Large Product Key Memory for Pretrained Language Models

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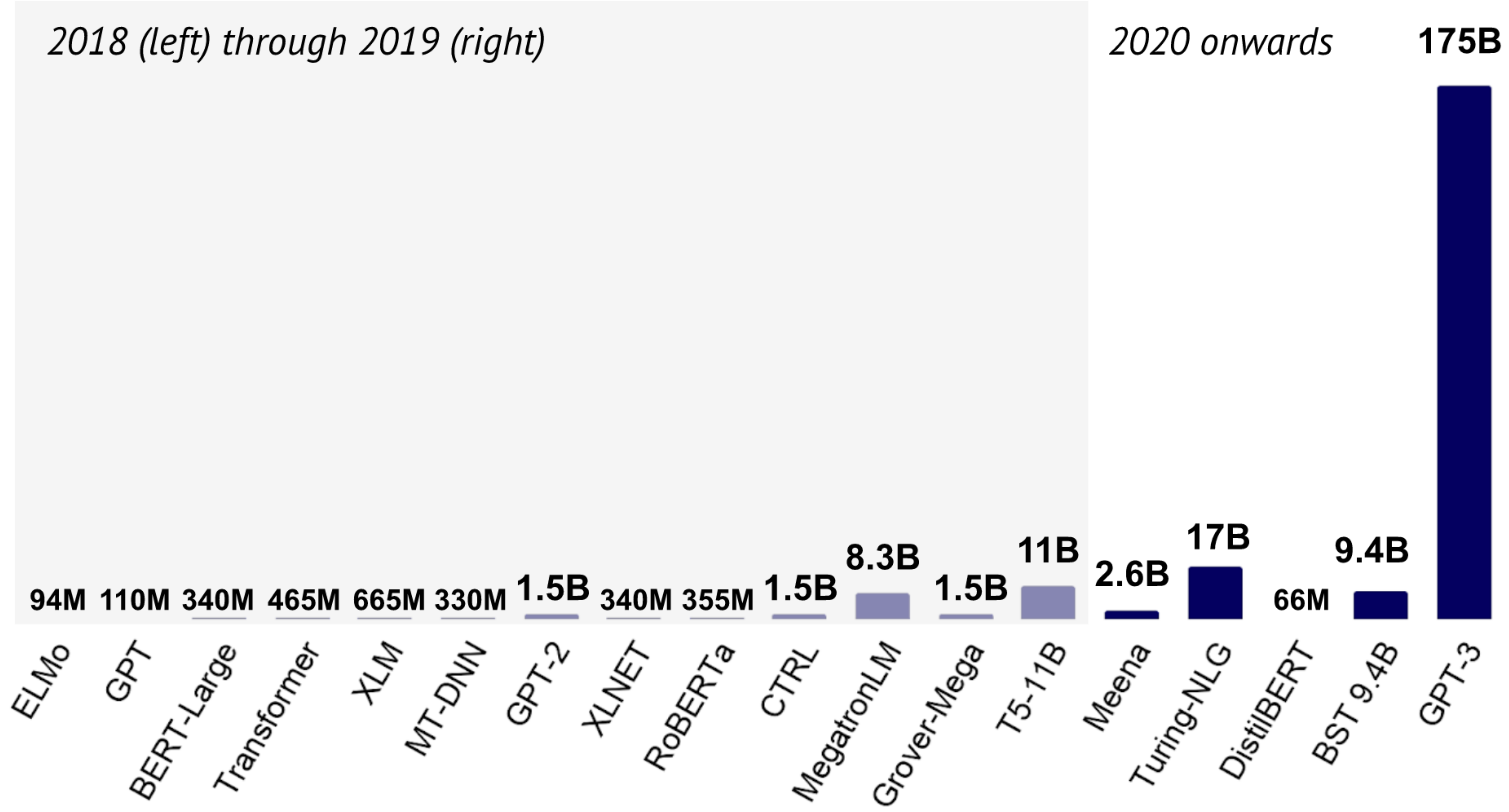
Recent NLP Trends

Large Product Key Memory for Pretrained Language Models



Decoupling Parameters & Performance

Large Product Key Memory for Pretrained Language Models

Model	# Layers	# Params	Inference Speed (batch/sec)
$\text{BERT}_{\text{BASE}}$	12	110M	79.8
$\text{BERT}_{\text{BASE}}$ +PKM	12	506M	61.4
$\text{BERT}_{\text{BASE}}$ +ResM	12	**515M**	**59.3**
$\text{BERT}_{\text{LARGE}}$	24	**340M**	**43.1**
$\text{BERT}_{\text{LARGE}}$ +PKM	24	860M	37.2
$\text{BERT}_{\text{LARGE}}$ +ResM	24	876M	36.1

Product Key Memory

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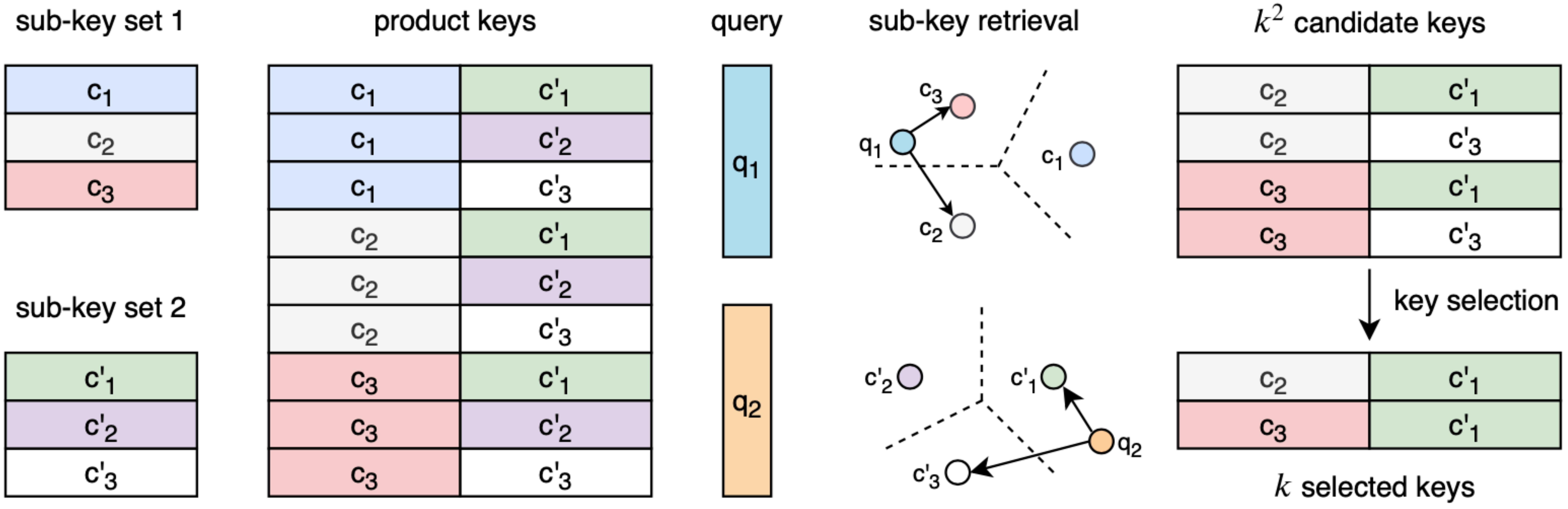

Product Key Memory : Pseudo Code

Large Product Key Memory for Pretrained Language Models

```
import torch
import torch.nn as nn
import torch.nn.functional as F

def product_key_memory(query, dim, d_model, d_query, n_head):

  b , t , _ , h = query.shape , n_head

  query = nn.Linear(d_model,d_query)(query)
  query = nn.Dropout(self.MaskedBatchNorm(query))
  query_list = query.chunk(2, dim = -1)

  query = torch.stack(query_list).reshape(2,b,t,h,-1)
  #self.key = nn.parameters(),
  weight = torch.matmul(query_list,self.key,transpose_a = True)
  scores, indices = weight.topk(k=self.topk, dim=-1)
  scores = F.softmax(scores,dim = -1) #normalize

  top_k = sorted(dict((indices,scores)).items(), key=lambda x: x[1],reverse=True)[:10]
  top_k_indice = [indice for indice,score in top_k]

  out = nn.EmbeddingBag(n_key**2,dim,mode='sum')(top_k_indice)

  return nn.Dropout(out)
```

PKM Performance

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Model	Memory			MLM		
	$\widetilde{MU}$ (4L/8L) (%)	KL_u (4L/8L)	KL_w (4L/8L)	WT-2 (ppl)	WT-103 (ppl)	PG-19 (ppl)
(a) BERT$_{\text{BASE}}$ †	-	-	-	3.49	3.86	6.18
(b) +500k steps	-	-	-	3.40	3.72	5.88
(c) +PKM	2.2/84.1	1.62/0.89	1.99/1.13	3.26	3.39	5.53
(d) +ResM	75.0/81.0	1.50/0.71	1.80/0.92	3.26	3.36	5.45
(e) +Init +PKM	97.4/95.7	0.53/0.69	0.68/0.88	3.14	3.26	5.22
(f) +Init +ResM	**98.2/97.3**	**0.45/0.46**	**0.58/0.60**	**3.10**	**3.20**	**5.14**

Catastrophic Drift

Large Product Key Memory for Pretrained Language Models

Model	QA SQuAD 1.1 (EM/F1)	GLUE MNLI-(m/mm) (Acc)	QQP (Acc)	QNLI (Acc)	SST-2 (Acc)	CoLA (Matt)	Avg -
(a) $\text{BERT}_{\text{BASE}}^{\dagger}$	82.7/89.8	84.3/84.5	91.0	89.3	92.8	60.8	83.8
(b) +500k steps	83.3/90.1	84.8/84.9	91.2	89.2	92.4	61.4	84.0
(c) +PKM	81.9/89.1	84.4/85.0	91.1	89.0	93.6	59.7	83.8
(d) +ResM	81.5/89.4	84.6/84.8	91.0	88.2	93.2	62.8	84.1
(e) +Init +PKM	83.8/90.6	85.8/85.6	91.2	90.0	93.6	63.6	85.0
(f) +Init +ResM	**83.9/90.8**	**86.0/85.8**	**91.4**	**90.4**	**94.0**	**64.1**	**85.3**
(g) $\text{BERT}_{\text{BASE}}^{\star}$	81.1/88.5	83.9/84.4	91.0	88.4	92.9	59.8	83.4
(h) $\text{BERT}_{\text{LARGE}}^{\star}$	83.3/90.6	86.2/86.1	91.4	90.4	93.8	64.1	85.3

Solutions

Large Product Key Memory for Pretrained Language Models

- Initialization from Pretrained Weights
- Residual Memory Layer

Model Architecture

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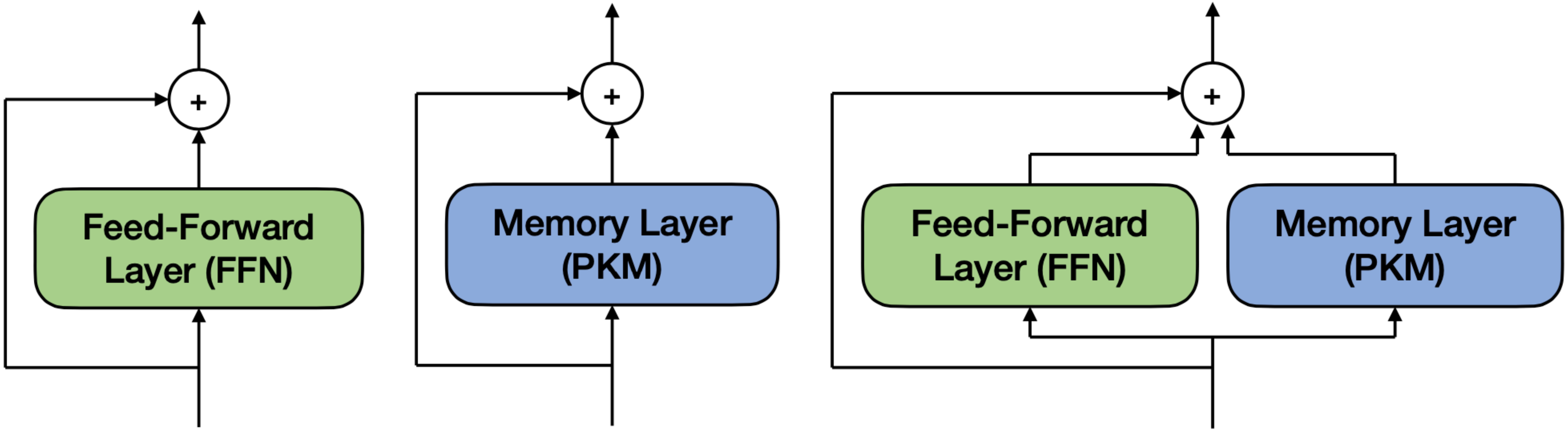

(a) FFN layer (b) PKM layer (c) ResM layer

ResM Performance

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Model	QA SQuAD 1.1 (EM/F1)	GLUE MNLI-(m/mm) (Acc)	QQP (Acc)	QNLI (Acc)	SST-2 (Acc)	CoLA (Matt)	**Avg** -
(a) $\text{BERT}_{\text{BASE}}{}^{\dagger}$	82.7/89.8	84.3/84.5	91.0	89.3	92.8	60.8	83.8
(b) +500k steps	83.3/90.1	84.8/84.9	91.2	89.2	92.4	61.4	84.0
(c) +PKM	81.9/89.1	84.4/85.0	91.1	89.0	93.6	59.7	83.8
(d) +ResM	81.5/89.4	84.6/84.8	91.0	88.2	93.2	62.8	84.1
(e) +Init +PKM	83.8/90.6	85.8/85.6	91.2	90.0	93.6	63.6	85.0
(f) +Init +ResM	**83.9/90.8**	**86.0/85.8**	**91.4**	**90.4**	**94.0**	**64.1**	**85.3**
(g) $\text{BERT}_{\text{BASE}}{}^{\star}$	81.1/88.5	83.9/84.4	91.0	88.4	92.9	59.8	83.4
(h) $\text{BERT}_{\text{LARGE}}{}^{\star}$	83.3/90.6	86.2/86.1	91.4	90.4	93.8	64.1	85.3

Further Implications

Large Product Key Memory for Pretrained Language Models

Model	MLM PG-19 (ppl)	QA SQuAD 1.1 (EM/F1)	GLUE MNLI-m (Acc)	GLUE SST-2 (Acc)
DistilBERT*	20.61	77.4/85.7	82.0	91.6
+Init +ResM	5.75	80.4/88.3	84.1	93.3
$\text{BERT}_{\text{BASE}}$*	11.82	81.1/88.5	83.9	92.9