Lab: Data-Dependence and Pointer Aliasing

(Week 3)

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School of Computer Science and Engineering

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Quiz-1 + Lab-Exercise-1 + Assignment-1

- A set of quizzes on WebCMS (5 points)
  - LLVM compiler and its intermediate representation
  - Code graphs (including ICFG and PAG)
- Lab-Exercise-1 (5 points)
  - Implement a graph traversal on a general graph
- Assignment-1 (20 points)
  - **Control-flow**: Implement a context-sensitive graph traversal on a CodeGraph (i.e., ICFG) and print **feasible** paths from a source node to a sink node on the graph
  - **Data-flow**: Implement Andersen's inclusion-based constraint solving for points-to analysis
  - Implement a taint checker using control-flow analysis and data-flow analysis.

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  - Implement a taint checker using control-flow analysis and data-flow analysis.
  - **Specification and code template**: `https://github.com/SVF-tools/Software-Security-Analysis/wiki/Assignment-1`
  - **SVF APIs for control- and data-flow analysis** `https://github.com/SVF-tools/Software-Security-Analysis/wiki/SVF-CPP-API`

Andersen's Pointer Analysis

Algorithm

```
define i32 @main() #0 {
entry:
  %a1 = alloca i8, align 1          // O1
  %a = alloca ptr, align 8          // O2
  %b1 = alloca i8, align 1          // O3
  %b = alloca ptr, align 8          // O4
  store ptr %a1, ptr %a, align 8
  store ptr %b1, ptr %b, align 8
  call void @swap(ptr %a, ptr %b)
  ret i32 0
}

define void @swap(ptr %p, ptr %q) #0 {
entry:
  %0 = load ptr, ptr %p, align 8
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  ret void
}
```

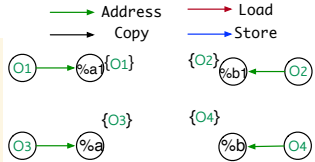

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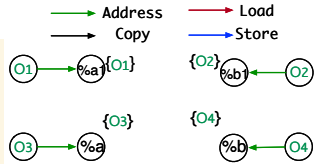

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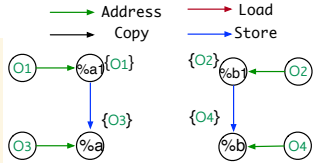

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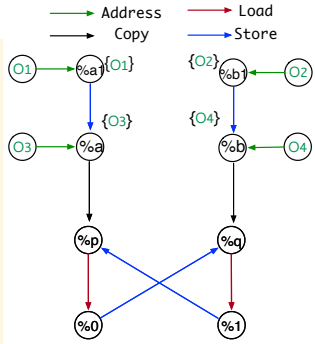


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V: a set of nodes in graph
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WorkList: a vector of nodes
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5    p <- popFromWorklist()
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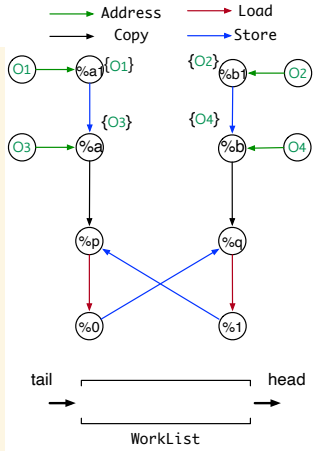


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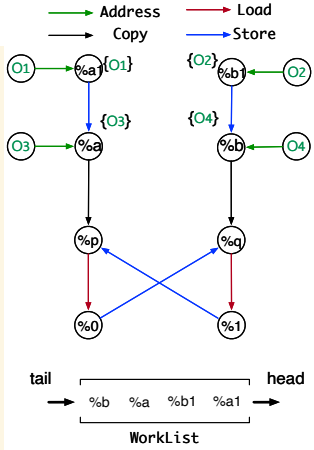


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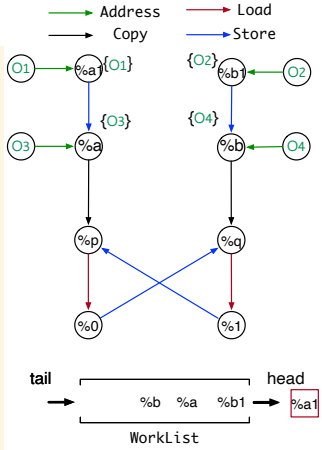


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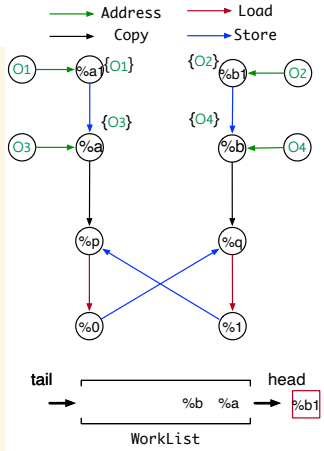


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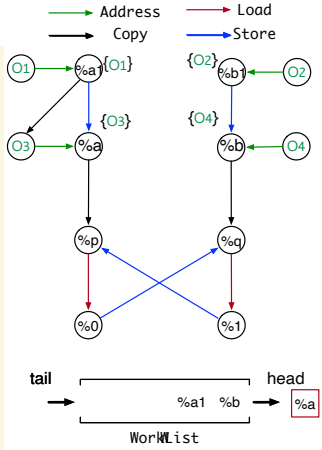


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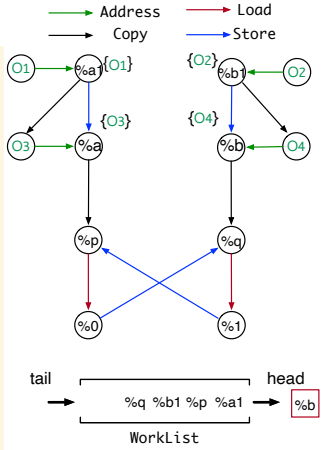


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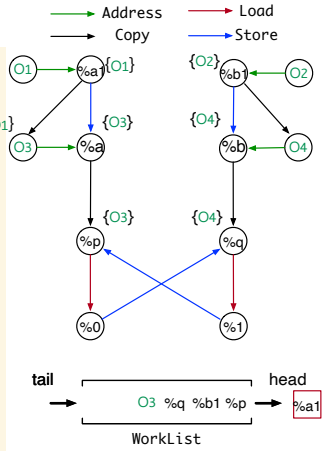


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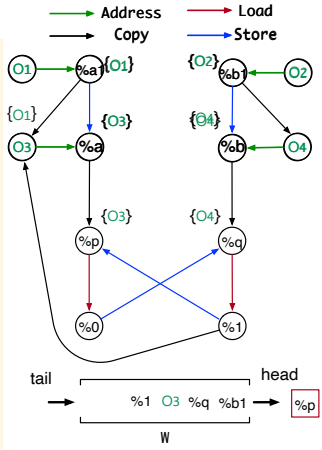


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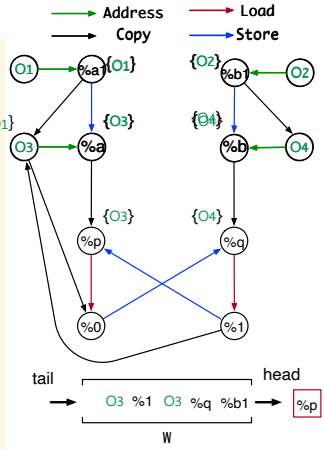


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V: a set of nodes in graph
E: a set of edges in graph
WorkList: a vector of nodes
1  foreach o --Address--> p do                    // Address rule
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3      pushIntoWorklist(p)
4  while WorkList ≠ ø do
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8        if q --Copy--> o ∉ E then
9          E <- E ∪ { q --Copy--> o }            // Add copy edge
10         pushIntoWorklist(q)
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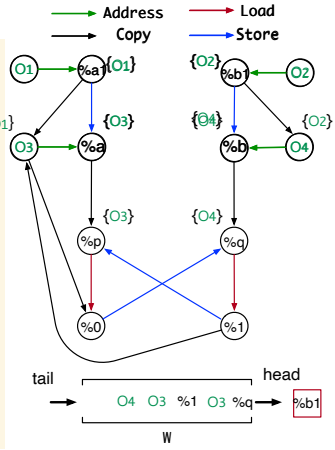
```

Andersen's Pointer Analysis

Algorithm

```
define i32 @main() #0 {
entry:
  %a1 = alloca i8, align 1          // O1
  %a = alloca ptr, align 8          // O2
  %b1 = alloca i8, align 1          // O3
  %b = alloca ptr, align 8          // O4
  store ptr %a1, ptr %a, align 8
  store ptr %b1, ptr %b, align 8
  call void @swap(ptr %a, ptr %b)
  ret i32 0
}

define void @swap(ptr %p, ptr %q) #0 {
entry:
  %0 = load ptr, ptr %p, align 8
  %1 = load ptr, ptr %q, align 8
  store ptr %1, ptr %p, align 8
  store ptr %0, ptr %q, align 8
  ret void
}
```

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Andersen's Pointer Analysis

Algorithm

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  %b = alloca ptr, align 8          // O4
  store ptr %a1, ptr %a, align 8
  store ptr %b1, ptr %b, align 8
  call void @swap(ptr %a, ptr %b)
  ret i32 0
}

define void @swap(ptr %p, ptr %q) #0 {
entry:
  %0 = load ptr, ptr %p, align 8
  %1 = load ptr, ptr %q, align 8
  store ptr %1, ptr %p, align 8
  store ptr %0, ptr %q, align 8
  ret void
}
```

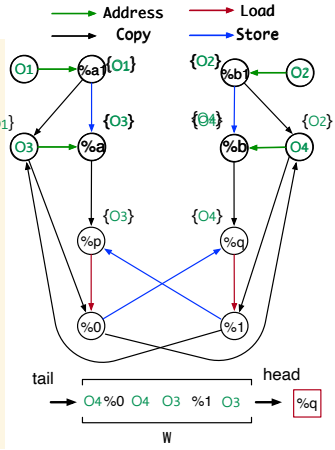


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Andersen's Pointer Analysis

Algorithm

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  store ptr %a1, ptr %a, align 8
  store ptr %b1, ptr %b, align 8
  call void @swap(ptr %a, ptr %b)
  ret i32 0
}

define void @swap(ptr %p, ptr %q) #0 {
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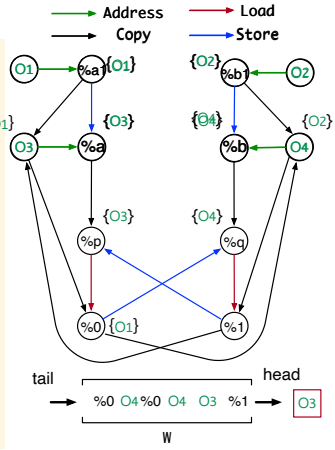
  %0 = load ptr, ptr %p, align 8
  %1 = load ptr, ptr %q, align 8
  store ptr %1, ptr %p, align 8
  store ptr %0, ptr %q, align 8
  ret void
}
```

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Andersen's Pointer Analysis

Algorithm

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  %b = alloca ptr, align 8          // O4
  store ptr %a1, ptr %a, align 8
  store ptr %b1, ptr %b, align 8
  call void @swap(ptr %a, ptr %b)
  ret i32 0
}

define void @swap(ptr %p, ptr %q) #0 {
entry:
  %0 = load ptr, ptr %p, align 8
  %1 = load ptr, ptr %q, align 8
  store ptr %1, ptr %p, align 8
  store ptr %0, ptr %q, align 8
  ret void
}
```

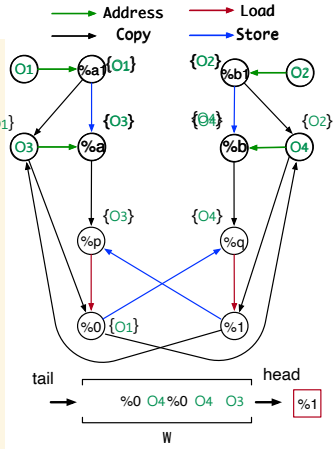


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Andersen's Pointer Analysis

Algorithm

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  %a1 = alloca i8, align 1          // O1
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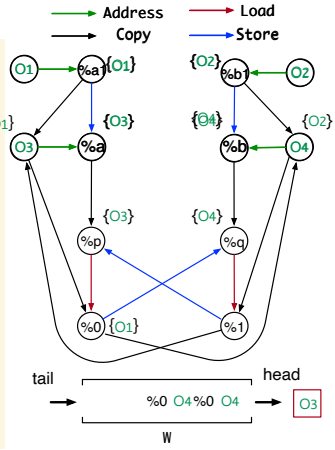
  %b1 = alloca i8, align 1          // O3
  %b = alloca ptr, align 8          // O4
  store ptr %a1, ptr %a, align 8
  store ptr %b1, ptr %b, align 8
  call void @swap(ptr %a, ptr %b)
  ret i32 0
}

define void @swap(ptr %p, ptr %q) #0 {
entry:
  %0 = load ptr, ptr %p, align 8
  %1 = load ptr, ptr %q, align 8
  store ptr %1, ptr %p, align 8
  store ptr %0, ptr %q, align 8
  ret void
}
```

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Andersen's Pointer Analysis

Algorithm

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  store ptr %a1, ptr %a, align 8
  store ptr %b1, ptr %b, align 8
  call void @swap(ptr %a, ptr %b)
  ret i32 0
}

define void @swap(ptr %p, ptr %q) #0 {
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  %0 = load ptr, ptr %p, align 8
  %1 = load ptr, ptr %q, align 8
  store ptr %1, ptr %p, align 8
  store ptr %0, ptr %q, align 8
  ret void
}
```

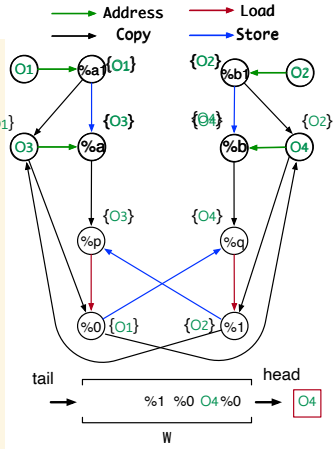


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Andersen's Pointer Analysis

Algorithm

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  store ptr %a1, ptr %a, align 8
  store ptr %b1, ptr %b, align 8
  call void @swap(ptr %a, ptr %b)
  ret i32 0
}

define void @swap(ptr %p, ptr %q) #0 {
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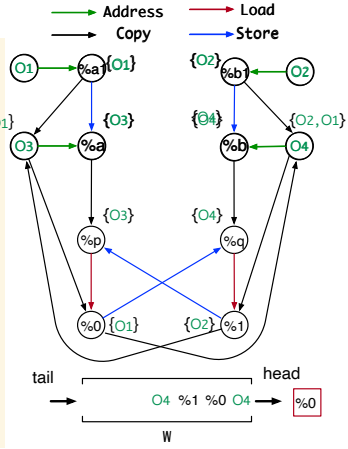
  store ptr %1, ptr %p, align 8
  store ptr %0, ptr %q, align 8
  ret void
}
```

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Andersen's Pointer Analysis

Algorithm

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  store ptr %b1, ptr %b, align 8
  call void @swap(ptr %a, ptr %b)
  ret i32 0
}

define void @swap(ptr %p, ptr %q) #0 {
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  %0 = load ptr, ptr %p, align 8
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  store ptr %1, ptr %p, align 8
  store ptr %0, ptr %q, align 8
  ret void
}
```

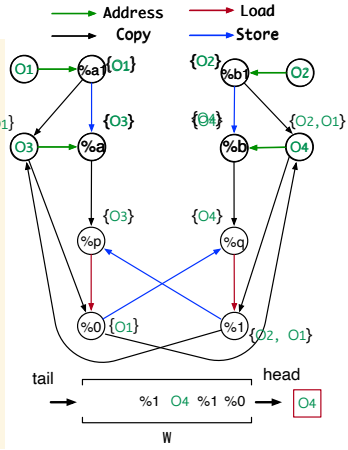


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Andersen's Pointer Analysis

Algorithm

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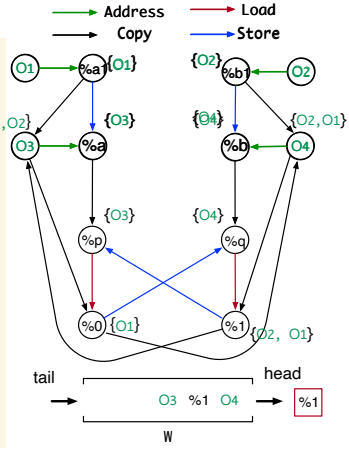
  store ptr %a1, ptr %a, align 8
  store ptr %b1, ptr %b, align 8
  call void @swap(ptr %a, ptr %b)
  ret i32 0
}

define void @swap(ptr %p, ptr %q) #0 {
entry:
  %0 = load ptr, ptr %p, align 8
  %1 = load ptr, ptr %q, align 8
  store ptr %1, ptr %p, align 8
  store ptr %0, ptr %q, align 8
  ret void
}
```

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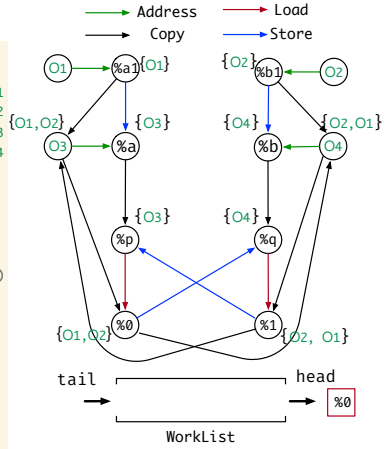
Andersen's Pointer Analysis

Algorithm

```
define i32 @main() #0 {
entry:
%a1 = alloca i8, align 1        // O1
%b1 = alloca i8, align 1        // O2
%a = alloca i8*, align 8        // O3
%b = alloca i8*, align 8        // O4
store i8* %a1, i8** %a, align 8
store i8* %b1, i8** %b, align 8
call void @swap(i8** %a, i8** %b)
ret i32 0
}
define void @swap(i8** %p, i8** %q)
#0 {
entry:
%0 = load i8** %p, align 8
%1 = load i8** %q, align 8
store i8* %1, i8** %p, align 8
store i8* %0, i8** %q, align 8
ret void
}
```

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```
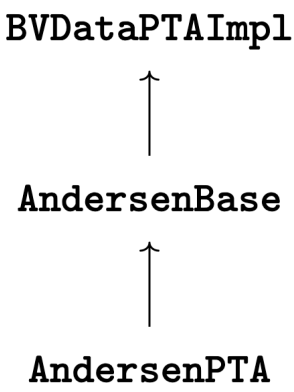

Assignment Structure

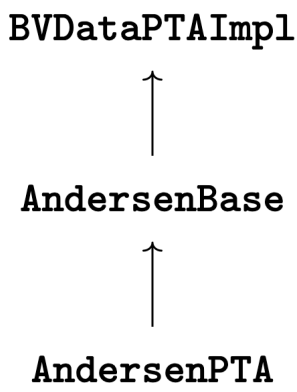
- You will be working on `AndersenPTA`'s `solveWorklist` method.

Assignment Structure



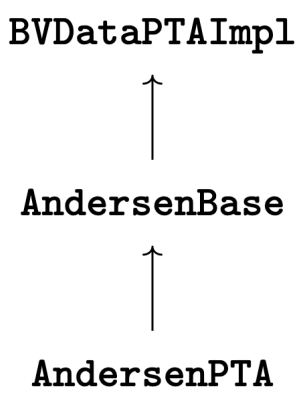
- You will be working on `AndersenPTA`'s `solveWorklist` method.
- Constraint graph is the field `consCG`.

Assignment Structure



- You will be working on `AndersenPTA`'s `solveWorklist` method.
- Constraint graph is the field `consCG`.
- Address edge processing is done for you.

Assignment Structure



- You will be working on `AndersenPTA`'s `solveWorklist` method.
- Constraint graph is the field `consCG`.
- Address edge processing is done for you.
- Note in the API there is a `getDirectInEdges`/`getDirectOutEdges` but no `getCopyIn/OutEdges`. This is intentional, use the `Direct` variant.
- You will reuse this assignment for assignment 4, make sure it is clean. :)