SySCD
A System-Aware Parallel Coordinate Descent Algorithm

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UC Berkeley

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IBM Research

*equal contribution

Parallel Coordinate Descent

$$\min_{\boldsymbol{\alpha}} f(A\boldsymbol{\alpha}) + \sum_i g_i(\alpha_i)$$

Parallel Coordinate Descent

Input: Training data matrix $A \in \mathbb{R}^{d \times n}$
Initial model $\boldsymbol{\alpha} = \mathbf{0}$, $\mathbf{v} = \mathbf{0}$

for $t = 1, 2, \ldots$ **do**
  parfor $j \in$ RandomPermutation(n) **do**
    Find δ minimizing $f(\mathbf{v} + A_{:,j}\delta) + g_j(\alpha_j + \delta)$
    $\alpha_j \leftarrow \alpha_j + \delta$
    $\mathbf{v} \leftarrow \mathbf{v} + \delta A_{:,j}$
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1. Inefficient cache accesses
2. Write-contention on **v**
3. Scalability across NUMA nodes

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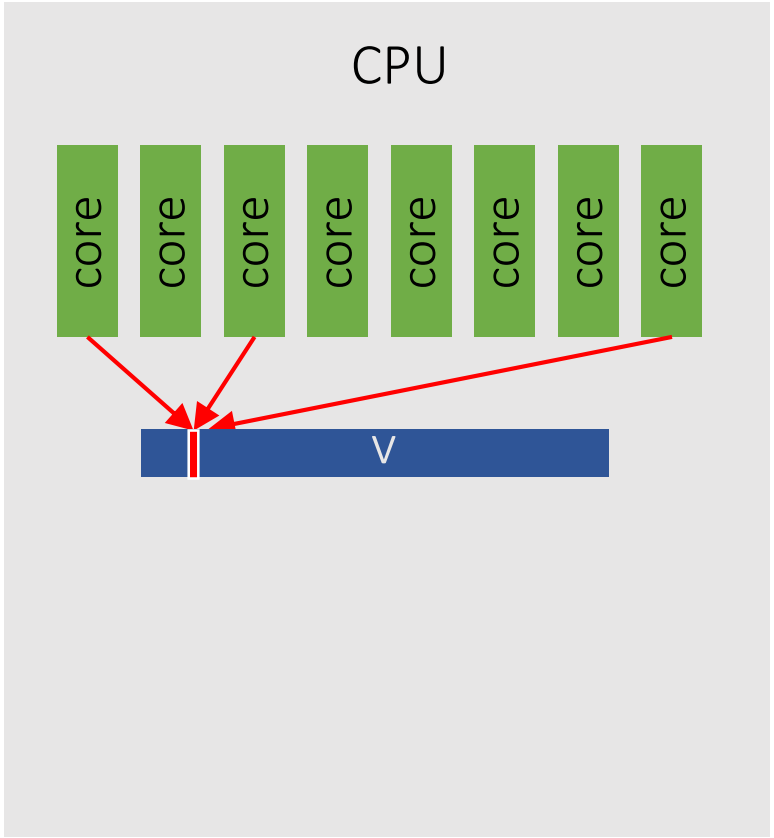
Resolving write-contention on **v**



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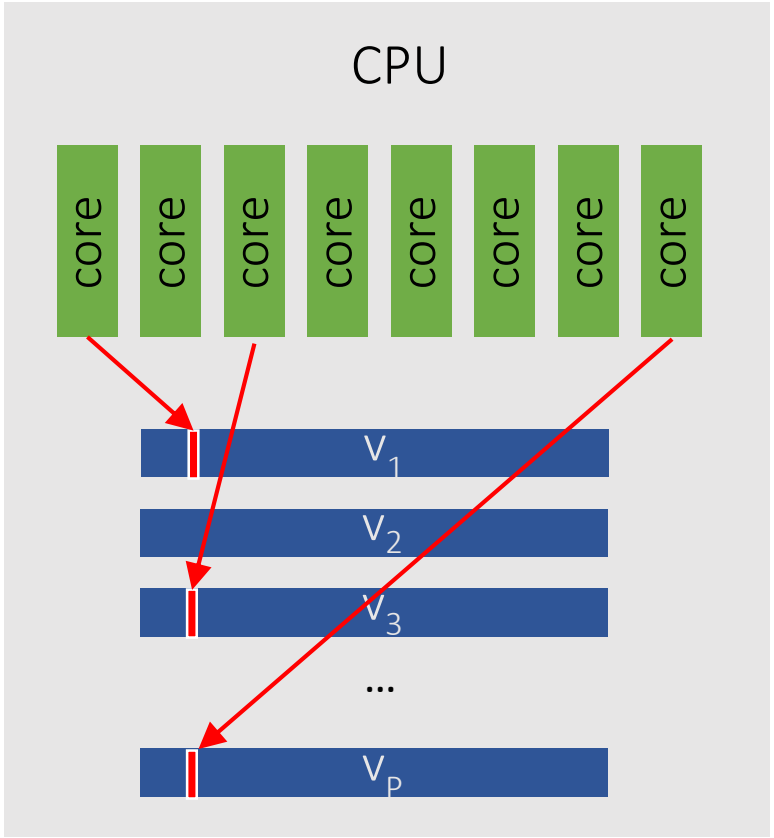

Resolving write-contention on **v**

→ replicate **v** across threads

Parallel Coordinate Descent

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5: Find δ minimizing $f(\mathbf{v} + A_{:,j}\alpha_j) + g_j(\alpha_j + \delta)$
6: $\alpha_j \leftarrow \alpha_j + \delta$
7: $\mathbf{v} \leftarrow \mathbf{v} + \delta A_{:,j}$
8: **end parfor**

10: **end for**

Resolving write-contention on **v**

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for $t = 1, 2, \ldots$ **do**

threads

  $\mathbf{v}_p \leftarrow \mathbf{v} \quad \forall p \in [P]$

  parfor $j \in \text{RANDOMPERMUTATION}(n)$ **do**

    Find δ minimizing $\hat{f}(\mathbf{v}_p, A_{:,j}, \alpha_j) + g_j(\alpha_j + \delta)$

    $\alpha_j \leftarrow \alpha_j + \delta$

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  $\mathbf{v} \leftarrow \sum_p \mathbf{v}_p$

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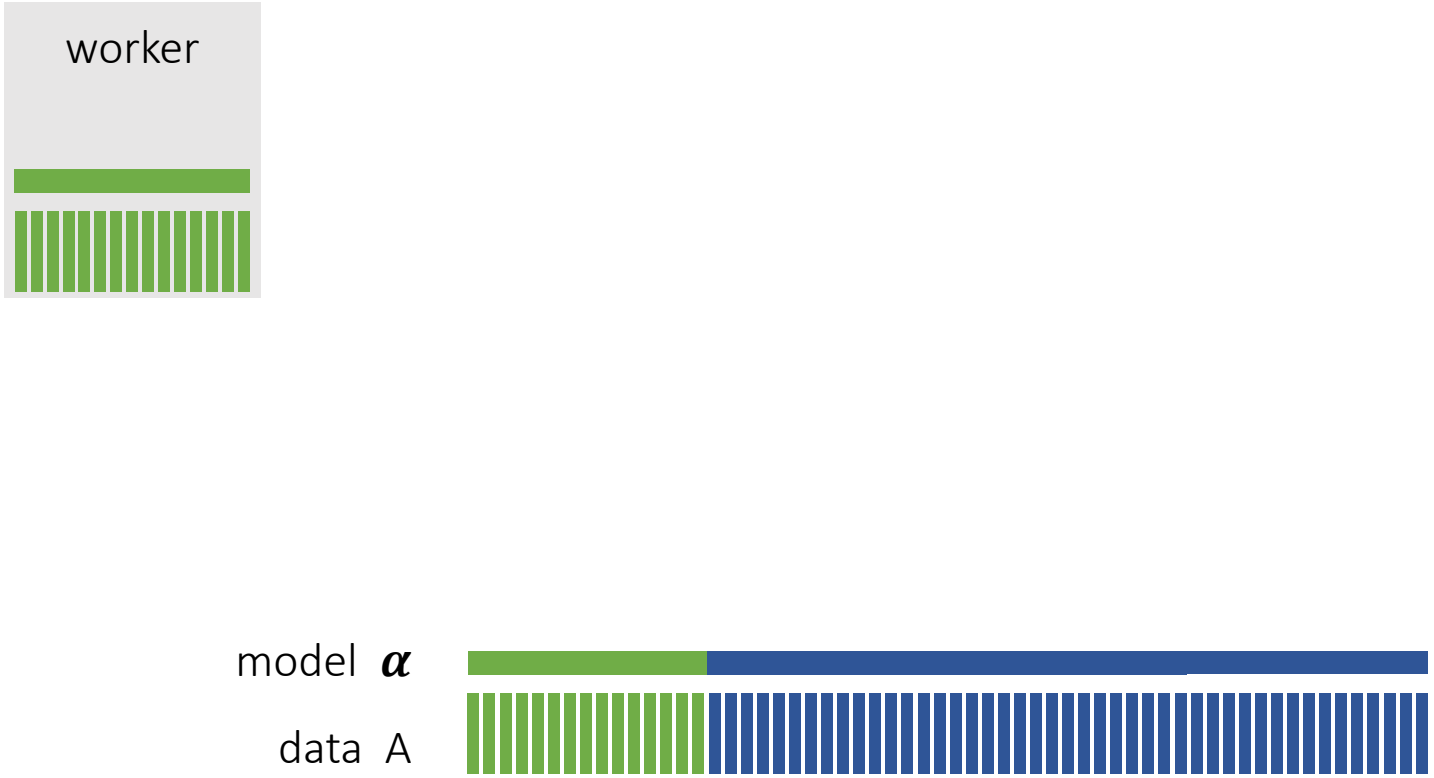
auxiliary model inspired by CoCoA [Smith'18]

Connection to Distributed Methods



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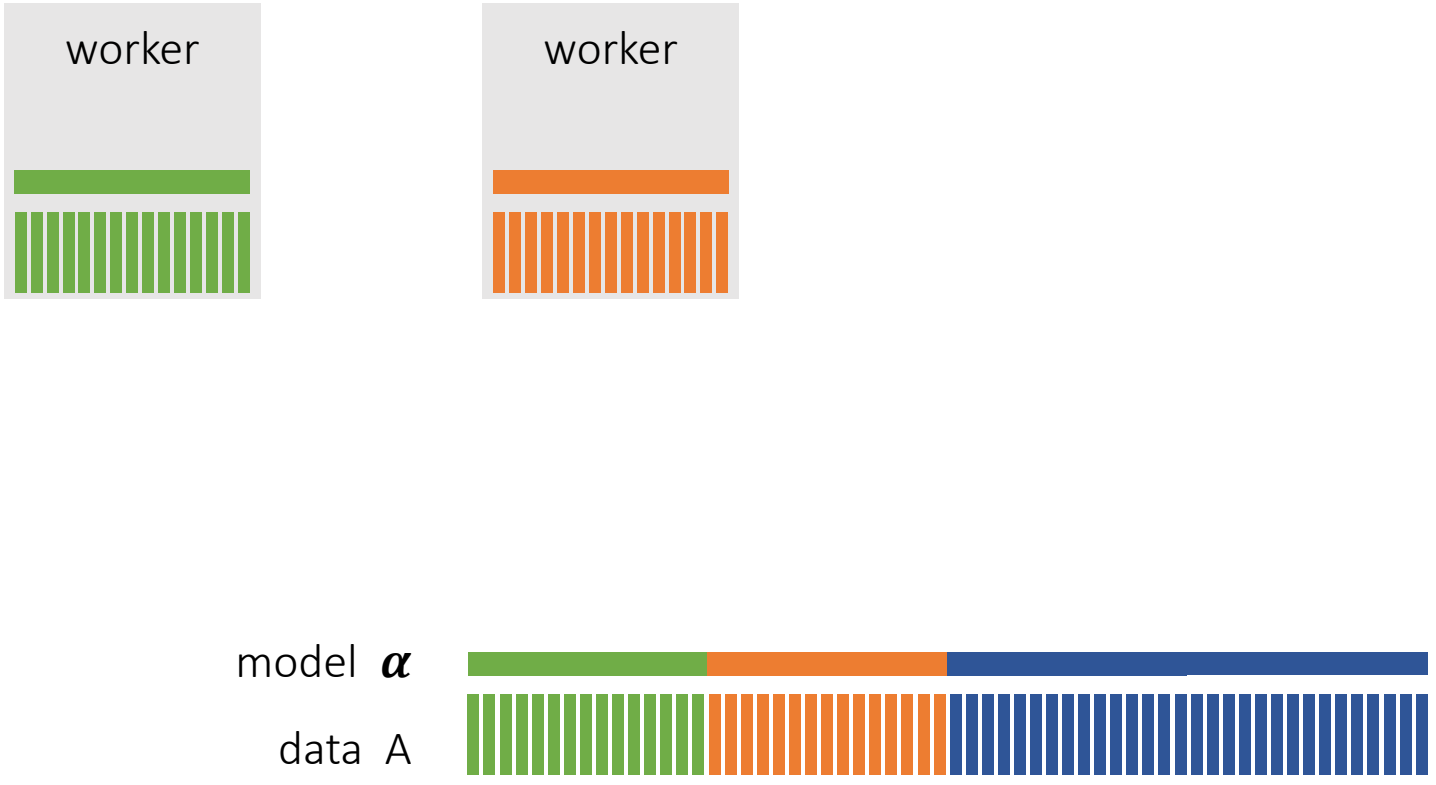

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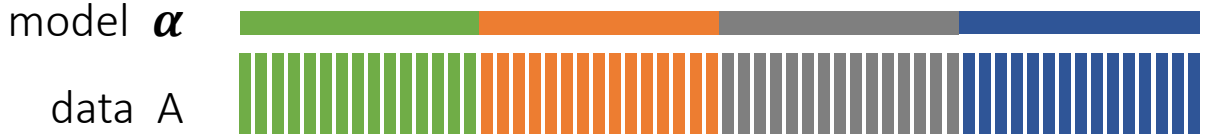

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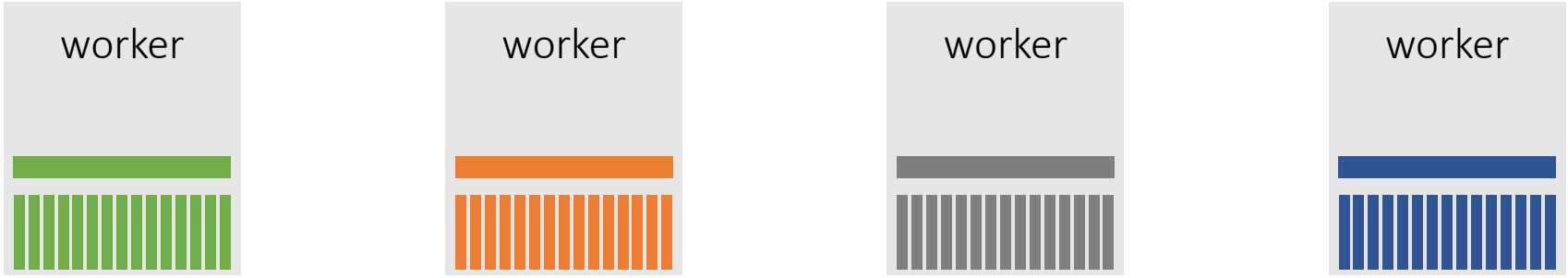

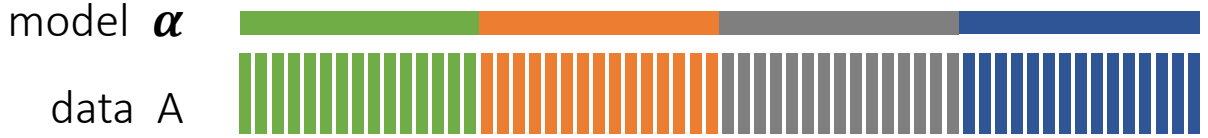

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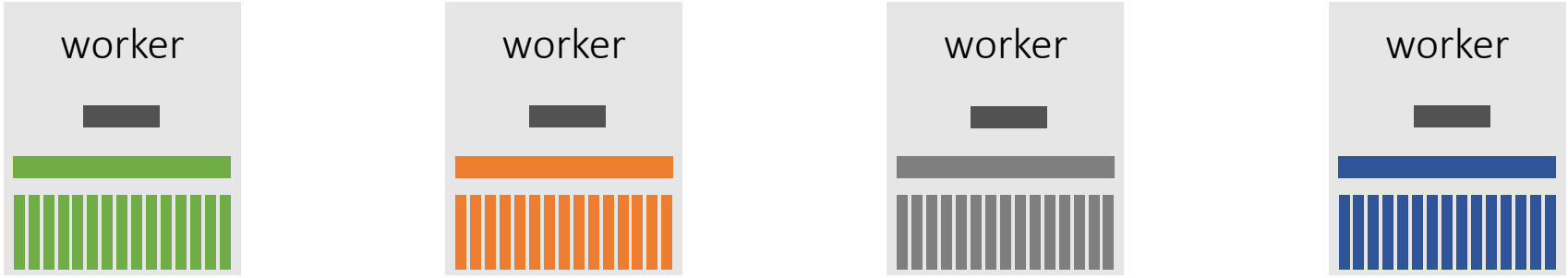

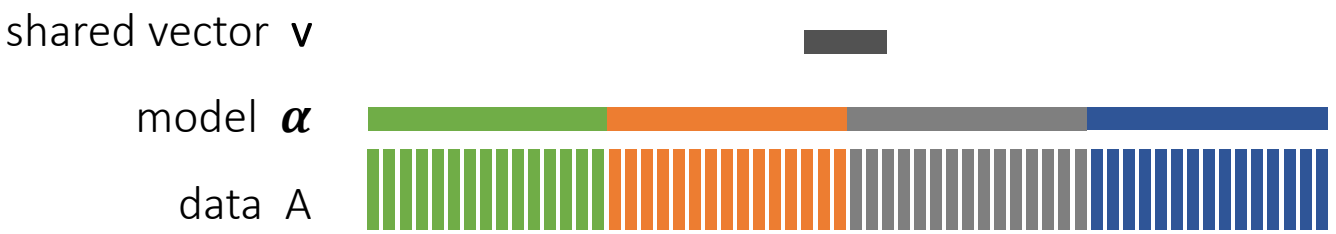

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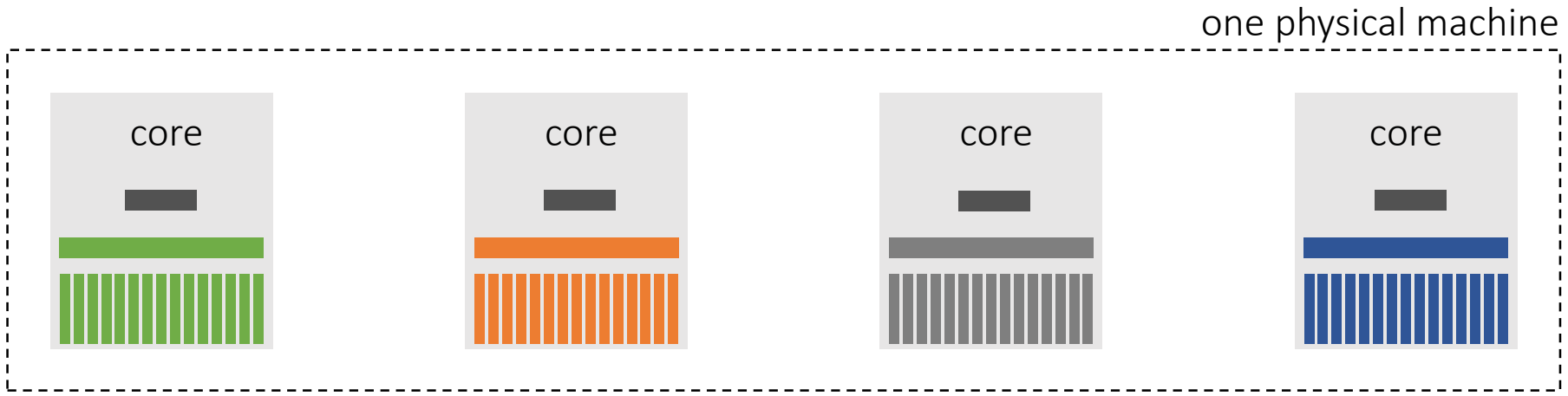
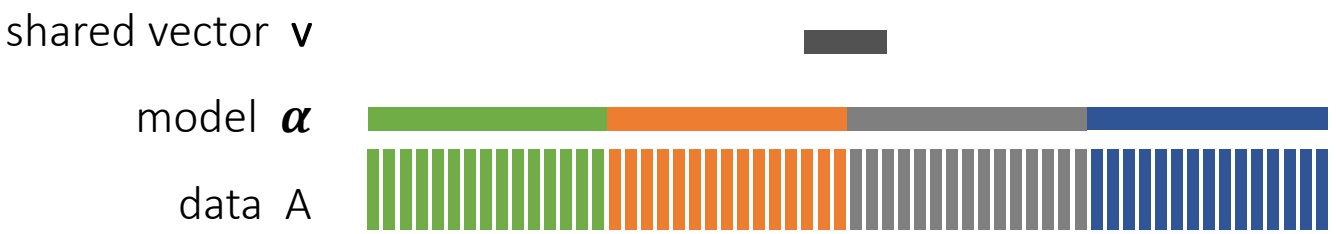
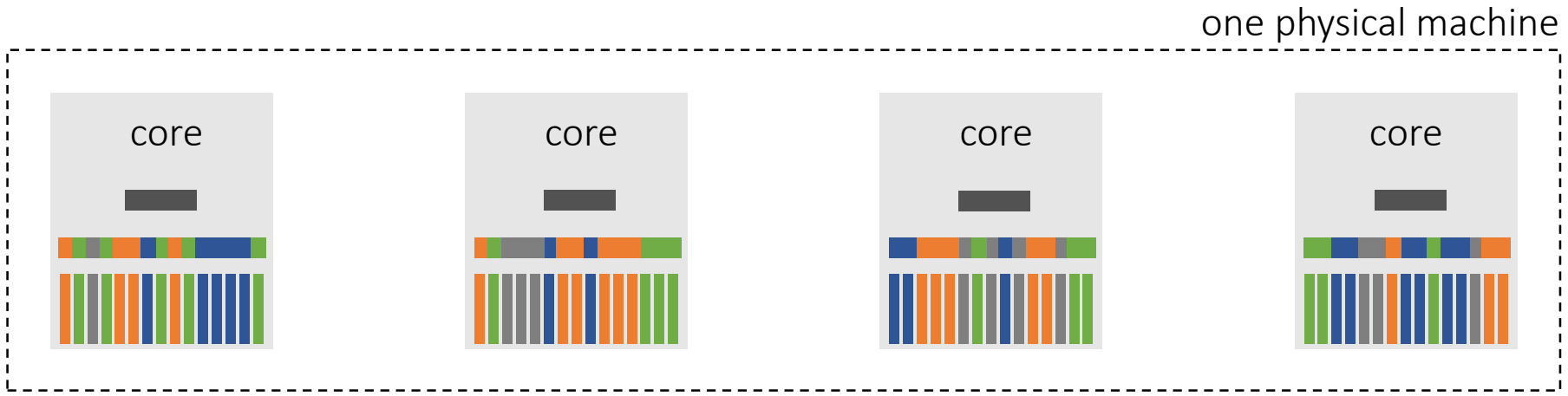
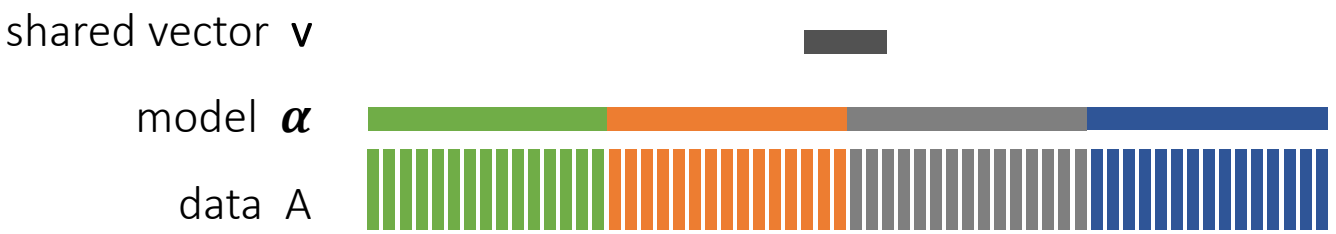




Repartitioning





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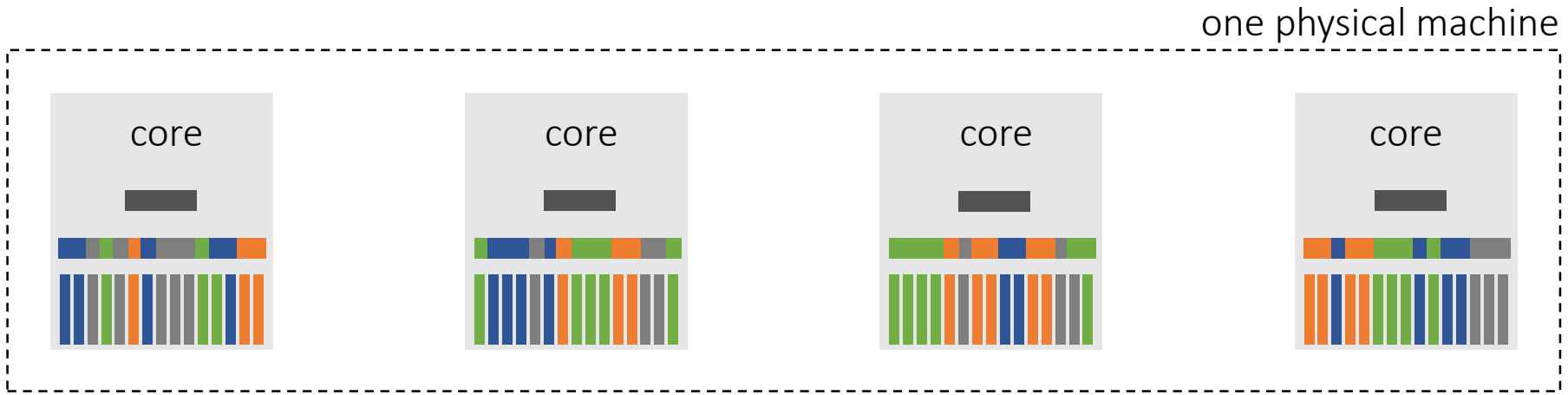

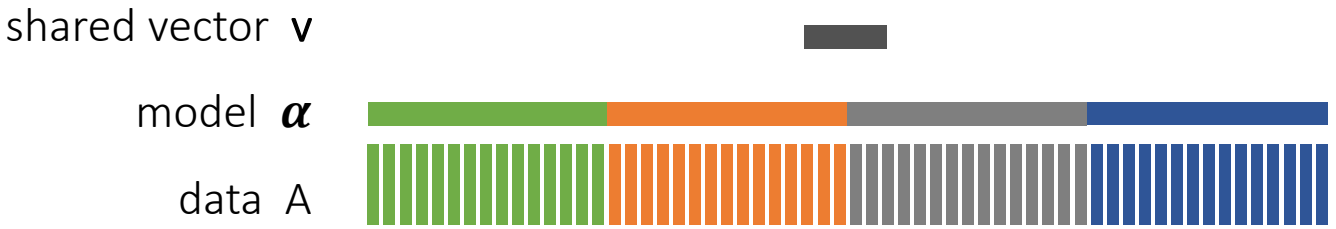

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  - ✓ theoretically sound parallel method
  - ✓ scales to large degrees of parallelism

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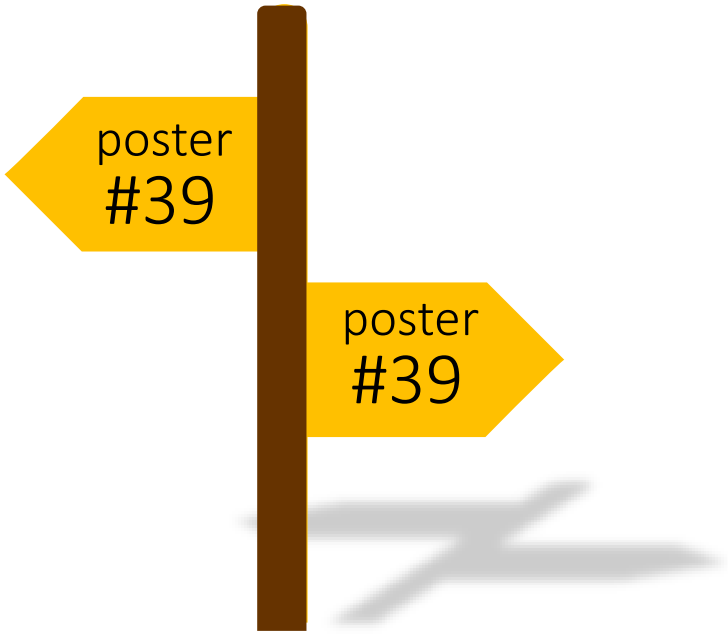

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