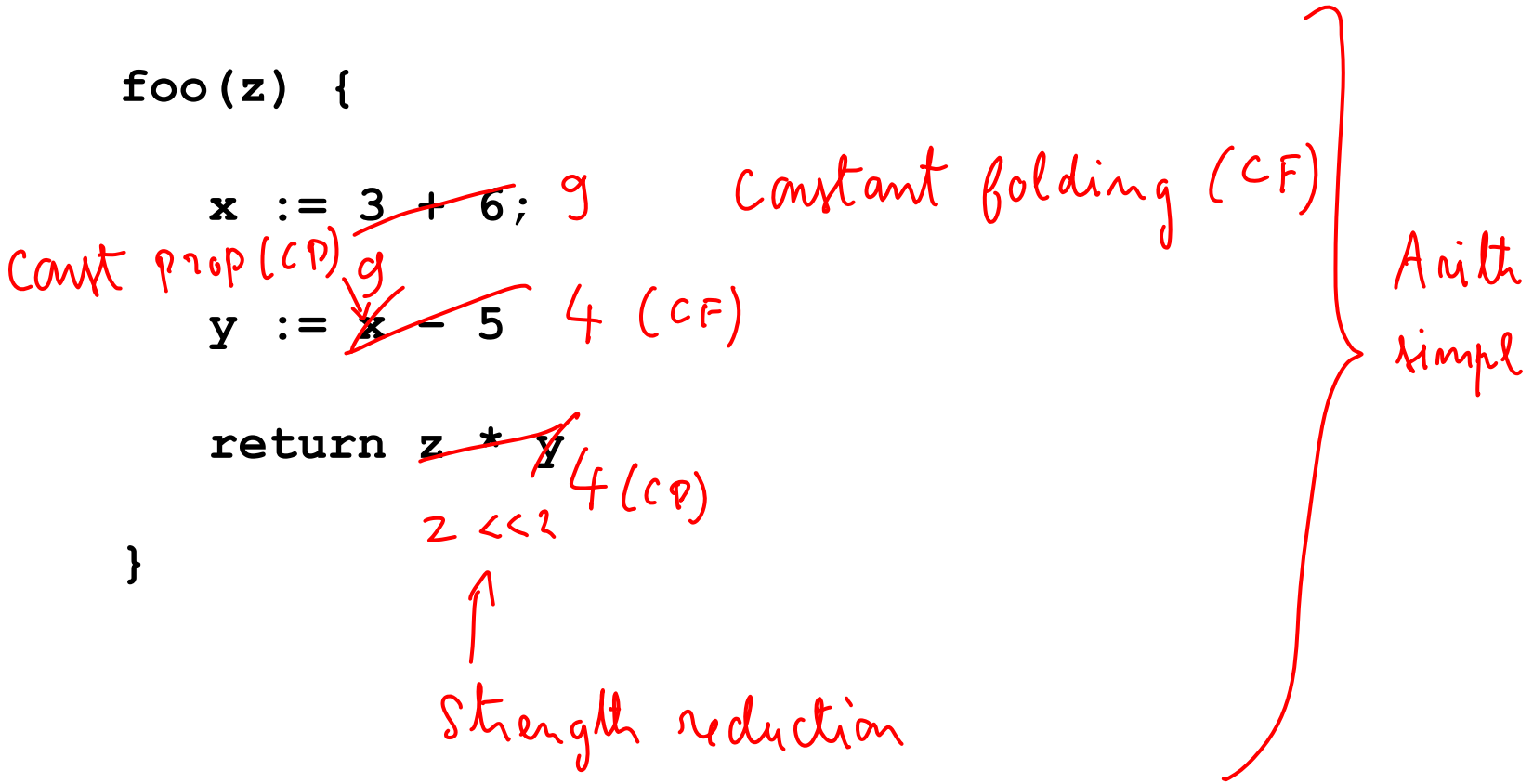
Tour of common optimizations

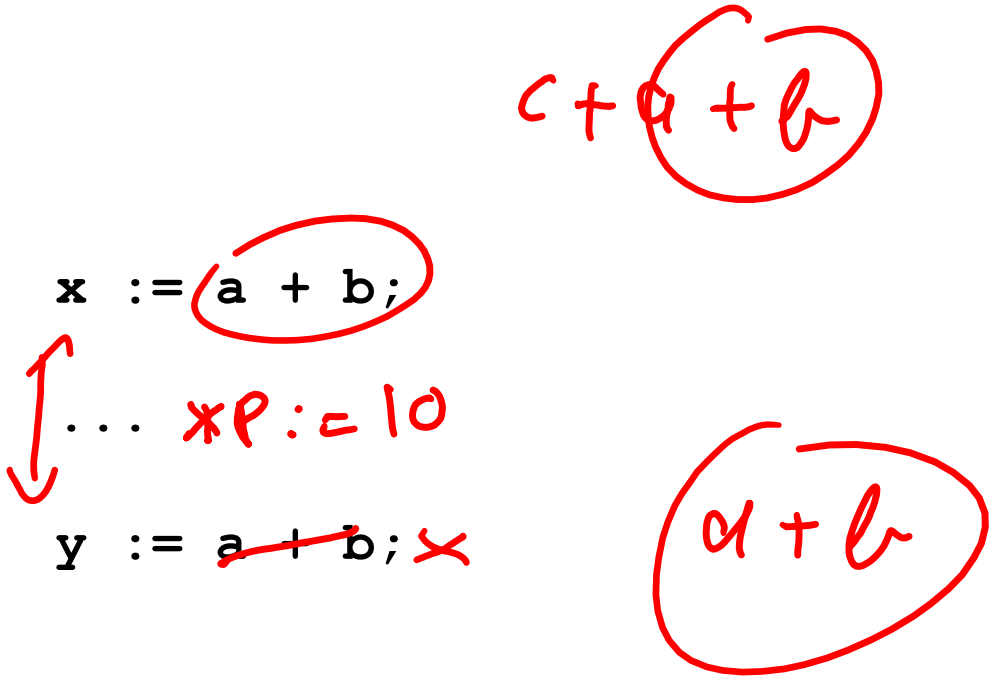
Simple example

```
foo(z) {

    x := 3 + 6;

    y := x - 5

    return z * y

}
```

Simple example



Another example



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);
} else {
}
...

y := a + b;
```

t := a + b

t := a + b

t

Another example

```
a = read()
...

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

...

y := a + b;

...
```

Partial Redundancy Elimination PRE

Another example

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

Another example

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

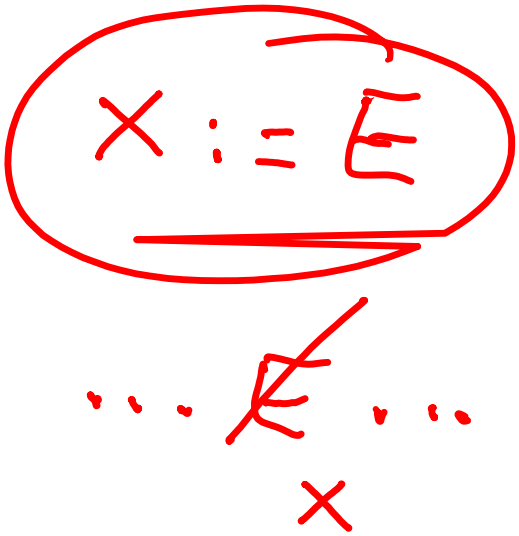
} x, y not modified

copy prop

Another example

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

What if we run CSE now?



Another example

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

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

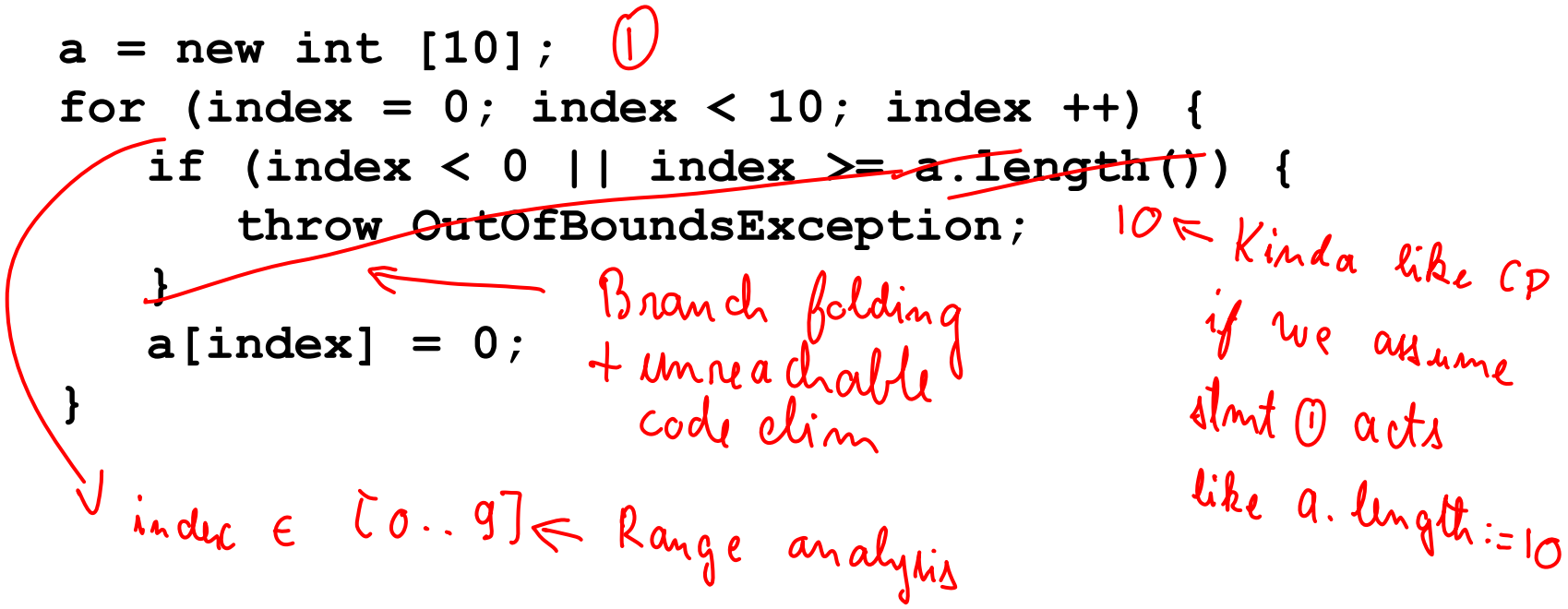
- In “lowered” Java:

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



Another example

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

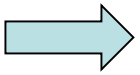
x = 5

Another example

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

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 := b[j]

t

Loop invariant code motion

Another example

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

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

h * w 4

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