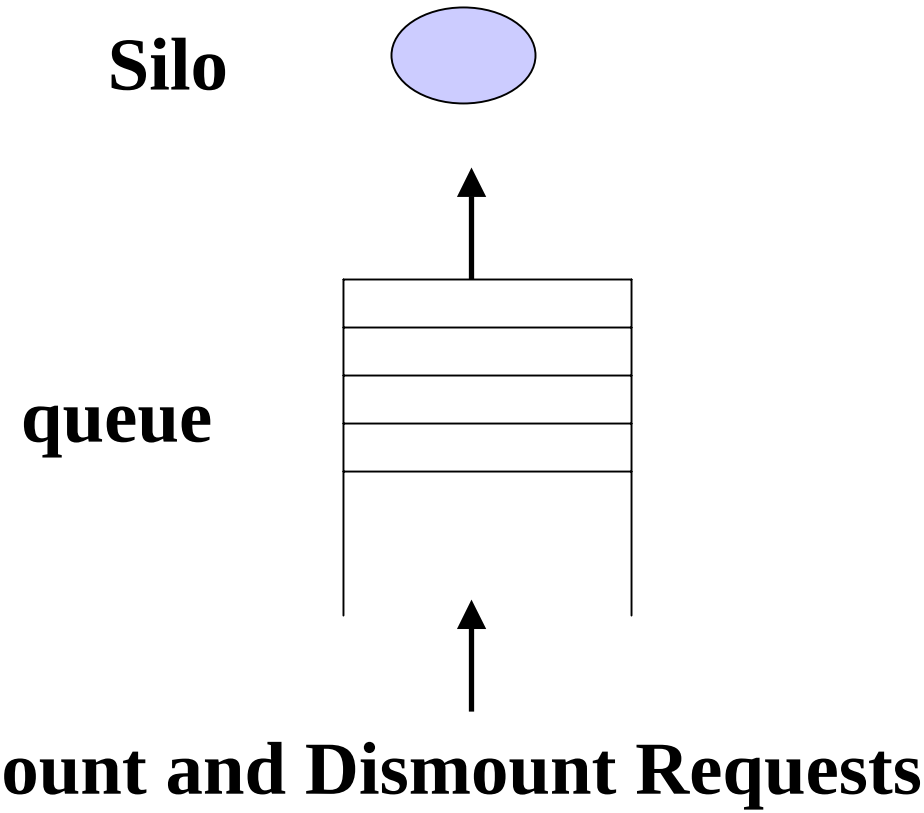
Silo Example



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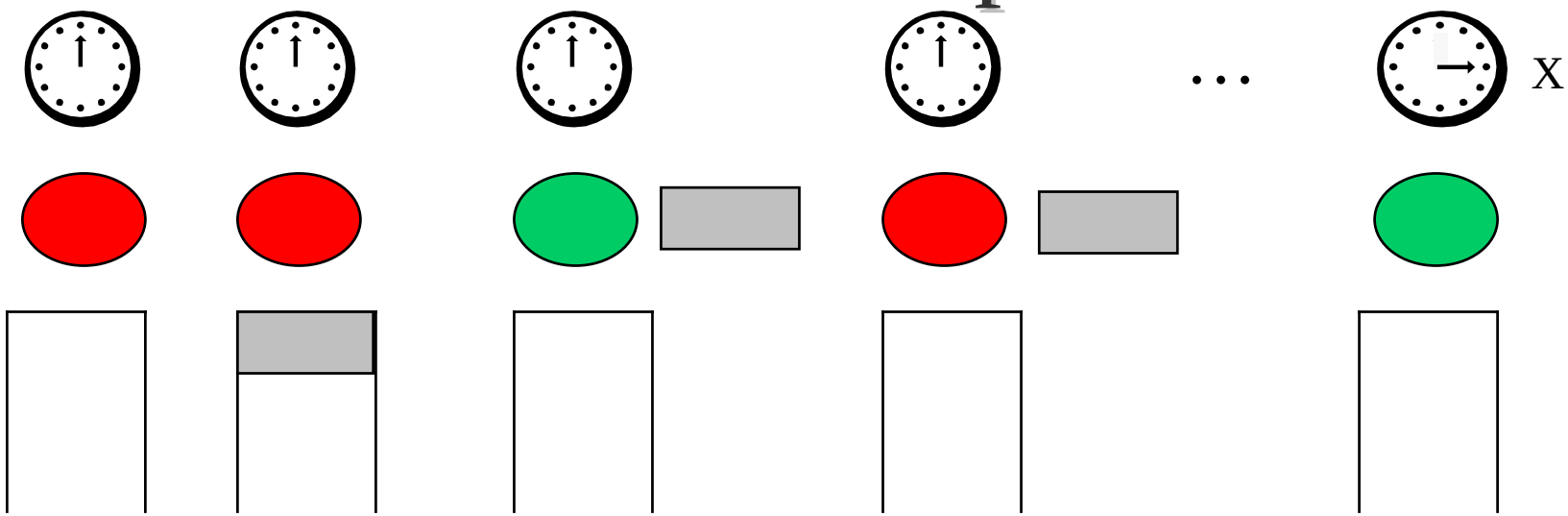
Silo Example



IDLE

REQUEST ARRIVES

THREAD IS RESUMED

THREAD IS SUSPENDED UNTIL TIME X

THREAD IS RESUMED AND RETURNS SUCCESS

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Silo Example

- Many details of a real silo were ignored.
- As in real system, if request arrival rate exceeds rate at which requests can be processed, queue length grows.
- Example is a typical server with a queue.
- Example is representative of how other servers are simulated. Each one is a thread and typically has a queue.

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Estimating Delay Parameters

- Once code was implemented, service time parameters had to be estimated.
- Examples include time to mount a tape, time to load a tape and I/O transfer rates.
- Some parameters are constants and others vary.
- Estimates obtained from multiple sources.
- Parameters are configurable.

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Validation

- Checking that the predicted results closely match what would be observed in a real system.
- All components were individually validated and the simulator as a whole was also validated.
- Dozens of validation runs were performed for simplified cases where the exact answers are known and cases where simulator was configured like the real MSS.
- Validation is an on-going process.

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Running the Simulator

- Simulator is configured with a primitive ASCII configuration file.
- It is currently run on an IBM Power4 system.
- It takes about 24 wall clock hours and 7 GB of memory for a 6 month simulation.

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Limitations

- Simulator cannot predict the workload.
- All approaches to configuring the MSS are limited in the same way.
- Fortunately, workload is fairly well behaved.
- Not all components of the MSS currently taken into account.
- Metrics are averages and have error bounds of about 15%.

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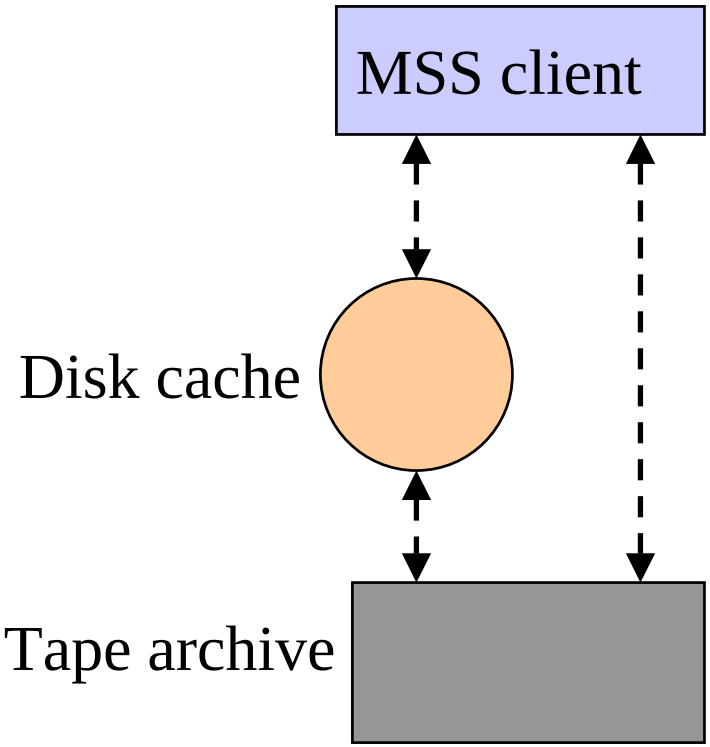
Example of Simulator Use



- Simulator was used to study benefits of expanding the disk cache.
- Read hit ratio was primary metric.
- Cache sizes and migration and staging policies were varied.

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Example of Simulator Use

- Simulation runs showed that there was a fair number of files that were read back within about 30 days of being written.
- Simulator was then used to help size a disk cache to offload reads from the tapes and provide faster response time to users.
- Estimated read hit ratios were around 60%.

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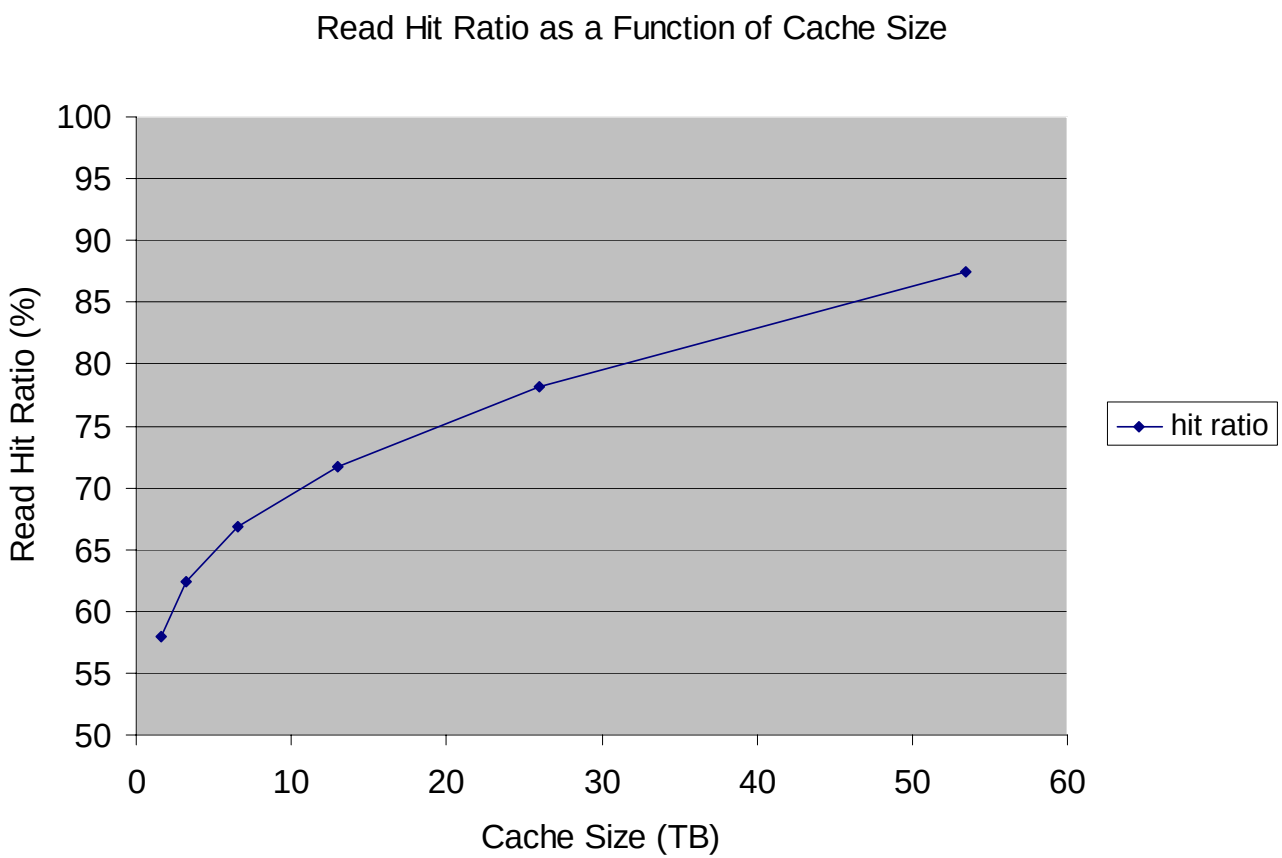
Predicted Read Hit Ratio



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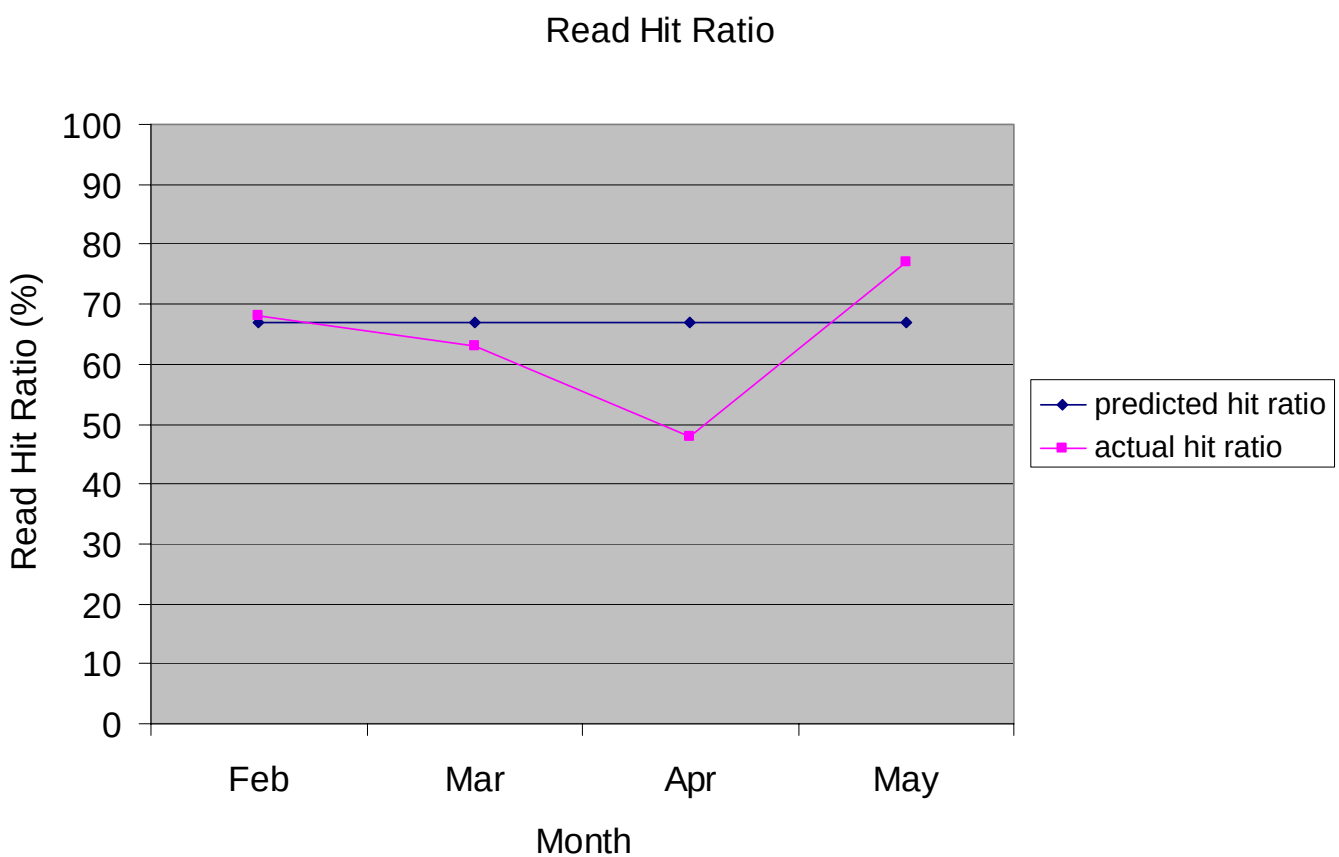
Actual Read Hit Ratio



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Future Uses of Simulator

- Study the effect of tape throughput density (ratio of transfer rate to capacity) on MSS performance
- Experiment with synthetic workloads
- Study what the most cost effective way to improve MSS performance might be

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Questions?

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