DB101 – Five-minute rules

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Back in the 1960s...

ORGANIZATION AND MAINTENANCE OF LARGE

ORDERED INDICES

by

R. Bayer

and

E. McCreight

Back in the 1970s…

Information Retrieval

A Relational Model of Data for Large Shared Data Banks

E. F. Codd
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Future users of large data banks must be protected from having to know how the data is organized in the machine (the internal representation). A prompting service which supplies such information is not a satisfactory solution. Activities of users at terminals and most application programs should remain unaffected when the internal representation of data is changed and even when some aspects of the external representation are changed. Changes in data representation will often be needed as a result of changes in query, update, and report

Back in the 1980s…

THE 5 MINUTE RULE FOR TRADING MEMORY FOR DISC ACCESSES
and
THE 10 BYTE RULE FOR TRADING MEMORY FOR CPU TIME

Jim Gray
Franco Putzolu

THE FIVE MINUTE RULE
Data referenced every five minutes
should be memory resident.

ACM SIGMOD conf 1987, p 396-398

ABSTRACT: If an item is accessed frequently enough, it should be main memory resident. For current technology, "frequently enough" means about every five minutes.

These results depend on current price ratios of processors, memory and disc accesses These ratios are changing and hence the constants in the rules are changing.

Prices to fetch each time vs to hold

The derivation of the five minute rule goes as follows: A disc, and half a controller comfortably deliver 15 random accesses per second and are priced at about 15K$ [Tandem] So the price per disc access per second is about 1K$/a/s. The extra CPU and channel cost for supporting a disc is 1K$/a/s. So one disc access per second costs about 2K$/a/s. **$2K / (a/s)**

A megabyte of main memory costs about 5K$, so a kilobyte costs 5$.

If making a 1Kb data record main-memory resident saves 1a/s, then it saves about 2K$ worth of disc accesses at a cost of 5$, a good deal. If it saves .1a/s then it saves about 200$, still a good deal. Continuing this, the break-even point is one access every 2000/5 ~ 400 seconds.

So, any 1KB record accessed more frequently than every 400 seconds should live in main memory 400 seconds is "about" 5 minutes, hence the name. the Five Minute Rule.

Calculation parameters

Let:

RI: expected interval in seconds between references to the data (second/access).

M$: the cost of a byte of main memory ($/byte)

A$: the cost of a disc access per second ($/access/second). **$ / (a/s)**

B: the size of the data (byte).

Then, assuming B < Bmax, the savings in dollars of keeping the record B main memory resident is.

$$\frac{A\$}{RI} - M\$*B \frac{\$ / (a/s)}{s/a} - \$/b \times b \Leftrightarrow \$-\$$$

At the break-even point, this expression is zero. Solving for RI gives

$$RI = \frac{A\$}{M\$*B} \frac{\$ / (a/s)}{\$/b \times b} = s/a$$

"… 10 years later"

$$BreakEvenReferenceInterval\ (seconds) = \frac{PagesPerMBofRAM}{AccessPerSecondPerDisk} \times \frac{PricePerDiskDrive}{PricePerMBofRAM}$$

$$\frac{PagesPerGBofRAM}{PricePerGBofRAM} \times \frac{PricePerDiskDrive}{AccessesPerSecondPerDisk}$$

The future, as seen from 1987

Extrapolating these trends to 1996, the 5 minute rule will become the 5 hour rule -- data used once every five hours will be main memory resident. In that time-frame, there will be considerable interest in optimizing cpu cache occupancy since main memory will begin to look like secondary storage to processors and their memory caches.

Notes and conclusions

1. Applies beyond databases
2. Rules for provisioning, not for operations
3. In-memory storage plus buffer pool for I/O
4. “Scientific” investment decisions
5. It’s about the method and formula, not the constants!
6. Crucial parameter: record or page size
    a. For b-trees, max #comparisons per I/O device time
    b. Alternative: latency × bandwidth

Related readings

1. “The five-minute rule ten years later, and other computer storage rules of thumb” SIGMOD Rec 1997
2. “The five-minute rule 20 years later and how flash memory changes the rules” CACM 2009
3. “The five-minute rule 30 years later and its impact on the storage hierarchy” CACM 2019