Tour of common optimizations

Simple example

```
foo(z) {
                 9
    x := 3 + 6;
         9
    y := x - 5   4

    return z * y 4
           2 << 2
}
```

Simple example

```
foo(z) {

    x := ~~3 + 6~~; 9             Constant folding (CF)
Const prop (CP)  9
    y := ~~x - 5~~   4 (CF)

    return ~~z * y~~  4 (CP)
                z << 2
}
```

Strength reduction

Arith simpl

Another example

```
x := a + b;

...

      x
y := ~~a + b~~;
```

Another example

```
x := a + b;

...

y := ~~a + b~~; x
```

only if x, a, b not modified!

Another example

```
if (...) {
    a := read(); ←
    x := a + b;
    y := x
    print(x);
} else {y := a + b
                  }
...print(y)

y := a + b;
```

Another example

```
if (...) {
    a := read();t := a + b
    x := ~~a + b~~;t
    print(x);
} else { t := a + b }

...

y := ~~a + b~~;t
```

Partial Redundancy Elimination PRE

Another example

```
x := y
...
z := z + ~~x~~ y
```

Another example

x := y

...

z := z + ~~x~~ y

} x,y not modified

copy prop

Another example

V = E

```
x := y
. . .
z := z + y
```

~~y~~ x

E

What if we run CSE now?

V = E

⋮

... E ...

Another example

x := y

. . .

z := z + ~~y~~ x

What if we run CSE now?

Another example

~~`x := y**z`~~

`...`

`x := ...`

Another example

~~x := y**z~~

. . .

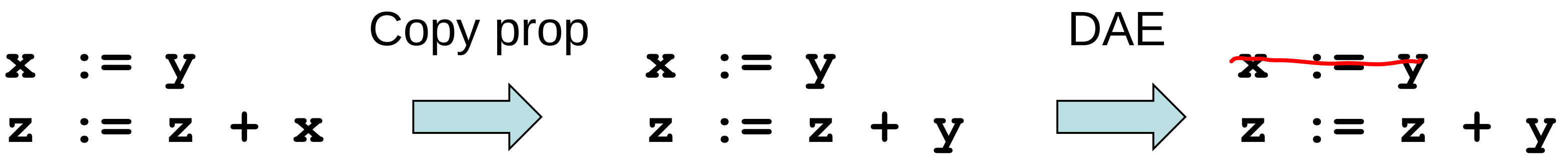
x := . . .

if x is not used

dead assignment elim

(unused assignment elim)

- Often used as a clean-up pass



x := y
z := z + x

Copy prop

x := y
z := z + y

DAE

~~x := y~~
z := z + y

Another example

```
if (false) {
   ...
}
```

Another example

```
if (false) {

    ...

}
```

dead code elim
(unreachable code elim)

Another common clean up opt

Another example

- In Java:

```
a = new int [10];
for (index = 0; index < 10; index ++) {
   a[index] = 100;
}
```

Another example

- In “lowered” Java:

```
      a = new int [10]; a.length = 10
      for (index = 0; index < 10; index ++) {
ind ∈ [0..9] ← if (index < 0 || index >= a.length()) {
            throw OutOfBoundsException; 10
         }
         a[index] = 0;
      }
```

Another example

- In “lowered” Java:

```
a = new int [10];
for (index = 0; index < 10; index ++) {
   if (index < 0 || index >= a.length()) {
      throw OutOfBoundsException;
   }
   a[index] = 0;
}
```

①

10 ← Kinda like CP if we assume stmt ① acts like a.length := 10

Branch folding + unreachable code elim

index ∈ [0..9] ← Range analysis

Another example

```
p := &x;
*p := 5
y := x + 1;
```

Another example

`p := &x;`
X `*p := 5`
`y :=` ~~`x + 1;`~~ 6
5

pointer / alias analysis

```
x := 5;
*p := 3
y := x + 1;
```

⇨ ???

Another example

```
for j := 1 to N
    for i := 1 to M
        a[i] := a[i] + b[j]
```

Another example

```
for j := 1 to N            t := b[j]
    for i := 1 to M
        a[i] := a[i] + ~~b[j]~~ t
```

Loop invariant

Code motion

Another example

```
area(h,w) { return h * w }

h := ...;
w := 4;
a := ~~area~~(h,w)
     h*w
```

Another example

```
area(h,w) { return h * w }

h := ...;
w := 4;
a := ~~area(h,w)~~
       ~~h * w~~
        ~~h * 4~~
         h << 2
```

Many "silly" opts become important after inlining

Optimization themes

- Don’t compute if you don’t have to
  - unused assignment elimination
- Compute at compile-time if possible
  - constant folding, loop unrolling, inlining
- Compute it as few times as possible
  - CSE, PRE, PDE, loop invariant code motion
- Compute it as cheaply as possible
  - strength reduction
- Enable other optimizations
  - constant and copy prop, pointer analysis
- Compute it with as little code space as possible
  - unreachable code elimination