

Tour of common optimizations

How excited are you about this course?

- A. Super excited
- B. A little excited
- C. Not that excited
- D. Not at all excited

How nervous are you about this course?

- A. Super nervous
- B. A little nervous
- C. Not that nervous
- D. Not at all nervous

What is your primary reason for 231?

- A. I'm doing research and compilers and related areas, so I want to learn about compilers
- B. I'm not doing research in this area, but still want to learn about compilers
- C. A friend recommended it
- D. I want to only take AI and Machine learning courses, but the program requires me to take other classes too, so here I am. Ugh
- E. Other

Simple example

```
foo(z) {  
    x := 3 + 6;  
    y := x - 5  
    return z * y  
}
```

Simple example

```
foo(z) {
```

```
  x := 3 + 6; 9
```

constant folding (CF)

const prop (CP)

```
  y := x - 5 4 (CF)
```

```
  return z * y 4 (CP)
```

$z \ll 2$



Strength reduction

Arith
simpl

Another example

x := a + b;

...

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;  
    print(x);  
}
```

...

```
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

Another example

x := y

...

z := z + ~~x~~ y

} x, y not modified
copy prop

Another example

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

What if we run CSE now?

Another example

x := **y**

...

z := **z** + ~~**y**~~ **X**

What if we run CSE now?

Another example

x := yz**

...

x := ...

Another example

~~$x := y * z$~~

...

$x := \dots$

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

Another example

- In “lowered” Java:

```
a = new int [10]; ①
for (index = 0; index < 10; index ++) {
  if (index < 0 || index >= a.length()) {
    throw OutOfBoundsException;
  }
  a[index] = 0;
}
```

Branch folding
+ unreachable
code elim

$index \in [0..9]$ ← Range analysis

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


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

t := b[j]

*Loop invariant
Code motion*

Another example

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

```
h := ...;
```

```
w := 4;
```

```
a := area(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