NetAdaptV2: Efficient Neural Architecture Search with Fast Super-Network Training and Architecture Optimization

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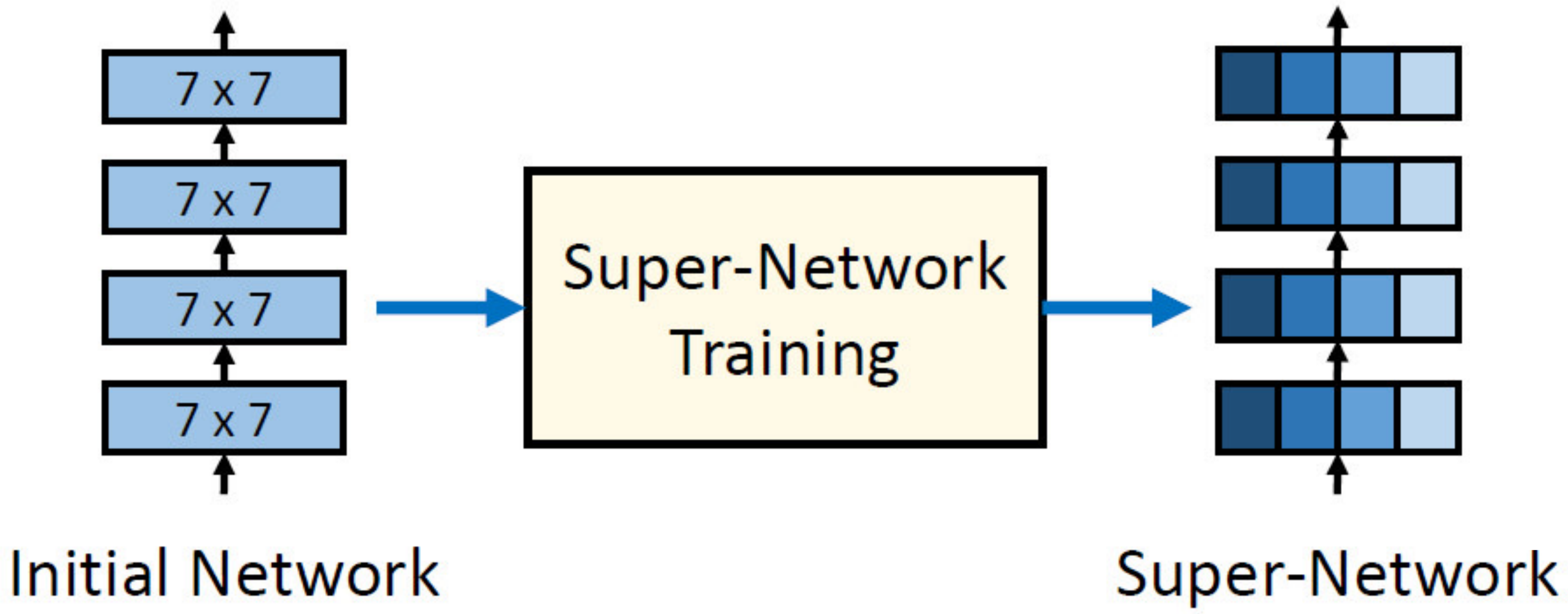
Introduction

- NetAdaptV2 is a neural architecture search (NAS) algorithm that can discover high-performance networks in a short time
    - Up to **5.8x** search time reduction with **better** accuracy on ImageNet
- NetAdaptV2
    - balances and minimizes the time of each NAS step to **improve speed**
    - supports non-differentiable search metrics to **improve network performance**

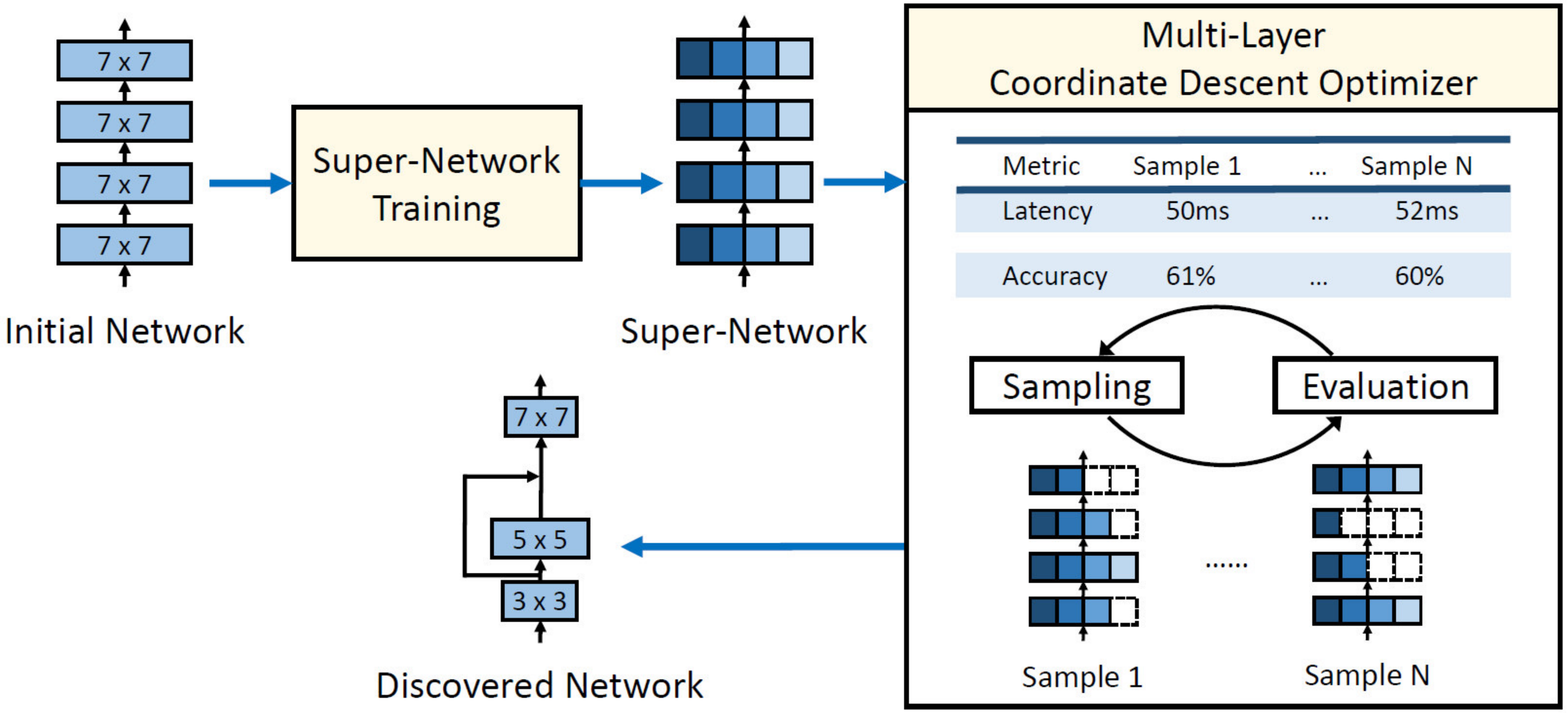
Algorithm Overview

- 1) Train a super-network by jointly training networks in the search space



Algorithm Overview

- 1) Train a super-network by jointly training networks in the search space
- 2) Search for the optimal network using the proposed optimizer
  - It samples networks and evaluates them without further training



Metric	Sample 1	...	Sample N
Latency	50ms	...	52ms
Accuracy	61%	...	60%

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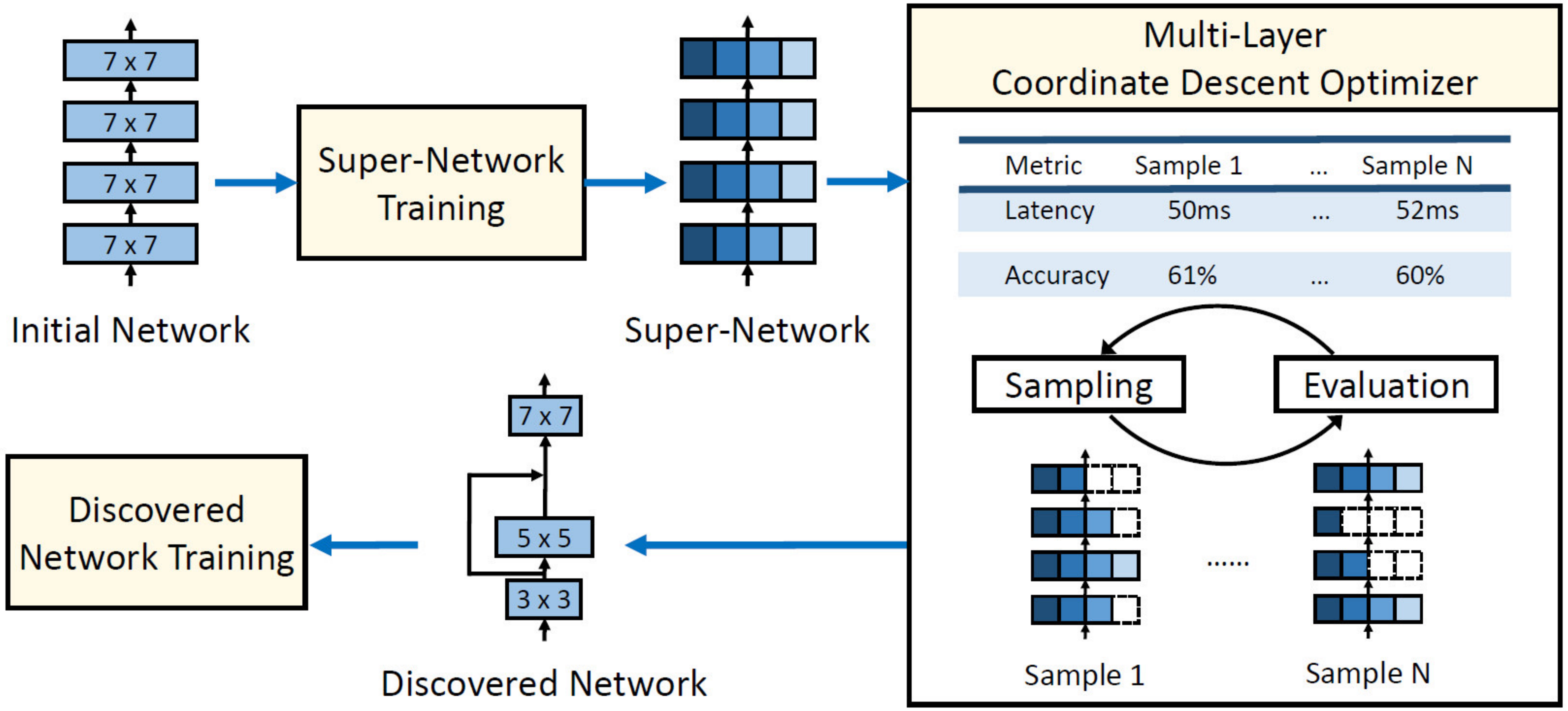
- 3) Fine-tune the discovered network until convergence



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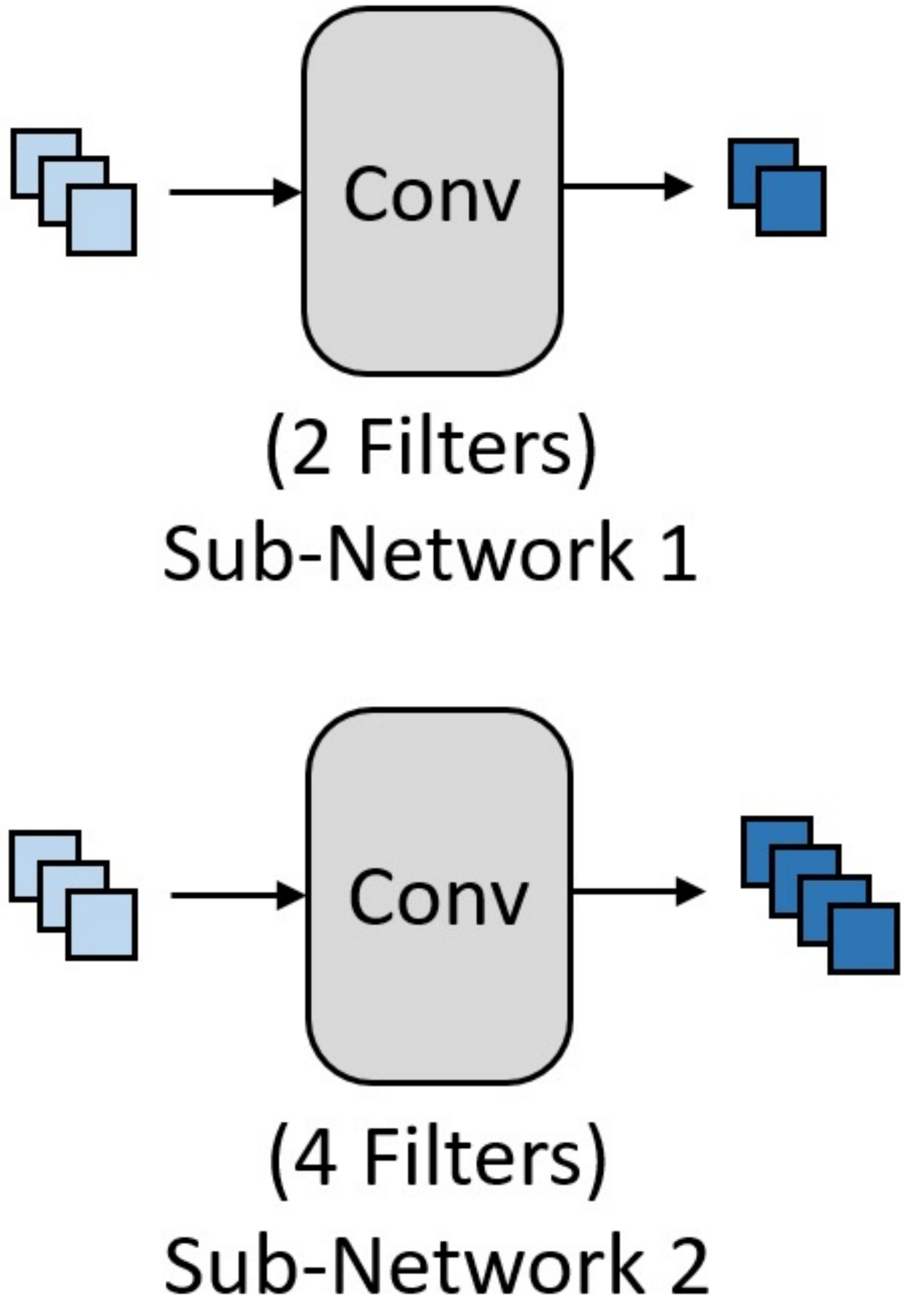
Proposed Techniques

- 1) Train a super-network by jointly training networks in the search space
  - **Ordered dropout (OD):** reduce the time for training a super-network
- 2) Search for the optimal network using the proposed optimizer
  - **Channel-level bypass connections (CBCs):** reduce the time for evaluating samples
  - **Multi-layer coordinate descent (MCD):** reduce the time for evaluating samples while supporting non-differentiable search metrics
- 3) Fine-tune the discovered network until convergence

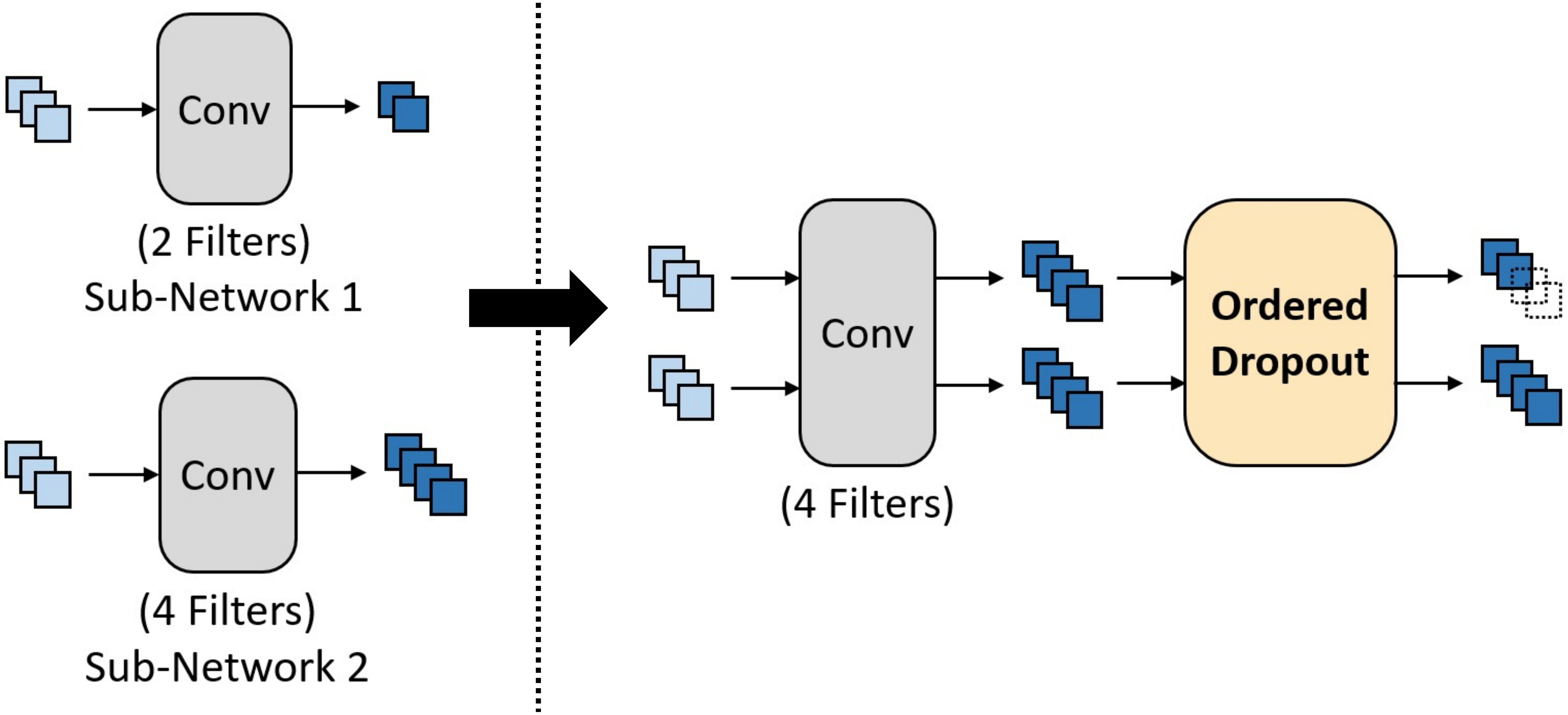
Ordered Dropout

- Train multiple networks in a single pass to speed up super-network training



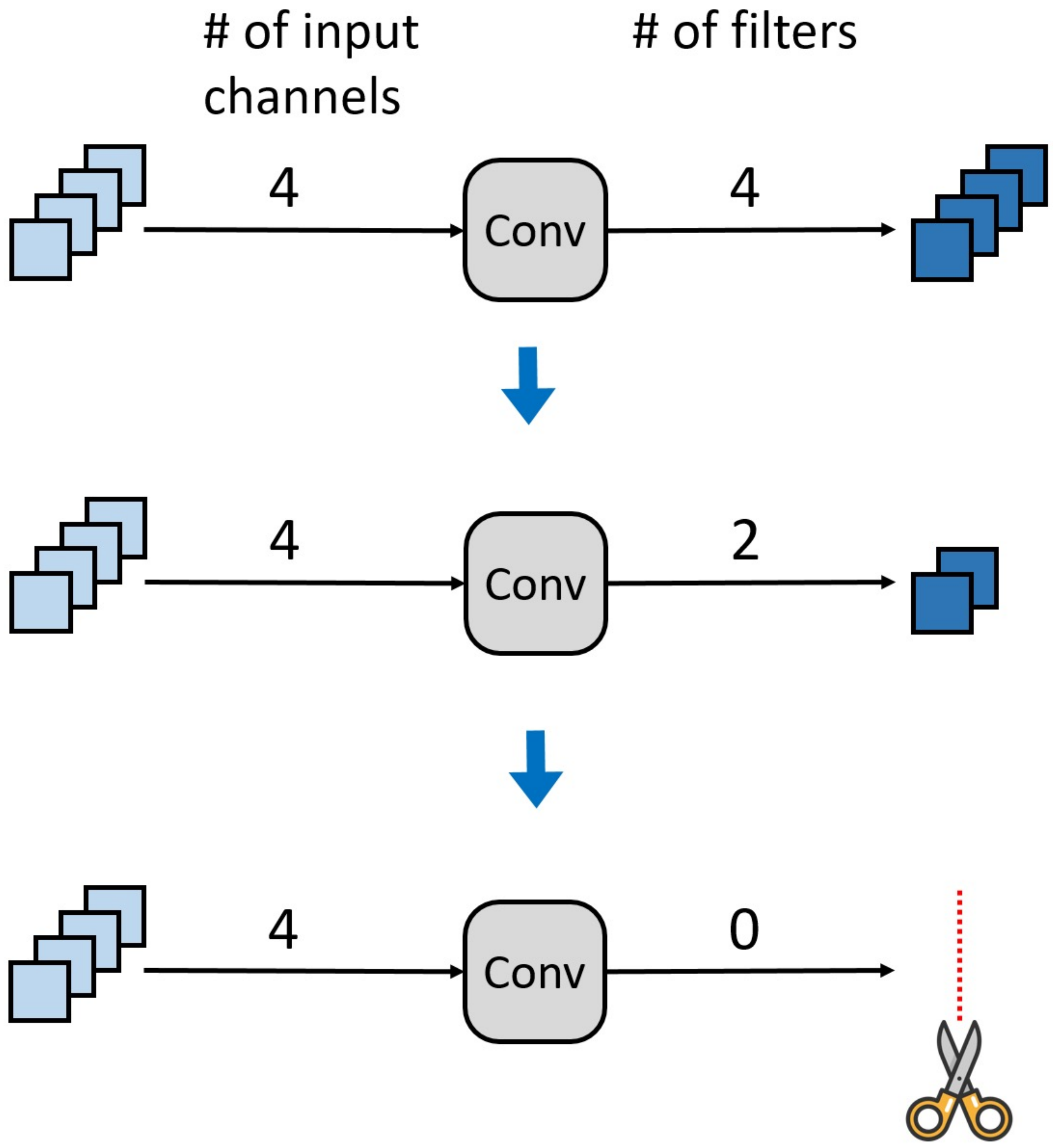
Ordered Dropout

- Train multiple networks in a single pass to speed up super-network training
- Architecture simulation: zero out different channels for different input images
  - Always zero out the last channels to avoid the training-evaluation mismatch



Channel-Level Bypass Connections

- NetAdaptV2 searches layer width, network depth, and kernel size



W/o CBCs

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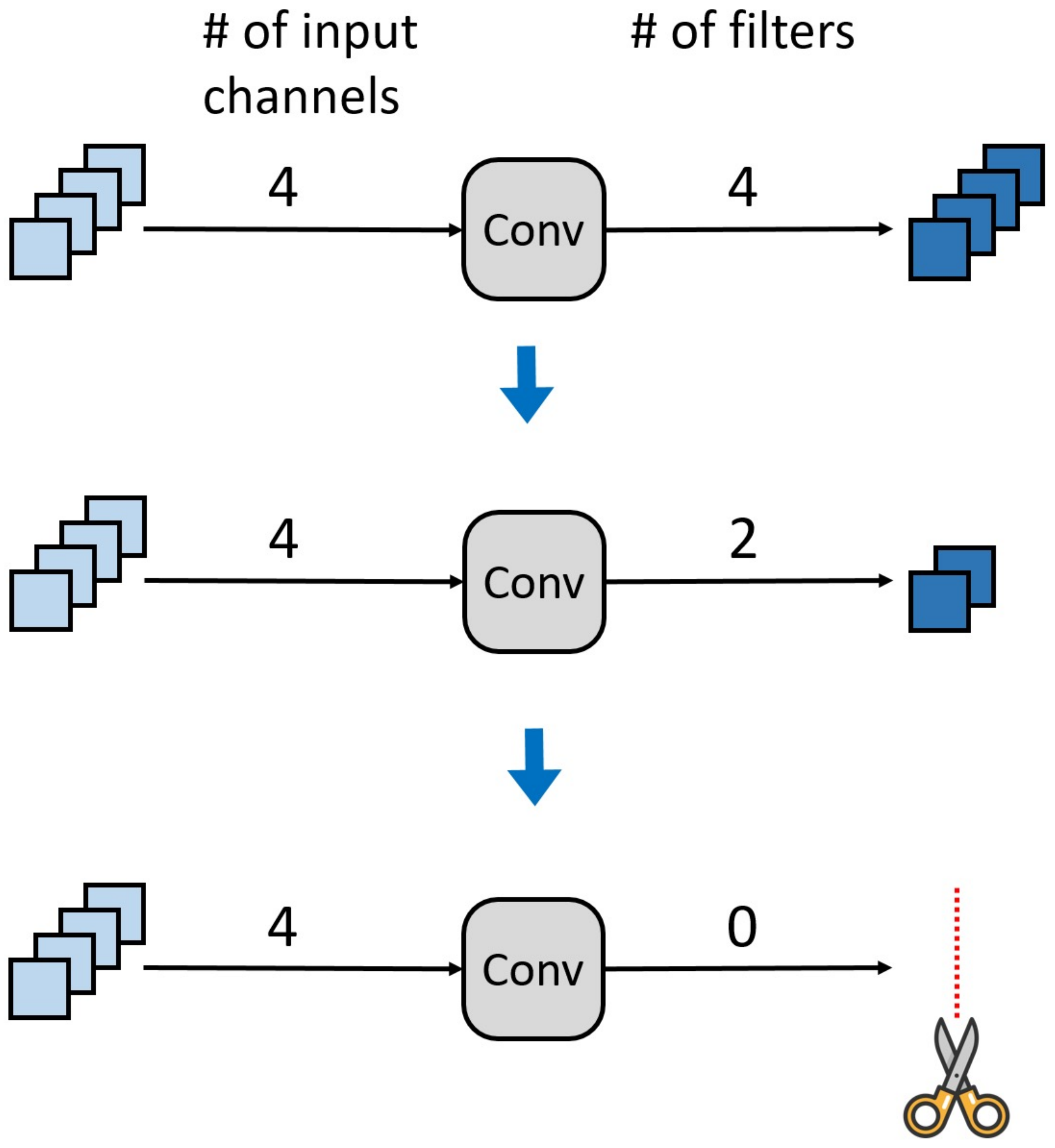
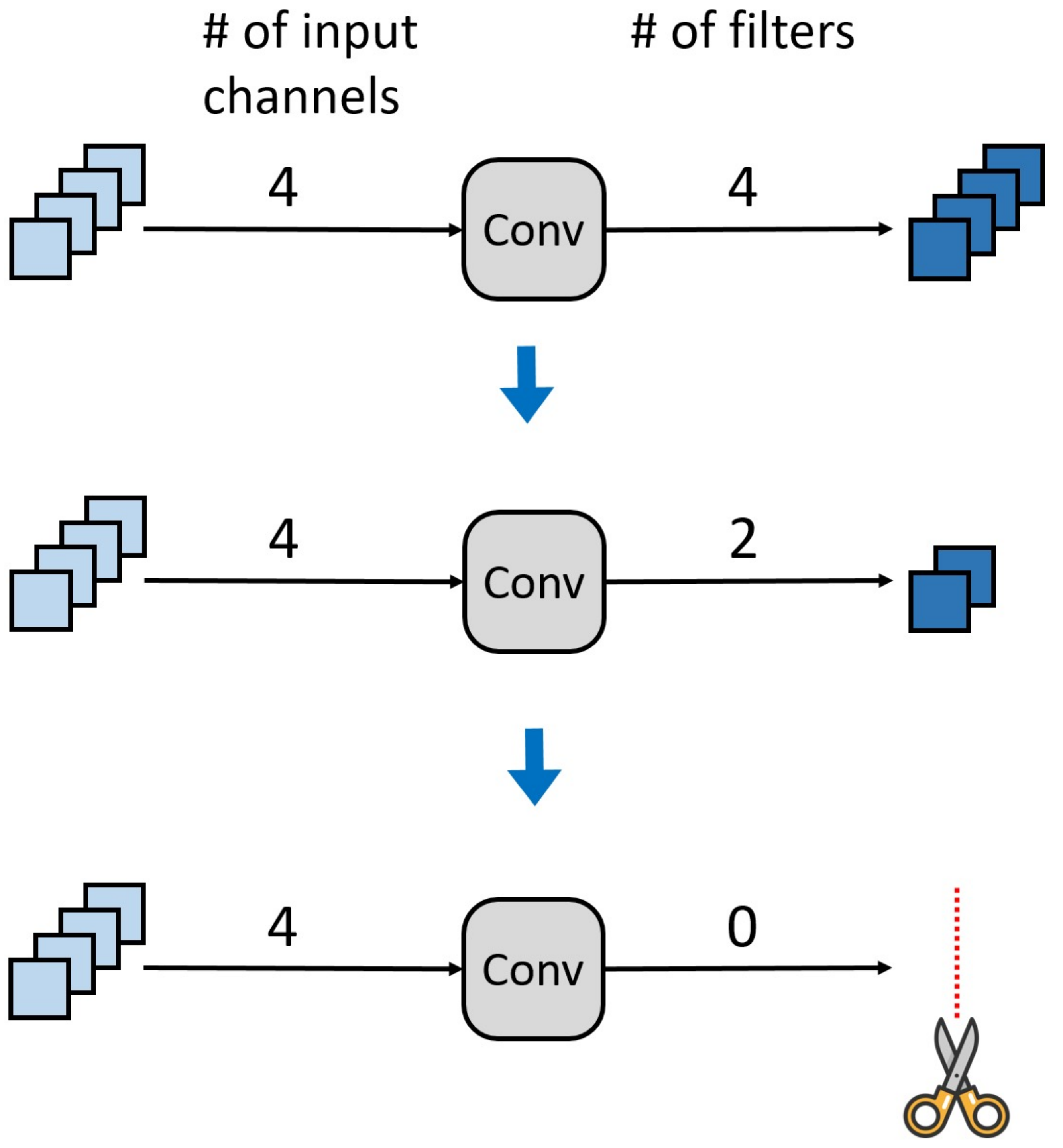


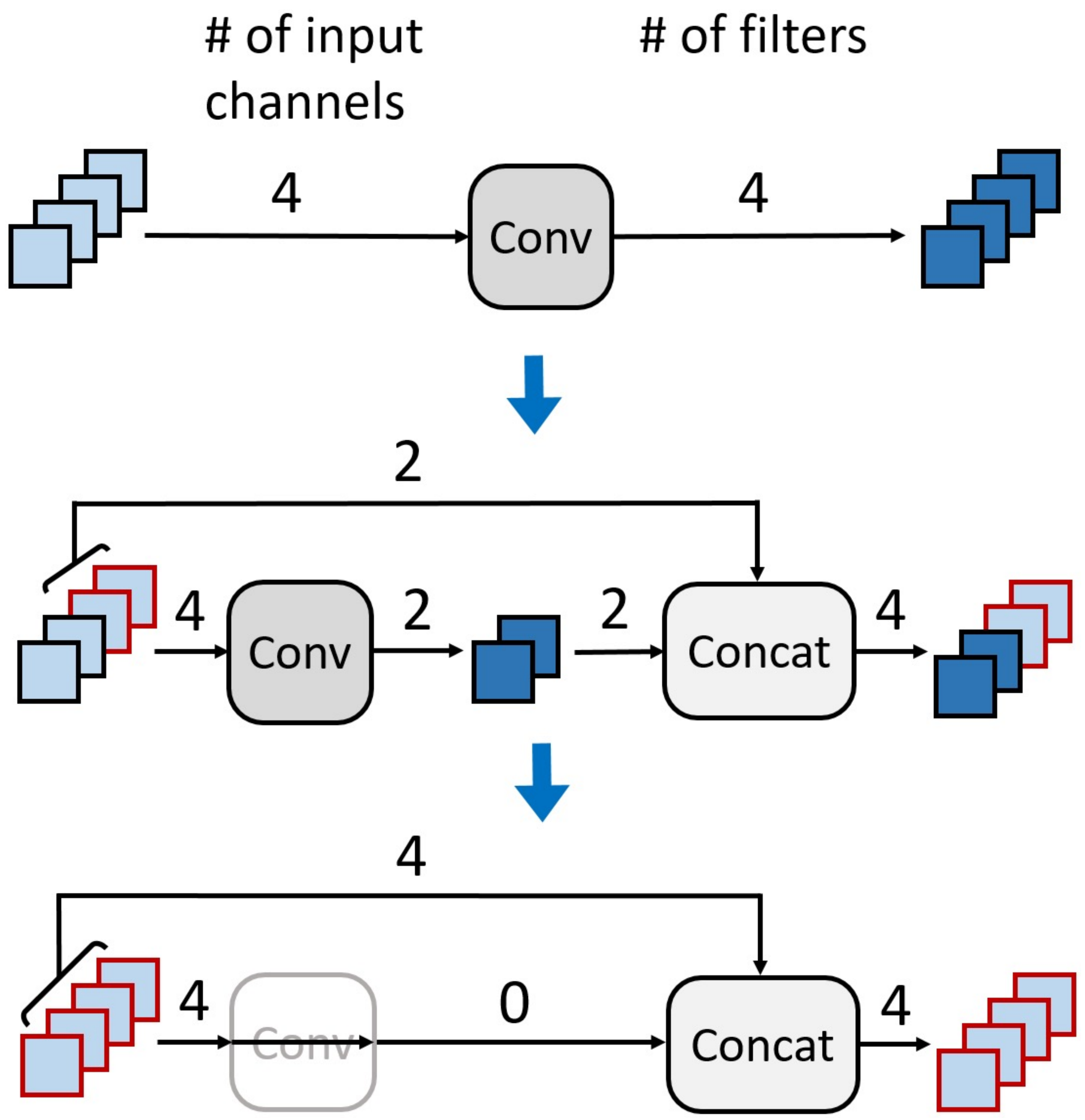
W/o CBCs

Channel-Level Bypass Connections

- NetAdaptV2 searches layer width, network depth, and kernel size
- CBCs merge network depth and layer width into a single search dimension and allow searching only layer width
  - High-level idea: when a filter is removed, an input channel is bypassed



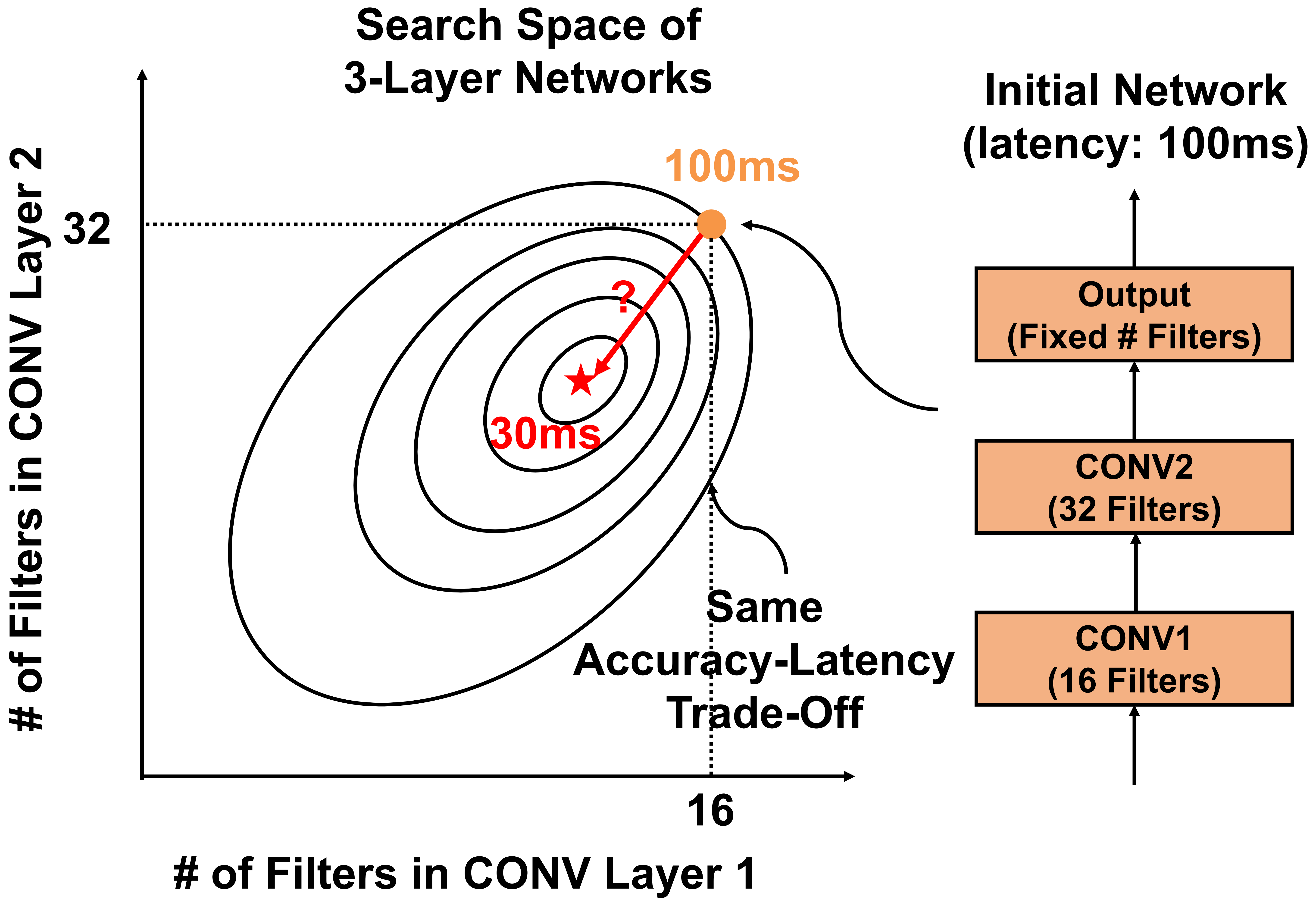
W/o CBCs



W/ CBCs

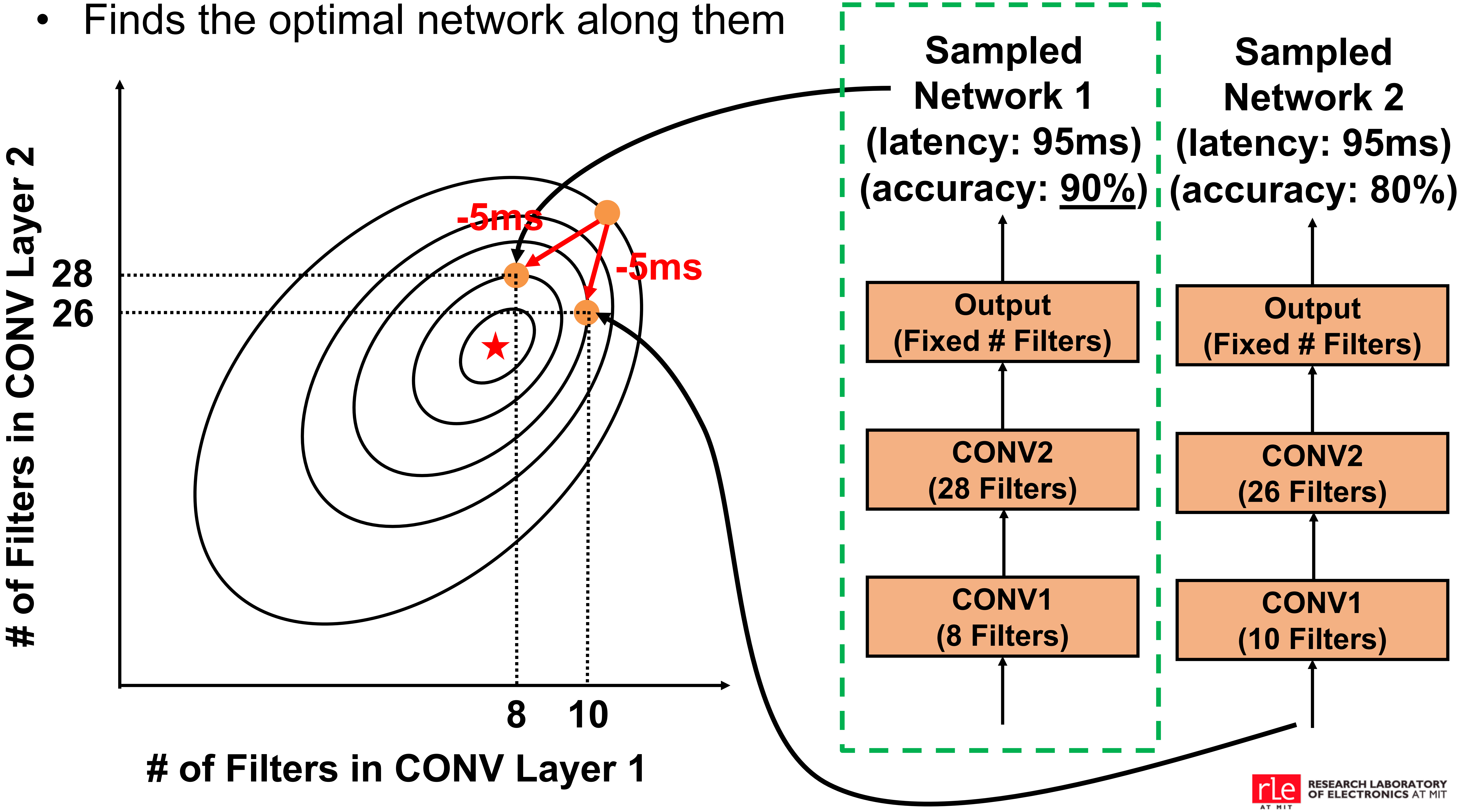
Multi-Layer Coordinate Descent

- MCD gradually and iteratively shrinks an initial network until the given constraints are satisfied



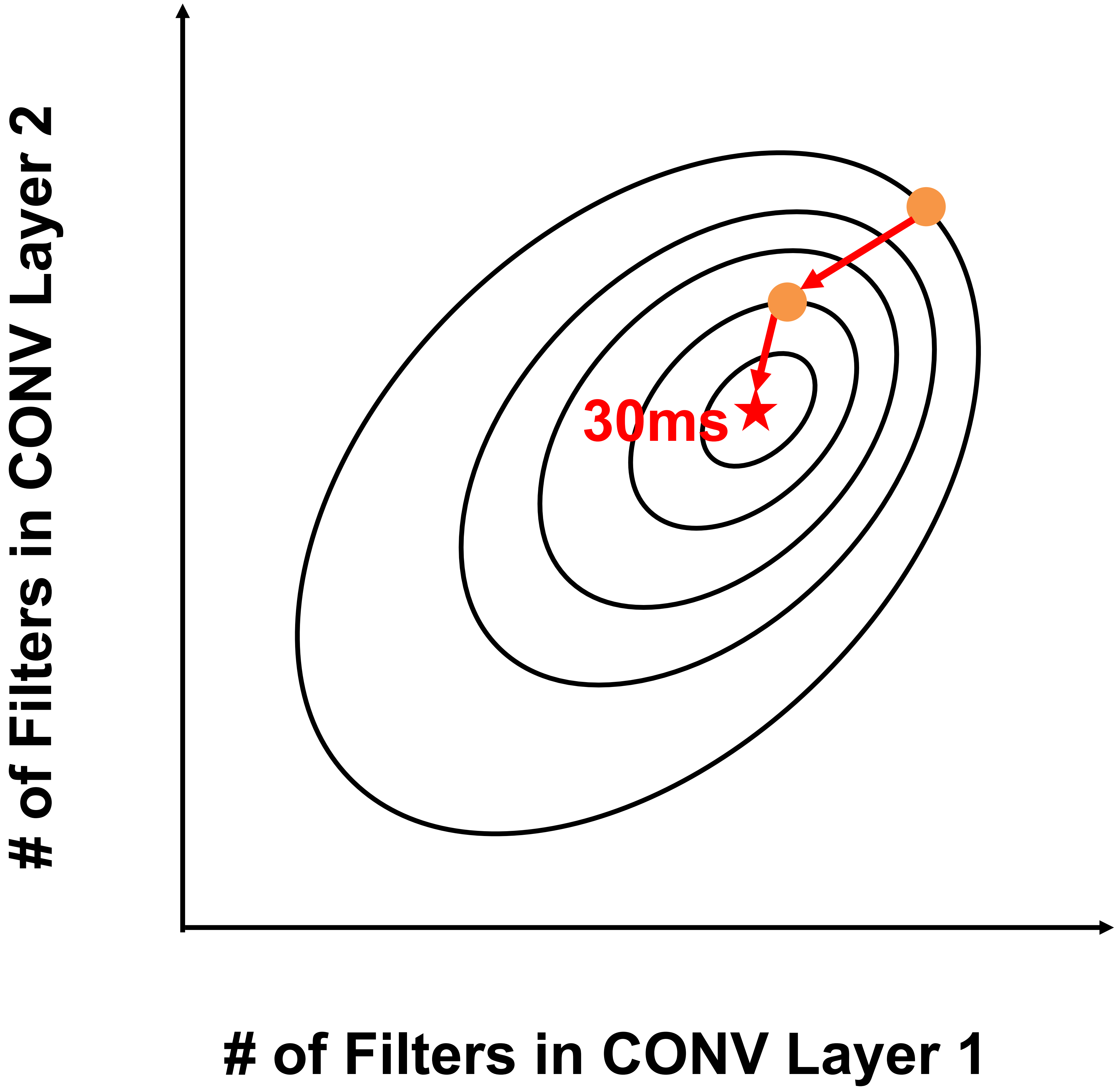
Multi-Layer Coordinate Descent

- In each iteration, MCD
  - Generates *J* coordinate directions by randomly shrinking *L* layers
  - Finds the optimal network along them



Multi-Layer Coordinate Descent

- This process continues until the given constraints are satisfied



Multi-Layer Coordinate Descent

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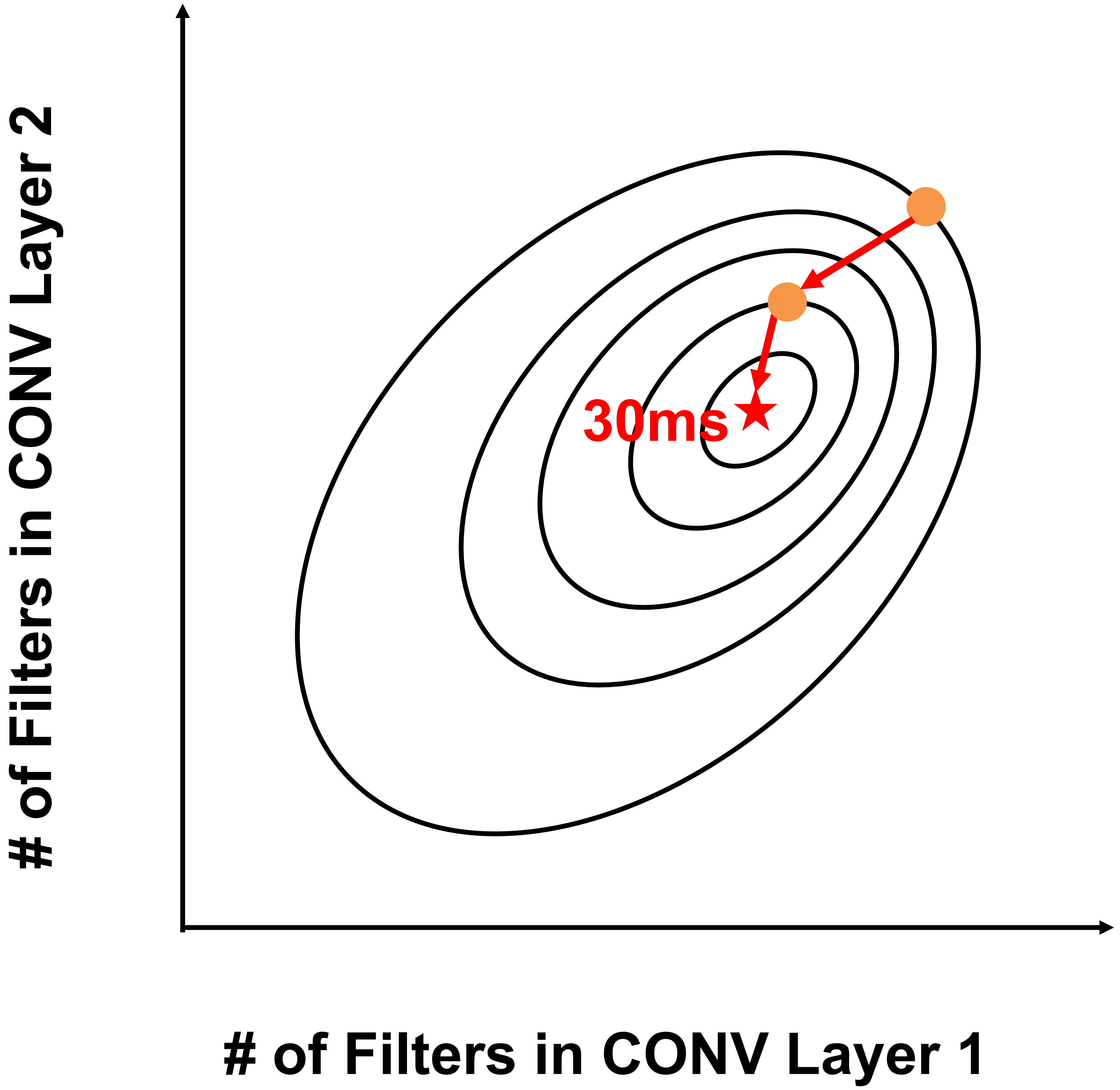
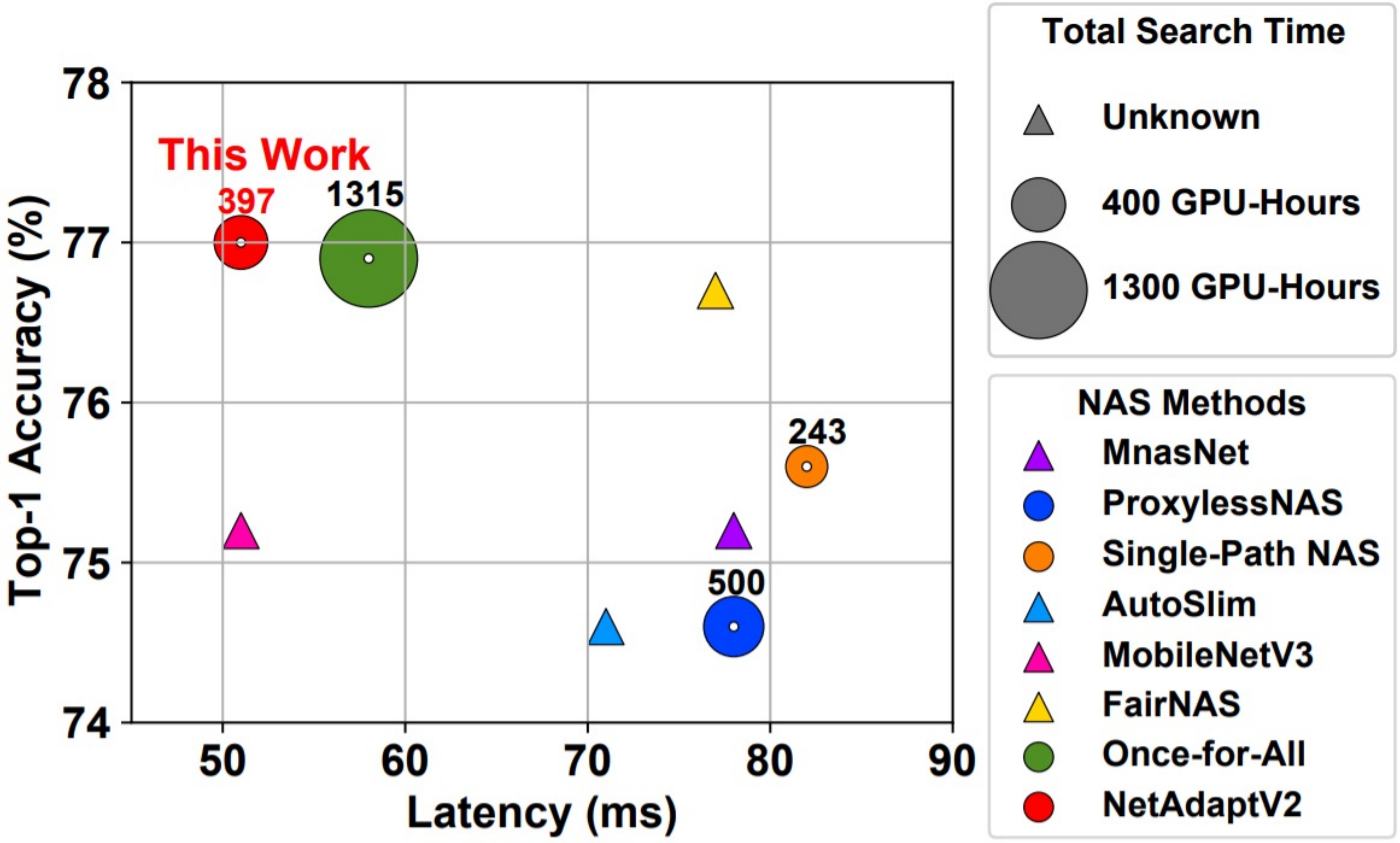


MCD does not require the search metrics to be differentiable

NetAdaptV2 Results

NetAdaptV2 achieves better accuracy-latency or accuracy-MAC trade-offs than related works with much lower search time



▲ Latency-Guided Search

Method	Top-1 Accuracy	MAC (M)	Search Time
NSGANetV2-m	78.3%	312	1674
EfficientNet-B0	77.3%	390	-
MixNet-M	77.0%	360	-
NetAdaptV2	78.5%	314	656

▲ MAC-Guided Search

- Dataset: ImageNet
- Latency measured on a Pixel 1 CPU
- Search time (GPU-Hours) measured on V100s (BigNAS on TPU V3s)

Thank You for Watching

Project website: http://netadapt.mit.edu