A Brief Introduction to DS2

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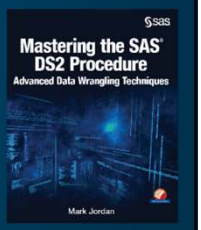

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Objectives

- Describe the DS2 programming language.
- Identify when it is most appropriate to use the DS2 language.
- Compare the DS2 DATA program to Base SAS DATA step execution.
- Understand basic DS2 Syntax
  - Explain DS2 variable declaration and its effect on variable scope.
  - Name three DS2 system methods and the conditions under which they execute.
- Parallel Processing in DS2
  - Describe the similarities and differences between DS2 DATA and THREAD programs
  - Convert a DS2 DATA program to a DS2 thread.
  - Execute DS2 threads from a DS2 DATA program

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Introduction to DS2

- Advanced data manipulation language
- DATA step-like syntax
- Closely integrated with SQL
- Convenient reusability

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Base SAS DATA Step

```
data _null_;
    Text='Hello, World!';
    put Text=;
run;
```

DS2 Data Program

```
data _null_;
    method init();
        Text='Hello, World!';
        put Text=;
    end;
enddata;
run;
```

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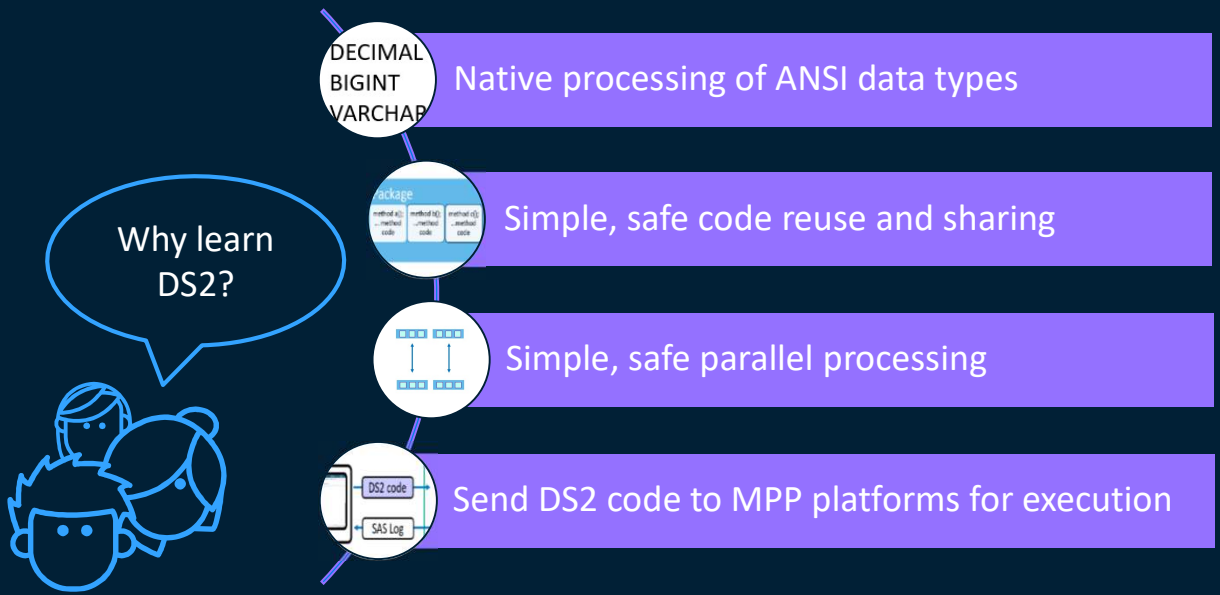
DS2 Superpowers



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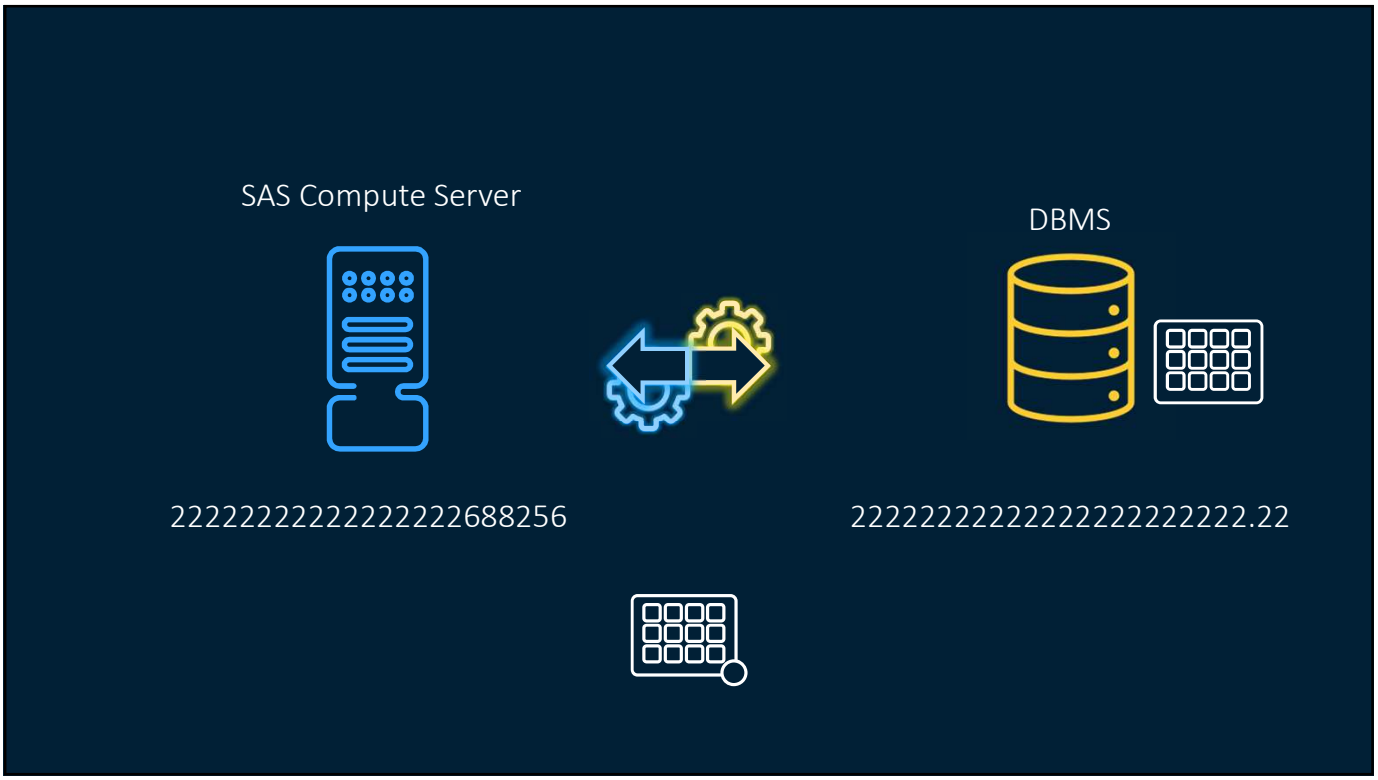

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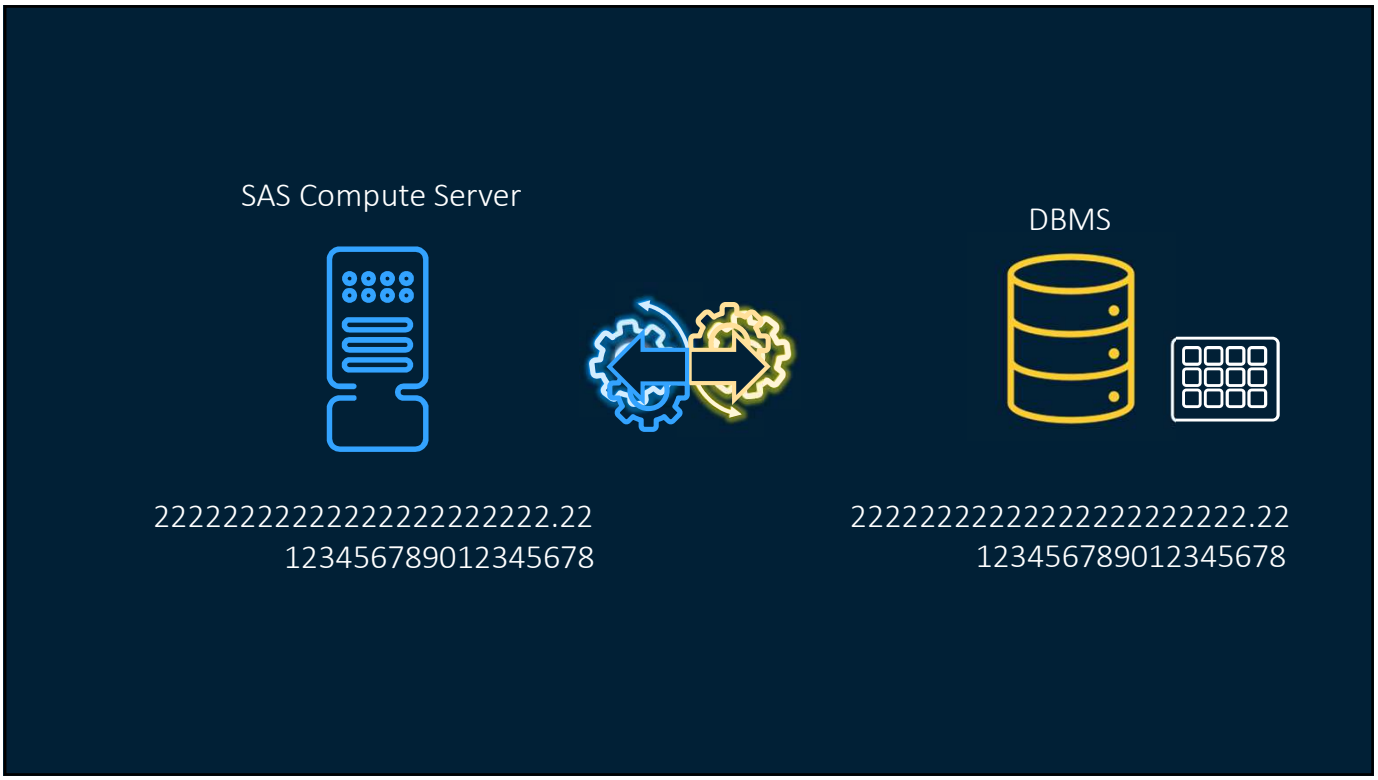
SAS Compute Server
DBMS
22222222222222222222.22
123456789012345678
22222222222222222222.22
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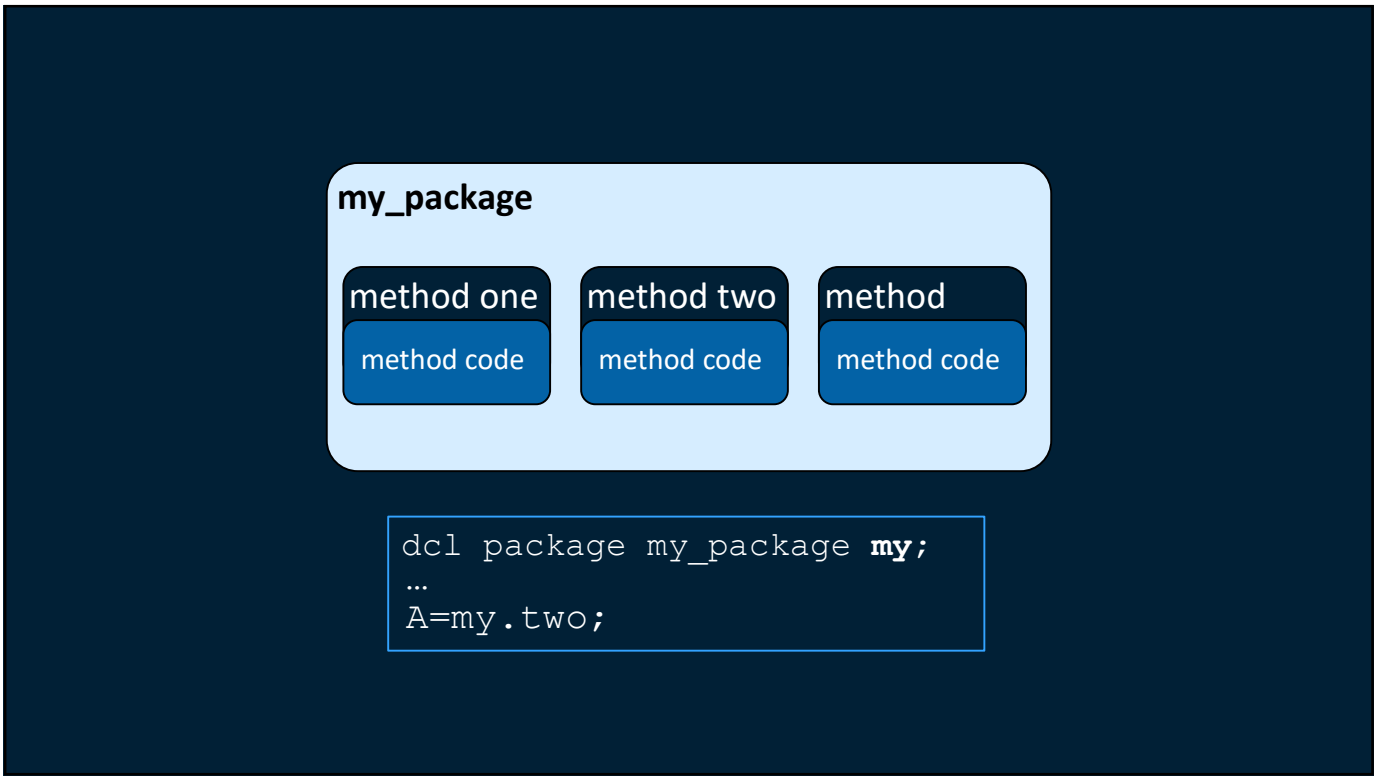
7


my_package
method one
method code
method two
method code
method
method code
dcl package my_package my;
…
A=my.two;

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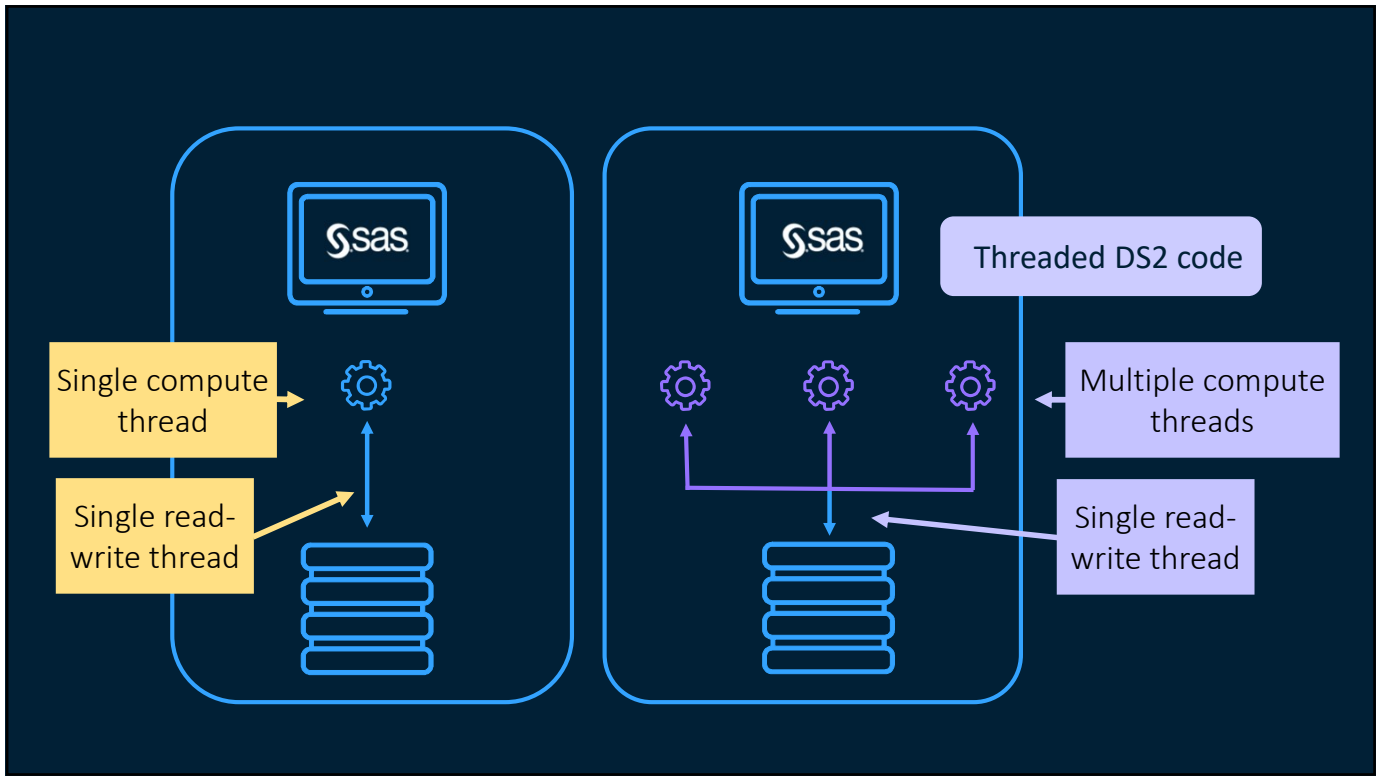
Single compute thread
Single read-write thread
Threaded DS2 code
Multiple compute threads
Single read-write thread

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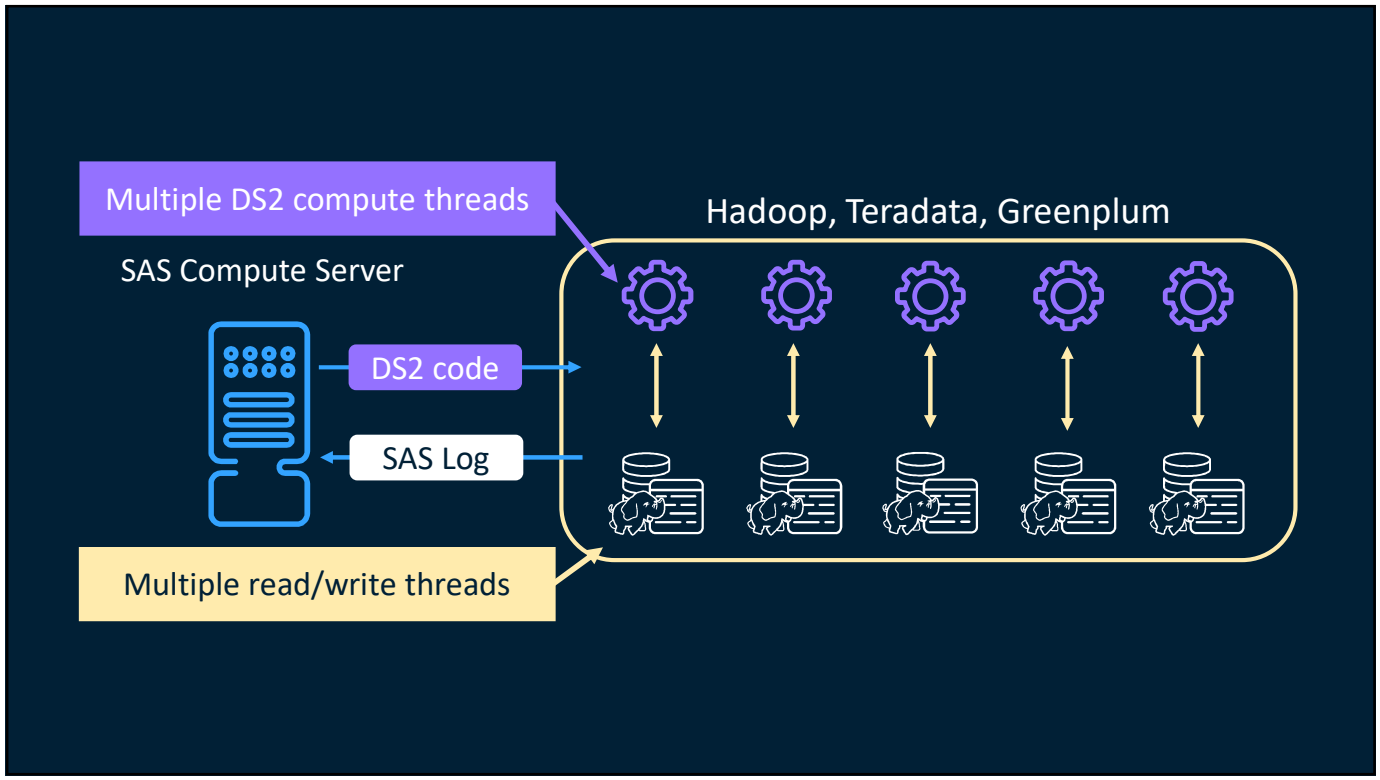
Multiple DS2 compute threads
SAS Compute Server
DS2 code
SAS Log
Multiple read/write threads
Hadoop, Teradata, Greenplum

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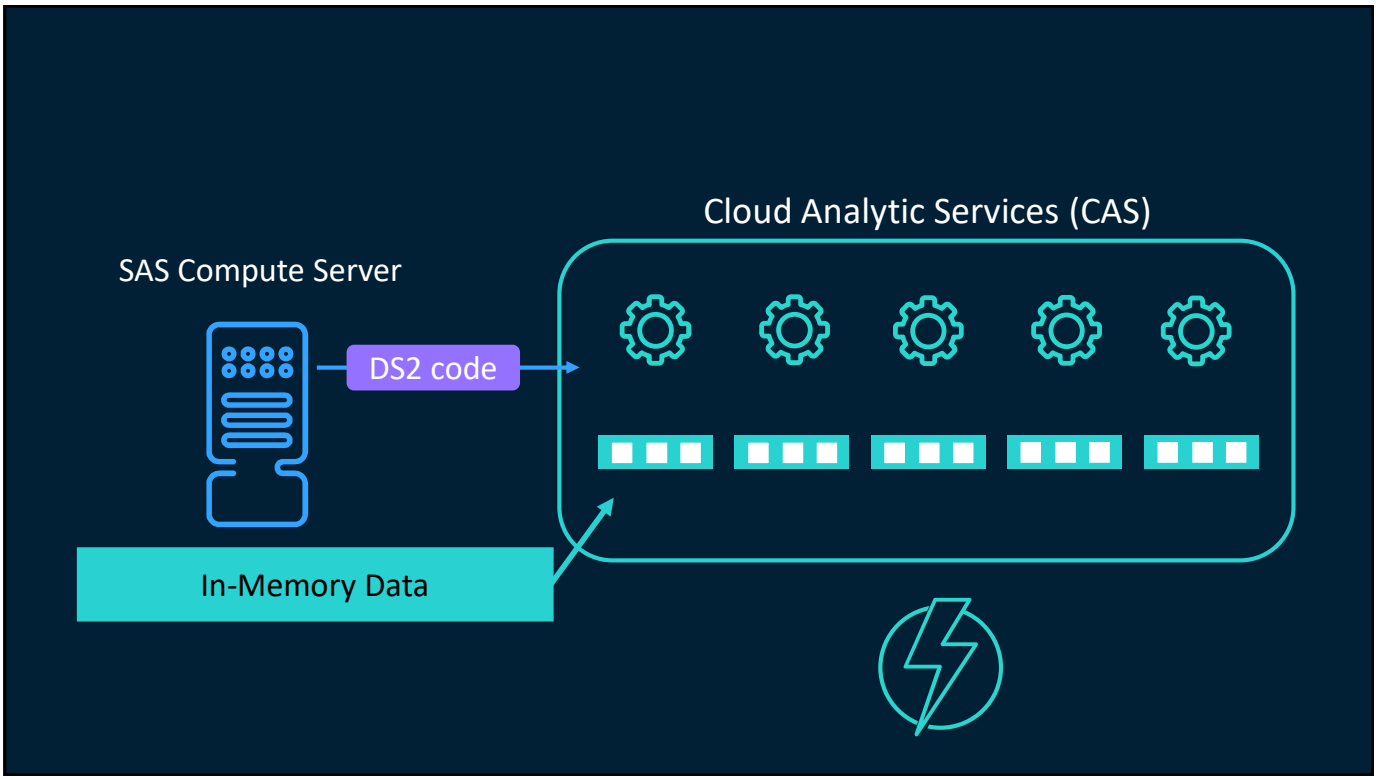
Cloud Analytic Services (CAS)
SAS Compute Server
DS2 code
In-Memory Data

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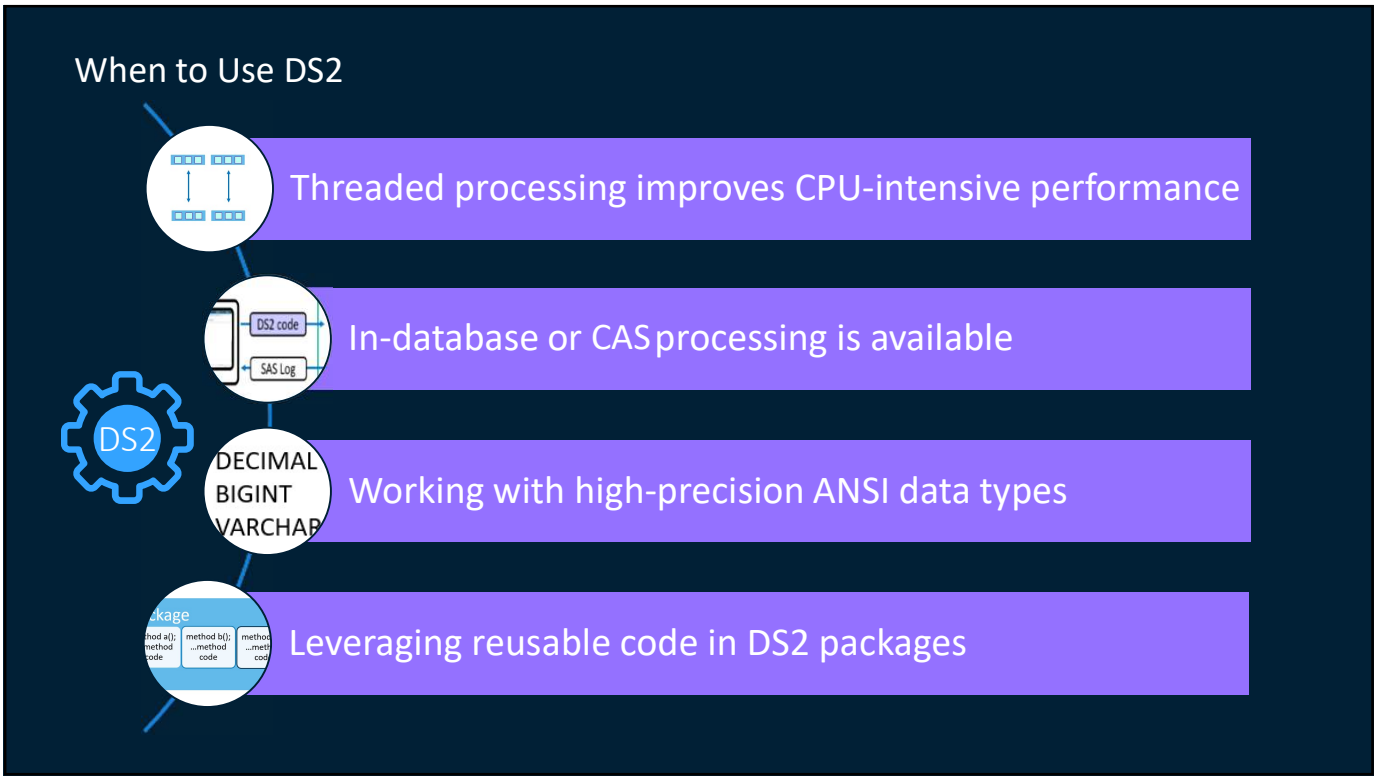
When to Use DS2
Threaded processing improves CPU-intensive performance
DS2 code
SAS Log
In-database or CAS processing is available
DS2
DECIMAL
BIGINT
VARCHAR
Working with high-precision ANSI data types
Leveraging reusable code in DS2 packages

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DS2 Program Types

```
proc ds2;
package work.pgk;
   <more program statements>
endpackage;
run;
thread work.thread;
   <more program statements>
endthread;
run;
data my.table;
   <more program statements>
enddata;
run;
quit;
```

In the SAS windowing environment, program blocks without a RUN before the QUIT statement won't execute.

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Data programs

- begin with a DATA statement
- end with an ENDDATA statement
- require a RUN statement to execute.

```
data my.table;
```

```
enddata;
run;
```

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Methods

- Begin with a METHOD statement
- End with an END statement
- Contain all executable statements in the program
- System or user-defined

```
data my.table;
   method myMethod(double x);
      put 'myMethod';
   end;
   method init();
      put 'INIT';
   end;
enddata;
run;
```

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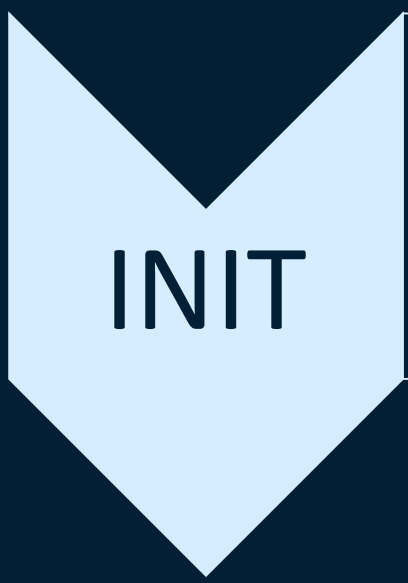
System Methods Control Data Program Flow



- Called when data program begins execution
- Each statement executed only once
- At END, automatically calls the RUN method

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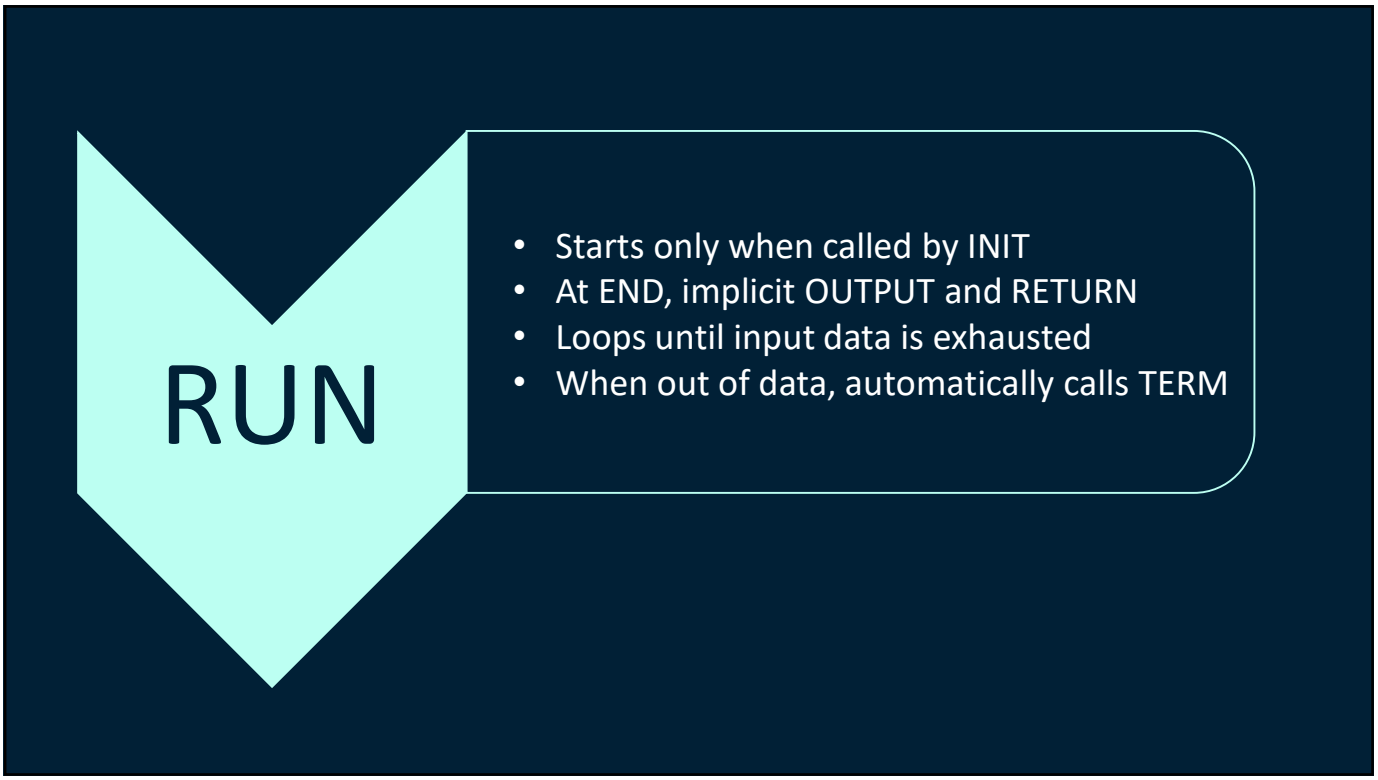
RUN
Starts only when called by INIT
At END, implicit OUTPUT and RETURN
Loops until input data is exhausted
When out of data, automatically calls TERM

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Term
Starts only when called by RUN
Each statement executed only once
At END, DS2 program execution terminates

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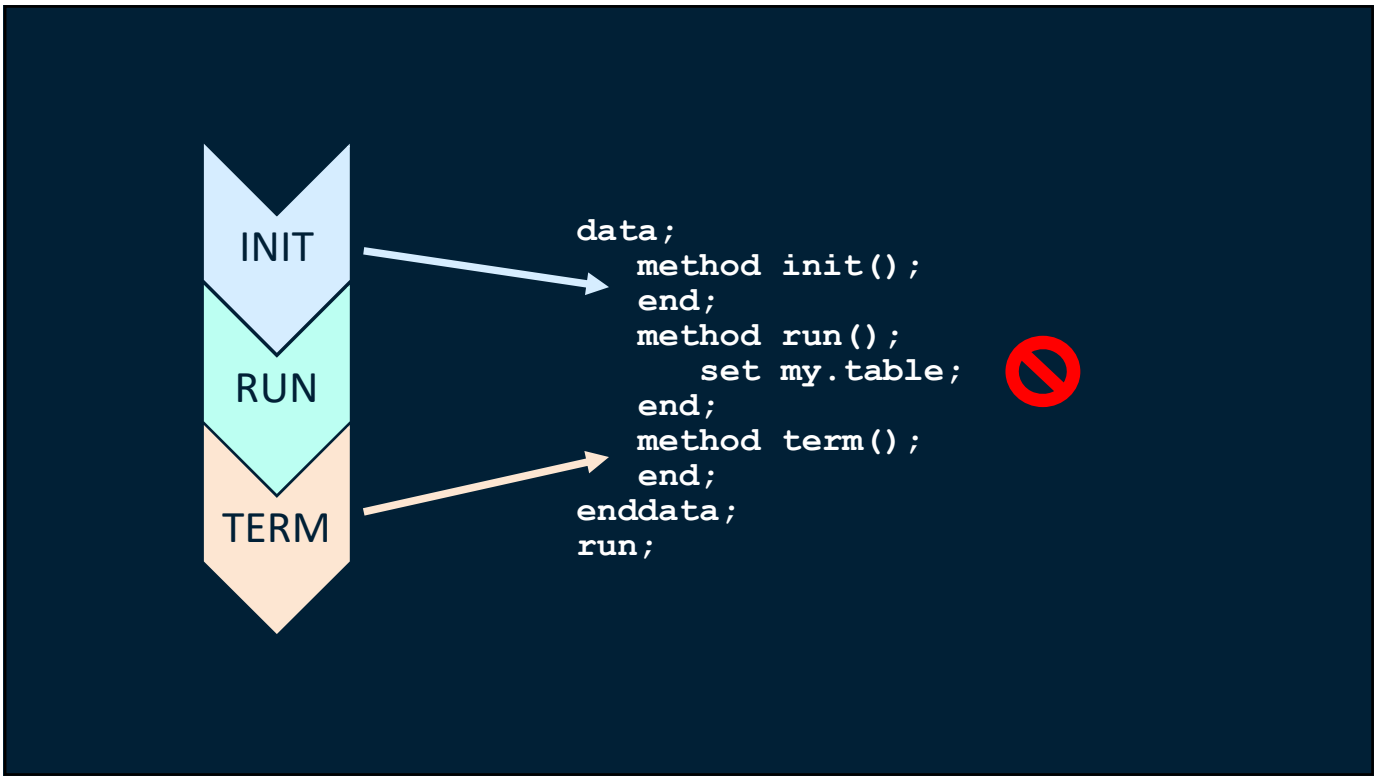

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Declaration Statements

```
data;
   dcl double Amount;
   retain Amount 0;
   method run();
      dcl int year;
      set orion.banks;
      amount=1000;
      do year=1 to 5;
         amount=sum(amount,amount*rate);
      end;
   end;
enddata;
```

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Variable declaration

DECLARE|DCL *data-type variable-list*
<HAVING LABEL '*string*' | FORMAT | INFORMAT> ;

```
/* Declare three DOUBLE variables formatted dollar12.2*/
dcl double Var1 Var2 Var3 having format dollar12.2;

/* Declare a high-precision fixed point numeric variable */
dcl decimal(35,5) Var1;

/* Declare a fixed-width character variable labeled 'My Text'*/
dcl char(25) Var1 having label 'My Text';
```

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```
data;
   dcl double Value;
   method run();
      set orion.banks;
      do Month='JAN','FEB','MAR';
         do i=1 to 3;
            Value=10**i;
            if i > x then output;
         end;
      end;
   end;
enddata;
run;
```

```
WARNING: No DECLARE for referenced variable month;
         creating it as a global variable of type char(3).
WARNING: No DECLARE for referenced variable i;
         creating it as a global variable of type double.
WARNING: No DECLARE for referenced variable x;
         creating it as a global variable of type double.
```

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DATA Step

- KEEP
- DROP
- RETAIN

DS2

- KEEP
- DROP
- RETAIN

```
ERROR: Compilation error.
```

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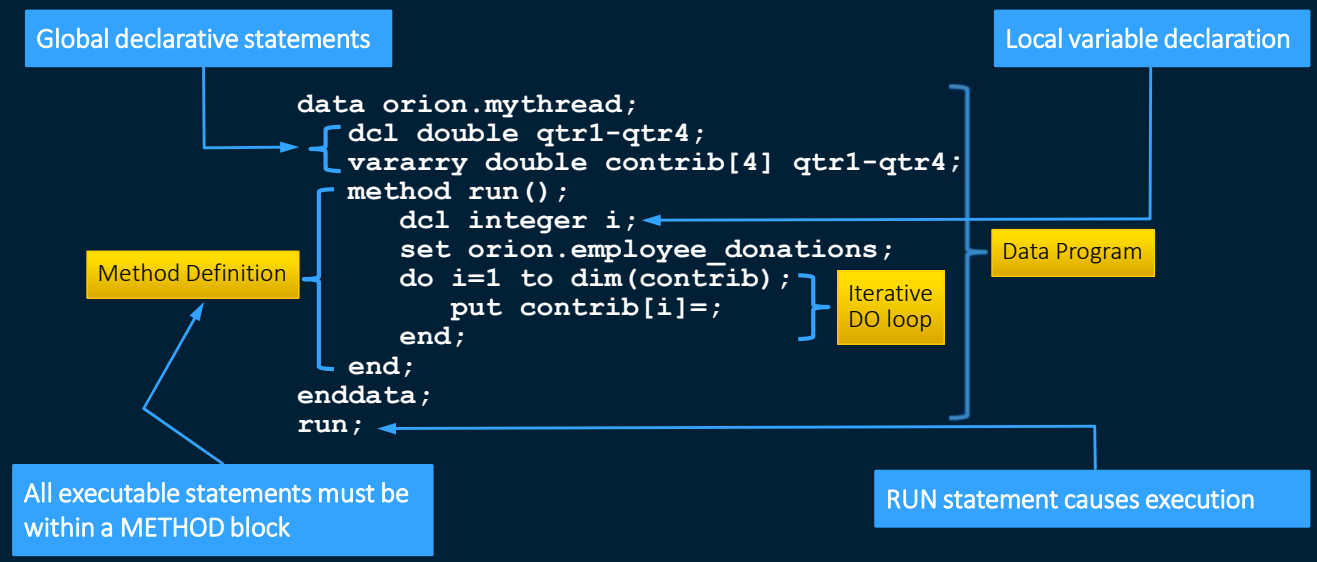
DS2 data program block structure



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Package programs

DS2 packages are collections of methods and variables stored in SAS libraries.

- Simplify re-using code in DS2 DATA and Thread programs.
- Predefined packages ship with SAS to extend DS2 capabilities.
- User-defined packages enable easy, secure sharing of proprietary algorithms.
- Packages enable object-oriented programming for the DS2 language
  - Can accept parameters when instantiated
  - Can include user-defined constructor and destructor methods
  - Global variables in a package are private to the package instance and do not affect the PDV of the DATA program in which they are used

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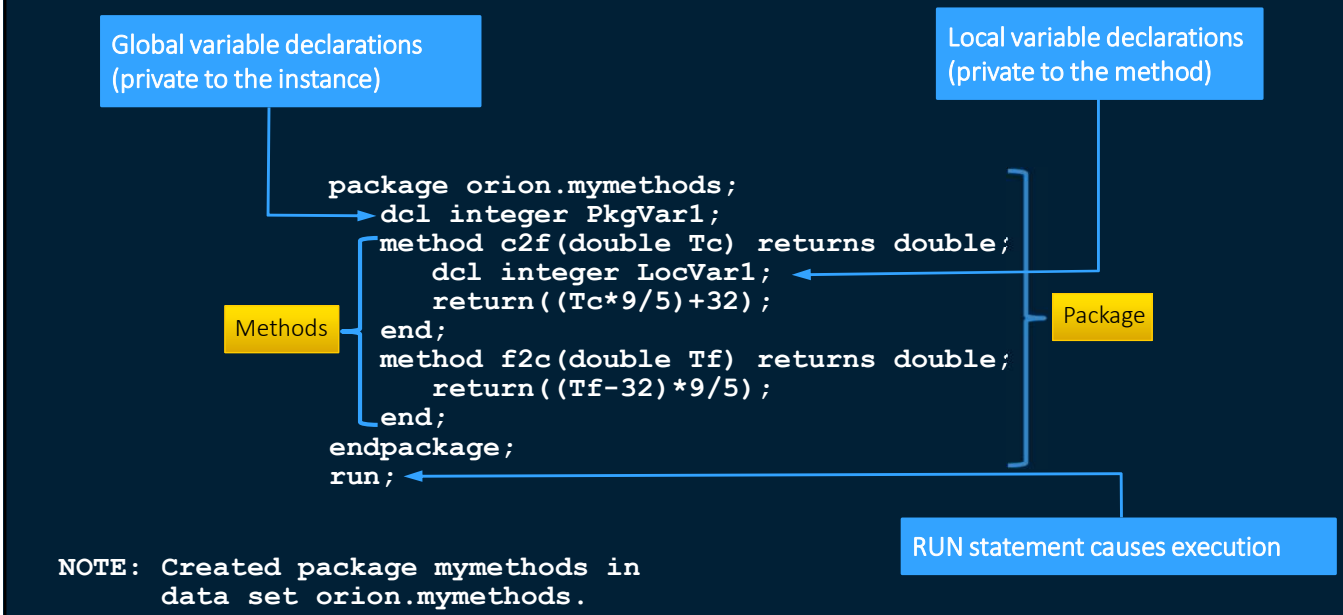
Package programs



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Thread programs

- Threads are programs stored in SAS libraries and used for parallel processing in DS2
- Similar to DATA programs in that they
  - Enforce a more structured programming syntax
  - Require all executable code to be included in a method definition
  - Require at least explicitly written system method
  - Global variables appear in the PDV of the DATA program in which they are used
- Similar to DS2 packages in that they
  - can be re-used when stored in permanent SAS libraries.
  - can contain user-defined methods.
  - can accept parameters

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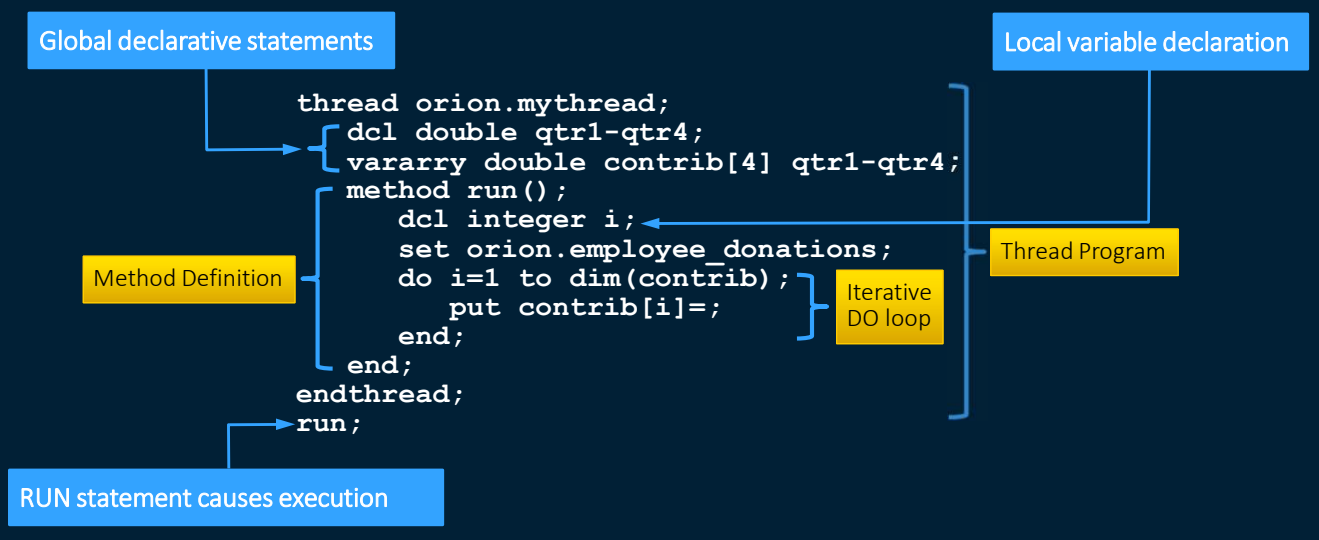
Thread programs




```
NOTE: Created thread mythread in data set orion.mythread.
```

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User-Defined Methods

METHOD *Name* (<IN_OUT>*data-type Parameter1* …)
,<IN_OUT>*data-type ParameterN*
<RETURNS *data-type*>;
… more DS2 code …
<RETURN *value*>**;**
END;

- can accept parameters
- parameters can be either standard or IN_OUT
- IN_OUT parameter values can be modified
- can return a value
- execute only when called
- can be called multiple times

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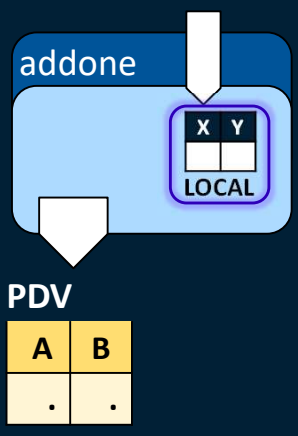
Returning a value

```
dcl int A B;
method addone(int x) returns int;
   dcl int y;
   y=x+1;
   return y;
end;
method init();
   B=3;
   A=addone(B-2);
end;
```



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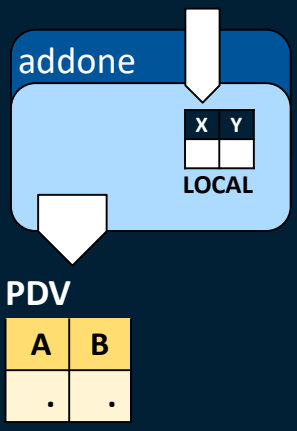
```
dcl int A B;
method addone(int x) returns int;
   dcl int y;
   y=x+1;
   return y;
end;
method init();
   B=3;
   A=addone(B-2);
end;
```



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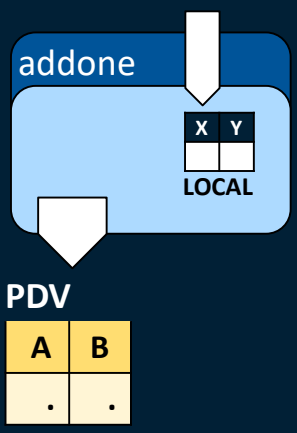
Standard Parameters

```
dcl int A B;
method addone(int x) returns int;
   dcl int y;
   y=x+1;
   return y;
end;
method init();
   B=3;
   A=addone(B-2);
end;
```



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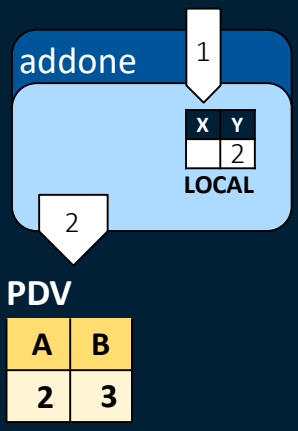
```
dcl int A B;
method addone(int x) returns int;
   dcl int y;
   y=x+1;
   return y;
end;
method init();
   B=3;
   A=addone(B-2);
end;
```



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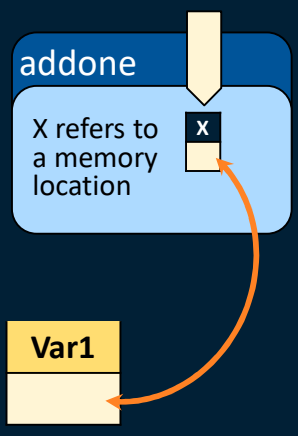
IN_OUT Parameters

```
method addone(in_out int X);
   x=x+1;
end;
```




```
ERROR: Parse failed:  method addone
(in_out  >>> vararray <<<  int x[4]);

ERROR: In call of addone: argument 1 is 'in_out'; therefore, the type
       of the argument must be identical to the type of the method
       parameter (requires int, found double)
```

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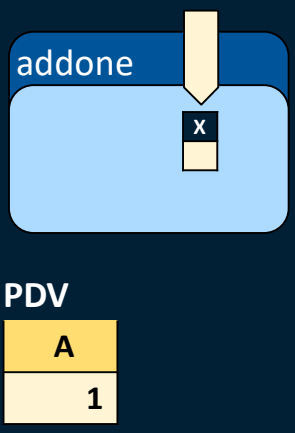
```
dcl int A;
method addone(in_out int X);
   x=x+1;
end;
method init();
   A=3-2;
   addone(A);
end;
```



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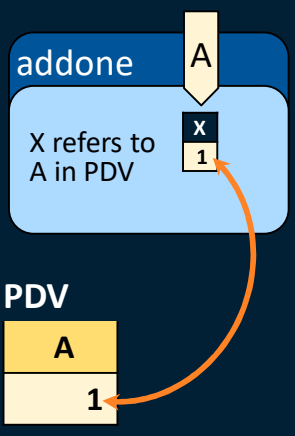
```
dcl int A;
method addone(in_out int X);
   x=x+1;
end;
method init();
   A=3-2;
   addone(A);
end;
```



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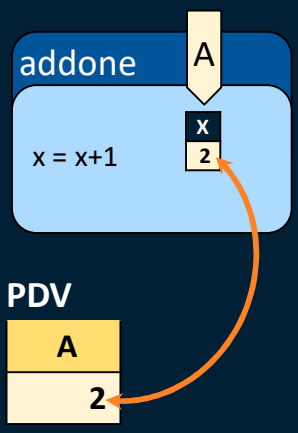
```
dcl int A;
method addone(in_out int X);
   x=x+1;
end;
method init();
   A=3-2;
   addone(A);
end;
```



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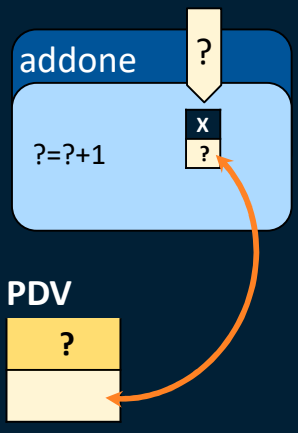
```
method addone(in_out int X);
   x=x+1;
end;
method init();
   addone(3-2);
end;
```




```
ERROR: Compilation error.
ERROR: In call of addone: argument 1 is 'in_out'; therefore, the
       argument must be a modifiable value.
ERROR: Line 22: Attempt to obtain a value from a void expression.
```

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Variable Scope

```
data;
   dcl double Value;
   method init();
      Value=5000;
   end;
   method run();
      set orion.banks;
      Total=sum(value,value*rate);
   end;
   method term();
      dcl char(12) Value;
      Value='Just Testing';
      put Value=;
   end;
enddata;
run;
```

PDV

Value N 8	Name $ 29	Rate N 8	Total N 8

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DATA step vs. DS2 data program

```
data _null_;
   /* Section 1 */
   if _n_ =1 then do;
      Text='**> Starting';
      put Text;
   end;
   /* Section 2 */
      set orion.banks end=last;
      put _all_;
   /* Section 3 */
   if last then do;
      Text='**> All done!';
      put Text;
   end;

run;
```

```
data _null_;
 /* Section 1 */
 method init();
    Text='**> Starting';
    put Text;
 end;
/* Section 2 */
method run();
   set orion.banks;
   put _all_;
end;
/* Section 3 */
method term();
   Text='**> All done!';
   put Text;
end;
enddata;
run;
```

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Converting to DATA Step DS2

PROC DSTODS2 IN=*fully-qualified-DATA-step-file-name*
OUT=*ds2-program-file-name*
OUTDIR=*path-for-output-file*;

```
proc dstods2 in ="&path/demos/ds203d02a.sas"
             out="ds203d02a_ds2.sas"
             outdir="&path/demos/";
run;


   set orion.banks /* END = LAST */;
```

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Converting a DS2 Data Program to a Thread

```
thread my_sas.thRetirement;
   dcl package my_sas.pkgBankMethods bank();
   dcl double valueInitial valueFinal having format dollar12.2;
   keep Employee_ID, Employee_Name value:;
   dcl int _count;
   keep Employee_ID, Employee_Name value:;
   method run();
      dcl int duration;
      set orion.employees;
      valueInitial=Salary*.1;
      Duration=year(today())-year(employee_hire_date);
      valueFinal=bank.interest(ValueInitial,.04, Duration);
   end;
   method term();
      put '*** Thread' _threadid_ 'of' _nthreads_ 'processed'
          _count 'rows on' _hostname_;
   end;
endthread;
```

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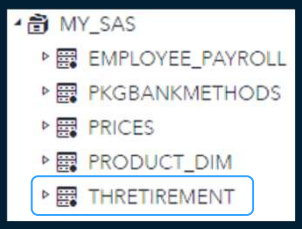
```
NOTE: Created thread thretirement in data set my_sas.thretirement.
```



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```
data;
   dcl thread my_sas.thRetirement ret;
   method run();
      set from ret threads=3;
   end;
enddata;
run;
```

threadid=1

Total	Employee_ID	Qtr1	Qtr2	Qtr3	Qtr4
.	.	.	.	.	.

threadid=2

Total	Employee_ID	Qtr1	Qtr2	Qtr3	Qtr4
.	.	.	.	.	.

threadid=3

Total	Employee_ID	Qtr1	Qtr2	Qtr3	Qtr4
.	.	.	.	.	.

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The THREADS= option specifies the number of threads to execute in parallel.

- Over threading can negatively affect performance.
- &SYSNCPU is a good starting point

```
set from ret threads=&SYSNCPU;
```

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Executing DS2 Threads in Base SAS and in CAS

This demonstration illustrates improving performance of a CPU-bound DATA step using DS2 threaded processing.

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Questions?

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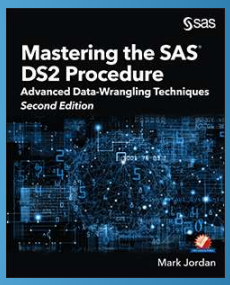

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