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Exploring DATA Step Merges and PROC SQL Joins

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Abstract

Explore the various DATA step merge and PROC SQL join processes. This presentation examines the similarities and differences between each, and provides examples of effective coding techniques. Attendees examine the objectives and principles behind merging and joining, as well as the coding constructs associated with inner and outer merges and joins, hash techniques, and selected Set operators.

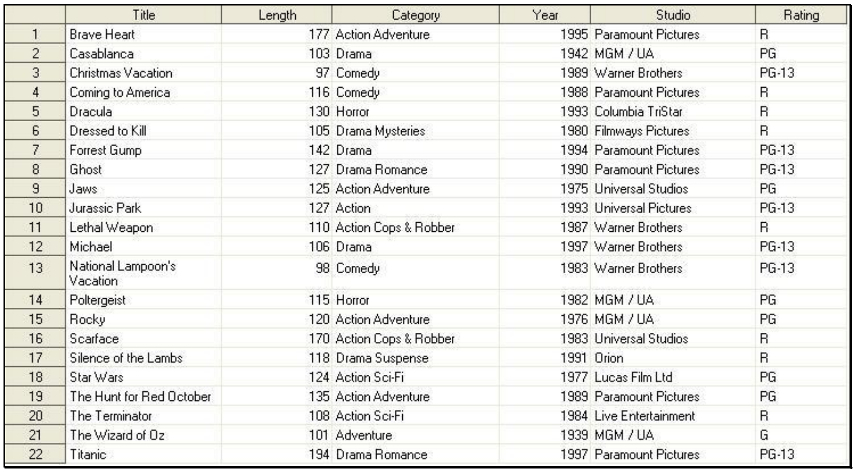
Introduction

This paper illustrates the similarities and differences between the Base-SAS® software DATA step merge and PROC SQL join techniques. We'll examine two "key" topics that most users are confronted with when working with their tables of data, conditional logic scenarios and merges/joins. This paper introduces brief explanations, guidelines and "simple" techniques for users to consider when confronted with conditional logic scenarios and merges/joins. You are encouraged to explore these and other techniques to make your SAS® experience an exciting one.

Example Tables

The data used in all the examples in this paper consist of a selection of movies that I've viewed over the years. The Movies table contains four character columns: title, category, studio, and rating, and two numeric columns: length and year. The data stored in the Movies table is shown below.

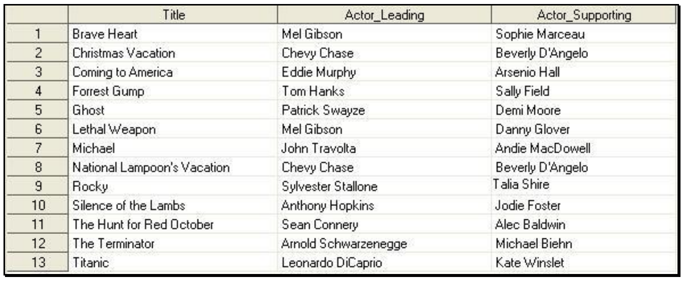
MOVIES Table



	Title	Length	Category	Year	Studio	Rating
1	Brave Heart	177	Action Adventure	1995	Paramount Pictures	R
2	Casablanca	103	Drama	1942	MGM / UA	PG
3	Christmas Vacation	97	Comedy	1989	Warner Brothers	PG-13
4	Coming to America	116	Comedy	1988	Paramount Pictures	R
5	Dracula	130	Horror	1993	Columbia TriStar	R
6	Dressed to Kill	105	Drama Mysteries	1980	Filmways Pictures	R
7	Forrest Gump	142	Drama	1994	Paramount Pictures	PG-13
8	Ghost	127	Drama Romance	1990	Paramount Pictures	PG-13
9	Jaws	125	Action Adventure	1975	Universal Studios	PG
10	Jurassic Park	127	Action	1993	Universal Pictures	PG-13
11	Lethal Weapon	110	Action Cops & Robber	1987	Warner Brothers	R
12	Michael	106	Drama	1997	Warner Brothers	PG-13
13	National Lampoon's Vacation	98	Comedy	1983	Warner Brothers	PG-13
14	Poltergeist	115	Horror	1982	MGM / UA	PG
15	Rocky	120	Action Adventure	1976	MGM / UA	PG
16	Scarface	170	Action Cops & Robber	1983	Universal Studios	R
17	Silence of the Lambs	118	Drama Suspense	1991	Orion	R
18	Star Wars	124	Action Sci-Fi	1977	Lucas Film Ltd	PG
19	The Hunt for Red October	135	Action Adventure	1989	Paramount Pictures	PG
20	The Terminator	108	Action Sci-Fi	1984	Live Entertainment	R
21	The Wizard of Oz	101	Adventure	1939	MGM / UA	G
22	Titanic	194	Drama Romance	1997	Paramount Pictures	PG-13

The data stored in the ACTORS table consists of three columns: title, actor_leading, and actor_supporting, all of which are defined as character columns. The data stored in the Actors table is illustrated below.

ACTORS Table



	Title	Actor_Leading	Actor_Supporting
1	Brave Heart	Mel Gibson	Sophie Marceau
2	Christmas Vacation	Chevy Chase	Beverly D'Angelo
3	Coming to America	Eddie Murphy	Arsenio Hall
4	Forrest Gump	Tom Hanks	Sally Field
5	Ghost	Patrick Swayze	Demi Moore
6	Lethal Weapon	Mel Gibson	Danny Glover
7	Michael	John Travolta	Andie MacDowell
8	National Lampoon's Vacation	Chevy Chase	Beverly D'Angelo
9	Rocky	Sylvester Stallone	Talia Shire
10	Silence of the Lambs	Anthony Hopkins	Jodie Foster
11	The Hunt for Red October	Sean Connery	Alec Baldwin
12	The Terminator	Arnold Schwarzenegge	Michael Biehn
13	Titanic	Leonardo DiCaprio	Kate Winslet

The Process of Merging and Joining

A merge or join is the process of combining two or more tables' side-by-side (horizontally). Its purpose is to gather and manipulate data from across tables for exciting insights into data relationships. The process consists of a matching process between a table's rows bringing together some or all of the tables' contents, as illustrated below.

The ability to define relationships between multiple tables and retrieve information based on these relationships is a powerful feature of the relational model. A merge or join of two or more tables provides a means of gathering and manipulating data. Merges and joins are specified on a minimum of two tables at a time, where a column from each table is used for the purpose of connecting the two tables. Connecting columns should have ***"like"*** values and the same column attributes since the processes' success is dependent on these values.

Contrasting Merges and Joins

The difference between a DATA step merge and a join are subtle, but differences do exist.

Merge Features

1. Relevant only to the SAS System – not portable to other vendor data bases.
2. More steps are often needed than with the SQL procedure.
3. Data must first be sorted using by-value.
4. Requires common variable name.
5. Duplicate matching column is automatically overlaid.
6. Results are not automatically printed.

Join Features

1. Portable to other vendor data bases.
2. Data does not need to be sorted using BY-value.
3. Does not require common variable name.
4. Duplicate matching column is not automatically overlaid.
5. Results are automatically printed unless NOPRINT option is specified.

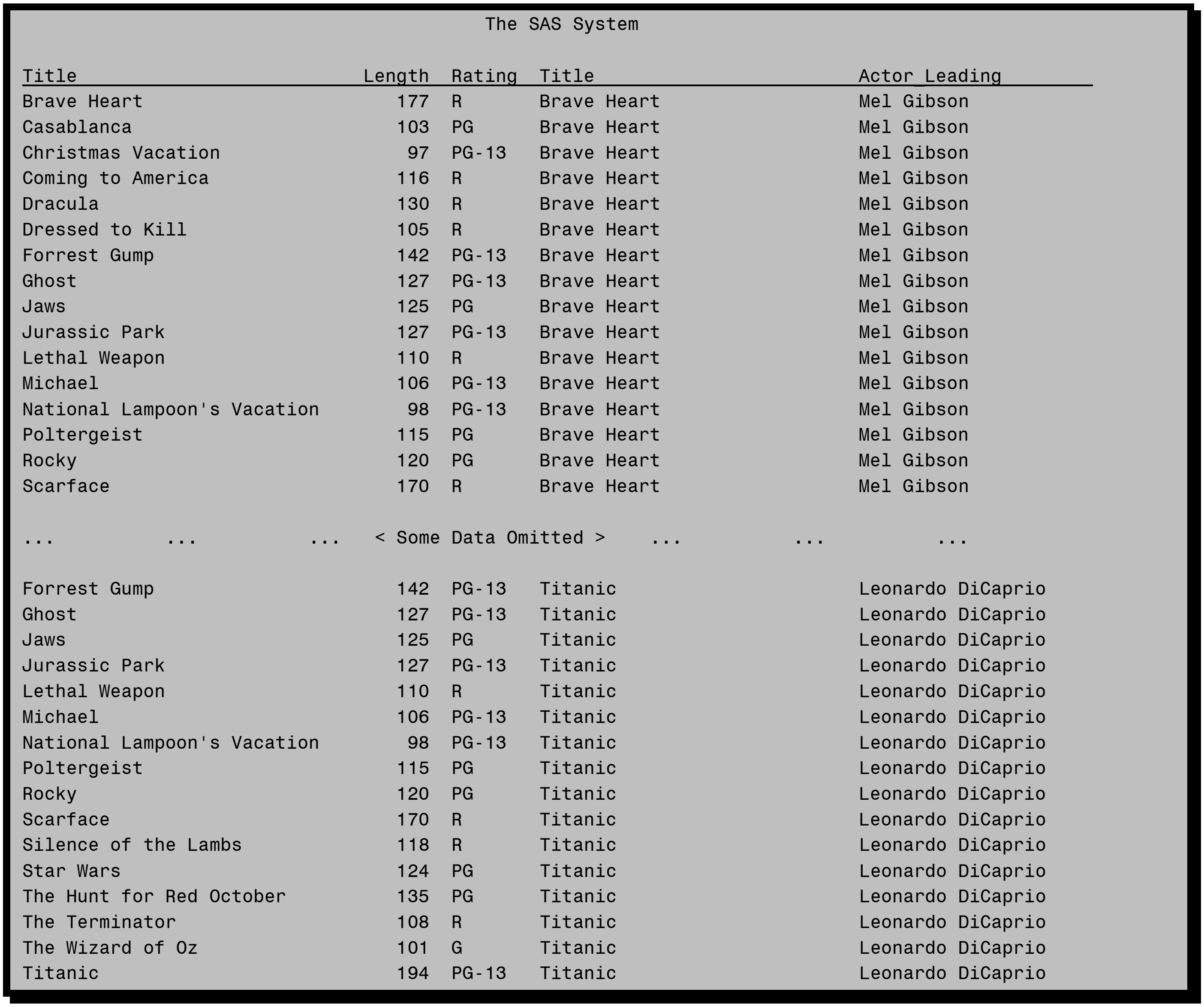
Cartesian Product

A Cartesian Product is defined as a result set of all the possible rows and columns contained in two or more data sets or tables. The DATA step doesn't really lend itself to easily creating a Cartesian Product – PROC SQL is the desired approach. Its most noticeable coding characteristic is the absence of a WHERE-clause. The resulting set of data resulting from a Cartesian Product can be extremely large and unwieldy as illustrated below, that is a set of 286 rows. Although rarely produced, a Cartesian Product join nicely illustrates a base (or internal representation) for all joins.

Code

```
PROC SQL;
  SELECT *
    FROM MOVIES(KEEP=TITLE LENGTH RATING),
         ACTORS(KEEP=TITLE ACTOR_LEADING);
QUIT;
```

Results

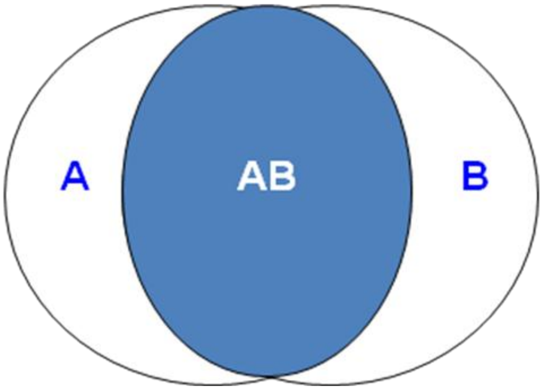


```
                                           The SAS System

Title                          Length  Rating  Title                    Actor_Leading
Brave Heart                       177  R       Brave Heart              Mel Gibson
Casablanca                        103  PG      Brave Heart              Mel Gibson
Christmas Vacation                 97  PG-13   Brave Heart              Mel Gibson
Coming to America                 116  R       Brave Heart              Mel Gibson
Dracula                           130  R       Brave Heart              Mel Gibson
Dressed to Kill                   105  R       Brave Heart              Mel Gibson
Forrest Gump                      142  PG-13   Brave Heart              Mel Gibson
Ghost                             127  PG-13   Brave Heart              Mel Gibson
Jaws                              125  PG      Brave Heart              Mel Gibson
Jurassic Park                     127  PG-13   Brave Heart              Mel Gibson
Lethal Weapon                     110  R       Brave Heart              Mel Gibson
Michael                           106  PG-13   Brave Heart              Mel Gibson
National Lampoon's Vacation        98  PG-13   Brave Heart              Mel Gibson
Poltergeist                       115  PG      Brave Heart              Mel Gibson
Rocky                             120  PG      Brave Heart              Mel Gibson
Scarface                          170  R       Brave Heart              Mel Gibson

...          ...          ...   < Some Data Omitted >    ...          ...          ...

Forrest Gump                      142  PG-13   Titanic                  Leonardo DiCaprio
Ghost                             127  PG-13   Titanic                  Leonardo DiCaprio
Jaws                              125  PG      Titanic                  Leonardo DiCaprio
Jurassic Park                     127  PG-13   Titanic                  Leonardo DiCaprio
Lethal Weapon                     110  R       Titanic                  Leonardo DiCaprio
Michael                           106  PG-13   Titanic                  Leonardo DiCaprio
National Lampoon's Vacation        98  PG-13   Titanic                  Leonardo DiCaprio
Poltergeist                       115  PG      Titanic                  Leonardo DiCaprio
Rocky                             120  PG      Titanic                  Leonardo DiCaprio
Scarface                          170  R       Titanic                  Leonardo DiCaprio
Silence of the Lambs              118  R       Titanic                  Leonardo DiCaprio
Star Wars                         124  PG      Titanic                  Leonardo DiCaprio
The Hunt for Red October          135  PG      Titanic                  Leonardo DiCaprio
The Terminator                    108  R       Titanic                  Leonardo DiCaprio
The Wizard of Oz                  101  G       Titanic                  Leonardo DiCaprio
Titanic                           194  PG-13   Titanic                  Leonardo DiCaprio
```

Match Merging or Joining

Merging or joining two or more tables together is a relatively easy process in the SAS System. The most reliable way to merge or join two or more tables together, and to avoid creating a Cartesian product, is to reduce the resulting set of data using one or more common columns. *The result of a* ***Matched merge or join*** *is illustrated by the shaded area (AB) in the following Venn diagram.*

Venn Diagram – Matched Merge or Join



To illustrate how a match merge or join works, two tables are linked together using the movie title (TITLE) in the following diagram.

MOVIES		**ACTORS**
☞**Title**	←— = —→	☞**Title**
Length		**Actor_Leading**
Category		Actor_Supporting
Year		
Studio		
Rating		

Merge Code

```
PROC SORT DATA=MOVIES;
   BY TITLE;
RUN;

PROC SORT DATA=ACTORS;
  BY TITLE;
RUN;

DATA  MERGED;
   MERGE  MOVIES (IN=M KEEP=TITLE LENGTH RATING)
               ACTORS (IN=A KEEP=TITLE ACTOR_LEADING);
   BY TITLE;
   IF M AND A;
RUN;

PROC PRINT DATA=MERGED NOOBS;
RUN;
```

Results

```
                                  The SAS System

         Title                          Length    Rating    Actor_Leading

         Brave Heart                      177     R         Mel Gibson
         Christmas Vacation                97     PG-13     Chevy Chase
         Coming to America                116     R         Eddie Murphy
         Forrest Gump                     142     PG-13     Tom Hanks
         Ghost                            127     PG-13     Patrick Swayze
         Lethal Weapon                    110     R         Mel Gibson
         Michael                          106     PG-13     John Travolta
         National Lampoon's Vacation       98     PG-13     Chevy Chase
         Rocky                            120     PG        Sylvester Stallone
         Silence of the Lambs             118     R         Anthony Hopkins
         The Hunt for Red October         135     PG        Sean Connery
         The Terminator                   108     R         Arnold Schwarzenegge
         Titanic                          194     PG-13     Leonardo DiCaprio
```

The corresponding SQL procedure code to produce a “matched” row result set is shown below.

SQL Code

```
PROC SQL;
  CREATE  TABLE  JOINED  AS
    SELECT  *
      FROM MOVIES(KEEP=TITLE LENGTH RATING),
            ACTORS(KEEP=TITLE ACTOR_LEADING)
      WHERE  MOVIES.TITLE = ACTORS.TITLE;

  SELECT * FROM JOINED;
QUIT;
```

Results

```
                                  The SAS System

         Title                          Length    Rating    Actor_Leading
         ------------------------------------------------------------------------

         Brave Heart                      177     R         Mel Gibson
         Christmas Vacation                97     PG-13     Chevy Chase
         Coming to America                116     R         Eddie Murphy
         Forrest Gump                     142     PG-13     Tom Hanks
         Ghost                            127     PG-13     Patrick Swayze
         Lethal Weapon                    110     R         Mel Gibson
         Michael                          106     PG-13     John Travolta
         National Lampoon's Vacation       98     PG-13     Chevy Chase
         Rocky                            120     PG        Sylvester Stallone
         Silence of the Lambs             118     R         Anthony Hopkins
         The Hunt for Red October         135     PG        Sean Connery
         The Terminator                   108     R         Arnold Schwarzenegge
         Titanic                          194     PG-13     Leonardo DiCaprio
```

Asymmetric Merging and Joining

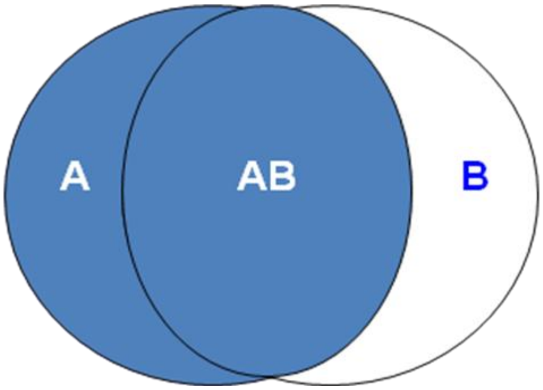
A typical merge or join consists of a process of relating rows in one table with rows in another symmetrically. But occasionally, rows from one or both tables that have no related rows can be retained. This approach is sometimes referred to as an asymmetric type of join because its primary purpose is row preservation. This type of processing is a significant feature offered by the outer join construct.

There are syntax and operational differences between inner (natural) and outer joins. The obvious difference between an inner and outer join is the way the syntax is constructed. Outer joins use keywords such as LEFT JOIN, RIGHT JOIN, and FULL JOIN, and has the WHERE clause replaced with an ON clause. These distinctions help identify outer joins from inner joins. But, there are operational differences as well.

Unlike an inner join, the maximum number of tables that can be specified in an outer join construct is two. Similar to an inner join, an outer join relates rows in both tables. But this is where the similarities end because the resulting set of data also includes rows with no related rows from one or both of the tables. This special handling of “matched” and “unmatched” rows of data is what differentiates a symmetric inner join from an asymmetric outer join. Essentially the resulting set of data from an outer join process contains rows that “match” the ON-clause plus any “unmatched” rows from the left, right, or both tables.

The result of a ***Left Outer merge or join*** is illustrated by the shaded areas (A and AB) in the following Venn diagram.

Venn Diagram – Left Outer Merge or Join



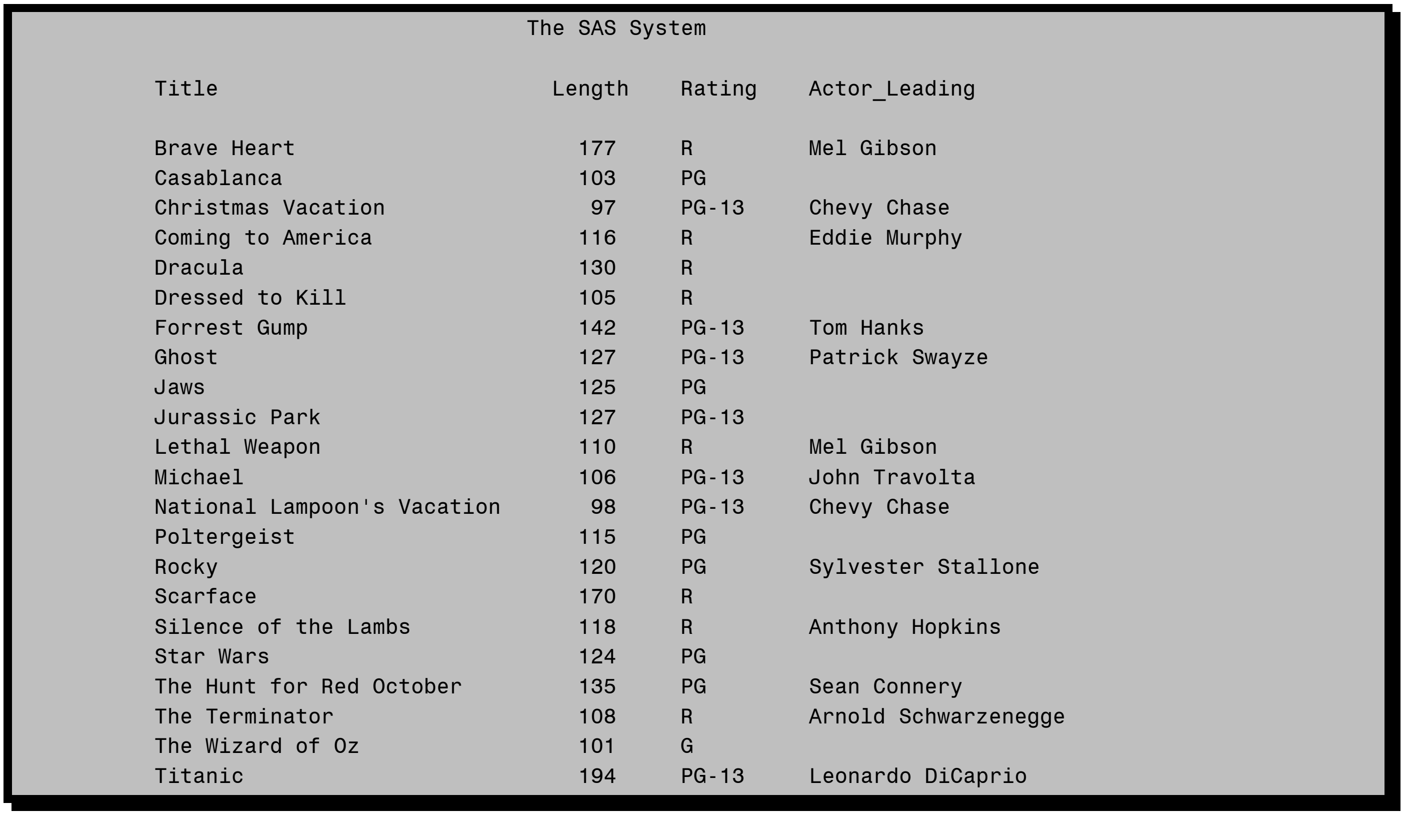
Left Outer Merge or Join

The result of a Left Outer merge or join produces matched rows from both tables while preserving all unmatched rows from the left table. The following merge code illustrates a left outer merge construct that selects “matched” movies based on their titles from the MOVIES and ACTORS tables, plus all “unmatched” movies from the MOVIES table.

Merge Code

```
PROC SORT DATA=MOVIES;
  BY TITLE;
RUN;

PROC SORT DATA=ACTORS;
  BY TITLE;
RUN;

DATA  LEFT_OUTER_MERGE;
     MERGE  MOVIES (IN=M KEEP=TITLE LENGTH RATING)
                    ACTORS (IN=A KEEP=TITLE ACTOR_LEADING);
        BY  TITLE;
            IF  M;
RUN;

PROC PRINT DATA=LEFT_OUTER_MERGE NOOBS;
RUN;
```

Results



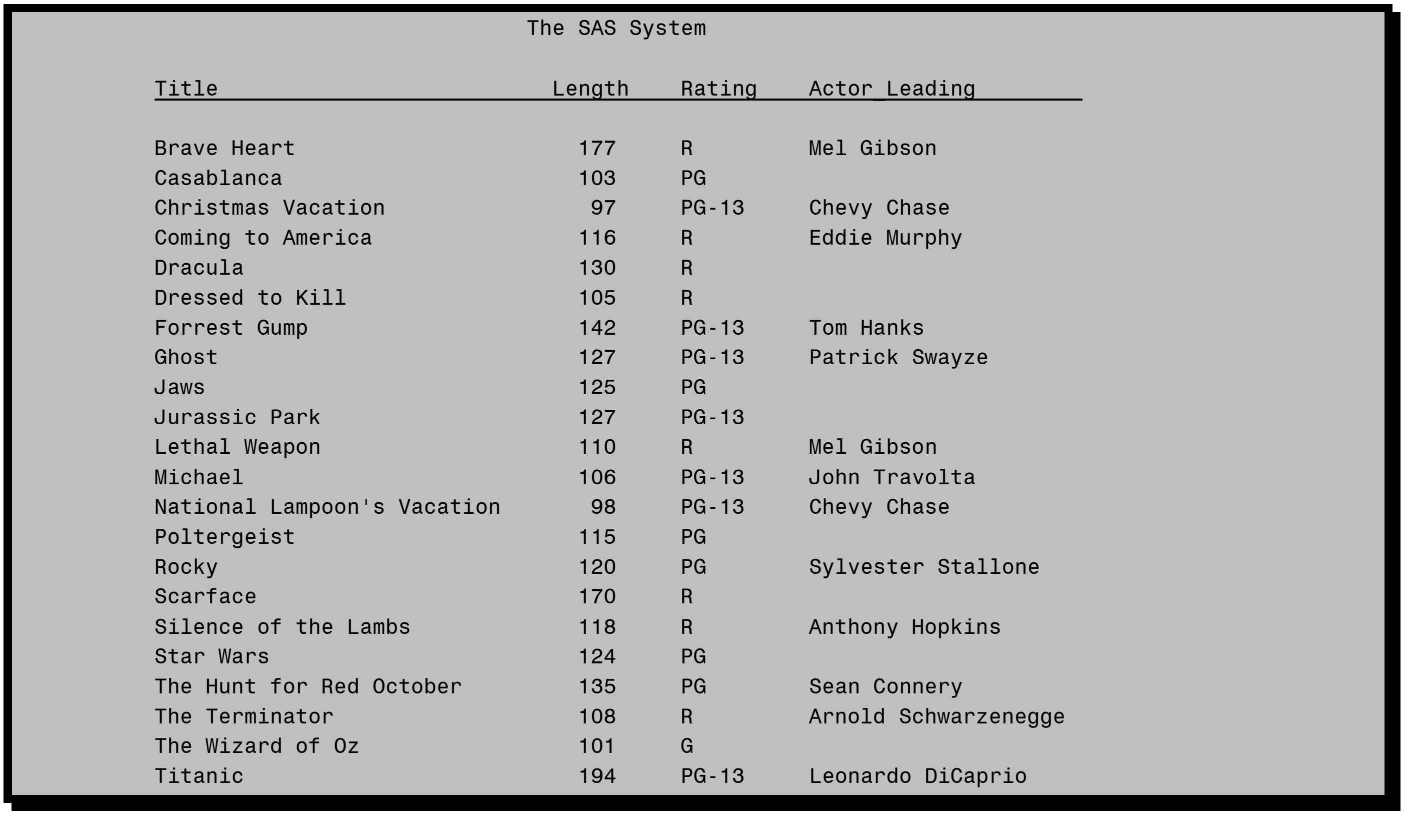
```
                                  The SAS System

           Title                           Length    Rating    Actor_Leading

           Brave Heart                       177     R         Mel Gibson
           Casablanca                        103     PG
           Christmas Vacation                 97     PG-13     Chevy Chase
           Coming to America                 116     R         Eddie Murphy
           Dracula                           130     R
           Dressed to Kill                   105     R
           Forrest Gump                      142     PG-13     Tom Hanks
           Ghost                             127     PG-13     Patrick Swayze
           Jaws                              125     PG
           Jurassic Park                     127     PG-13
           Lethal Weapon                     110     R         Mel Gibson
           Michael                           106     PG-13     John Travolta
           National Lampoon's Vacation        98     PG-13     Chevy Chase
           Poltergeist                       115     PG
           Rocky                             120     PG        Sylvester Stallone
           Scarface                          170     R
           Silence of the Lambs              118     R         Anthony Hopkins
           Star Wars                         124     PG
           The Hunt for Red October          135     PG        Sean Connery
           The Terminator                    108     R         Arnold Schwarzenegge
           The Wizard of Oz                  101     G
           Titanic                           194     PG-13     Leonardo DiCaprio
```

The corresponding SQL procedure code to produce a left outer join row result set is shown below.

SQL Code

```
PROC SQL;
  CREATE  TABLE  LEFT_OUTER_JOIN  AS
    SELECT  *
      FROM MOVIES(KEEP=TITLE LENGTH RATING)
        LEFT JOIN
            ACTORS(KEEP=TITLE ACTOR_LEADING)
        ON MOVIES.TITLE = ACTORS.TITLE;

  SELECT * FROM LEFT_OUTER_JOIN;
QUIT;
```

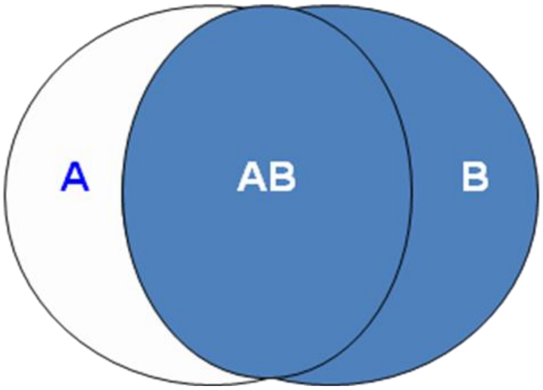
Results



```
                             The SAS System

Title                          Length    Rating    Actor_Leading

Brave Heart                      177     R         Mel Gibson
Casablanca                       103     PG
Christmas Vacation                97     PG-13     Chevy Chase
Coming to America                116     R         Eddie Murphy
Dracula                          130     R
Dressed to Kill                  105     R
Forrest Gump                     142     PG-13     Tom Hanks
Ghost                            127     PG-13     Patrick Swayze
Jaws                             125     PG
Jurassic Park                    127     PG-13
Lethal Weapon                    110     R         Mel Gibson
Michael                          106     PG-13     John Travolta
National Lampoon's Vacation       98     PG-13     Chevy Chase
Poltergeist                      115     PG
Rocky                            120     PG        Sylvester Stallone
Scarface                         170     R
Silence of the Lambs             118     R         Anthony Hopkins
Star Wars                        124     PG
The Hunt for Red October         135     PG        Sean Connery
The Terminator                   108     R         Arnold Schwarzenegge
The Wizard of Oz                 101     G
Titanic                          194     PG-13     Leonardo DiCaprio
```

The result of a ***Right Outer merge or join*** is illustrated by the shaded areas (B and AB) in the following Venn diagram.

Venn Diagram – Right Outer Merge or Join



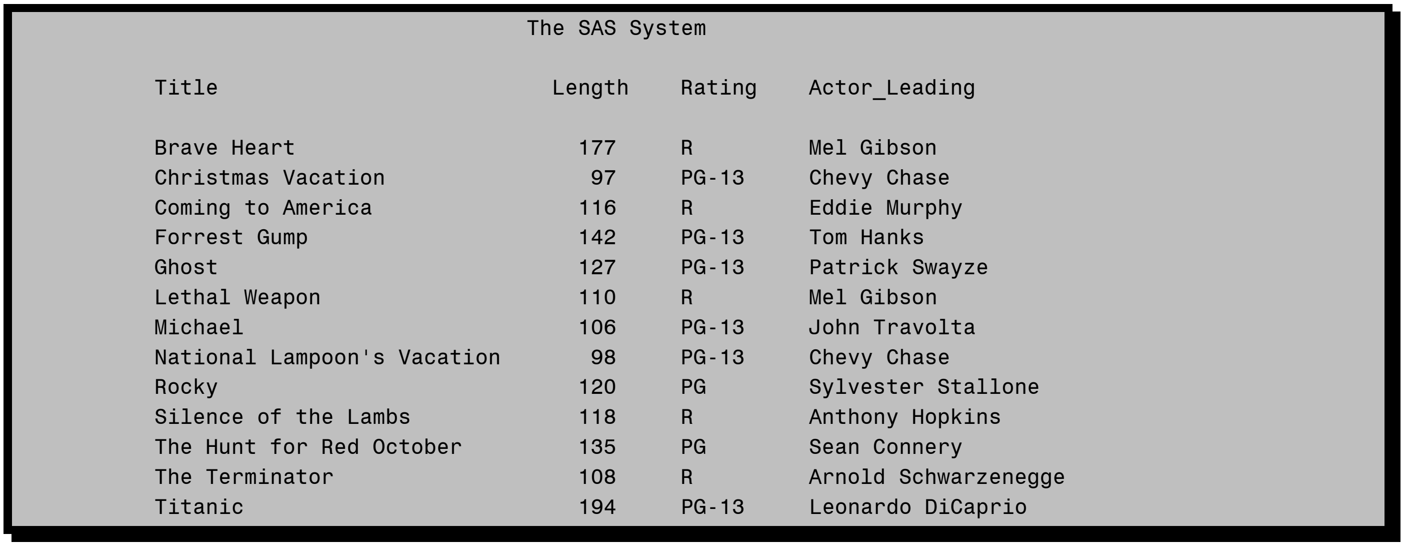
Right Outer Merge or Join

The result of a Right Outer merge or join produces matched rows from both tables while preserving all unmatched rows from the right table. The following merge code illustrates a right outer merge construct that selects “matched” movies based on their titles from the MOVIES and ACTORS tables, plus all “unmatched” movies from the ACTORS table.

Merge Code

```
PROC SORT DATA=MOVIES;
  BY TITLE;
RUN;

PROC SORT DATA=ACTORS;
  BY TITLE;
RUN;

DATA  RIGHT_OUTER_MERGE;
   MERGE  MOVIES (IN=M KEEP=TITLE LENGTH RATING)
              ACTORS (IN=A KEEP=TITLE ACTOR_LEADING);
    BY  TITLE;
       IF  A;
RUN;

PROC PRINT DATA=RIGHT_OUTER_MERGE NOOBS;
RUN;
```

Results



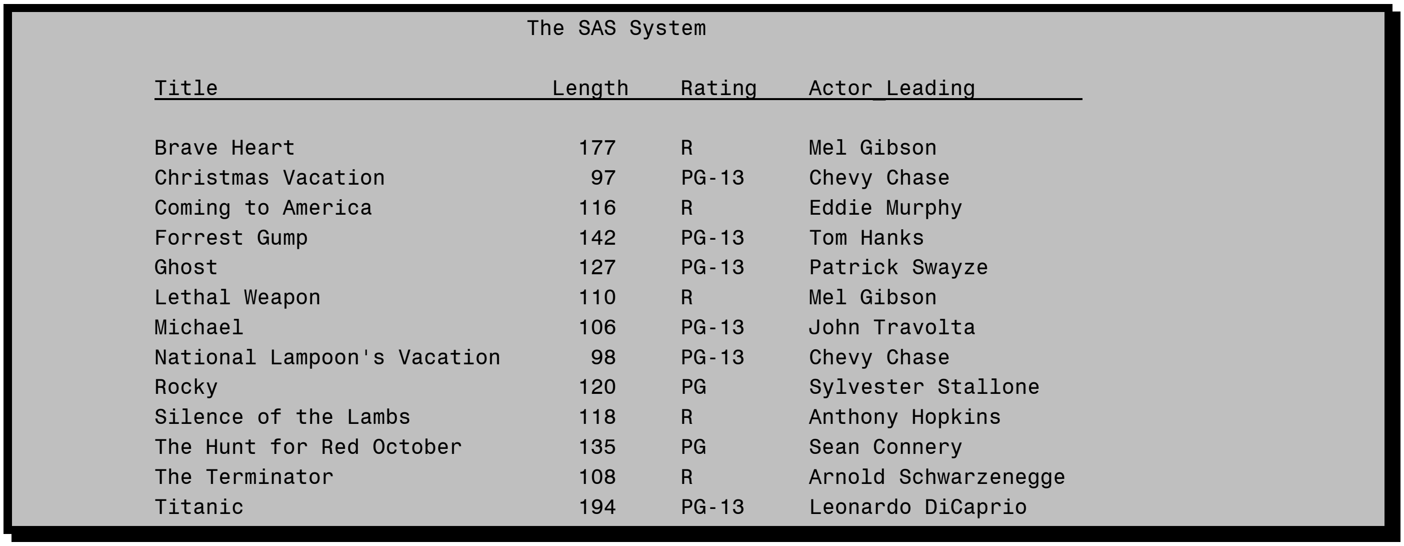
```
                                   The SAS System

           Title                          Length    Rating    Actor_Leading

           Brave Heart                      177     R         Mel Gibson
           Christmas Vacation                97     PG-13     Chevy Chase
           Coming to America                116     R         Eddie Murphy
           Forrest Gump                     142     PG-13     Tom Hanks
           Ghost                            127     PG-13     Patrick Swayze
           Lethal Weapon                    110     R         Mel Gibson
           Michael                          106     PG-13     John Travolta
           National Lampoon's Vacation       98     PG-13     Chevy Chase
           Rocky                            120     PG        Sylvester Stallone
           Silence of the Lambs             118     R         Anthony Hopkins
           The Hunt for Red October         135     PG        Sean Connery
           The Terminator                   108     R         Arnold Schwarzenegge
           Titanic                          194     PG-13     Leonardo DiCaprio
```

The corresponding SQL procedure code to produce a right outer join row result set is shown below.

SQL Code

```
PROC SQL;
  CREATE  TABLE  RIGHT_OUTER_JOIN  AS
    SELECT  *
      FROM MOVIES(KEEP=TITLE LENGTH RATING)
        RIGHT JOIN
            ACTORS(KEEP=TITLE ACTOR_LEADING)
        ON MOVIES.TITLE = ACTORS.TITLE;

  SELECT * FROM RIGHT_OUTER_JOIN;
QUIT;
```

Results



```
                                       The SAS System

           Title                          Length    Rating    Actor_Leading
           ______________________________________________________________________

           Brave Heart                       177    R         Mel Gibson
           Christmas Vacation                 97    PG-13     Chevy Chase
           Coming to America                 116    R         Eddie Murphy
           Forrest Gump                      142    PG-13     Tom Hanks
           Ghost                             127    PG-13     Patrick Swayze
           Lethal Weapon                     110    R         Mel Gibson
           Michael                           106    PG-13     John Travolta
           National Lampoon's Vacation        98    PG-13     Chevy Chase
           Rocky                             120    PG        Sylvester Stallone
           Silence of the Lambs              118    R         Anthony Hopkins
           The Hunt for Red October          135    PG        Sean Connery
           The Terminator                    108    R         Arnold Schwarzenegge
           Titanic                           194    PG-13     Leonardo DiCaprio
```

Conclusion

The Base-SAS DATA step and SQL procedure are wonderful languages for SAS users to explore and use in a variety of application situations. This paper has presented explanations, guidelines and "simple" techniques for users to consider when confronted with conditional logic scenarios and merges/joins. You are encouraged to explore these and other techniques to make your SAS experience an exciting one.

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Trademark Citations

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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 more than four 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 17 "Best" contributed paper awards. His popular SAS Tips column, "Kirk's Korner of Quick and Simple Tips", appears regularly in several SAS User Group newsletters and Web sites, and his fun-filled SASword Puzzles is featured in SAScommunity.org.

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