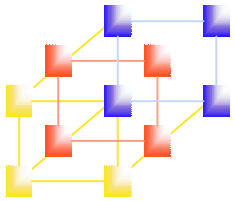
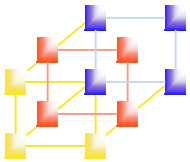
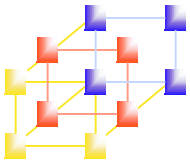


Chapter 2 Assemblers
-- 2.4 Assembler Design Options



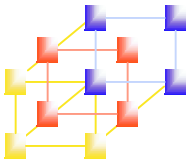
Outline

- One-pass assemblers
- Multi-pass assemblers
- Two-pass assembler with overlay structure



Load-and-Go Assembler

- Load-and-go assembler generates their object code in memory for immediate execution.
- No object program is written out, no loader is needed.
- It is useful in a system with frequent program development and testing
  - The efficiency of the assembly process is an important consideration.
- Programs are re-assembled nearly every time they are run, efficiency of the assembly process is an important consideration.

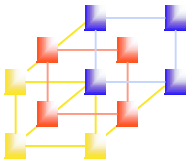


One-Pass Assemblers

- Scenario for one-pass assemblers
  - Generate their object code in memory for immediate execution – *load-and-go* assembler
  - External storage for the intermediate file between two passes is slow or is inconvenient to use
- Main problem - Forward references
  - Data items
  - Labels on instructions
- Solution
  - Require that all areas be defined before they are referenced.
  - It is possible, although inconvenient, to do so for data items.
  - Forward jump to instruction items cannot be easily eliminated.
    - `Insert (label, address_to_be_modified) to SYMTAB`
    - `Usually, address_to_be_modified is stored in a linked-list`

Sample program for a one-pass assembler Figure 2.18, pp. 94

Line	Loc	Source statement			Object code
0	1000	COPY	START	1000	
1	1000	EOF	BYTE	C'EOF'	454F46
2	1003	THREE	WORD	3	000003
3	1006	ZERO	WORD	0	000000
4	1009	RETADR	RESW	1	
5	100C	LENGTH	RESW	1	
6	100F	BUFFER	RESB	4096	
9		.			
10	200F	FIRST	STL	RETADR	141009
15	2012	CLOOP	JSUB	RDREC	48203D
20	2015		LDA	LENGTH	00100C
25	2018		COMP	ZERO	281006
30	201B		JEQ	ENDFIL	302024
35	201E		JSUB	WRREC	482062
40	2021		J	CLOOP	302012
45	2024	ENDFIL	LDA	EOF	001000
50	2027		STA	BUFFER	0C100F
55	202A		LDA	THREE	001003
60	202D		STA	LENGTH	0C100C
65	2030		JSUB	WRREC	482062
70	2033		LDL	RETADR	081009
75	2036		RSUB		4C0000
110					



Forward Reference in One-pass Assembler

- Omits the operand address if the symbol has not yet been defined
- Enters this undefined symbol into SYMTAB and indicates that it is undefined
- Adds the address of this operand address to a list of forward references associated with the SYMTAB entry
- When the definition for the symbol is encountered, scans the reference list and inserts the address.
- At the end of the program, reports the error if there are still SYMTAB entries indicated undefined symbols.
- For Load-and-Go assembler
  - Search SYMTAB for the symbol named in the END statement and jumps to this location to begin execution if there is no error

Object Code in Memory and SYMTAB Figure 2.19(a), pp.95

After scanning line 40 of the program in Fig. 2.18

Memory address	Contents			
1000	454F4600	00030000	00xxxxxx	xxxxxxxx
1010	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
•				
•				
•				
2000	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxx14
2010	100948--	--00100C	28100630	----48--
2020	--3C2012			
•				
•				
•				

Symbol	Value	
LENGTH	100C	
RDREC	*	2013 0
THREE	1003	
ZERO	1006	
WRREC	*	201F 0
EOF	1000	
ENDFIL	*	201C 0
RETADR	1009	
BUFFER	100F	
CLOOP	2012	
FIRST	200F	

Object Code in Memory and SYMTAB Figure 2.19(b), pp.96

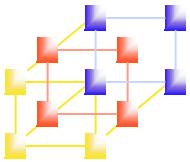
After scanning line 160 of the program in Fig. 2.18

Memory address	Contents			
1000	454F4600	00030000	00xxxxxx	xxxxxxxx
1010	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
•				
•				
•				
2000	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxx14
2010	10094820	3D00100C	28100630	202448--
2020	--3C2012	0010000C	100F0010	030C100C
2030	48----08	10094C00	00F10010	00041006
2040	001006E0	20393020	43D82039	28100630
2050	----5490	0F		
•				
•				
•				

Symbol	Value
LENGTH	100C
RDREC	203D
THREE	1003
ZERO	1006
WRREC	*
EOF	1000
ENDFIL	2024
RETADR	1009
BUFFER	100F
CLOOP	2012
FIRST	200F
MAXLEN	203A
INPUT	2039
EXIT	*
RLOOP	2043

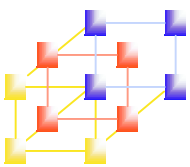
201F → 2031 | 0

2050 | 0



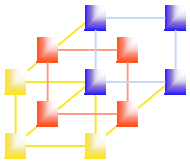
If One-Pass Assemblers Need to Produce Object Codes

- If the operand contains an undefined symbol, use 0 as the address and write the Text record to the object program.
- Forward references are entered into lists as in the load-and-go assembler.
- When the definition of a symbol is encountered, the assembler generates another Text record with the correct operand address of each entry in the reference list.
- When loaded, the incorrect address 0 will be updated by the latter Text record containing the symbol definition.



Object code generated by one-pass assembler Figure 2.18, pp.97

```
HCOPY  001000001 07A
T001000 09 454F46 000003 000000
T00200F 15 141009 48 000000 100C28 100630 000004 800003C2012
T00201C 02 2024
T002024 19 0010000C100F0010030C100C480000081009 4C0000F1001000
T00201302203D
T00203D 1E 041006 001006 E02039 302043 D82039 281006 300000 54900F 2C203A 382043
T002050 02 205B
T00205B 07 10100C 4C0000 05
T00201F 02 2062
T002031 02 2062
T002062 18 041006 E02061 302065 50900F DC2061 2C100C 382065 4C0000
E00200F
```

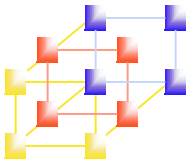


Multi-Pass Assemblers

- For a two pass assembler, forward references in symbol definition are not allowed:

```
ALPHA    EQU     BETA
BETA     EQU     DELTA
DELTA    RESW    1
```

  - Symbol definition must be completed in pass 1.
- Prohibiting forward references in symbol definition is not a serious inconvenience.
  - Forward references tend to create difficulty for a person reading the program.

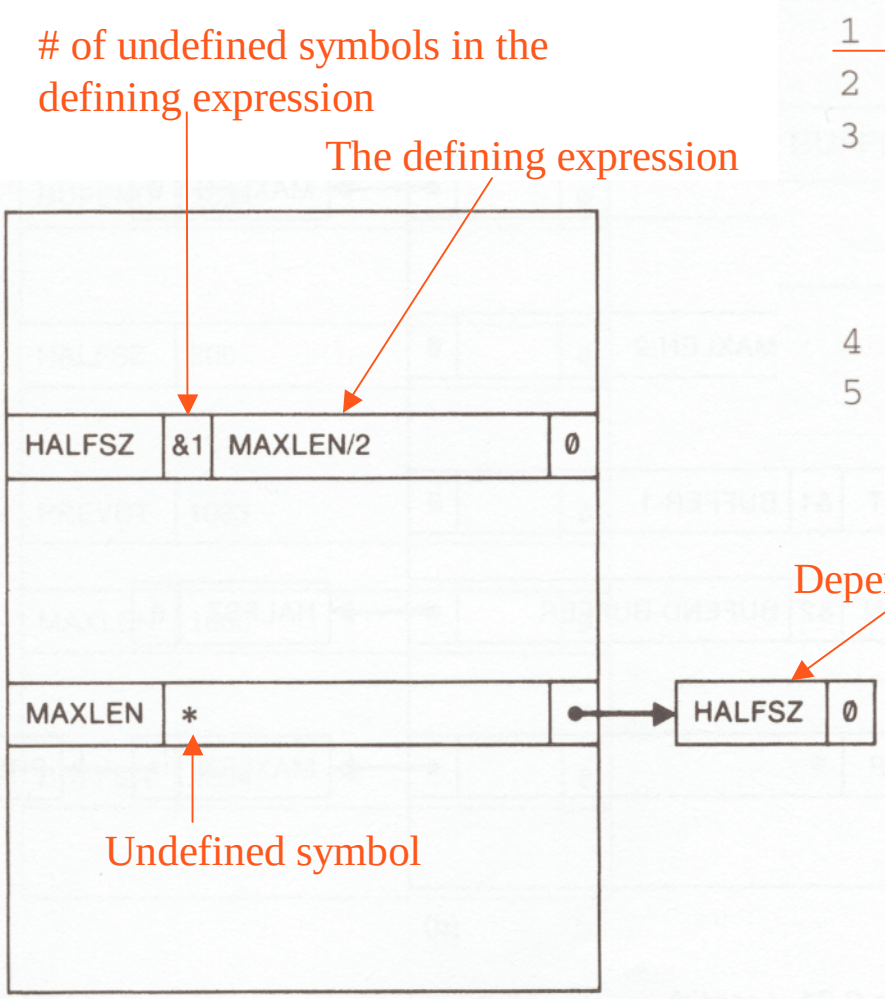


Implementation

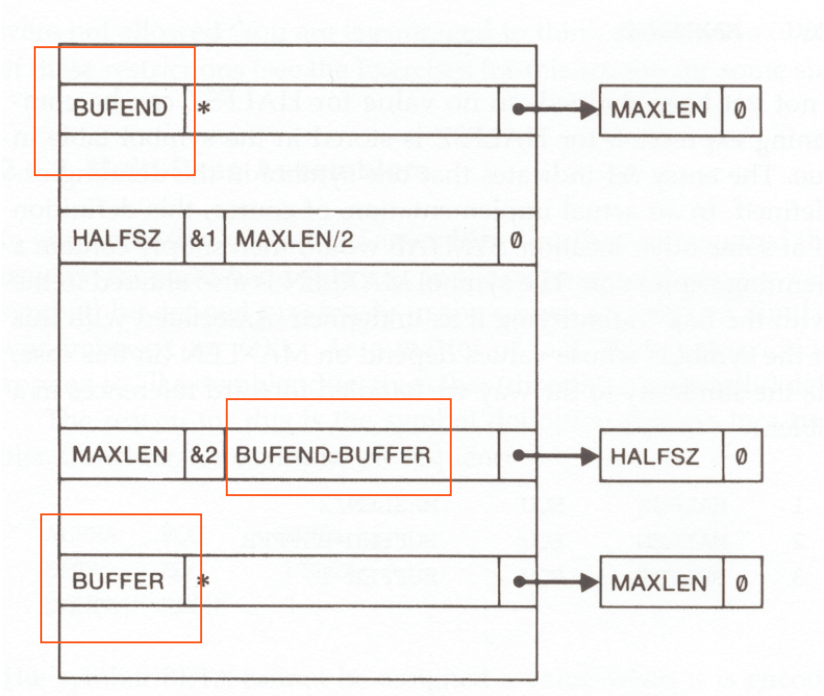
- For a forward reference in symbol definition, we store in the SYMTAB:
  - The symbol name
  - The defining expression
  - The number of undefined symbols in the defining expression
- The undefined symbol (marked with a flag *) associated with a list of symbols depend on this undefined symbol.
- When a symbol is defined, we can recursively evaluate the symbol expressions depending on the newly defined symbol.

Multi-pass assembler example
Figure 2.21, pp. 99-101

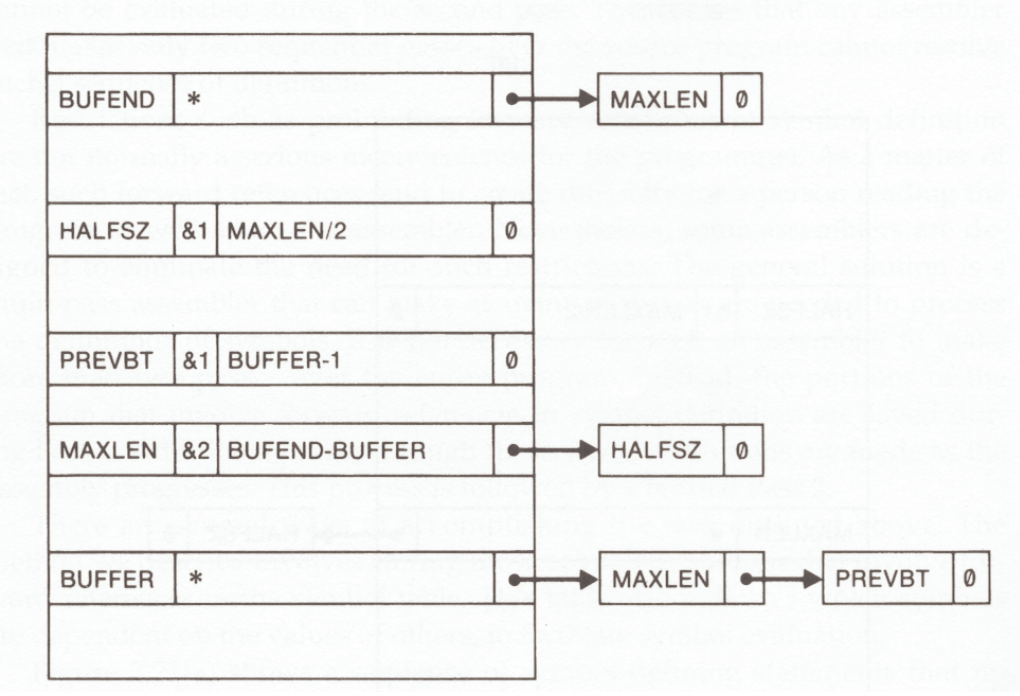
```
1     HALFSZ    EQU    MAXLEN/2
2     MAXLEN    EQU    BUFEND-BUFFER
3     PREVBT    EQU    BUFFER-1
                       .
                       .
                       .
4     BUFFER    RESB   4096
5     BUFEND    EQU    *
```



Multi-pass assembler example
Figure 2.21, pp. 99-101

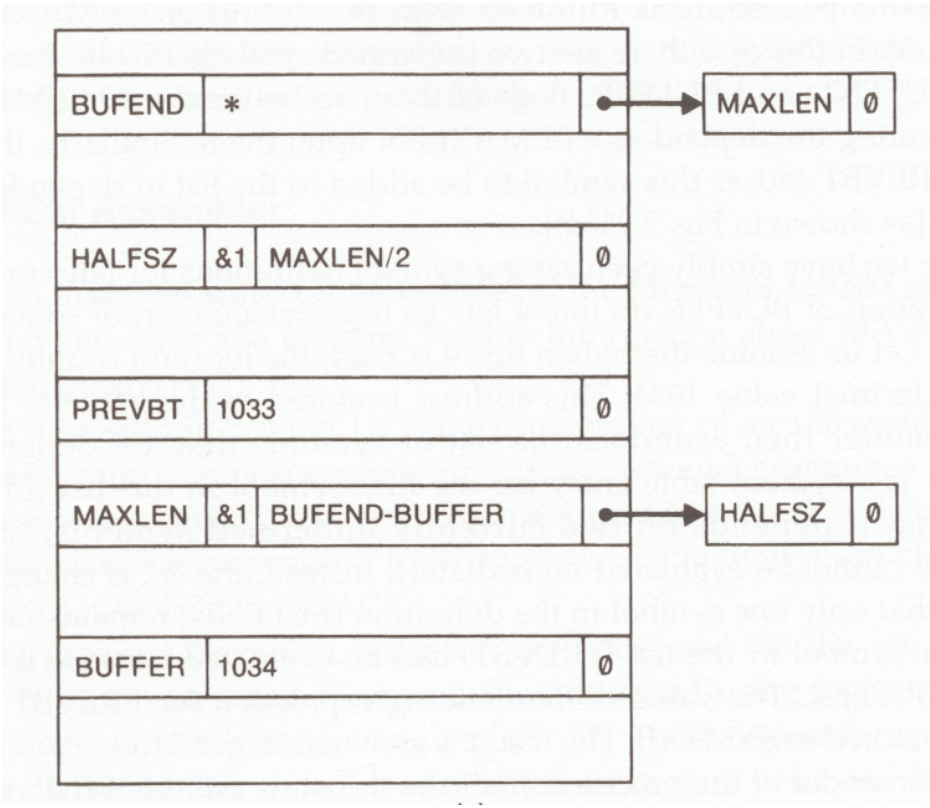


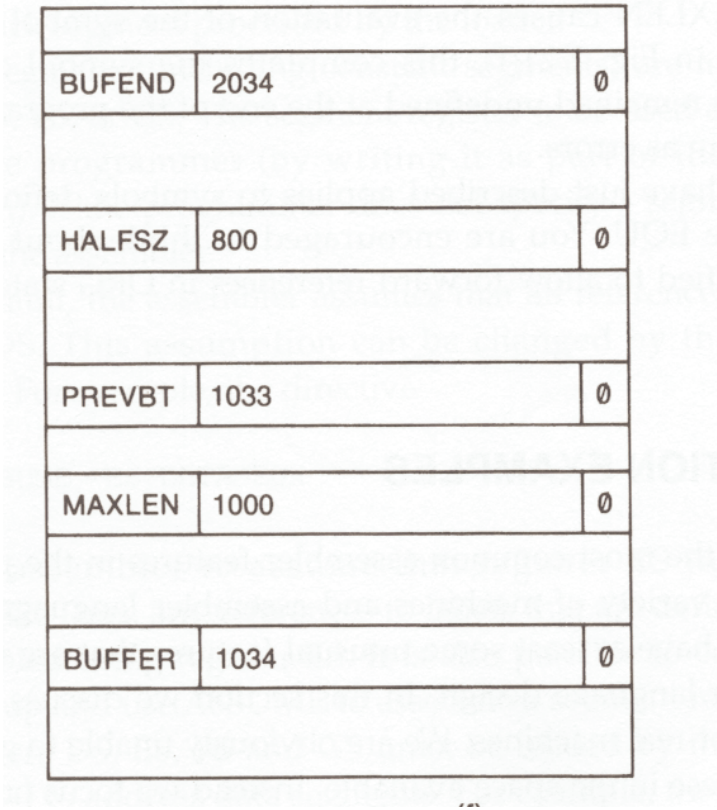
2 MAXLEN EQU BUFEND-BUFFER



3 PREVBT EQU BUFFER-1

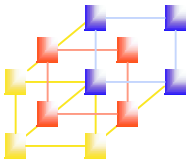
Multi-pass assembler example
Figure 2.21, pp. 99-101






```
4    BUFFER    RESB    4096
```

```
5    BUFEND    EQU     *
```



Two-pass assembler with overlay structure

- When memory is not enough
  - Pass 1 and pass 2 are never required at the same time
  - Three segments
  - Overlay program