SAS Advanced Programming with Efficiency in Mind: A Real Case Study

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ABSTRACT

This paper uses a real work example to demonstrate the concept and some basic tips of SAS programming efficiency. The first section of the paper introduces the background of a SAS application and its performance metrics. The second section analyzes the structure and features of the SAS application. The third section analyzes the log of the application to identify efficiency issues. In addition, in this section a log analysis utility is introduced. The fourth section provides a re-developed version of the application with performance improved to reduce 99.6% of its runtime. The last section tries to raise awareness of SAS programming efficiency and suggests some basic tips. The application discussed in the paper has been tested with SAS 9.2, 9.3 and 9.4 on Windows machines. The target audience includes SAS programmers from beginner to advanced level.

INTRODUCTION

Did you ever have any SAS applications that took longer than you expected to run? It could be hours, or even days long. Most of us find it frustrating when things like that happened, especially when you had a tight deadline to meet, or you had to run the job many times within a limit of time. Many programmers might think it is caused by the nature of their SAS application, such as big data sets, complex process, and limitation of computing power and resources, etc. Moreover, it was not uncommon that many SAS application developers/programmers did not realize that there usually were efficiency issues. This paper uses an example to raise the awareness of SAS programming efficiency, introduce a log analysis utility, and provide some basic tips.

I.1 BACKGROUND

UM-KECC is a multidisciplinary research center within the UM School of Public Health (SPH). UM-KECC was formed in 1993 and its mission is “to promote health, improve clinical practice and patient outcomes, optimize resource utilization, and inform public policy regarding organ failure and organ transplantation.” UM-KECC pursues this mission “through high quality research, advances in biostatistics, and post-graduate education and training.” (www.kecc.sph.umich.edu).

UM-KECC has been working with CMS to develop quality measures of ESRD patient care for years. Each quarter, as one tiny part of the large efforts, UM-KECC produces lists of ESRD patients included in the dialysis facility compare (QDFC) measures for more than 6,000 Medicare dialysis facilities nationwide. There are five measures: M1, M2, M3, M4, and M5. In each quarter, there are more than 21.7K patient list files (21,870 for 201607, 21,702 for 201604) created. This whole process consists of five similar SAS jobs, one for each measure.

M1_DFC_Patient_Lists.sas
M2_DFC_Patient_Lists.sas
M3_DFC_Patient_Lists.sas
M4_DFC_Patient_Lists.sas
M5_DFC_Patient_Lists.sas
I.2 PROCESS TIME

The process time varies for the jobs. The M5 job took about 10 hours. (And it could occasionally even take longer than 69 hours for some reason in reality. It was the worst case we had!) The rest took from 18 seconds to around 16 hours. The total process times for the last two quarters were about 19.4 hours and 33.4 hours.

<table>
<thead>
<tr>
<th>Jobs</th>
<th>201604</th>
<th>201607</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1_DFC_Patient_Lists.sas</td>
<td>4:16:02.04</td>
<td>4:11:53.18</td>
</tr>
<tr>
<td>M3_DFC_Patient_Lists.sas</td>
<td>1:39:45</td>
<td>2:30:09</td>
</tr>
<tr>
<td>M4_DFC_Patient_Lists.sas</td>
<td>4:49:30.74</td>
<td>16:17:07.14</td>
</tr>
<tr>
<td>M5_DFC_Patient_Lists.sas</td>
<td>10:02:30.96</td>
<td>11:02:17.87</td>
</tr>
<tr>
<td>total</td>
<td>19:26:14.02</td>
<td>33:21:57.52</td>
</tr>
</tbody>
</table>

II. CODE ANALYSIS

You may wonder why some of these simple jobs can take more than 10 hours. Moreover, 19 to 33 hours of total runtime of the production is way too long. Are there any efficiency issues? Can the application be improved? Let us start with examining the SAS code, in order to see what the issues could be and identify how to fix them. In the following sections, our analysis and redevelopment will use M5 job as an example. The rest of these jobs are identical in terms of the code design, structure, functionality, and issues, etc. Please see Figure 1.1 and Figure 1.2 for the code listings.
CODE LOGIC

It is a simple job and it has two requirements:

1. **Create data**: Put facility information (6,499 observations), patient information (2,819,069 observation) and measure results (6,423,888 observations) together to create a patient-measure level data set containing information for patients included in the measure for all facilities. Also, perform a few data manipulations.

2. **Print data**: Print patient-measure information by facility in plain text format with file extension .txt.

Figure 1.2 Original Code Snapshot Two

```sas
/*MVUS13-FILE_MVUS13_DPQ_PatientLists_original_MVUS13.sas*/
data measure_plist;
merge saifill.RS_pilot_edate.(in=a) facinfo (in=bfacinfo);
by facility;
if a and bfacinfo;
  facility=(trim(facility))", " ||trim(period)||", " ||state;
format sort scott.;
run;
proc sort data=measure_plist;
by network facility surname first_name ;
rw;
proc sql;
select count(distinct facility) into: numprovs;
from &measure_plist;
quit;
put &numprovs;
data_numprovs;
length numprovs $0.;
umprovs=strip(&numprovs);
call symput('numprovs', &numprovs);
rw;
proc sql;
select distinct facility into :provs --proc&numprovs &trim
from &measure_plist;
quit;
ods listing file="Outfile";
%put '==================================================' &&provs;
%put data prolevel:
%put '==================================================' &&facility;
sas listing file="Outfile";
title "CONFIDENTIAL: Patients included in the &name, measure reported in the";
titles "Quarterly Dialysis Compare-Preview for Month, &year, Report.", title3 "&name Certification Number &provs &facility";
ods listing file="Outfile";
proc print data=prolevel nomiss split=' ' uniform;
```

CODE DESIGN AND STRUCTURE

This code has two parts, one for each subtask. The first part consists of PROCs and DATA steps. The second subtask is implemented with a %MACRO %do loop that creates and prints out one data set for each facility. As a result, there are more than 6,000 DATA steps and PROCs generated by the %MACRO/%DO loop at runtime.

1. **Create data**: Four PROC SORTs, two DATA MERGEs.

2. **Print data**: Two PROC SQLs, one DATA _NULL_, one %MACRO %do loop of 1 DATA step and ODS/PROC PRINT.

SAS FEATURES

There are many SAS features, including some advanced ones, in this SAS application.
- DATA STEP MERGE, PROC SQL, PROC SORT;
- %MACRO, &&VAR&N, CALL SYMPUT, INTO:, %Do loop; DATA _NULL_
- Data type conversion (+0), function COMPRESSION(), STRIP(), TRIM();
- ODS LISTING, Dynamic titles, PROC PRINT options, etc.
- System options: LS, NODATE, NONUMBER, NOCENTER, ERRORS, SOURCE2, MPRINT.

**CRITICAL THINKING**

Does it need to be so complicated (using so many steps and features)? Is %macro really needed? (Can the %macro be avoided?) Which features/steps did take most of the runtime? Would the large number of small DATA steps and PROCs be an efficiency issue? Or is the long runtime due to the large size of the input SAS data sets? To answer these questions, I inspected the log files of the job along with the SAS code.

**III.1 LOG ANALYSIS: OBSERVATION & ESTIMATION**

The log file is lengthy. It has more than 45,000 lines. We need to search for the key words ‘real time’ to see how long each step took. First, let us look at the runtime for task one -- the creation of measure-patient data set. The facility info data has about 6,600 records. The measure data has about 6.5 million observations. The patient info data set has about 2.5 million records. The DATA step and PROC SORT processed these data sets within a few minutes. It is fast to create the measure-patient data set. Since SAS is so powerful, the sizes of the data sets in this application are not the issue (Please see Figure 2.1 and Figure 2.2 for details.)

**Figure 2.1 Log Snapshot One**

![Log Snapshot One](image)

**Figure 2.2 Log Snapshot Two**

![Log Snapshot Two](image)

Now let us look at the runtime for task two – the creation of the facility specific patient list files. Every time a list file was created, one small DATA step and one PROC PRINT were executed. After scanning the log file, we noticed that the process only used about 5.3 seconds or so per facility.

However, since there were more than 6,000 facilities, the total runtime ended up as about 10 hours. The stop value of the %DO loop was 6,375 for this case. Therefore, the total run time was about 5.28*6375/(60*60) seconds = 9.35 hours. (Please see Figure 2.3 and Figure 2.4 for details)
III.2 LOG ANALYSIS: STATISTICS

To get the statistics of the runtime of the SAS application, I developed a simple SAS utility to analyze the full lengthy SAS log file (457,581 lines in this case). The log analysis utility consists of two small %macros: %log_io_search(), %log_io_data() and a PROC MEANS. (Please see Figure 3.1 for details.)
The first macro `%log_io_search` uses a DATA _NULL_ step to search through the log file, extract the key information for each step, and write out them into a txt file. (Figure 3.2)

The second macro `%log_io_data` again uses a DATA step to search through the output text file generated from the first step and put the results in a better text format. (Figure 3.3)
In addition, it puts them into a SAS data set for further analysis. (Figure 3.4)

![Figure 3.4 Log Analysis Results Snapshot Three](image)

Then PROC MEANS summarizes the runtime of the whole process recorded in the SAS log file. As an example, the statistics of the M5 job for the 201607 run are shown below (Figure 3.5).

![Figure 3.5 Log Analysis Results](image)

There are 6,428 DATA steps, 3 large ones, and 6,426 small ones. The large data steps only took a few minutes. And the 6,426 small data steps took more than 10 hours: 39,211/(60*60) seconds =10.89 hours. The PROC steps took less than a minute.

Based on the statistics shown above, we can tell that the %MACRO/%DO structure is very time consuming in this application. It posts an efficiency issue. In the next section, we will show the redevelopment of this application to make it more efficient.

**IV. REDEVELOPING THE APPLICATION**

Once we have identified the cause of the long runtime, we can redesign the application with efficiency in mind.

The first area to improve the original SAS application is to reduce the number of steps. Some data steps and procs can be combined, some steps and the %macro and data sorting can be avoided. SAS view can be used to replace data set. In addition, we can reduce the size of the log file by getting rid of macro related lines and fixing invalid data errors. That will make the log file more readable and save some I/O time as well. Second, and most importantly, for the reporting part, we can use a simple but powerful technique to avoid the 6,000+ small data steps: We use the SAS BY processing mechanism and DATA step **FILE statement** instead of the loops of DATA steps and PROC PRINTs.
Here is the outline of the re-developed SAS application. The new code only contains one PROC SQL view and one DATA step. There is no %macro/PROC PRINT/SORT. It uses a DATA step FILE statement with option FILEVAR= to write out facility specific reports.

```
PROC SQL; CREATE VIEW ... AS ...; QUIT;
DATA ...;
  SET ...;
  BY FACID;
  IF _FN= ... FACID ...;
  FILE WRITEOUT FILEVAR=_FN ...;
  PUT ...;
RUN;
```

The new SAS application has only about 80 lines. (The original one has about 150 lines.)

Figure 4.1a Redeveloped Code (part 1)

Figure 4.1b Redeveloped Code (part 2)
The key SAS features used in the new application is FILE statement and its option FILEVAR=.

```
FILEVAR=variable
```

defines a variable whose change in value causes the FILE statement to close the current output file and open a new one the next time the FILE statement executes. The next PUT statement that executes writes to the new file that is specified as the value of the FILEVAR= variable.

Restriction: The value of a FILEVAR= variable is expressed as a character string that contains a physical filename.

Interaction: When you use the FILEVAR= option, the file specification is just a placeholder, not an actual filename or a fileref that has been previously assigned to a file. SAS uses this placeholder for reporting processing information to the SAS log. It must conform to the same rules as a fileref.

The new SAS application produces the same results much more efficiently. Moreover, the log file (Figure 4.2) is nice and clean. It lists all the output files orderly. The runtime is 2.25 minutes (Figure 4.3). Can you believe it? The new application reduced the process time from about 10 hours to about 2 minutes. Comparing to the original version, it saved 99.6% of the runtime.

```
V. CONCLUSIONS
```

This real case study shows us that programming with efficiency in mind can make a great difference:
- 79 lines vs. 150 lines
- 1 step vs. 6,384 steps
- 22,518,989 vs. 61,852,446 records processed
- 00:02:30 vs. 11:02:17 (hh:mm:ss). Process time saved 99.62%.

Besides raising awareness for programming efficiency and introducing a log analysis utility, this case study presented two important suggestions to promote the performance of SAS applications.
First, developing a better SAS application requires a better understanding of the problem the application is to solve; once the problem is well understood, the programmer’s problem solving skills help to design the right algorithm to tackle the problem. This design phase should involve as many knowledge and skills as possible, such as analytics, modular and parallel, data structure, logic/abstract/model and system thinking, etc.

Second, the application developer/programmer’s SAS knowledge, experience, and skills also play an important role in programming efficiency. Here are some general SAS programming tips that can be usefully to improve application performance: use as fewer steps as possible if applicable; combine steps/remove unnecessary steps; process only the required variables and observations; avoid complex macro if you can; use simple/non-macro coding effective techniques; do not fall in love with your “hammer”, know and pick the right tool to use; be machine, human and computing environment friendly.

REFERENCES

SAS Online Documentations for SAS 9.2, 9.3 and 9.4. (http://support.sas.com/documentation)

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