Enterprise COBOL: A Tool for Growth

COBOL Changes - Big Picture

Recent COBOL Compiler Versions

- OS/VS COBOL - (a.k.a. " COBOL I") no longer supported

- VS COBOL II - no longer supported (March 2001)

- All compilers after this require Language Environment (LE):
  - COBOL/370 - no longer supported (V1R1) (September 1997)
  - COBOL for MVS & VM - no longer supported (V1R2) (Dec. '01)
  - COBOL for OS/390 & VM (V2R1, V2R2) (Dec. '04)

  - IBM Enterprise COBOL for z/OS & OS/390 (V3R1-V3R4)
    - V4R1 December, 2007; V4R2 October, 2009

Major New Features - General

- Pointers and Address-of special register
- Reference modification (sub-stringing)
- Scope-terminators (END-*verb*)
- In-line PERFORM
- INITIALIZE statement
- EVALUATE statement
- Intrinsic function support
- Increased element and table size (128MB)

Major New Features - General, continued

- Local-storage section
- Recursive programs
- DLL (Dynamic Link Library) support
  - Code DLLs in COBOL, call from other languages
  - Call DLLs from COBOL program
- Dynamic file allocation
- Support for HFS (Hierarchical File System) files
- Compile and run under z/OS UNIX
- DB2 co-processor
- CICS co-translator

Major New Features - LE functions

- Dynamic allocation of storage
  - Build large tables outside of load module
- Error handling
  - No need for Assembler STAE or SPIE routines
- New dump format
  - Ability to take snapshot memory dumps
- International services
  - Date, time, currency formatting, for example

Major New Features - Improved interoperability with C

- Null-terminated strings
- Long names, mixed-case names
- Pass arguments in alternative ways
  - By reference - pointer to item
  - By content - pointer to copy of item
  - By value - copy of item in argument list directly
- Function-like behavior ("RETURNING" clause)

Major New Features - Internet / Web oriented

- Unicode support - translate between codepages
- XML support
  - XML PARSE
    - XML PARSE VALIDATING WITH schema (V4R2)
  - XML GENERATE
- Object Oriented COBOL
  - Uses JVM (Java Virtual Machine)
- COBOL - Java Interoperability

COBOL Changes - format

- COBOL programs may be written in mixed case, since at least 1988
  - Just a style issue, but studies have shown this is easier to read:

```
 Identification division.
 program-id.  exer01.
*  Copyright (C) 2008 by Steven H. Comstock

 environment division.
 input-output section.
 file-control.
     select zinputa assign to zinputa.
     select reprt assign to reprt.

 data division.
 file section.
 fd  zinputa
     block contains 0 records.
 01  zinputa-record                  pic x(100).

 fd  reprt.
 01  reprt-rec                       pic x(106).
```

COBOL Changes - format, continued

- The word "filler" is optional
  - Makes data structure stand out more cleanly:

```
working-storage section.
 01  in-record.
     05 in-part-number       pic x(9).
     05 in-description       pic x(30).
     05                      pic x(5).
     05 in-unit-price        pic 9999v999.
     05 in-quantity-on-hand  pic 99999.
     05 in-quantity-on-ord   pic 999.
     05 in-reorder-level     pic 999.
     05 in-switch            pic xx.
     05 in-old-part-no       pic x(9).
     05 in-category          pic x(10).
     05                      pic x(17).

 01  reprt-record.
     05                         pic x(1)  value spaces.
     05 reprt-part-number       pic x(9).
     05                         pic x(3)  value spaces.
     05 reprt-description       pic x(30).
     05                         pic x(3)  value spaces.
     05 reprt-quantity-on-hand  pic 99999.
     05                         pic x(55) value spaces.
```

COBOL Changes - format, continued

- Data types can now be specified as "packed-decimal" instead of "comp-3" and "binary" instead of "comp"
  - Again, a style issue, but it is more accurate / concise:

```
01  calc-stuff.
    02  number-items  pic s9(9)   binary         value +0.
    02  gross-sales   pic s9(v)99 packed-decimal value 0.00.
    02  tax-rate      pic s9v999  packed-decimal value 0.062.
```

COBOL Changes - format, continued

- You can use the underscore (_) instead of a dash (-) in user defined words (data items, paragraphs, sections, and so on)
  - In Enterprise COBOL V4R2 and later; *e.g.*:

```
01  calc_stuff.
    02  number_items  pic s9(9)   binary         value +0.
    02  gross_sales   pic s9(v)99 packed-decimal value 0.00.
    02  tax_rate      pic s9v999  packed-decimal value 0.062.
```

This is also useful for processing XML from COBOL, since most XML names tend to have underscores instead of dashes (although both are allowed)

COBOL Changes - Tables

- ► Maximum of 7 dimensions (up from 3)
- ► Maximum of 128MB per table (up from 128K)
- ► Initialize table with VALUE at elementary level:

```
01  Sales-table.
    05  Department occurs 20 times.
        10  Dept-name pic x(20) value spaces
        10  Dept-sales-amt pic s9(5)v99 packed-decimal value 0.
```

COBOL Changes - Working-Storage

- The size of working storage has been expanded to 128MB (up from 1MB)
  - Allows for more data-driven code and less fragmentation of routines, perhaps

All Data Items Must Be Described

- Two clauses are relevant to the description:
  - USAGE IS clause
    - Strangely enough, both the words USAGE and IS are optional - the compiler looks for the actual allowed data types
  - PICTURE clause
    - Required for some usages; for others, it is not allowed

USAGE Types

► Here is the complete list of reserved words for USAGE:

BINARY	**- same as COMP and COMP-4; binary integer**
COMP	**- binary integer data**
COMP-1	**- single precision floating point (PIC not allowed)**
COMP-2	**- double precsion floating point (PIC not allowed)**
COMP-3	**- packed decimal data**
COMP-4	**- binary integer data**
NOTE:	**binary, comp, comp-4 are all the same; values in these kinds of fields may be truncated, based on compiler options and the particular work being done**
COMP-5	**- binary integer, but will never be truncated**
PACKED-DECIMAL	**- same as comp-3**
INDEX	**- binary value: displacement into a table (PIC not allowed)**
DISPLAY	**- character string; single byte characters**
DISPLAY-1	**- character string; double byte characters**
NATIONAL	**- character string; UTF-16 (Unicode)**
POINTER	**- address of data item (PIC not allowed)**
PROCEDURE-POINTER	**- address of program entry point (8 bytes) (PIC not allowed)**
FUNCTION-POINTER	**- address of program entry point (4 bytes) (PIC not allowed)**
OBJECT-REFERENCE	**- handle for accessing a class in OO COBOL (PIC not allowed)**

PICTURE Clause

- A PICTURE (or simply PIC) clause is required for these data types:
  - Numeric data
    - Binary, comp, comp-4, comp-5
    - Comp-3, packed-decimal
  - String data
    - Display
    - Display-1
    - National

PICTURE Clause, continued

- A data item may have a PIC clause with no USAGE
  - In that case, the implied USAGE is
    - DISPLAY if the PIC has no G nor N items
    - DISPLAY-1 if the PIC has G items, or N items if the compiler option NSYMBOL is DBCS
    - NATIONAL if the PIC has N items and the compiler option NSYMBOL is NATIONAL (the default)

Non-numeric Literals

- Non-numeric literals may be bounded by single quotes (apostrophes) or double quotes - even in the same program
  - As long as the opening delimiter is the same as the closing delimiter
- Independent of the QUOTE / APOST compiler setting
  - Which now just indicates what character to use for the figurative constant QUOTE[S]

```
01  column-headers.
    02  pic x(10) value 'Employee Number'.
    02  pic x(3)  value spaces.
    02  pic x(20) value "Last Name".
```

Non-numeric Literal data - new options

- Hexadecimal literals: x'4A'

- Null terminated literals: z'Title of book'

- National literals: N'Heavy' (UTF-16)

- National hexadecimal literals: nx'672C'

Reference modification

- *data-name*(*start*:[*length*]) - examples:

```
move fielda to fieldb (5:7)

move fielda (N:3) to fieldb

move fielda (M+2): to fieldb (3: (xy-3)/2)
```

Pointers and addresses

► A data item defined as pointer has an implicit definition of a 4 byte item intended to hold the address of some location in memory:

```
01  list-anchor       pointer.
01  current-element   pointer.
01  no-more           pointer value null.
```

► Pointer data items may only be used in:

- SET statements
- Comparisons (and only for EQUAL or NOT EQUAL)
- CALL - you may pass pointers as parameters

Pointers and addresses, 2

- A pointer data item may only have a value of NULL
  - A reserved word meaning the value is not currently meaningful / valid
- Examples of using pointers:

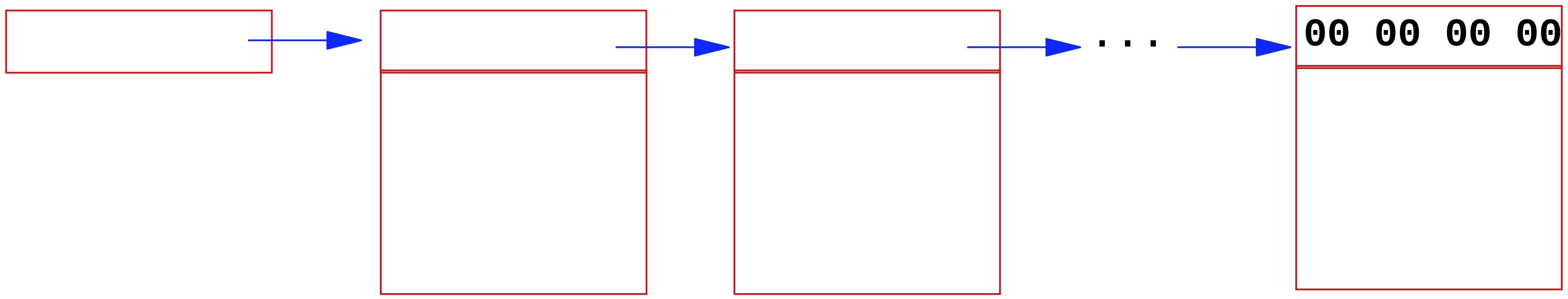
```
set current-element to list-anchor

if list-anchor not = current-element ...

set list-anchor to null

call 'walker' using current-element
```

Pointers and addresses, 3

- You can reference the address of any data item
  - Level 01 and 77 items in linkage section can be sending or receiving fields
  - For all other data items, the address of the item can only be used for sending (locating) the item
- The Address of an item is a special register that is implicitly defined

Pointers and addresses, 4

- Addresses and pointers can work together to process all the items in a linked list:



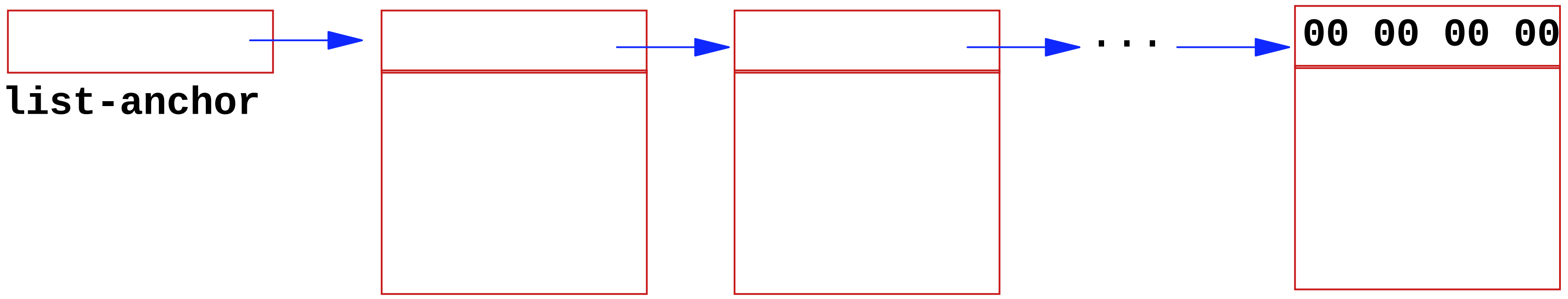
```
linkage section.
01 list-anchor pointer.
01 acct-rec.
   02  next-rec pointer.
   02  account-bal
        pic s9(5)v99
        packed-decimal.
```

```
procedure division using list-anchor.
  set address of acct-rec to list-anchor
  perform until next-rec is null
    add account-bal to total-bal
    set address of acct-rec to next-rec
  end-perform
```

Note also above: in-line perform

Pointers and addresses, 5

► Addresses and pointers can work together to process all the items in a linked list:

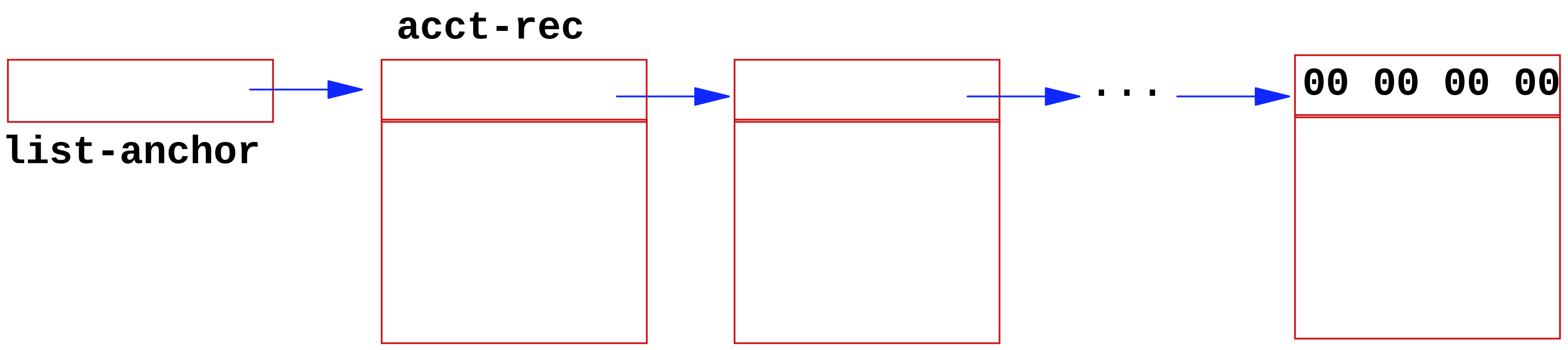


```
linkage section.
01 list-anchor pointer.
01 acct-rec.
   02  next-rec pointer.
   02  account-bal
        pic s9(5)v99
        packed-decimal.
```

```
procedure division using list-anchor.
  set address of acct-rec to list-anchor
  perform until next-rec is null
    add account-bal to total-bal
    set address of acct-rec to next-rec
  end-perform
```

Pointers and addresses, 6

- Addresses and pointers can work together to process all the items in a linked list:

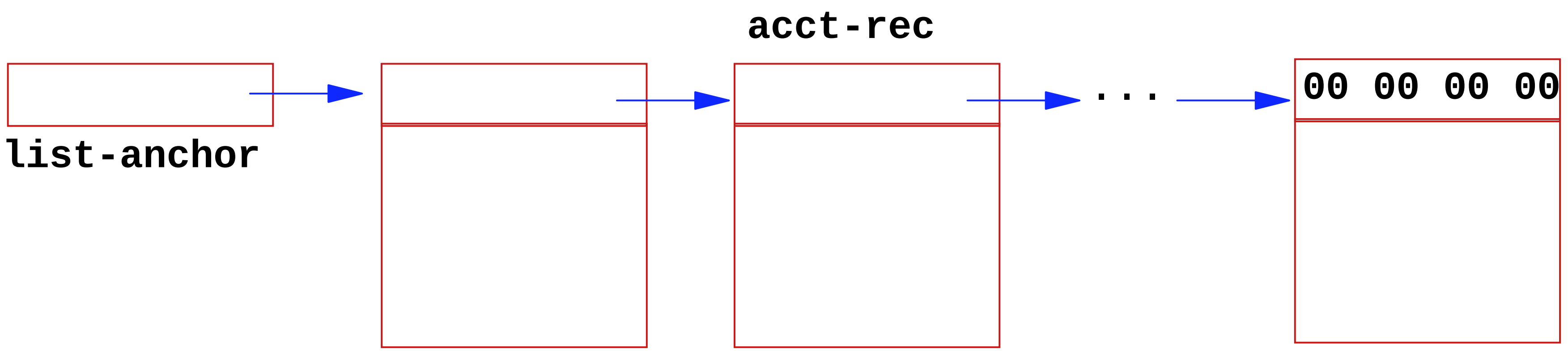


```
linkage section.
01 list-anchor pointer.
01 acct-rec.
   02  next-rec pointer.
   02  account-bal
        pic s9(5)v99
        packed-decimal.
```

```
procedure division using list-anchor.
  set address of acct-rec to list-anchor
  perform until next-rec is null
    add account-bal to total-bal
    set address of acct-rec to next-rec
  end-perform
```

Pointers and addresses, 7

- Addresses and pointers can work together to process all the items in a linked list:



```
linkage section.
01 list-anchor pointer.
01 acct-rec.
   02  next-rec pointer.
   02  account-bal
        pic s9(5)v99
        packed-decimal.
```

```
procedure division using list-anchor.
  set address of acct-rec to list-anchor
  perform until next-rec is null
    add account-bal to total-bal
    set address of acct-rec to next-rec
  end-perform
```

Scope terminators

- COBOL II introduced scope terminators to the language:

```
IF                           ...                     END-IF
CALL     ... ON OVERFLOW                         ... END-CALL
CALL     ... ON EXCEPTION   ... NOT ON EXCEPTION  ... END-CALL
READ     ... AT END         ... NOT AT END        ... END-READ
READ     ... INVALID KEY    ... NOT INVALID KEY   ... END-READ
DELETE   ... INVALID KEY    ... NOT INVALID KEY   ... END-DELETE
REWRITE  ... INVALID KEY    ... NOT INVALID KEY   ... END-REWRITE
START    ... INVALID KEY    ... NOT INVALID KEY   ... END-START
WRITE    ... END OF PAGE    ... NOT END OF PAGE   ... END-WRITE
ADD      ... ON SIZE ERROR ... NOT ON SIZE ERROR ... END-ADD
COMPUTE  ... ON SIZE ERROR ... NOT ON SIZE ERROR ... END-COMPUTE
DIVIDE   ... ON SIZE ERROR ... NOT ON SIZE ERROR ... END-DIVIDE
MULTIPLY ... ON SIZE ERROR ... NOT ON SIZE ERROR ... END-MULTIPLY
SUBTRACT ... ON SIZE ERROR ... NOT ON SIZE ERROR ... END-SUBTRACT
RETURN   ... AT END         ... NOT AT END        ... END-RETURN
SEARCH   ... AT END                               ... END-SEARCH
STRING   ... ON OVERFLOW    ... NOT ON OVERFLOW   ... END-STRING
UNSTRING ... ON OVERFLOW    ... NOT ON OVERFLOW   ... END-UNSTRING
```

Evaluate

- Along with end-if, the other statement programmers always pick up on, even if they had no training, is evaluate - it's just so useful

```
evaluate trans-id
  when 'A' perform add-trans
  when 'D' perform delete-trans
  when 'R'
  when 'U' perform update-trans
  when other perform bad-trans
end-evaluate


Evaluate trans-id
  when '1' perform trans-1-routine
  when '2' thru '4' perform trans-234-routine
  when 'A' perform trans-skip
  when not 'B' thru 'Z'
    perform other-numeric-trans
  when other perform trans-error
end-evaluate
```

Evaluate True

- But many don't realize you can evaluate True (or False) in addition to evaluating a data item:

```
Evaluate true
  when tax-collected = tax-owed
    perform audit-this-miracle
  when tax-collected < tax-owed
    perform initiate-collect
  when tax-collected > tax-owed
    perform initiate-refund
end-evaluate

Evaluate true
  when hourly-rate < min-wage
    compute hourly-rate = hourly-rate * 1.10
    perform min-message
  when hourly-rate > president-salary
    if president-salary > threshold-of-pain
      perform depose-current-president
      perform install-new-president
    end-if
  when other perform normal-salary-action
end-evaluate
```

Evaluate on conditional expressions

- You can also evaluate on complex expressions:

```
Evaluate one-a < one-b and hold-time < curr-time
  when true perform gotcha
  when false perform gotme
end-evaluate
```

Evaluate on condition names

- You can also evaluate on level-88 names:

```
evaluate true
  when exempt continue
  when management perform human-sacrifice
  when hourly perform substantial-raise
  when other perform modest-raise.


* This assumes something like:

01 Employee-type Pic X.
   88 exempt value 'E' 'P' 'Q'.
   88 management value 'M' 'V'.
   88 hourly value 'H' thru 'L'.
```

Evaluate with Also

- "Also" is used to separate multiple tests

```
Evaluate co-type also co-size also co-color
  when '1' also 'BIG' also 'BLUE'
    perform found-IBM
  when '1' also 'TALL' also 'GREEN'
    perform found-Celtics
  when 'F' also 'HEAVY' also 'BLACK+BLUE'
    perform found-NY-Giants
  when 'Y' also 'LEAN' also 'PAISLEY'
    perform found-yuppie-co
  when other
    perform no-match-on-co
end-evaluate
```

- Notice your WHEN clauses have to have the same number of ALSOs as your EVALUATE clause

Continue

- With the advent of all the scope terminators, many programmers adopted a style of "minimum punctuation"
  - Which in the Procedure Division means: only periods needed are at the end of a paragraph or section header and the end of a paragraph or section body
  - Of course, this lead to a rash of errors, especially for code that used NEXT SENTENCE: NEXT SENTENCE goes on a hunt for the next period ...

Continue, 2

- When using the new style, the second example is almost certainly what you want:

```
Move 'ANTELOPE' to animal-type
If item = ideal-value
   move 'SAN DIEGO' to zoo-id
   if unit-cost > maximum-cost
      next sentence
   else
      move unit-cost to maximum-cost
   End-if
   Move 'AARDVARK' to animal-type
else
   perform item-check
End-if
Move animal-type to print-animal-type.
Stop run.
```

```
Move 'ANTELOPE' to animal-type
If item = ideal-value
    move 'SAN DIEGO' to zoo-id
    if unit-cost > maximum-cost
       continue
    else
       move unit-cost to maximum-cost
    End-if
    Move 'AARDVARK' to animal-type
else
    perform item-check
End-if
Move animal-type to print-animal-type.
Stop run.
```

Initialize

- Another new statement in COBOL II was INITIALIZE - a quick way to set a lot of data items to an initial value
  - Numeric items go to zero, everything else to spaces
  - Useful to intialize a table, instead of using a loop
  - Since you can initialize a table with VALUE clauses at the elementary level, the most useful application might be to re-initialize the values for a table for each new use

Initialize, 2

- An example:

```
01 Customer-rec.
   05 Customer-number pic x(8).
   .
   .
   .
   05 Invoices occurs 7 times.
      10 Invoice-date pic 9(8).
      10 Invoice-referenc pic x(5).
      10 Invoice-balance pic s9(7)v99 packed-decimal.
   .
   .
   .

In the procedure division, code:

    initialize invoices

or

    initialize customer-rec
```

CALL - passing arguments

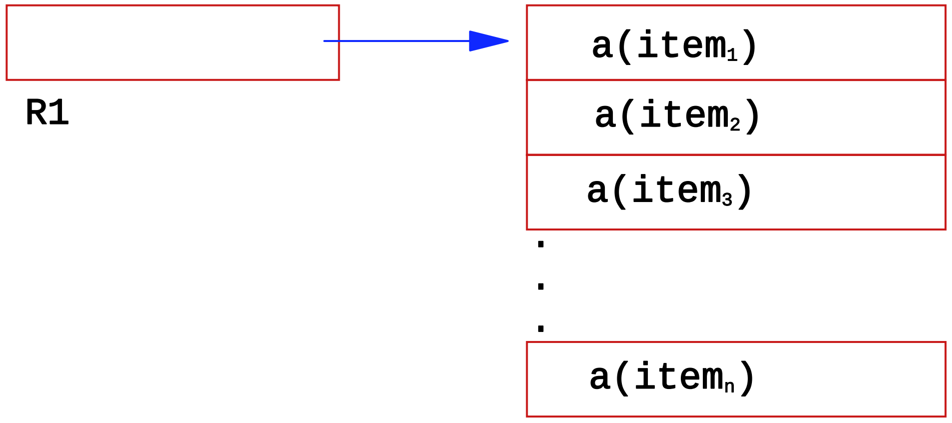
- Between COBOL II and COBOL 3 (LE COBOL), new ways of passing (and receiving) arguments have evolved
- Classically, you coded:

  CALL '*routine*' USING *item*$_1$, *item*$_2$, ...

  and behind the scenes, COBOL set up a list of addresses of the arguments, with R1 pointing to the list

CALL - passing arguments, 2

- Classic argument format:



CALL - passing arguments, 3

- The first change was to allow passing an argument by content - which means passing the address of a copy of the item
  - This allows passing literals in the argument string
  - And it also ensures if the called routine changed an argument, it only changed the copy, not the original data - protecting the data item's value from change

- Of course, then we had to have a way to describe the original style, so that became "by reference" and is the default so old code compiles correctly

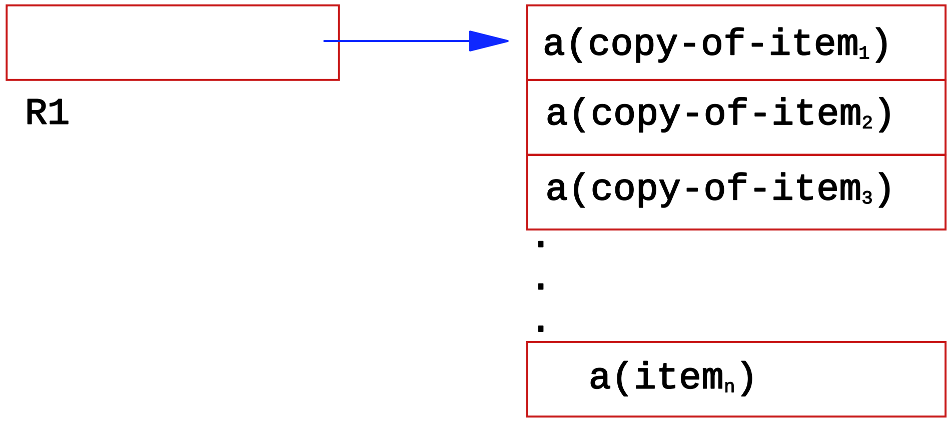
CALL - passing arguments, 4

- You can mix and match how you pass arguments: once you specify "by content" that is in effect for all subsequent arguments until you switch back by coding "by reference":

```
CALL 'CALC1' USING
  by content   'City tax',
               base-amt,
               city-rate,
  by reference city-tax,
               total-tax
```

CALL - passing arguments, 5

- Mixed by content and by reference arguments:



CALL - passing arguments, 6

- The next change was to allow passing an argument by value - which means passing a copy of the item's value right in the list of addresses!
  - Like by reference and by content, by value is transitive (applies to subsequent arguments until changed), and you can mix and match all three styles
- Also, not all data types can be passed by value: only binary, float, pointer, and single characters

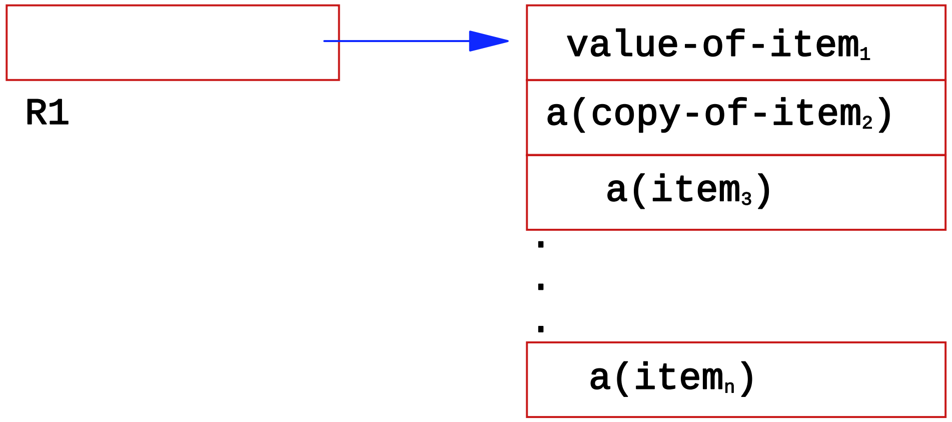
CALL - passing arguments, 7

- Here's a mixed bag of arguments:

```
CALL 'CALCA' USING
  by value     use-count,
               max-count,
  by content   'City tax',
  by reference base-amt,
               city-rate,
  by content   state-rate,
  by reference total-tax
```

CALL - passing arguments, 8

► Mixed by value, by content, and by reference arguments:



CALL - passing arguments, 9

- Once you add BY VALUE in CALL, however, you need to add it to the PROCEDURE DIVISION header for its parameters

- A subroutine can't tell the difference between items passed BY REFERENCE and BY CONTENT: they are both pointers to data; the subroutine can't tell if it's the original or a copy

- But for BY VALUE, the subroutine needs to know it will find a value and not an address

CALL - passing arguments, 10

- For example:

```
PROCEDURE DIVISION USING
  by value     use-count,
               max-count,
  by reference tax-type,
               base-amt,
               city-rate,
               state-rate,
               total-tax
```

- Note that there are no by content specifications here: by content is not allowed in the procedure division header

- Of course, all the items here have to be defined in the linkage section

CALL - passing arguments, 11

- WHY?
  - To make it easier to call between COBOL and C!
  - C thinks of arguments being passed on a stack, and a subroutine is expected to pop them off the stack
    - But z Series machines don't have [that kind of] a stack, so "by value" provides a reasonable simulation of stack behavior!

CALL - RETURNING

- One other change to CALL: a CALL statement can have a RETURNING phrase:

  CALL '*routine*' USING ... RETURNING *data-item*

- *data-item* can be an elementary item or a group item

- The called *routine* must have a similar phrase in its procedure division header:

  PROCEDURE DIVISION USING ... RETURNING *data-item*

CALL - RETURNING, 2

- When a subroutine and its caller are set up to use RETURNING:
  - The subroutine must place a value in the named data-item before returning
  - The caller can use the data-item as any other item
  - The caller should not count on RETURN-CODE to be meaningful

CALL - RETURNING, 3

- WHY?
  - Because now a COBOL program can call a C function directly! No need to code a complete C subroutine to use some of the neat facilities available
  - Secondarily, a COBOL program can look like a function to a C caller
  - Note that COBOL to COBOL calls can use this facility too

Language Enviroment

- Beginning with COBOL/370, all COBOL, PL/I, and C compilers use a common runtime package: Language Environment (LE)
- Although LE has gotten some bad press, it is overall a good thing:
  - Simplifies inter-language communication
  - Provides a suite of useful callable routines
  - Provides common code for mathematical functions and the like: more consistent results across languages
  - Common dump format and debugging tools

Language Enviroment, 2

- We won't discuss LE in detail here (different course, more money), but LE provides several capabilities that are especially useful for the COBOL programmer

  - The ability to dynamically acquire storage outside your program without need for an intermediate Assembler subroutine

  - The ability to work with environment variables

  - [Indirect] support of intrinsic functions

Intrinsic Functions

- In 1989, the ISO did something they had never done before: they amended an existing standard
  - Primarily because the new standard was way late
- IBM took the opportunity of this amendment to start the next line of COBOL compilers, the LE versions (sometimes called "COBOL 3" informally)
  - The main enhancement to COBOL, aside from LE support, was the addition of intrinsic functions

Intrinsic Functions, 2

- By now, there are over 50 intrinsic functions supported in the current COBOL compilers
- "Intrinsic" because they are part of the language, not an add on
- "Functions" because they are invoked like a function: they are passed zero to three arguments and return a single value

Intrinsic Functions, 3

- Here's a laundry list of the functions - you can get a general idea which ones might be useful in your work:

ACOS
ANNUITY
ASIN
ATAN
CHAR
COS
CURRENT-DATE
DATE-OF-INTEGER
DATE-TO-YYYYMMDD
DATEVAL
DAY-OF-INTEGER
DAY-TO-YYYYDDD
DISPLAY-OF
FACTORIAL
INTEGER
INTEGER-OF-DATE
INTEGER-OF-DAY
INTEGER-PART
LENGTH
LOG
LOG10
LOWER-CASE
MAX
MEAN
MEDIAN
MIDRANGE
MIN
MOD
NATIONAL-OF
NUMVAL
NUMVAL-C
ORD
ORD-MAX
ORD-MIN
PRESENT-VALUE
RANDOM
RANGE
REM
REVERSE
SIN
SQRT
STANDARD-DEVIATION
SUM
TAN
UNDATE
UPPER-CASE
VARIANCE
WHEN-COMPILED
YEAR-TO-YYYY
YEARWINDOW

Tricks Using Modern COBOL

- Here's some things you couldn't do in COBOL before COBOL 3:
  - Dynamically allocate storage outside your program
  - Dynamically allocate a file from a COBOL program!
  - Create, set, change, access values in environment variables

Tricks Using Modern COBOL, 2

- Here's some things you couldn't do in COBOL before COBOL 3:

  - Call z/OS UNIX kernel services directly
  - Call C functions directly
  - Create and use DLLs (Dynamic Link Libraries)
  - Take a snapshot dump and keep running

Tricks Using Modern COBOL, 3

- Here's some things you couldn't do in COBOL before COBOL 3:
  - Use the DB2 coprocessor
  - Access files in the Hierarchical File System (HFS)
  - Code CGI programs to handle Web requests
  - Code your own condition handlers without having to use an Assembler ESTAE routine

Tricks Using Modern COBOL, 4

- Here's some things you couldn't do in COBOL before COBOL 3:
  - Code recursive programs
  - Code programs with multiple currency symbols, including the Euro
  - Use ALL as a subscript (certain intrinsic functions), simplifying table work in certain situations

Debugging

- In COBOL II, there's a compile time option called FDUMP
  - If a program compiled with this option abended, it would produce a formatted dump of working storage: each data item by name and it's value
  - This greatly simplifies locating data items for debugging
  - At the cost of much larger object modules

Debugging, 2

- COBOL 3 (COBOL/370 and its follow-ons) removed FDUMP but provided a new alternative - TEST
- TEST originally had two parameters:
  - SYM | NOSYM - embed (don't embed) the symbol table in the object code, like FDUMP used to do
  - {NONE | STMT | PATH | BLOCK | ALL} - indicating the program should be compiled to allow the debug tool to have "hooks" at certain points in the program

Debugging, 3

- In COBOL for OS/390 & VM (V2R2 of the new compilers), an additional suboption was added to TEST:
  - {SEPARATE | NOSEPARATE} - if you requested SEPARATE, at compile time you supply a DD statement named SYSDEBUG and the symbol table is written out there
    - Keeping the object module small; the object module just contains the name of the file
    - If the program abends, the symbol table file is dynamically allocated and used

Enterprise COBOL for z/OS ("COBOL 4")

- The Enterprise COBOL series of compilers have been designed to run under z/OS (as well as OS/390); the major enhancements are:
  - Unicode support
  - XML PARSE and XML GENERATE
  - Integrated CICS translator (analogous to the DB2 coprocessor)

Enterprise COBOL for z/OS ("COBOL 4"), 2

- The Enterprise COBOL series of compilers have been designed to run under z/OS (as well as OS/390); the major enhancements are:
  - Debugging enhancements
  - Limited multi-threading support
  - COBOL-Java interoperability

COBOL 4 - Unicode Support

- Unicode support was introduced in V1R1 and extended in V4R1 of this compiler; major ways support is provided:
  - Unicode data type (National)
  - Unicode literals and Unicode hexadecimal literals
  - Automatic conversion between UTF-16 and EBCDIC for DISPLAY and ACCEPT

COBOL 4 - Unicode Support, 2

- Unicode support was introduced in V1R1 and extended in V4R1 of this compiler; major ways support is provided:
  - Automatic conversion from EBCDIC to UTF-16 for MOVE when source is DISPLAY and target is EBCDIC
  - Intrinsic functions DISPLAY-OF and NATIONAL-OF to do explicit code page conversions

COBOL 4 - Unicode Support, 3

- Unicode support was introduced in V1R1 and extended in V4R1 of this compiler; major ways support is provided:
  - Following verbs support Unicode data:
    - SEARCH
    - INSPECT
    - STRING / UNSTRING
    - DISPLAY
    - EVALUATE
    - Intrinsic functions: LOWER-CASE, UPPER-CASE, MAX, MIN, ORD-MAX, ORD-MIN, REVERSE
    - Figurative constants: ZERO, SPACE, HIGH-VALUE, LOW-VALUE, QUOTE

COBOL 4 - XML Support

- XML support was introduced in V1R1 and extended in V3R3 and again in V4R1 and V4R2 of this compiler; major ways support is provided:
  - XML PARSE - given an input XML document, extract the field and attribute values into COBOL data types
  - XML GENERATE - given a COBOL structure, build an XML document
  - In V4R1, support was provided for many of the XML toolkit features to be available implicitly
  - In V4R2, support was added to validate an XML document against a schema, as part of the XML PARSE verb

COBOL 4 - XML Support, 2

- XML support was introduced in V1R1 and extended in V3R3 and again in V4R1 and V4R2 of this compiler

  - This support allows you to take an existing transaction handling program (online or batch) and build a wrapper around it to handle XML style requests:

    * Convert incoming transaction from Unicode to EBCDIC - if needed
    * XML PARSE to build a COBOL style transaction from the XML style data
    * Call the transaction handler passing the COBOL style data
    * Accept the COBOL style results back
    * XML GENERATE to build an XML style response
    * Convert EBCDIC to Unicode - if needed
    * Transmit result back to sender

COBOL 4 - Debugging - again

- In V4R1 of the Enterprise COBOL compiler, the TEST compiler option was revised as follows:

```
{NOTEST | TEST({HOOK|NOHOOK}
                        [,{NOSEPARATE | SEPARATE}]
                        [,{NOEJPD | EJPD}]) }
```

- The parameters may be specified in any order, and the meanings of the parameters are on the following pages

COBOL 4 - Debugging - again, 2

- HOOK causes compiled-in hooks to be generated at every statement, label, and path point (place where logic flow can change); NOOPTIMIZE is forced
- NOHOOK - no compiled-in hooks are generated; the Debug Tool dynamic debug facility may still be used
- NOSEPARATE - debugging information is embedded in the object code (SYSDEBUG DD statement points to target)
- SEPARATE - debugging information is stored in an external file, and the file name is embedded in the object code

COBOL 4 - Debugging - again, 3

- NOEJPD - disables support for Debug Tool JUMPTO and GOTO commands, allowing normal optimization for OPTIMIZE option

- EJPD - enables support for Debug Tool JUMPTO and GOTO commands, at the price of reduced levels of optimization

COBOL 4 - Debugging - again, 4

- Notice the reference to "Debug Tool dynamic debug facility" two pages ago
- For some level of the Debug Tool, and some level of COBOL, even if you have not compiled with debug hooks, the Debug Tool can dynamically insert hooks when invoked
    - I'm not sure of the product levels because I've decided to write flawless code, so I have no need for debugging tools of any kind :-)

Enterprise COBOL: A Summing Up

- Enterprise COBOL is the latest version of a continually improving product; it truly can help you with business applications in the modern world by:
  - Enhancing capabilities for existing code (larger data items, dynamic storage, enhanced CALL facilities, etc.)
  - Supporting more open technologies (such as XML, Unicode, DLLs, Java, z/OS UNIX, even CGIs on a Web server)
  - Simplifying debugging in a complex environment (common dump format, symbol table format on abend, debug tool hooks)

Enterprise COBOL - References

Enterprise COBOL IBM manuals found at:
  http://www.ibm.com/systems/z/os/zos/bkserv/zswpdf/#enterprise_cobol41

COBOL standard
  http://www.cobolstandards.com/

Unicode standard
  http://www.unicode.org/

World Wide Web Consorition (W3C)
  http://www.w3.org/ (follow links here to XML, HTML, etc.)

Training on COBOL and other technologies discussed here
  http://www.trainersfriend.com

The Trainer's Friend

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