

# Parallel Programming

## Dependencies

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**High Performance and  
Automatic Computing**

## On dependencies and parallel execution

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- Two independent instructions can be executed  
“concurrently” = “in parallel” (by different resources)

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Parallel execution: **NO** time ordering!

- When two instructions are executed in parallel, **NO** assumptions about start, duration, end.
- Dependencies  $\Rightarrow$  ordering  
The “right” ordering is dictated by the semantics of the program
- Some dependencies can be removed by duplicating data

# True / Flow dependency

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$\{x = 1, y = 2, a = 3\}$

...

$y := a * x + y$

$w := 3 * y$

...

$\{y = 5, w = 15\}$

## True / Flow dependency

---

```
{x = 1, y = 2, a = 3}
```

```
...
```

```
y := a * x + y
```

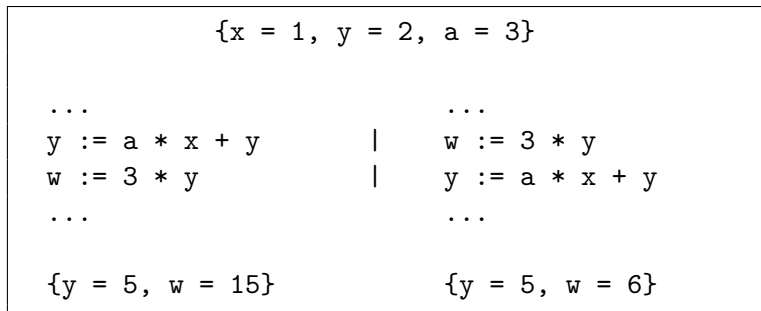
```
w := 3 * y
```

```
...
```

```
{y = 5, w = 15}
```

- The value of `w` depends on the updated value of `y`

# True / Flow dependency



- The value of  $w$  depends on the updated value of  $y$
- The semantics of the program depends on the **order** of the statements



# Anti dependency

---

$\{x = 1, y = 2, a = 3\}$

...

$w := 3 * y$

$y := a * x + y$

...

$\{y = 5, w = 6\}$

- The value of  $w$  depends on the initial value of  $y$

# Anti dependency

$\{x = 1, y = 2, a = 3\}$

...		...
$w := 3 * y$		$y := a * x + y$
$y := a * x + y$		$w := 3 * y$
...		...
$\{y = 5, w = 6\}$		$\{y = 5, w = 15\}$

- The value of  $w$  depends on the initial value of  $y$
- The semantics of the program depends on the **order** of the statements

# Output dependency

---

$\{x = 1, y = 2, a = 3\}$

...

$w := 3 * y$

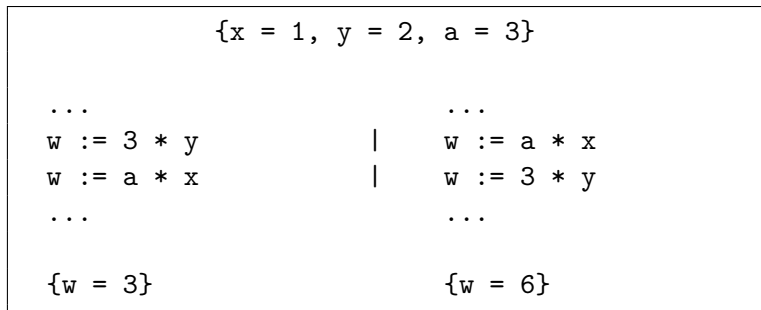
$w := a * x$

...

$\{w = 3\}$

- The value of  $w$  depends on the order of the statements

# Output dependency



- The value of  $w$  depends on the order of the statements
- The semantics of the program depends on the **order** of the statements