Compiler Optimisation

4-from-ssa – Conversion from SSA (addendum)

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Introduction

Things to watch out for when converting from SSA.

- Effect of optimisation
- Critical edges
- Lost copy problem
- Swap problem

Effect of Optimisation

Optimisations can prevent conversion by just merging variables

Example

```
a = x + y
```

```
b = x + y
```

```
a = 17
```

```
c = x + y
```

Just a basic block

Effect of Optimisation

Optimisations can prevent conversion by just merging variables

Example

$a_0 = x_0 + y_0$

$b_0 = x_0 + y_0$

$a_1 = 17$

$c_0 = x_0 + y_0$

Convert to SSA.

Note that b_0 and c_0 are copies of a_0

Effect of Optimisation

Optimisations can prevent conversion by just merging variables

Example

$a_0 = x_0 + y_0$

$b_0 = a_0$

$a_1 = 17$

$c_0 = a_0$

Optimise the redundant expressions. What will happen if we merge variables now?

Effect of Optimisation

Optimisations can prevent conversion by just merging variables

Example

```
a = x + y
b = a
a = 17
c = a    (x+y)
```

If we merge a_0 and a_1 back into a, then c gets the wrong value

So, keep variables, use copies in predecessors of ϕ nodes[1]

[1] As in lecture-3.

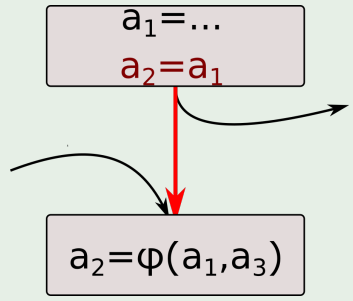
Critical Edges

Copies on predecessors difficult with *critical edges*.

Critical Edge

A CFG edge whose destination has multiple predecessors and whose source has multiple successors.

Example



Source has multiple successors: a copy in the source means all of its successors get the copy. If the copy is live into them then potential semantics change.

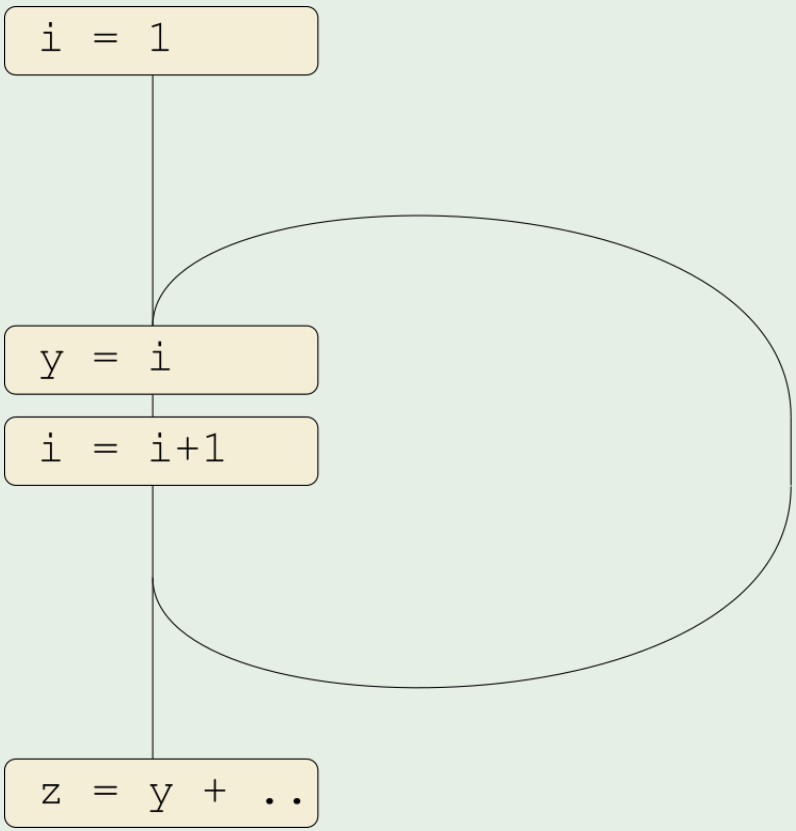
Destination has multiple predecessors: If there was only one, we could put the copy in the destination and probably wouldn't need the phi node anyway

Lost copy problem

- Most SSA algorithms *split* critical edges
- Next example shows necessary splitting to prevent lost copy

Lost copy problem

Example

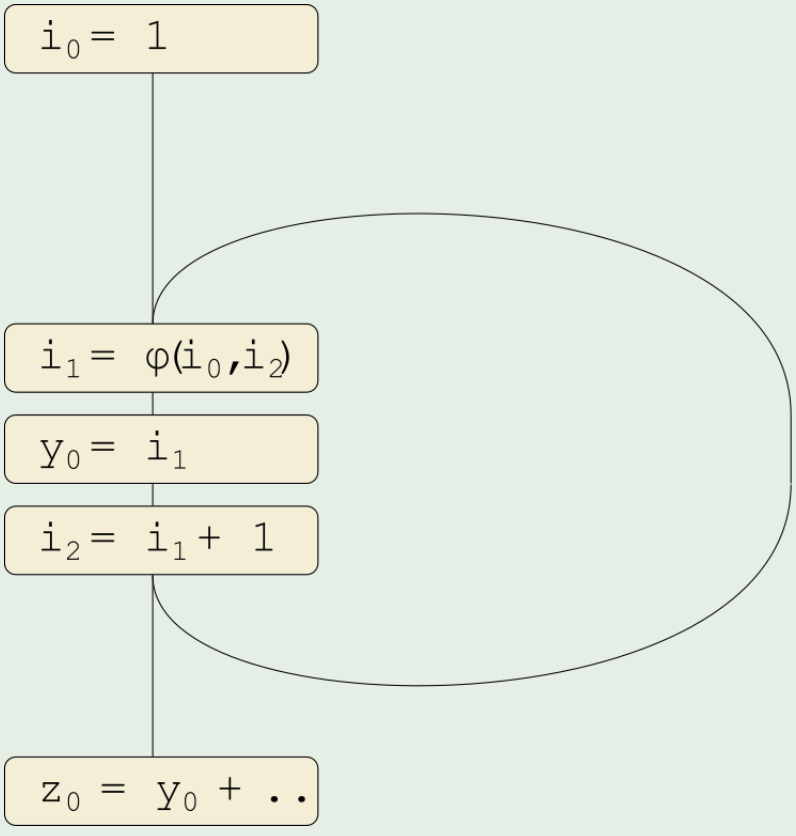


A simple loop

Convert to SSA

Lost copy problem

Example



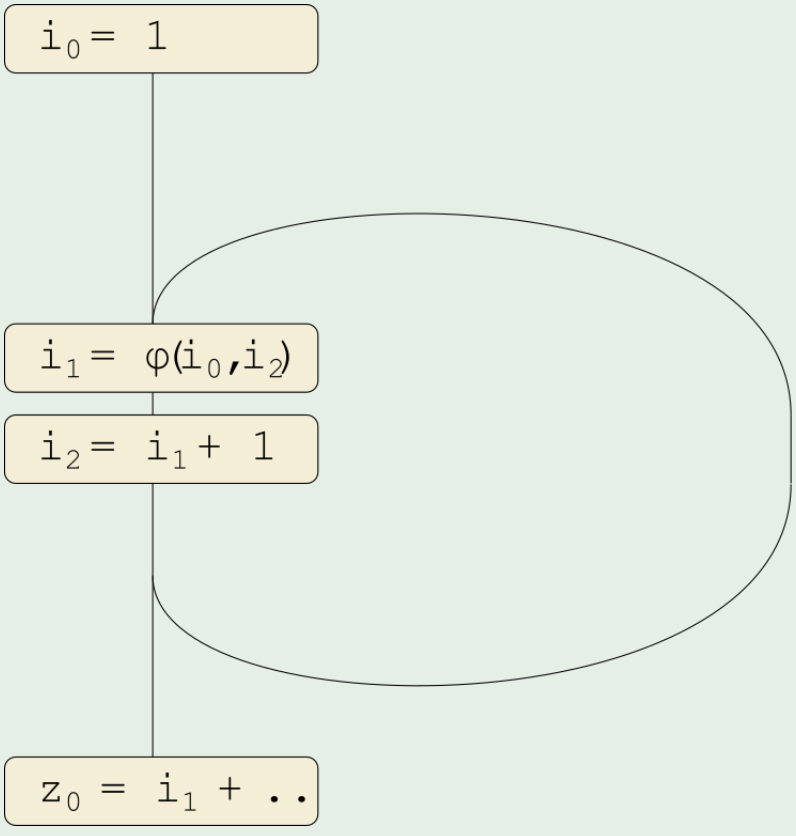
Converted to SSA

y_0 now redundant

Optimisation: *Replace uses with i_1 and remove definition*

Lost copy problem

Example



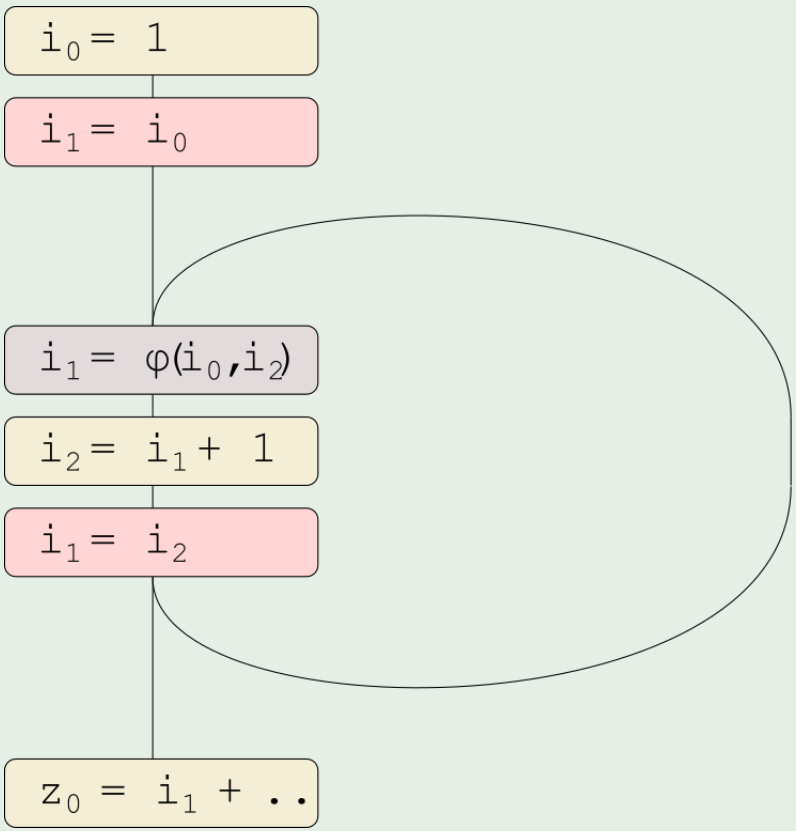
y_0 removed

Try to convert from SSA

Place copies without splitting

Lost copy problem

Example

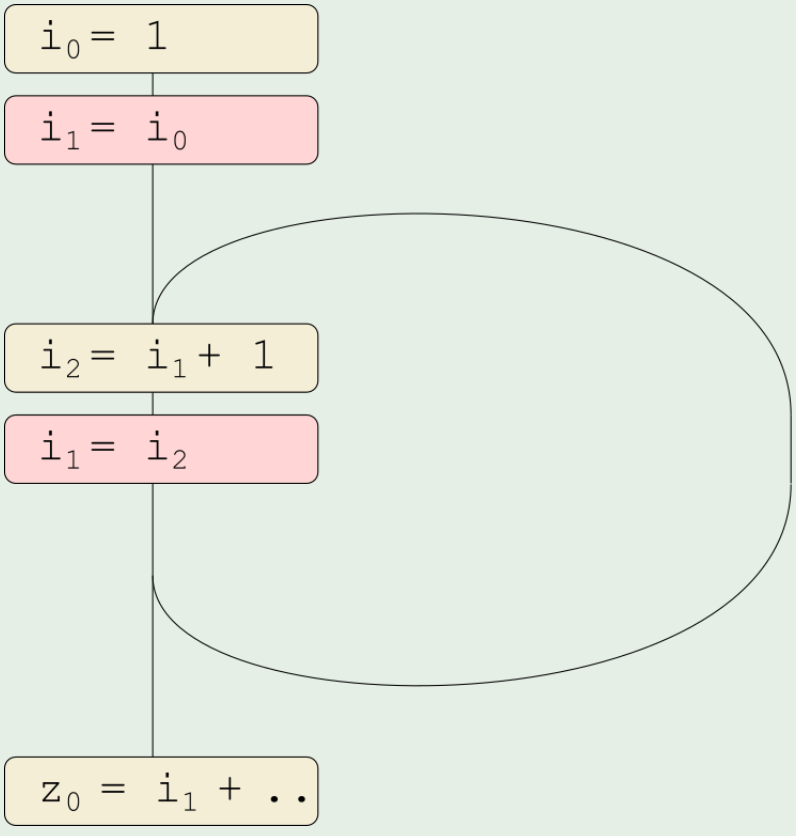


Copies placed

Now remove ϕ

Lost copy problem

Example



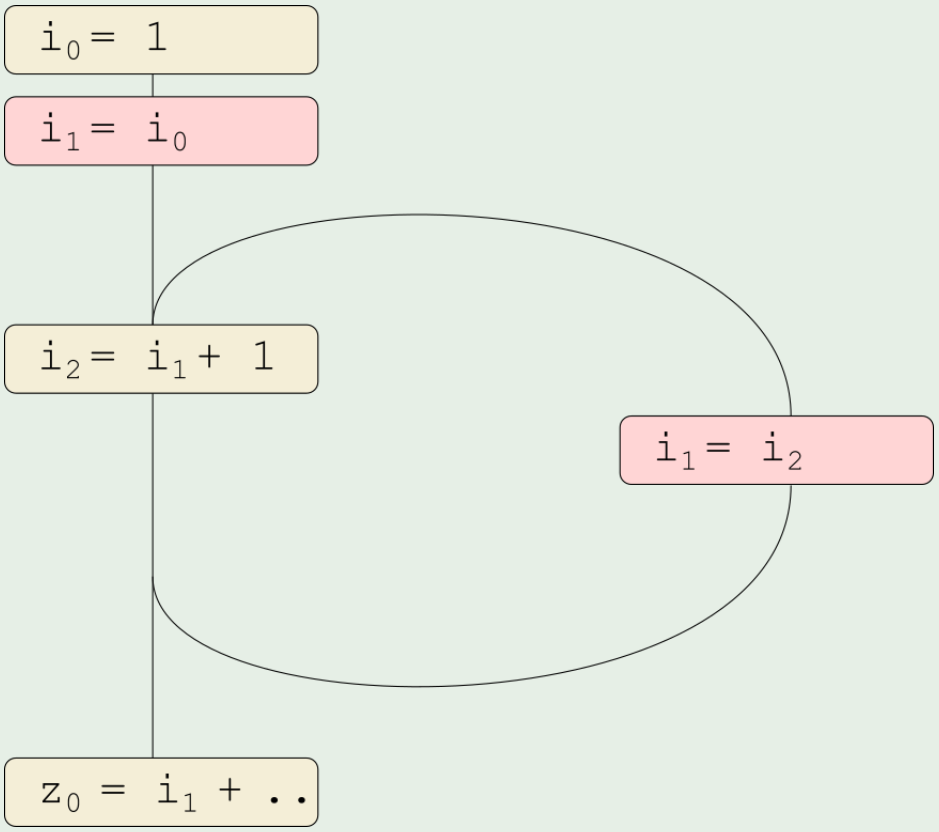
Note: Back edge is **critical** and i_1 is live in to loop exit

Does z_0 use the same version of i_1 as before the copy?

Instead, split loop's back edge

Lost copy problem

Example



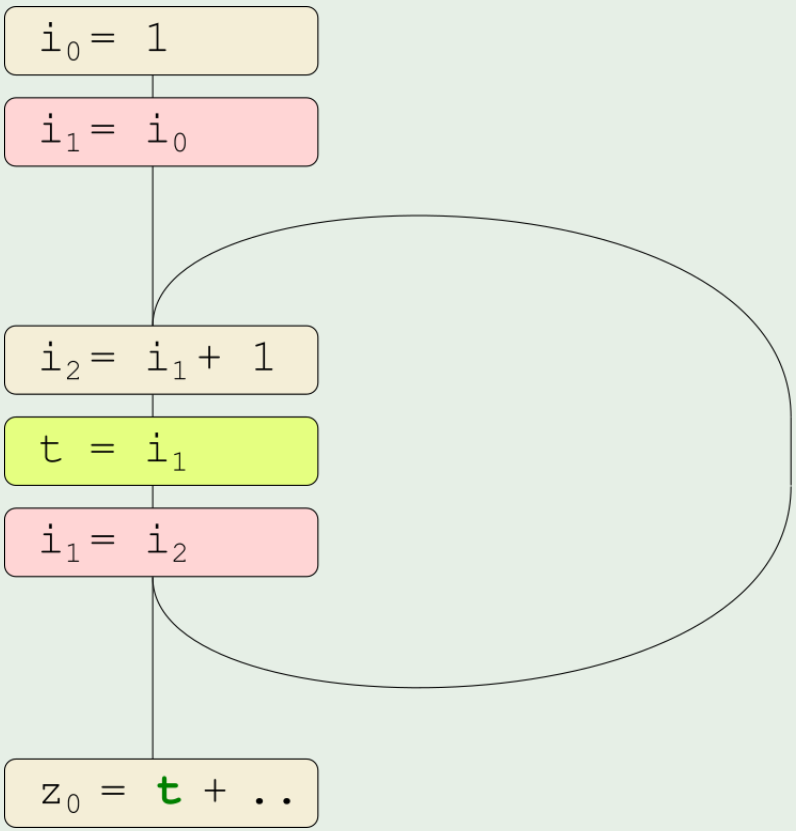
Edge split keeps semantics

Extra jump can be expensive inside hot loops

Instead, use temporaries to remember correct values

Lost copy problem

Example



Extra temporary in place

Swap problem

- ϕ nodes execute simultaneously in parallel
  - i.e. All read their operands at once, before any assignments
- Copies do not
  - Naive conversion with copies can cause incorrect behaviour

Example

Simultaneous phis, swap values	Naive copy, swap lost[2]	Temporary inserted
		$\mathtt{t} = x_1$
$\mathbf{x_1} = \phi(x_0, \mathbf{y_1})$	$x_1 = y_1$	$x_1 = y_1$
$\mathbf{y_1} = \phi(y_0, \mathbf{x_1})$	$y_1 = x_1$	$y_1 = \mathtt{t}$

[2] Assume $x_1 = x_0$, $y_1 = y_0$ placed in another block.

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