2001

B-Nodes: A Proposed New Technique for Database Design and Implementation

S.P Maj
Edith Cowan University, p.maj@cowan.edu.au

G Kohli
Edith Cowan University

B-Nodes: A Proposed New Technique for Database Design and Implementation

S. P. Maj and G. Kohli

Department of Computer Science
Edith Cowan University, Western Australia
p.maj@cowan.edu.au

Abstract

There exist a wide range of methods that can be used for the analysis and design of IT systems. However a survey of a wide range of methods and a detailed analysis of one structured method indicated the lack of a simple method for modeling hardware. The ORACLE database provides detailed guidelines regarding the minimum platform to run the database and how to derive table spaces (system, user, applications, rollback etc) size of shared pool buffer, Redo log buffer pool etc.that can be used to define hard disc capacity. The system can then be optimised. However little guidance is given regarding the performance of other devices (microprocessor, RAM, bus structures etc). This paper evaluates the new B-Node modeling technique as a possible standard technique in structured systems analysis and design for evaluating hardware performance.

Keywords

Systems Analysis and Design, modeling, B-Nodes

INTRODUCTION

There are a wider range of systems analysis methods that employ a variety of different modeling tools and techniques. A method consists of phases or stages that in themselves may consist of sub-phases. Systems analysis and design methods include: ad hoc (Jones 1990), waterfall (Royce 1970), participative (Mumford and Wier 1979), soft systems (Checkland 1981), prototyping (Nauumann and Jenkins 1982), incremental (Gibb 1988), spiral (Boehm 1984), reuse (Matsumoto and Ohno 1989), formal (Andrews and Ince 1991), rapid application development (Martin 1991), object oriented (Coad and Yourdon 1991) and software capability (Humphrey 1990). Regardless of the underlying theme of each information system all methods must provide techniques for modeling data, processes and system functions. However, there appears to be no simple technique that will model the digital infrastructure (hardware and software) to determine if it will perform to an acceptable standard required by the analysis and design specifications. The Structure Systems Analysis and Design Method (SSADM) was evaluated in-depth as a method for developing an information system. SSADM is mandatory for UK central government software development projects. This method is sponsored by the Central Computer and Telecommunications Agency (CCTA) and the National Computing Center (NCC) thereby further ensuring its importance within the software industry within the UK. SSADM provides tools that allow the estimation of storage requirements. From the Composite Logical Data Design and Logical Design Volumes, detailed information about the data volumes may be extracted. It is possible to obtain detailed information about: data space for each data group, volumes of each data group, volumes of relationships, variance of volumes over time etc. However, according to Ashworth,

> '*The prediction of overall system performance is a difficult area and there are several simulation programs and experts system programs available which attempt to predict and improve system performance either generally or for specific hardware and software*.' (Ashworth and Goodland 1990)

Other than this there are no simple tools or techniques that can be used for the selection of hardware. Furthermore, SSADM employ a range of different, heterogeneous performance metrics that include: MPS, CPU time, disk access time, number of instructions per database call etc. Such benchmark metrics are in themselves problematic as it is not possible to directly relate the technical specification to metrics typically used in the Service Level agreement e.g. Transactions/s, Throughput etc.

Database design using ORACLE

Oracle provides technical specifications for the minimum platform to run the database (e.g. Uni-processor Pentium 300MHz, 128Mbytes RAM and 1.2 Gbytes Hard Disc space for the database installation). Other architectural solutions include: Symmetric Multiprocessor Systems (SMP), Clusters, Massively Parallel

Processing Systems (MPP) and Non-uniform Memory Access Computers (NUMA)) Table 1 (R Greenwald 1999).However, beyond this, little guidance is provided for the selection of hardware.

Ranking	Scalability	Manageability	Availability	Price
Best	MPP	Uni-processor	Cluster	Uni-processor
	Cluster	SMP	MPP	SMP
	NUMA	NUMA	NUMA	Cluster
	SMP	MPP	SMP	NUMA
Worst	Uni-processor	Cluster	Uniprocessor	MPP

Table 1: Processor Architectures

Standard Entity Relationship Diagrams (ERD's) are used to determine the number of tables needed from which it is possible to calculate the upper and lower table space limits for the user, applications, roll backs etc. Hence the size of the hard disc can be calculated. The main emphasis here is database sizing for current and future needs. It is then possible to tune the Oracle database using performance views such as V$SYSTEM_EVENT and V$SESSION_WAIT. Solutions to I/O bottlenecks include: disk striping technologies to spread I/O across spindles (e.g. Redundant Array of Independent Disks (RAID) technology), use of table-space to segregate and target different types of I/O, distribute system overheads evenly across spindles.

Following this it is possible to optimize the database using either a cost-based or rule-based criteria. Cost based optimizer depends upon Logical reads, CPU, and Network calls. The cost base optimiser has access to statistics relating to the tables and indexes, such as the size of the table, the min and max value in indexed columns. The cost based optimiser uses the INIT.ORA parameter DB_FILE_MULTI_BLOCK_READ to estimate the number of I/O's required to perform a full table scan.
indexed columns.

Bandwidth Nodes

A PC is a collection of heterogeneous technologies (microprocessor, electronic memory, hard disc drive etc). Comparison of the relative performance of these different technologies is difficult due to the use of heterogeneous units that include: MHz, nanoseconds, seek times in milliseconds etc. However a PC and its associated sub-modules (microprocessor, electronic memory, hard disc drive etc) may be modeled using B-Nodes (Maj, Veal et al. 2000). Each B-Node can be treated as a data source/sink capable of, to various degrees, data storage, processing and transmission. The performance of each B-Node may be calculated, to a first approximation, by Bandwidth = Clock Speed x Data Path Width (B = C x D) with units in either MBYTES/S. The use of a common fundamental unit (MBYTES/S) allows the relative performance of these heterogeneous technologies to be directly compared. The use of B-Nodes using the performance metrics of MBYTES/S and Images/s has been confirmed experimentally (Maj, Veal et al. 2000). Furthermore, the use of a simple, fundamental unit allows other derived metrics to be used. By example, the units Images/s may be more meaningful to a typical user because it relates directly to their perception of performance. An image is defined as 1024x1024 pixels with a color depth of 3 bytes per pixel i.e. 3MBytes. To a first approximation, smooth animation requires approximately 30 Images/s (90MBYTES/S). The performance of each B-Node may be calculated using this metric. We have therefore a common unit of measurement, relevant to common human perception, with decimal based units, that can be applied to different nodes and identify performance bottlenecks. Similarly other metrics may be derived.

Device	Clock Speed (MHz)	Data Width (Bytes)	Bandwidth (MBYTES/S) B = C x D	Bandwidth (Images/s)
Processor	400	8	3200	1066
DRAM	16 (60ns)	8	128	42
Hard Disc	60rps	90Kb	5.4	1.8
CROM	(30 speed)	(150Kbytes/s)	4.6	1.5
ISA Bus	8	2	16	5.3
Ethernet	100	1/8	12.5	4.1

Table2: Bandwidth

The B-Node model has been successfully applied to a wide range of PC architectures allowing a direct comparison not only between different B-Nodes within a given PC but also comparisons between different PC's. Using B-Nodes it was possible to analyze PC's with different Intel microprocessors (8088/6, 286, 386, 486 etc.) and various associated bus structures (Micro Channel Architecture, Extended Industry Standard Architecture, Video Electronic Standards (VESA) Local Bus).

B-Nodes typically operate sub-optimally due to their operational limitations and also the interaction between other slower nodes. For example, a microprocessor may need two or more clock cycles to execute an instruction. Similarly a data bus may need multiple clock cycles to transfer a single data word. The simple bandwidth equation can be modified to take this into account i.e. Bandwidth = Clock x Data Path Width x Efficiency (B = C x D x E). The early Intel 8088/86 required a memory cycle time of 4 clocks cycles (Efficiency = ¼) however, for the Intel 80x86 series, including the Pentium, the memory cycle time consists of only 2 clocks (Efficiency = ½) for external DRAM. Efficiencies can be calculated for each device and the performance calculated accordingly.

B-Nodes and E-Business Architecture

Using a structured systems analysis and design method, such as SSADM, it is possible to design a database for an e-business system. For such a system the Customer Model can be used to describe the user behavior patterns in which the number of clients, type of resources requested, pattern of usage etc are all used to determine the workload characteristics. Workload characteristics, in conjunction with the resource infrastructure model will determine site performance and whether or not the Service Level Agreements can be met. Customer Behavior Modeling methods have been successfully used to determine aggregate metrics for E-Commerce web sites (Menasce, Almeida et al. 1999). Using these various models it is possible to obtain a wide variety of different performance metrics that include: Hits/s, Page Views/Day, Unique Visitors etc. Furthermore, the SSADM method employs a range of different, heterogeneous performance metrics that include: MPS, CPU time, disk access time, number of instructions per database call etc. Given this wide range of different units performance evaluation is problematic. By example how can the units of Hit/s be used to select the bus structure of a PC? However, if a web server is modeled as a B-Node then the performance metric is bandwidth with units of MBYTES/s. The sub-modules of a server (microprocessor, hard disc, electronic memory etc) and also be modeled as B-Nodes, again using the same performance metric. The use of fundamental units (MBYTES/s) allow other units to be derived and used e.g. transactions per second (tps). Assuming the messages in a client/server interaction are 10kbytes each, the performance of each B-Node can be evaluated using the units of transactions/s (Table 3)

Device	Clock Speed (MHz)	Data Width (Bytes)	Efficiency	Bandwidth (MBYTES/S) B = C x D x E	Bandwidth (Tps)	Load (Tps)	Utilization
Processor	400	8	0.5	1600	160k	250	<1%
DRAM	16 (60ns)	8	0.5	64	6.4k	250	4%
Hard Disc	60rps	90Kb	0.5	2.7	270	250	93%
CROM	(30 speed)	(150kBytes/s)	0.5	2.3	230	250	>100%
ISA Bus	8	2	0.25	4	400	250	63%
Ethernet	100	1/8	0.9	11.25	1.1k	250	23%

Table 3: Bandwidth (Transactions/s)

If the demand on this server is 250 Transactions/s it is a simple matter to determine both performance bottlenecks and also the expected performance of the equipment upgrades. From table 2 it is possible to determine that for this web server, the hard disc drive, CDROM and ISA bus are inadequate. The metric of transactions/s can easily be converted to the fundamental unit of MBYTES/S, which can then be used to determine the required performance specification of alternative bus structures, CDROM devices and hard discs. A PCI (32 bit) bus structure is capable of 44MBYTES/S. A 40-speed CDROM device has a bandwidth of approximately 6MBYTES/S. Similarly replacing the single hard disc drive by one with a higher performance specification (rpm and higher track capacity) results is a new server capable of meeting the required workload.

CONCLUSIONS

A survey of a wide range of methods and a detailed analysis of one structured method (SSADM) indicated the lack of a simple method for modeling hardware. Similarly some software vendors provide only limited guidance for the selection of hardware. A possible modeling method is B-Nodes. B-Nodes are easy to use, scalable and hence can be used for PC modules (microprocessor, hard disc etc). The use of recursive decomposition allows detail to be controlled. An e-commerce server infrastructure may be modeled as a B-Node or collection of B-Nodes (microprocessor, hard disc etc). B-Nodes use a fundamental performance metric (MBYTES/S) from which other, more meaningful metrics may be derived. As B-Nodes use abstraction they are independent of underlying technologies and are applicable not only for old and current technologies but may well be of value for some time to come.

REFERENCES

Andrews, D. and D. Ince (1991). Practical Formal Methods with VDM. New York, McGraw Hill.

Ashworth, C. and M. Goodland (1990). SSADM: A Practical Approach. London, McGraw-Hill.

Boehm, B. W. (1984). "A software development environment for improving productivity." Computer 17(6): 30-42.

Checkland, P. B. (1981). Systems Thinking, Systems Practice. Chichester, John Wiley.

Coad, P. and E. Yourdon (1991). Object-oriented Analysis. Englewood Cliffs, NJ, Prentice-Hall.

Gibb, T. (1988). Principles of Software Engineering Management. Reading, MA, Wesley.

Humphrey, W. S. (1990). Managing the Software process. Reading, MA, Addison-Wesley.

Jones, G. W. (1990). Software Engineering. New York, Wiley.

Maj, S. P., D. Veal, et al. (2000). Is Computer Technology Taught Upside Down? 5th Annual SIGCSE/SIGCUE Conference on Innovation and Technology in Computer Science Education, Helskinki, Finland, ACM.

Martin, J. (1991). Rapid Application Development. New York, Macmillan.

Matsumoto, Y. E. and Y. E. Ohno (1989). Japanese Perspectives in Software Engineering Practice. Reading, MA, Addison-Wesley.

Menasce, D. A., V. A. F. Almeida, et al. (1999). A Methodology for Workload Characterization for E-Commerce Servers. 1999 ACM Conference in Electronic Commerce, Denver, CO, ACM.

Mumford, E. and M. Wier (1979). Computer Systems in Work Design - the ETHICS Method. London, Associated Business Press.

Nauumann, J. D. and A. M. Jenkins (1982). Prototyping: the new paradigm for systems development. MIS Quarterly.

Royce, W. W. (1970). Managing the development of large software systems: concepts and techniques. WESCON.

R Greenwald, R. S., J Stern (1999). Oracle Essentials, O'Reilly.

COPYRIGHT