



# System Software

## CSN-252

### Program Linking



## Program Linking

- Programs with many control sections
- Resolve the problems with EXTREF and EXTDEF from different control sections
- Linking
  1. User, 2. Assembler, 3. Linking loader
- Example
  - Use modification records for both relocation and linking
    - Constants
    - Internal reference
    - external reference

0000	PROGA	START	0	
		EXTDEF	LISTA, ENDA	
		EXTREF	LISTB, ENDB, LISTC, ENDC	
		:		
0020	REF1	LDA	LISTA	03201D
0023	REF2	+LDT	LISTB+4	77100004
0027	REF3	LDX	#ENDA-LISTA	050014
		:		
0040	LISTA	EQU	*	
		:		
0054	ENDA	EQU	*	
				Base 10
0054	REF4	WORD	ENDA-LISTA+LISTC	000014
0057	REF5	WORD	ENDC-LISTC-10	FFFFFF6
005A	REF6	WORD	ENDC-LISTC+LISTA-1	00003F
005D	REF7	WORD	ENDA-LISTA-(ENDB-LISTB)	000014
0060	REF8	WORD	LISTB-LISTA	FFFFC0
		END	REF1	

0000	PROGB	START	0	
		EXTDEF	LISTB, ENDB	
		EXTREF	LISTA, ENDA, LISTC, ENDC	
		:		
0036	REF1	+LDA	LISTA	03100000
003A	REF2	LDT	LISTB+4	772027
003D	REF3	+LDX	#ENDA-LISTA	05100000
		:		
0060	LISTB	EQU	*	
		:		
0070	ENDB	EQU	*	
0070	REF4	WORD	ENDA-LISTA+LISTC	000000
0073	REF5	WORD	ENDC-LISTC-10	FFFFFF6
0076	REF6	WORD	ENDC-LISTC+LISTA-1	FFFFFFF
0079	REF7	WORD	ENDA-LISTA-(ENDB-LISTB)	FFFFFF0
007C	REF8	WORD	LISTB-LISTA	000060
		END	REF1	

```

0000  PROGC START      0
          EXTDEF      LISTC, ENDC
          EXTREF      LISTB, ENDB, LISTA, ENDA
          :
0018  REF1  +LDA      LISTA          03100000
001C  REF2  +LDT      LISTB+4        77100004
0020  REF3  +LDX      #ENDA-LISTA    05100000
          :
0030  LISTC EQU      *
          :
0042  ENDC EQU      *

0042  REF4  WORD      ENDA-LISTA+LISTC  000030
0045  REF5  WORD      ENDC-LISTC-10     000008
0048  REF6  WORD      ENDC-LISTC+LISTA-1 000011
004B  REF7  WORD      ENDA-LISTA-(ENDB-LISTB) 000000
004E  REF8  WORD      LISTB-LISTA       000000
          END          REF1

```

### Approach:

- Evaluate as much of the expression as it can
- Pass remaining terms to the loader via modification records

0000	PROGC	START	0	
		EXTDEF	LISTC, ENDC	
		EXTREF	LISTB, ENDB, LISTA, ENDA	
		:		
0018	REF1	+LDA	LISTA	1, 3, 5
001C	REF2	+LDT	LISTB-4	2, 4, 6, 8
0020	REF3	+LDX	#ENDA-LISTA	7, 9, 0
		:		
0030	LISTC	EQU	*	
		:		
0042	ENDC	EQU	*	
0042	REF4	WORD	ENDA-LISTA+LISTC	2, 6
0045	REF5	WORD	ENDC-LISTC-10	4
0048	REF6	WORD	ENDB-LISTB+LISTA-1	0, 3, 5
004B	REF7	WORD	ENDA-LISTA-(ENDB-LISTB)	8
004E	REF8	WORD	LISTB-LISTA-10	1, 7, 9
		END	REF1	

```

H PROGA 000000 000063
D LISTA 000040 ENDA 000054
R LISTB ENDB LISTC ENDC
:
T0000200A 03201D 77100000 050014
:
T0000540F000014 FFFFF6 00003F 000014 FFFFC0
M000024 05 +LISTB
M000054 06 +LISTC
M000057 06 +ENDC
M000057 06 -LISTC
M00005A 06 +ENDC
M00005A 06 -LISTC
M00005A 06 +PROGA
M00005D 06 -ENDB
M00005D 06 +LISTB
M000060 06 +LISTB
M000060 06 -PROGA
E000020

```