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SDP4Bit: Toward 4-bit Communication Quantization in Sharded Data Parallelism for LLM Training

Jinda Jia , Cong Xie*, Hanlin Lu, Daoce Wang, Hao Feng, Chenmgming Zhang, Baixi Sun, Haibin Lin, Zhi Zhang, Xin Liu, Dingwen Tao†*

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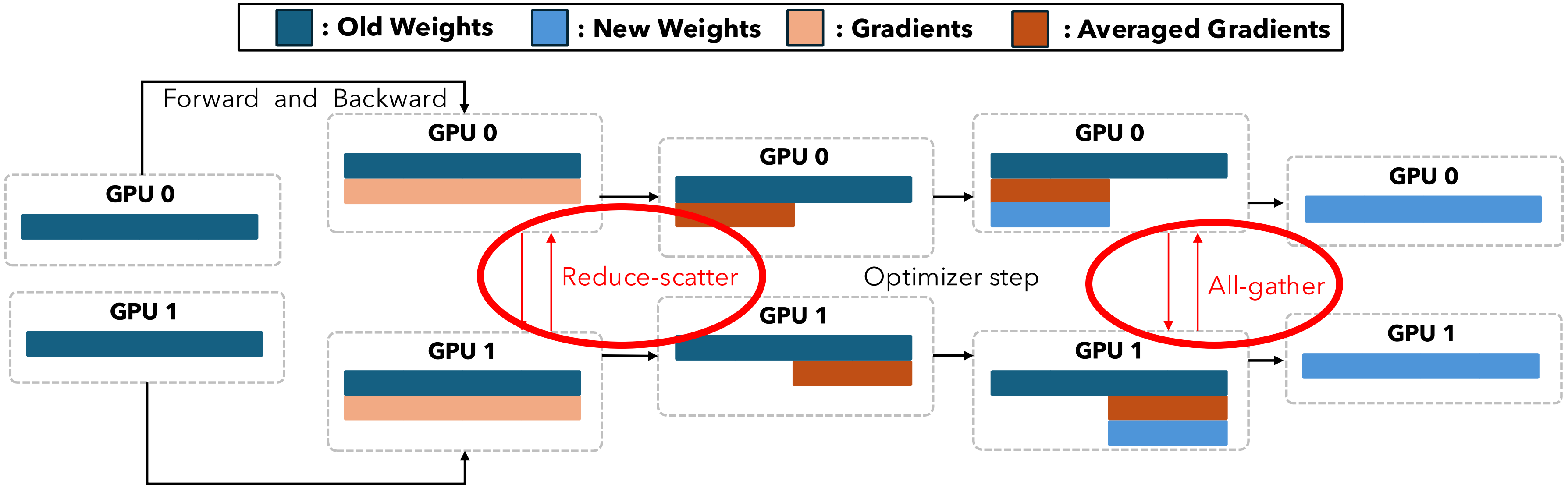
ByteDance

* Equaly contributed first authors

† *Correspoding author*

Communication Overhead is Large During Training

Communication is slow, especially inter-node communication.



Communication pattern for Shared Data Parallelism

What SDP4Bit Can Achieve?

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Weight Communication:

16 bits → 4 bits

Gradient Communication :

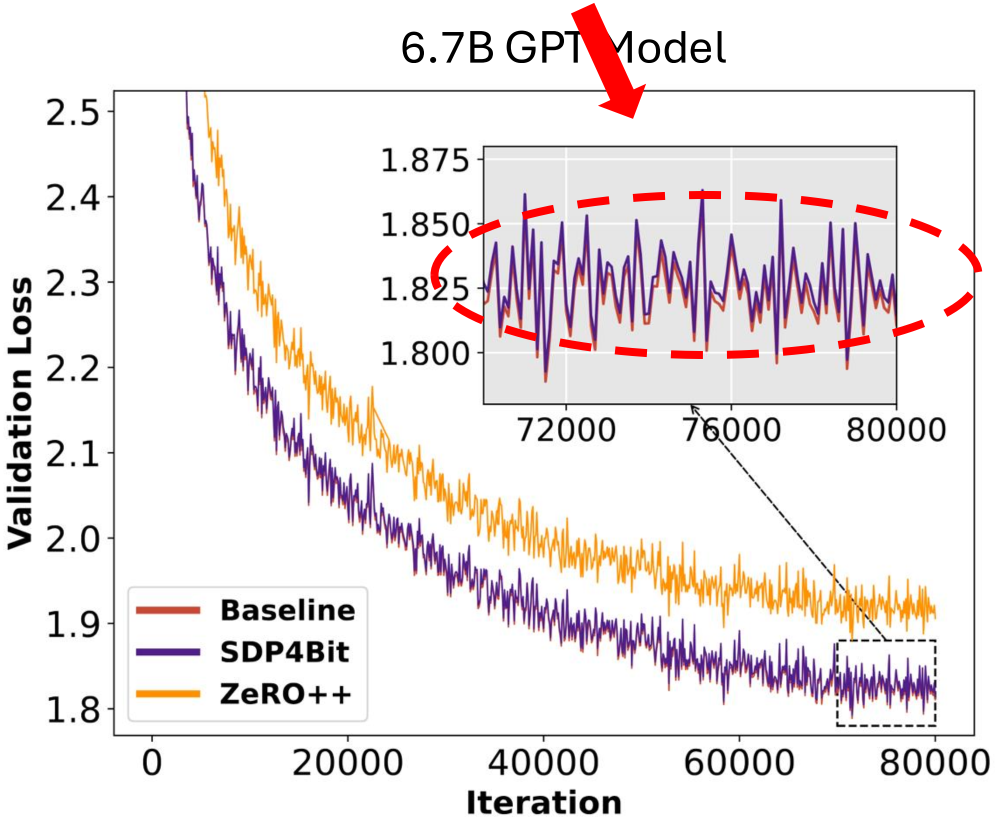
Intra Node: 32 bits → 8 bits *(can be hidden)*

Inter Node: 32 bits → 4 bits

4x reduction for weight

8x reduction for gradient

Almost no accuracy loss



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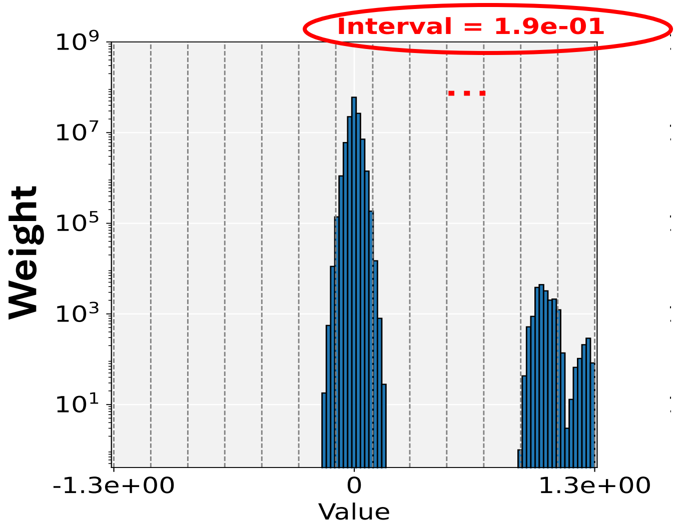
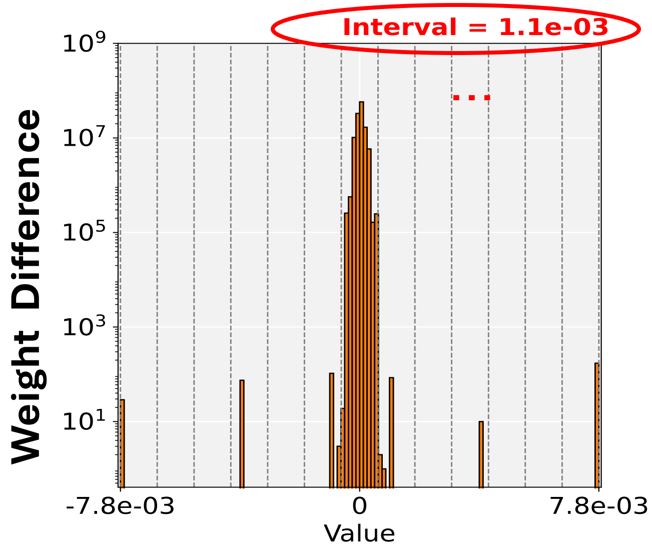
Weight Compression Strategy





Weight Differences usually have a smaller range, so that can achieve a much lower compression error.

Use weight difference communication pattern, and quantize weight differences into 4 bits.

Gradient Compression Strategy

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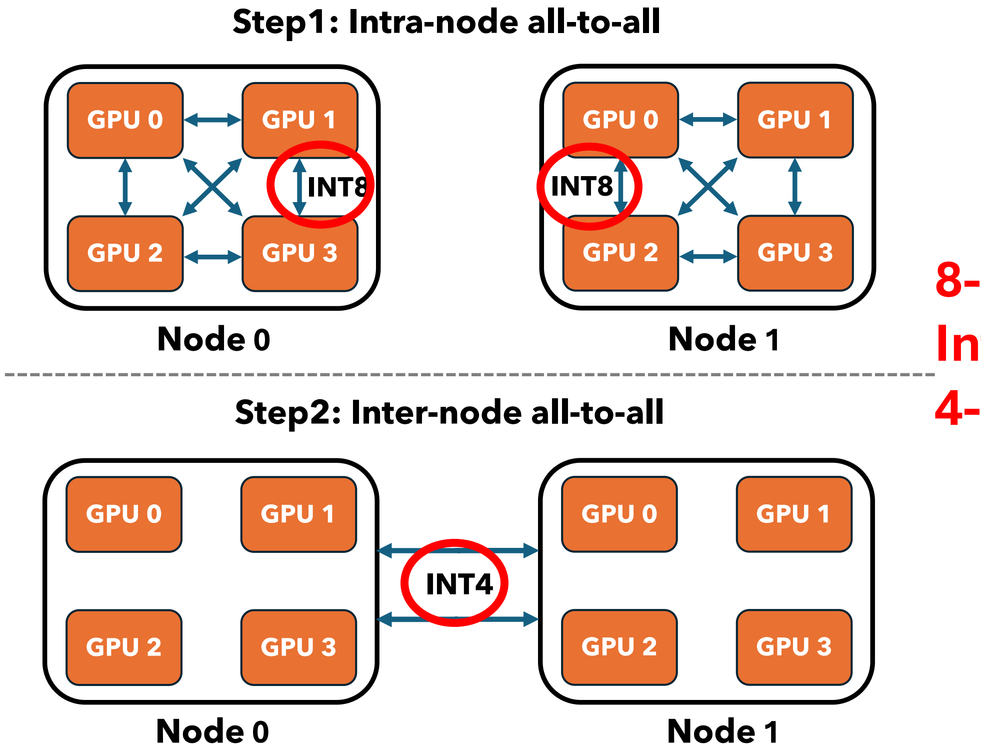
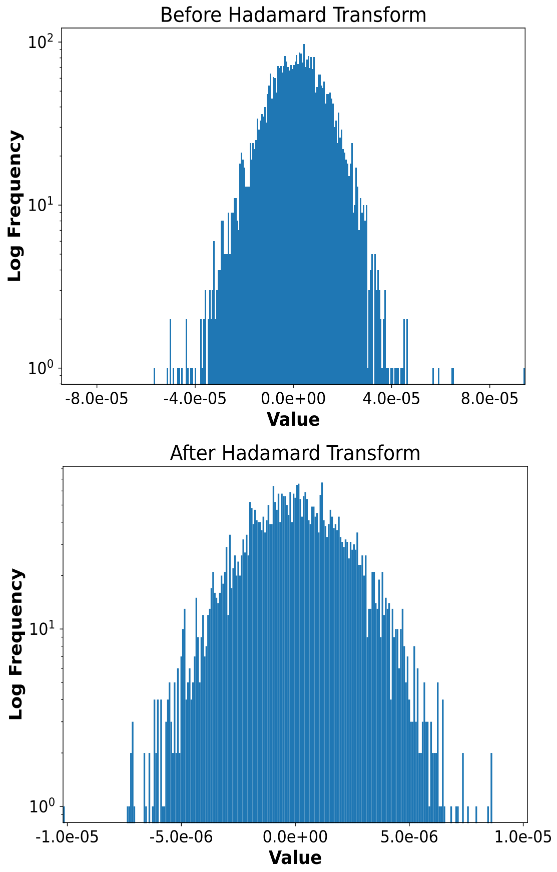


8-bit quantization for Intra-node
4-bit for Inter-node



Using Hadamard Transformation to alleviate gradient outliers. (zero-overhead integration)

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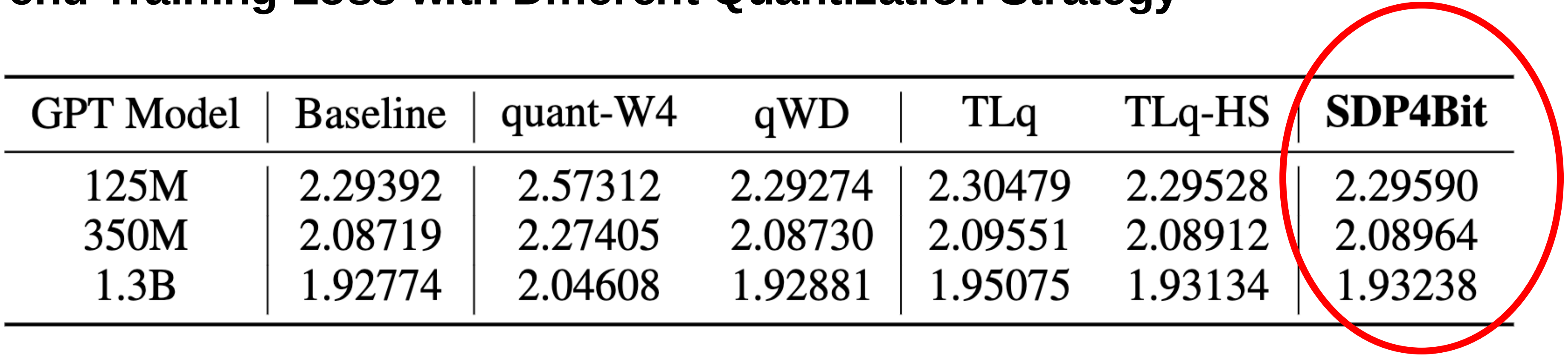
Experiments

- ➢ **End-to-end Training Loss with Different Quantization Strategy**



GPT Model	Baseline	quant-W4	qWD	TLq	TLq-HS	**SDP4Bit**
125M	2.29392	2.57312	2.29274	2.30479	2.29528	2.29590
350M	2.08719	2.27405	2.08730	2.09551	2.08912	2.08964
1.3B	1.92774	2.04608	1.92881	1.95075	1.93134	1.93238

Final loss is close to the baseline.

Experiments

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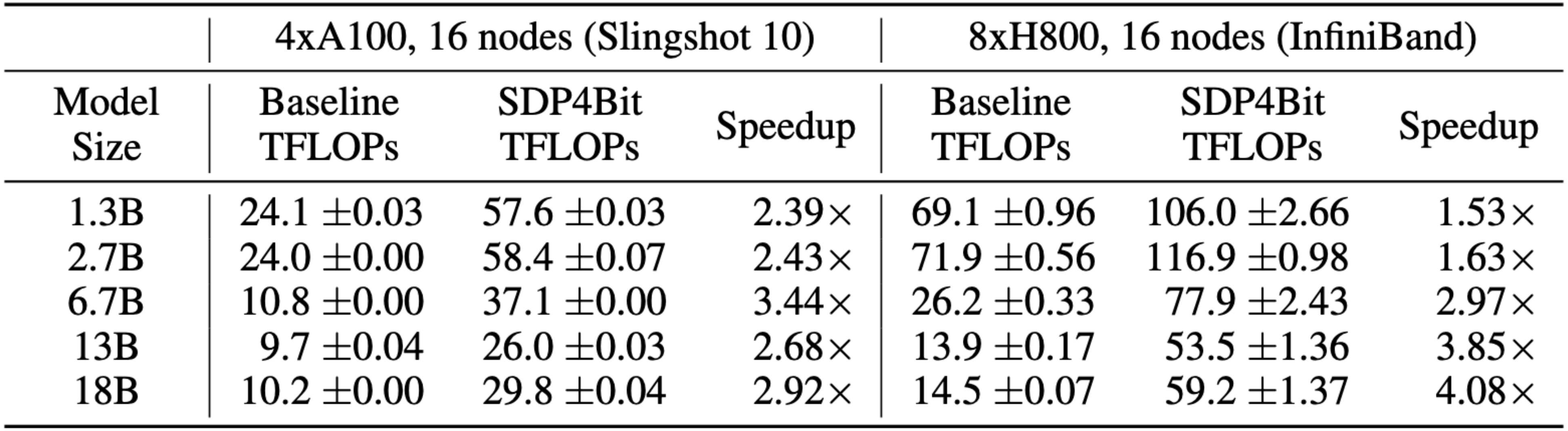
➢ E2E Training Throughput with Different Models



	4xA100, 16 nodes (Slingshot 10)			8xH800, 16 nodes (InfiniBand)		
Model Size	Baseline TFLOPs	SDP4Bit TFLOPs	Speedup	Baseline TFLOPs	SDP4Bit TFLOPs	Speedup
1.3B	24.1 ±0.03	57.6 ±0.03	2.39×	69.1 ±0.96	106.0 ±2.66	1.53×
2.7B	24.0 ±0.00	58.4 ±0.07	2.43×	71.9 ±0.56	116.9 ±0.98	1.63×
6.7B	10.8 ±0.00	37.1 ±0.00	3.44×	26.2 ±0.33	77.9 ±2.43	2.97×
13B	9.7 ±0.04	26.0 ±0.03	2.68×	13.9 ±0.17	53.5 ±1.36	3.85×
18B	10.2 ±0.00	29.8 ±0.04	2.92×	14.5 ±0.07	59.2 ±1.37	4.08×

Up to 4.08× Throughput Improvement.

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Looking forward to see you on Dec 11

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Poster Session 2

Wed 11 Dec 4:30 p.m. PST — 7:30 p.m. PST

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