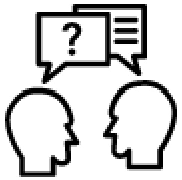
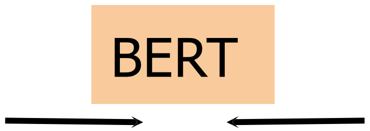
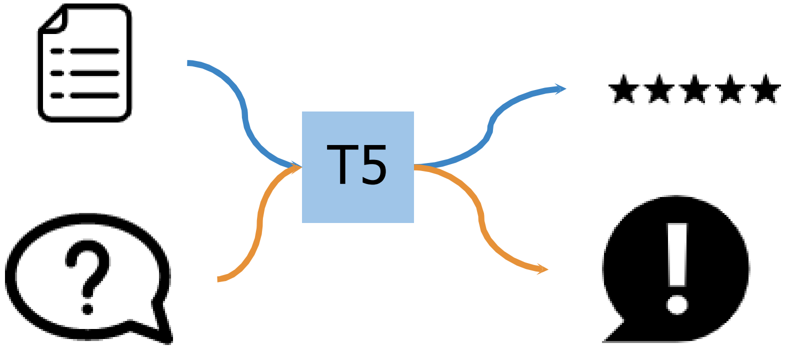
Question Answering

Question Answering



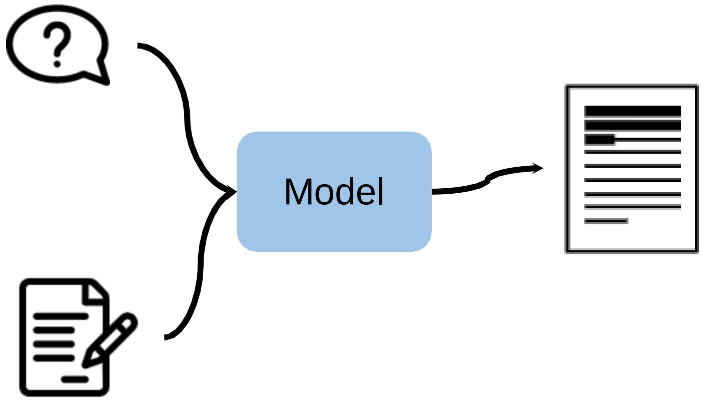


Transfer learning

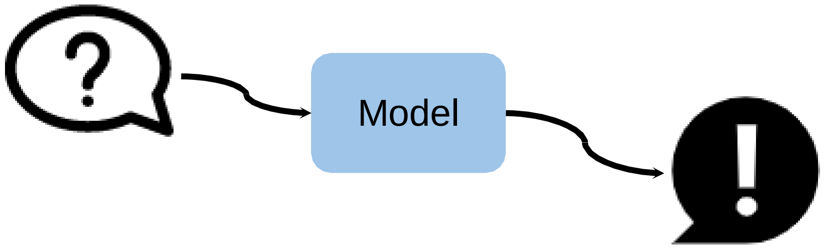


Question Answering

Context-based



Closed book



- Not just the model

Data

Training

Model

Data

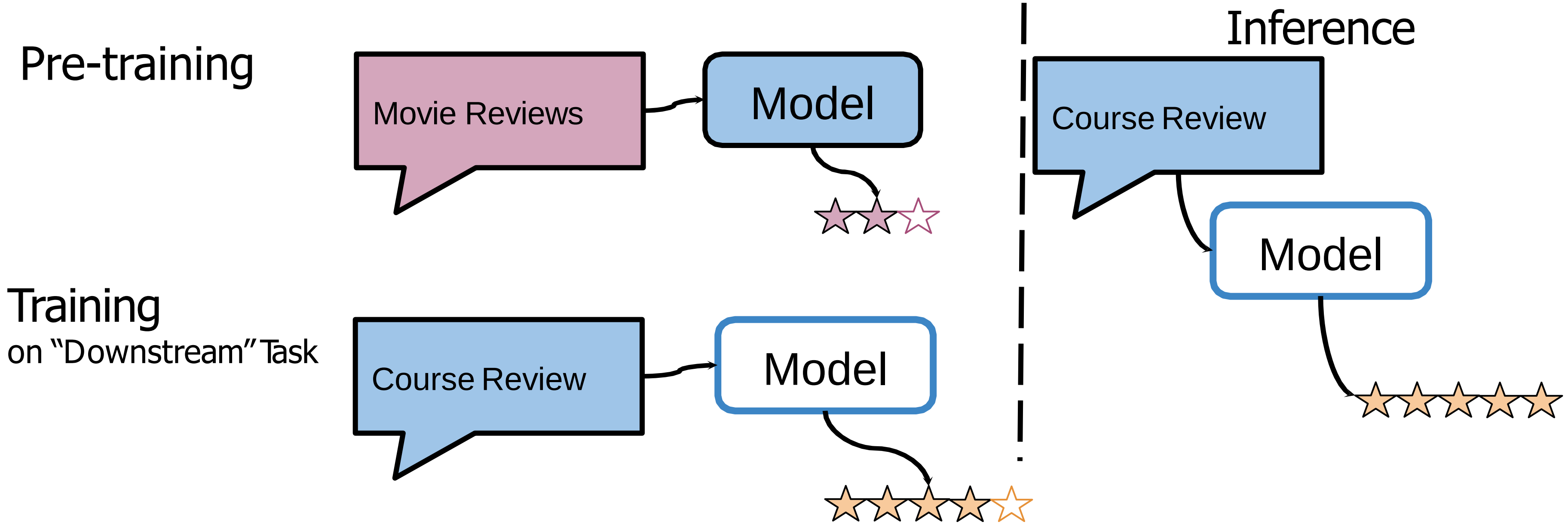
Training

Model

Transfer Learning!

Classical training

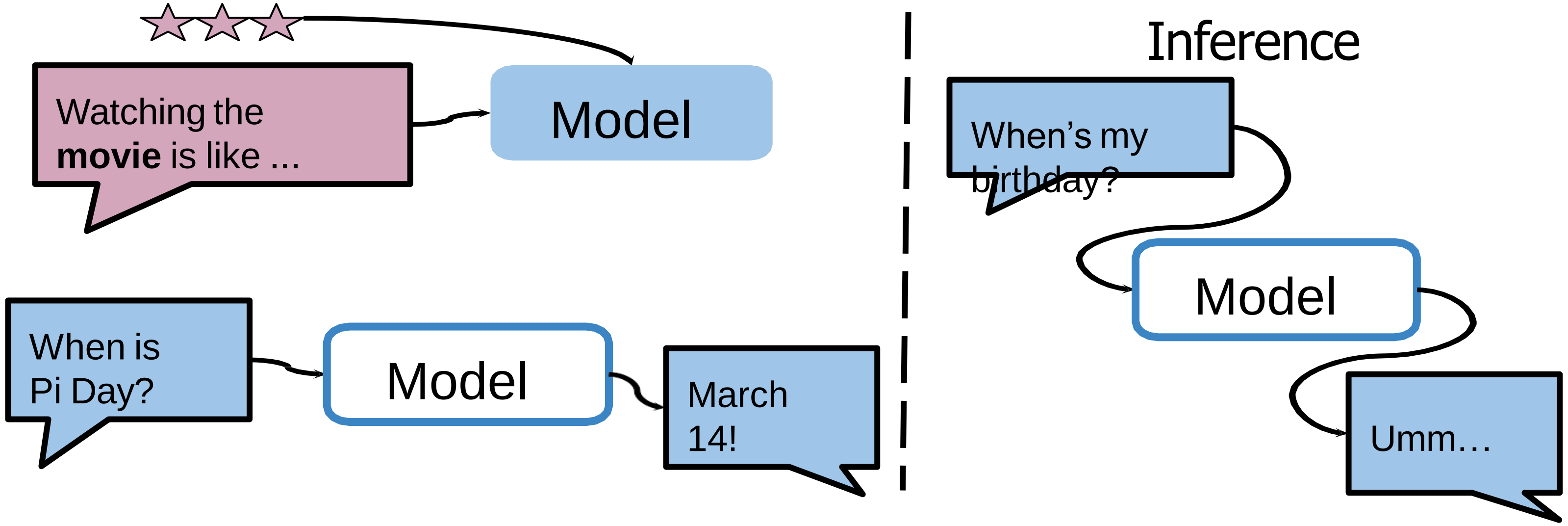
- Transfer learning



Transfer Learning: Different Tasks

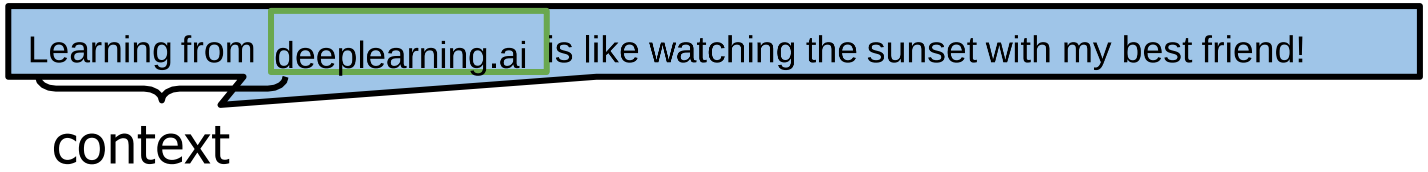
Pre-Training
Sentiment Classification

Training
Downstream task:
Question Answering

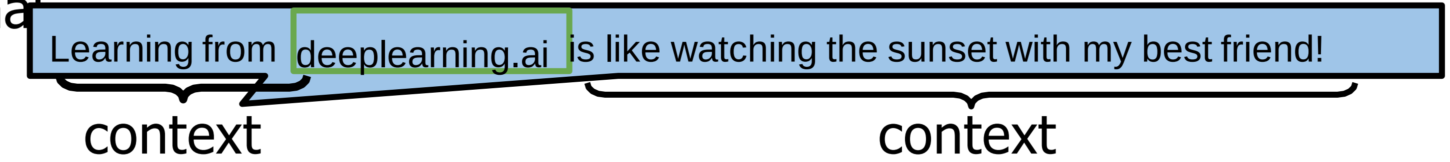


- BERT: Bi-directional Context

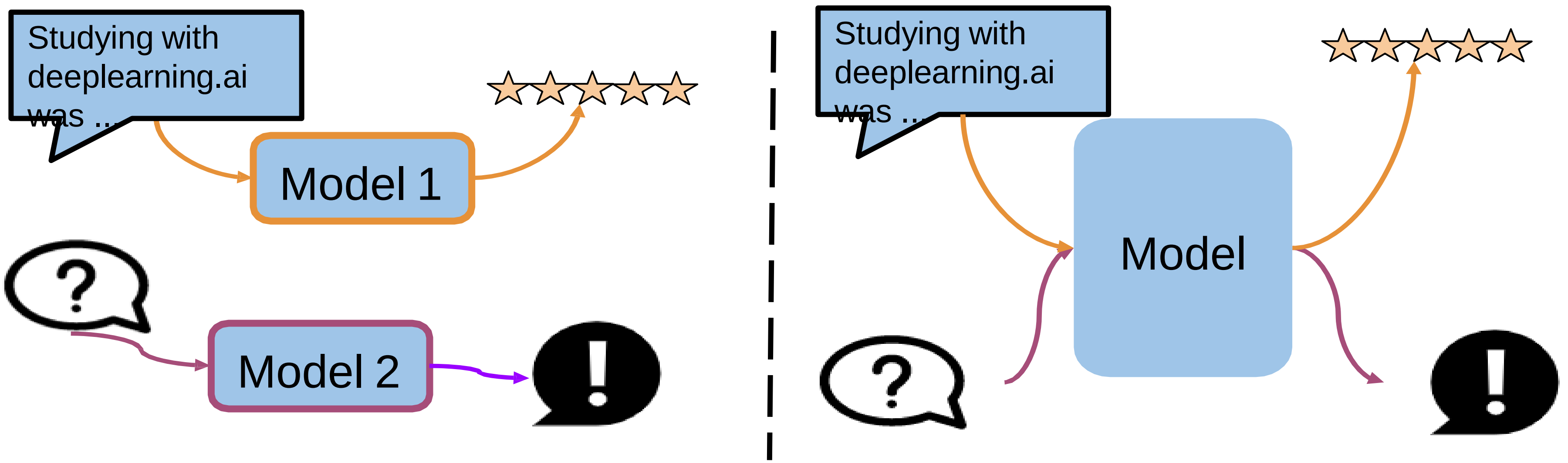
Uni-directional



Bi-directional



T5: Single task vs. Multi task



- T5: more data, better performance

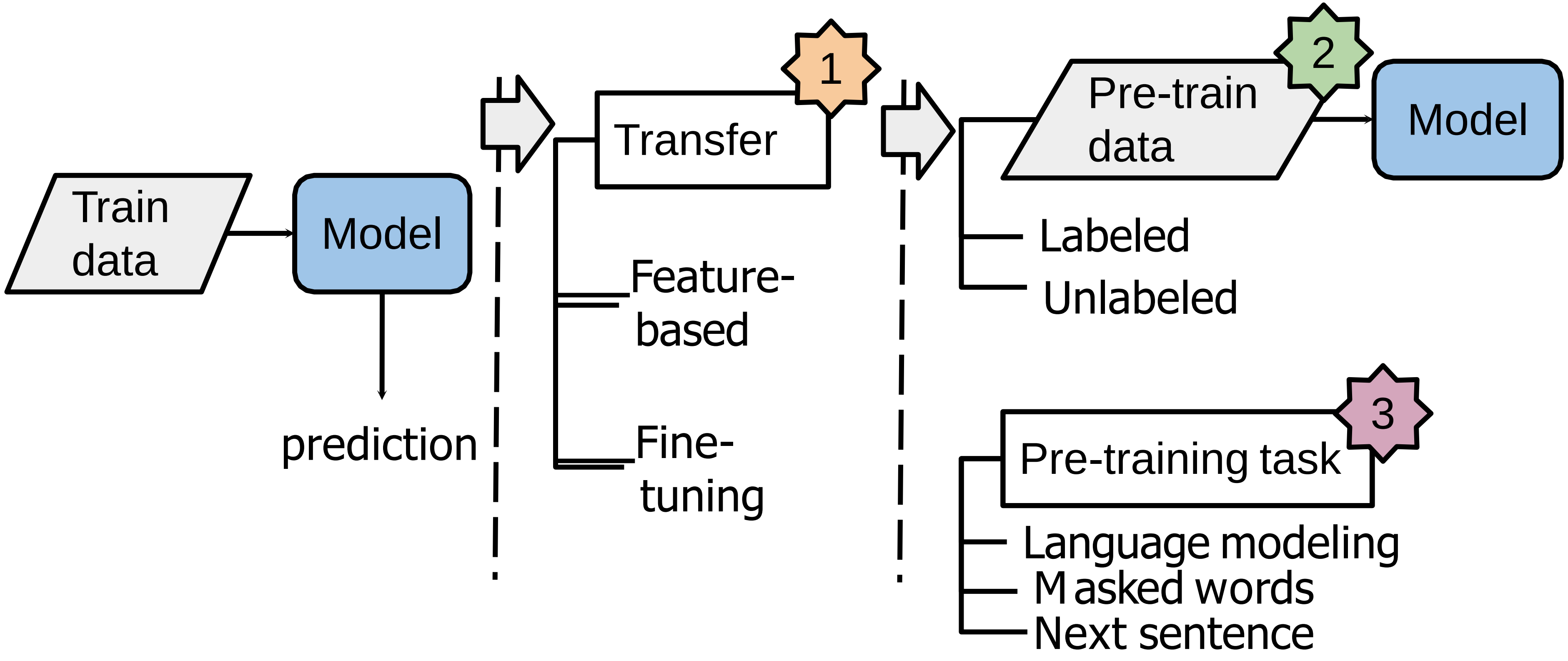
English
wikipedia
~13 GB

C4
Colossal **C**lean
Crawled
Corpus
~800 GB

Desirable Goals of

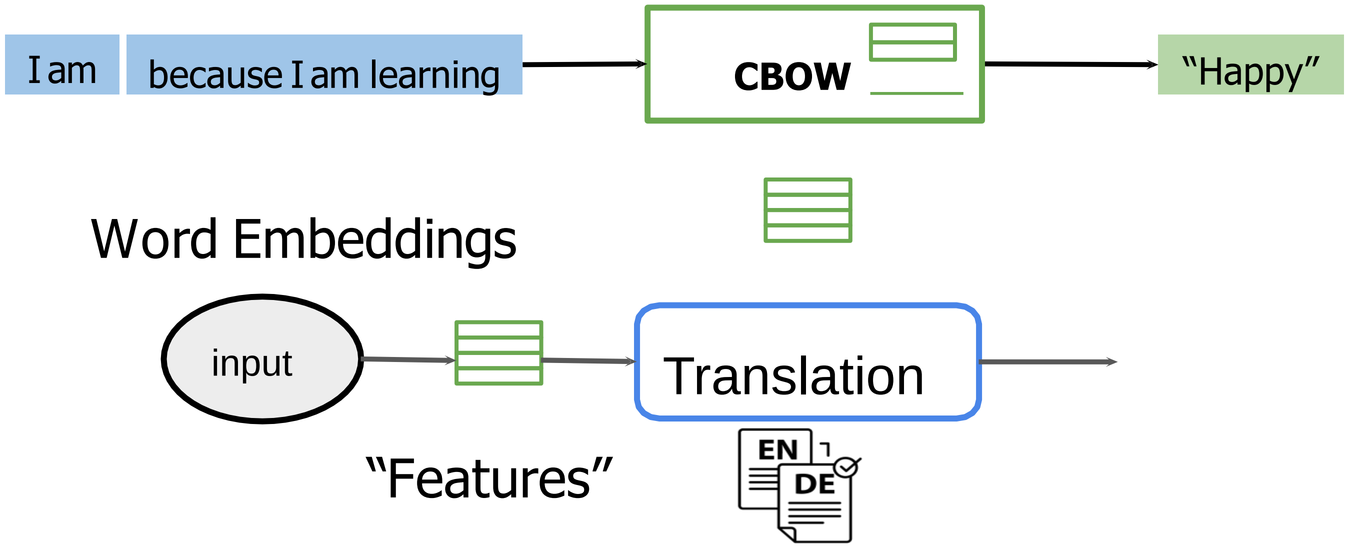
Transfer learning

- Desirable Goals: Reduce training time Improve predictions; Small datasets

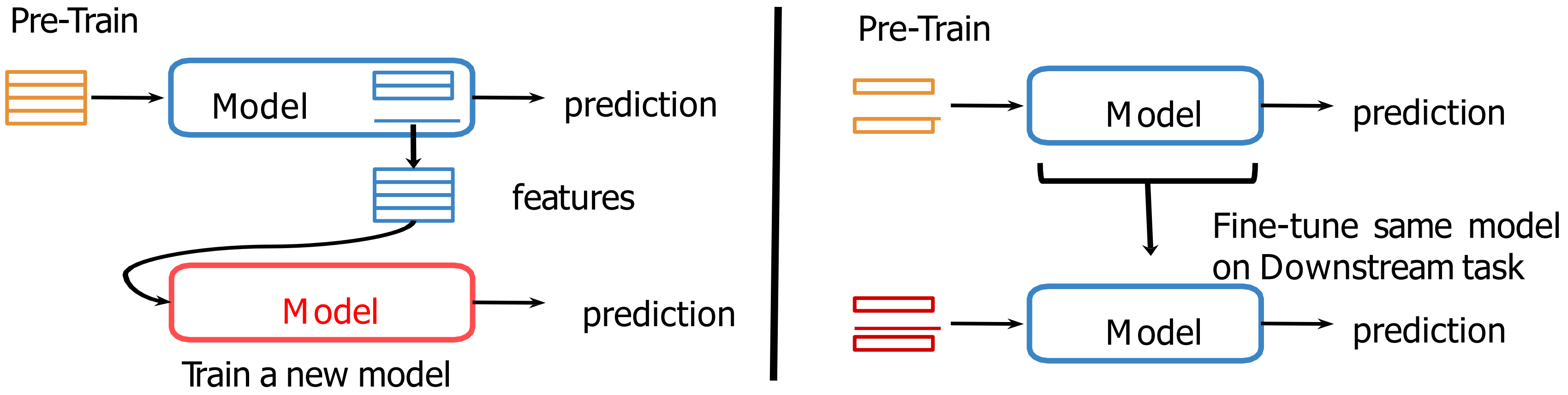


General purpose learning

Transfer 1

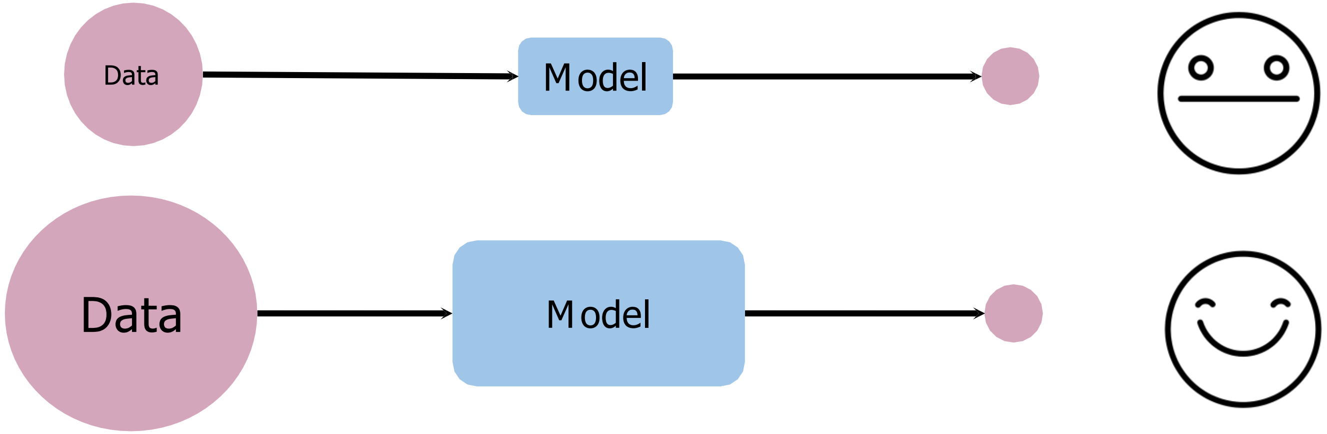


- Feature-based vs. Fine-Tuning



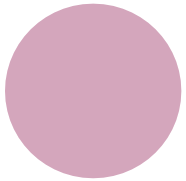
Pre-train data

- Data and performance



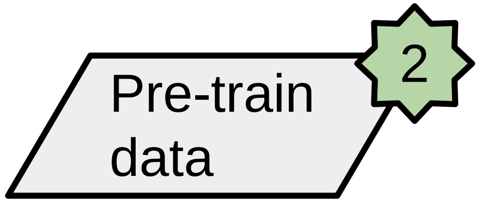
- Labeled vs Unlabeled Data

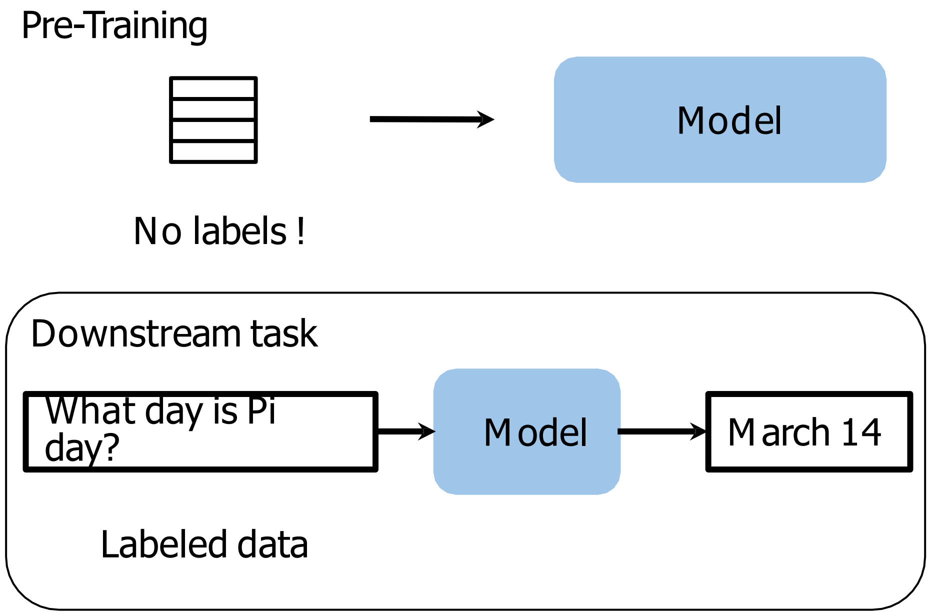
Labeled text data



Unlabeled text data

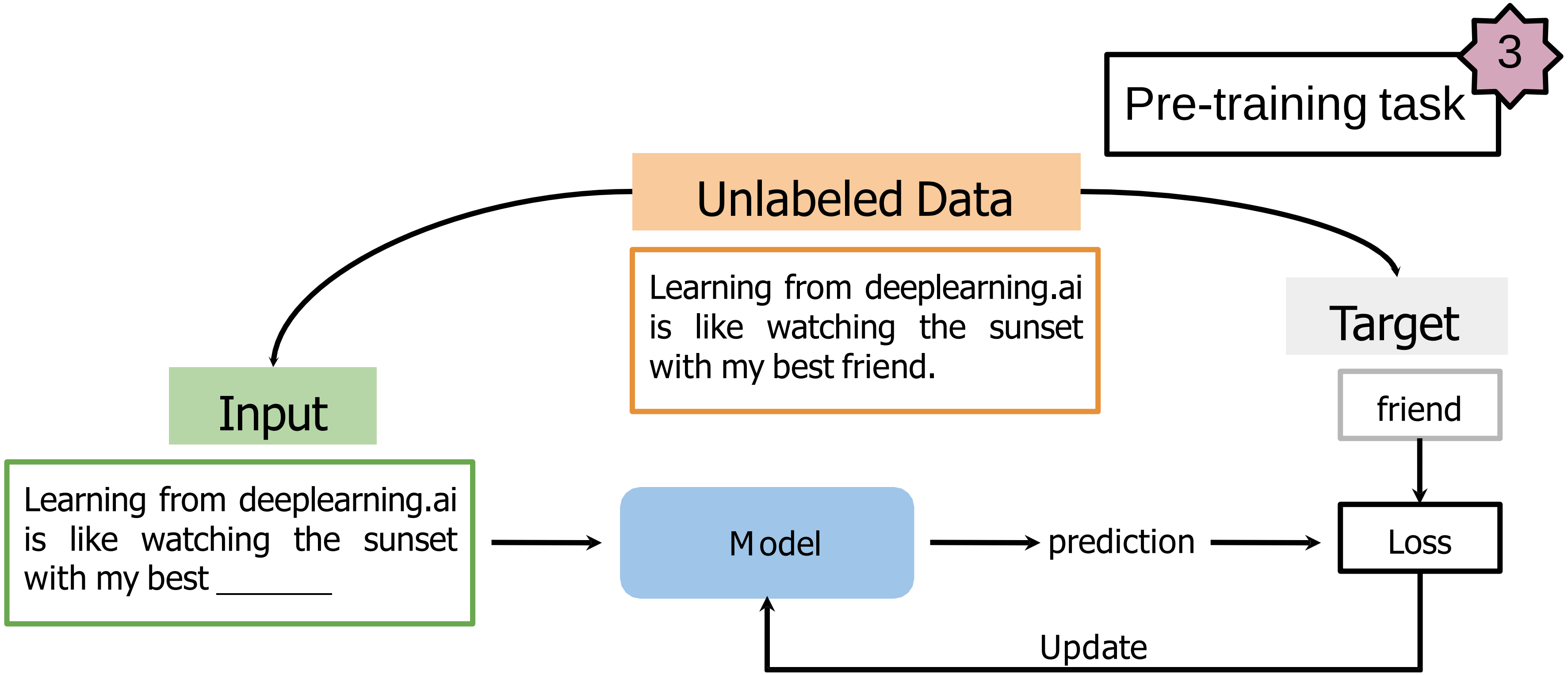
Transfer learning with unlabeled data





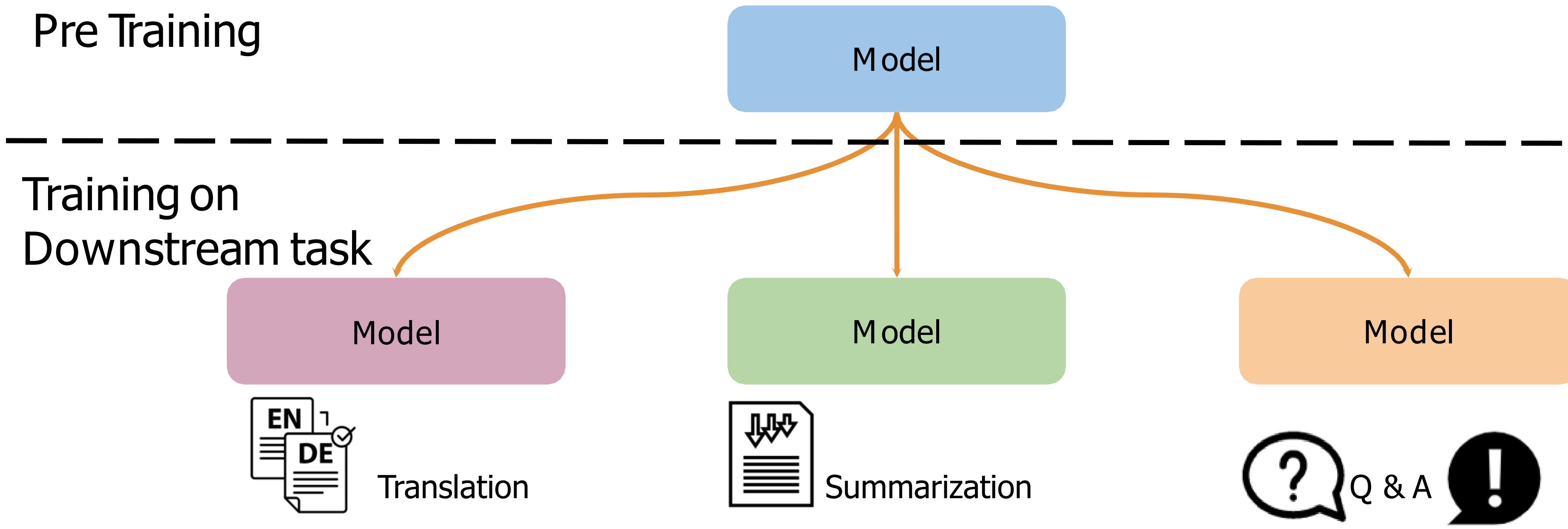
Which tasks work with **unlabeled** data?

Self-supervised tasks

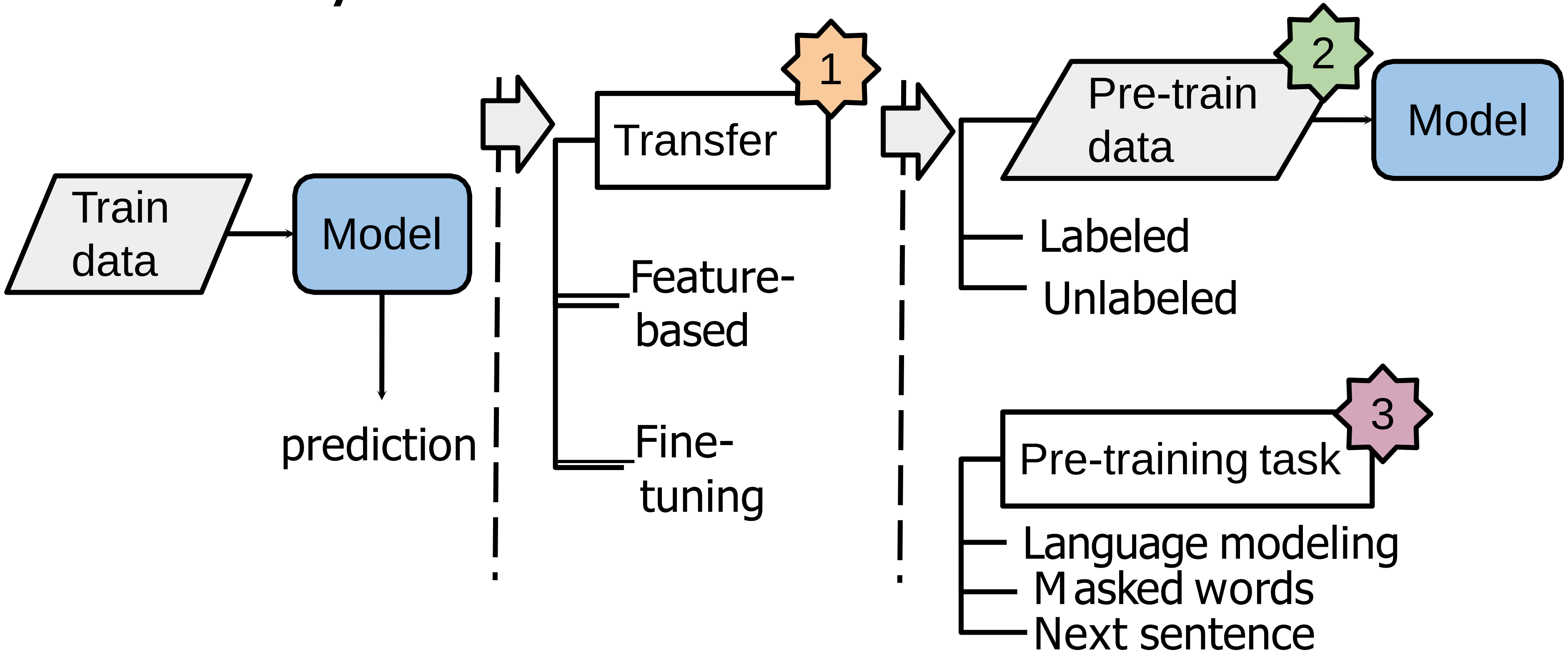


Language modeling

Fine-tune a model for each downstream task



Summary



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ELMo, GPT, BERT, T5 - Outline

CBOW ELMo GPT BERT T5

… right …

- Context

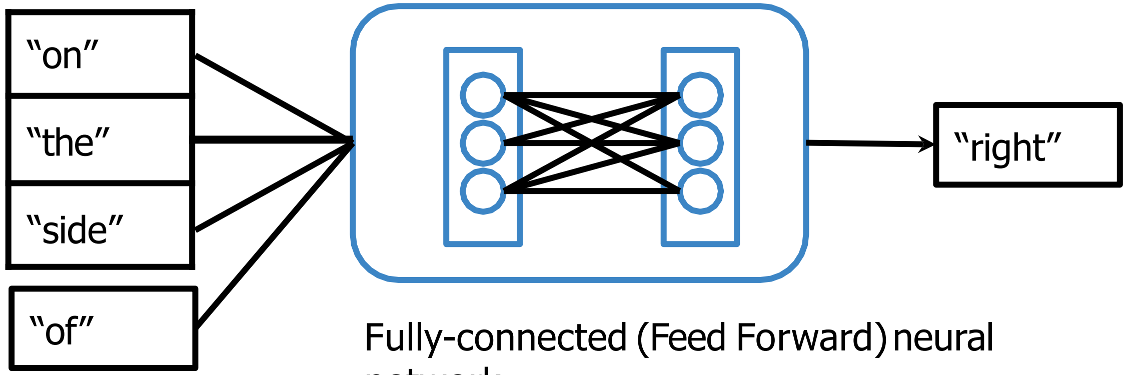
… they were on the right …

… they were on the right side of the street

Continuous Bag of Words

… they were on the right side of the street

Fixed window Fixed window



Fully-connected (Feed Forward) neural network

Need more context?

… they were on the right side of the street.

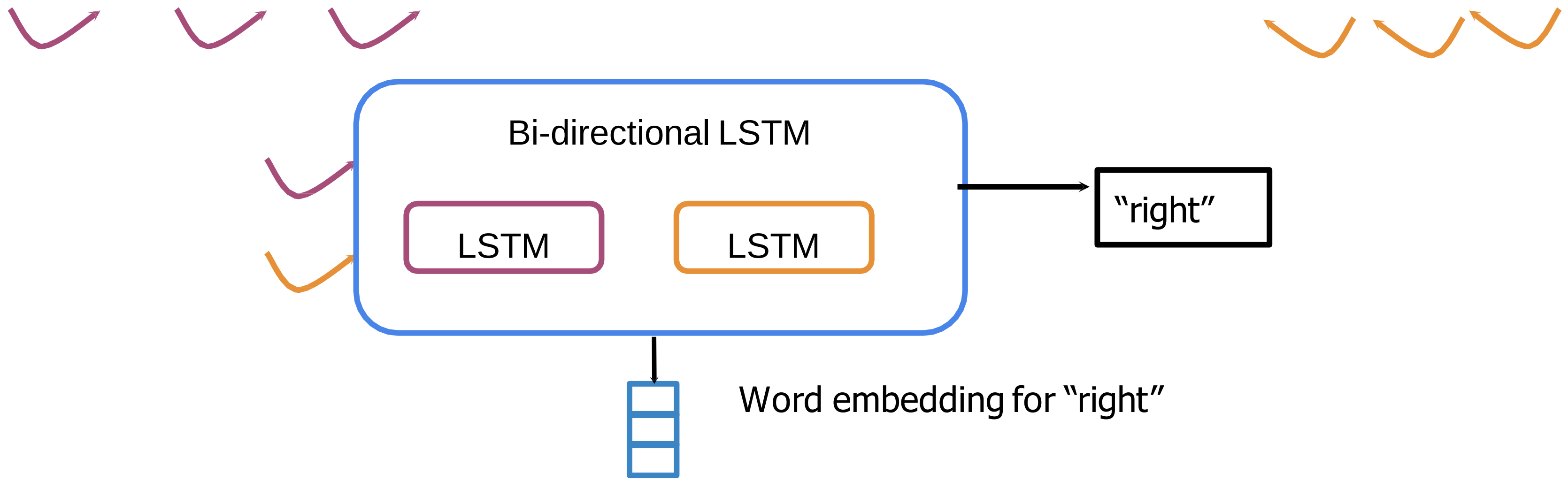
Fixed window Fixed window

… they were on the right side of history.

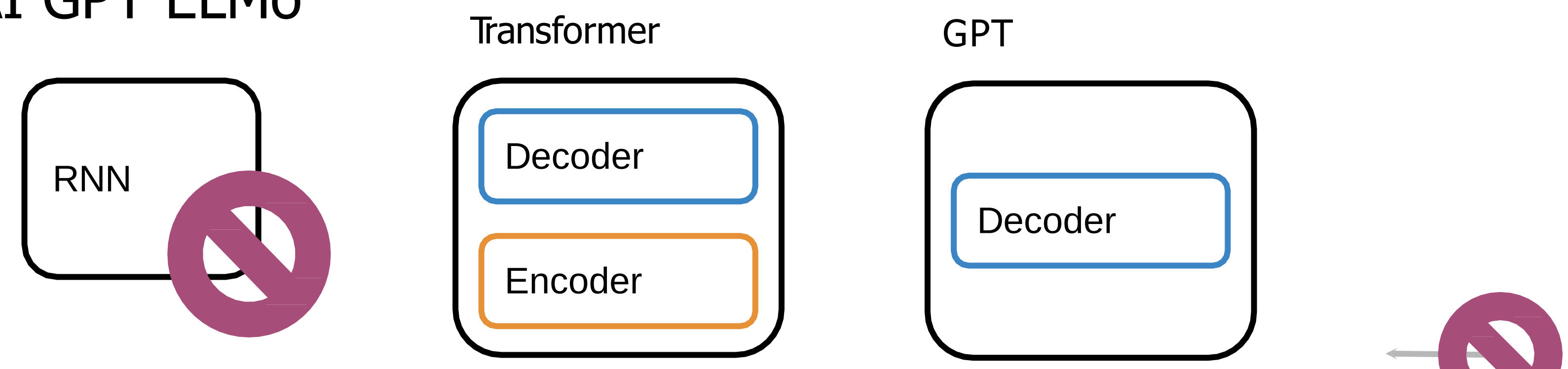
The legislators believed that they were on the right side of history, so they changed the law.

ELMo: Full context using RNN

The legislators believed that they were on the _____ side of history so they changed the law.



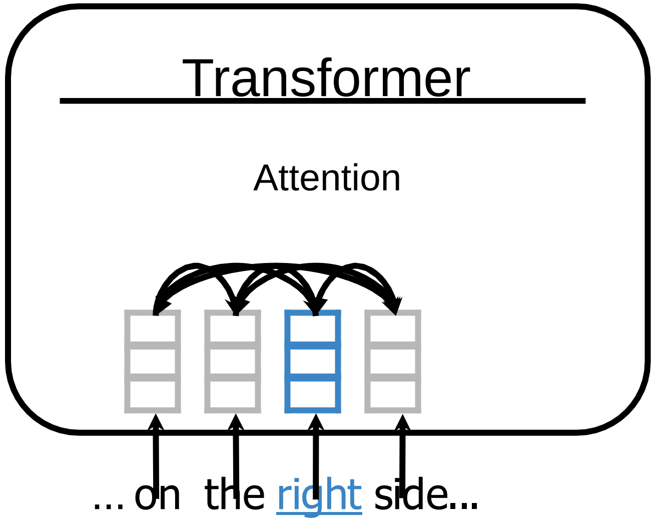
- Open AI GPT ELMo



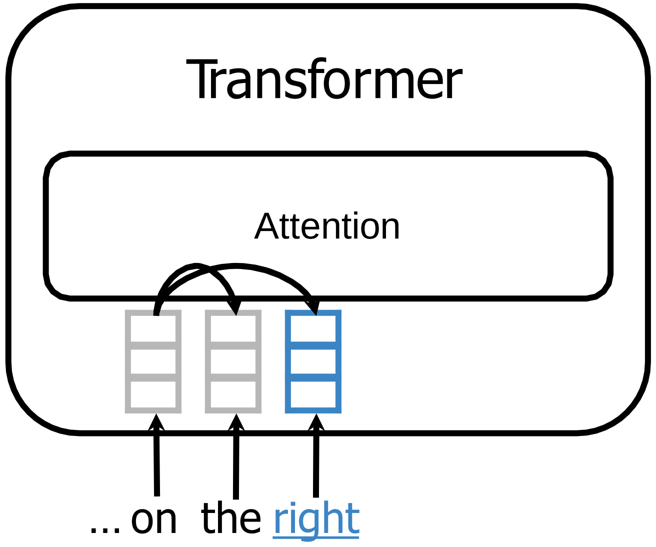
The legislators believed that they were on the _____

Uni-directional

GPT: Uni-directional

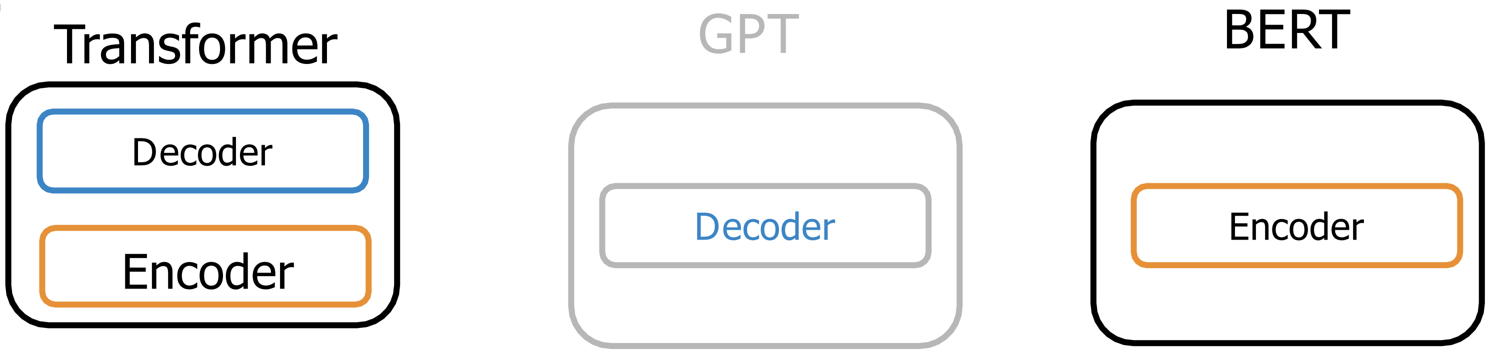


Each word can peek at itself!



No peeking!

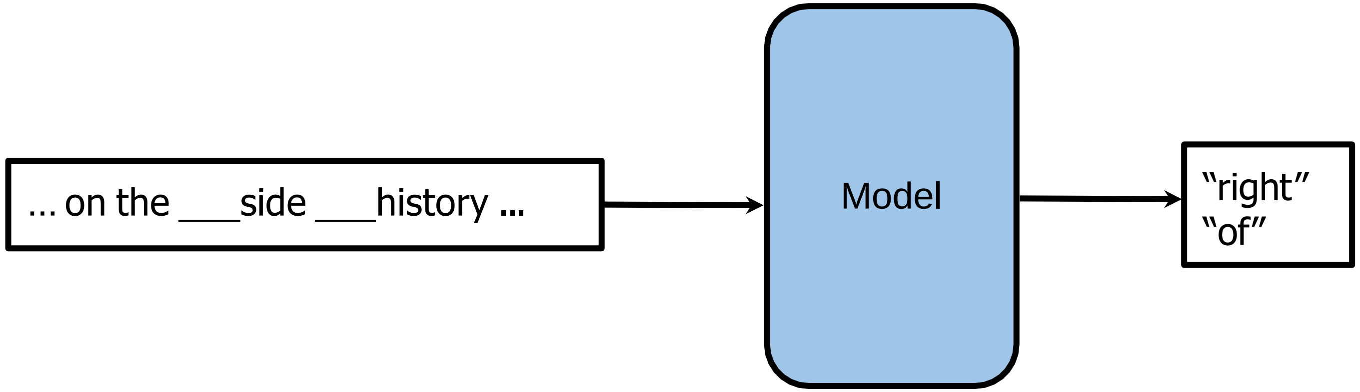
BERT



The legislators believed that they were on the ________ side of history, so they changed the law.

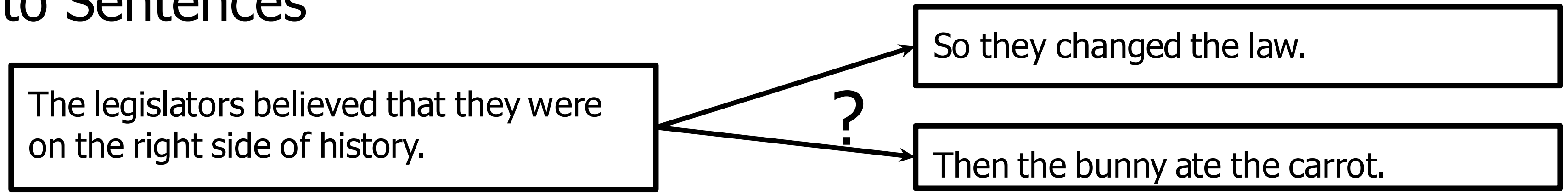
Bi-directional

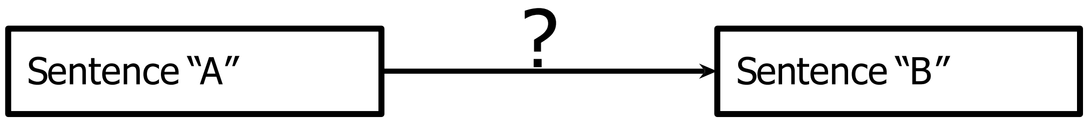
Transformer + Bi-directional Context



Multi-Mask Language Modeling

- BERT: Words to Sentences





Next Sentence Prediction

BERT Pre-training Tasks

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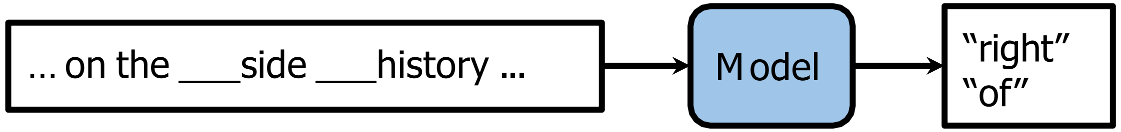
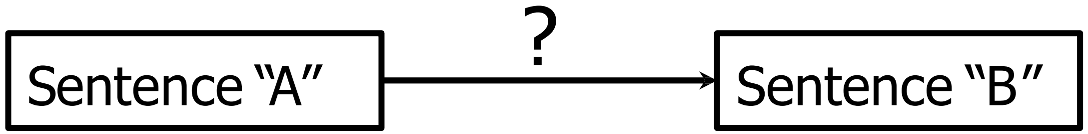
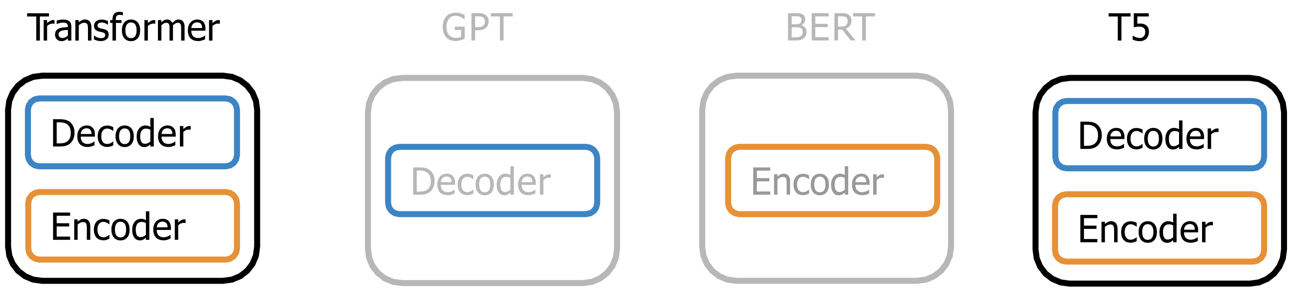
Multi-Mask Language Modeling



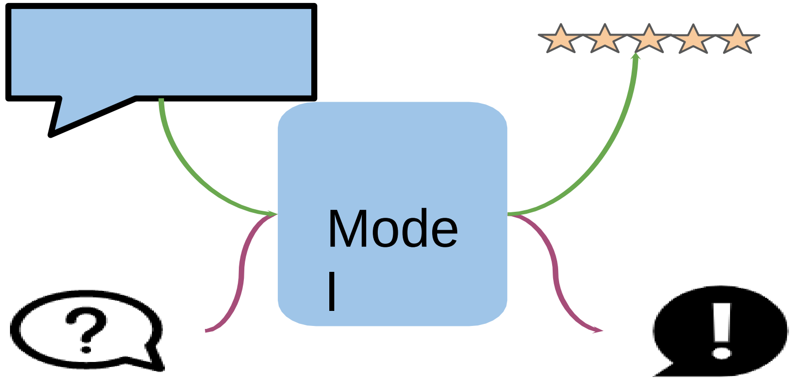
Next Sentence Prediction



T5: Encoder vs. Encoder-Decoder

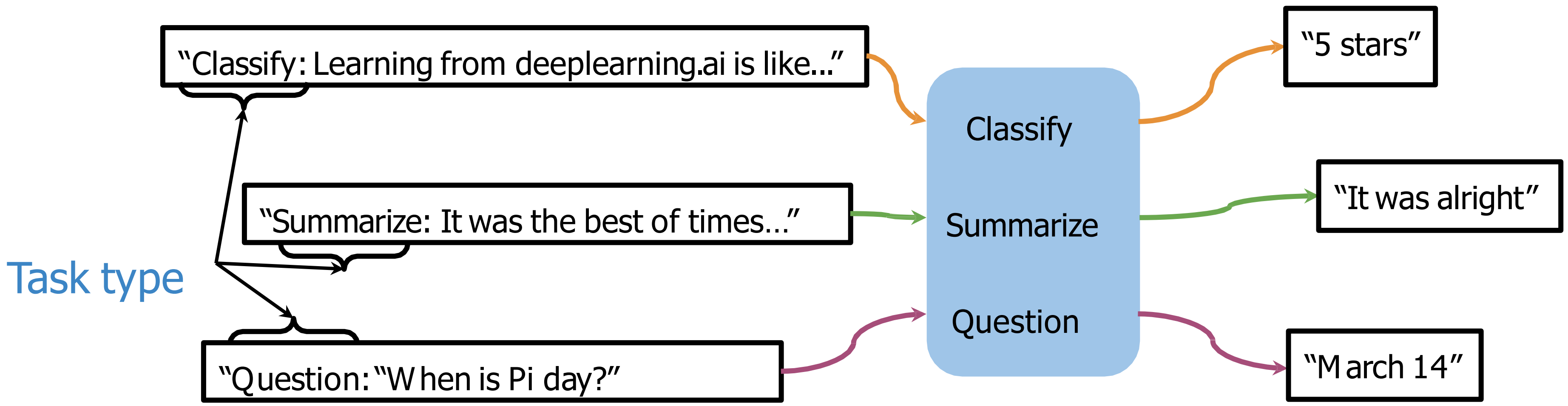


- T5: Multi-task
  - Studying with deeplearning.ai was ...



How
?

T5: Text-to-Text



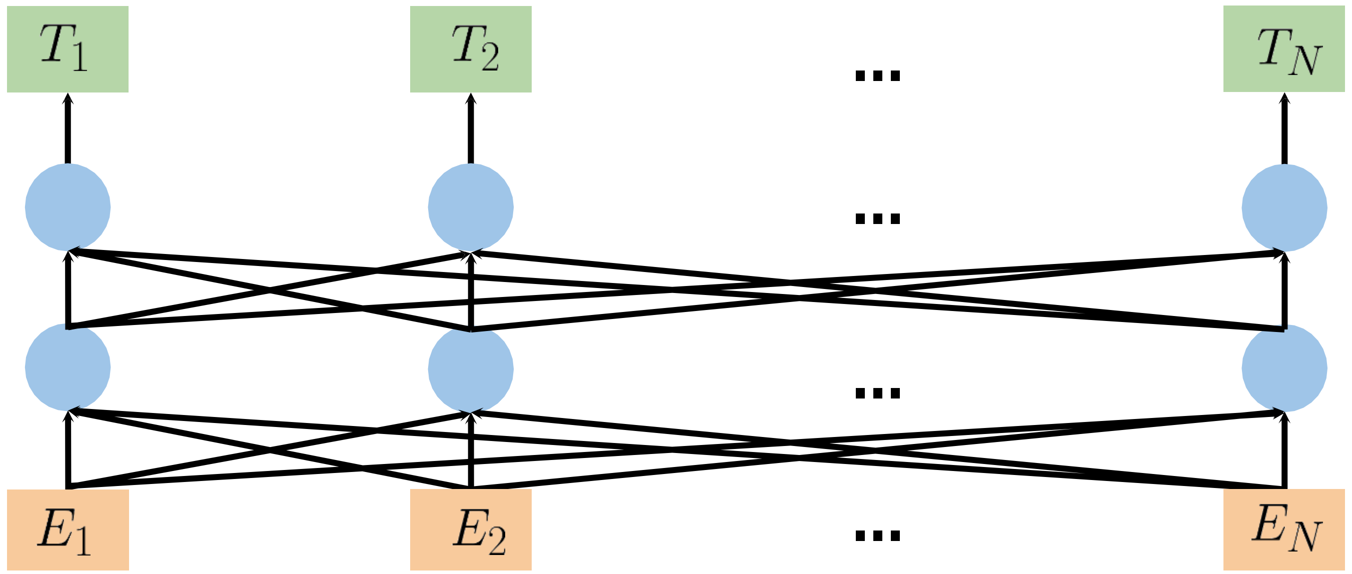
- Summary

CBOW	ELMo	GPT	BERT	T5
Context window FFNN	Full sentence Bi-directional Context RNN	Transformer: Decoder Uni-directional Context	Transformer: Encoder Bi-directional Context Multi-Mask Next Sentence Prediction	Transformer: Encoder - Decoder Bi-directional Context Multi-Task

Bidirectional Encoder Representations from Transformers (BERT)

- BERT architecture
- BERT pre-training works

Makes use of transfer learning/pre-training:



BERT

- A multi layer bidirectional transformer
- Positional embeddings
- BERT_base:
  - 12 layers (12 transformer blocks); 12 attentions heads; 110 million parameters
- BERT pre-training

After school Lukasz does his ____________ in the library.

Masked language modeling (MLM)

After school Lukasz does his homework in the library.

After school __________ his homework in the ________

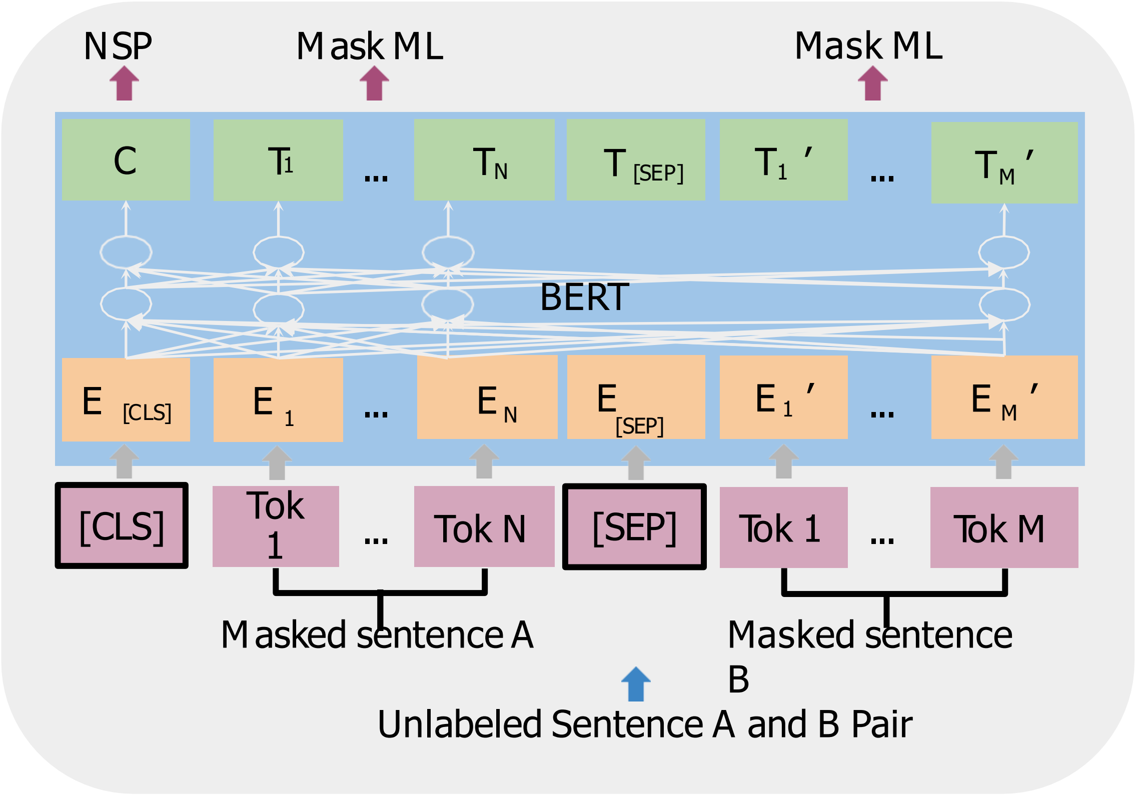
BERT Objective

- ○ Understand how BERT inputs are fed into the model
- ○ Visualize the output
- ○ Learn about the BERT objective

- Formalizing the input

Input	[CLS]	my	dog	is	cute	[SEP]	he	likes	play	##ing	[SEP]
Token Embeddings	$E_{[CLS]}$	E_{my}	E_{dog}	E_{is}	E_{cute}	$E_{[SEP]}$	E_{he}	E_{likes}	E_{play}	$E_{\#\#ing}$	$E_{[SEP]}$
	+	+	+	+	+	+	+	+	+	+	+
Segment Embeddings	E_A	E_A	E_A	E_A	E_A	E_A	E_B	E_B	E_B	E_B	E_B
	+	+	+	+	+	+	+	+	+	+	+
Position Embeddings	E_0	E_1	E_2	E_3		E_5	E_6	E_7			

Visualizing the output



- [CLS]: a special classification symbol added in front of every input
- [SEP]: a special separator token

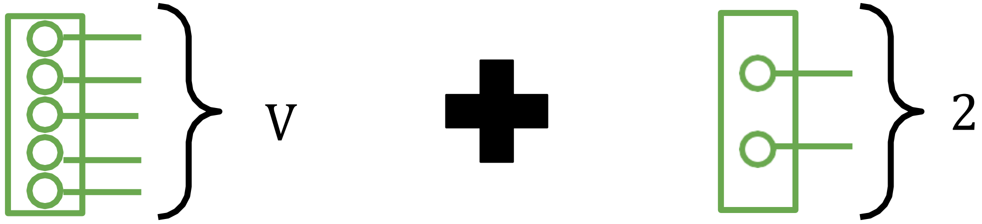
BERT Objective

Objective 1:
Multi-Mask LM

Loss: Cross Entropy Loss

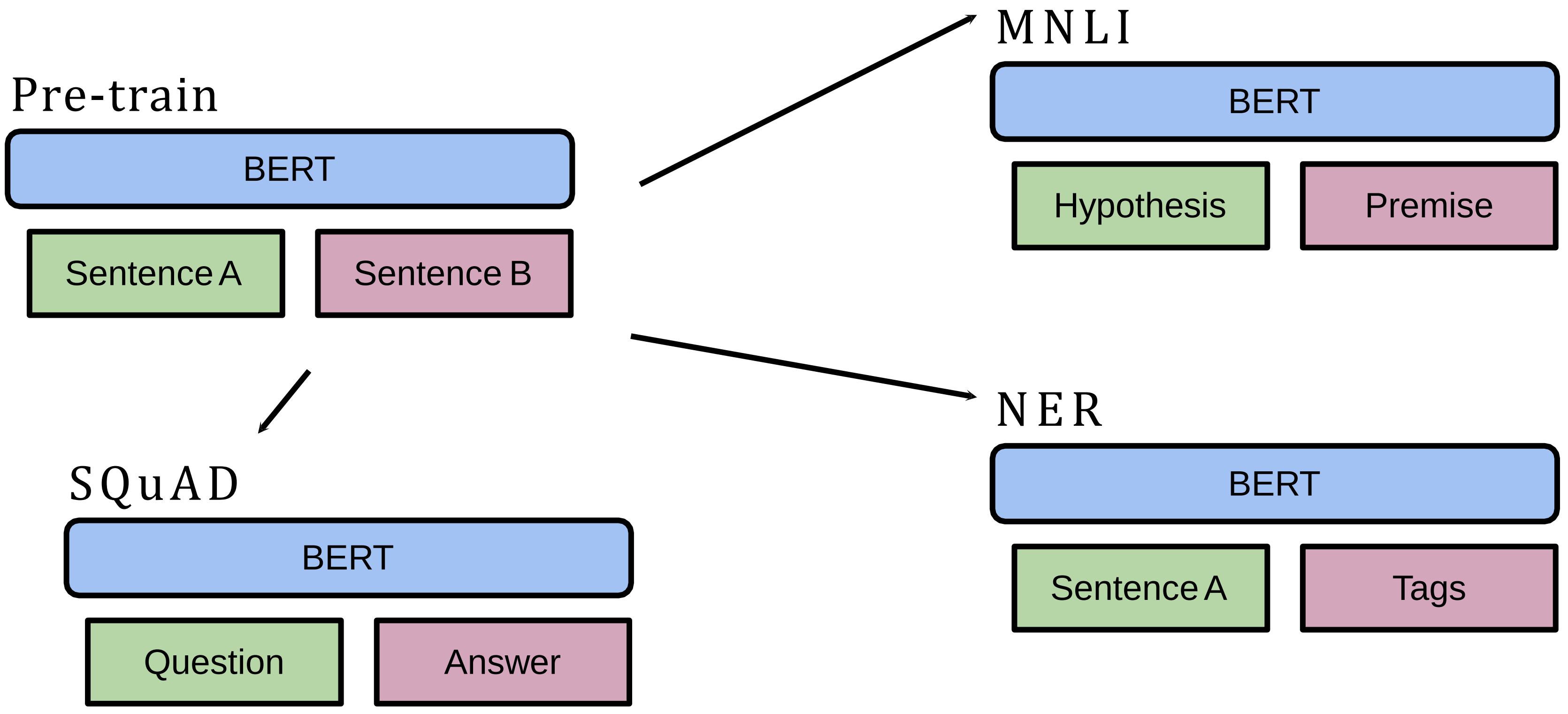
Objective 2:
Next Sentence Prediction

Loss: Binary Loss

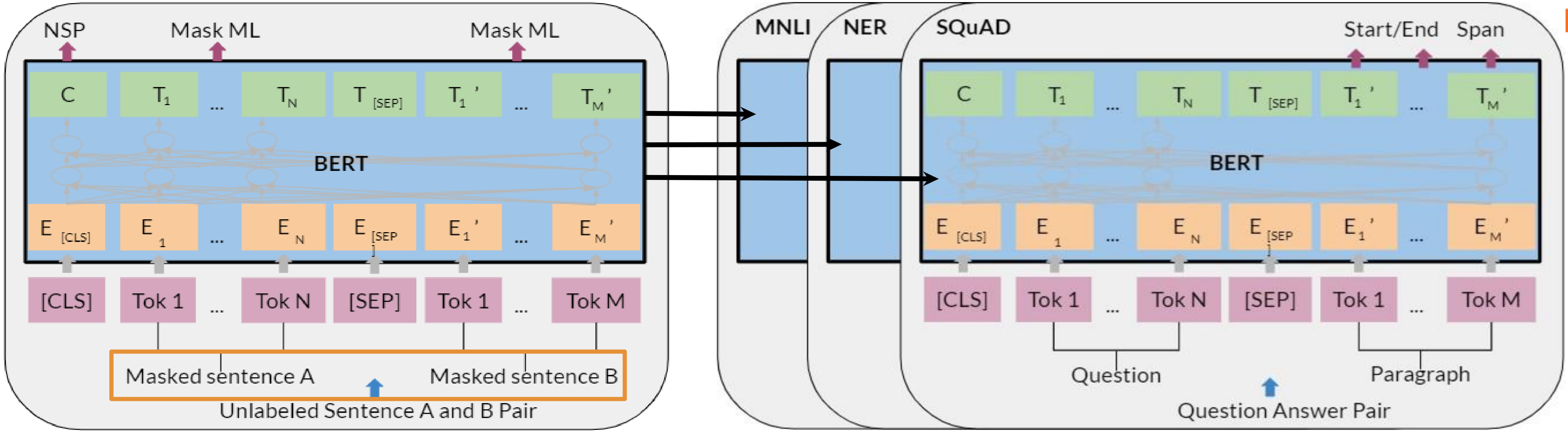


- Summary
    - BERT objective
    - Model inputs/outputs

Fine-tuning BERT: Outline



Inputs



- Summary

Sentence A	Sentence B	Sentence	Entities
Text	Ø	Sentence	Paraphrase
Question	Passage	Article	Summary
Hypothesis	Premise	⋮	

Transformer - T5 Model

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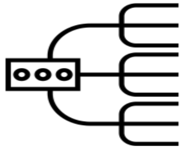
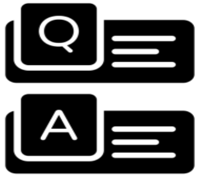
- Understand how T5 works
- Recognize the different types of attention used
- Overview of model architecture

Text to Text



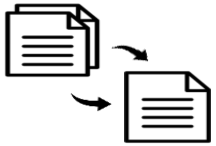
Classification



Question Answering (Q&A)

Machine Translation

Summarization



Sentiment

Transformer - T5 Model

Original text

Thank you ~~for inviting~~ me to your party ~~last~~ week.

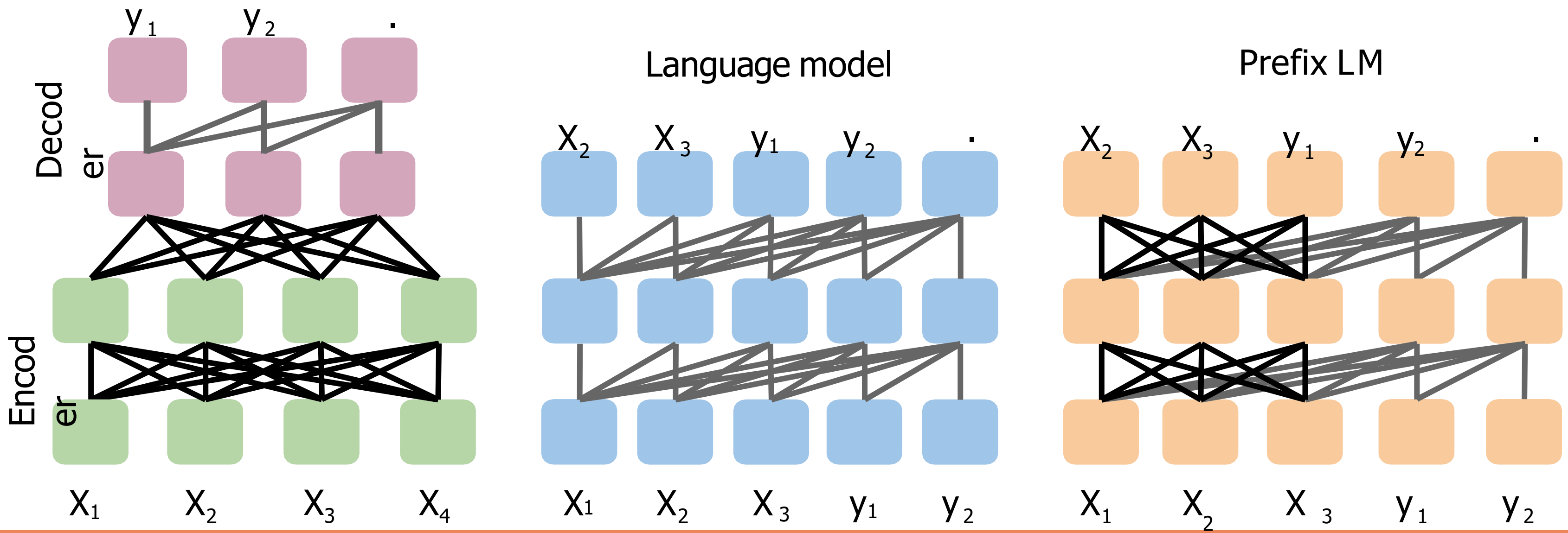
Inputs

Thank you <X> me to your party <Y> week.

Targets

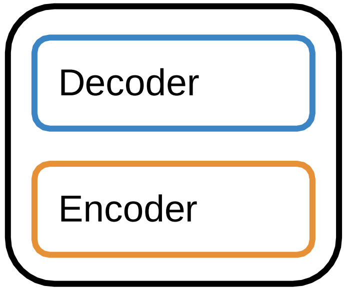
<X> for inviting <Y> last <Z>

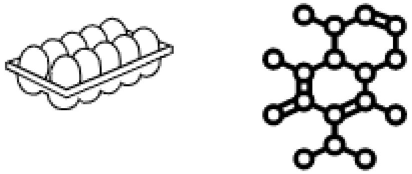
- Model Architecture



Model Architecture

- Encoder/decoder
- 12 transformer blocks each
- 220 million parameters

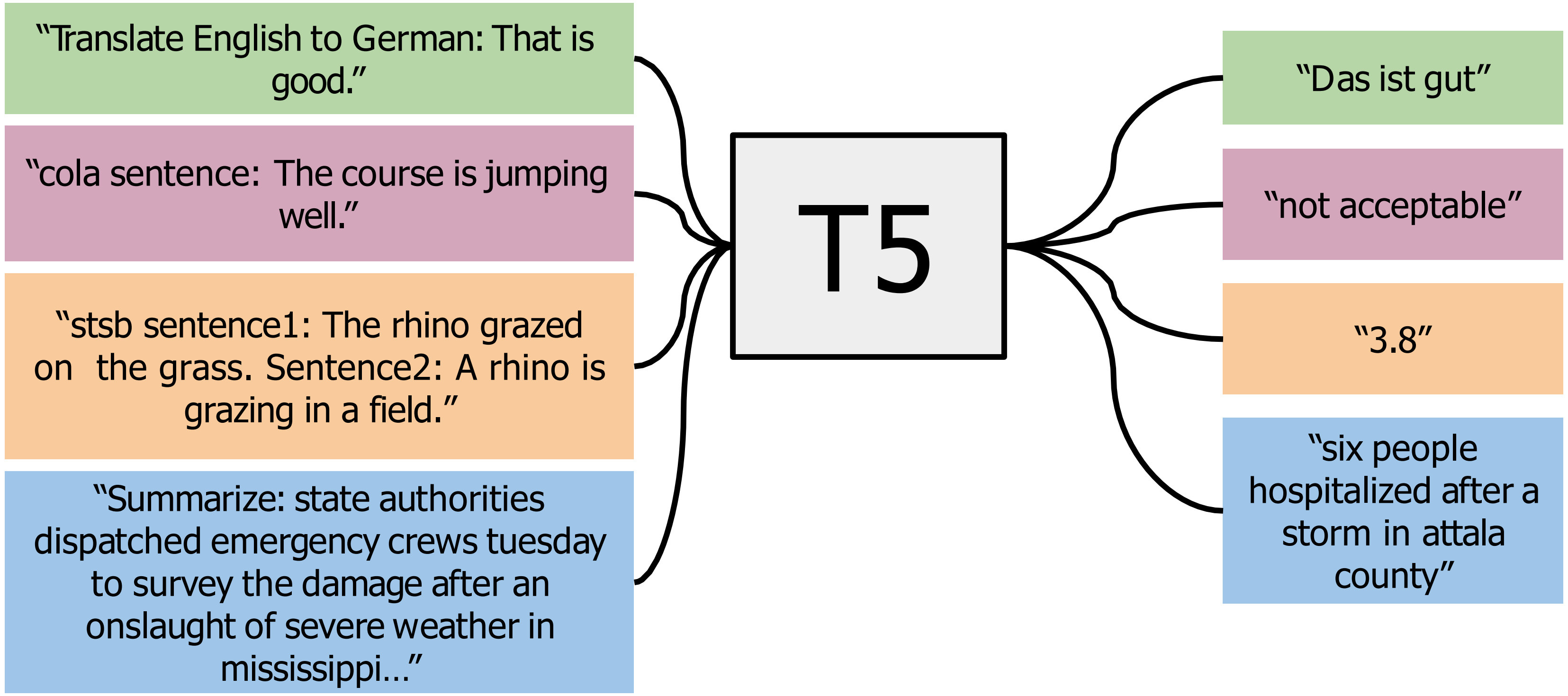




©Exploring the Limits of Transfer learning with a unified text to Text Transformer. Raffel et. al. 2020

- Summary
  - Prefix LM attention
  - Model architecture
  - Pre-training T5 (MLM)

Multi-task training strategy



Input and Output Format

Machine translation:

- translate English to German: That is good.

- Predict entailment, contradiction , or neutral
  - mnli premise: I hate pigeons hypothesis: My feelings towards pigeons are filled with animosity. target: entailment
- Winograd schema
  - The city councilmen refused the demonstrators a permit because *they* feared violence

Multi-task Training Strategy

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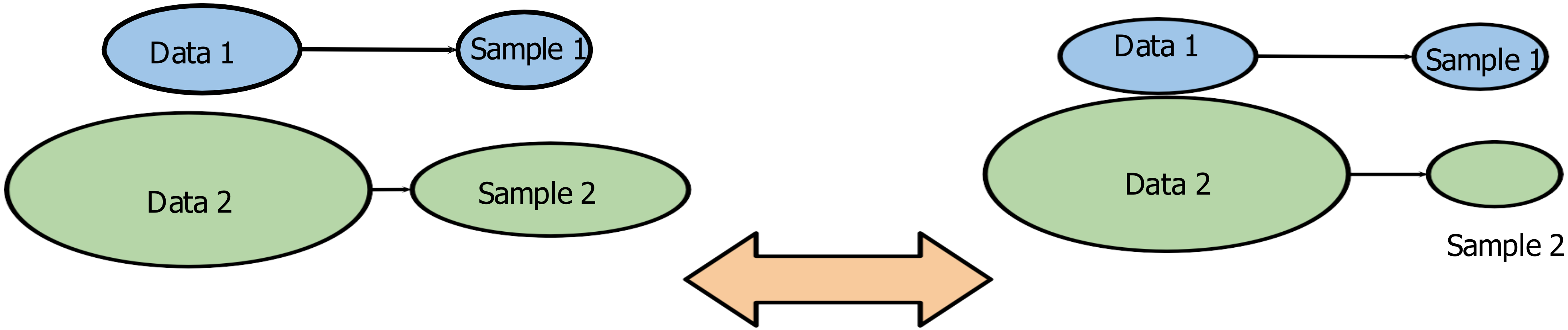
Fine-tuning method	GLUE	CNNDM	SQuAD	SGLUE	EnDe	EnFr	EnRo
* All parameters	**83.28**	**19.24**	**80.88**	**71.36**	**26.98**	**39.82**	**27.65**
Adapter layers, $d = 32$	80.52	15.08	79.32	60.40	13.84	17.88	15.54
Adapter layers, $d = 128$	81.51	16.62	79.47	63.03	19.83	27.50	22.63
Adapter layers, $d = 512$	81.54	17.78	79.18	64.30	23.45	33.98	25.81
Adapter layers, $d = 2048$	81.51	16.62	79.47	63.03	19.83	27.50	22.63
Gradual unfreezing	82.50	18.95	79.17	**70.79**	26.71	39.02	26.93

How much data from each task to train on?

Data Training Strategies

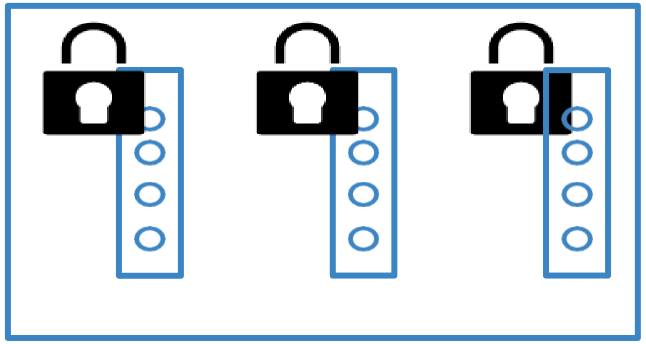
Examples-proportional mixing

Equal mixing

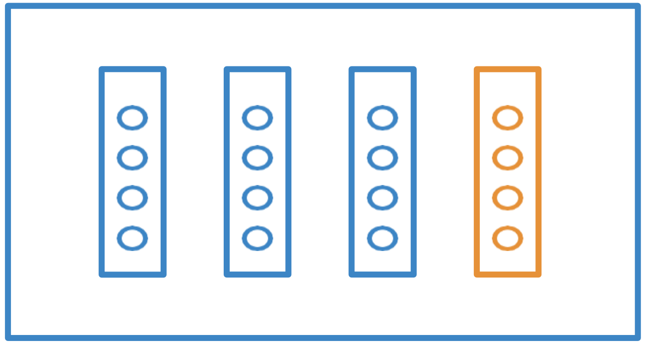


Temperature-scaled mixing

- Gradual unfreezing vs. Adapter layers

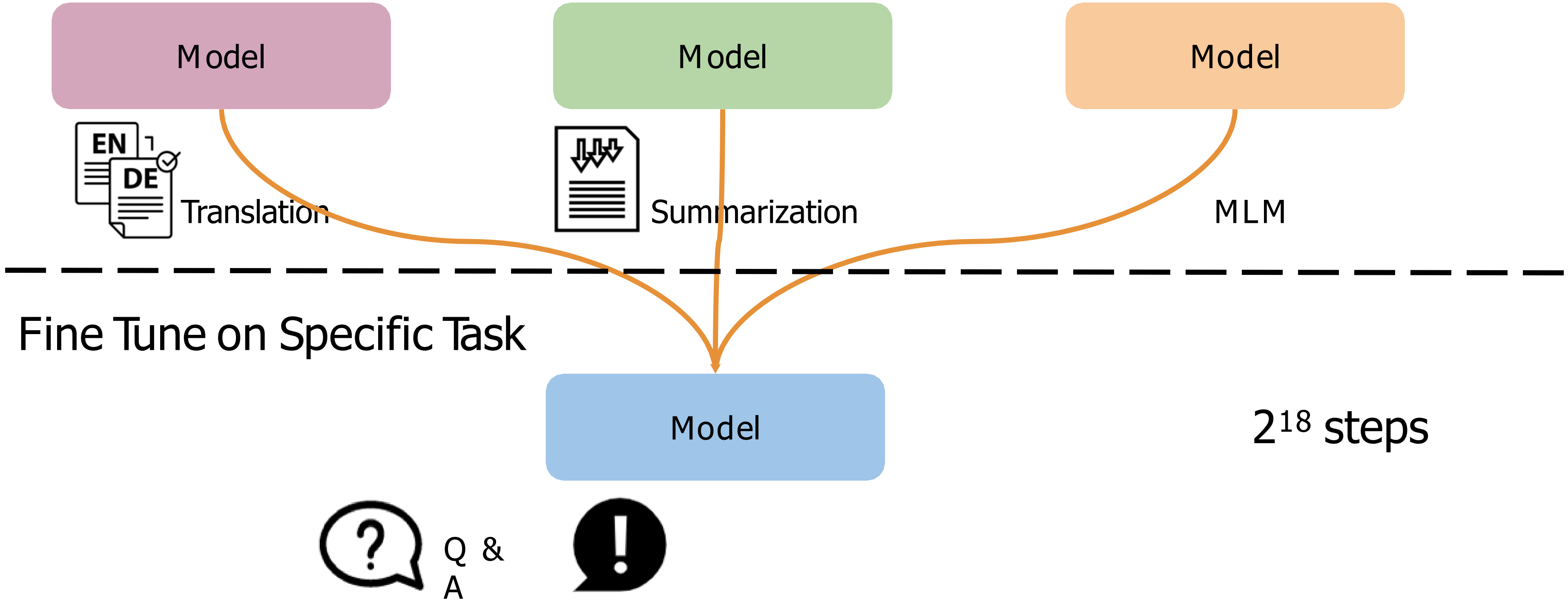


Gradual unfreezing



Adapter layers

Fine-tuning

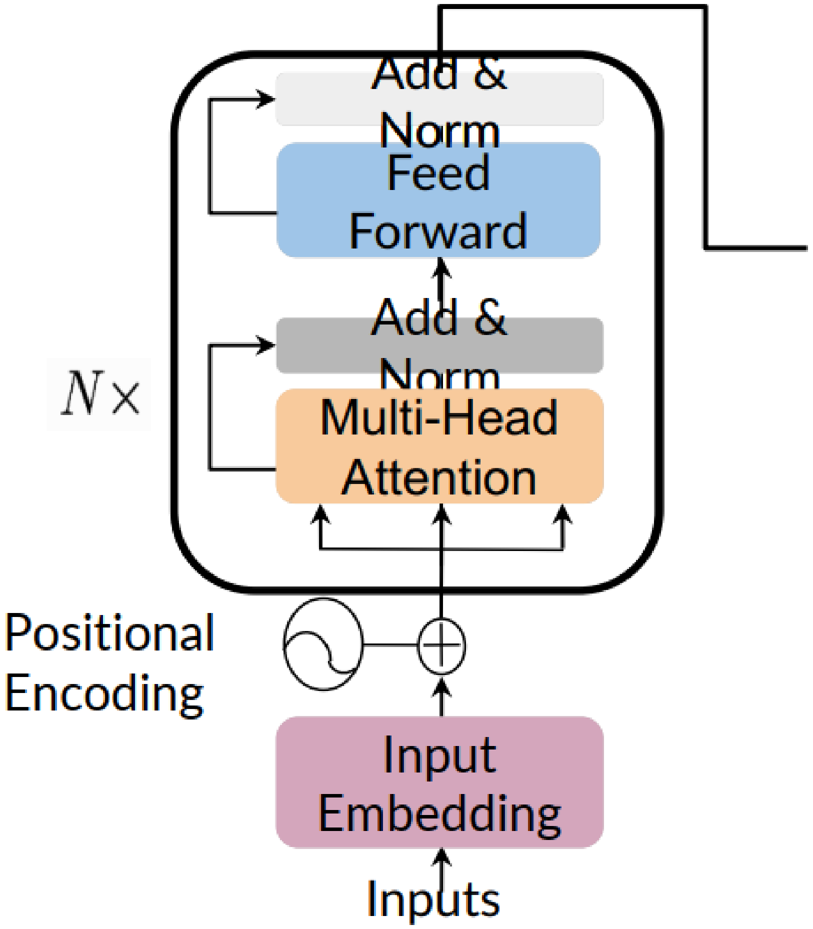


2^{18} steps

GLUE Benchmark

- General Language Understanding Evaluation
  - A collection used to train, evaluate, analyze natural language
  - understanding systems
  - Datasets with different genres, and of different sizes and difficulties
  - Leaderboard
- Tasks Evaluated on
  - Sentence grammatical or not?
  - Sentiment; Paraphrase; Similarity
  - Questions duplicates; Answerable; Contradiction
  - Entailment; Winograd (co-ref)
- General Language Understanding Evaluation
  - Drive research; Model agnostic; Makes use of transfer learning

Question Answering - Transformer encoder



Feedforward:

```
[
    LayerNorm,
    dense,
    activation,
    dropout_middle,
    dense,
    dropout_final
]
```

Encoder block:

```
[
    Residual(
        LayerNorm,
        attention,
        dropout_,
    ),
    Residual(
        feed_forward,
    )
]
```

Data examples

Question: What percentage of the French population today is non - European ?

Context: Since the end of the Second World War , France has become an ethnically diverse country . Today , **approximately five percent** of the French population is non - European and non - white . This does not approach the number of non - white citizens in the United States (roughly 28 – 37 % , depending on how Latinos are classified ; see Demographics of the United States) . Nevertheless , it amounts to at least three million people , and has forced the issues of ethnic diversity onto the French policy agenda . France has developed an approach to dealing with ethnic problems that stands in contrast to that of many advanced , industrialized countries . Unlike the United States , Britain , or even the Netherlands , France maintains a " color - blind " model of public policy . This means that it targets virtually no policies directly at racial or ethnic groups . Instead , it uses geographic or class criteria to address issues of social inequalities . It has , however , developed an extensive anti - racist policy repertoire since the early 1970s . Until recently , French policies focused primarily on issues of hate speech — going much further than their American counterparts — and relatively less on issues of discrimination in jobs , housing , and in provision of goods and services .

Target: Approximately five percent

Implementing Q&A with T5

- Load a pre-trained model
- Process data to get the required inputs and outputs: "question: Q context: C" as input and "A" as target
- Fine tune your model on the new task and input
- Predict using your own model