CPU Benchmarking Survey

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***Abstract*—This report explores CPU benchmarking, covering key performance metrics, types of benchmarks, and their uses. It discusses the importance of CPU benchmarking and also provides a brief history of benchmarking and its role in understanding processor performance.**

***Index Terms*—CPU benchmarking, processor performance, performance metrics**

I. Introduction

A CPU benchmark is designed to evaluate the performance of a computer or device CPU (or SoC) by running specific tests and workloads to compare their results.
Ideally, benchmarks should be used instead of the real application only if the application is unavailable or too difficult and costly to port to the processor.

II. Purpose of Benchmarking

The purpose of CPU benchmarking is to compare the performance of different CPU models and generations. It overcomes the limitations of comparing models based on the specifications provided. Benchmarking helps make an informed decision about selecting the best CPU for the required applications. It identifies potential bottlenecks in system performance that can enhance system optimization.

III. History of CPU Benchmarking

A. Standard EDP (Electronic Data Processing) Reports

The earliest attempts at CPU benchmarking trace back to 1962 in the form of Auerbach Corporation's Standard EDP Reports. These reports used a specific format to describe various features of computers in the market [5].

B. The Application Benchmark

The logical extension of Auerbach's benchmark tasks was advocated around 1965. The application benchmark was a set of routines executed on different computer configurations. The routines were used for specific applications and the comparison was based on total throughput time [5].

C. The Synthetic Benchmark

The synthetic benchmark came into being around 1969. Benchmarking was simplified with machine-independent tasks that helped in standardized and cost-effective comparisons. This method was easy to use, highly flexible, and could produce repeatable experiments [5].

D. The Standardized Benchmarks

Organizations like the Whetstone Benchmark and the Dhrystone Benchmark were introduced to measure floating-point and integer performance, respectively.

E. Modern Benchmarks

The introduction of multimedia and gaming workloads created a need for benchmarks focused on graphics and multi-threaded tasks. 3DMark became a widely recognized benchmark for graphics and gaming in the 1990s. By the 2000s, with the rise of multi-core processors, benchmarks began assessing parallel processing capabilities.

IV. Types of CPU Benchmark

- Synthetic Benchmark: A synthetic benchmark is a test designed to measure raw CPU performance using artificial workloads or simulations, instead of real-world tasks [3].
- Real-World Application Benchmark: It evaluates the system performance based on actual software or tasks in real-world scenarios [3].
- Gaming Benchmark: It assesses the system's performance by running graphically intensive video games to measure frame rates, graphics rendering, and overall gameplay smoothness [6].
- Micro-Benchmarks: It measures the performance of small and specific operations such as integer or floating-point operations, often focusing on low-level tasks [4].

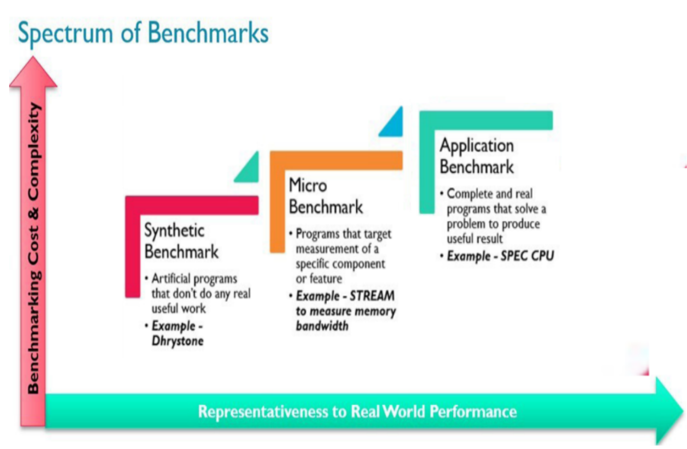

Fig. 1. Spectrum of Benchmarks

V. Available Benchmarks

A. Open-source Benchmarks

Phoronix Test Suite, Sysbench, CoreMark, Dhrystone, and Whetstone are a few examples of open-source benchmarks [2].

B. Licensed Benchmarks

Geekbench, PassMark, TPC Benchmarks, Ansys Fluent Benchmarks, PCMark, 3DMark and SYSmark (by BAPCo) are some examples of licensed benchmarks [2].

VI. Performance Metrics

- Clock Speed: It indicates how fast the CPU can process instructions. It is measured in gigahertz (GHz) [7]-[8].
- Instructions Per Cycle (IPC): IPC measures how many instructions a CPU can process in one clock cycle. A higher IPC means better performance for a given clock speed as it indicates a CPU is more efficient at executing tasks [9].
- Single-core Performance: The ability of the CPU to perform tasks using a single core, typically evaluated through benchmarks like Cinebench. Single-core performance is crucial for tasks that require sequential processing [3].
- Multi-core Performance: The CPU's ability to handle multiple tasks concurrently across all its cores. It is measured through multi-core benchmarks like Geekbench. Multi-core performance is critical for tasks like video rendering, scientific simulations, and modern workloads optimized for parallel processing [3].
- Core Count: The number of cores in a CPU determines how many tasks or threads the CPU can handle simultaneously. More cores generally mean better multithreaded performance, especially in workloads like video editing, rendering, and multitasking [9].
- Threads: Threads represent virtual cores created by simultaneous multithreading. More threads allow better performance in multithreaded tasks, though it is not always as efficient as having additional physical cores [9].
- Floating-Point Performance: It measures how efficient a CPU can perform floating-point calculations. Benchmarks like Linpack and Whetstone focus on floating-point performance [9].
- Memory Bandwidth: The rate at which the data can be read from or written to the CPU's memory subsystem. Higher bandwidth is beneficial for memory-intensive tasks such as video editing and large dataset analysis [10].
- Latency: It measures the delay between the instruction input and the start of its execution. Lower latency ensures a faster response time, especially for real-time applications [10].

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