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TEXAS
The University of Texas at Austin

An Efficient Training Framework for Reversible Neural Architectures

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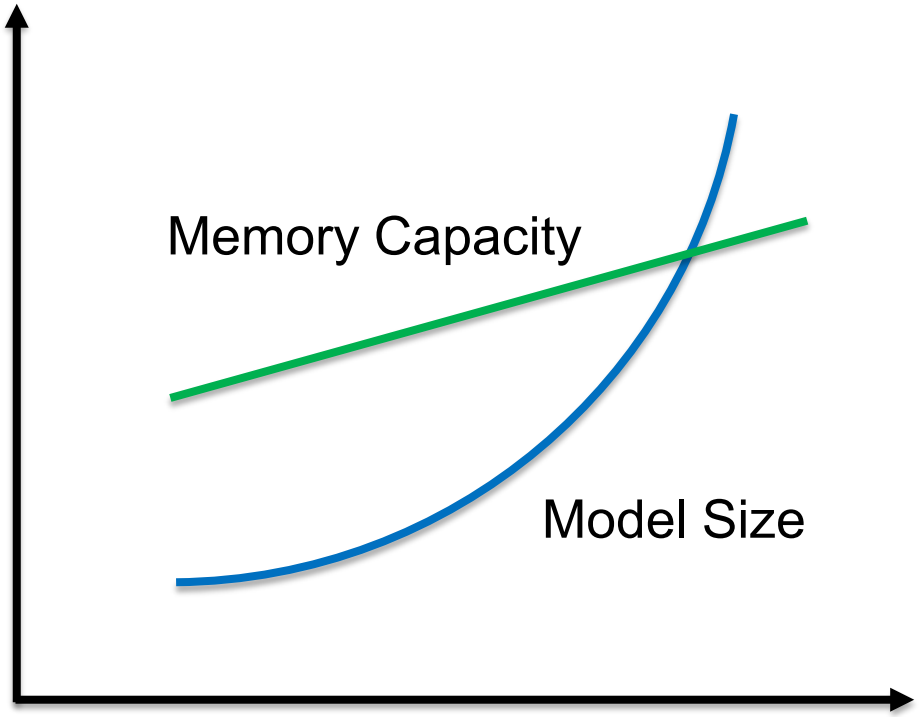
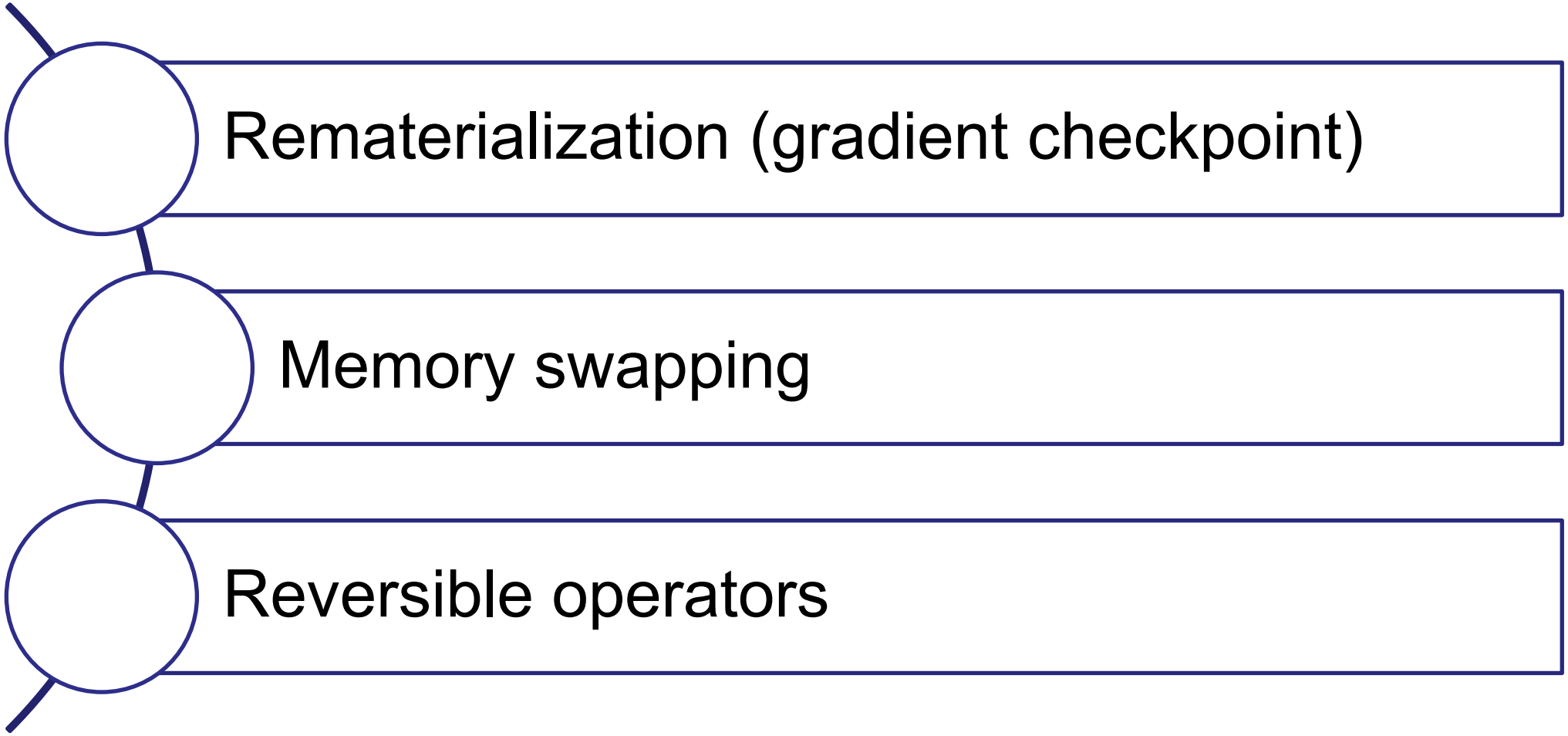
Large model hits memory capacity

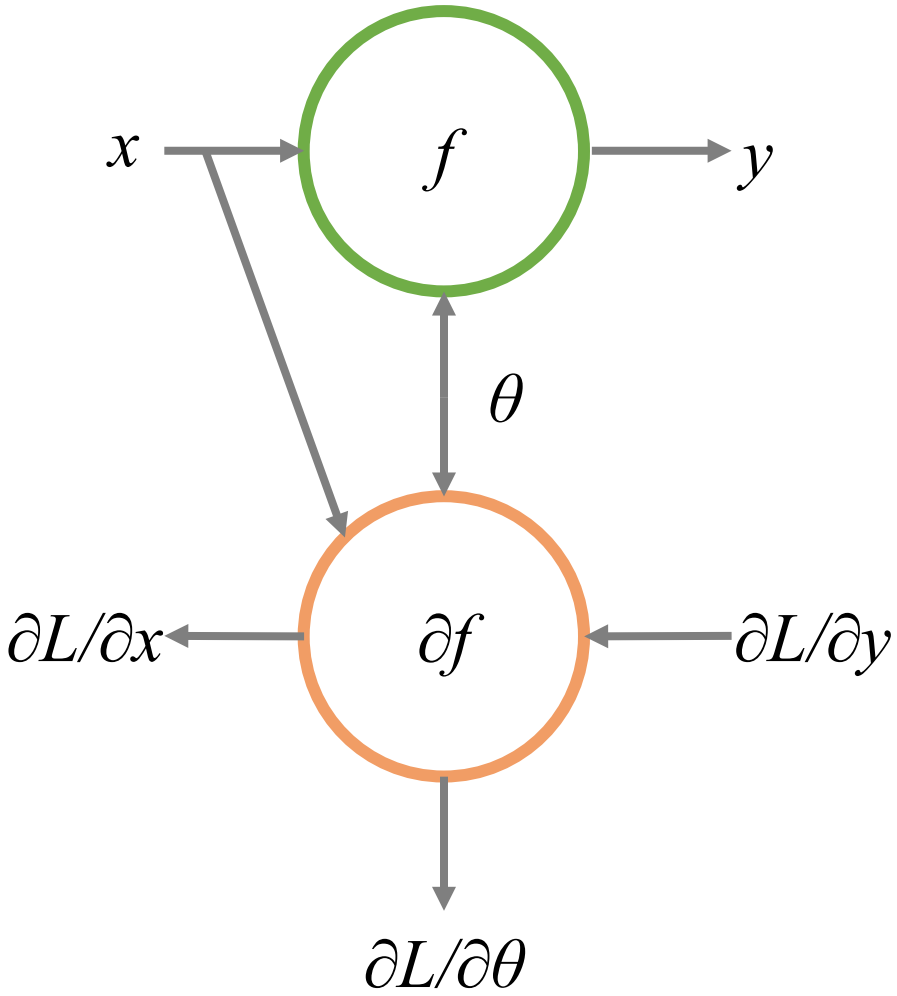


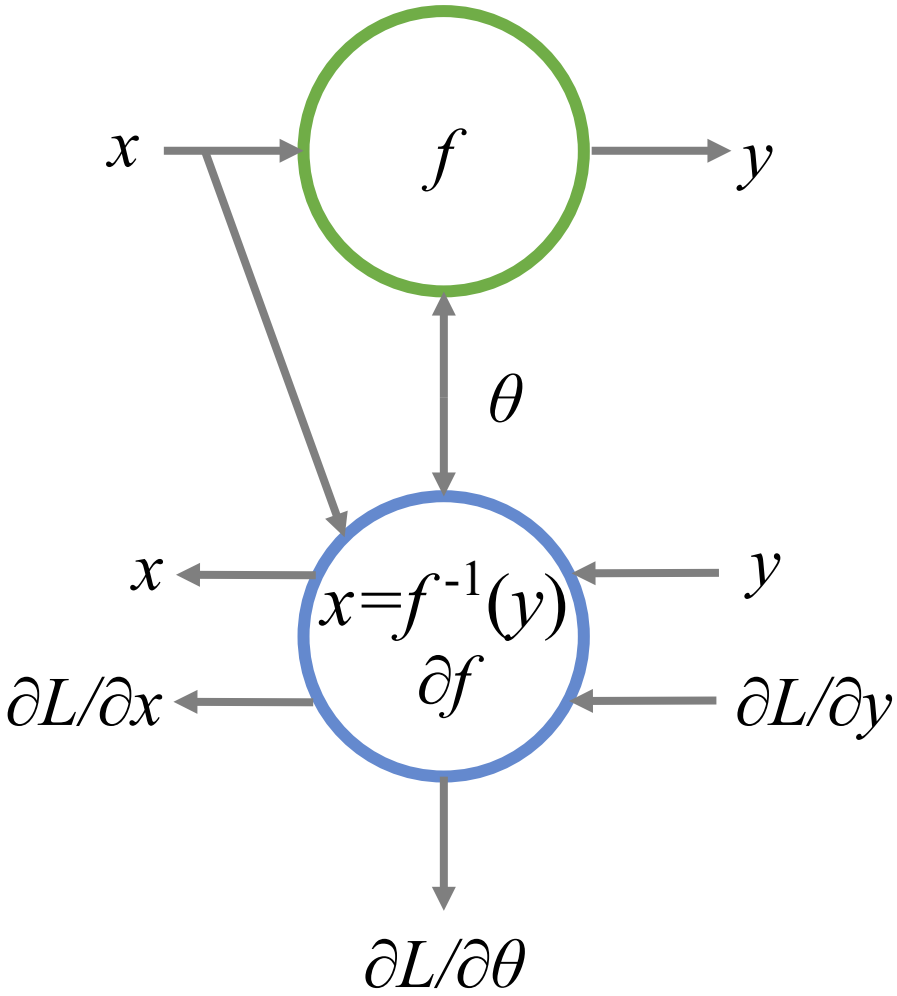
Mini-batch size of **1** in extreme cases.

Memory saving



Reversible operators





Related work

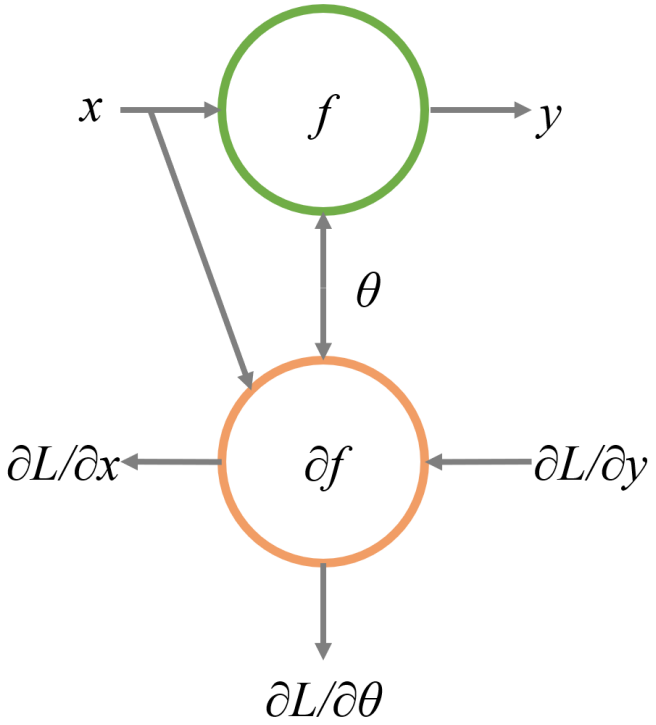
- Scheduling and graph optimization
  - Gradient checkpoint: [Chen et al. 2016], [Jain et al. 2020]
  - Memory swapping: [Zhang et al. 2019]

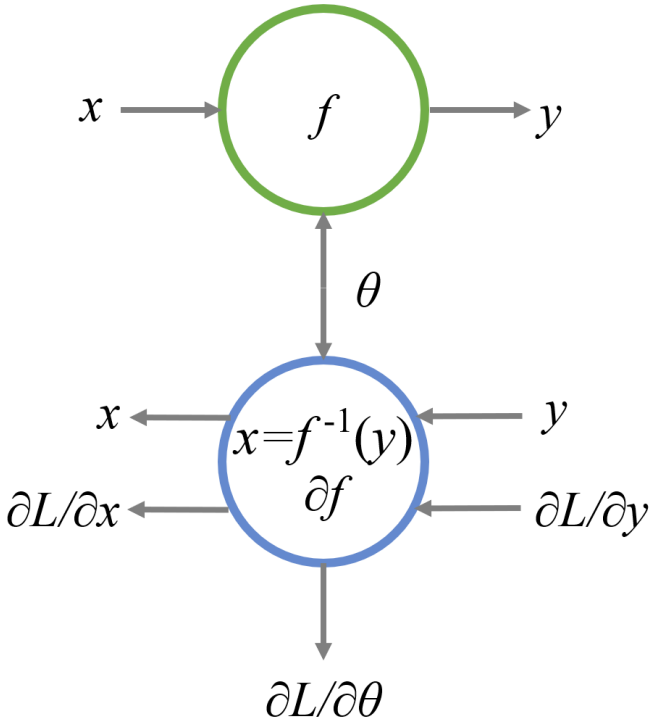
- Reversible neural networks
  - Implicitly reversible operator, e.g., convolution layers with a stride of 1
  - Inplace ABN [Bulò et al. 2018]
  - Neural ordinary differential equations [Chen et al. 2018]
  - Reversible residual architecture [Gomez et al. 2017]
  - Reformer [Kitaev et al. 2020]

- No work on scheduling for reversible neural networks.

What is the optimal scheduling for reversible neural architectures?

Two modes of a reversible operator

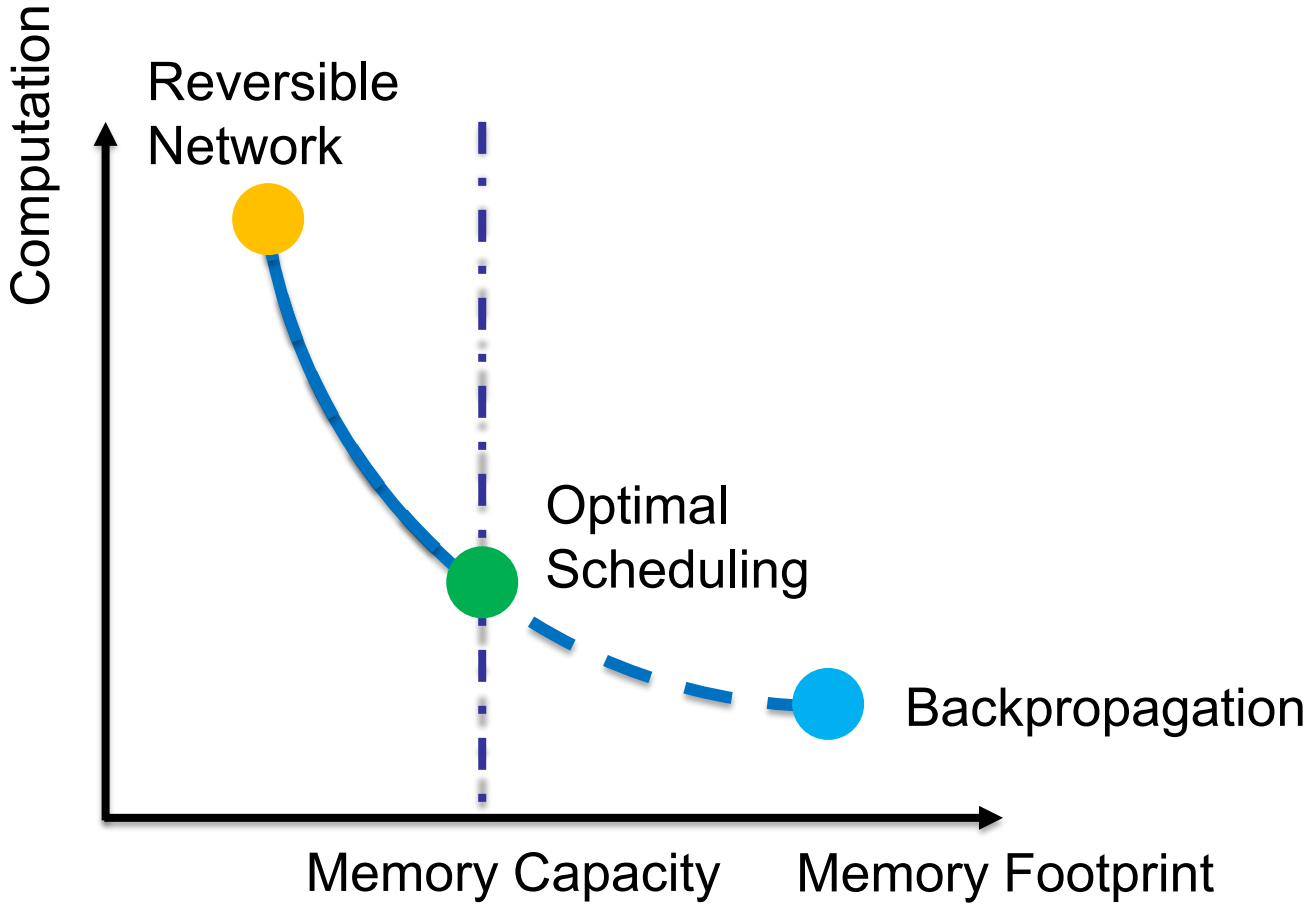




Mode	Forward	Backward	Computation cost	Memory cost
M-Mode	Discard x	Recover x from y	$x = f^{-1}(y)$	0
C-Mode	Save x	Use x directly	0	Size of x

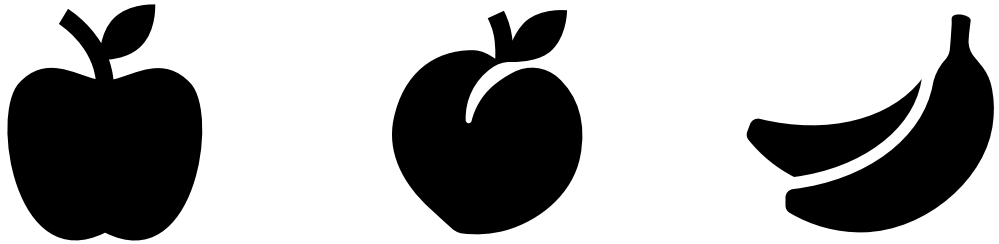
Scheduling problem

- For a neural network with n reversible operators, there are 2^n possible solutions.



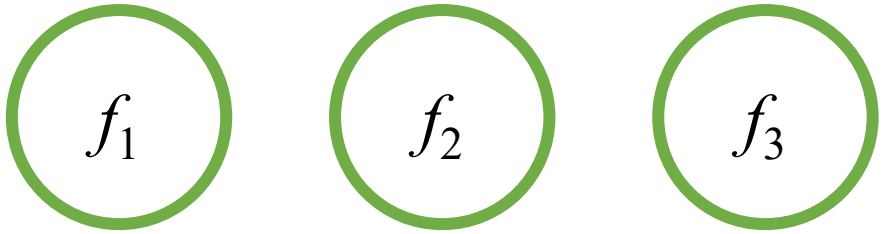
0/1 Knapsack problem

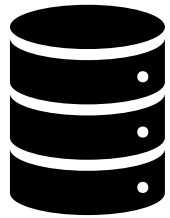
- n items
- Value, weight
- Bag capacity
- Fill the bag with the maximum value.



Scheduling problem

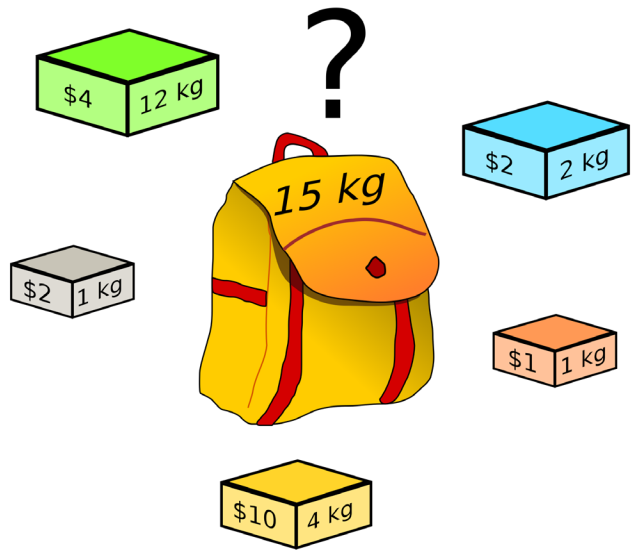
- n reversible layers
- Extra execution time, memory footprint
- Memory capacity
- Fill the memory with the maximum saved time.





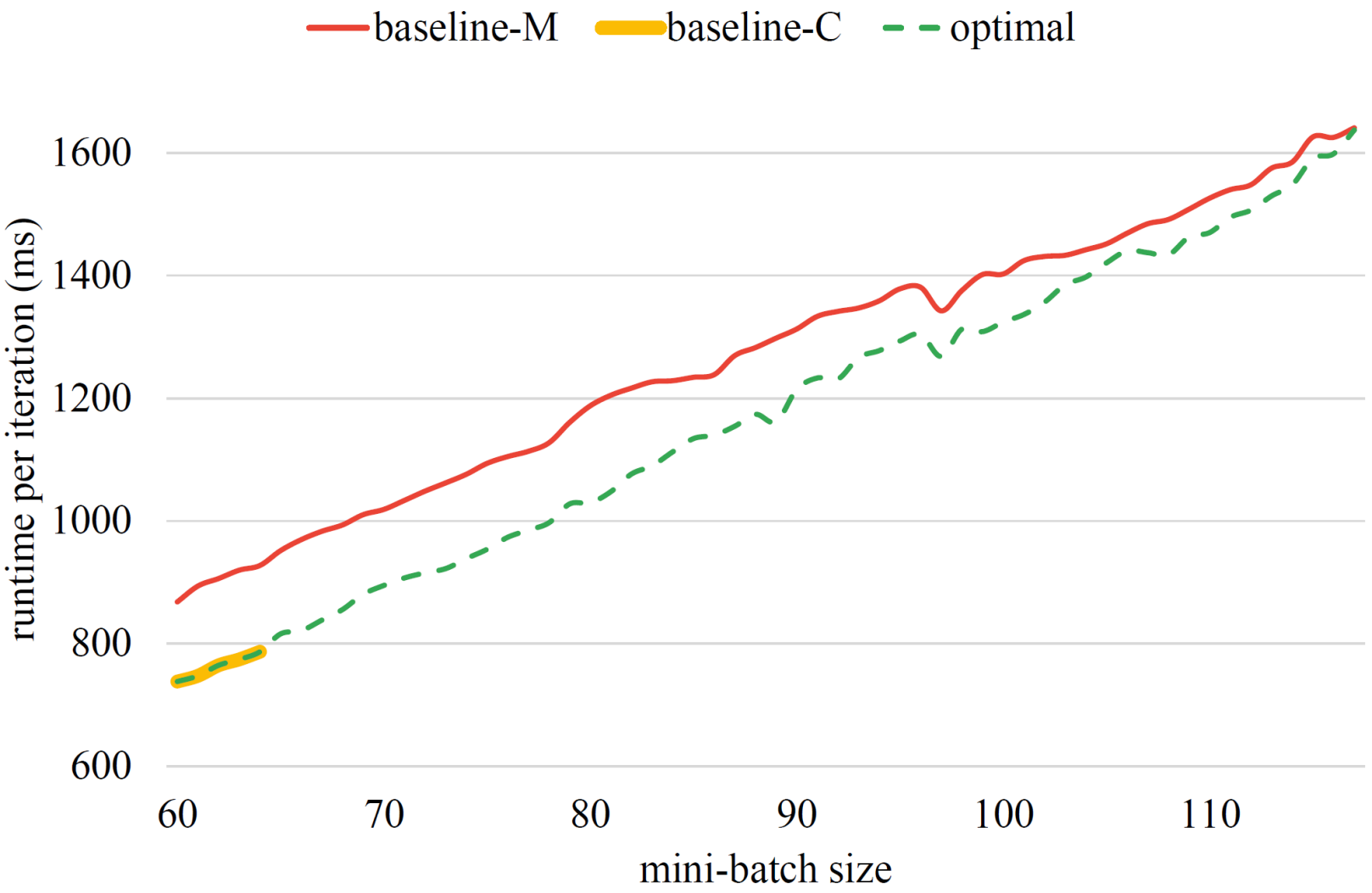
Algorithm and framework

- Use dynamic programming algorithm to solve the scheduling problem (knapsack problem).

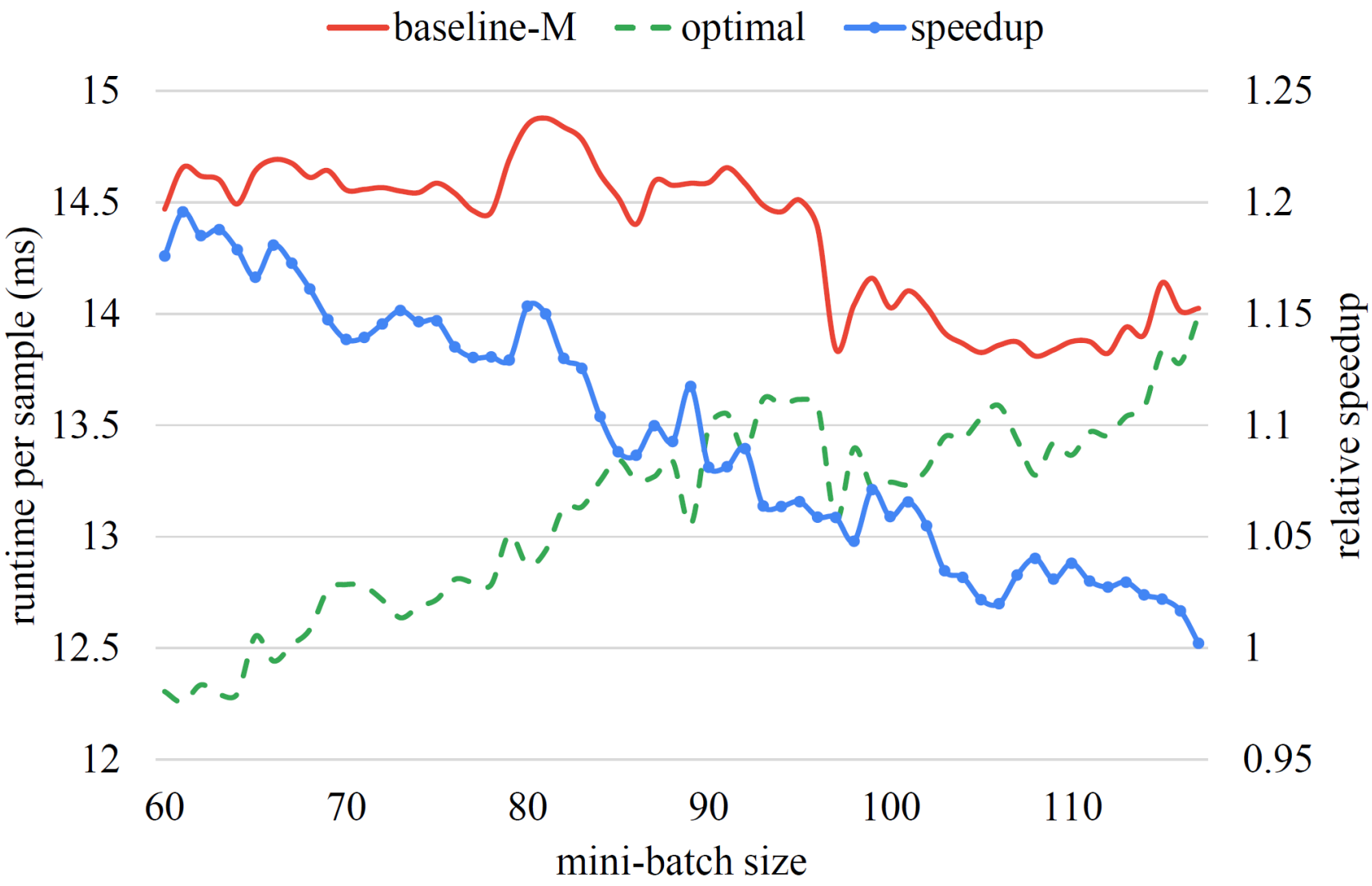


Reversibility analysis → Profiling → Decision via DP → Efficient training

Results on RevNet-104



Results on RevNet-104



Conclusions

- **New Perspective**. Scheduling for reversible architectures.
- **Optimality**. The problem can be solved use DP.
- **Automation**. Our framework provides a fully automated solution.

More in our paper

- Details regarding problem formulation
- What is the optimal batch size?
- More experiments on various reversible neural networks

Thank you!