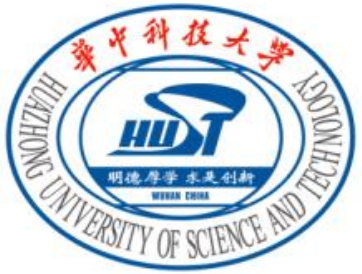

A Cost-Efficient Failure-Tolerant Scheme for Distributed DNN Training

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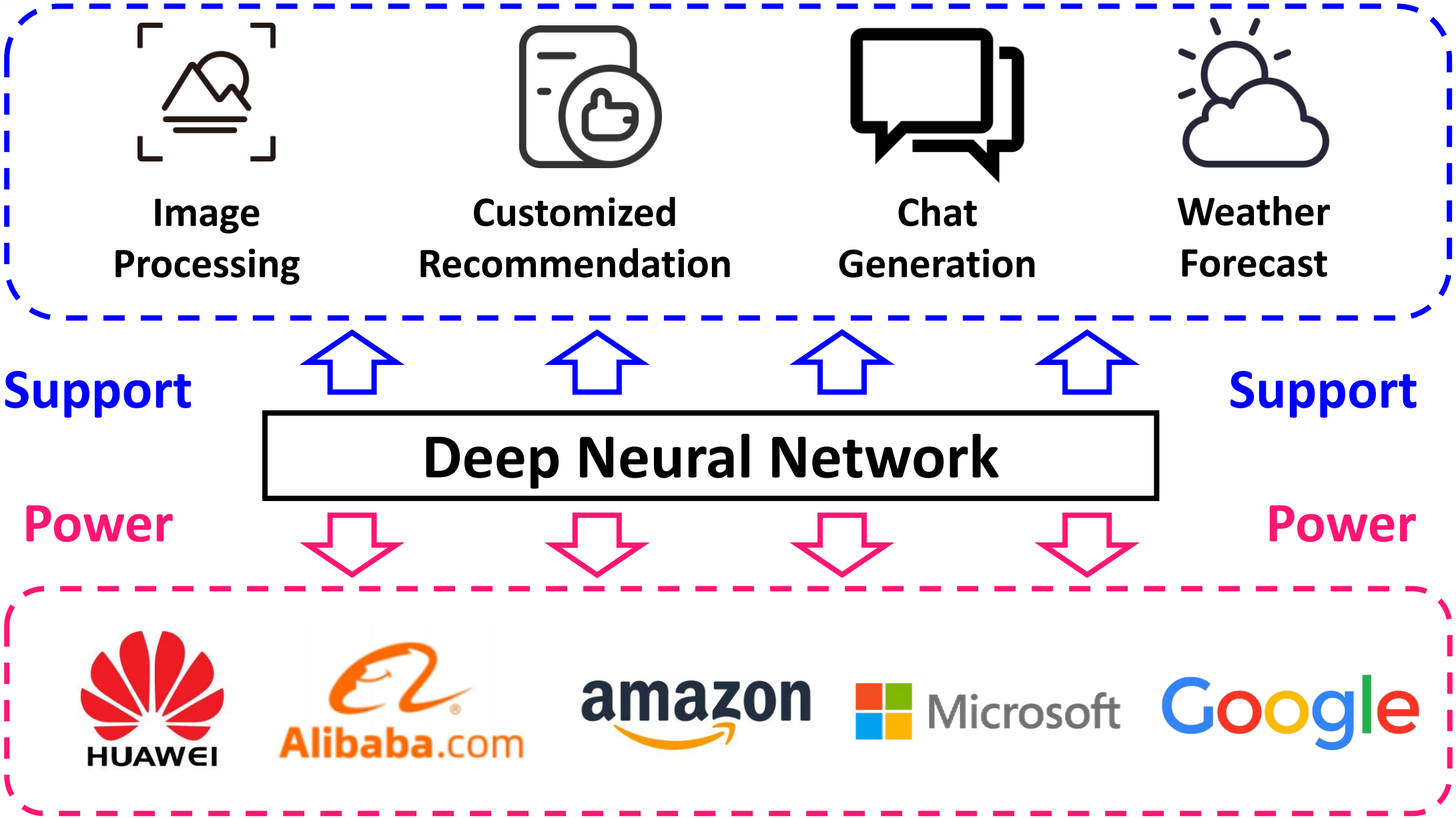
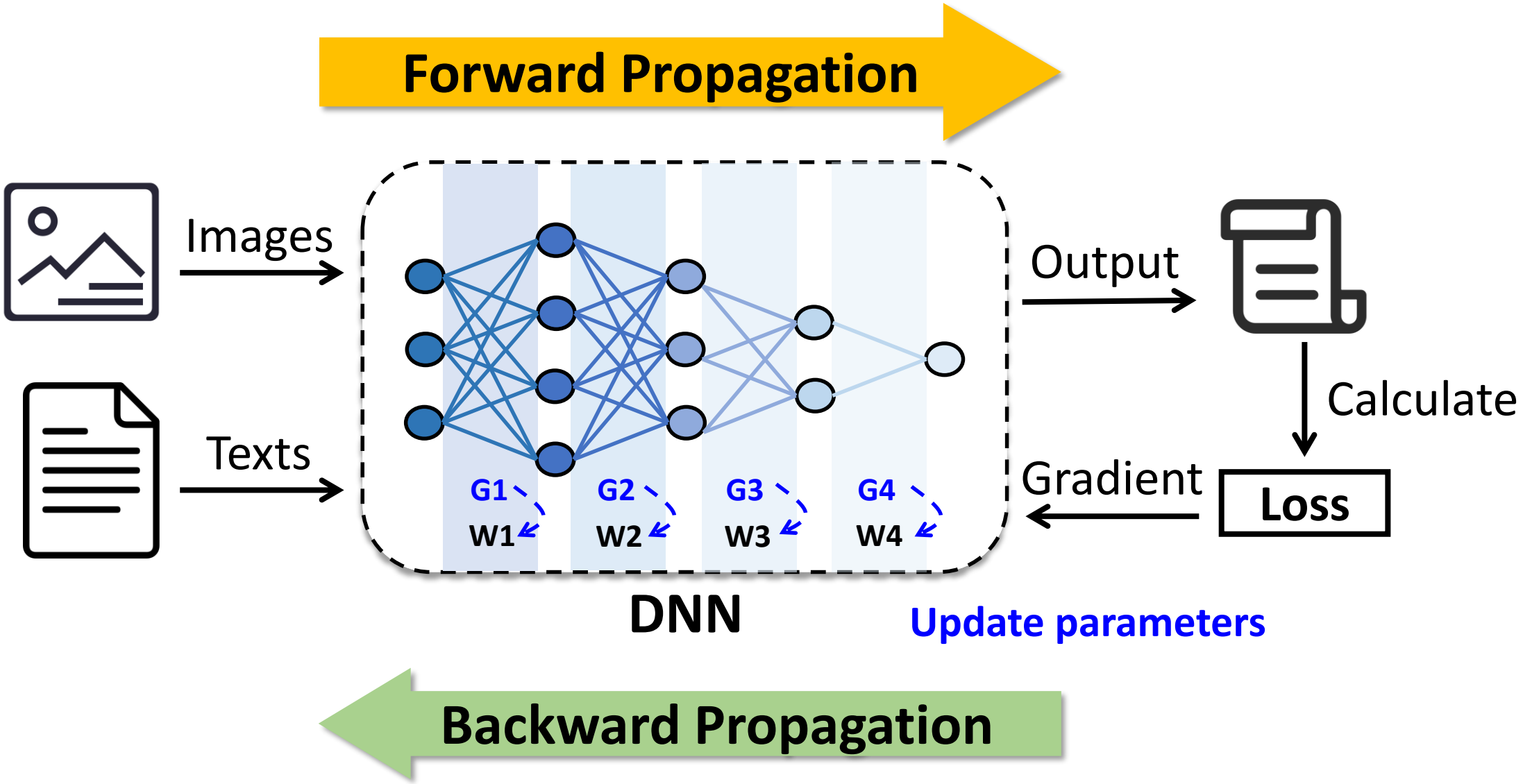
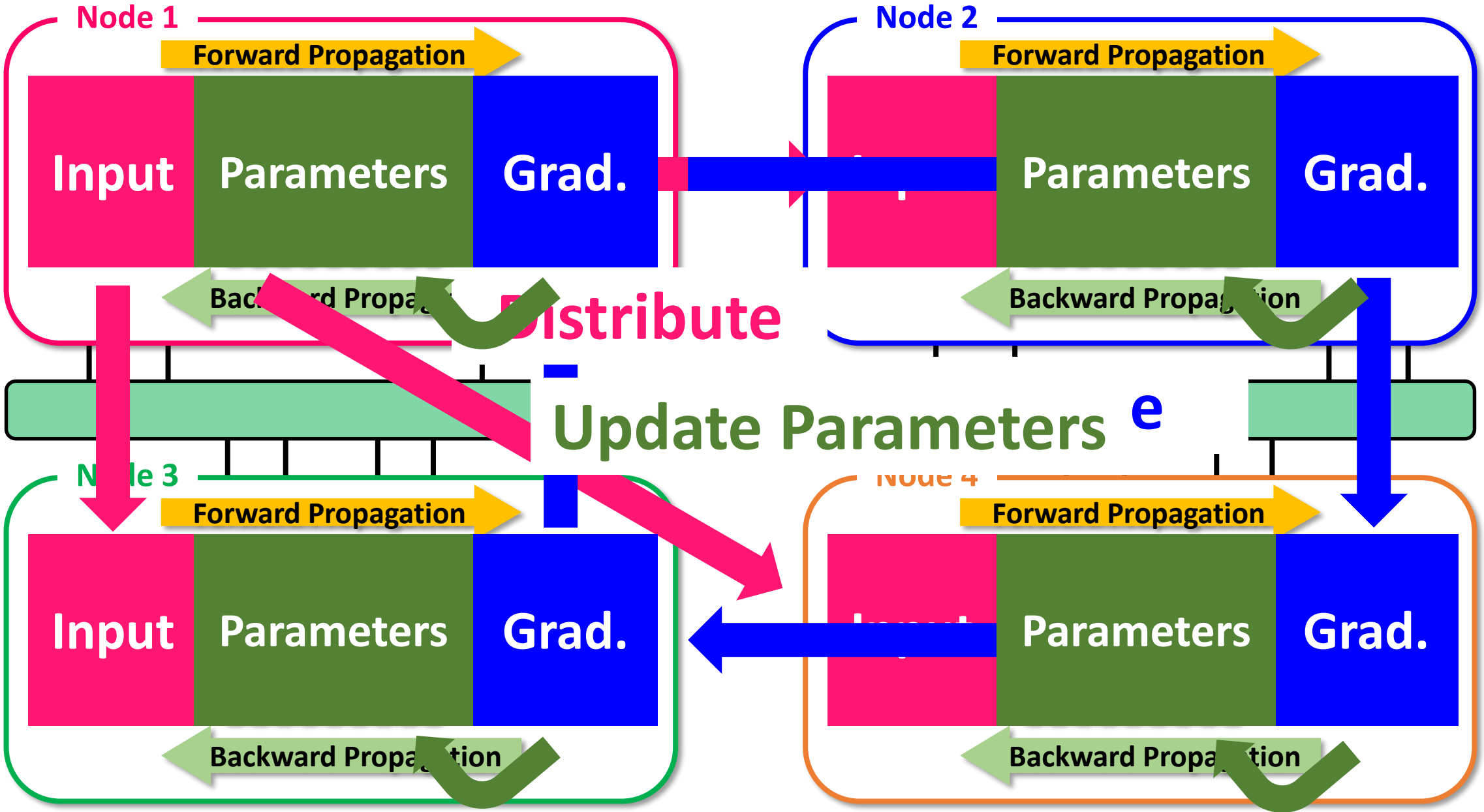
Deep Neural Network (DNN)



DNN Training

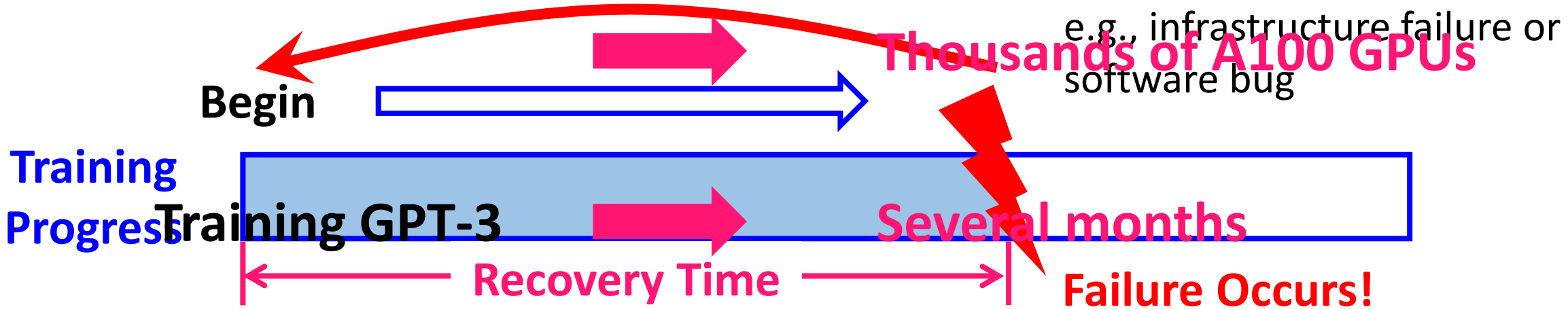


Distributed DNN Training

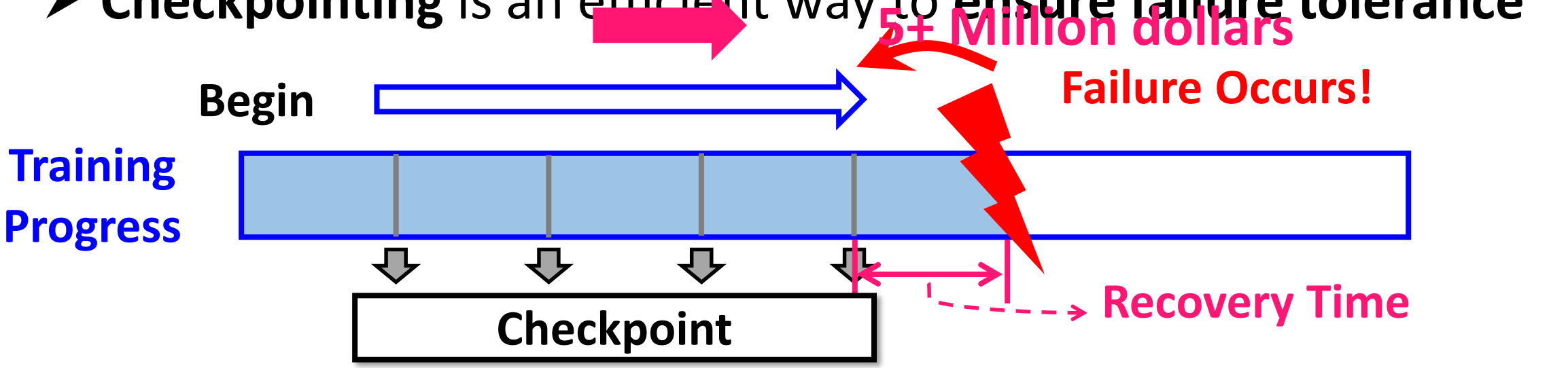


The importance of Failure Tolerance

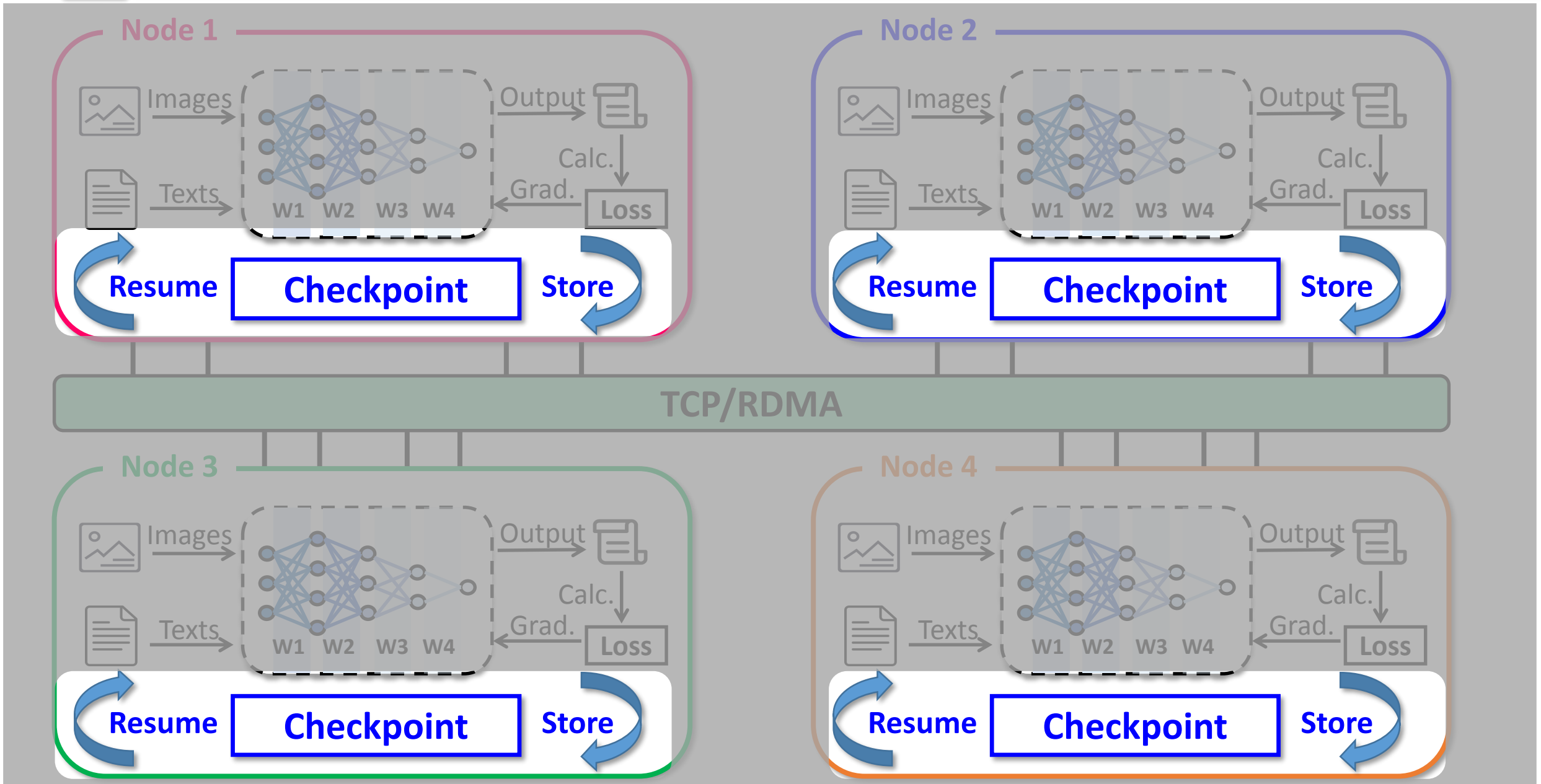
- DNN training is **time-consuming** and **expensive**



- **Checkpointing** is an efficient way to **ensure failure tolerance**



Checkpointing in Distributed DNN Training



The Need of Frequent Checkpointing

- Failures are common in large-scale GPU clusters
  - **The mean time between failures** is low to **a few minutes**
- Frequent job switches in the preemptive GPU cluster scheduling
  - **The interval between two switches** may be only **a few seconds**

Frequent Checkpointing

⇩

High Runtime Overhead

Existing Checkpointing Schemes are Inefficient

- **Synchronous checkpointing**[1]
  - Introduce **severe training stall**
  - Suffer from **high runtime overhead**
- **Asynchronous checkpointing**[2-4]
  - Two-phase checkpointing
  - Pipeline the checkpointing with computation
  - Sub-optimal due to **monolithic** checkpointing process
  - **Fail to** fully pipeline checkpointing with communication

[1] PyTorch@NIPS'19 [2] SCAR@ICML'19 [3] DeepFreeze@CCGRID'20 [4] CheckFreq@FAST'21

Persistent Memory (PM)

- Intel Optane PM
- Samsung Memory-Semantic CXL (Compute Express Link) SSD

OR

Byte-addressable **Fine-grained Persistence** **Near-DRAM performance**

Our Design

LightCheck: A cost-efficient checkpointing scheme for distribued DNN training

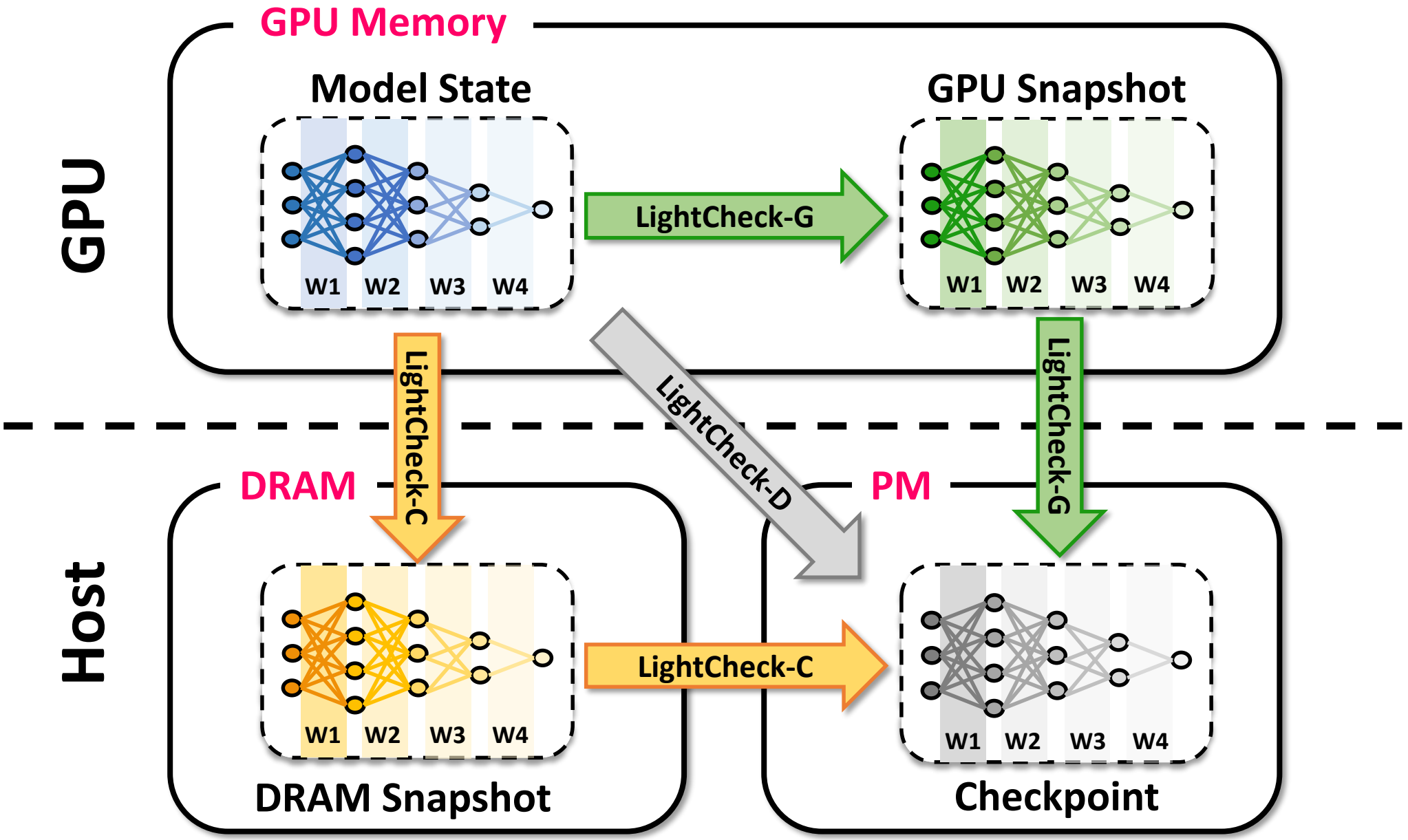
- **Asynchronous layer-wise checkpointing**
  - Fine-grained pipelining
  - Communication-aware

  ➡ **Minimizing training stalls**

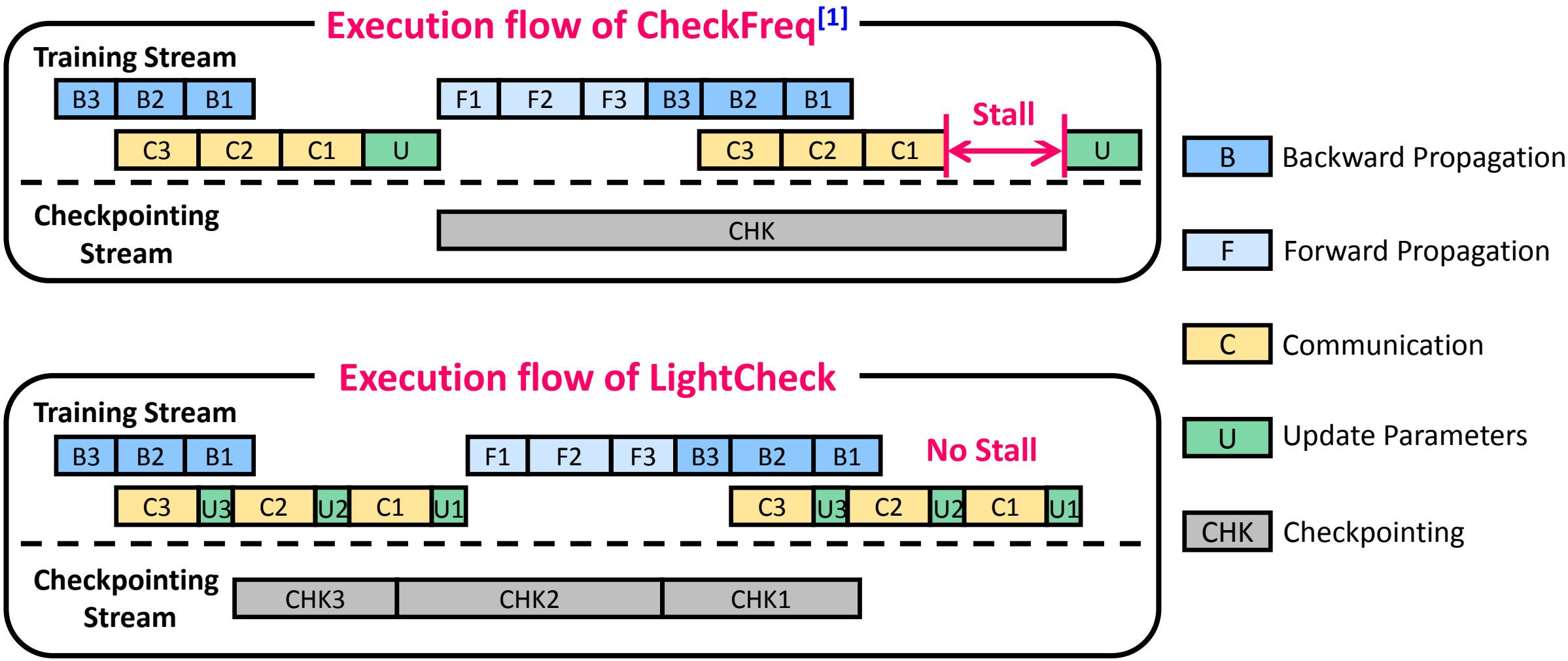
- **Efficient persistent memory management**
  - Direct access
  - Metadata-aware

  ➡ **Fully exploiting persistent memory**

Checkpointing Strategies

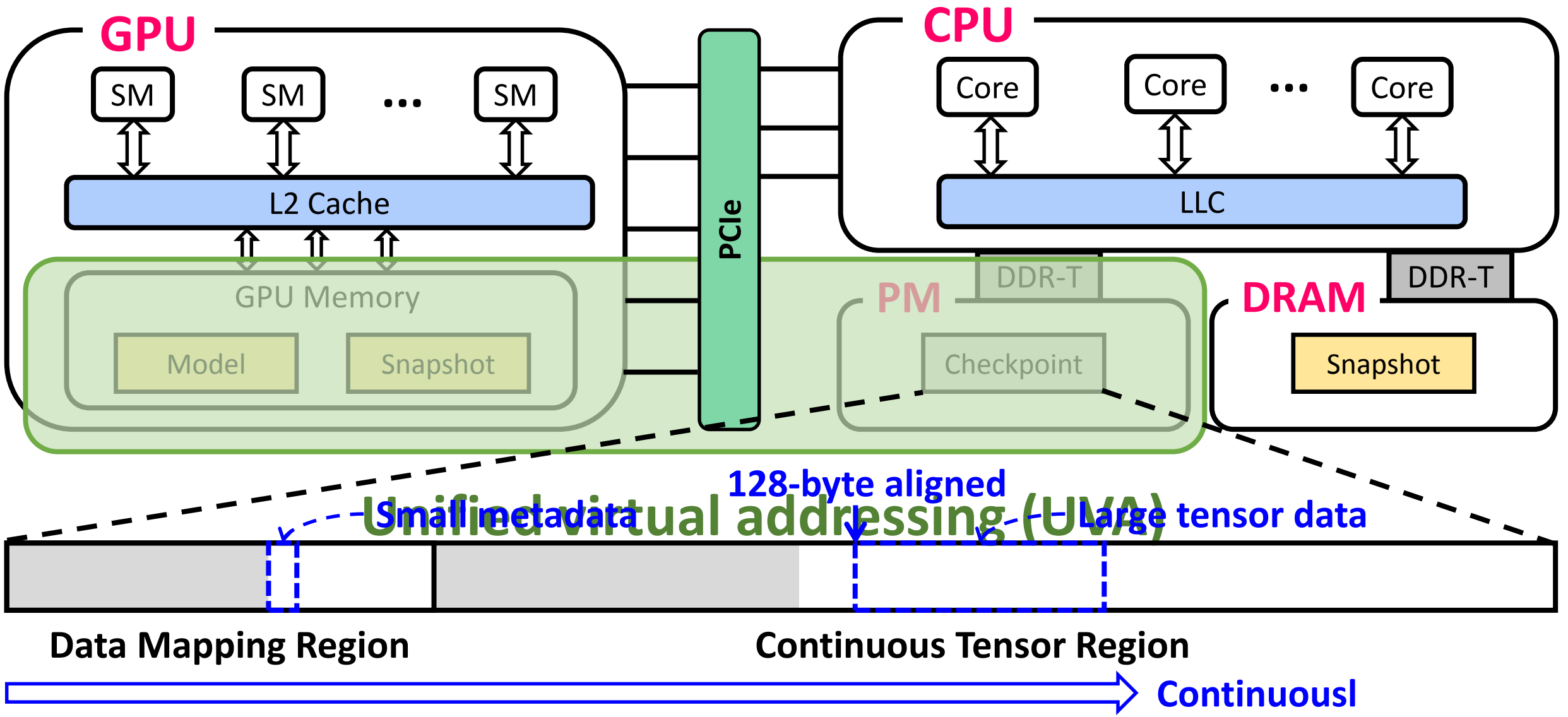


Asynchronous Layer-wise Checkpointing



[1] J. Mohan, A. Phanishayee, and V. Chidambaram, “Checkfreq: Frequent, fine-grained dnn checkpointing,” in FAST, 2021

Efficient persistent memory management



Evaluation

- **Platform**
  - Three nodes connected via 100 Gbps Mellanox InfiniBand switch
- **DNN Models**
  - ResNet-18, VGG-16, Inception-V3, AlexNet, GPT-2, BERT
- **Comparisons**
  - CheckFreq, Pytorch

Sever Configuration

Machine	CPU	GPU	Memory	Storage	Network
3 nodes	Intel Xeon Gold 6230R, 26 cores	1 Tesla V100, 16GB	192GB DRAM, 6 X 128GB Intel Optane PM Modules	3.6TB HDD	100Gbps Mellanox InfiniBand Switch

Checkpointing Frequency

- Limit runtime overhead within 5%

Models	Checkpoint Size (MB)	Number of Iterations					
		LightCheck-G	LightCheck-C	LightCheck-D	LightCheck-disk	CheckFreq	torch.save
ResNet-18	90	1	1	1	7	20	102
VGG-16	1,056	6	6	6	64	146	904
Inception-V3	183	14	14	14	30	40	118
AlexNet	467	8	8	8	95	164	1,084
GPT-2	1,508	6	6	6	46	100	682
BERT	4,004	10	10	10	82	200	1,100

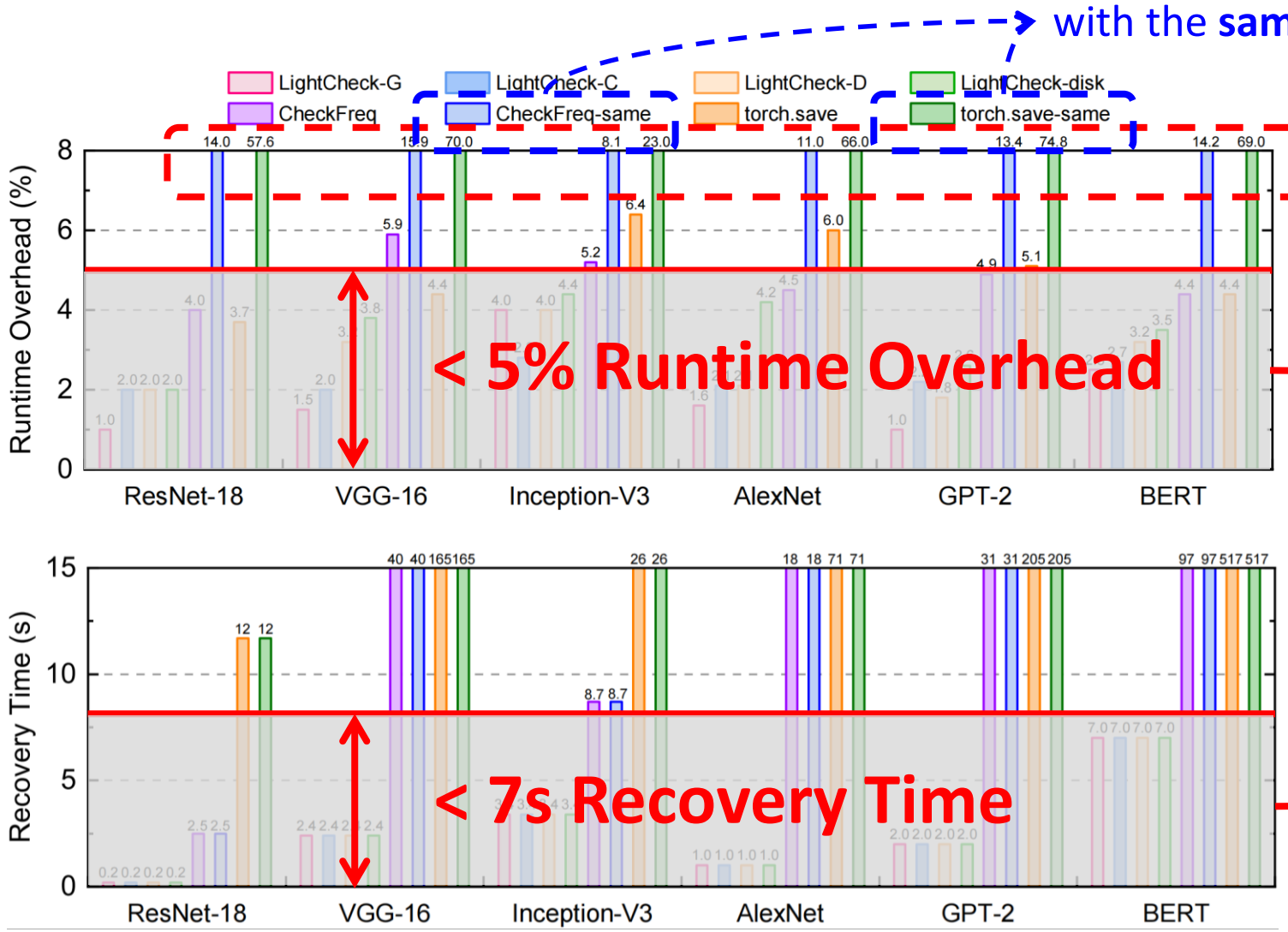
LightCheck can ach
with **mode**

Asynchronous layer-wise checkpointing **reduces** the runtime overhead

to 10X to 2X

Overall Performance

- With the aboved checkpointing frequency

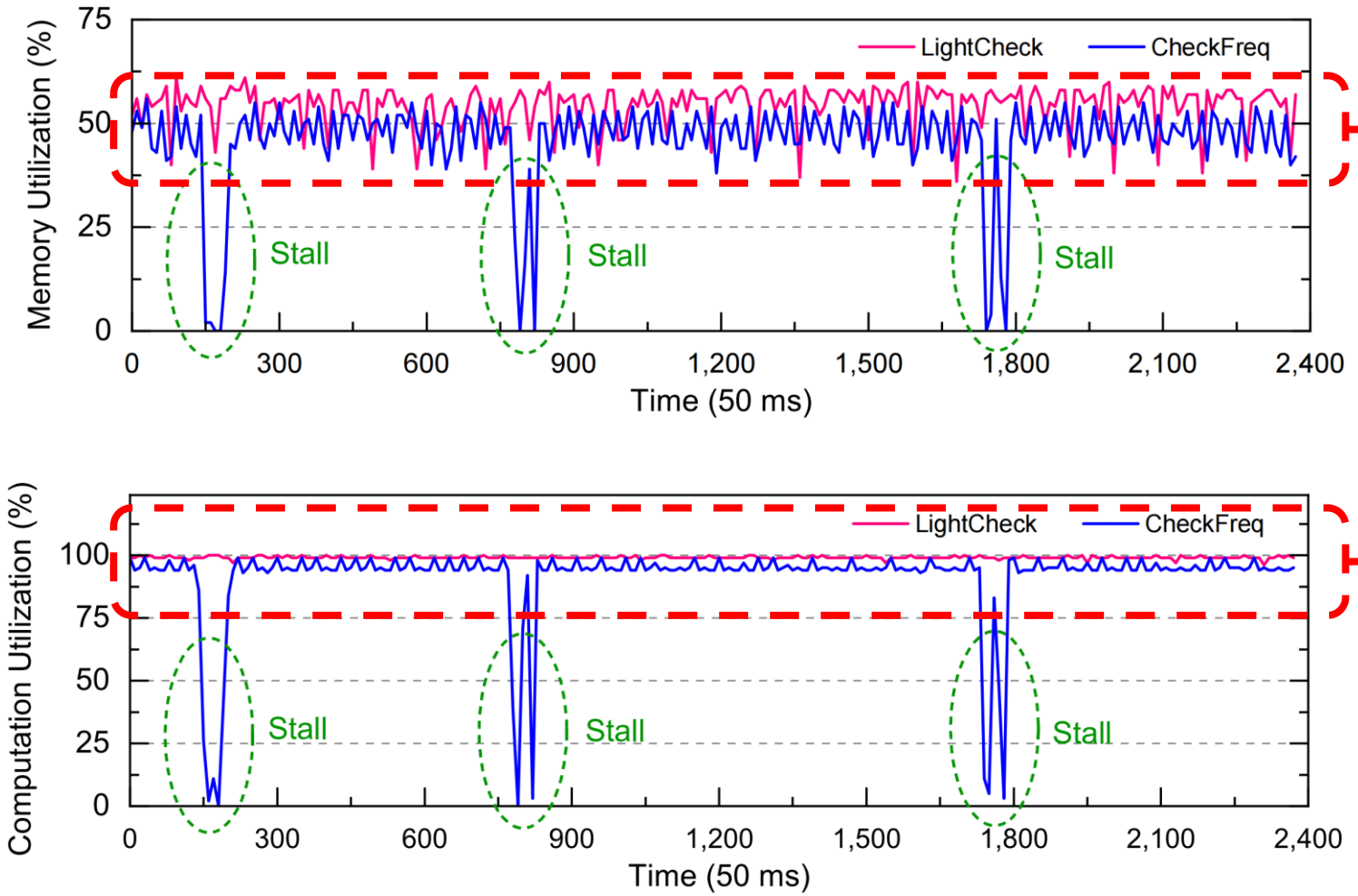


Incuring **high** runtime overhead when performing **frequent** checkpointing

LightCheck provides **lower** recovery time and overhead than existing schemes

GPU Utilization

- Record the GPU utilization every 50 ms, VGG-16



LightCheck **eliminates** training stall by leveraging find-grained pipelining

Conclusion

- **LightCheck: A cost-efficient checkpointing scheme for DNN training**
  - Asynchronous layer-wise checkpointing
  - Efficient persistent memory management
- More evaluation results and analysis are in the paper
- Available at: https://github.com/LighT-chenml/LightCheck.git

Thank you! Q&A