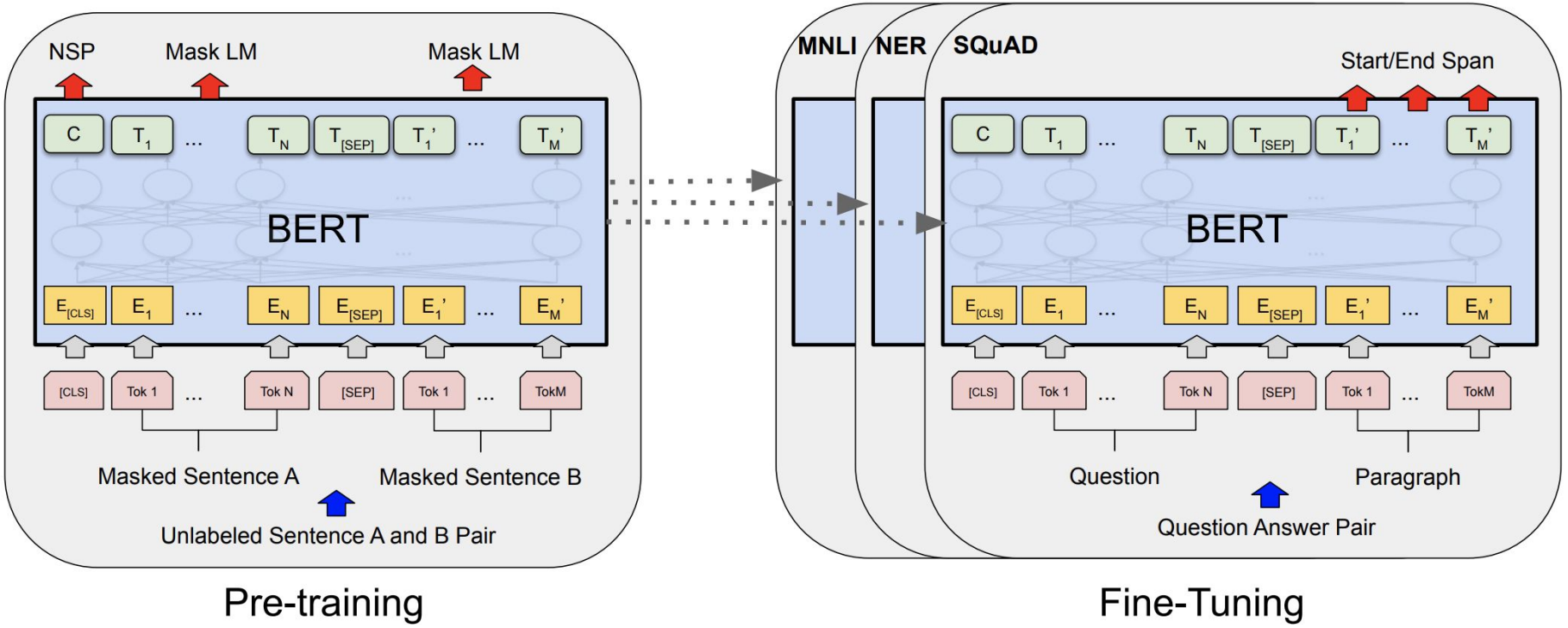
The BERTs family

Longer, bigger, smaller, smarter

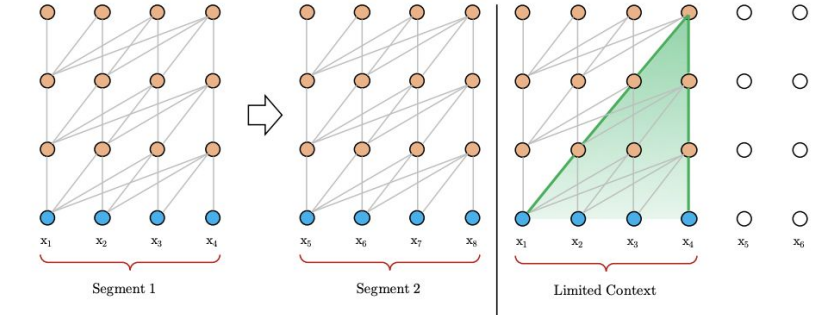
BERT

Full transformer
Masked LM to learn bi-directional LM
Next sentence prediction to learn discourse

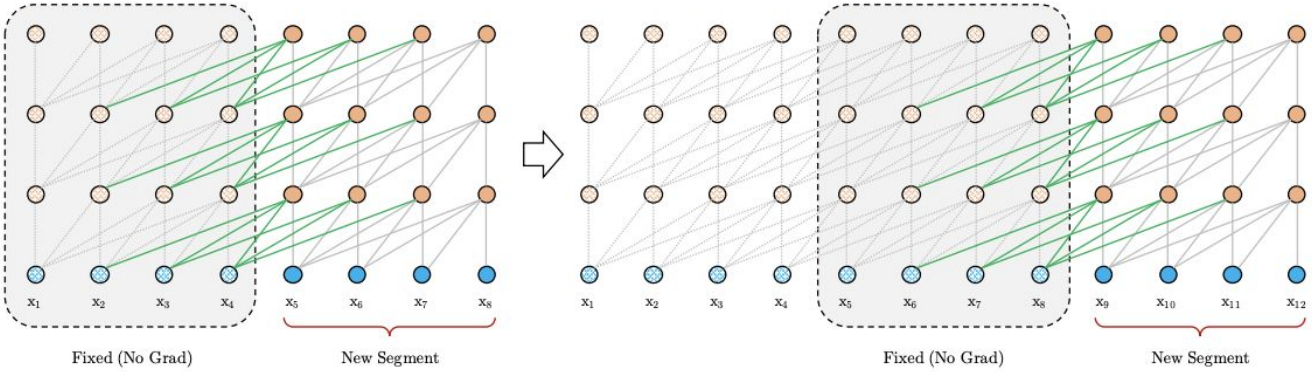


https://arxiv.org/abs/1810.04805

XL-transformer



Chunking limits the length of context



Let next chunk attention has access to previous chunk

(a) Training phase.

Transformer-XL: Attentive Language Models Beyond a Fixed-Length Context

XLNet

- Transformer-XL + permutation LM
- Mask LM creates mismatch between training and test
- Add attention masks to simulate random permutation orders

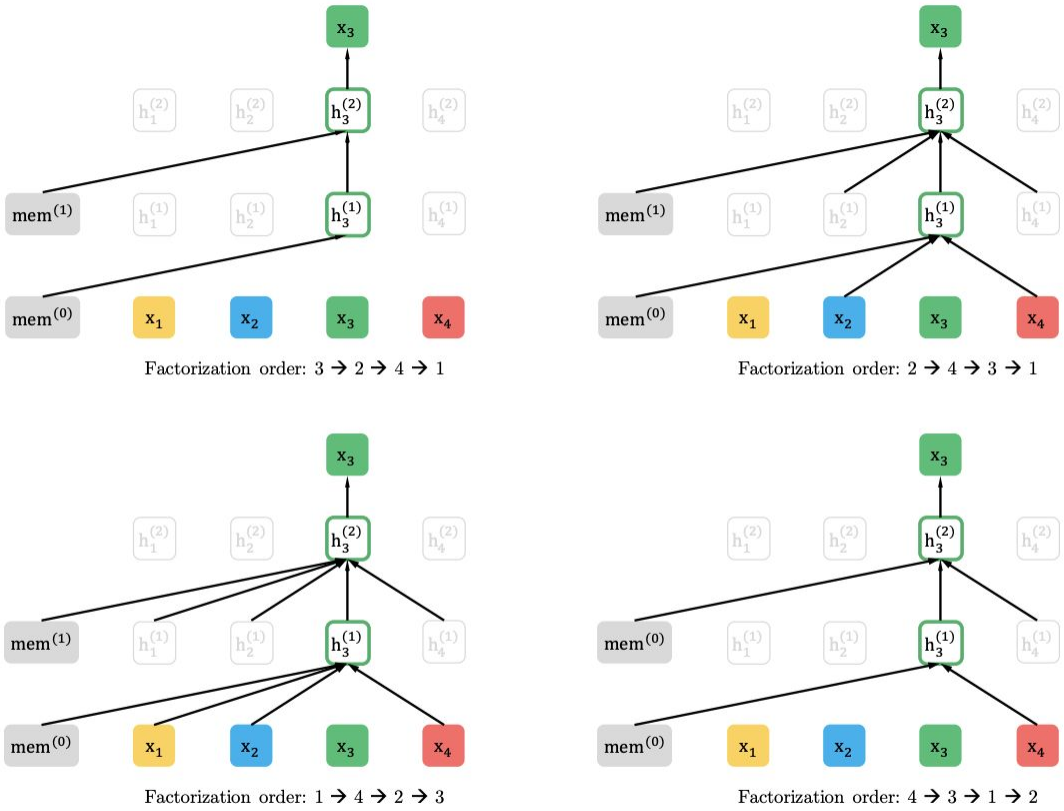


Figure 1: Illustration of the permutation language modeling objective for predicting x_3 given the same input sequence $\mathbf{x}$ but with different factorization orders.

Transformer-XL: Attentive Language Models Beyond a Fixed-Length Context
XLNet: Generalized Autoregressive Pretraining for Language Understanding

Roberta (Robustly optimized BERT approach)

A trick and tuning study

Dynamic masking > static

Next sentence prediction is not optimal

Larger batch + higher learning rate

Masking	SQuAD 2.0	MNLI-m	SST-2
reference	76.3	84.3	92.8
Our reimplementation:			
static	78.3	84.3	92.5
dynamic	78.7	84.0	92.9

bsz	steps	lr	ppl	MNLI-m	SST-2
256	1M	1e-4	3.99	84.7	92.7
2K	125K	7e-4	**3.68**	**85.2**	**92.9**
8K	31K	1e-3	3.77	84.6	92.8

RoBERTa: A Robustly Optimized BERT Pretraining Approach

Side note on large batch size training

Don't Decay the Learning Rate, Increase the Batch Size

Samuel L. Smith, Pieter-Jan Kindermans, Chris Ying, Quoc V. Le

It is common practice to decay the learning rate. Here we show one can usually obtain the same learning curve on both training and test sets by instead increasing the batch size during training. This procedure is successful for stochastic gradient descent (SGD), SGD with momentum, Nesterov momentum, and Adam. It reaches equivalent test accuracies after the same number of training epochs, but with fewer parameter updates, leading to greater parallelism and shorter training times. We can further reduce the number of parameter updates by increasing the learning rate ϵ and scaling the batch size $B \propto \epsilon$. Finally, one can increase the momentum coefficient m and scale $B \propto 1/(1-m)$, although this tends to slightly reduce the test accuracy. Crucially, our techniques allow us to repurpose existing training schedules for large batch training with no hyper-parameter tuning. We train ResNet-50 on ImageNet to 76.1% validation accuracy in under 30 minutes.

Accurate, Large Minibatch SGD: Training ImageNet in 1 Hour
Don't Decay the Learning Rate, Increase the Batch Size

Megatron-LM

Distributed training

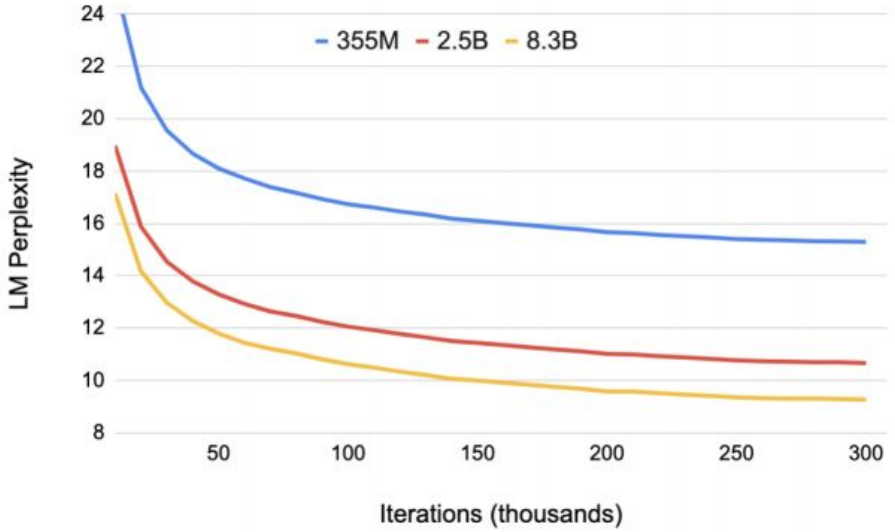
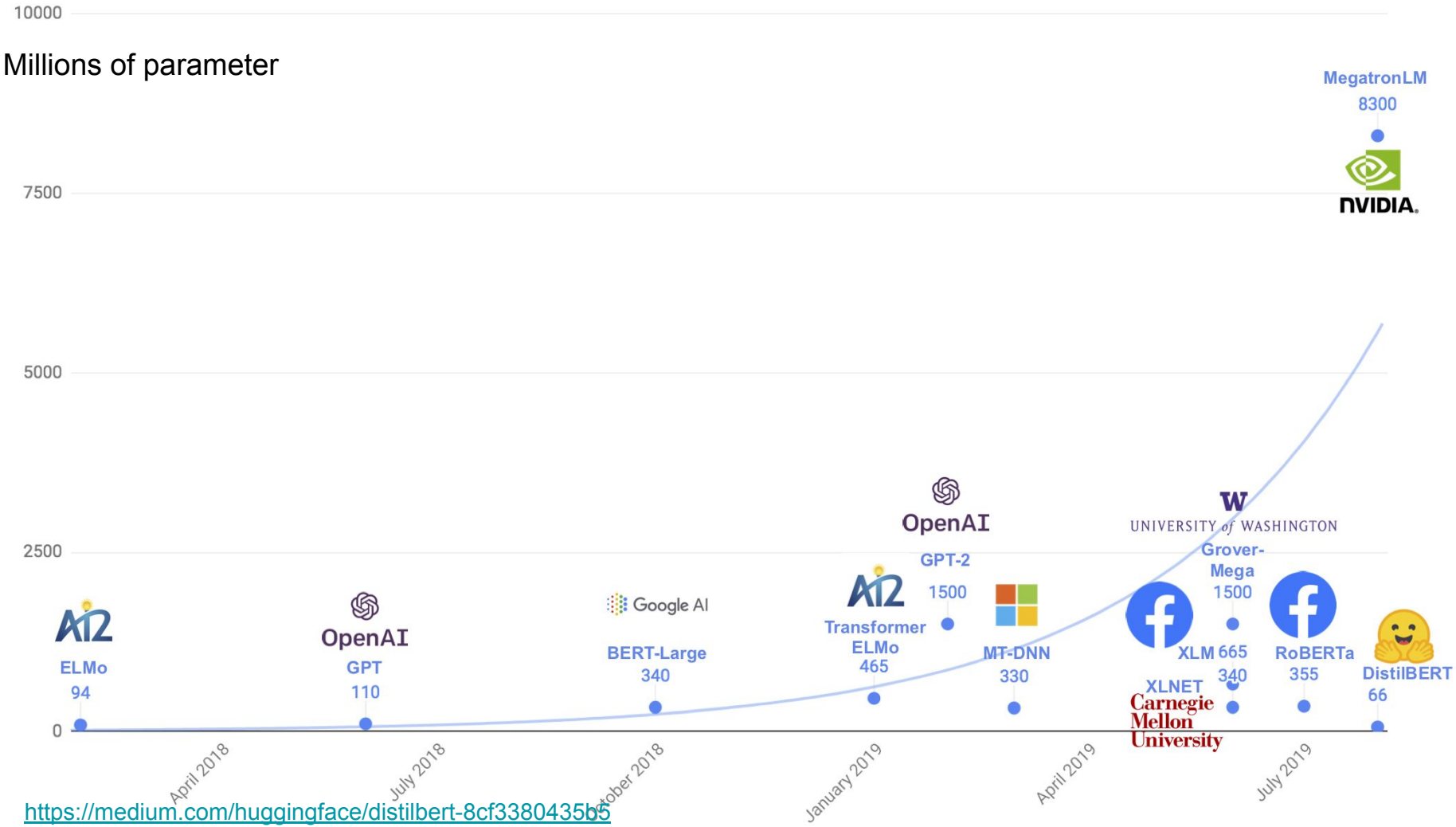


Figure 7. Validation set perplexity. All language models are trained for 300k iterations. Larger language models converge noticeably faster and converge to lower validation perplexities than their smaller counterparts.



https://medium.com/huggingface/distilbert-8cf3380435b5

Distill bert

Knowledge distillation to get smaller models

Reduce the # of transformer layers by half. Use tricks in Roberta.

Use KL-divergence between teacher and student model

“Cheaper training”
eight 16GB V100 GPUs for approximately three and a half days

	Nb of parameters (millions)	Inference Time (s)
GLUE BASELINE (ELMo + BiLSTMs)	180	895
BERT base	110	668
DistilBERT	66	410

	Macro Score	CoLA	MNLI	MNLI-MM	MRPC		QNLI	QQP		RTE	SST-2	STS-B		WNLI
		mcc	acc	acc	acc	f1	acc	acc	f1	acc	acc	pearson	spearmanr	acc
GLUE BASELINE (ELMo + BiLSTMs)	68.7	44.1	68.6 (avg)		70.8	82.3	71.1	88.0	84.3	53.4	91.5	70.3	70.5	56.3
BERT base	78.0	55.8	83.7	84.1	86.3	90.5	91.1	90.9	87.7	68.6	92.1	89.0	88.6	43.7
DistilBERT	75.2	42.5	81.6	81.1	82.4	88.3	85.5	90.6	87.7	60.0	92.7	84.5	85.0	55.6

https://github.com/huggingface/transformers https://medium.com/huggingface/distilbert-8cf3380435b5

ALBERT

Want higher hidden units without growing the model. Factorized embedding matrix

VxE -> VxE+ExH

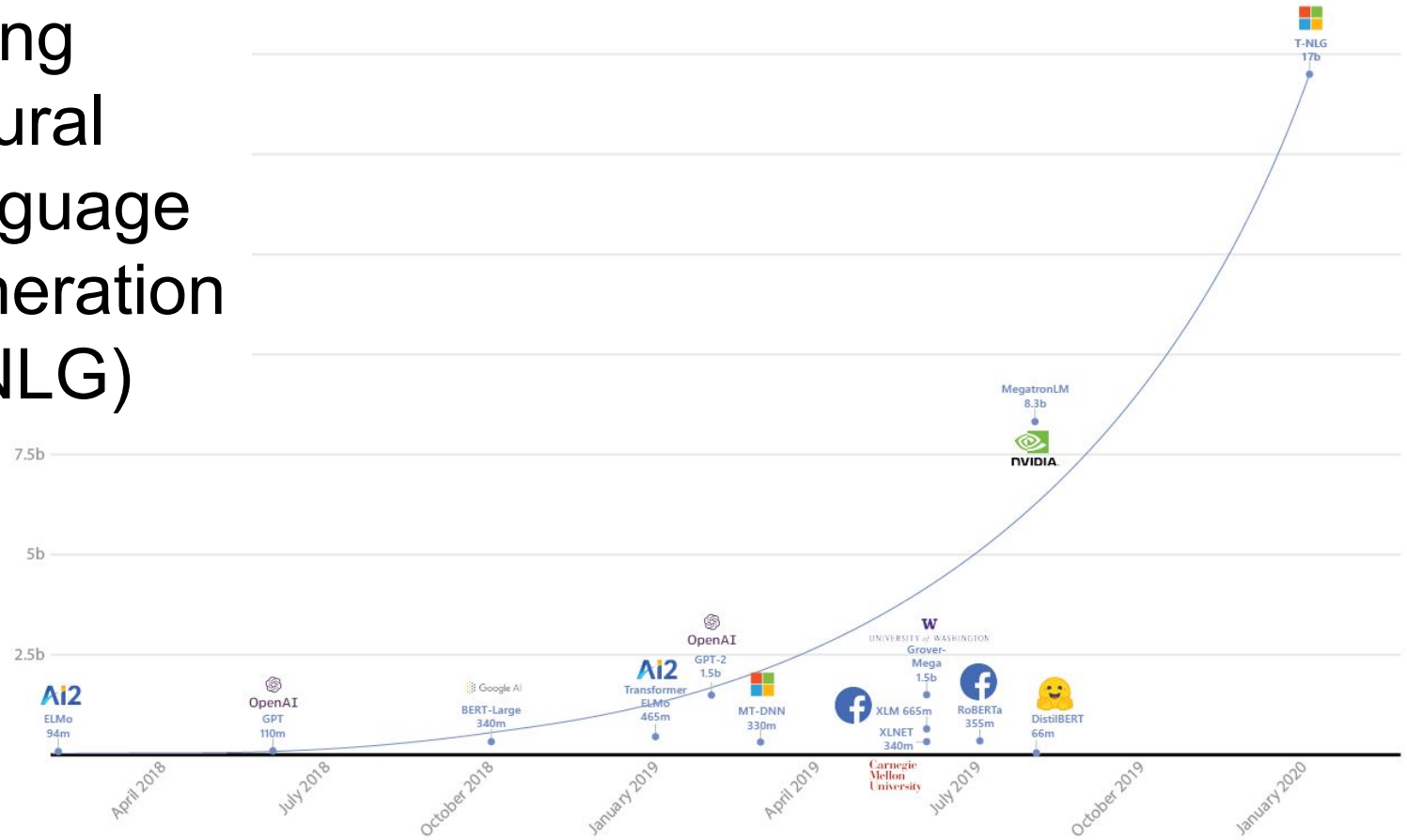
Share attention layer parameters across layers. More stable training as a side effect.

NSP is easy compared to LM tasks (multi-task imbalance)
Next sentence prediction (random sentence) -> Sentence order prediction (swapped sentence or not)

Model		Parameters	Layers	Hidden	Embedding	Parameter-sharing	Avg	Speedup
BERT	base	108M	12	768	768	False	82.1	17.7x
	large	334M	24	1024	1024	False	85.1	3.8x
	xlarge	1270M	24	2048	2048	False	76.7	1.0
ALBERT	base	12M	12	768	128	True	80.1	21.1x
	large	18M	24	1024	128	True	82.4	6.5x
	xlarge	59M	24	2048	128	True	85.5	2.4x
	xxlarge	233M	12	4096	128	True	**88.7**	1.2x

Some experiments show dropout hurt performance

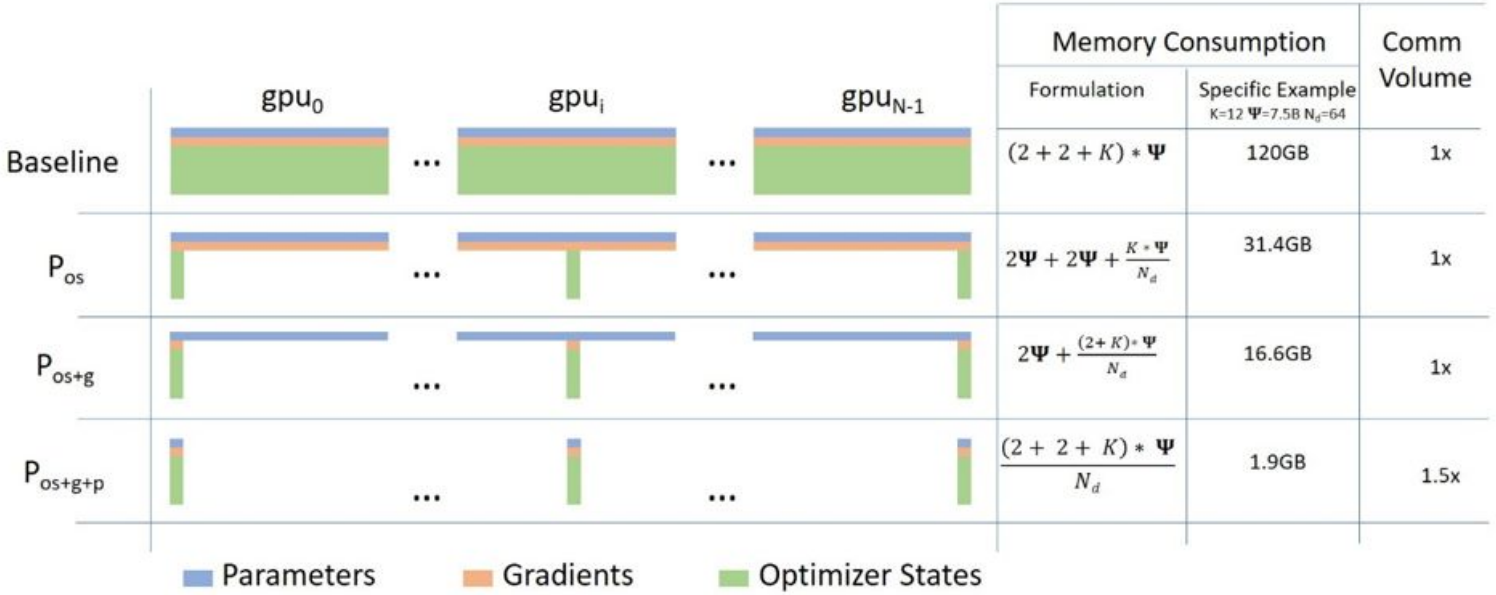
Turing Natural Language Generation (T-NLG)



https://www.microsoft.com/en-us/research/blog/turing-nlg-a-17-billion-parameter-language-model-by-microsoft/

Zero & DeepSpeed

Clever management of training parameters across GPUs and machines



	Memory Consumption		Comm Volume
	Formulation	Specific Example K=12 Ψ=7.5B N_d=64	
Baseline	$(2+2+K)*\Psi$	120GB	1x
P_{os}	$2\Psi+2\Psi+\frac{K*\Psi}{N_d}$	31.4GB	1x
P_{os+g}	$2\Psi+\frac{(2+K)*\Psi}{N_d}$	16.6GB	1x
P_{os+g+p}	$\frac{(2+2+K)*\Psi}{N_d}$	1.9GB	1.5x

https://www.microsoft.com/en-us/research/blog/zero-deepspeed-new-system-optimizations-enable-training-models-with-over-100-billion-parameters/

T-NLG

	LAMBADA (acc) strict	WikiText-103 (test adj. ppl)
Open AI GPT-2 1.5B	52.66 (63.24)*	17.48
Megatron-LM 8.3B	66.51	10.81
T-NLG 17B	67.98	10.21

*Open AI used additional processing (stopword filtering) to achieve higher numbers than the model achieved alone. Neither Megatron nor T-NLG use this stopword filtering technique.

Can do Q/A by just LOTs of internet text

When did WW2 end?	WW2 ended in 1945.
How many people live in the US?	There are over 300 million people living in the US.

Longer, bigger, smaller, smarter

XLNet

Megatron

Roberta

Distill Bert

Albert

T-NLG

CTRL

For language generation, with style control signal

Style (embedding)

Wikipedia *Anarchism is* a political philosophy that advocates the abolition of all forms of hierarchy and domination, including capitalism, patriarchy, racism, sexism, heterosexism and other oppressive social structures.\n\nThe term "anarchism" was coined by Pierre-Joseph Proudhon in his book "The

Books *Anarchism is* the \n only true and practical form of Socialism. It has been said that Socialism \n will never be established until it can be proved to work in practice. The \n same may be said, with equal truth, about Anarchism. But if we are not able \n to prove its practicability at present, then let us

CTRL: A CONDITIONAL TRANSFORMER LANGUAGE MODEL FOR CONTROLLABLE GENERATION

Horror *A knife* handle pulled through the open hole in the front. I jumped when the knife hit.\n\nEyes widened in horror. Her scream was the only sound I heard besides her sobs.\n\nThe spider touched her feet as it started to dig into the top of her arch. The creature's tears began to

Reviews *A knife* is a tool and this one does the job well.\n\nRating: 4.0\n\nI bought these for my husband who has been using them to cut up his own meat since he got them. He says they are very sharp so be careful when you use them, but that doesn't seem like much of an issue because he's used

Can use url as control signal

Condition on topic, dates, etc.

Links https://www.cnn.com/2014/09/20/us-president-meets-british-pm
JUST WATCHED\n\nObama meets with British PM\n\nMUST WATCH\n\nStor
highlights\n\nPresident Barack Obama met with Britain's Prime Minister David Cameron

Links https://www.cnn.com/2018/09/20/us-president-meets-british-pm
JUST WATCHED\n\nTrump and May meet for first time\n\nMUST WATCH\n\nWashingto
(CNN) President Donald Trump, who has been criticized by some in the UK over his decision to leav
the European Union, met with British Prime Minister Theresa May, a White House official said o
Thursday.

Links https://www.cnn.com/style/09/20/2018/george-clooney-interview
George Clooney on the future of his acting career\n\nBy\n\nUpdated 10:51 AM ET, Thu September 20, 2018\n\nChat with us in Facebook Messenger. Find out what's happening in the world as it unfolds.\n\nPhotos:George Clooney, 'Ocean's 8'\n\nActor George Clooney attends a photocall for "Ocean's 8" at Grauman's Chinese Theatre on August 31, 2018, in Los Angeles.\n\n...

Links https://www.cnn.com/politics/09/20/2018/george-clooney-interview
JUST WATCHED\n\nGeorge Clooney on the Trump administration\n\nMUST WATCH\n\n(CNN) Actor and activist George Clooney, who has been a vocal critic of President Donald Trump, said he is "ready to go back into the political arena" after his role in an anti-Trump documentary was cut from theaters this week.\n\n...

Latest (from Google)

Reformer: The Efficient Transformer (https://arxiv.org/abs/2001.04451)

Use Hash and reversible layer to reduce memory footprint