Benchmarks

- Must be representative of actual workloads
- Early Benchmarking Techniques (70s and 80s)
- Speed of ADD or MULTIPLY
- SORT
- Whetstone (fp)
- Dhrystone (int)
- Linpack
- Lawrence Livermore Loops (LLLs)

An Overview of Common Benchmarks R. Weicker, IEEE Computer, Dec 1990

- Most Common Stone Age Benchmarks
- Whetstone
- Dhrystone
- Linpack
- Sieve of Eratosthenes
- EDN Benchmarks

Table A. Statement distribution in percentages. *

Statement	Dhrystone	Whetstone	Linpack/saxpy
Assignment of a variable	20.4	14.4	-
Assignment of a constant	11.7	8.2	-
Assignment of an expression (one operator)	17.5	1.4	-
Assignment of an expression (two operators)	1.0	24.3	48.5
Assignment of an expression (three operators)	1.0	1.6	-
Assignment of an expression (>three operators)	-	6.8	-
One-sided if statement, "then" part executed	2.9	0.5	-
One-sided if statement, "then" part not executed	3.9	0.1	2.2
Two-sided if statement, "then" part executed	4.9	4.0	-
Two-sided if statement, "else" part executed	1.9	4.0	-
For statement (evaluation)	6.8	17.3	49.3
Goto statement	-	0.5	-
While/repeat statement (evaluation)	4.9	-	-
Switch statement	1.0	-	-
Break statement	1.0	-	-
Return statement (with expression)	4.9	-	-
Call statement (user procedure)	9.7	11.9	-
Call statement (user function)	4.9	-	
Call statement (system procedure)	1.0	-	
Call statement (system function)	1.0	4.7	-
	100	100	100

*Because of rounding, all percentages can add up to a number slightly below or above 100.

Table B. Operator distribution in percentages.

Operator	Dhrystone	Whetstone	Linpack/saxpy
+ (int/char)	21.0	11.9	14.1
- (int)	5.0	6.0	-
* (int)	2.5	6.0	-
/ (int)	0.8	-	-
Integer arithmetic	29.3	23.9	14.1
+ (float/double)	-	14.9	14.1
- (float/double)	-	2.1	-
* (float/double)	-	9.3	14.1
/ (float/double)	-	4.6	-
Floating-point arithmetic	-	30.9	28.2
<, <= (incl. loop control)	10.1	10.7	14.5
Other relational operators	11.7	2.8	0.6
Relational	21.8	13.5	15.1
Logical	3.3	-	0.2
Indexing (one-dimensional)	5.9	24.5	42.3
Indexing (two-dimensional)	3.4	-	-
Indexing	9.3	24.5	42.3
Record selection	7.6	-	-
Record selection via pointer	15.1	-	-
Record selection	22.7	-	-
Address operator (C)	5.0	3.6	-
Indirection operator (C)	8.4	3.6	-
C-specific operators	13.4	7.2	-
Total	100	100	100

Operand distribution

Table C. Operand data-type distribution in percentages.

Operand Data Type	Dhrystone	Whetstone	Linpack/saxpy
Integer	57.0	55.7	67.2
Char	19.6	-	-
Float/double	-	44.3	32.8
Enumeration	10.9	-	-
Boolean	4.2	-	-
Array	0.8	-	-
String	2.3	-	-
Pointer	5.3	-	-
	100	100	100

Operand Locality

Table D. Operand locality distribution in percentages.

Operand Locality	Dhrystone	Whetstone	Linpack/saxpy
Local	48.7	0.4	49.5
Global	8.3	56.3	-
Parameter (value)	10.6	18.6	17.0
Parameter (reference)	6.8	1.9	24.6
Function result	2.3	1.3	-
Constant	23.4	21.6	8.8
	100	100	100

Whetstone – an early FP Benchmark

Table 1. Procedure profile for Whetstone.*

Procedure	Percent	What is done there
Main program	18.9	
p3	14.4	FP arithmetic
p0	11.6	Indexing
pa	1.9	FP arithmetic
User code	46.8	
Trigonometric functions	21.6	Sin, cos, atan
Other math functions	31.7	Exp, log, sqrt
Library functions	53.3	
Total	100	

*Because of rounding, all percentages can add up to a number slightly below or above 100.

Linpack

Table 2. Procedure profile for Linpack.

Procedure	Percent	What is done there
Main program	0.0	
matgen	13.8	
sgefa	6.2	
saxpy	77.1	$y[i] = y[i] + a*x[i]$
isamax	1.6	
Miscellaneous	1.2	
User code	100	
Library functions	0.0	

Dhrystone

Table 3. Dhrystone procedure profile.

Procedure	Percent	What is done there
Main program	18.3	
User procedures	65.7	
User code	84.0	
strcpy	8.0	String copy (string constant)
strcmp	8.1	String comparison (string variables)
Library functions	16.1	
Total	100	

Stone Age Benchmarks

- Small loops
- Heavy use of global variables
- Most part of exec time spent in 1 or 2 loops
- Code size small
- Dead code elimination eliminates most of code
- Cheating and unfair optimizations
- SPEC and TPC founded in 1988

Benchmarks

- CPU Benchmarks
- (SPEC/SPLASH/STREAMS)
- Transactions Processing Benchmarks
- Embedded and Media Benchmarks
- HPC (Supercomputing) Benchmarks
- Cloud/Big Data Benchmarks
- Web Server Benchmarks
- Browser Benchmarks
- PC Benchmarks
- Parallel Processing Benchmarks (NPB)
- Java Benchmarks (SPECjvm98, SPECjvm2008)
- GPU Benchmarks

Standard Performance Evaluation Corporation

Benchmarks

- CPU
- Graphics/Workstations
- ACCEL/MPI/OMP
- Java Client/Server
- Mail Servers
- Network File System
- Power
- SIP
- SOA
- Virtualization
- Web Servers

- Results Search

- Submitting Results
  CPU/Java/Power/SFS
  SIP/Virtualization
  ACCEL/MPI/OMP
  SPECapc/SPECviewperf/SPECwpc

Tools

- SERT
- PTDaemon
- Chauffeur WDK

SPEC's Benchmarks

CPU

- **SPEC CPU2006**
  [benchmark info] [published results] [support] [order benchmark]
  Designed to provide performance measurements that can be used to compare comput
  systems, SPEC CPU2006 contains two benchmark suites: CINT2006 for measuring ar
  performance, and CFP2006 for measuring and comparing compute-intensive floating p

- **SPEC CPUv6**
  [info]
  The CPU Search Program seeks to to encourage those outside of SPEC to assist us ir
  CPU-intensive benchmark suite, currently designated as SPEC CPUv6.

- **SPEC CPU2000**
  [Retired]

- **SPEC CPU95**
  [Retired]

SPEC CPU Benchmarks

- SPEC CPU 1989 (10 programs, 4C INT, 6F FP)
- SPEC CPU 1992 (20 prog, 6 C INT, 14 FP (2 C, 12F))
- SPEC CPU 1995 (18 programs, 8 C INT, 10 F FP)
- SPEC CPU 2000 (26 p, 12 INT (11C,
  - 1C++), 14 FP (10F, 4C))
- SPEC CPU 2006 (29 prog, 12INT,17 FP) (C,C++, F)
- SPEC CPU 2014/2015

TPC Benchmarks

- Database and Transactions Benchmarks
- TPC (Transactions Processing Council) – formed in August 1988
- www.tpc.org
- Founder – Mr. Serlin (convinced 8 companies to have benchmarks for Transactions workloads)
- Full members of TPC are companies like Oracle, Cisco, SAP, Cloudera, HP, IBM, Huawei, Teradata, Microsoft, Redhat, Vmware
- Dr. Jim Gray was an early major contributor.

TPC Benchmarks
www.tpc.org

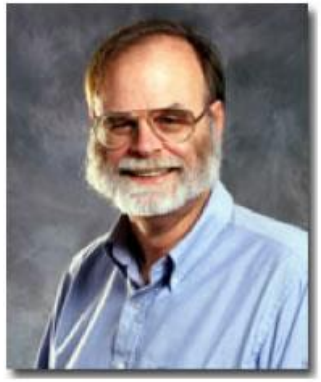
Current Benchmarks

- TPC-C
- TPC-H
- TPC-E
- TPC-DS
- TPC-VMS
- TPC-Energy

Obsolete Benchmarks

TPC-A
TPC-B
TPC-D
TPC-R
TPC-W
TPC-App

TPC Benchmarks – Jim Gray, a TPC Benchmarking Pioneer



- Dr. Jim Gray was an early major contributor.
- Jim Gray was Tandem's TPC-rep in 1988
- He wrote a 1985 paper called "A Measure of Transactions Processing Power" and created the Debit-Credit benchmarks which 4 years later became the first TPC Benchmark TPC-A.
- Led Top-Gun Benchmark work at Tandem (1987)
- Won Turing award in 1998
- NAE Member
- He was in Microsoft for about 10 years when he was lost at sea in Jan 2007

Transaction Categories

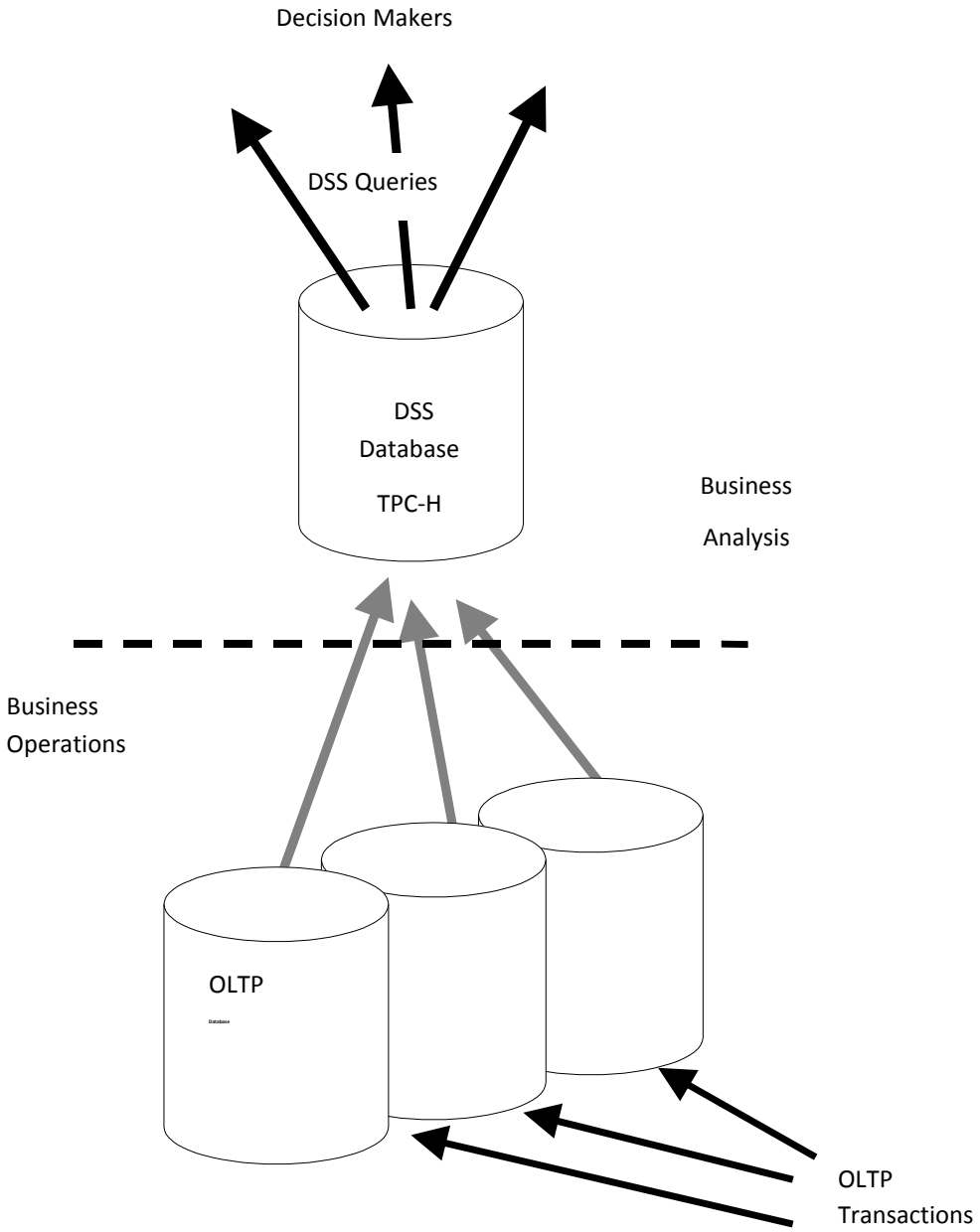
- OLTP and DSS
- On Line Transactions Processing
- Decision Support Systems
- OLAP (On Line Analytics Processing)

On-line Transaction Processing (OLTP) Workloads

- Day to day business workloads
  - Airline reservation, www.travelocity.com, expedia.com
  - On-line bank tellers
- Characterized by a large number of clients who continually access and update small portions of the database through short-running transactions

Decision Support Systems (DSS)

- Business analysis purposes
- Information from the OLTP side of a business is periodically fed into the DSS database and analyzed.
- Contrast to OLTP - DSS is characterized by long running queries that are primarily read-only, may span a large fraction of the database.


Decision Makers
DSS Queries
DSS
Database
TPC-H
Business
Analysis
Business
Operations
OLTP
Database
OLTP
Transactions

TPC Benchmarks
www.tpc.org

Current Benchmarks

- TPC-C (OLTP)
- TPC-H (DSS)
- TPC-E (OLTP)
- TPC-DS (DSS)
- TPC-VMS (Run rules for virtualized runs)
- TPC – Energy (run rules for power/energy)
- TPC-Big data benchmark on the way