

# Types of Workloads

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  - > Kernels
  - > Synthetic Programs
  - > Application Benchmarks: Sieve, Ackermann's Function, Debit-Credit, SPEC

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## Terminology

- **Test workload:** Any workload used in performance studies. Test workload can be real or synthetic.
- **Real workload:** Observed on a system being used for normal operations.
- **Synthetic workload:**
  - > Similar to real workload
  - > Can be applied repeatedly in a controlled manner
  - > No large real-world data files
  - > No sensitive data
  - > Easily modified without affecting operation
  - > Easily ported to different systems due to its small size
  - > May have built-in measurement capabilities.

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## Test Workloads for Computer Systems

1. Addition Instruction
2. Instruction Mixes
3. Kernels
4. Synthetic Programs
5. Application Benchmarks

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## Addition Instruction

- Processors were the most expensive and most used components of the system
- Addition was the most frequent instruction

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## Instruction Mixes

- Instruction mix = instructions + usage frequency
- Gibson mix: Developed by Jack C. Gibson in 1959 for IBM 704 systems.

1.	Load and Store	31.2
2.	Fixed-Point Add and Subtract	6.1
3.	Compares	3.8
4.	Branches	16.6
5.	Floating Add and Subtract	6.9
6.	Floating Multiply	3.8
7.	Floating Divide	1.5
8.	Fixed-point Multiply	0.6
9.	Fixed-point Divide	0.2
10.	Shifting	4.4
11.	Logical, And, Or, etc.	1.6
12.	Instructions Not Using Registers	5.3
13.	Indexing	18.0
	Total	100.0

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## Instruction Mixes (Cont)

- ❑ Disadvantages:
  - Complex classes of instructions not reflected in the mixes.
  - Instruction time varies with:
    - ❑ Addressing modes
    - ❑ Cache hit rates
    - ❑ Pipeline efficiency
    - ❑ Interference from other devices during processor-memory access cycles
    - ❑ Parameter values
    - ❑ Frequency of zeros as a parameter
    - ❑ The distribution of zero digits in a multiplier
    - ❑ The average number of positions of preshift in floating-point add
    - ❑ Number of times a conditional branch is taken

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## Instruction Mixes (Cont)

- ❑ Performance Metrics:
  - MIPS = Millions of Instructions Per Second
  - MFLOPS = Millions of Floating Point Operations Per Second

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## Kernels

- ❑ Kernel = nucleus
- ❑ Kernel = the most frequent function
- ❑ Commonly used kernels: Sieve, Puzzle, Tree Searching, Ackerman's Function, Matrix Inversion, and Sorting.
- ❑ Disadvantages: Do not make use of I/O devices

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## Synthetic Programs

- ❑ To measure I/O performance lead analysts to use Exerciser loops
- ❑ The first exerciser loop was by Buchholz (1969) who called it a synthetic program.
- ❑ A Sample Exerciser: See program listing Figure 4.1 in the book

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## Synthetic Programs

- ❑ Advantage:
  - Quickly developed and given to different vendors.
  - No real data files
  - Easily modified and ported to different systems.
  - Have built-in measurement capabilities
  - Measurement process is automated
  - Repeated easily on successive versions of the operating systems
- ❑ Disadvantages:
  - Too small
  - Do not make representative memory or disk references
  - Mechanisms for page faults and disk cache may not be adequately exercised.
  - CPU-I/O overlap may not be representative.
  - Loops may create (synchronizations) better or worse performance.

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## Application Benchmarks

- ❑ For a particular industry: Debit-Credit for Banks
- ❑ Benchmark = workload (Except instruction mixes)
- ❑ Some Authors: Benchmark = set of programs taken from real workloads
- ❑ Popular Benchmarks

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## Example Benchmarks

- ❑ TPC
- ❑ SPEC
- ❑ Whetstone
- ❑ U.S. Steel
- ❑ LINPACK
- ❑ Dhrystone
- ❑ Lawrence Livermore Loops
- ❑ Digital Review Labs
- ❑ Abingdon Cross Image-Processing Benchmark

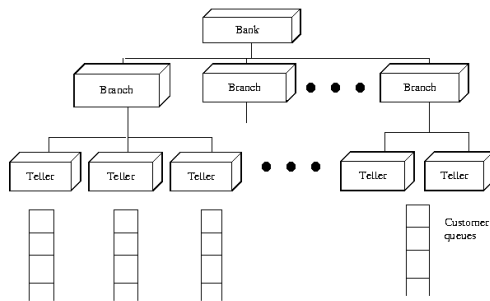
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## Debit-Credit Benchmark

- ❑ A de facto standard for transaction processing systems.
- ❑ First recorded in Anonymous et al (1975).
- ❑ In 1973, a retail bank wanted to put its 1000 branches, 10,000 tellers, and 10,000,000 accounts online with a peak load of 100 Transactions Per Second (TPS).
- ❑ Each TPS requires 10 branches, 100 tellers, and 100,000 accounts.

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## Debit-Credit (Cont)



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## Debit-Credit Benchmark (Continued)

- ❑ Metric: price/performance ratio.
- ❑ Performance: Throughput in terms of TPS such that 95% of all transactions provide one second or less response time.
- ❑ Response time: Measured as the time interval between the arrival of the last bit from the communications line and the sending of the first bit to the communications line.
- ❑ Cost = Total expenses for a five-year period on purchase, installation, and maintenance of the hardware and software in the machine room.
- ❑ Cost does not include expenditures for terminals, communications, application development, or operations.

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## Pseudo-code Definition of Debit-Credit

- ❑ See Figure 4.5 in the book
- ❑ Four record types: account, teller, branch, and history.
- ❑ Fifteen percent of the transactions require remote access
- ❑ Transactions Processing Performance Council (TPC) was formed in August 1988.
- ❑ TPC Benchmark™ A is a variant of the debit-credit
- ❑ Metrics: TPS such that 90% of all transactions provide two seconds or less response time.

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## TPC

- ❑ <http://www.tpc.org/>
- ❑ TPC-C simulates a complete computing environment where a population of users executes transactions against a database. TPC-C performance is measured in new-order transactions per minute. The primary metrics are the transaction rate (tpmC), and the associated price per transaction (\$/tpmC).

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## TPC-E

- **TPC-E** uses a database to model a brokerage firm with customers who generate transactions related to trades, account inquiries, and market research. The brokerage firm in turn interacts with financial markets to execute orders on behalf of the customers and updates relevant account information. The TPC-E metric is given in transactions per second (tps).

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## TPC-H

- **TPC-H** is a decision support benchmark. It consists of a suite of business oriented ad-hoc queries and concurrent data modifications. The performance metric reported by TPC-H is called the TPC-H Composite Query-per-Hour Performance Metric (QphH@Size) for a specific database size. The TPC-H Price/Performance metric is expressed as \$/QphH@Size.

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## TPC-Energy

- **TPC-Energy** contains the rules and methodology for measuring and reporting an energy metric in TPC Benchmarks. This includes the energy consumption of system components associated with typical business information technology environments.

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## SPEC Benchmark Suite

- Systems Performance Evaluation Cooperative (SPEC): Non-profit corporation formed by leading computer vendors to develop a standardized set of benchmarks.
- [www.spec.org](http://www.spec.org)
- **SPEC CPU2006** designed to provide performance measurements that can be used to compare compute-intensive workloads on different computer systems, contains two benchmark suites: **CINT2006** for measuring and comparing compute-intensive integer performance, and **CFP2006** for measuring and comparing compute-intensive floating point performance.

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## SPEC (Cont)

- The elapsed time to run two copies of a benchmark on each of the N processors of a system (a total of 2N copies) is measured and compared with the time to run two copies of the benchmark on a reference system (which is VAX-11/780 for Release 1.0).
- For each benchmark, the ratio of the time on the system under test and the reference system is reported as **SPECthruput** using a notation of #CPU@Ratio. For example, a system with three CPUs taking 1/15 times as long as the reference system on GCC benchmark has a SPECthruput of **3@15**.
- Measure of the per processor throughput relative to the reference system. Uses the geometric mean.
- Base, Peak, Rate

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## Summary



- Synthetic workload are representative, repeatable, and avoid sensitive information
- Add instruction – most frequent instruction initially
- Instruction mixes, Kernels, synthetic programs
- Application benchmarks: Sieve, Ackerman, ...
- Benchmark standards: Debit-Credit, SPEC

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