STDISCM: Parallel & Distributed Concepts

Fundamental Task of Parallel (Work) Computing

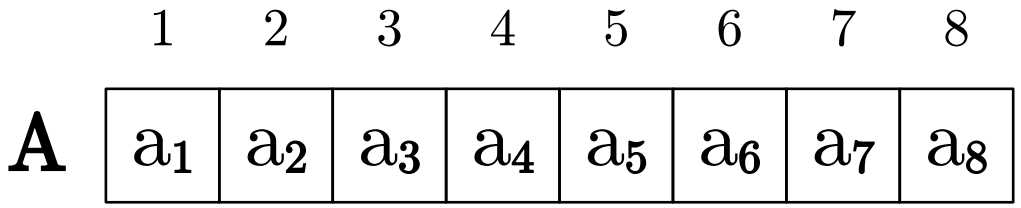
Given additional workers,
how can you make a task quicker?

Given additional computers,
how can you make an algorithm/program quicker?

Given additional processors,
how can you make an algorithm/program quicker?

Example Task 1: Simple Search

Task: Given an array of numbers **A**, determine if the number **x** is in the array.



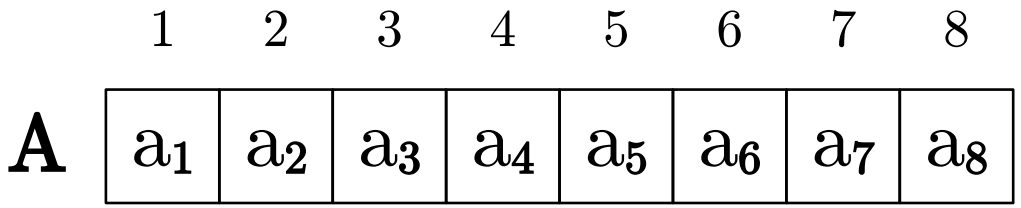
Task:

$a_1 == x?$
$a_2 == x?$
$a_3 == x?$
$a_4 == x?$
$a_5 == x?$
$a_6 == x?$
$a_7 == x?$
$a_8 == x?$

Worst Case: done in 8 steps

Example Task 1: Simple Search

Task: Given an array of numbers **A**, determine if the number **x** is in the array.



Subtask 1:

a_1==x?
a_2==x?
a_3==x?
a_4==x?

Subtask 2:

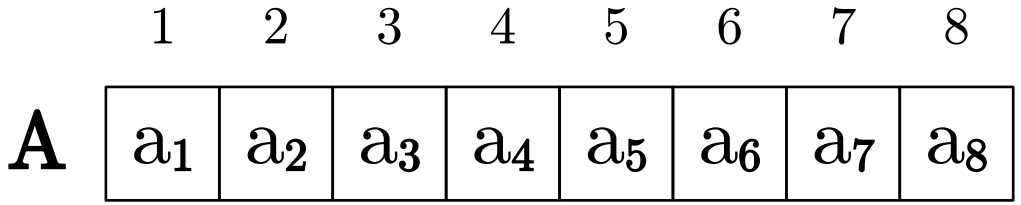
a_5==x?
a_6==x?
a_7==x?
a_8==x?

Subtask 1 and Subtask 2 run at the same time (in parallel)

Worst Case: done in 4 steps

Example Task 2: Find a prime number

Task: Given an array of numbers **A**, determine if there is a prime number in **A**. If there is, return the prime number and its location/index.



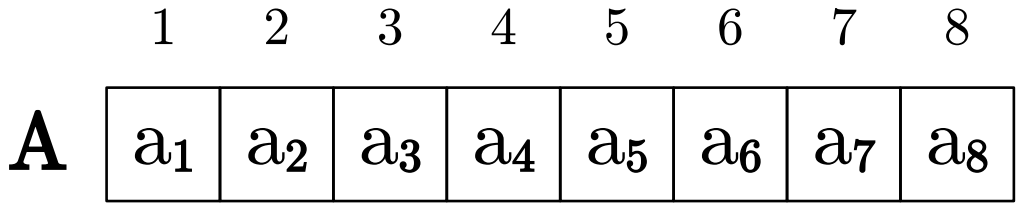
Task:

a_1 prime?
a_2 prime?
a_3 prime?
a_4 prime?
a_5 prime?
a_6 prime?
a_7 prime?
a_8 prime?

Worst Case: done in 8 steps

Example Task 2: Find a prime number

Task: Given an array of numbers **A**, determine if there is a prime number in **A**. If there is, return the prime number and its location/index.



Subtask 1:

a_1 prime?
a_2 prime?
a_3 prime?
a_4 prime?

Subtask 2:

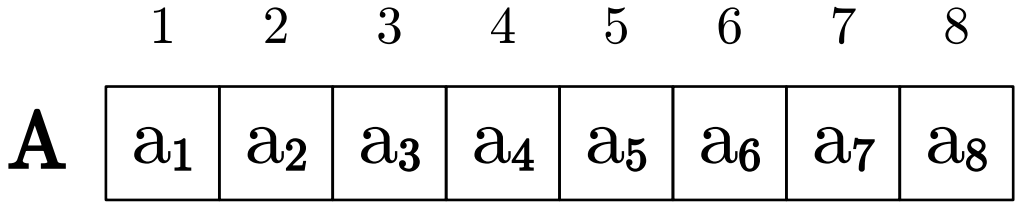
a_5 prime?
a_6 prime?
a_7 prime?
a_8 prime?

Subtask 1 and Subtask 2 run at the same time (in parallel)

Worst Case: done in 4 steps

Example Task 3: Find the maximum number

Task: Determine the maximum number, a_{max}, in the array of numbers **A.**



Task:

$a_{max} \leftarrow a_1$

$a_{max} \leftarrow \mathbf{max}(a_{max}, a_2)$

$a_{max} \leftarrow \mathbf{max}(a_{max}, a_3)$

$a_{max} \leftarrow \mathbf{max}(a_{max}, a_4)$

$a_{max} \leftarrow \mathbf{max}(a_{max}, a_5)$

$a_{max} \leftarrow \mathbf{max}(a_{max}, a_6)$

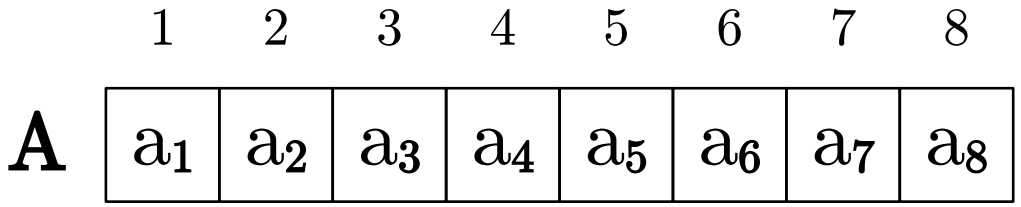
$a_{max} \leftarrow \mathbf{max}(a_{max}, a_7)$

$a_{max} \leftarrow \mathbf{max}(a_{max}, a_8)$

Worst Case: done in 8 steps

Example Task 3: Find the maximum number

Task: Determine the maximum number, a_{max}, in the array of numbers **A.**



Subtask 1:

$a_{max1} \leftarrow a_1$

$a_{max1} \leftarrow \mathbf{max}(a_{max1}, a_2)$

$a_{max1} \leftarrow \mathbf{max}(a_{max1}, a_3)$

$a_{max1} \leftarrow \mathbf{max}(a_{max1}, a_4)$

Subtask 2:

$a_{max2} \leftarrow a_5$

$a_{max2} \leftarrow \mathbf{max}(a_{max2}, a_6)$

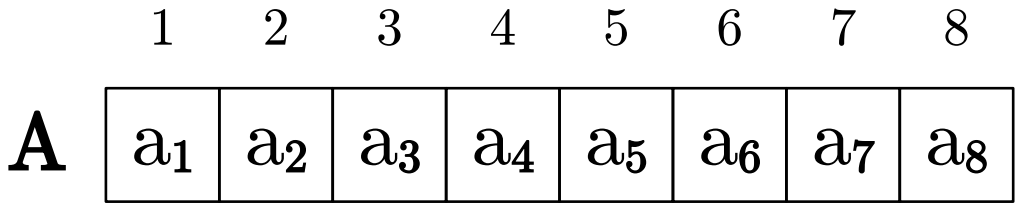
$a_{max2} \leftarrow \mathbf{max}(a_{max2}, a_7)$

$a_{max2} \leftarrow \mathbf{max}(a_{max2}, a_{48})$

Worst Case: done in ? steps

Example Task 3: Find the maximum number

Task: Determine the maximum number, a_{max}, in the array of numbers **A.**



Subtask 1:

$a_{max1} \leftarrow a_1$

$a_{max1} \leftarrow \mathbf{max}(a_{max1}, a_2)$

$a_{max1} \leftarrow \mathbf{max}(a_{max1}, a_3)$

$a_{max1} \leftarrow \mathbf{max}(a_{max1}, a_4)$

a_{max1}

Subtask 2:

$a_{max2} \leftarrow a_5$

$a_{max2} \leftarrow \mathbf{max}(a_{max2}, a_6)$

$a_{max2} \leftarrow \mathbf{max}(a_{max2}, a_7)$

$a_{max2} \leftarrow \mathbf{max}(a_{max2}, a_{48})$

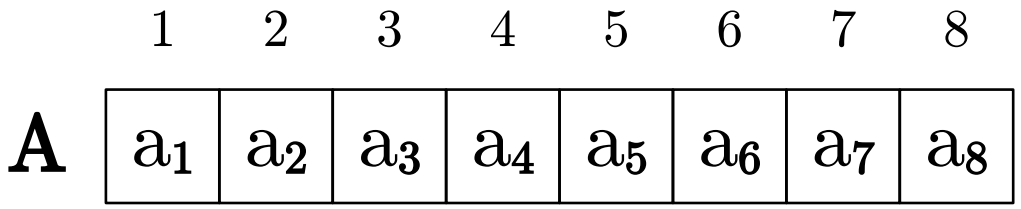
a_{max2}

Main Task: $a_{max} \leftarrow \mathbf{max}(a_{max1}, a_{max2})$

Worst Case: done in 4+1 steps

Example Task 1: Simple Search

Task: Given an array of numbers **A**, determine if the number **x** is in the array.



Subtask 1:
a_1==x?
a_2==x?

Subtask 2:
a_3==x?
a_4==x?

Subtask 3:
a_5==x?
a_6==x?

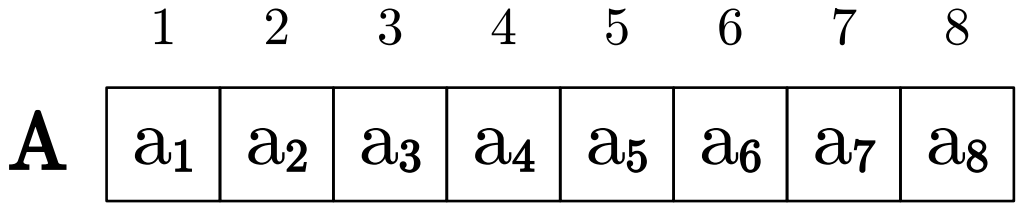
Subtask 4:
a_7==x?
a_8==x?

Subtasks 1, 2, 3, and 4 run at the same time (in parallel)

Worst Case: done in 2 steps

Example Task 2: Find a prime number

Task: Given an array of numbers **A**, determine if there is a prime number in **A**. If there is, return the prime number and its location/index.



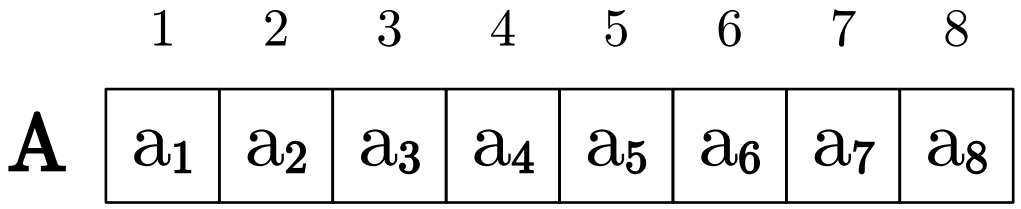
Subtask 1:	Subtask 2:	Subtask 3:	Subtask 4:
a_1 prime?	a_3 prime?	a_5 prime?	a_7 prime?
a_2 prime?	a_4 prime?	a_6 prime?	a_8 prime?

Subtasks 1, 2, 3, and 4 run at the same time (in parallel)

Worst Case: done in 2 steps

Example Task 3: Find the maximum number

Task: Determine the maximum number, a_{max}, in the array of numbers **A.**



Step 1:

Subtask 1: $a_{max1} \leftarrow \mathbf{max}(a_1, a_2)$

Subtask 2: $a_{max2} \leftarrow \mathbf{max}(a_3, a_4)$

Subtask 3: $a_{max3} \leftarrow \mathbf{max}(a_5, a_6)$

Subtask 4: $a_{max4} \leftarrow \mathbf{max}(a_7, a_8)$

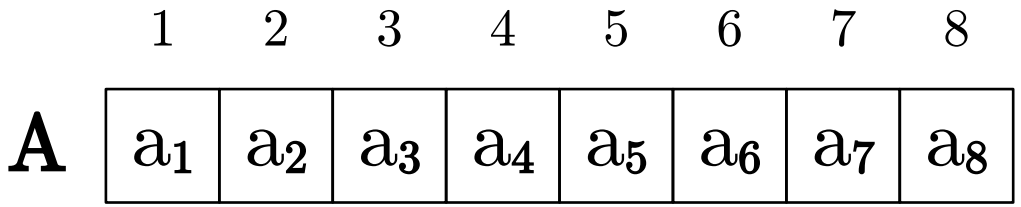
Step 2:

Subtask 5: $a_{max1} \leftarrow \mathbf{max}(a_{max1}, a_{max2})$

Subtask 6: $a_{max3} \leftarrow \mathbf{max}(a_{max3}, a_{max4})$

Example Task 3: Find the maximum number

Task: Determine the maximum number, a_{max}, in the array of numbers **A.**



Step 2:

Subtask 5: $a_{max1} \leftarrow \mathbf{max}(a_{max1}, a_{max2})$

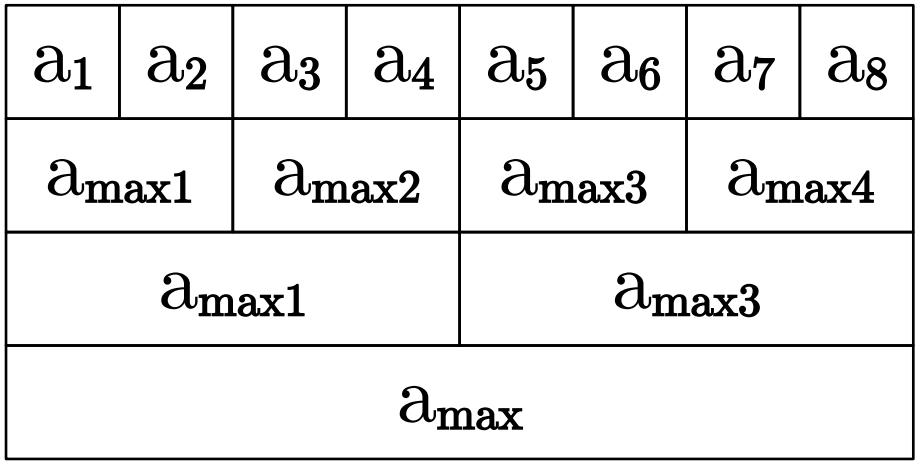
Subtask 6: $a_{max2} \leftarrow \mathbf{max}(a_{max3}, a_{max4})$

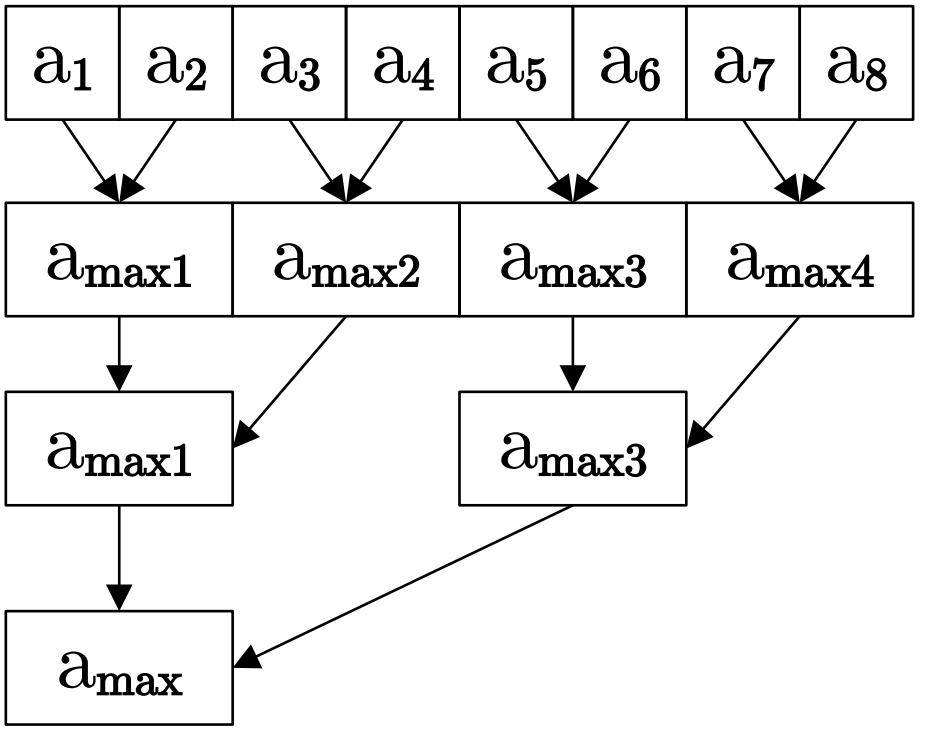
Step 3:

Subtask 7: $a_{max} \leftarrow \mathbf{max}(a_{max1}, a_{max3})$

Done in 3 steps ($\log_2(8)$ steps)

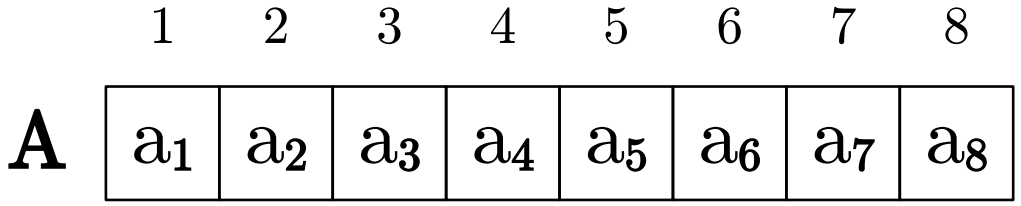
Example Task 3: Visualized





Example Task 4: Find the sum of all number in **A**

Task: Determine the sum of all numbers in **A.**



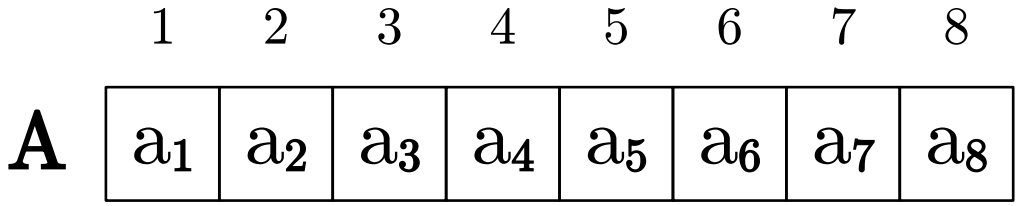
Task:

$$\begin{aligned}
\text{sum} &\leftarrow a_1 \\
\text{sum} &\leftarrow \text{sum} + a_2 \\
\text{sum} &\leftarrow \text{sum} + a_3 \\
\text{sum} &\leftarrow \text{sum} + a_4 \\
\text{sum} &\leftarrow \text{sum} + a_5 \\
\text{sum} &\leftarrow \text{sum} + a_6 \\
\text{sum} &\leftarrow \text{sum} + a_7 \\
\text{sum} &\leftarrow \text{sum} + a_8
\end{aligned}$$

Worst Case: done in 8 steps

Example Task 4: Find the sum of all number in **A**

Task: Determine the sum of all numbers in **A.**



Step 1:

Subtask 1: $sum_1 \leftarrow a_1 + a_2$

Subtask 2: $sum_1 \leftarrow a_3 + a_4$

Subtask 3: $sum_3 \leftarrow a_5 + a_6$

Subtask 4: $sum_4 \leftarrow a_7 + a_8$

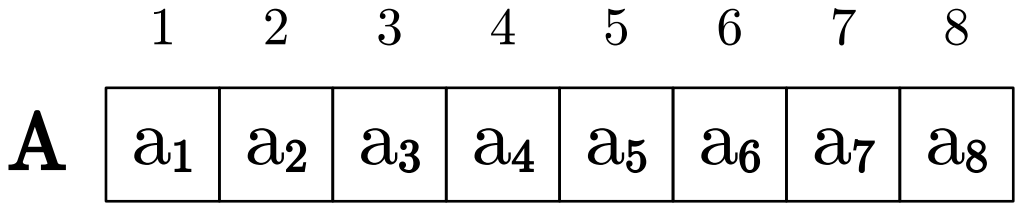
Step 2:

Subtask 5: $sum_1 \leftarrow sum_2 + sum_1$

Subtask 6: $sum_3 \leftarrow sum_4 + sum_3$

Example Task 4: Find the sum of all number in **A**

Task: Determine the sum of all numbers in **A.**



Step 2:

Subtask 5: $sum_1 \leftarrow sum_2 + sum_1$

Subtask 6: $sum_3 \leftarrow sum_4 + sum_3$

Step 3:

Subtask 7: $sum \leftarrow sum_1 + sum_3$

Done in 3 steps ($\log_2(8)$ steps)

Example Task 4: Visualized