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Top Ten SAS® Performance Tuning Techniques

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Abstract

The Base-SAS® software provides users with many choices for accessing, manipulating, analyzing, processing and producing quality data and results. Partly due to the power offered by the SAS software and the size of data sources, many application developers and end-users are in need of guidelines for more efficient use. This presentation highlights my personal top ten list of performance tuning and coding techniques for SAS users to apply in their applications. Attendees learn DATA and PROC step language statements and options that will help conserve CPU, I/O, data storage, and memory resources while accomplishing tasks involving processing, sorting, grouping, joining (merging), and summarizing data.

Introduction

When developing SAS program code and/or applications, efficiency is not always given the attention it deserves, particularly in the early phases of development. System performance requirements can greatly affect the behavior an application exhibits. Active user participation is crucial to understanding application and performance requirements.

Attention should be given to each individual program function to assess performance criteria. Understanding user expectations (preferably during the early phases of the application development process) often results in a more efficient application. Consequently, the difficulty associated with improving efficiency as coding nears completion is often minimized. This paper highlights several areas where a program's performance can be improved when using SAS software.

Efficiency Objectives

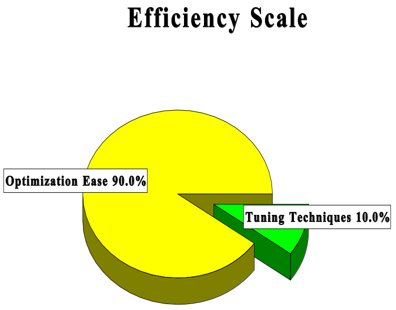
Efficiency objectives are best achieved when implemented as early as possible, preferably during the design phase. But when this is not possible, for example when customizing or inheriting an application, efficiency and performance techniques can still be "applied" to obtain some degree of improvement. Efficiency and performance strategies can be classified into five areas: CPU Time, Data Storage, Elapsed Time, I/O, and Memory.

Jeffrey A. Polzin of SAS Institute Inc. has this to say about measuring efficiency, *"CPU time and elapsed time are baseline measurements, since all the other measurements impact these in one way or another."* He continues by saying, *"... as one measurement is reduced or increased, it influences the others in varying degrees."*

The simplest of requests can fall prey to one or more efficiency violations, such as retaining unwanted datasets in work space, not subsetting early to eliminate undesirable observations, or reading wanted as well as unwanted variables. Much of an application's inefficiency can be avoided with better planning and knowing what works and what does not prior to beginning the coding process. Most people do not plan to fail - they just fail to plan. Fortunately, efficiency gains can be realized by following a few guidelines.

Guidelines to Hold Dear

The difference between an optimized software application (or process) versus one that has not been optimized is often dramatic. By adhering to practical guidelines, an application can achieve efficiency in direct relationship to economies of scale. Generally, as much as 90% of efficiency improvements can be gained quickly and with relative ease by applying simple strategies. But, the final 10% can often be a challenge. Consequently, you will need to be the judge as to whether your application has reached "relative" optimal efficiency while maintaining a virtual balance between time and cost.



The following suggestions are not meant as an exhaustive list of all known efficiency techniques, but as a sampling of proven methods that can provide some measure of efficiency. Performance tuning techniques are presented for the following resource areas: CPU time, data storage, I/O, memory, and programming time. Selective coding examples are illustrated in ***Table 1***.

CPU Time

1) Use KEEP= or DROP= data set options to retain desired variables.
2) Use WHERE statements, WHERE= data set option, or WHERE clauses to subset SAS datasets.
3) Create and access SAS datasets rather than ASCII or EBCDIC raw data files.
4) Use IF-THEN / ELSE or SELECT-WHEN / OTHERWISE in the DATA step, or a Case expression in PROC SQL to conditionally process data.
5) Use the DATASETS procedure COPY statement to copy datasets with indexes.
6) Use procedures such as PROC SQL when appropriate to consolidate the number of process steps.
7) Turn off the Macro facility when not needed.
8) Avoid unnecessary sorting - plan its use.
9) Use procedures that support the CLASS statement to take advantage of group processing without sorting.
10) Use the Stored Program Facility for complex DATA steps.

< and two more for good measure >

11) CPU time and elapsed time can be reduced with the SASFILE statement.
12) Use DATA step hash programming techniques to merge (or join) SAS datasets.

Data Storage

1) Use KEEP= or DROP= data set options to retain desired variables.
2) Process only the variables you need which removes unwanted variables from the program data vector (PDV).
3) Use LENGTH statements to reduce the size of a variable.
4) Use data compression strategies to reduce the amount of storage used to store datasets.
5) Create character variables for data that won’t be used for analytical purposes.
6) Shorten data by using informats and formats.
7) Use a DATA _NULL_ when writing to external files.
8) When the default physical BLKSIZE of 6KB is used more DASD space is often needed to hold a specified amount of data.
9) When insufficient disk space is unavailable to perform a sort process, consider using the SORT procedure’s TAGSORT option.
10) Remove unwanted SAS datasets with PROC DATASETS.

I/O

1) Read only data that is needed from external data files.
2) Minimize the number of times a large dataset is read by subsetting in a single DATA step.
3) Use KEEP= or DROP= data set options to retain only desired variables.
4) Use WHERE statements to subset data.
5) Use data compression for large datasets.
6) Use the DATASETS procedure COPY statement to copy datasets with indexes.
7) Use the SQL procedure to consolidate steps.
8) Store data in SAS datasets, not external files to avoid excessive read processing.
9) Perform data subsets early to reduce the number of reads.
10) Use indexed datasets to improve access to data subsets.

< and two more for good measure >

11) Use the OUT= option with PROC SORT to reduce I/O operations.
12) Experiment with different values for the BUFNO= option to adjust the number of open page buffers when processing SAS datasets.

Memory

1) Read only data that is needed.
2) Process only the variables you need which removes unwanted variables from the program data vector (PDV).
3) Use WHERE statements, WHERE data set options, or WHERE clauses to subset datasets when possible.
4) Avoid storing SAS catalogs in memory because they consume large quantities of memory.
5) If using arrays, create them as _TEMPORARY_ to reduce memory requirements.
6) Increase the REGION size when the amount of available memory is insufficient.
7) Use the SORTSIZE= system option to limit the amount of memory that is available to sorting.
8) Use the SUMSIZE= system option to limit the amount of memory that is available to summarization procedures.
9) Use the MEMSIZE= system option to control memory usage with the SUMMARY procedure.
10) Use the MVARSIZE= system option to specify the maximum size of in-memory macro variable values.

Programming Time

1) Use the SQL procedure for code simplification.
2) Use procedures whenever possible.
3) Document programs and routines with comments.
4) Utilize macros for redundant code.
5) Code for unknown data values.
6) Assign descriptive and meaningful variable names.
7) Store formats and labels with the SAS data sets that use them.
8) Use the DATASETS procedure COPY statement to copy data sets with indexes.
9) Test program code using "complete" test data.
10) Assign redundant steps to function keys, particularly during debugging and tuning operations.

Survey Results

A survey was conducted to elicit responses from participants on efficiency and performance. The ***Efficiency and Performance Survey*** is illustrated in ***Table 2***. Analyzing the responses from each participant provided a better appreciation for what users and application developers look for as they apply efficiency methods and strategies.

The purpose for constructing the survey in the first place began in order to assess the general level of understanding that people have with various efficiency methods and techniques. What was found was quite interesting. The majority of users and application developers want their applications to be as efficient as possible. Many go to great lengths to implement sound strategies and techniques achieving splendid results. Unfortunately for others, a lack of familiarity with effective techniques often results in a situation where the application works, but may not realize its true potential.

Survey participants often indicated that efficiency and performance tuning is not only important, but essential to their application. Many cite response time as a critical objective and are always looking for ways to improve this benchmark. Charles Edwin Shipp of Shipp Consulting offers these comments on applying efficiency techniques, *"Efficiency shouldn't be considered as a one-time activity. It is best to treat it as a continuing process of reaching an optimal balance between competing resources and activities."*

Program Code Examples

The following program examples illustrate the application of a few popular efficiency techniques. Techniques are presented in the areas of CPU time, data storage, I/O, memory, and programming time.

1. Using the KEEP= data set option instructs the SAS System to load only the specified variables into the program data vector (PDV), eliminating all other variables from being loaded.

```
data af_users;
  set sands.members
       (keep=name company phone user);
  if user = 'SAS/AF';
run;
```

2. The CLASS statement provides the ability to perform by-group processing without the need for data to be sorted first in a separate step. Consequently, CPU time can be saved when data is not already in the desired order. The CLASS statement can be used in the MEANS and SUMMARY procedure.

```
proc means data=mortgage;
  var prin  interest;
  class state;
run;
```

3. By using IF-THEN/ELSE statements opposed to IF-THEN statements without the ELSE, the SAS System stops processing the conditional logic once a condition holds true for any observation.

```
data capitols;
  set states;
  if state='CA' then capitol = 'Sacramento';
  else if state='FL' then capitol = 'Tallahassee';
  else if state='TX' then capitol = 'Austin';
run;
```

4. To avoid using default lengths for variables in a SAS dataset, use the LENGTH statement. Significant space can be saved for numeric variables containing integers since the 8-byte default length is reduced to the specified size. Storage space can be reduced significantly.

4. (Continued)

```
data _null_;
  length pageno rptdate 4;
  set  sales;
  file report  header=h;
  put @10 item   $20.
      @35 sales    comma6.2;
return;
h:
  rptdate=today();
  pageno + 1;
  put  @20 'Sales Report'
     /   @1 rptdate  mmddyy10.
     / @30 'Page ' pageno 4.  //;
return;
run;
```

5. To subset data without first running a DATA step use a WHERE statement in a procedure. I/O and memory requirements may be better for it.

```
proc print data=af_users  n  noobs;
  where user = 'SAS/AF';
  title1 'SAS/AF Programmers/Users';
run;
```

6. Use the SQL procedure to simplify and consolidate coding requirements. CPU, I/O, and programming time may improve.

```
proc sql;
  title1 'SAS/AF Programmers/Users';
  select * from  sands.members
       where user = 'SAS/AF'
          order by name;
quit;
```

7. To improve data storage and I/O requirements, consider compressing large datasets.

```
data  sands.members (compress = yes);
  <  additional statements  >
run;
```

Table 1. Program Code Examples

Other universally accepted findings consist of using WHERE, LENGTH, CLASS and KEEP=/DROP= data set options to retain only those variables necessary to the application; avoiding unnecessary sorting; verify the efficiency of simple and/or composite indexes using the IDXNAME= or IDXWHERE= OPTION; using SAS functions; and constructing DATA _NULL_ steps as effective techniques to improve the efficiency of an application.

Techniques receiving "strong" (between "Sometimes" and "Always"), but not unanimous, support among survey participants include using system options to control resources; deleting unwanted WORK datasets; combining two or more steps into a single step; storing and using formats and informats; creating and using simple and composite indexes consisting of discriminating variables; using the APPEND procedure to concatenate two data sets; constructing IF-THEN/ELSE statements to improve conditional processing; and saving intermediate files, especially for large multi-step jobs.

Sunil Kumar Gupta of Gupta Programming offers these suggestions on assigning informats, formats, and labels, *"Informats, formats, and labels are stored with many of our important SAS datasets to minimize processing time. A reason for using this technique is that many popular procedures use stored formats and labels as they produce output, eliminating the need to assign them in each individual step. This provides added incentives and value for programmers and end-users, especially since reporting requirements are usually time critical."*

A very interesting approach being used more users to achieve greater efficiency is to use the SQL Pass-Through Facility to access data stored in one or more database environments. The advantage for users is that this forces all processing to be performed on the host database (e.g., Oracle, DB2, Access, etc.) which is where it should be. Also, the SAS software and its associated processing costs are automatically transferred to the host database for even greater efficiencies.

The techniques cited by survey participants as "Sometimes" being used to achieve efficiency include using DATA set options, using data compression, conserving memory by turning off unnecessary components and/or options, using the SQL procedure to consolidate and simplify multiple operations, using the Stored Program Facility, creating and using DATA and SQL views to control environments where duplication of data is rampant, and using the DATASETS procedure COPY statement for databases with one or more indexes.

Learning Necessary Techniques

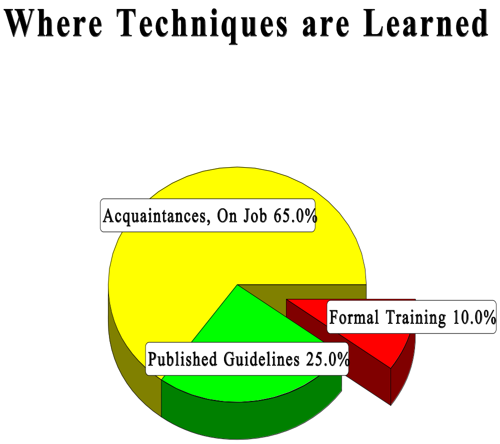
So how do people learn about efficiency techniques? A small number learn through formal training. Others find published guidelines (e.g., book(s), manuals, articles, etc.) on the subject. The majority indicated they learn techniques as a result of a combination of prior experiences, through acquaintances (e.g., User Groups), and/or on the job.

Any improvement is better than no improvement. Consequently, adhering to a practical set of guidelines can benefit significantly for many years to come. Survey responses revealed the following concerns:

1) An insufficient level of formal training exists on efficiency and performance.

2) A failure to plan in advance of the coding phase.

3) Insufficient time and inadequate budgets can often be attributed to ineffective planning and implementation of efficiency strategies.



Conclusion

The value of implementing efficiency and performance strategies into an application cannot be over-emphasized. Careful attention should be given to individual program functions, since one or more efficiency techniques can often affect the architectural characteristics and/or behavior an application exhibits.

Efficiency techniques are learned in a variety of ways. Many learn valuable techniques through formal classroom instruction, while others find value in published guidelines such as books, manuals, articles, and videotapes. But the greatest value comes from other's experiences, as well as their own, by word-of-mouth, and on the job. Whatever the means, a little efficiency goes along way.

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Trademark Citations

About the Author

Kirk Paul Lafler is consultant and founder of Software Intelligence Corporation and has been using SAS since 1979. He is a SAS Certified Professional, provider of IT consulting services, trainer to SAS users around the world, and sasCommunity.org Advisory Board member. As the author of four books including PROC SQL: Beyond the Basics Using SAS, Kirk has written nearly five hundred peer-reviewed papers, been an Invited speaker and trainer at more than three hundred SAS International, regional, local, and special-interest user group conferences and meetings, and is the recipient of 19 "Best" contributed paper, hands-on workshop (HOW), and poster awards. His popular SAS Tips column, "Kirk's Korner of Quick and Simple Tips", appears regularly in several SAS User Group newsletters and websites, and his fun-filled SASword Puzzles is featured in SAScommunity.org.

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EFFICIENCY AND PERFORMANCE SURVEY

Contact: ____ Organization: ____
Telephone: ________________________________ Contact Date: ____

"I am conducting a survey for a regional SAS user group paper that I am writing. The topic of the paper is efficiency and how it relates to the SAS Software. Could you spare a few minutes to answer a few questions on this subject?"

1. Are efficiency and performance issues important in your environment? □ Yes □ No □ Sometimes

2. Have you received any training (formal or informal) in efficiency and performance strategies? □ Yes □ No

3. Do you take the time to resolve efficiency and performance issues in an application? □ Yes □ No □ Sometimes

4. Rate whether the following efficiency measurement categories have importance in your environment.
(Use the following rating scale: 1=Not Important, 2=Somewhat Important, 3=Very Important.)

a. _____ CPU Time b. _____ Data Storage c. _____ Elapsed Time d. _____ I/O e. _____ Memory

5. In response to question #4, which measurement has the greatest importance in your environment? ________________
Why?: ____

6. At what time(s) during the application development process do you consider using efficiency and performance techniques?

□ Requirements Definition Phase
□ Analysis Phase
□ Design Phase
□ Coding Phase

□ Testing Phase
□ Implementation Phase
□ Maintenance/Enhancement Phase

7. Rate the following techniques and/or strategies that you have used in your environment to improve a program's/application's efficiency and/or performance? *(Use the following rating scale: 1=Never, 2=Sometimes, 3=Always.)*

_____ Use System Options such as BUFNO=, BUFOBS=, BUFSIZE= COMPRESS=, etc.
_____ Use DATA Step Options such as NOMISS or NOSTMTID.
_____ Use the LENGTH Statement to reduce the size of numeric variables and storage space.
_____ Use numeric variables for analysis purposes, otherwise create character variables - less CPU intensive.
_____ Use the KEEP / DROP statements or KEEP= / DROP= data set options to select only variables desired.
_____ Delete Unwanted Datasets in the WORK area.
_____ Combine Steps to minimize the number of DATA and/or PROC steps.
_____ Use Data Compression using the COMPRESS= data set option.
_____ Conserve on Memory (e.g., turning off NOMACRO, array processing)
_____ Use Formats and Informats to save CPU during complex logic assignments.
_____ Avoid unnecessary sorting with PROC SORT.
_____ Control sorting by combining two or more variables at a time when sorting is necessary.
_____ Use Subsetting IF statements to subset data sets.
_____ Use WHERE statements to subset data sets.
_____ Use indexes to optimize the retrieval of data.
_____ Construct IF-THEN/ELSE statements to process condition(s) with greatest frequency first.
_____ Save intermediate files in multi-step applications.
_____ Use PROC APPEND versus SET statement to concatenate datasets.
_____ Use PROC SQL to consolidate multiple operations into one step.
_____ Use the PROC SQL Pass-Through Facility to pass logic to target database for processing.
_____ Use the Stored Program Facility to store SAS DATA steps in a compiled format.
_____ Use DATA Views and SQL Views to create "virtual" tables.
_____ Use SAS Functions to perform common tasks.
_____ Use the DATASETS Procedure COPY statement to copy datasets with built-in indexes.
_____ Use the DATA _NULL_ step to avoid creating a dataset when one is not needed but processing is.
_____ Use a CLASS statement in procedures that support it to avoid having to sort data.
Other: ____

8. Would you like a copy of the completed paper? □ Yes □ No

Thank you for participating in this survey!

Table 2. Efficiency and Performance Survey