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It's Not Just About HLASM – You Need the Binder to 'Assemble' the Parts!

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February 2013

Session# 12922

SHARE in San Francisco 2013

Trademarks

System z Social Media Channels

- **Top Facebook pages related to System z:**
  - **IBM System z**
  - **IBM Academic Initiative System z**
  - **IBM Master the Mainframe Contest**
  - **IBM Destination z**
  - **Millennial Mainframer**
  - **IBM Smarter Computing**
- **Top LinkedIn groups related to System z:**
  - **System z Advocates**
  - **SAP on System z**
  - **IBM Mainframe- Unofficial Group**
  - **IBM System z Events**
  - **Mainframe Experts Network**
  - **System z Linux**
  - **Enterprise Systems**
  - **Mainframe Security Gurus**
- **Twitter profiles related to System z:**
  - **IBM System z**
  - **IBM System z Events**
  - **IBM DB2 on System z**
  - **Millennial Mainframer**
  - **Destination z**
  - **IBM Smarter Computing**
- **YouTube accounts related to System z:**
  - **IBM System z**
  - **Destination z**
  - **IBM Smarter Computing**
- **Top System z blogs to check out:**
  - **Mainframe Insights**
  - **Smarter Computing**
  - **Millennial Mainframer**
  - **Mainframe & Hybrid Computing**
  - **The Mainframe Blog**
  - **Mainframe Watch Belgium**
  - **Mainframe Update**
  - **Enterprise Systems Media Blog**
  - **Dancing Dinosaur**
  - **DB2 for z/OS**
  - **IBM Destination z**
  - **DB2utor**

Agenda

- What is the binder?
- What does the binder do?
- How do I tell the binder to do what it does?
- What else comes with the binder?
- What else can I tell the binder to do?

What is the binder?

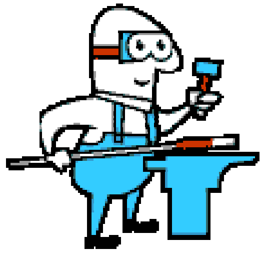
- Wikipedia® under linker (computing):

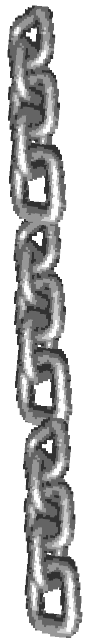
  … a computer program that takes one or more object files generated by a compiler and combines them into a single executable program.

  In IBM mainframe environments such as OS/360 this program is known as a linkage editor.”

- In z/OS the program management binder does this and more!

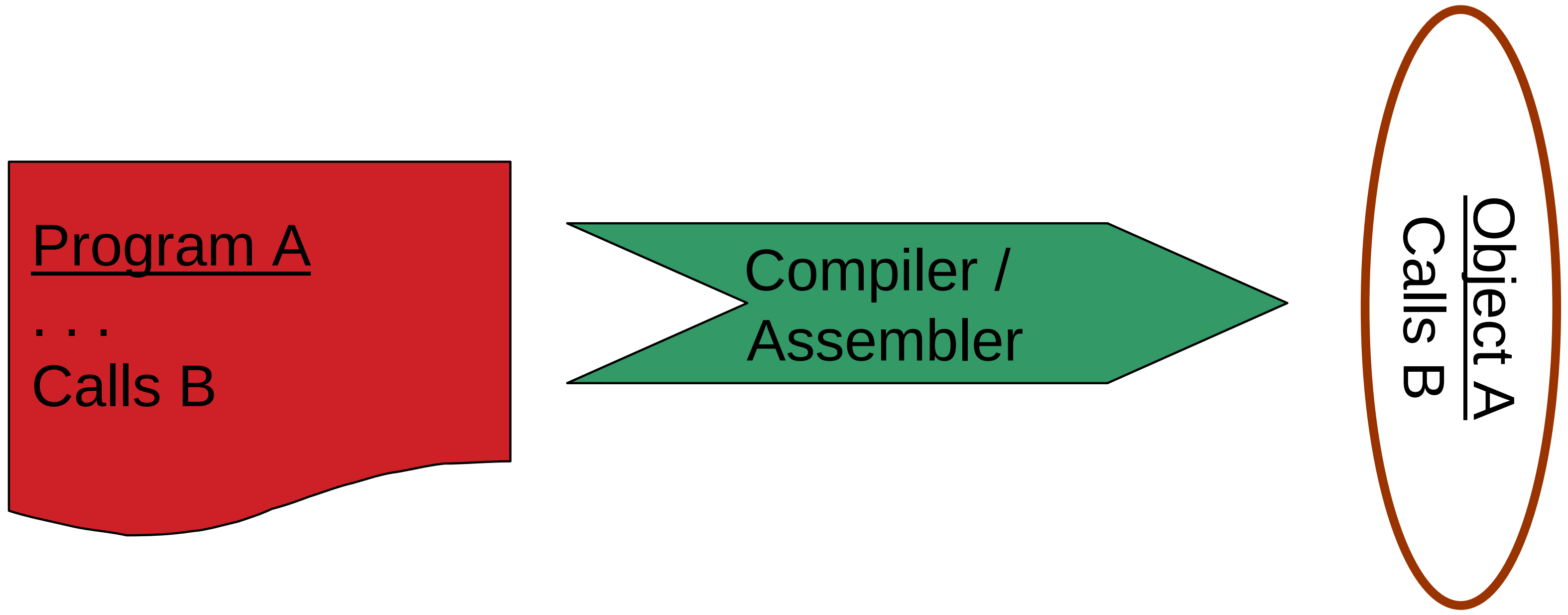
linkage editor





- In the old days!

compiler / assembler



compiler / assembler object modules

[X]OBJ Object A - Calls B

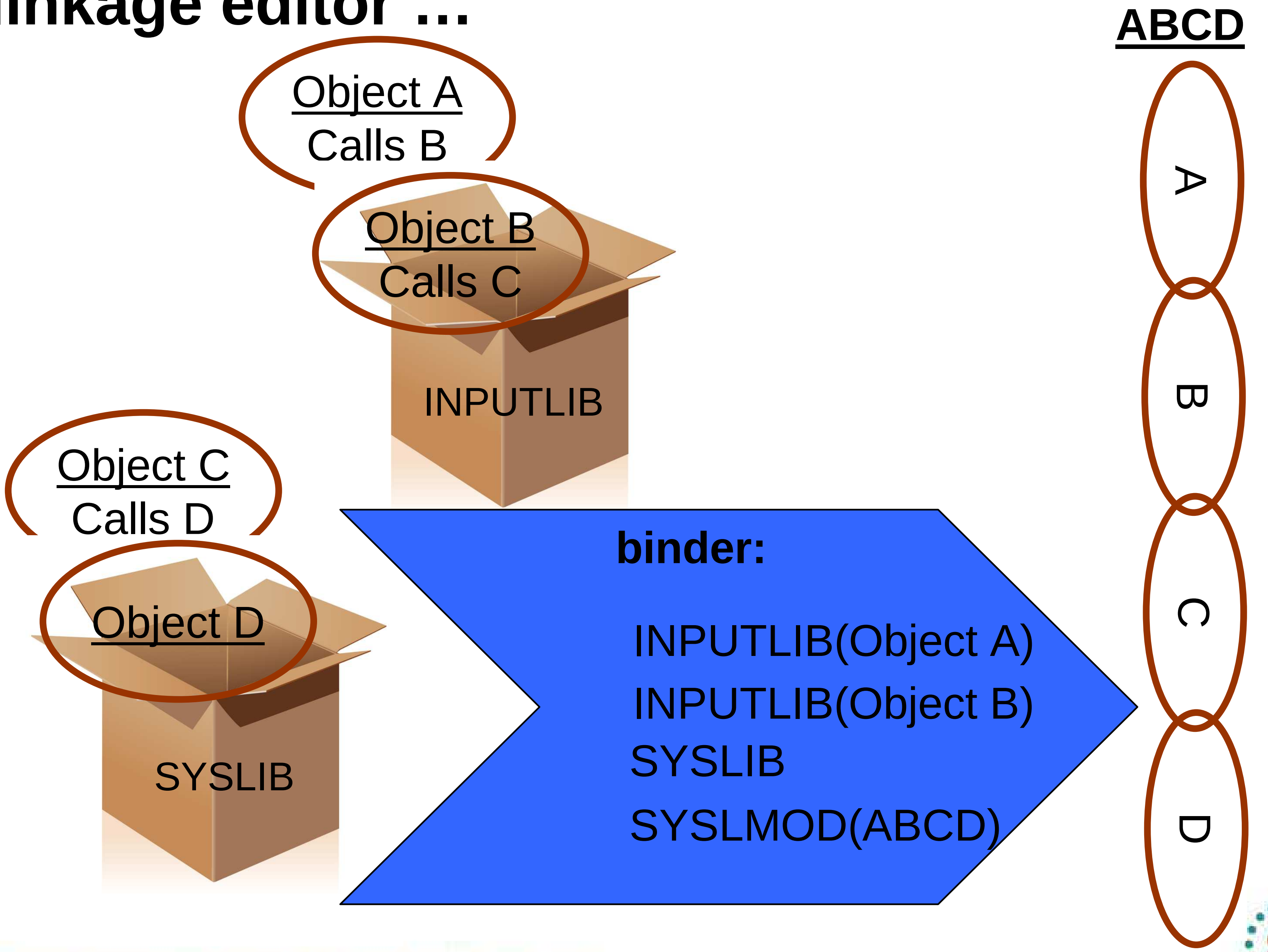
```
.ESD      ..  ..A       ........B      ....                            00000001
.TXT ...  ..  ......                                                   00000002
.RLD      ..    ........                                               00000003
.END                            1569623400 010613030                   00000004
```

GOFF Object B - Calls C

```
.0..............................................................................
.........................................................................B......
..................................................................Ø......B_IDRL..
..................................................................Ø......B_PRV...
.........................................................................B_TEXT..
.........................................................................B.......
.........................................................................C.......
................................................................................
................................................................................
............................569623400 01062013030130829500.......................
```

* Some lines deleted to make it fit

linkage editor …



executable programs

- Load Module (LM), always in a PDS
  - Records, so this is truly a top-to-bottom view

Load Module ABCD

```
.Ø.....0@@PPA2  ........C       .......çA       ........B       ........CFUNC
Ø×...............................................................................
Ø..5695PMB01 ........"
ØIdØ..5694A01   .........Ø..569623400 ............. Øâ.569623400 ....".........
.....M...... ..K..............ç...........Q.......Q.......Q.......Q.......Q....
..........&...................2013013013431601300.>........... ..........H.
```

* Chopped off on right and bottom and deleted other lines to make it fit

executable programs

- Program Object (PO), always in a PDS/E or UNIX file
  - Linear (binary), so bottom-left is maybe the middle

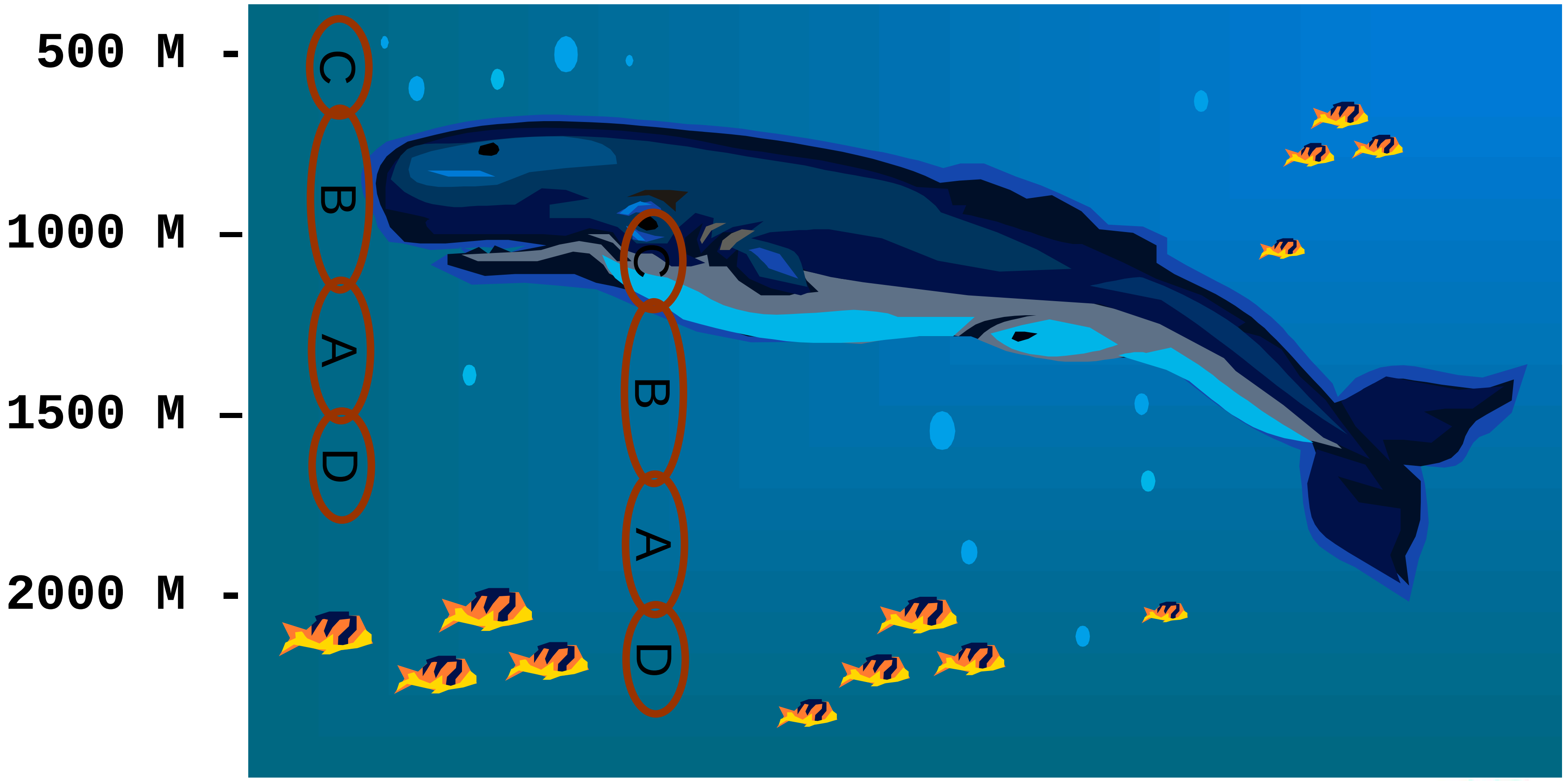
Program Object ABCD

```
IEWPLMH ...Ì...................Ì...........ð...........m...h....................
........................å...å...°O}...å0....².....ÈCEESTART..ì0.ª..åu.¢å0.....Ú
........Ø...Ø.......Ø.......................................ED  ....  ..........
L...........Ø{....Ø.......Ø..................&...&...............PRPRL.......
....SDSD...............Ø...Ø.......Ø.............Q.......8...............ED
...........SDSD...............Ø...Ø..å....Ø...............................
...................SDSD...............Ø...Ø..-....Ø.....................&....
..........................ERWXM.................../Ø..Ï....Ø..................
```

* Chopped off on right and bottom and deleted other lines to make it fit

linkage editor …

… *and* loader



MEMORY

linkage editor …

- Symbol resolution
  - all *external* symbol references which need to be satisfied
    - between all input parts
- Relocation
  - all modules combined, relocated relative to origin address
    - zero (or start of segment)
  - final relocation is done by the loader
    - based on information created by the binder

Program Management Binder

- BCP exclusive base element
  - Wave 0, along with SMP/E and High Level Assembler
- z/OS system linker
  - more than the linkage editor!
- Related utilities
- Programming interfaces

object file format summary

- Documented
  - Can be produced by non-IBM products
    - Dignus Systems/ASM, Systems/C, Systems/C++ cross-assembler/compilers

- Produced by IBM language translators
  - High Level Assembler (HLASM)
  - Language Environment translators
    - XL C/C++
    - Enterprise COBOL
    - Enterprise PL/I
  - … and their predecessors

- binder supports 3 flavors
  - OBJ
    - Traditional circa 360 object format
  - XOBJ
    - Initially produced by C/370 for use with the Prelinker
  - GOFF
    - Initially produced by XL C/C++ for XPLink
    - Also produced by High Level Assembler

better than the linkage editor!

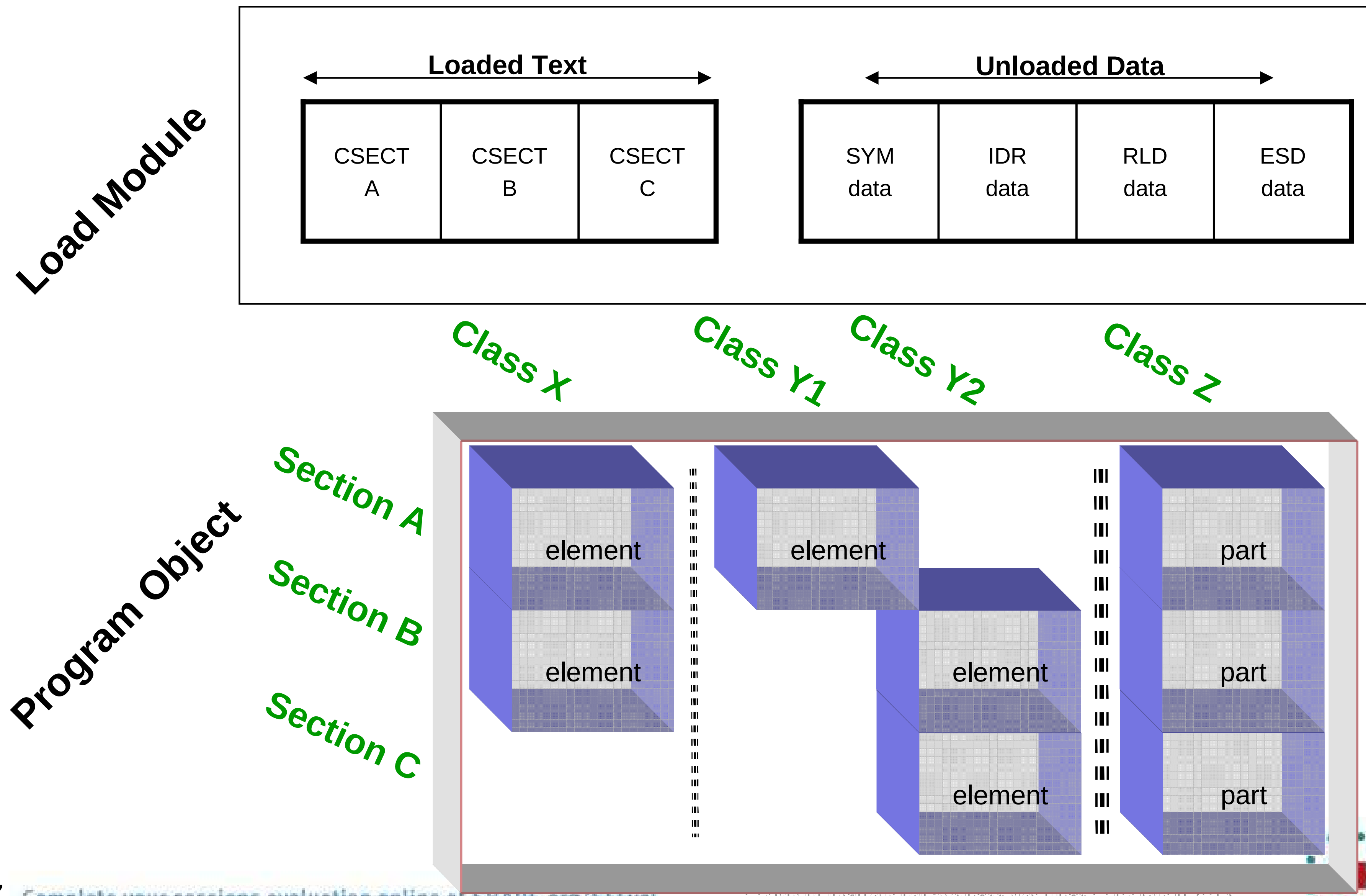
Load Modules

- Defined almost 50 years ago for S/360™
- Designed specifically for PDS members
  - Depends on hardware keys, format U data
  - Has critical data in directory entries
  - Can only be stored in PDSs
- Significant limitations
  - Symbol names limited to 8 characters
  - 32K maximum external symbols
  - Max size 16M, no split above/below 16M
- Pack maximum data in minimum bytes
  - Great goal, but limits extensibility
- Documented format is exploited by customers
  - Difficult to change

Program Objects

- Supported by first release of binder
- Designed to be device independent
  - Developed in conjunction with PDSEs
  - Essential for z/OS UNIX support
  - Can only be stored in PDSEs or UNIX files
- Supports symbol names up to 32767 in length and a module length of up to 1 gigabyte
- Designed to support system paging
  - All loadable data is in 4K blocks
  - Loader can treat as extension of page files
- More non-executable data saved
  - Reprocessing is faster and more automatic
  - Supports extra data for debuggers
- Undocumented so allows rapid enchancements
  - 5+ formats to date…

load module vs. program object



binder invocation

- **PGM=IEWL** (in JCL)
  - True name
    - **IEWBLINK** (default Link-Edit Utility for **SMP/E**)
  - aliases ala linkage editor names
    - HEWL, HEWLH096
    - HEWLDRGO, HEWLOAD, HEWLOADR
  - aliases of the modern day for binder loader
    - IEWBLDGO, IEWBLODI, IEWBLOAD
    - LOADER
    - IEWLDRGO, IEWLOADI, IEWLOAD, IEWLOADR
  - binder aliases of the modern day
    - IEWL, LINKEDIT
  - alias for customized options
    - IEWBODEF
    - Caution! for sysprogs, rarely used

but not this, the linkage editor !

- *Invocations of actual* <u>linkage editor</u> and <u>batch loader</u>
  - *HEWLD* (HEWLD)*
    - *Any remaining invocations of these are batch loader*
  - *IEWL* (IEWLF880) or HEWL* (HEWLKED)*
    - *Any remaining invocations of these are linkage editor*
  - *If you use any of these, I'd like to know!!!*
- ***<u>NOTE:</u>*** *Program Management loader used for PGM=yourpgm*
  - *That is <u>not</u> the Binder!*
  - *It's what is <u>mostly</u> used for program invocation*

more binder invocations…

- The usual suspects:
  - Batch LINKEDIT, IEWL, etc.
- Invoked as a program call:
  - SMP/E (it’s *not really* JCL!)
  - TSO LINK, LOAD, LOADGO
  - ld command (UNIX)
- Using the binder Application Programming Interfaces (APIs)
  - c89 (c++), cob2, pli, xlc (xlC)
  - IEBCOPY (sometimes!)
  - SPZAP
  - AMBLIST

Control Statements

- Your Wish is My Command!
  - Placement
    - Some depend on where the appear relative to others
    - Some depend on where they appear only relative to the same ones
  - Read into the program
  - Change or replace symbol names
  - Change relative locations
  - Specify entry points and their names
  - Specify where to find missing names and find them
  - Write out the program
  - Override options for a single program
  - All control statements have analagous API calls

Control Statements …
Read into the program

- Binder program (not API) starts by reading **SYSLIN**
  - Could be anything!
- **INCLUDE**
  - Explicitly, so always done
- **AUTOCALL**
  - Autocall, so only if it's found
- **IDENTIFY**
  - Not really reading, but associates user identificaton information to a section which was read in

Control Statements …
Change or replace symbol names

- **CHANGE**
  - Give a symbol definition and references a new name
- **REPLACE**
  - Delete a symbol, optionally give references to it a new name
    - If it’s a section, delete the entire section
- **RENAME**
  - Give a renameable symbol a new name
    - Only if there are unresolved symbols
      - *Prelinker compatibility*

Control Statements …
Change relative locations

- **ORDER**
  - Explicitly move a section before everything else
  - Optionally PAGE align it
- **PAGE**
  - Align a section to a 4K (or 2K) page boundary
- **ALIGNT** *new!*
  - Align a section, or element or part of it, on a specified boundary
- **EXPAND**
  - Add extra space (set to zeroes) at the end of a section or element

Control Statements …
Specify entry points and their names

- **ALIAS**
  - Give another name to call the program by
    - For partitioned datasets these are aliases
      - *Optionally give an entry point symbol name where that program name begins execution*
      - *Or it will default to an entry point name that matches this name, if there is one*
      - *Or the primary name if there is not a matching name*
    - For UNIX files these are either (hard) links or symbolic links
      - *However there is only ever one entry point, the same as the primary name*
- **ENTRY**
  - Give an entry point symbol name where the primary name of the program begins execution
- **NAME**
  - Give the primary name to call the program by

Control Statements …
Specify where to find missing names and find them

- Binder program (not API) starts by reading **SYSLIB**
  - After all else is done, before preparing to write out program
- **LIBRARY** (autocall)
  - Augments SYSLIB
  - Changes where symbols may or may not be found
- **IMPORT** (DLLs)
  - Tells what DLL an unresolved symbols should be in at run-time

Control Statements …
Write out the program

- Binder program (not API) writes to **SYSLMOD**
- Allocated to either a partitioned dataset or a UNIX pathname
  - May also include the NAME, in lieu of a NAME control statement
- **NAME**
  - Give a name to the program
    - For partitioned dataset, a member name
    - For UNIX, a filename
    - Optionally tells if the an existing program of that name may be replaced

Control Statements …
Override options for a single program

- PARMs are global, these affect only the NAMEd program being bound

MODE	- see AMODE, RMODE options
SETCODE	- see AC option
SETOPT	- generalization for any PARM
SETSSI	- see SSI option
ENTRY	- see EP option

Options
Who needs 'em !?

- Binder program (not API) will by default write a SUMMARY LIST to SYSPRINT (which must be allocated) containing:
  - Control statements
  - Most all messages
  - Processing options
  - Summaries of the saved program (if successful)
    - Name (location), type, time
    - Attributes
    - Entry points and aliases
  - Final return code
  - Summary of messages

Options …
Who needs ‘em !?

- UNIX command invocations (c89, ld) by default will write to **stderr**:
  - All messages severity 4 (WARNING) and higher
    - That is, no informational messages
  - Use the –V option to get most everything written to **stdout**

Options precedence rules (low to high)

1. Installation options from IEWBODEF
2. Primary invocation options, from one of the following:
    1. The PARM field of the JCL EXEC statement
    2. The first parameter passed to IEWBLINK, IEWBLOAD, etc.
    3. The PARMS parameter of IEWBIND FUNC=STARTD
3. ***The IEWPARMS DD statement – introduced in z/OS V1R11 !***
4. The OPTIONS parameter of IEWBIND FUNC=STARTD
5. IEWBIND_OPTIONS environment variables via the ENVARS parameter of IEWBIND FUNC=STARTD
6. Dynamic option changes from either:
    1. Options set from attributes by an INCLUDE -ATTR control statement or
    2. The SETOPT control statement, or
    3. The PARMS parameter, followed by the OPTION/OPTVAL parameter, of IEWBIND FUNC=SETO

OPTIONS option

- **OPTIONS=***ddname*
  - primarily invented to overcome JCL limitations…
    - typically in-stream data set
  - but can be convenient for example to have files of options common to a set of JCL
    - *making it easy to update options without changing JCL etc.*

Other option sources from UNIX

- makefiles
  - Environment variables which become make macros
    - LDFLAGS
- c89 – YAEV (“yet another environment variable”)
  - _C89_OPTIONS
  - _C89_OPERANDS
- ld – yikes, just like (you can guess why!)…
  - _LD_OPTIONS
  - _LD_OPERANDS

Types of options

- Options for **SYSPRINT**
  - Most common
- Behavior changing options
  - Next most common
- Program changing options
  - Depends on functional requirements

Options for SYSPRINT

- **LIST**, **MAP**, **XREF**
  - SMP/E Link-Editor Utility defaults:
    - LET, LIST, NCAL, XREF
    - NCAL once upon a time was unconditionally set
      - *now based on CALLIBS*
    - If you specify overrides, you must list the others too!
    - SMP/E is picky (it's *not really* JCL)
    - Avoid using control statements to specify options (SMP/E won't know)

Options for SYSPRINT …

- SYSPRINT
  - Messages (IEW2nnnns) also *SYSTERM*
  - DDname cross-reference
  - Message Summary

  - **LIST**ing of processing information
  - Module **MAP**
    - Includes Data Set Summary
  - Cross(**X**) **REF**erence between symbol definitions and references
    - includes DLL IMPORT/EXPORT table

Options for SYSPRINT …

- SYSPRINT extras; requires **MAP** or **XREF**
  - **Renamed symbol cross-reference**
    - Usually only for special predefined list of C symbol names
    - Also RENAME control statement
  - **Long symbol abbreviation table**
  - **Short Mangled Name report**
  - **Symbol References Not Associated with any AdCon**
    - “Dangling” External References
    - Also produced with **LIST**
    - Heading may be there even if no symbols
    - Due to external reference ESD entry from object module

Options for SYSPRINT … MAP

*** M O D U L E M A P ***

Class name and attributes

CLASS binding attribute

CLASS loading behavior

SEGMENT containing CLASS

Offset of LABEL **main** within section (CSECT) **this_is_a-g_name**

Offset of LABEL **main** within CLASS **C_CODE**

```
          ---------------
          CLASS   C_CODE               LENGTH =      160  ATTRIBUTES = CAT,   LOAD, RMODE=ANY
                                       OFFSET =        0 IN SEGMENT 001       ALIGN = DBLWORD
          ---------------

          SECTION    CLASS                                             ------- SOURCE --------
           OFFSET   OFFSET  NAME                 TYPE     LENGTH  DDNAME   SEQ  MEMBER

                         0  CEESTART            CSECT         7C  /0000001  01
                0        0     CEESTART            LABEL

                        80  this_is_a-g_name    CSECT         E0  /0000001  01
                0       80     this_is_a-g_name    LABEL
               28       A8     main                LABEL
```

Options for SYSPRINT … MAP …

```
*** M O D U L E  M A P ***

    ---------------
    CLASS   C_WSA           LENGTH =        24  ATTRIBUTES = MRG, DEFER , RMODE=ANY
                            OFFSET =         0 IN SEGMENT 002       ALIGN = DBLWORD
    ---------------

              CLASS
             OFFSET  NAME                TYPE     LENGTH   SECTION
                  0  $PRIV000011       PART            10
                 10  hw#S              PART            10   this_is_a-g_name
                 20  world             PART             4   world
```

Class name and attributes

binder made-up name for "private" symbol

SEGMENT containing CLASS

CLASS binding attribute

CLASS loading behavior

Offset of PART **world** within CLASS **C_WSA**

Options for SYSPRINT … XREF

C R O S S - R E F E R E N C E T A B L E

All address constants in section CEESTART in CLASS C_CODE

Location to which adcons in section CEESTART have resolved

```
TEXT CLASS = C_CODE

---------------  R E F E R E N C E  --------------------------  T A R G E T  ----------------------------------------
  CLASS                              ELEMENT         |                                            ELEMENT              |
  OFFSET SECT/PART(ABBREV)            OFFSET  TYPE  | SYMBOL(ABBREV)   SECTION (ABBREV)            OFFSET CLASS NAME   |
                                                     |                                                                  |
     2C  CEESTART                         2C V-CON  | CEEMAIN          CEEMAIN                          0 C_DATA       |
     68  CEESTART                         68 V-CON  | CEEFMAIN         $UNRESOLVED                                      |
     6C  CEESTART                         6C V-CON  | CEEBLLST         CEEBLLST                         0 B_TEXT       |
     74  CEESTART                         74 V-CON  | CEEBETBL         CEEBETBL                         0 B_TEXT       |
     78  CEESTART                         78 V-CON  | CEEROOTD         CEEROOTA                         0 B_TEXT       |
    14C  this_is_a-g_name                 CC A-CON  | CEESTART         CEESTART                         0 C_CODE       |
```

We can see that section CEESTART begins CLASS C_CODE

Options for SYSPRINT … XREF …

C R O S S - R E F E R E N C E T A B L E

Symbol world is a part… we know from the Module MAP…

Adcon at X'1C' in section hw#S refers to IMPORTED symbol printf. Location of printf not known until run-time.

```
TEXT CLASS = C_WSA

---------------  R E F E R E N C E  --------------------------  T A R G E T  ------------------------------------------
  CLASS                                  ELEMENT          |                                                ELEMENT                |
  OFFSET SECT/PART(ABBREV)                OFFSET   TYPE   | SYMBOL(ABBREV)    SECTION (ABBREV)              OFFSET CLASS NAME     |
                                                          |                                                                       |
      10 hw#S                                 10 A-CON    | world             $PRIV000003                       20 C_WSA          |
      18 hw#S                                 18 R-CON    | printf                                                                |
      1C hw#S                                 1C V-CON    | printf            $IMPORTED                                           |
      20 world                                20 A-CON    | this_is_a-g_name this_is_a-g_name                    0 C_CODE         |
      18 hw#S                                 18 A-CON    |                                                        B_IMPEXP       |
      1C hw#S                                 1C V-CON    | CEETHLOC          CEETLOCE                           8 B_TEXT         |
```

Options for SYSPRINT …

- **INFO** about service level of binder

- **MSGLEVEL** of lowest severity messages to write
  - Default is all (0)
  - Suppresses text, no change to return code!

- **LISTPRIV** for a listing of “private code” sections
  - and if so make it an error (YES)
  - or just informational (INFORM)

- **SYMTRACE** *new!*
  - Messages for all instances of a named symbol during processing

Behavior changing options
LET my program be executable

- **LET**=number
  - "LET this be an executable, even if the return code is equal to or less than number"
  - EXECUTABLE is an attribute in the program and in the case of datasets, in the directory
    - NX in ISPF member list means "Not Executable"
    - Nothing to do with the UNIX execute permission
  - "LET" in batch means LET=8
    - Unspecified or "NOLET" means LET=4

Behavior changing options …
Save a non-executable program

- **STORENX**
  - STORENX controls whether the "Not Executable" program is saved
    - The default is NOREPLACE (same as NO)…
    - That means by default, a "Not Executable" program WILL BE SAVED if it does not already exist!
    - STORENX=NEVER
      - *Did not always exist, so not the default*

Behavior changing options …
Execute an non-executable program

- What happens if I try to execute an NX program?
  - from batch

```
CSV016I REQUESTED MODULE STOREDNX IS NOT EXECUTABLE
CSV028I ABEND706-04  JOBNAME=BARRYLR   STEPNAME=GO
IEA995I SYMPTOM DUMP OUTPUT  467
SYSTEM COMPLETION CODE=706  REASON CODE=00000004
```

  - from UNIX… usually you will see…

```
BARRYL [478] /u/barryl/binder/SHARE/SHARE116 $  ./a.out
IEWPLMH: ./a.out 14: FSUM7351 not found
```

    - …shell semantics for a failed spawn, to treat as a shell script
    - as a DLL

```
CEE3512S An HFS load of module SNX.dll failed. The system return code was 0000000130; the reason code was 053B006C.
From entry point main at compile unit offset +000000A8 at entry offset +000000A8 at address 20F1AA10.
```

Behavior changing options …

- **CASE**
  - Applies to option values, control statements and API parameters
  - **UPPER** – Default is to uppercase
  - **MIXED** – Preserve the input as-is
    - c89 default

Program changing options

- **COMPAT**
  - The “compatibility” level of the program
  - Specified as z/OS releases
    - Or CURRENT
    - Or (older convention) as PM levels
  - Each COMPAT release means the program can be fully functional on that release and above
    - May execute on prior releases but other things may not work
      - *Like rebind, IEBCOPY, AMBLIST…*

Program changing options …

- **STRIPSEC/STRIPCL** to remove and list “unneeded” stuff
  - To see the “removed” report requires **MAP** option
  - **STRIPSEC=YES**
    - remove unneeed stuff
  - **STRIPSEC=PRIV** ***new in z/OS V1R13 !***
    - just unneeded “private” stuff
  - **STRIPCL=YES**
    - Remove class marked as “removable”

Program changing options ...

- **COMPRESS=YES (default is AUTO)**

  - Can significantly shrink size of <u>program object</u> on disk
  - **<u>No Change</u>** to size of in-storage program!
    - <u>No Change</u> to the program itself (loader / run-time data), only binder owned data
  - Distinguished in **Save Module Attributes** (**LIST** output):

```
MODULE SIZE (HEX)   00002BFC
DASD SIZE (HEX)     0000D000  (this had been 00015000)
```

  - Requires COMPAT(ZOSV1R7)

```
PROGRAM TYPE        PROGRAM OBJECT(FORMAT 4 OS COMPAT LEVEL
z/OS V1R7 )
```

    - AUTOmatically happens, if beneficial, with this or later COMPAT level
      - *default is COMPAT(MIN)*
      - *will still execute back to ZOSV1R3*
        - *but no rebind, AMBLIST, ZAP, etc.*

Program changing options …

- **EDIT=NO**
  - *Permanently deletes* the data that COMPRESS would have compressed
  - Thus *limited* rebind, AMBLIST, ZAP, etc. *anywhere*

```
MODULE SIZE (HEX)   00002BFC
DASD SIZE (HEX)     00005000
```

- Limitation is binder based so:
  - *AMBLIST of LM works because it doesn't use binder*
  - *Binder supports limited processing of INTENT=ACCESS LM*

Program changing options …

- **FILL=xx**
  - All unitialized areas (but not EXPANDed areas) will be set to this value
    - Some of the areas may be written to disk
    - Some “gaps” will only be “filled” when they are loaded
  - Program Object COMPAT=PM2 or later only! Else RC=4…
    - IEW2695W 4B37 OPTION SPECIFICATION FOR FILL IS NOT VALID FOR VERSION 1 PROGRAM OBJECT OR LOAD MODULE.
  - Intended as debugging aid (not to overcome poor programming!)
    - Also see Language Environment STORAGE options

Program changing options …

- **DYNAM=DLL** – Dynamic Link Library
  - exported symbols to SYSDEFSD as IMPORT control statements
  - Control information (visible in **MAP** and AMBLIST output, macros in ‘SYS1.MACLIB’)
    - IEWBLIT section B_LIT class – Loader Information Table
    - IEWBCIE section B_IMPEXP class – Import/Export table
- Language Environment high-level languages and High Level Assembler (LE provides macro)
- Execution requires Language Environment run-time support
  - Function “descriptors” enable dynamic linking
- Exploits deferred load C_WSA[64] class
  - Writable / Static Area
  - LE controls unique instance for each “enclave” of execution
- Dynamic resolution follows all static resolution

Program changing options …

- **SIGN=YES –** Program Signing *– new in z/OS V1R11 !*
  - Digital signature is written into program object
    - Constructed based on program data
    - Becomes part of program
    - PDSEs supported only!
  - Requires SAF/RACF setup & services
    - Require keyring or PKCS #11 token to sign
    - Program must be identified as requiring digital signature for execution
      - *… loader verifies correct digital signature prior to execution*
  - Cannot use traditional (SMP/E) service methodology since only signer can bind
    - Could use EDIT=NO

Option-less output

- Written to if exists
- **IEWDIAG**
  - All messages, as if MSGLVEL=0 and LIST=ALL
  - Useful when options cannot be passed (particularly API users)
- **IEWTRACE**
  - IBM service aid, shows key trace points throughout processing
  - TRACE option can limit range (default is ALL)
- **IEWDUMP**
  - IBM service aid, SNAP dump and binder formatted dump
  - Automatic on terminal (level 16) error
  - DUMP option can activate for specific ECODE (binder message or trace point)

So what comes with the binder?

- Batch binder
- Batch binder loader

- Legacy batch linkage editor
- Legacy batch loader

- TSO invocations of the above
- UNIX **ld** command to invoke batch binder

What else comes with the binder? Service aids

- **AMASPZAP** (Superzap)
  - Service aid to modify existing program objects
    - binders owns PO support, BCP service aids owns the LM
    - Can modify program text, but not change size, offsets, etc.
- **AMBLIST**
  - Service aid to list the contents of OBJ, GOFF, LM and PO
    - Fully deconstruct
    - PMAR, data and IDRs for programs
    - Segment map for POs
  - **amblist** UNIX command

What else comes with the binder? Binder APIs

- copy
  - IEBCOPY
  - cp, mv
- bind
  - write your own binder!
    - could have a direct-to-program compiler
    - c89 uses binder APIs
    - ld calls batch binder program

What else comes with the binder? Binder APIs …

- edit without rebinding
  - superZAP (change text so long as length is same)
  - change AMODE, RMODE, entry point, reusability attributes
  - add or delete aliases or IDRUs
- extract data
  - AMBLIST
  - Debuggers
  - Performance analyzers
  - nm
- regular APIs support both executable modules formats
  - So need not code separately (PO vs. LM)

What else comes with the binder? Binder APIs …

- 1 - Regular (original)
  - Establish dialog with binder (IEWBIND) and create one or more workmods under dialog
  - APIs have a version number indicative of parameter list and functionality
    - Default is Version 1 – don't use it!
  - Binder converts all executables into an internal format called ***workmod***

What else comes with the binder? Binder APIs …

- 2 - Fast Data Access
  - Only for Program Objects (Load Module format documented)
  - No ***workmod*** is created thus processing is streamlined
  - Read-Only access (cannot make *ANY* modifications!)
  - There are two interfaces
    - Request code interface
      - *Introduced in z/OS V1R5*
      - *Simplified parameter list*
      - *More dialog-like (as 'regular' API)*
      - *More functionality*
      - *As of z/OS V1R9 it is completely rewritten and internally an AMODE=64 program*
    - Unitary interface (original)
      - *Macro (IEWBFDA) provided for access and to simplify coding parameters*
      - *Limited functionality (comparable to GD request code only)*
      - *Functionally stabilized*

What else comes with the binder?
Binder APIs …

- 3 – C/C++ DLLs

  - Not really a different flavor!

  - Simplified C interfaces to both regular APIs and fast data access APIs

  - Simplifies management of binder (loading modules, creating buffers)
    - oriented to buffer data (records) returned

  - Provides extra utility interfaces
    - Create lists needed by some API calls
    - Test for end-of-data on get calls
    - Get Return/Reason codes (new APIs)
    - Get/Set cursor

  - Uses *contexts* – for regular APIs this represents workmod+dialog (no facility for multiple workmods in a single dialog)

What else comes with the binder? Binder APIs …

- 3 – C/C++ DLLs …
  - APIs in Dynamic Link Library (DLL)
    - **iewbndd.so**
    - **Iewbnddx.so** *— XPLINK new in z/OS V1R12*
  - C/C++ header file provides buffer structures, API prototypes and other needed data types – **__iew_api.h**
  - Side file links with application to access DLL
    - **iewbndd.x**
    - **Iewbnddx.x** *— XPLINK new in z/OS V1R12*
  - Installs into UNIX file system (/usr/lib, header in /usr/include)
  - Installs into datasets (SYS1.SIEAMIGE and SYS1.SIEASID) *new!*

What else comes with the binder? Binder APIs …

- Module data is returned in a buffer provided by the API caller

- IEWBUFF macro can help (but is not required)

- <u>Same buffer format used by both regular APIs and fast data APIs</u>

- Buffers have version numbers indicative of buffer format

  - Until z/OS V1.10 regular APIs required matching version numbers
  - Version numbers are ubiquitous

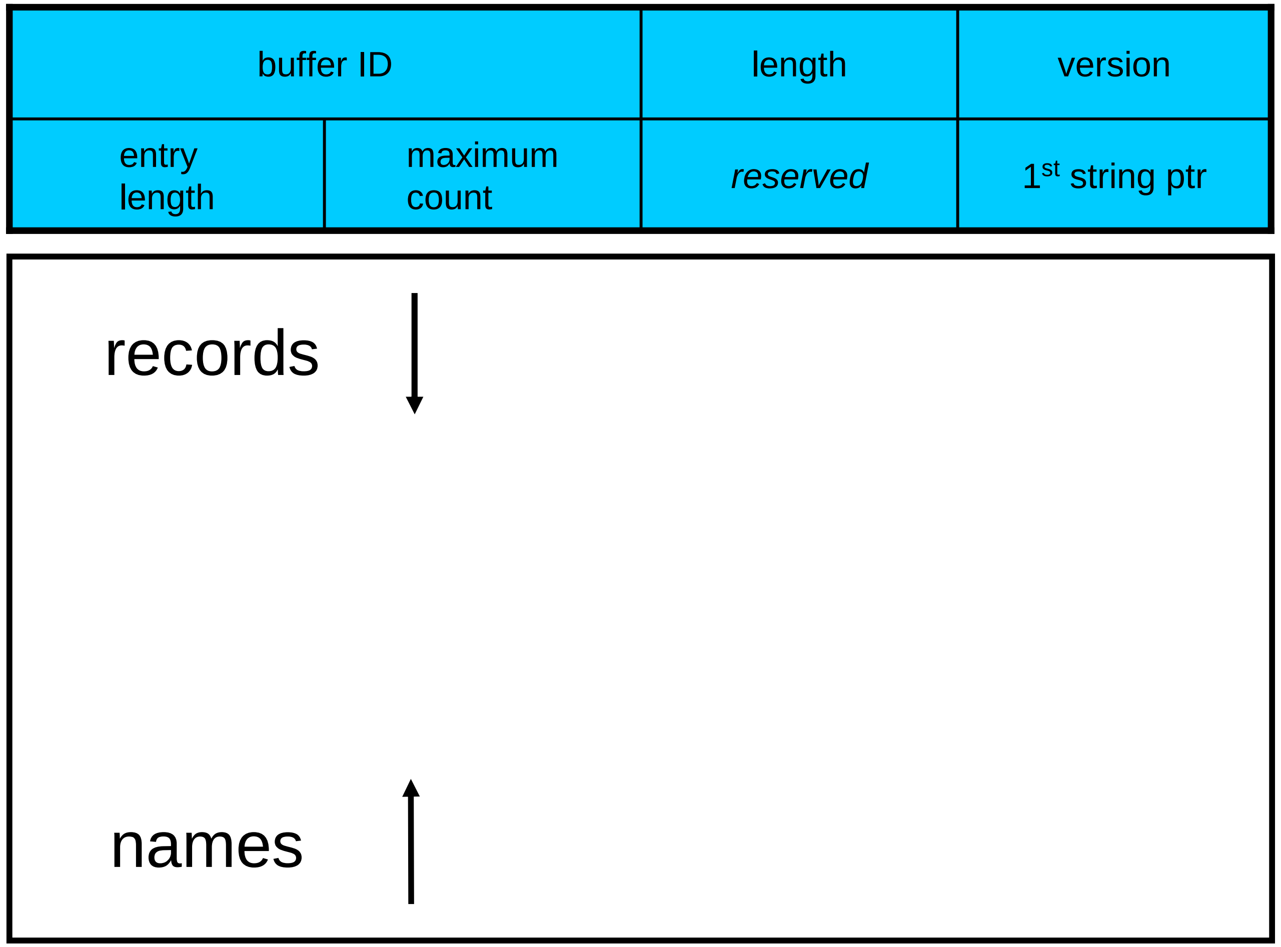
- The buffer ID must be consistent with the type of data being requested

  - For example, the buffer ID for ESDs is IEWBESD

What else comes with the binder? Binder APIs …

- Earlier buffer versions may not contain all information available from later PO formats
  - APIs will attempt to convert data to a format compatible with the buffer version
  - In some cases the conversion cannot be performed and the request will fail.
  - The most likely scenario in which this would happen is using a version 1 ESD buffer to retrieve information from PO format PO2 or greater with multiple text classes
    - *The differences between later PO versions are much smaller*

What else comes with the binder? Binder APIs …



What else comes with the binder? Binder APIs …

- IEWBUFF usage
  - Must specify BUFFER TYPE
    - ESD, RLD, NAME, TEXT etc.
  - Must specify FUNCTION
    - *MAPBUF* - *generate buffer mapping for selected buffer type*
    - *GETBUF* - *acquire storage for buffer*
    - *INITBUF* - *initialize buffer header*
    - *FREEBUF* - *release storage acquired via GETBUF*
  - MAPBUF must be used first since it specifies the buffer size used by GETBUF and values to be inserted in the buffer header.
    - *Buffer size can be specified as SIZE (record count) or BYTES*
    - *Should specify version number (VERSION). Default is version 1 - probably NOT what you want*

What else comes with the binder? Binder APIs …

- Class name are limited to 16 bytes
- Other ESD names are limited to 32K-1 bytes
- Binder generated names, demangle named and abbreviated names as they appear in the printed output are not how they look in the program
  - You *must* use the *real internal name* in the API
  - C/C++ APIs work with strings representing binder generated names
    - __iew_api_name_to_str
- Binder-generated names for sections and symbols are 4-byte binary numbers
  - Printed as $PRIVxxxxxx, where xxxxxx is the hexadecimal representation of the binary number
- C++ mangled names are used directly as is
  - no demangling provided by APIs

program management documentation

- SA22-7643 - z/OS MVS Program Management: User's Guide and Reference

for options & control statements

- SA22-7644 - z/OS MVS Program Management: Advanced Facilities

for binder **APIs**

- GA22-7589 - z/OS MVS Diagnosis: Tools and Service Aids

for **AMBLIST** and **SPZAP**

- SA22-7782 - z/OS TSO/E Command Reference

for **LINK** and **LOADGO**

- SA22-7802 - z/OS UNIX System Services Command Reference

for **c89** and **ld**