Program Slicing

Collection of Examples

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Overview

- Definition of executable slice (liveness analysis)
- Example with scalar variables
- Example with pointers to stack-allocated variables
- Example with strong and weak update in alias analysis
- Example with non-cyclic dynamic data structures
- Example with cyclic data structures
- Comparison of slice size

Reaching Defs with/out Pointers

$ReachingDefs(var,n,F) =$ *[without poi*

let

$F = (V,A,En,Ex),\ A' = A \backslash \{(x,n)\}$

return $\bigcup_{(x,n)\in A}$ *if* $var \notin def(x)$ *then* $ReachingDefs(var,x,(V,A',En$

else $\{x\}$

$ReachingDefs(var,n,F) =$ *[with po*

let

$F = (V,A,En,Ex),\ A' = A \backslash \{(x,n)\}$

return $\bigcup_{(x,n)\in A}$ *if* $var \notin def(x)$ *then* $ReachingDefs(var,x,(V,A',E$

else (if $\#def(x) = 1$ *then* $\{x\}$

else $\{x\} \cup ReachingDefs(var,x,(V,A',En,Ex))$

Program Dependence Graph

$DataDep(P) =$

let $CFG(P) = (V,A,En,Ex)$

$D = \bigcup_{n\in V, var\in use(n), x\in ReachingDefs(var,n,CFG(P))} \{(n,x)\}$

return (V,D)

$ProgramDep(P) =$

let $DataDep(P) = (V,D)$,

$ControlDep(P) = (V,C,In)$,

return $(V, D \cup C)$

Static Slice

$ReachableNodes(v,G) =$

let $G = (V,A)$

return $\{v\} \cup \bigcup_{(v,x)\in A} ReachableNodes(x,(V,A\backslash\{(v,x)\}))$

$StaticSlice(P,n,Vars) =$

let $F = CFG(P)$

$D = ProgramDep(P)$

return $\bigcup_{var\in Vars} \bigcup_{x\in ReachingDefs(var,n,F)} ReachableNodes(x,D)$

Example: Artificial Sum (only scalar vars)

```
   main() {
0    int a,b,i,j,n,y;
1    n=read();
6    a=0;
7    b=0;
8    i=n;
9    j=n;
10   while (i>0) {
11     a=a+1;
12     i=i-1;
13     j=i;
14     while (j>0) {
15       b=b+1;
16       j=j-1;
       }
     };
17   y=a+b;
18   write(y);
   }
```

$y = n + \sum_{i=1}^{n-1} i = \sum_{i=1}^{n} i$

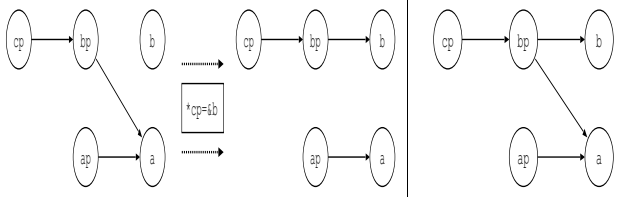
Example: With Pointers

```
   main() {
0    int a,b,i,j,n, *ap,*bp,**cp;
1    n=read();
2    cp=&bp
3    ap=&a;
4    bp=ap;
5    *cp=&b;
6    a=0;
7    b=0;
8    i=n;
9    j=n;
10   while (i>0) {
11     *ap=*ap+1;
12     i=i-1;
13     j=i;
14     while (j>0) {
15       *bp=*bp+1;
16       j=j-1;
       }
     }
17   y=*ap + *bp;
18   write(y);
   }
```

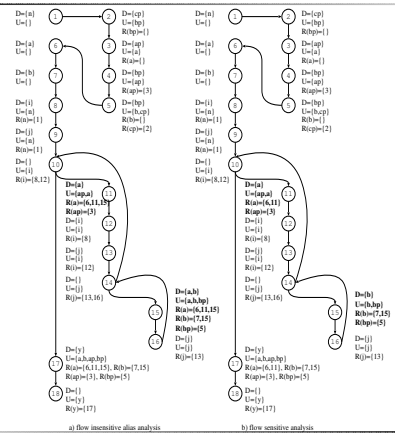
Slicing criterion 17: `*ap`

Example: Strong vs Weak Update

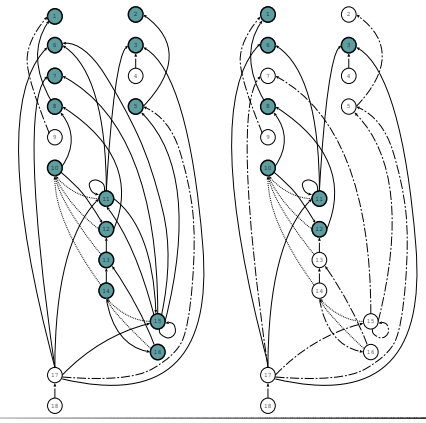
```
0    int a,b,i,j,*ap,*bp,**cp;
2    cp=&bp
3    ap=&a;
4    bp=ap;
5    *cp=&b;
```



Example: Reaching Definitions



Example: Computation of Slice



Example: With Pointers (Slices)

```
   main() {
     int a,b,i,j,n, *ap,*bp,**cp;
1    n=read();
2    cp=&bp;
3    ap=&a;
4    bp=ap;
5    *cp=&b;
6    a=0;
7    b=0;
8    i=n;
9    j=n;
10   while (i>0) }
11     *ap=*ap+1;
12     i=i-1;
13     j=i;
14     while (j>0) {
15       *bp=*bp+1;
16       j=j-1;
       }
     }
17   y= *ap +*bp;
18   write(y);
   }
```

Slicing criterion 17: `*ap`

Example: Comparison

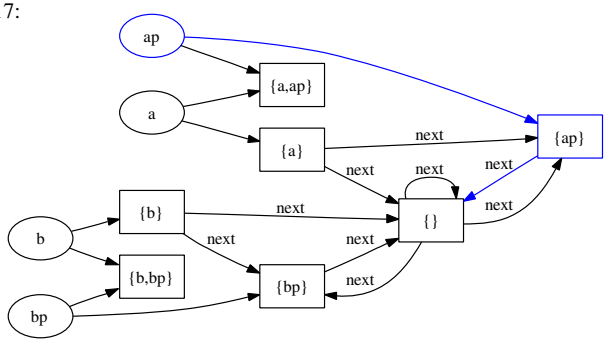
Program	Aliasanalysis	Slice	Si
Sum	none	{1,6,8,10,11,12,17}	
Sum (ptrs)	flow insensitive	{1,2,3,5,6,7,8,10,11, 12,13,14,15,16,17}	
Sum (ptrs)	flow sensitive	{1,3,6,8,10,11,12,17}	

Example: With Dynamic Data Structures

```
    main() {
    List *a,*b,*ap,*bp;
    int i,j,n;
1   n=read();
2   a=new List();
3   b=new List();
4   ap=a;
5   bp=b;
8   i=n;
9   j=n;
10  while (i>0) {
11    ap->next=new List();
11b   ap=ap->next;
12    i=i-1;
13    j=i;
14    while (j>0) {
15      bp->next=new List();
15b     bp=bp->next;
16      j=j-1;
      }
    }
17  ap->next = b; // conc
17b y=a;
18  write(length(y)-2)
  }
```


Example: Shape Analysis

17:



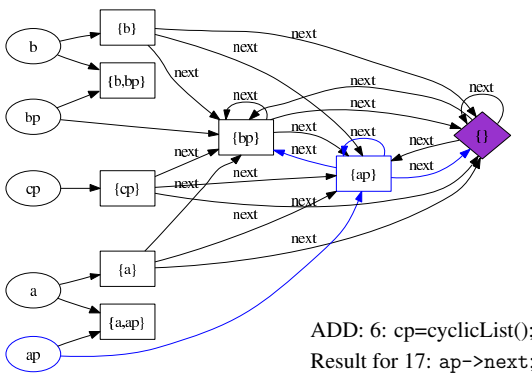
Result for 17: `ap->next;`

Example: With Dynamic Data Structures

```
    main() {
    List *a,*b,*ap,*bp;
    int i,j,n;
1   n=read();
2   a=new List();
3   b=new List();
4   ap=a;
5   bp=b;
8   i=n;
9   j=n;
10  while (i>0) {
11    ap->next=new List()
11b   ap=ap->next;
12    i=i-1;
13    j=i;
14    while (j>0) {
15      bp->next=new Lis
15b     bp=bp->next;
16      j=j-1;
      }
    }
17  ap->next = b; // con
17b y=a;
18  write(length(y)-2)
  }
```


Example: Shape Analysis with Cycle

17:



ADD: 6: cp=cyclicList();
Result for 17: `ap->next;`

Example: Comparison

Program	Aliasanalysis	Inner Loop in Slice
Sum	none	No
Sum (ptrs)	flow insensitive (weak update)	Yes
Sum (ptrs)	flow sensitive (strong update)	No
Sum (dyn)	heap represented by 1 node only	Yes
Sum (dyn)	shape analysis (strong update)	No
Sum (dyn+cycle)	shape analysis	Yes