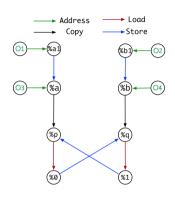
Assignment 3

Yulei Sui

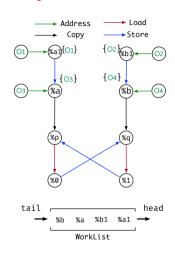
University of Technology Sydney, Australia

```
define i32 @main() #0 {
entry:
%a1 = alloca i8, alian 1
                               // 01
%b1 = alloca i8, alian 1
                               // O2
%a = alloca i8*, alian 8
                               // O3
%b = alloca i8*, alian 8
                               // 04
store i8* %a1, i8** %a, alian 8
store i8* %b1, i8** %b, alian 8
call void @swap(i8** %a, i8** %b)
ret i32 0
define void @swap(i8** %p, i8** %a)
#0 {
entry:
\%0 = load i8** \%p, alian 8
%1 = load i8** %a, alian 8
store i8* %1, i8** %p, alian 8
store i8* %0. i8** %a. alian 8
ret void
```



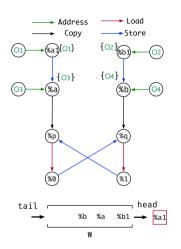
```
G = < V.E > // Constraint Graph
  V: a set of nodes in graph
   E: a set of edges in graph
  WorkList: a vector of nodes
  foreach address p = &o do // Address rule
        nts(p) = \{0\}
        pushIntoWorklist(p)
  while WorkList ≠ Ø do
      p ← popFromWorklist()
      foreach o E pts(p) do
         foreach store *p = q do// Store rule
             if a→o ∉ E then
                E \leftarrow E \cup \{q \rightarrow o\} // Add copy edge
                pushIntoWorklist(q)
10
         foreach load r = *p do // load rule
11
             if o→r ∉ F then
12
                E \leftarrow E \cup \{o \rightarrow r\} // Add copy edge
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                pushIntoWorklist(o)
14
      foreach p \rightarrow x \in E do
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                                    // Copy rule
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          pts(x) \leftarrow pts(x) \cup pts(p)
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call void @swap(i8** %a, i8** %b)
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define void @swap(i8** %p, i8** %a)
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\%0 = load i8** \%p, alian 8
%1 = load i8** %a, alian 8
store i8* %1, i8** %p, alian 8
store i8* %0. i8** %a. alian 8
ret void
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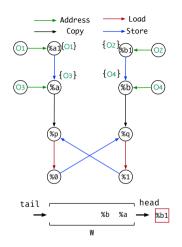
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ret i32 0
define void @swap(i8** %p, i8** %a)
#0 S
entry:
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store i8* %1, i8** %p, alian 8
store i8* %0. i8** %a. alian 8
ret void
```



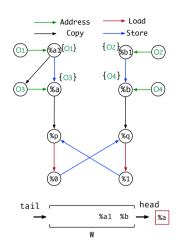
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store i8* %0. i8** %a. alian 8
ret void
```



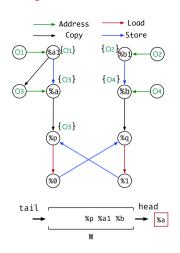
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store i8* %1, i8** %p, alian 8
store i8* %0. i8** %a. alian 8
ret void
```



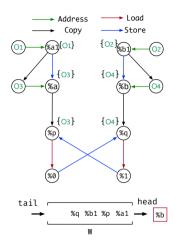
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store i8* %0. i8** %a. alian 8
ret void
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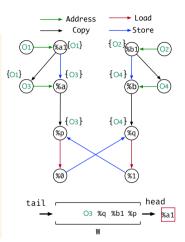
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ret i32 0
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#0 S
entry:
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store i8* %1, i8** %p, alian 8
store i8* %0. i8** %a. alian 8
ret void
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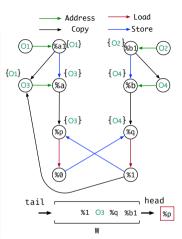
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call void @swap(i8** %a, i8** %b)
ret i32 0
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#0 S
entry:
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%1 = load i8** %a, alian 8
store i8* %1, i8** %p, alian 8
store i8* %0. i8** %a. alian 8
ret void
```



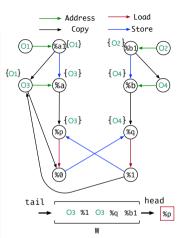
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                               // 04
store i8* %a1, i8** %a, alian 8
store i8* %b1, i8** %b, alian 8
call void @swap(i8** %a, i8** %b)
ret i32 0
define void @swap(i8** %p, i8** %a)
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entry:
\%0 = load i8** \%p, alian 8
%1 = load i8** %a, alian 8
store i8* %1, i8** %p, alian 8
store i8* %0. i8** %a. alian 8
ret void
```



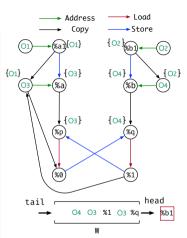
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store i8* %a1, i8** %a, alian 8
store i8* %b1, i8** %b, alian 8
call void @swap(i8** %a, i8** %b)
ret i32 0
define void @swap(i8** %p, i8** %a)
#0 S
entry:
\%0 = load i8** \%p, alian 8
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store i8* %0. i8** %a. alian 8
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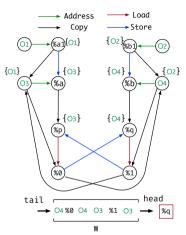
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store i8* %1, i8** %p, alian 8
store i8* %0. i8** %a. alian 8
ret void
```



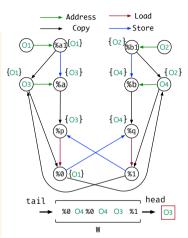
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ret i32 0
define void @swap(i8** %p, i8** %a)
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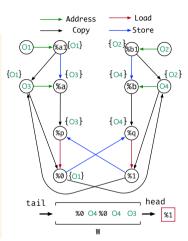
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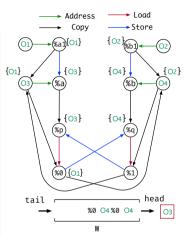
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  WorkList: a vector of nodes
  foreach address p = &o do // Address rule
        pts(p) = \{o\}
        pushIntoWorklist(p)
  while WorkList ≠ Ø do
      p ← popFromWorklist()
      foreach o E pts(p) do
         foreach store *p = q do// Store rule
             if a→o ∉ E then
                E \leftarrow E \cup \{q \rightarrow o\} // Add copy edge
                pushIntoWorklist(q)
10
         foreach load r = *p do // load rule
11
             if o→r ∉ F then
12
                E \leftarrow E \cup \{o \rightarrow r\} // Add copy edge
13
                pushIntoWorklist(o)
14
15
      foreach p \rightarrow x \in E do
                                    // Copy rule
16
          pts(x) \leftarrow pts(x) \cup pts(p)
          if pts(x) changed then
17
                 pushIntoWorklist(x)
18
```

```
define i32 @main() #0 {
entry:
%a1 = alloca i8, alian 1
                               // 01
%b1 = alloca i8, alian 1
                               // O2
%a = alloca i8*, alian 8
%b = alloca i8*, alian 8
                               // 04
store i8* %a1, i8** %a, alian 8
store i8* %b1, i8** %b, alian 8
call void @swap(i8** %a, i8** %b)
ret i32 0
define void @swap(i8** %p, i8** %a)
#0 {
entry:
\%0 = load i8** \%p, alian 8
%1 = load i8** %a, alian 8
store i8* %1, i8** %p, alian 8
store i8* %0. i8** %a. alian 8
ret void
```



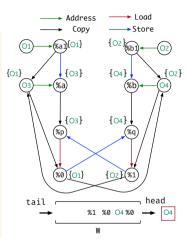
```
G = < V.E > // Constraint Graph
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                               // 01
%b1 = alloca i8, alian 1
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%a = alloca i8*, alian 8
%b = alloca i8*, alian 8
                               // 04
store i8* %a1, i8** %a, alian 8
store i8* %b1, i8** %b, alian 8
call void @swap(i8** %a, i8** %b)
ret i32 0
define void @swap(i8** %p, i8** %a)
#0 {
entry:
\%0 = load i8** \%p, alian 8
%1 = load i8** %a, alian 8
store i8* %1, i8** %p, alian 8
store i8* %0. i8** %a. alian 8
ret void
```



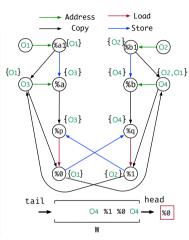
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      foreach p \rightarrow x \in E do
                                    // Copy rule
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          if pts(x) changed then
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```

```
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entry:
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                               // O2
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%b = alloca i8*, alian 8
                               // 04
store i8* %a1, i8** %a, alian 8
store i8* %b1, i8** %b, alian 8
call void @swap(i8** %a, i8** %b)
ret i32 0
define void @swap(i8** %p, i8** %a)
#0 {
entry:
\%0 = load i8** \%p, alian 8
%1 = load i8** %a, alian 8
store i8* %1, i8** %p, alian 8
store i8* %0. i8** %a. alian 8
ret void
```



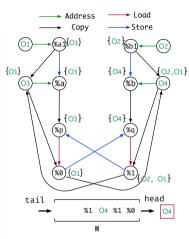
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        pushIntoWorklist(p)
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      p ← popFromWorklist()
      foreach o E pts(p) do
         foreach store *p = q do// Store rule
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                pushIntoWorklist(q)
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                E \leftarrow E \cup \{o \rightarrow r\} // Add copy edge
13
                pushIntoWorklist(o)
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                                    // Copy rule
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%b1 = alloca i8, alian 1
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%b = alloca i8*, alian 8
                               // 04
store i8* %a1, i8** %a, alian 8
store i8* %b1, i8** %b, alian 8
call void @swap(i8** %a, i8** %b)
ret i32 0
define void @swap(i8** %p, i8** %a)
#0 {
entry:
\%0 = load i8** \%p, alian 8
%1 = load i8** %a, alian 8
store i8* %1, i8** %p, alian 8
store i8* %0. i8** %a. alian 8
ret void
```



```
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  V: a set of nodes in graph
   E: a set of edges in graph
  WorkList: a vector of nodes
  foreach address p = &o do // Address rule
        nts(p) = \{0\}
        pushIntoWorklist(p)
  while WorkList ≠ Ø do
      p ← popFromWorklist()
      foreach o E pts(p) do
         foreach store *p = q do// Store rule
             if a→o ∉ E then
                E \leftarrow E \cup \{q \rightarrow o\} // Add copy edge
                pushIntoWorklist(q)
10
         foreach load r = *p do // load rule
11
             if o→r ∉ F then
12
                E \leftarrow E \cup \{o \rightarrow r\} // Add copy edge
13
                pushIntoWorklist(o)
14
15
      foreach p \rightarrow x \in E do
                                     // Copy rule
16
          pts(x) \leftarrow pts(x) \cup pts(p)
          if pts(x) changed then
17
                 pushIntoWorklist(x)
18
```

```
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                               // 01
%b1 = alloca i8, alian 1
                               // O2
%a = alloca i8*, alian 8
%b = alloca i8*, alian 8
                               // 04
store i8* %a1, i8** %a, alian 8
store i8* %b1, i8** %b, alian 8
call void @swap(i8** %a, i8** %b)
ret i32 0
define void @swap(i8** %p, i8** %a)
#0 {
entry:
\%0 = load i8** \%p, alian 8
%1 = load i8** %a, alian 8
store i8* %1, i8** %p, alian 8
store i8* %0. i8** %a. alian 8
ret void
```



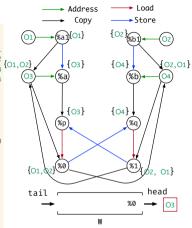
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         foreach store *p = q do// Store rule
             if a→o ∉ E then
                E \leftarrow E \cup \{q \rightarrow o\} // Add copy edge
                pushIntoWorklist(q)
10
         foreach load r = *p do // load rule
11
             if o→r ∉ F then
12
                E \leftarrow E \cup \{o \rightarrow r\} // Add copy edge
13
                pushIntoWorklist(o)
14
      foreach p \rightarrow x \in E do
                                     // Copy rule
16
          pts(x) \leftarrow pts(x) \cup pts(p)
          if pts(x) changed then
17
                 pushIntoWorklist(x)
18
```

```
define i32 @main() #0 {
entry:
%a1 = alloca i8, alian 1
                               // 01
                               // 02
%b1 = alloca i8, alian 1
%a = alloca i8*, alian 8
                               // 03
%b = alloca i8*, alian 8
                               // 04
store i8* %a1, i8** %a, alian 8
store i8* %b1, i8** %b, alian 8
call void @swap(i8** %a, i8** %b)
ret i32 0
define void @swap(i8** %p, i8** %a)
#0 S
entry:
\%0 = load i8** \%p, alian 8
%1 = load i8** %a, alian 8
store i8* %1, i8** %p, alian 8
store i8* %0. i8** %a. alian 8
ret void
```

```
Address
                               Load
                 Copy
                              → Store
                          {O2}
             (%a){O1}
    (01)
{01,02}
              {03}
                           {04}
                                       {02,01}
               {03}
                           {04}
             %p
             (%0)<sup>*</sup>{O1}
      tail
                                    head
                       O3 %1 O4
                        W
```

```
G = < V.E > // Constraint Graph
  V: a set of nodes in graph
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      p ← popFromWorklist()
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         foreach load r = *p do // load rule
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                E \leftarrow E \cup \{o \rightarrow r\} // Add copy edge
13
                pushIntoWorklist(o)
14
15
      foreach p \rightarrow x \in E do
                                     // Copy rule
16
          pts(x) \leftarrow pts(x) \cup pts(p)
          if pts(x) changed then
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```

```
define i32 @main() #0 {
entry:
%a1 = alloca i8, alian 1
                               // 01
                               // 02
%b1 = alloca i8, alian 1
%a = alloca i8*, alian 8
                               // 03
%b = alloca i8*, alian 8
                               // 04
store i8* %a1, i8** %a, alian 8
store i8* %b1, i8** %b, alian 8
call void @swap(i8** %a, i8** %b)
ret i32 0
define void @swap(i8** %p, i8** %a)
#0 S
entry:
\%0 = load i8** \%p, alian 8
%1 = load i8** %a, alian 8
store i8* %1, i8** %p, alian 8
store i8* %0. i8** %a. alian 8
ret void
```



```
G = < V.E > // Constraint Graph
  V: a set of nodes in graph
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                E \leftarrow E \cup \{o \rightarrow r\} // Add copy edge
13
                pushIntoWorklist(o)
      foreach p \rightarrow x \in E do
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entry:
%a1 = alloca i8, alian 1
                               // 01
                               // 02
%b1 = alloca i8, alian 1
%a = alloca i8*, alian 8
                               // 03
%b = alloca i8*, alian 8
                               // 04
store i8* %a1, i8** %a, alian 8
store i8* %b1, i8** %b, alian 8
call void @swap(i8** %a, i8** %b)
ret i32 0
define void @swap(i8** %p, i8** %a)
#0 {
entry:
\%0 = load i8** \%p, alian 8
%1 = load i8** %a, alian 8
store i8* %1, i8** %p, alian 8
store i8* %0. i8** %a. alian 8
ret void
```

```
Address
                             Load
                Copy
                            → Store
                        {O2}
            (%a){O1}
    (01)
{01,02}
             {03}
                        {04}
                                    {02,01}
                        {04}
              {03}
            %p
    {01,621(%0)
     tail
                                 head
                  Worklist
```

```
G = < V.E > // Constraint Graph
  V: a set of nodes in graph
   E: a set of edges in graph
  WorkList: a vector of nodes
  foreach address p = &o do // Address rule
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