An Efficient Checkpointing System for Large Machine Learning Model Training

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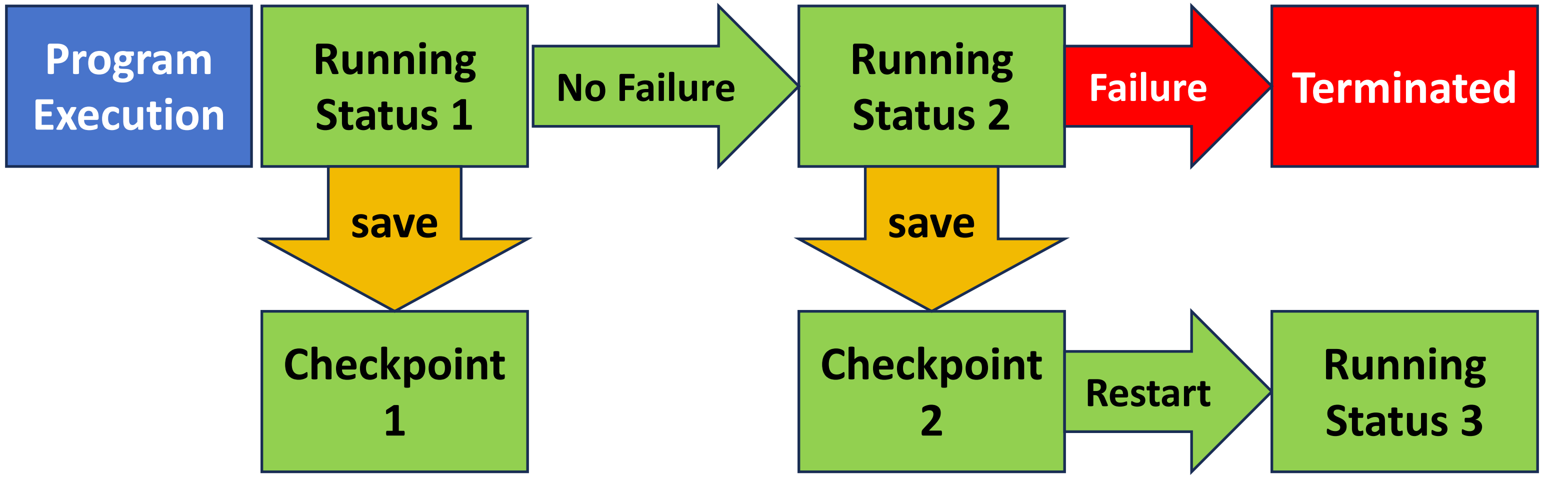
Outline

- Introduction
- Problem Definition
- Optimization Strategies
- Evaluation
- Conclusion

Checkpointing

- **What is Checkpointing?**
  - ➢Checkpointing is a technique that saves the state of program execution; upon a system failure, training can resume from the latest checkpoint

- **Why checkpointing needs improvement for large machine learning (ML) models?**
  - ➢As ML model sizes increase, frequently checkpointing can lead to significant performance and storage overhead



Problem definition

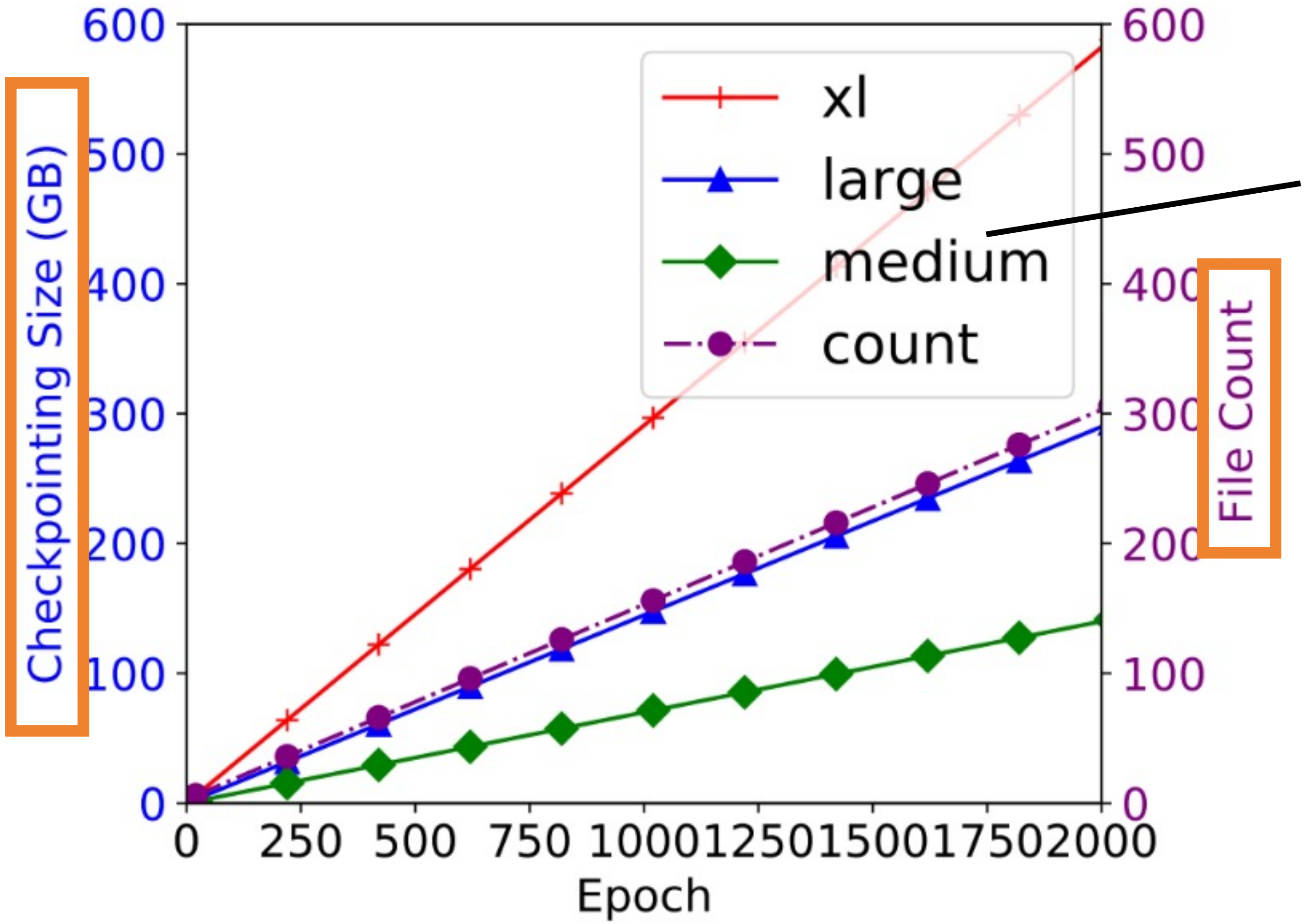
- The growing ML model size results in much larger checkpoint sizes

Model	Model Size	Checkpoint Size
GPT2-large	774M	2.9GB
GPT2-xl	1.5B	5.9GB
Vicuna	7B	13.4GB
OpenOrca	70B	14.5GB
LLama-2	70B	140GB
GLM	130B	70GB
BLOOM	176B	329GB
GPT3	175B	700GB

- Large language models: model size and checkpoint size

Problem definition (cont.)

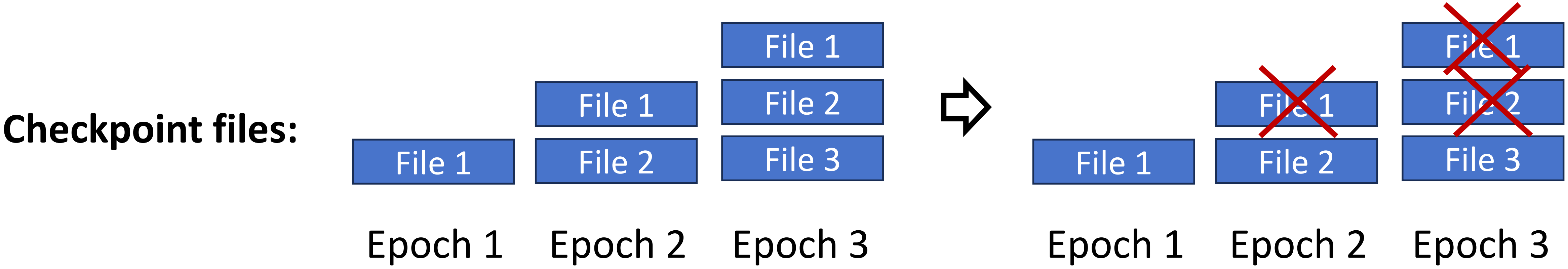
- We observed an increase in both the number of cumulative checkpoint files and the storage consumed by checkpoints



GPT2 variants:
GPT2-xl;
GPT2-large;
GPT2-medium

Optimization: *Periodic cleaning*

- Periodically and asynchronously delete outdated checkpoints while keeping the latest ones



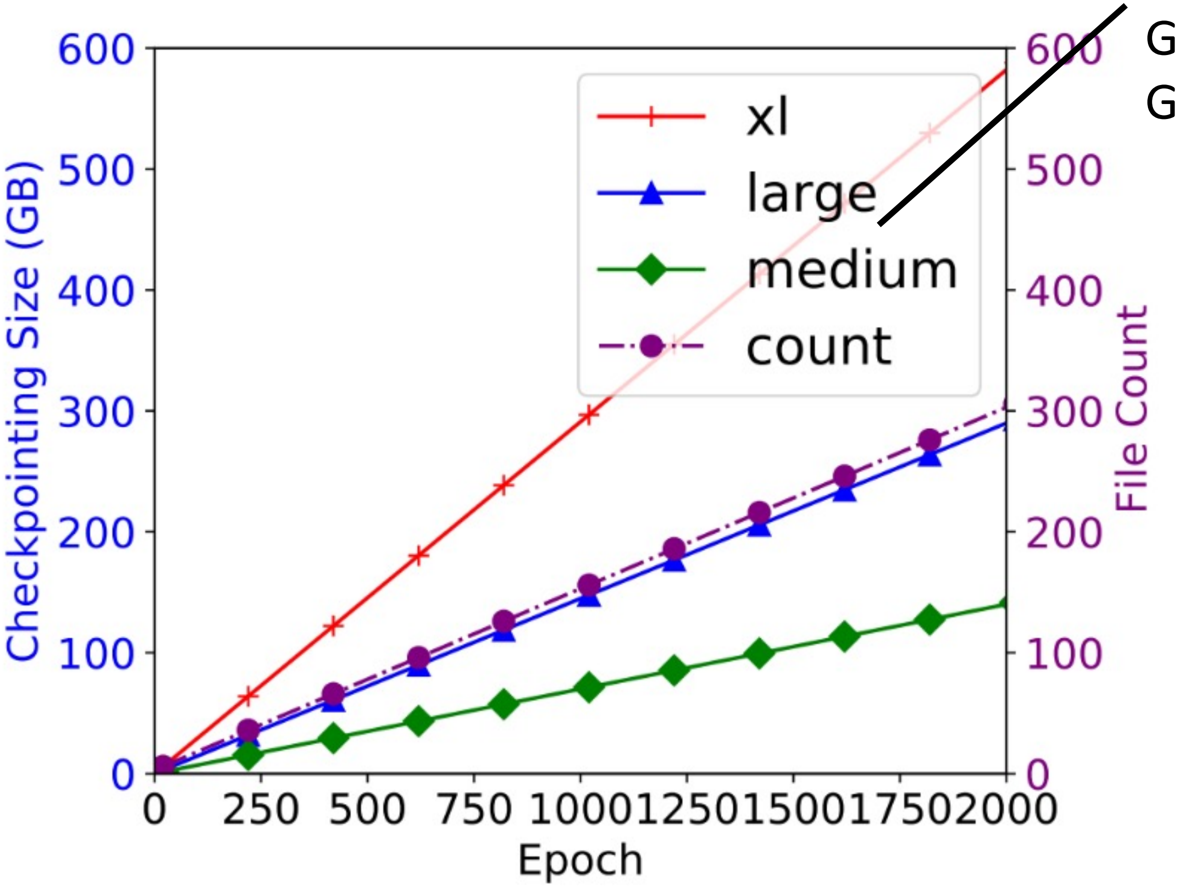
Optimization: *Staging*

- We observe that existing ML training writes checkpoints to parallel file systems
  - However, I/O bandwidth on parallel file system is much lower than local storage
  - E.g., I/O bandwidth is about 23 MB/s on NFS while 4.1 GB/s on local SSD

- Optimization:
  - Write checkpoints to the local file system like SSD
  - Spawn a separate process to move the outdated checkpoints to parallel file systems
  - The staging is independent from the training process

Evaluation: *Periodic cleaning*

GPT2 variants:
GPT2-xl;
GPT2-large;
GPT2-medium



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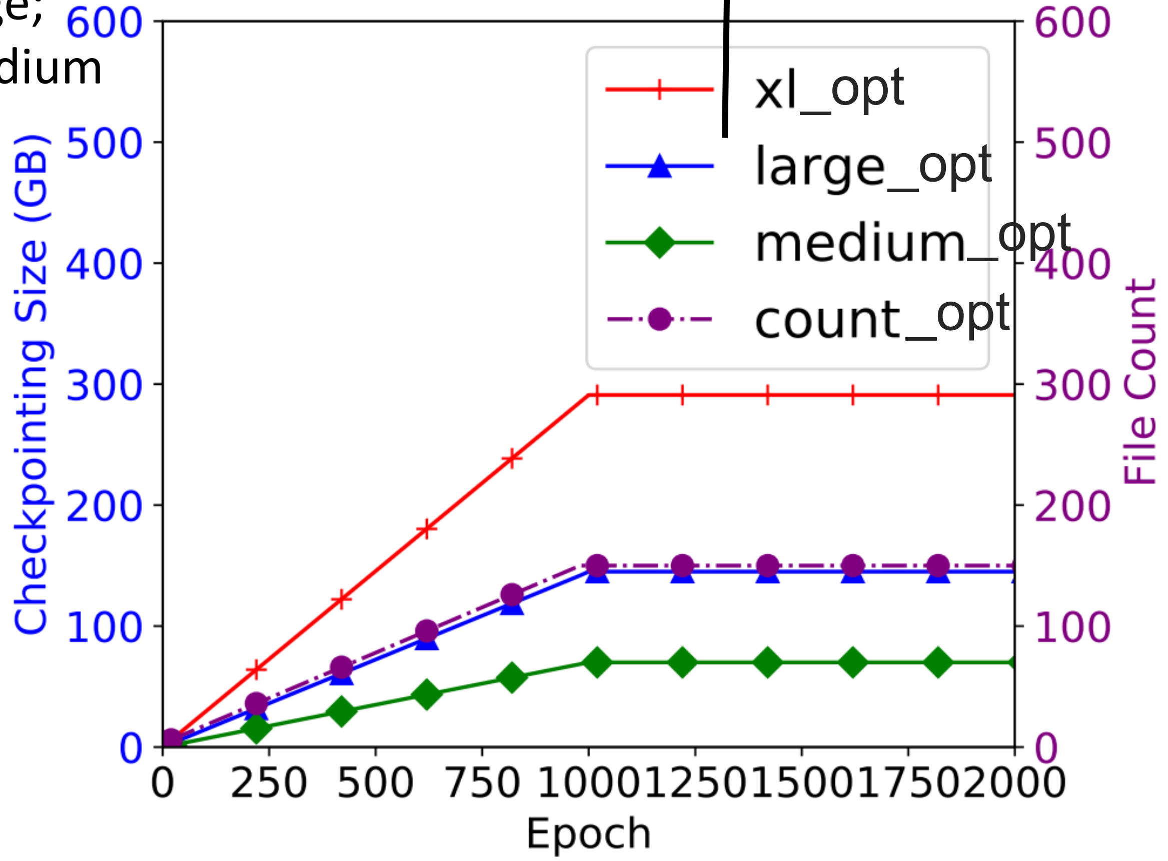
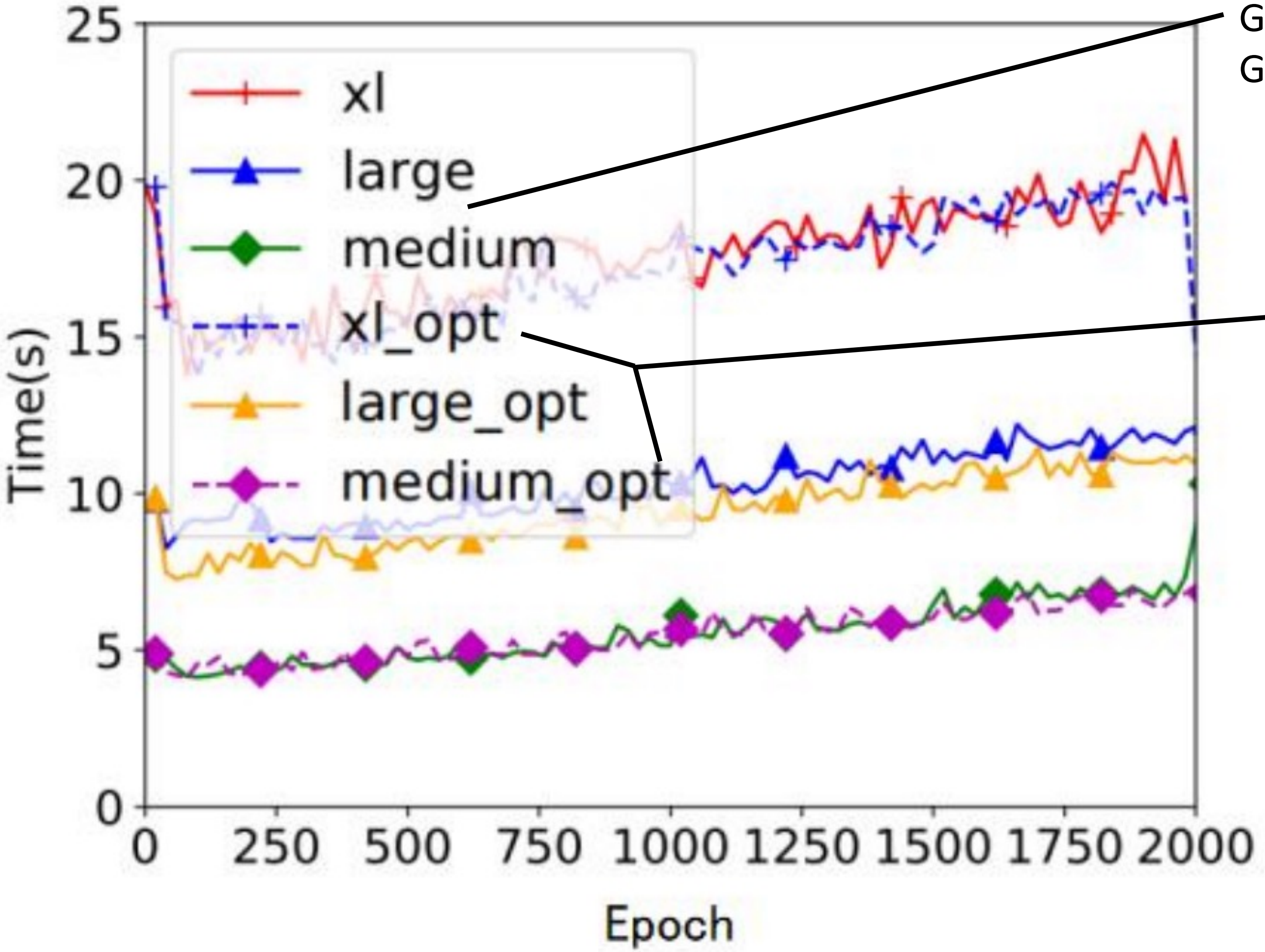
With periodic cleaning



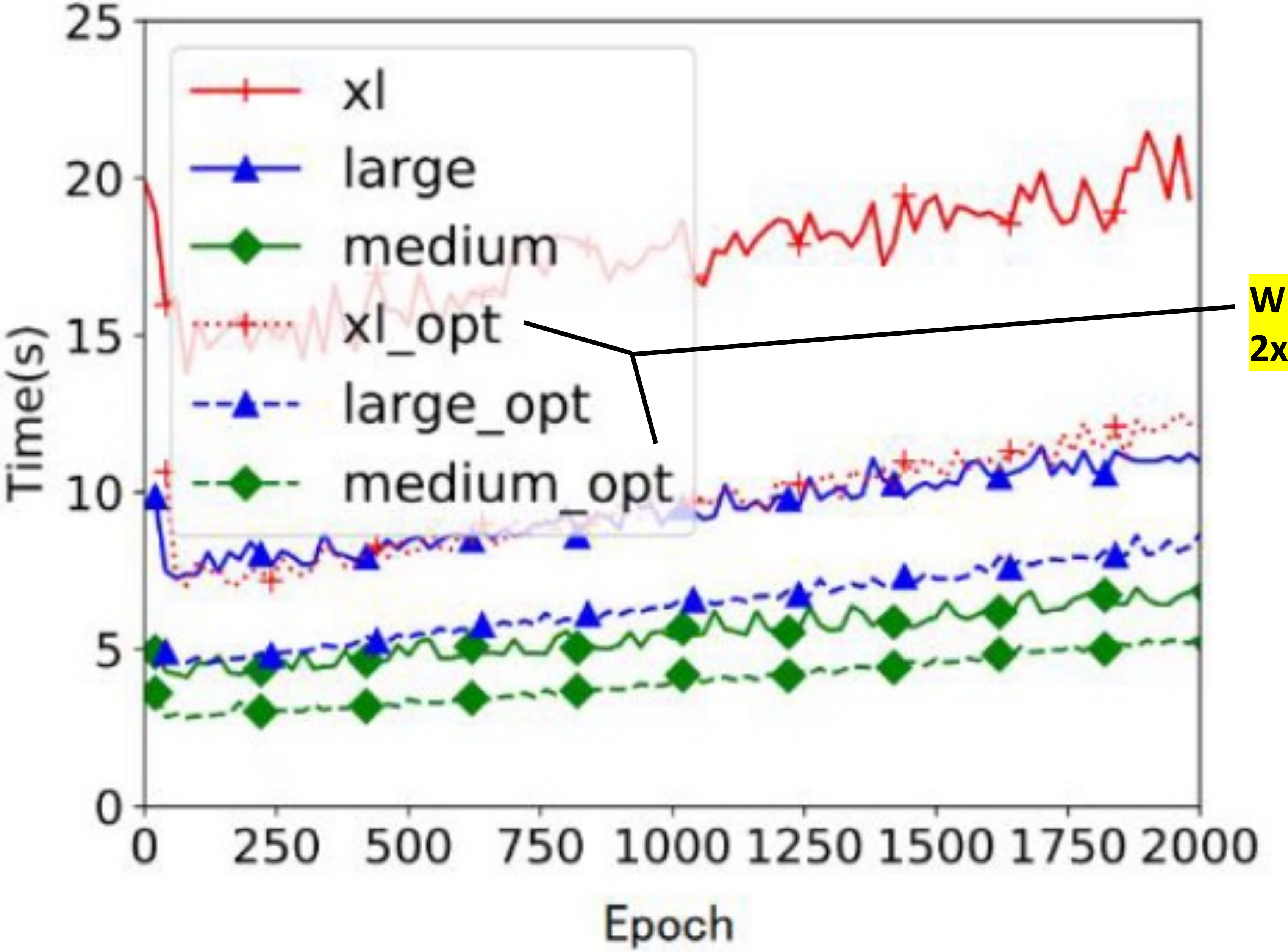
Evaluation: *Periodic cleaning (Cont.)*



GPT2 variants:
GPT2-xl;
GPT2-large;
GPT2-medium

With periodic cleaning

Evaluation: *Staging*



With staging: 2x speedup

Conclusion

- We characterize the checkpointing with respect to storage and performance in large ML model training
- We propose two checkpointing optimization strategies for large ML models
- We verify the effectiveness and reliability of the proposed optimizations with GPT-2 variants

Thank you

for your attention