

Assignment 2: Paging Policies

Linyun Fu

RIN: 660929569

Email: fula@cs.rpi.edu

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Question

Consider the following high-level code segment:

```
for (i=0;i<n;i++) {  
    B[i]=i*n;  
    A[i]=B[i]+m;  
    C[i]=A[i]*B[i];  
}  
for (i=0;i<n;i++) {  
    for (j=i;j<n;j++) {  
        B[j]+=A[i]*m;  
        C[j]-=A[j]+B[i];  
    }  
    B[i]+=C[n-1]+A[i];  
}
```

1. Using registers (denoted as R_i), create a machine language translation of this program loaded into the virtual address space (with the page size equal to 1024 words). Assume that this program starts in page 0 at the internal page address 994 (each page internal addresses start at 0 and end at 1023). The constants (like 0, 1 etc.) are placed in page 2 (at the addresses starting at 0), the static data (for example, n) in

page 3, and each of the arrays A, B, C is placed on its own page (page 4, 5 and 6 respectively).

After creating the machine code, write an expression that represents the string of page references generated during execution of this code segment (use the parameters n and i and notation $(\text{str})^n$ to denote n repetitions of the string str . In this string, represent n -th page by a single decimal digit $n-1$).

Answer

1 Code Translation and Page References

The machine code of the program is as follows.

Page	Internal address	Content	Page reference(s)
0	0	###	
0	:	:	
0	994	$(R_0) \leftarrow \text{ZERO}$	02
0	995	$(R_1) \leftarrow n$	03
0	996	$(R_2) \leftarrow m$	03
0	997	$(R_3) \leftarrow \text{ONE}$	02
0	998	compare R_0, R_1	0
0	999	branch.greaterequal*+8	0
0	1000	$B[R_0] \leftarrow R_0 * n$	035
0	1001	$(R_4) \leftarrow B[R_0]$	05
0	1002	$A[R_0] \leftarrow R_4 + R_2$	04
0	1003	$(R_5) \leftarrow A[R_0]$	04
0	1004	$C[R_0] \leftarrow R_5 * R_4$	06
0	1005	$(R_0) \leftarrow R_0 + R_3$	0
0	1006	branch*-8	0
0	1007	$(R_0) \leftarrow \text{ZERO}$	02
0	1008	compare R_0, R_1	0
0	1009	branch.greaterequal*+23	0
0	1010	$(R_4) \leftarrow R_0$	0

Page	Internal address	Content	Page reference(s)
0	1011	compare R_4, R_1	0
0	1012	branch.greaterequal*+12	0
0	1013	$R_5 \leftarrow B[R_4]$	05
0	1014	$R_6 \leftarrow A[R_0]$	04
0	1015	$R_6 \leftarrow R_6 * R_2$	0
0	1016	$B[R_4] \leftarrow R_5 + R_6$	05
0	1017	$R_5 \leftarrow C[R_4]$	06
0	1018	$R_6 \leftarrow A[R_4]$	04
0	1019	$R_7 \leftarrow B[R_0]$	05
0	1020	$R_7 \leftarrow R_6 + R_7$	0
0	1021	$C[R_4] \leftarrow R_5 - R_7$	06
0	1022	$R_4 \leftarrow R_4 + R_3$	0
0	1023	branch*-12	0
1	0	$R_4 \leftarrow B[R_0]$	15
1	1	$R_5 \leftarrow R_1 - R_3$	1
1	2	$R_5 \leftarrow C[R_5]$	16
1	3	$R_6 \leftarrow A[R_0]$	14
1	4	$R_6 \leftarrow R_5 + R_6$	1
1	5	$B[R_0] \leftarrow R_4 + R_6$	15
1	6	$R_0 \leftarrow R_0 + R_3$	1
1	7	branch*-23	1
1	:	:	
2	0	ZERO	
2	1	ONE	
2	:	:	
3	0	n	
3	1	m	
3	:	:	
4		A	
5		B	
6		C	

From the above translation, we know the string of page references during execution of this code segment is

02030302 (000350504040600)ⁿ 0002 (000 (00050400506040500600)ⁿ 151161411511)

$$(000\ (00050400506040500600)^{n-1}\ 151161411511) \cdots (000\ (00050400506040500600)^2\ 151161411511)\ (000\ 00050400506040500600\ 151161411511)\ 00$$