人工智能技术及应用

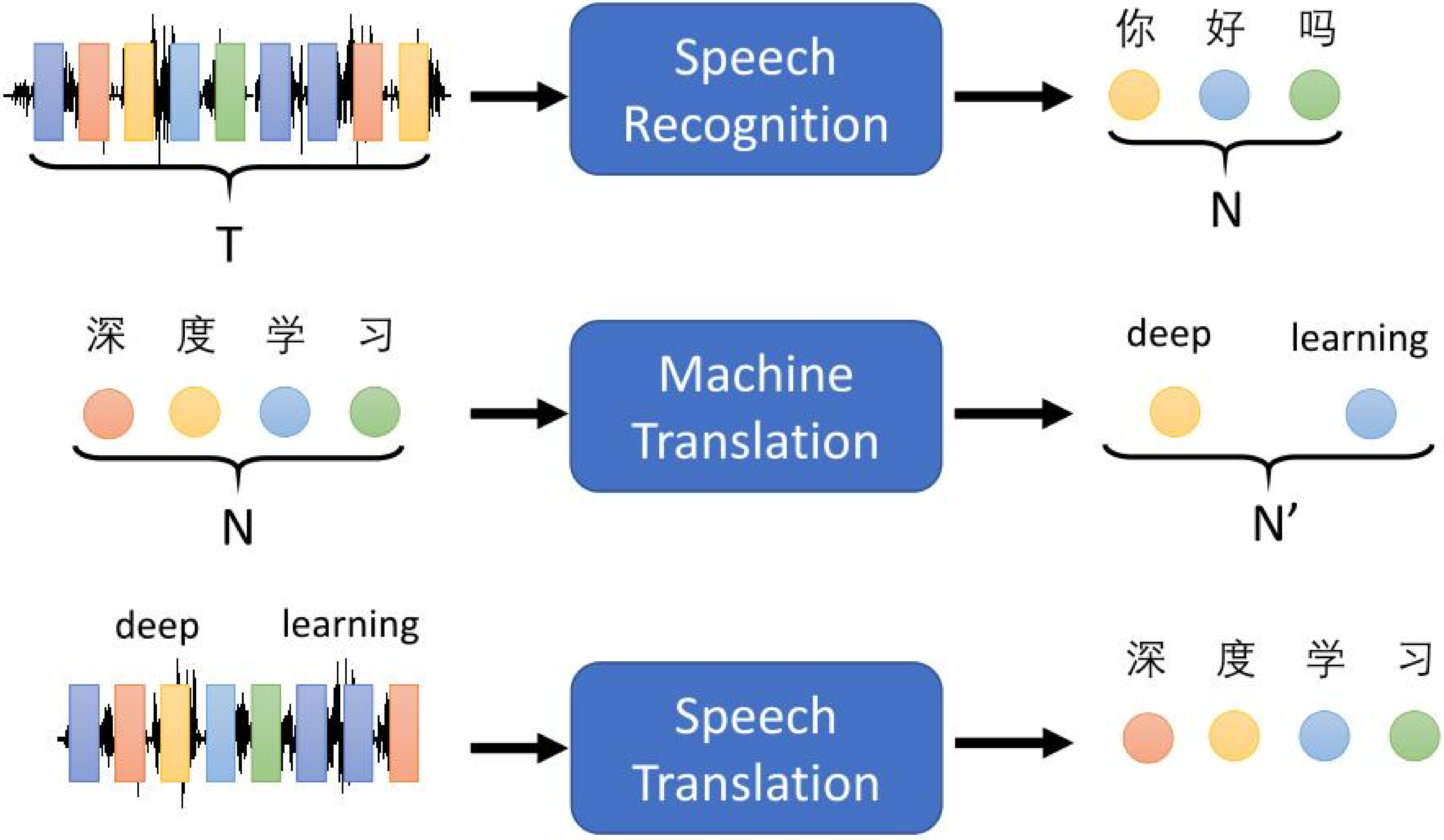
Artificial Intelligence and Application

Transformer

Sequence-to-sequence (Seq2seq)

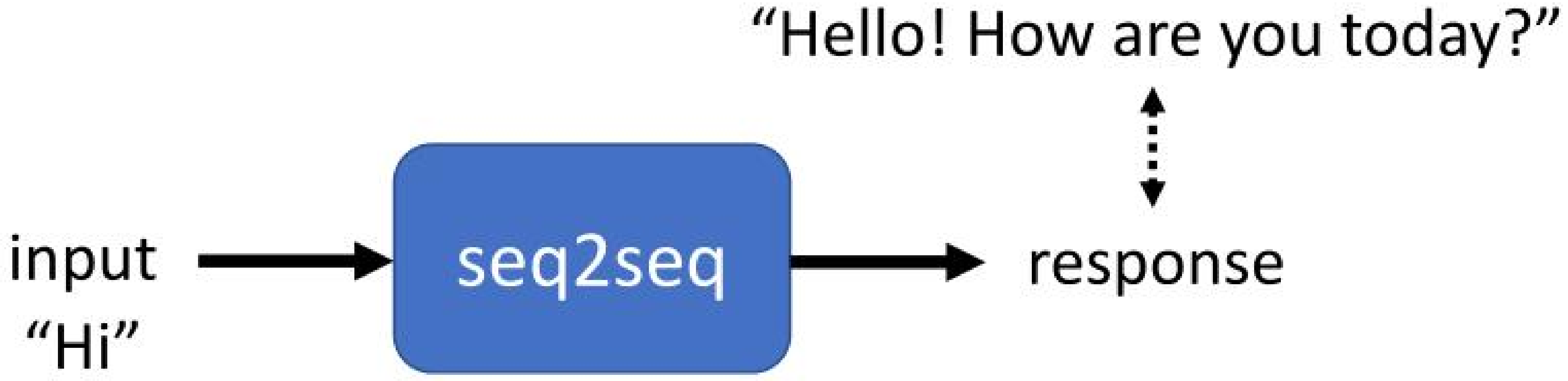
Input a sequence, output a sequence

The output length is determined by model.



Language without text

Seq2seq for Chatbot



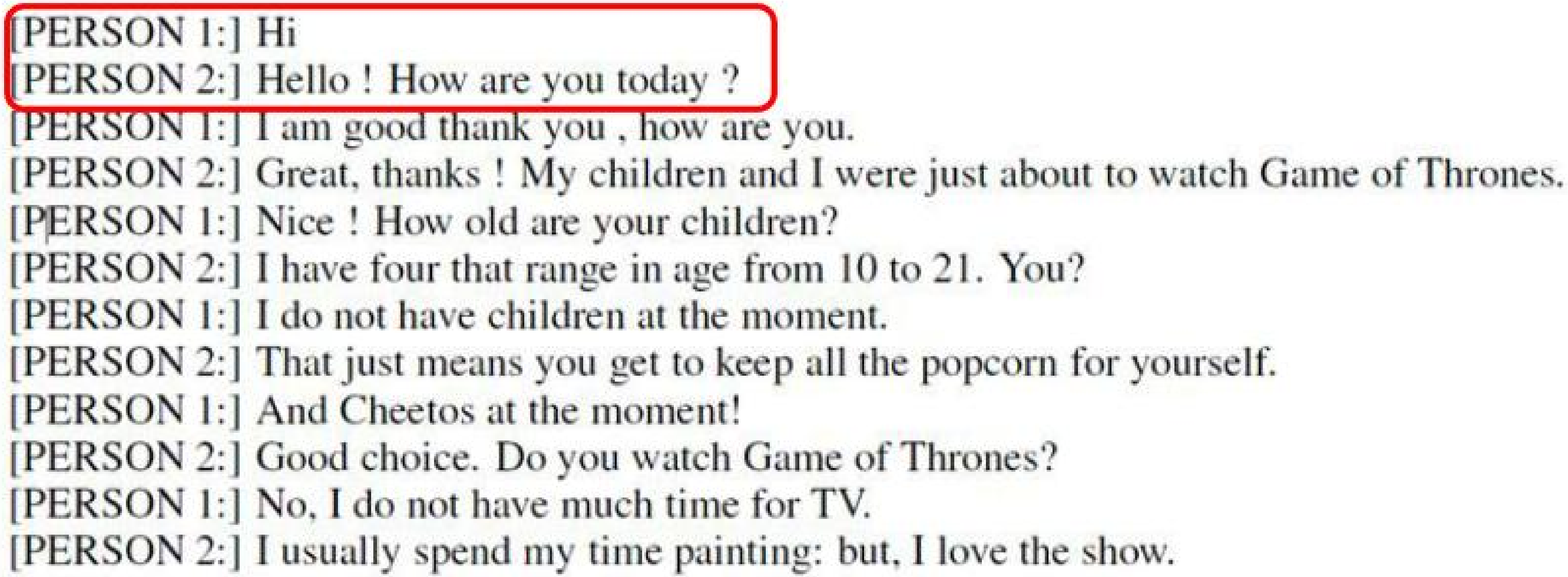
“Hello! How are you today?”

input “Hi”

seq2seq

response

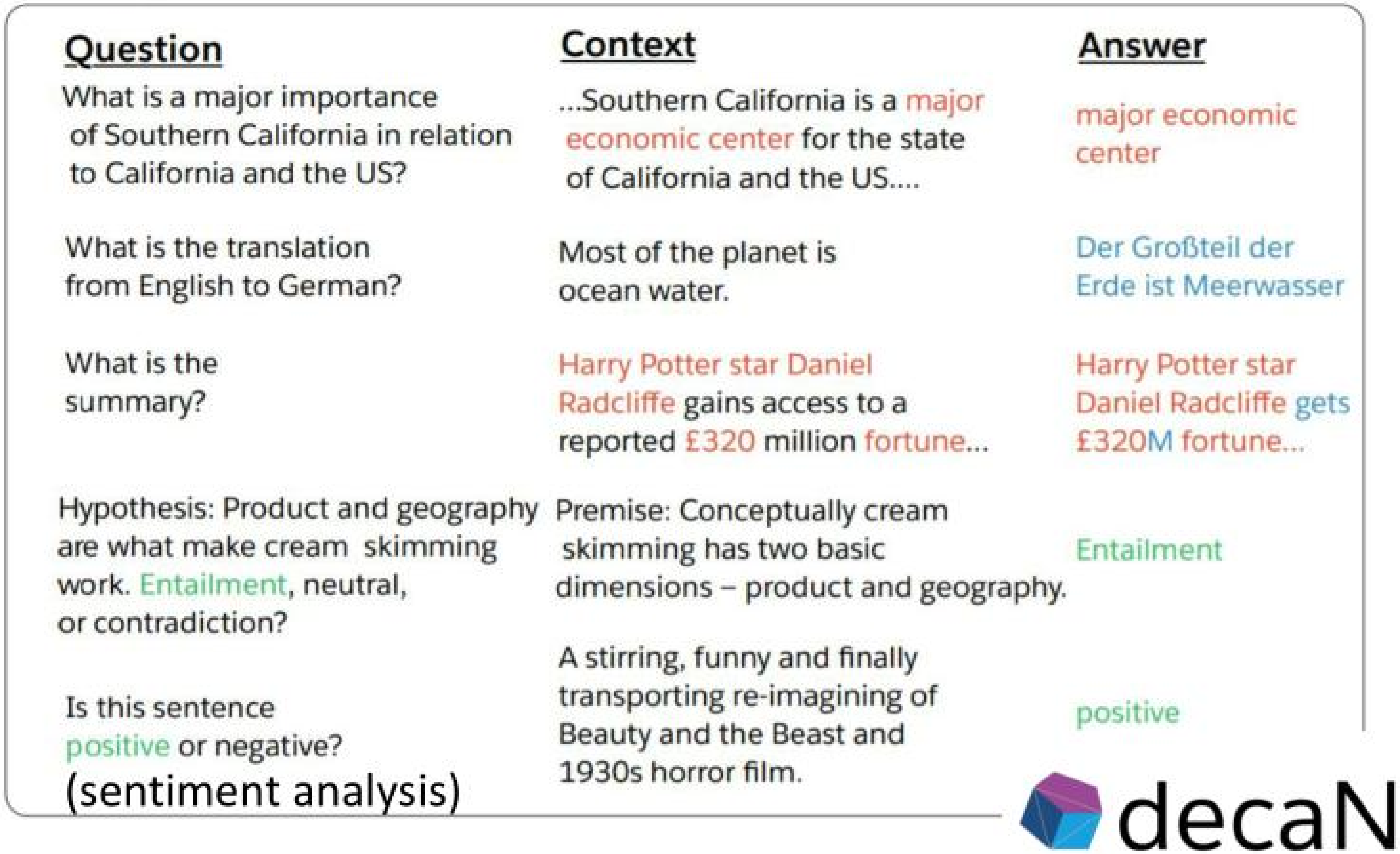
Training data:



[PERSON 1:] Hi
[PERSON 2:] Hello ! How are you today ?
[PERSON 1:] I am good thank you , how are you.
[PERSON 2:] Great, thanks ! My children and I were just about to watch Game of Thrones.
[PERSON 1:] Nice ! How old are your children?
[PERSON 2:] I have four that range in age from 10 to 21. You?
[PERSON 1:] I do not have children at the moment.
[PERSON 2:] That just means you get to keep all the popcorn for yourself.
[PERSON 1:] And Cheetos at the moment!
[PERSON 2:] Good choice. Do you watch Game of Thrones?
[PERSON 1:] No, I do not have much time for TV.
[PERSON 2:] I usually spend my time painting: but, I love the show.

Most Natural Language Processing applications …

Question Answering (QA)

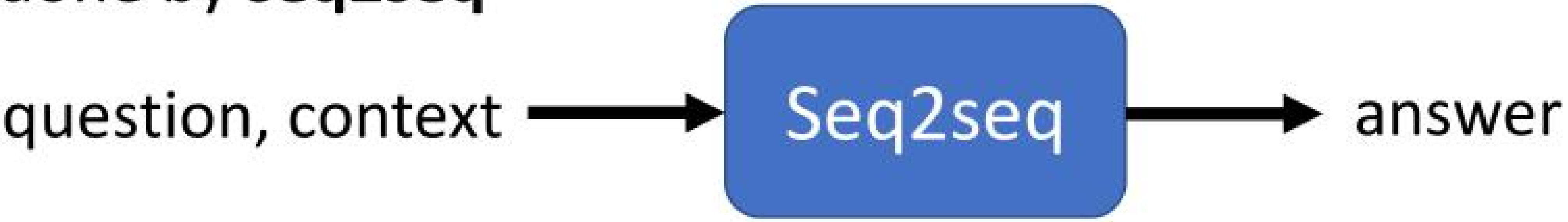


Question	Context	Answer
What is a major importance of Southern California in relation to California and the US?	…Southern California is a major economic center for the state of California and the US.…	major economic center
What is the translation from English to German?	Most of the planet is ocean water.	Der Großteil der Erde ist Meerwasser
What is the summary?	Harry Potter star Daniel Radcliffe gains access to a reported £320 million fortune…	Harry Potter star Daniel Radcliffe gets £320M fortune…
Hypothesis: Product and geography are what make cream skimming work. Entailment, neutral, or contradiction?	Premise: Conceptually cream skimming has two basic dimensions – product and geography.	Entailment
Is this sentence positive or negative?	A stirring, funny and finally transporting re-imagining of Beauty and the Beast and 1930s horror film.	positive

(sentiment analysis)

decaNLP

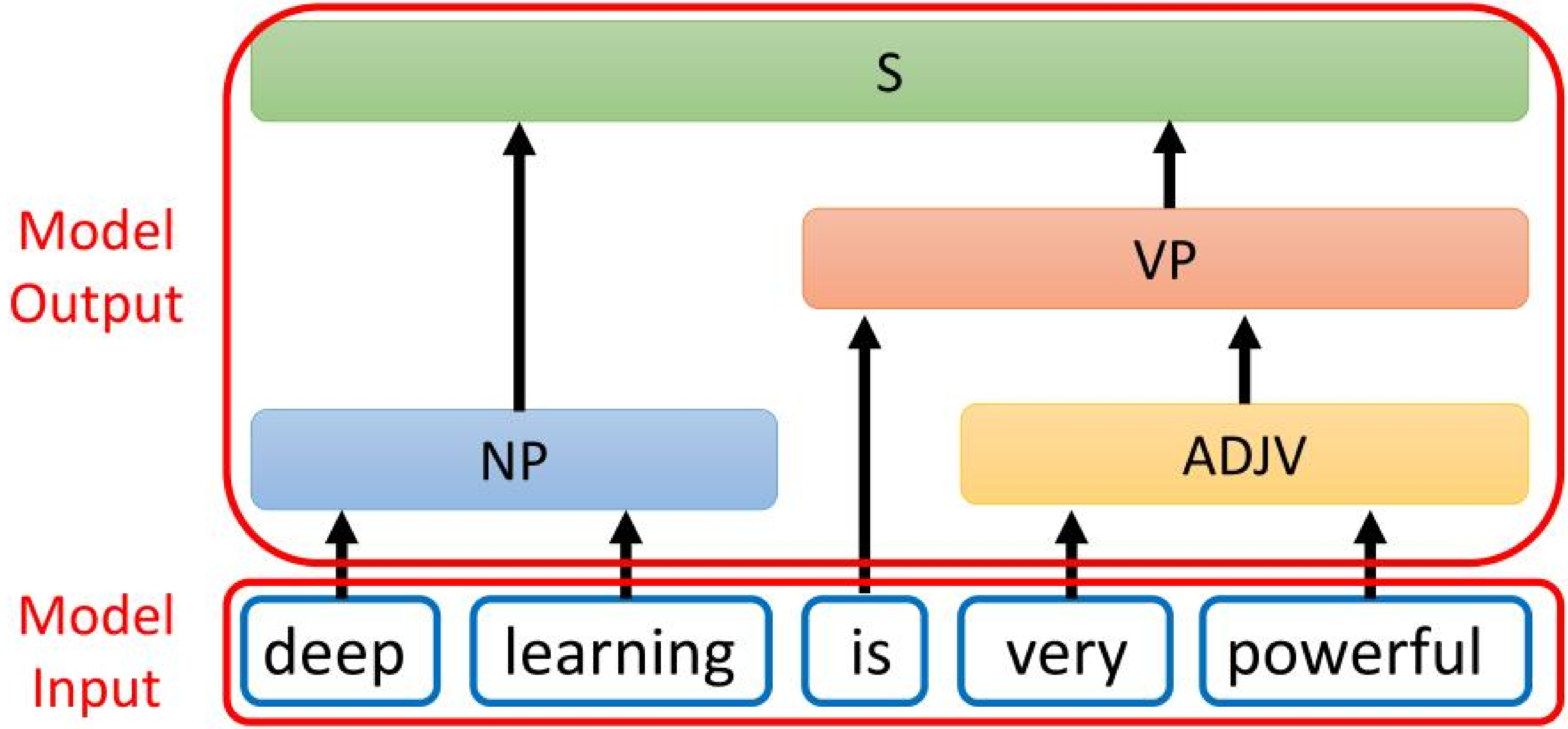
QA can be done by **seq2seq**



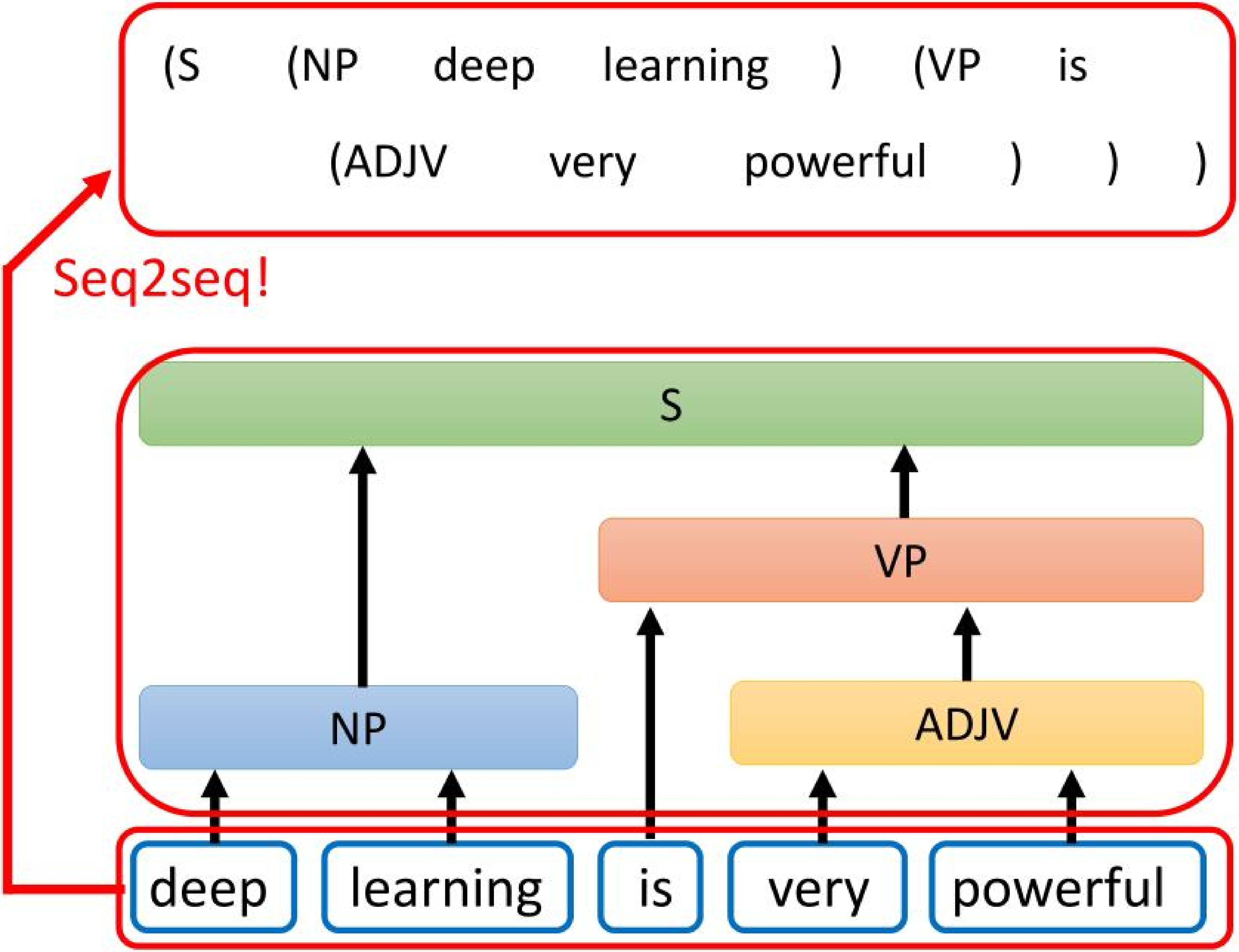
https://arxiv.org/abs/1806.08730
https://arxiv.org/abs/1909.03329

Seq2seq for Syntactic Parsing

Is it a sequence?



Seq2seq for Syntactic Parsing



(S (NP deep learning) (VP is (ADJV very powerful)))

Seq2seq!

Seq2seq for Syntactic Parsing

(S (NP deep learning) (VP is (ADJV very powerful)))

Grammar as a Foreign Language

Oriol Vinyals* Google vinyals@google.com

Lukasz Kaiser* Google lukaszkaiser@google.com

Terry Koo Google terrykoo@google.com

Slav Petrov Google slav@google.com

Ilya Sutskever Google ilyasu@google.com

Geoffrey Hinton Google geoffhinton@google.com

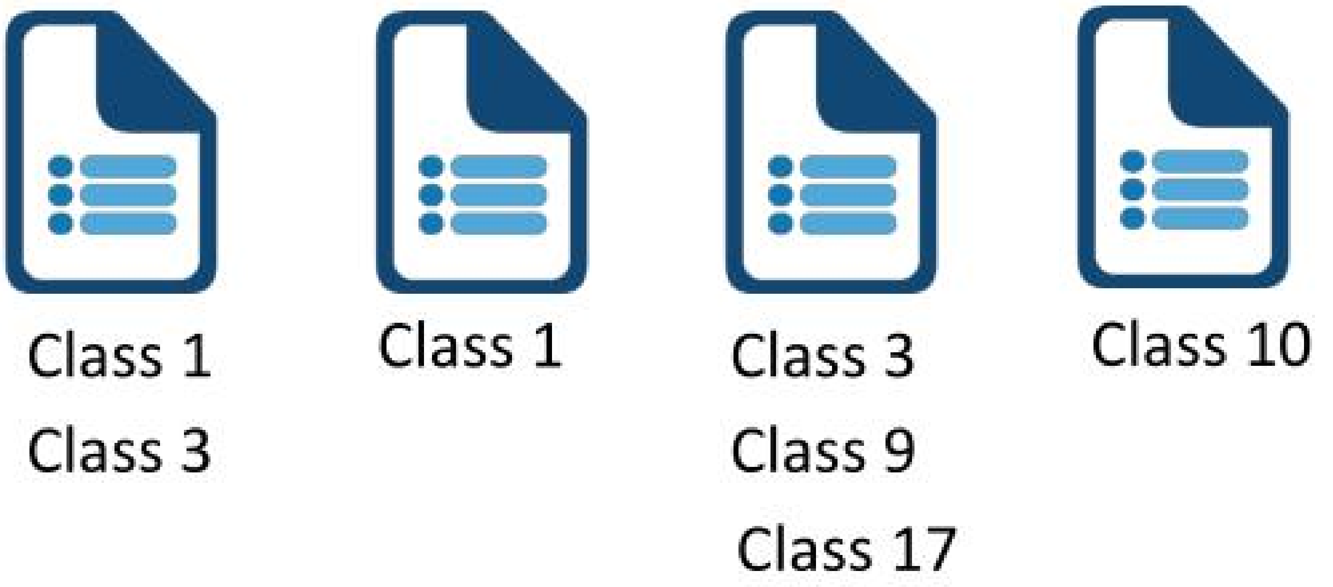
https://arxiv.org/abs/1412.7449

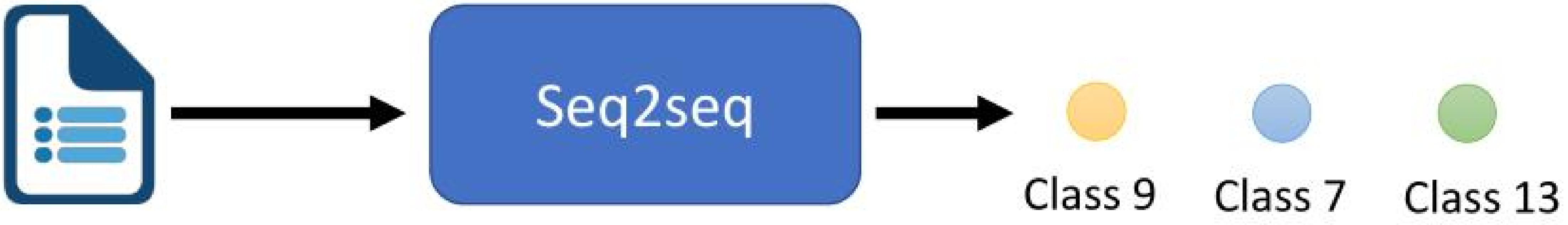
deep learning is very powerful

c.f. Multi-class Classification

Seq2seq for Multi-label Classification

An object can belong to multiple classes.

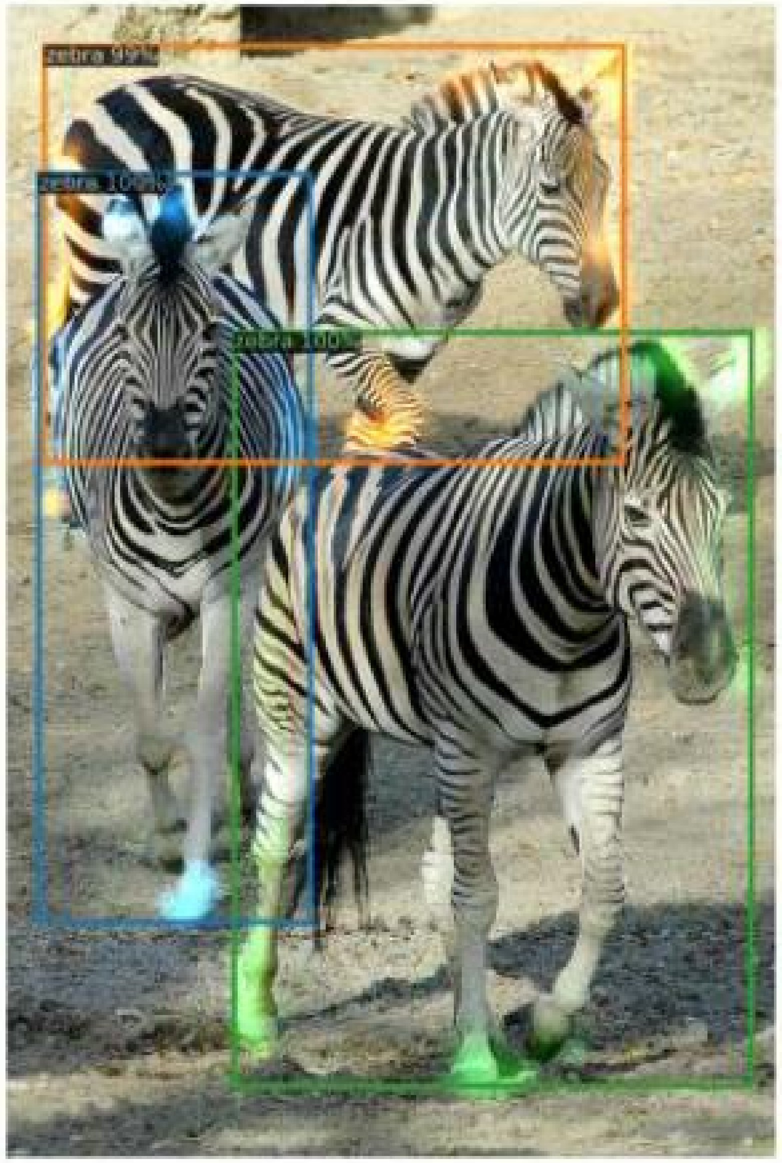


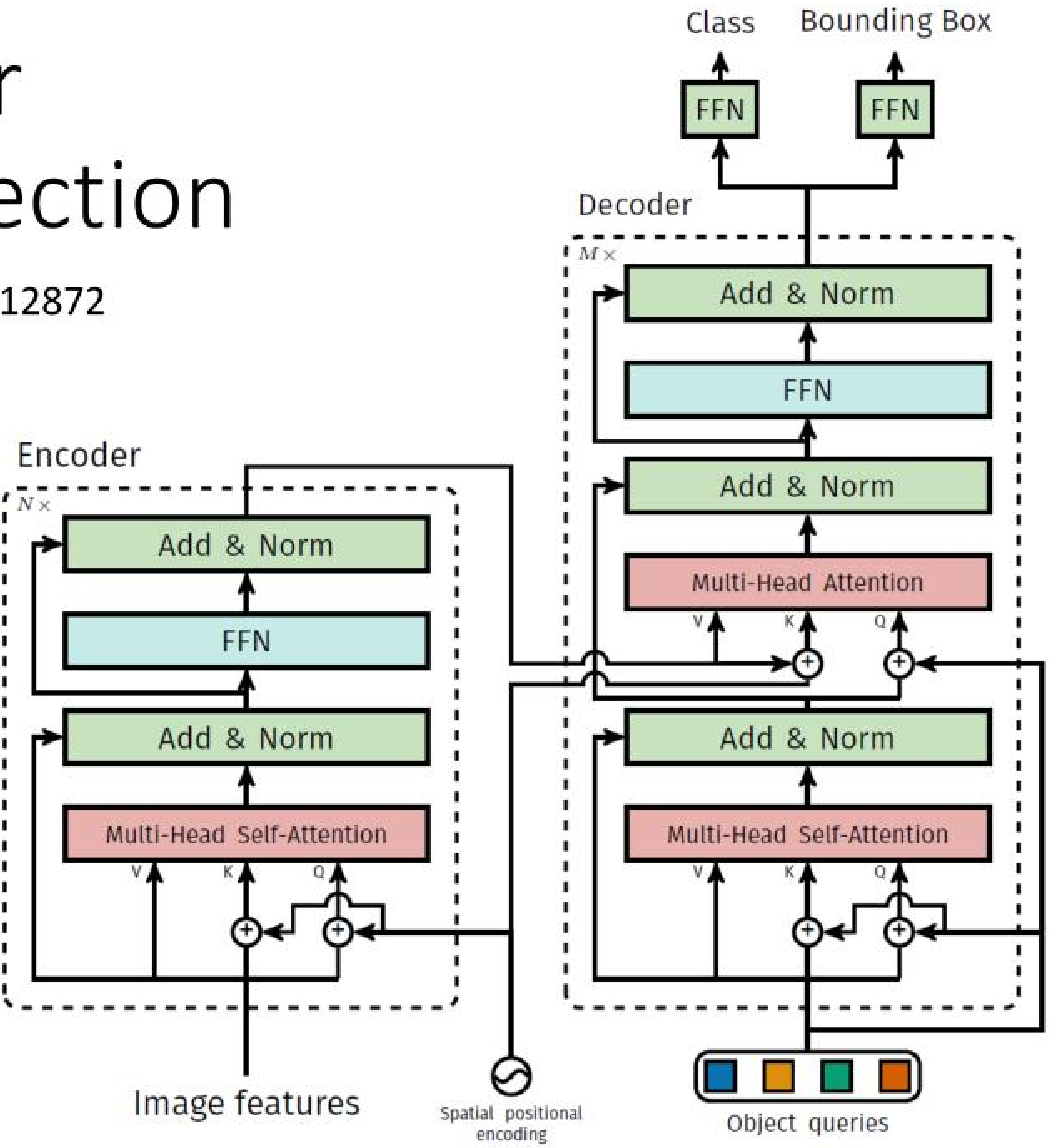


https://arxiv.org/abs/1909.03434
https://arxiv.org/abs/1707.05495

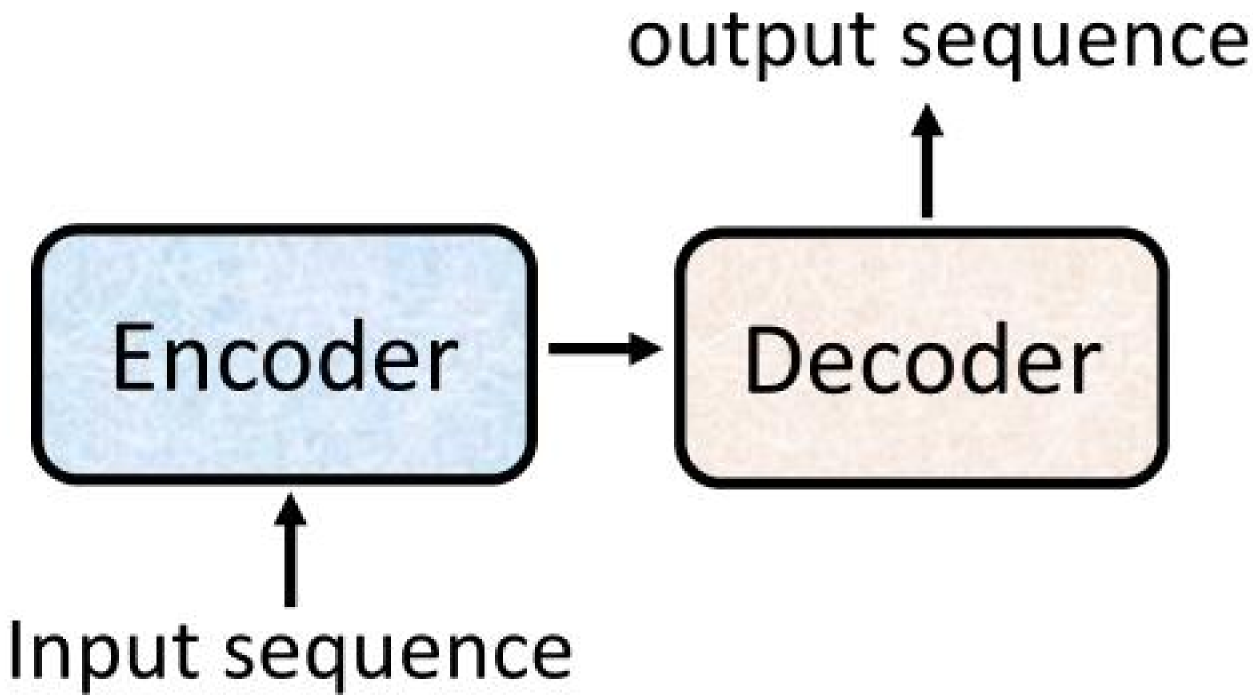
Seq2seq for Object Detection

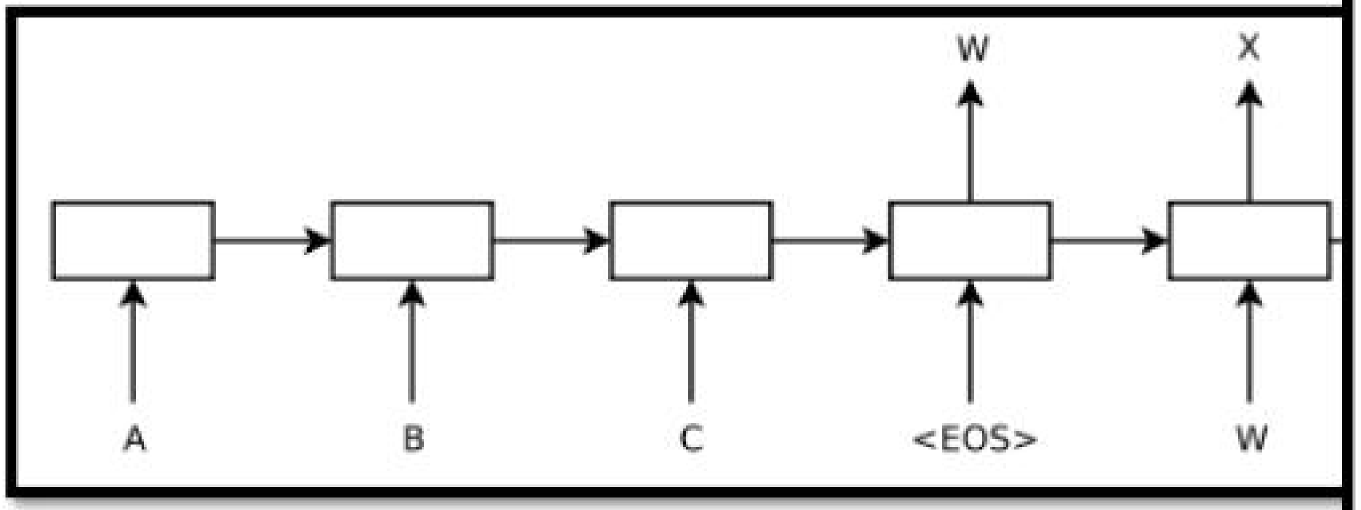
https://arxiv.org/abs/2005.12872





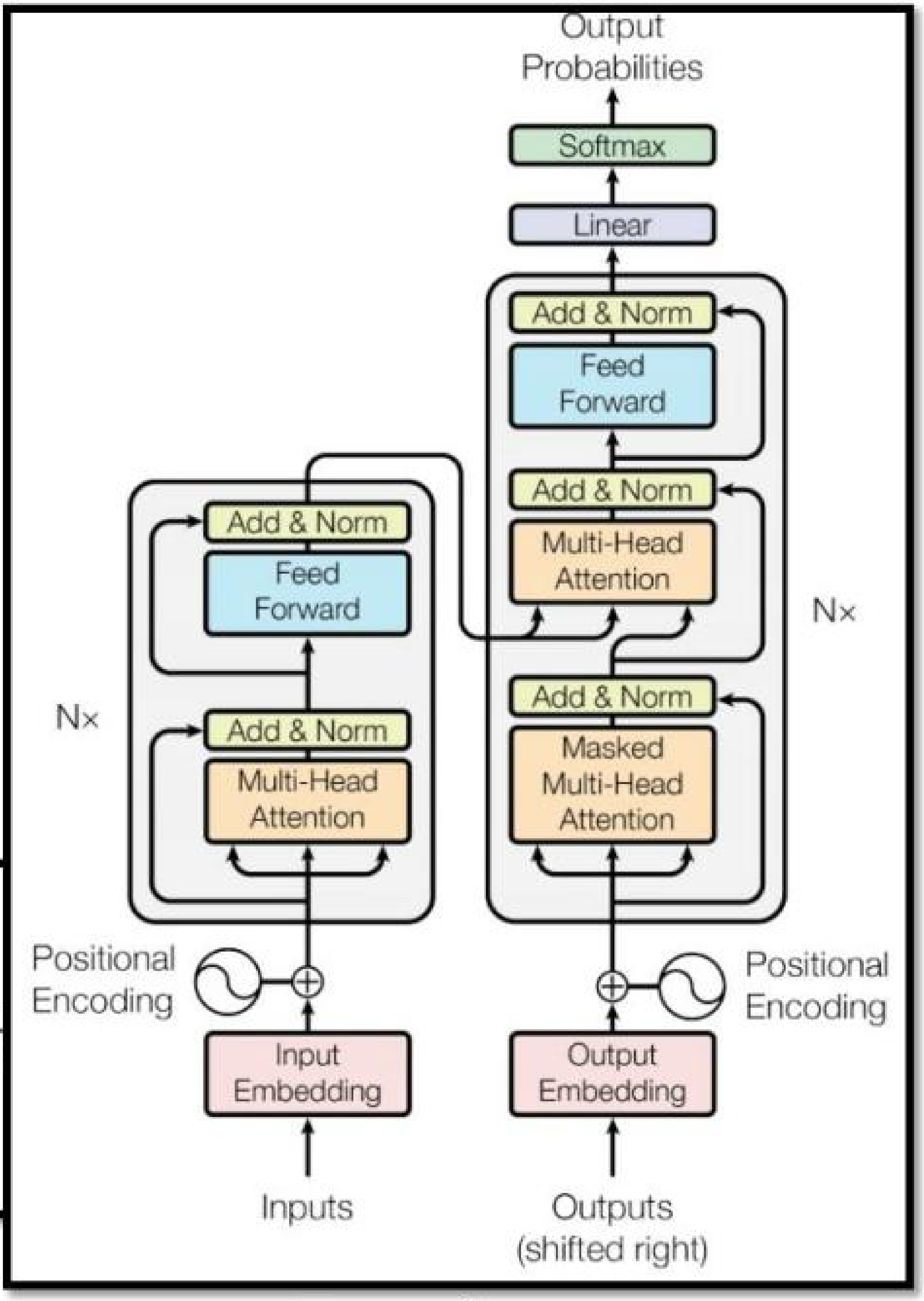
Seq2seq





Sequence to Sequence Learning with Neural Networks

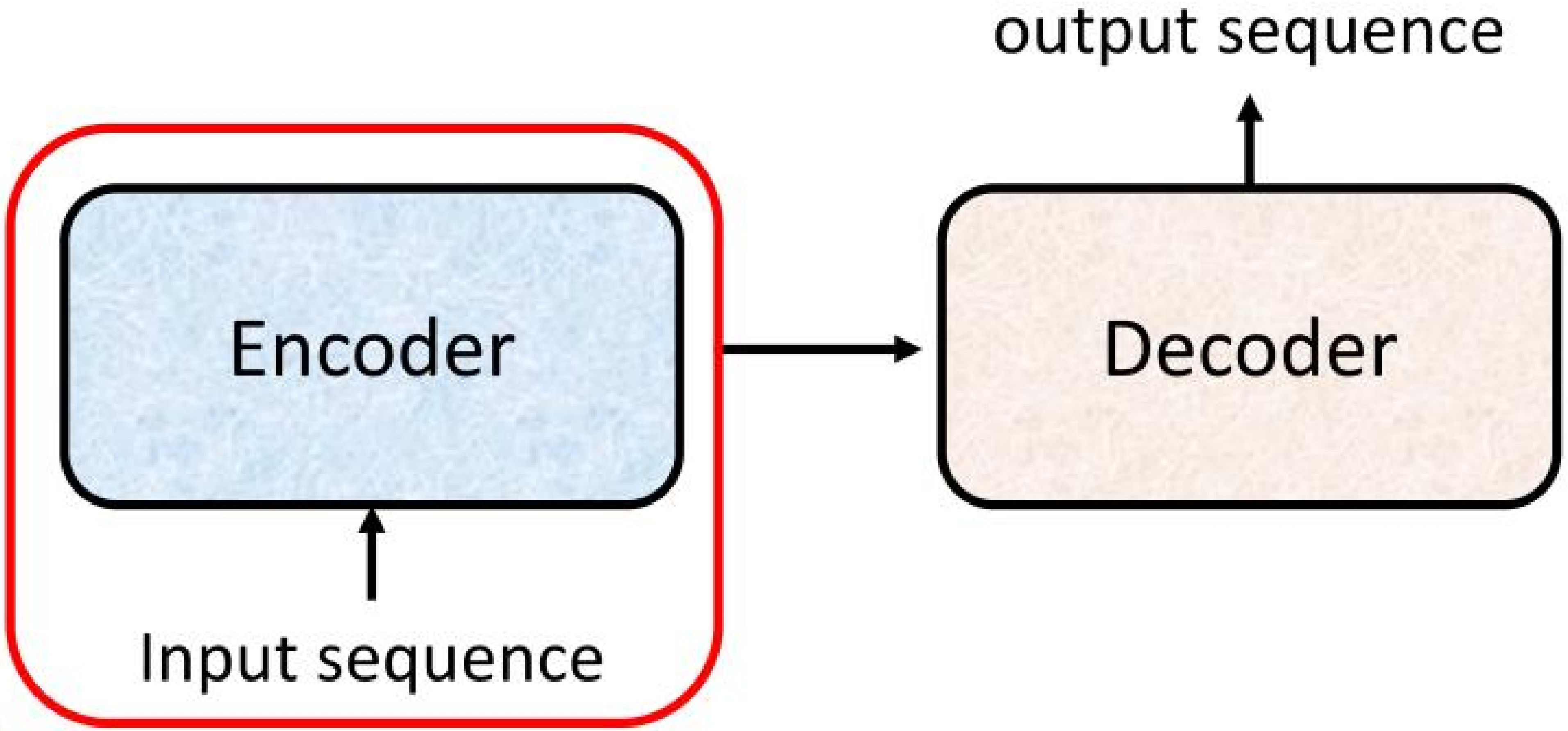
https://arxiv.org/abs/1409.3215



Transformer

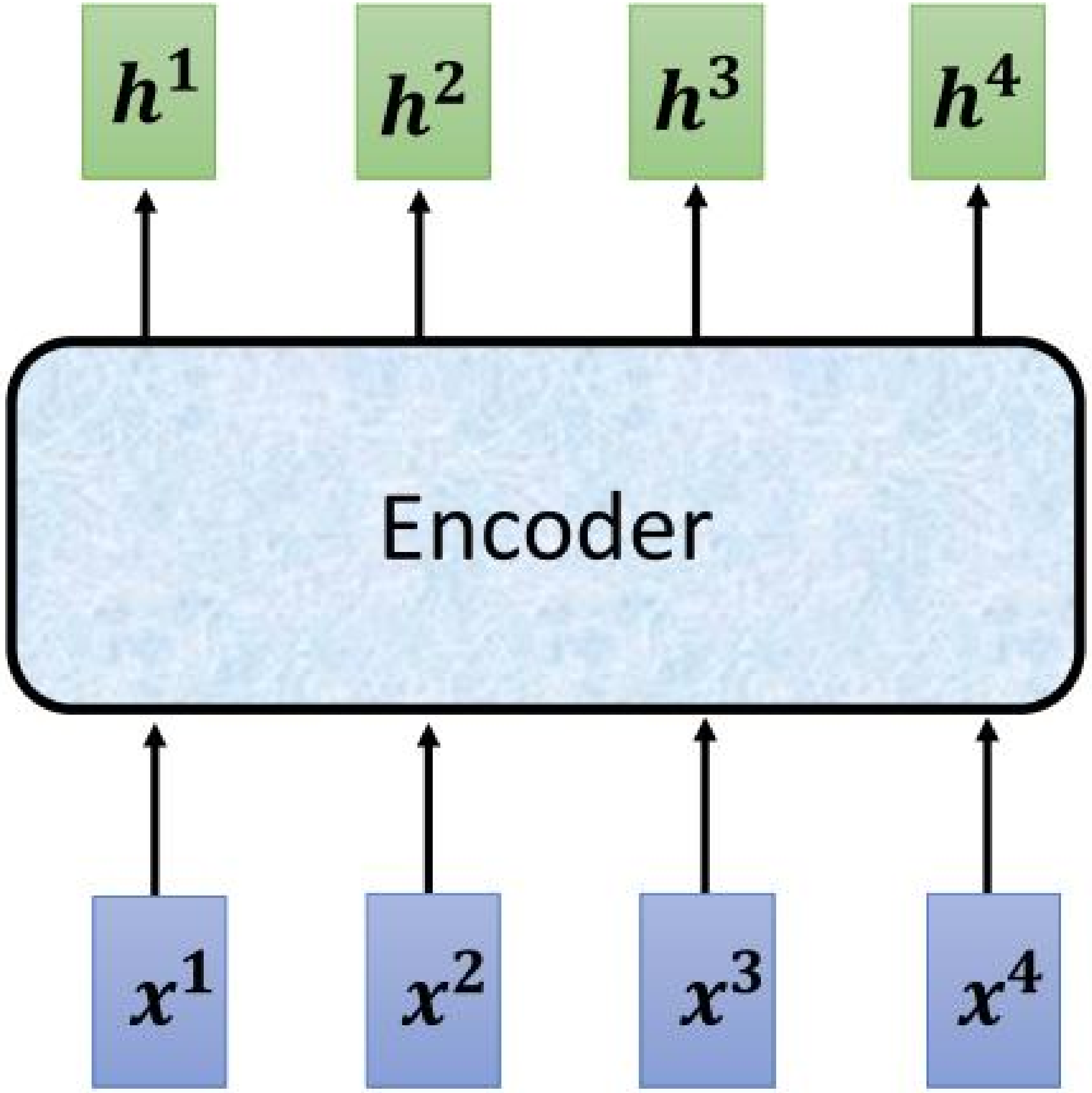
https://arxiv.org/abs/1706.03762

Encoder

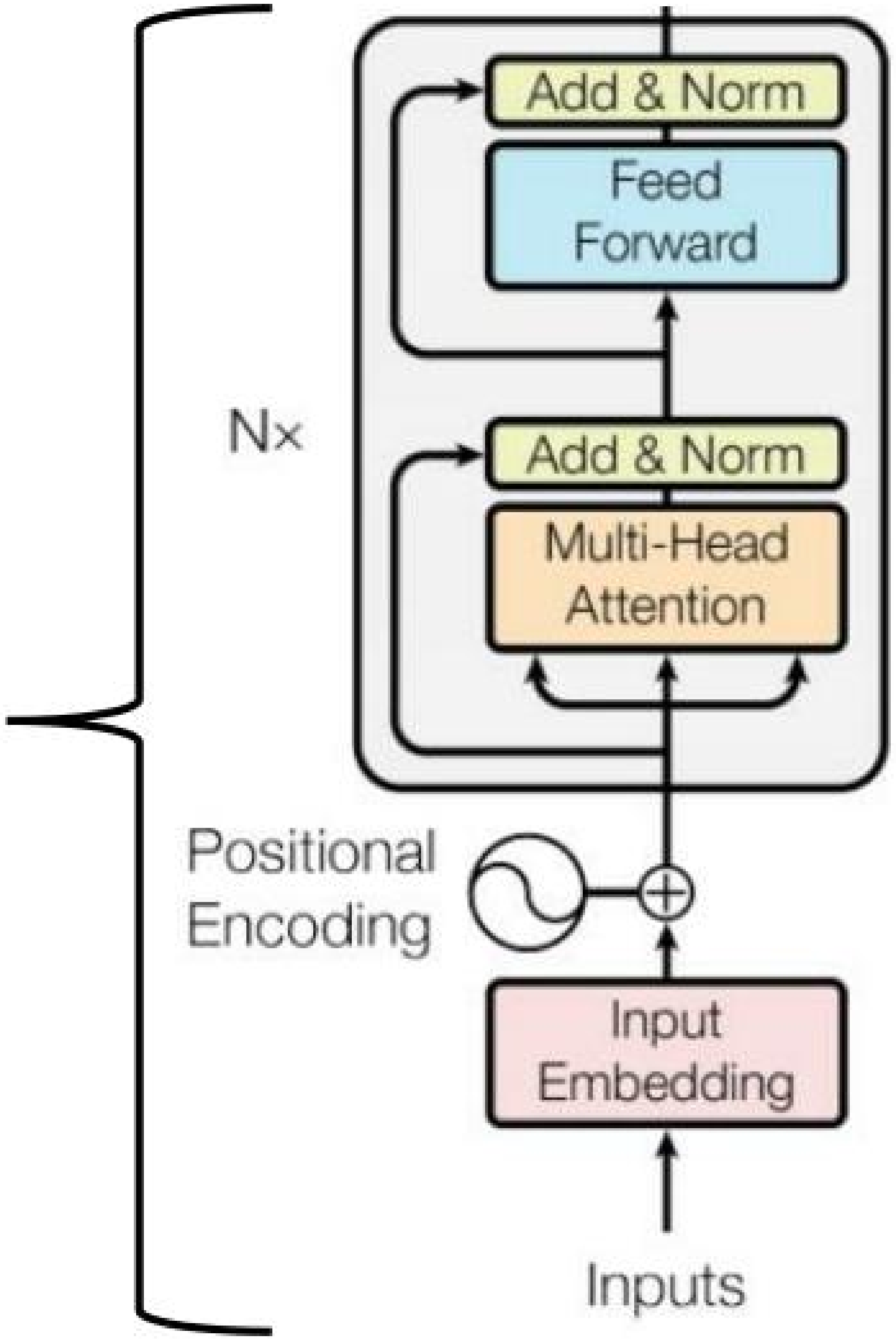


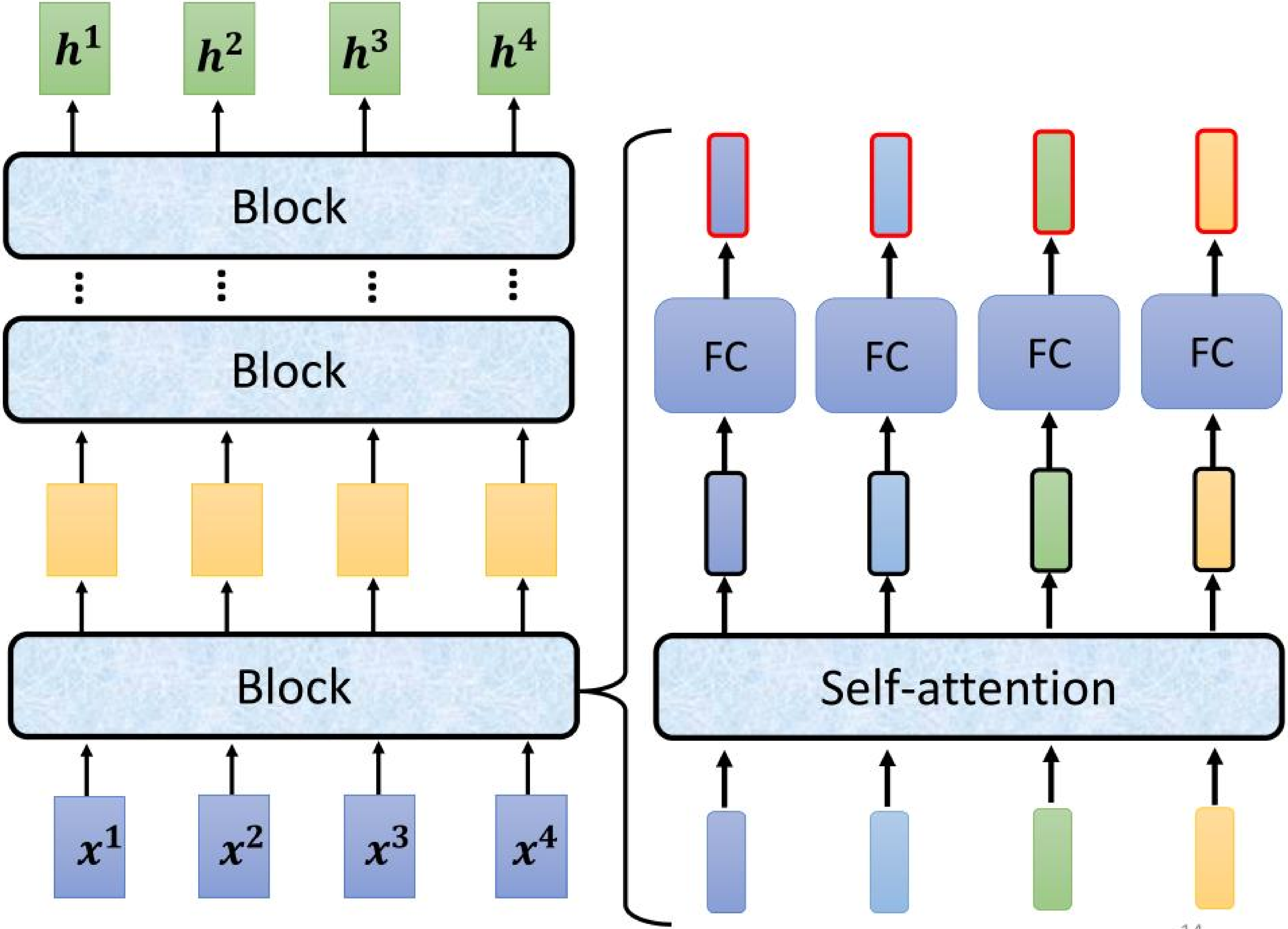
Encoder

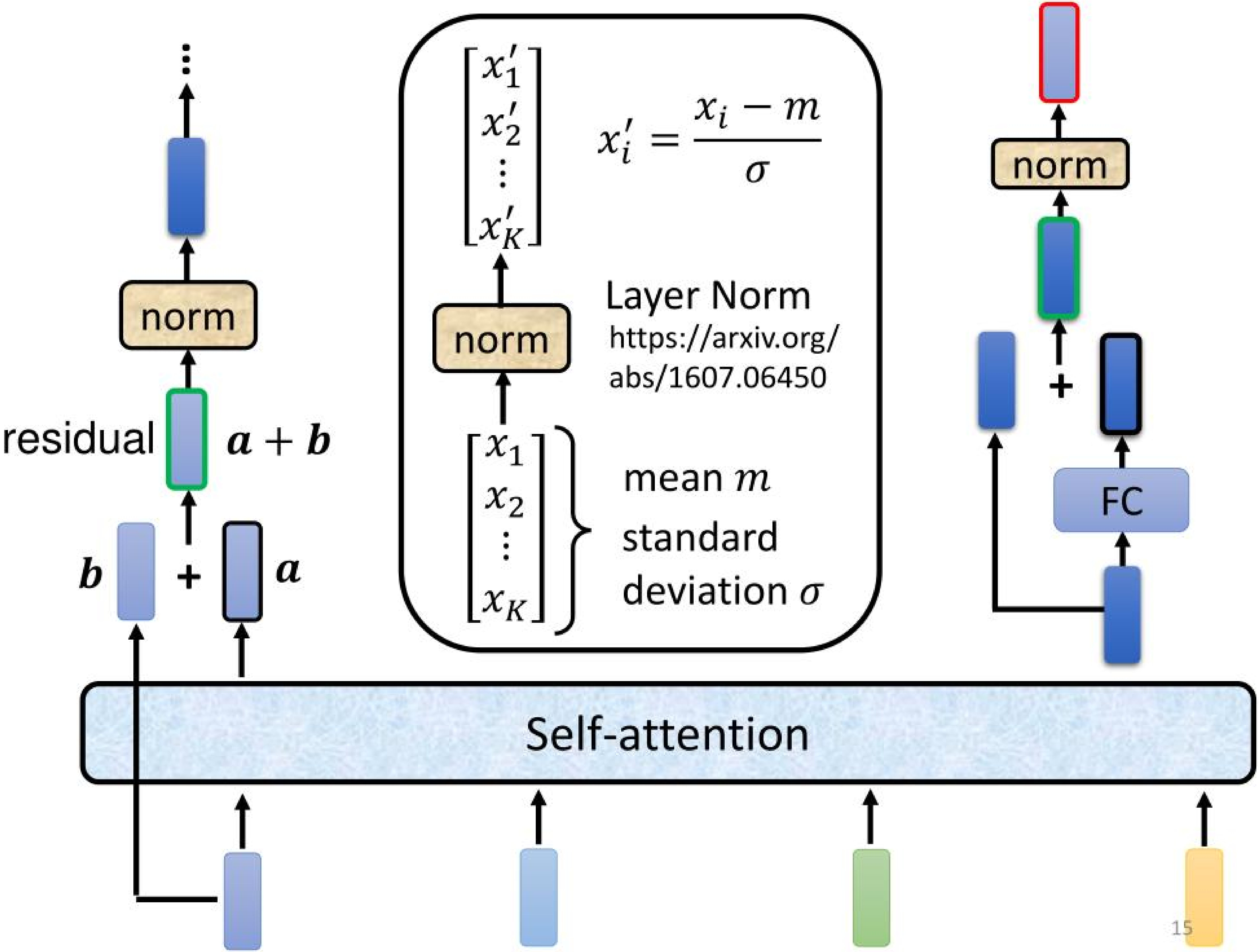
You can use **RNN** or **CNN**.



Transformer’s Encoder




h^1
h^2
h^3
h^4
Block
Block
Block
x^1
x^2
x^3
x^4
FC
FC
FC
FC
Self-attention



Layer Norm https://arxiv.org/abs/1607.06450

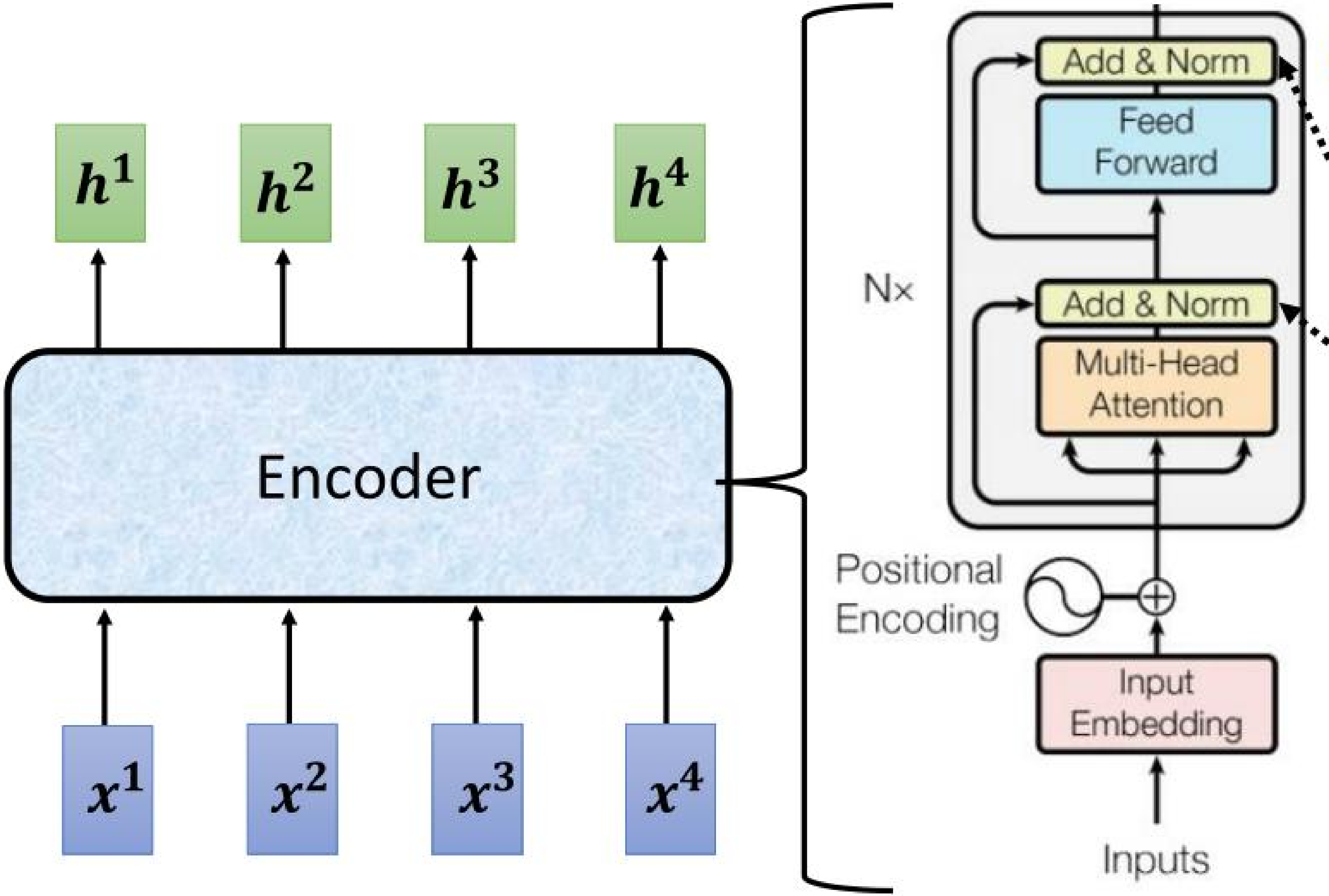
$$\begin{bmatrix} x_1' \\ x_2' \\ \vdots \\ x_K' \end{bmatrix} \qquad x_i' = \frac{x_i - m}{\sigma}$$

$$\left.\begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_K \end{bmatrix}\right\}$$

mean m

standard deviation σ

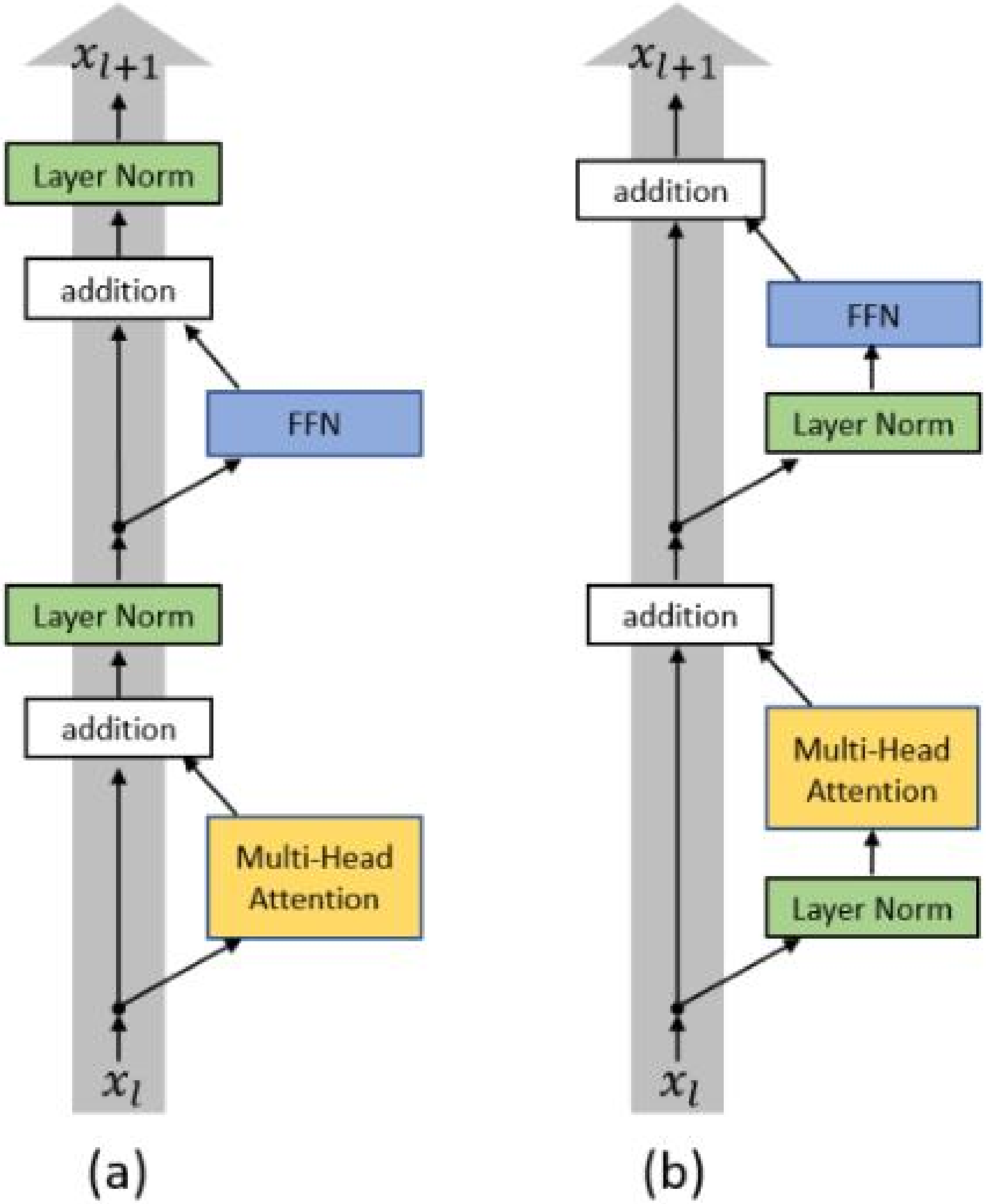
I use the **same** network architecture as **transformer encoder**.



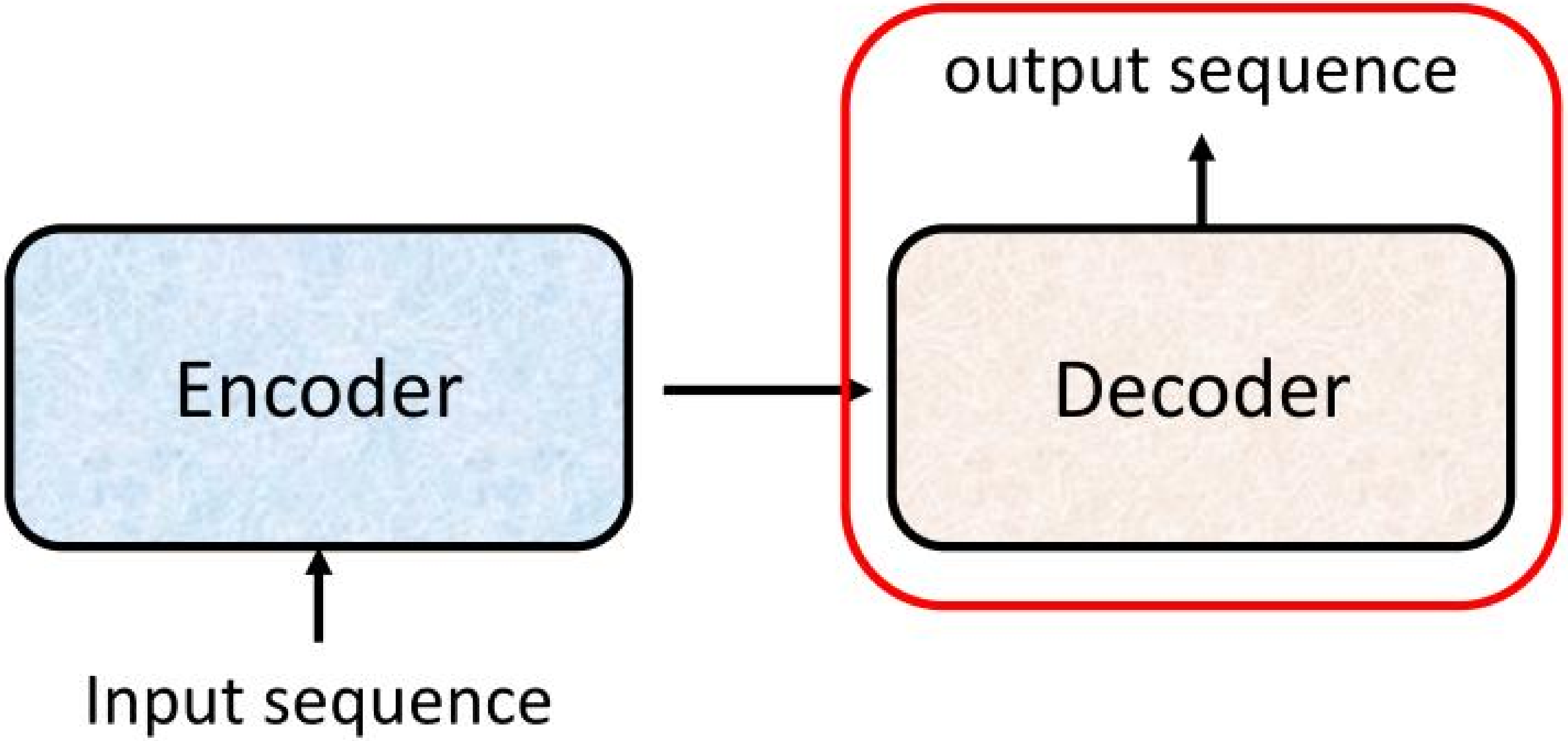
To learn more ……

- On Layer Normalization in the Transformer Architecture
- https://arxiv.org/abs/2002.04745

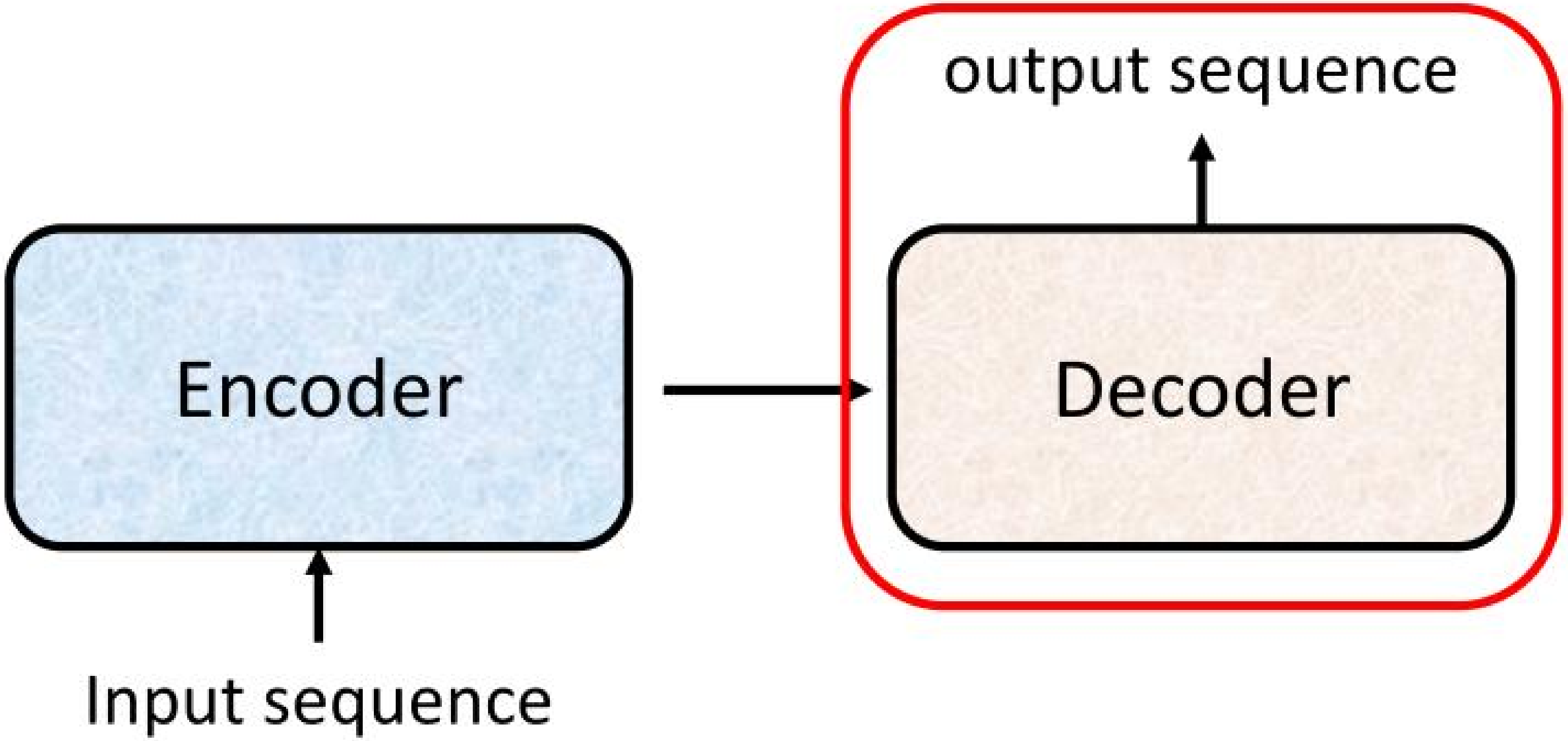
- PowerNorm: Rethinking Batch Normalization in Transformers
- https://arxiv.org/abs/2003.07845



Decoder

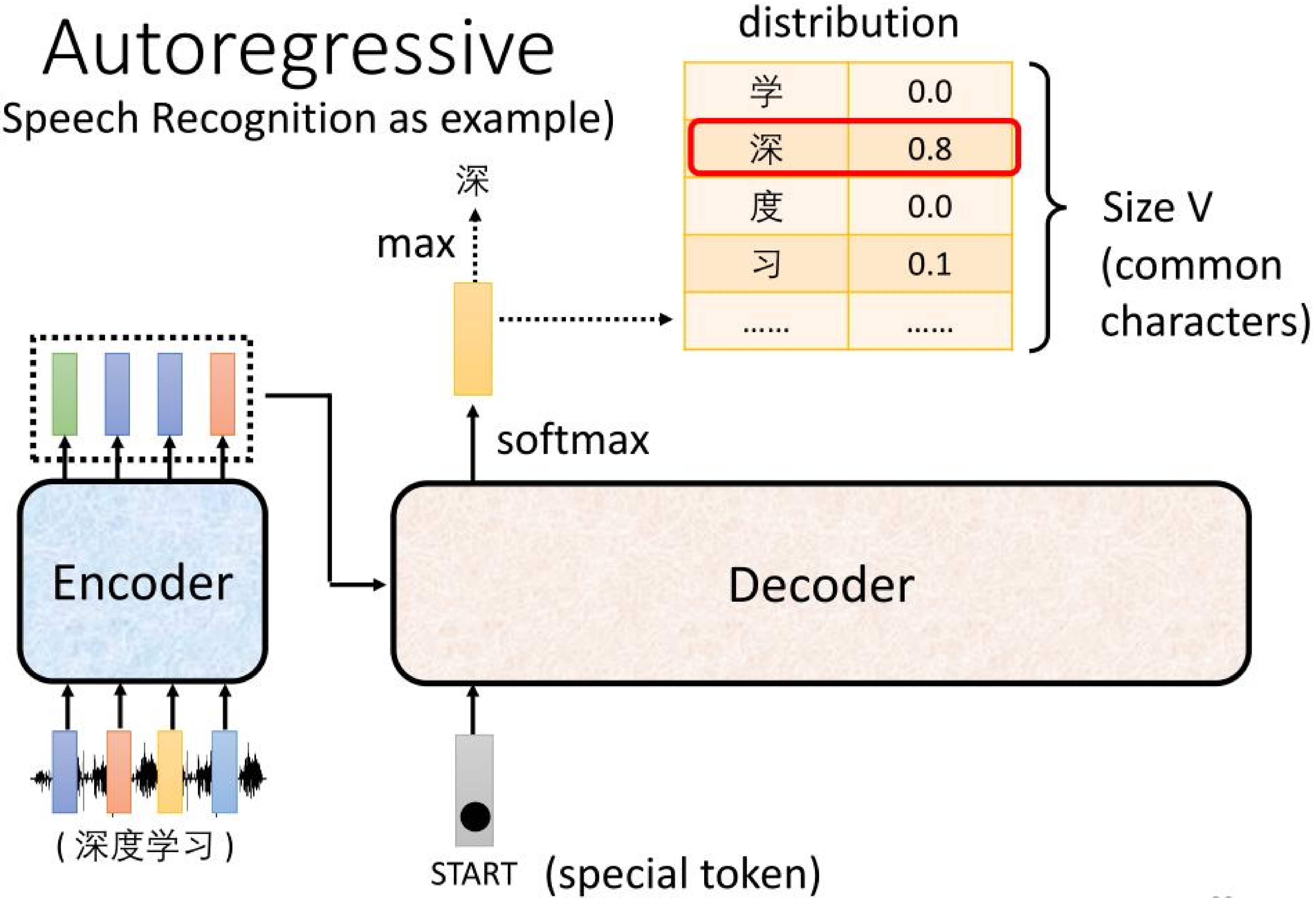


Decoder
– Autoregressive (AT)



Autoregressive

(Speech Recognition as example)

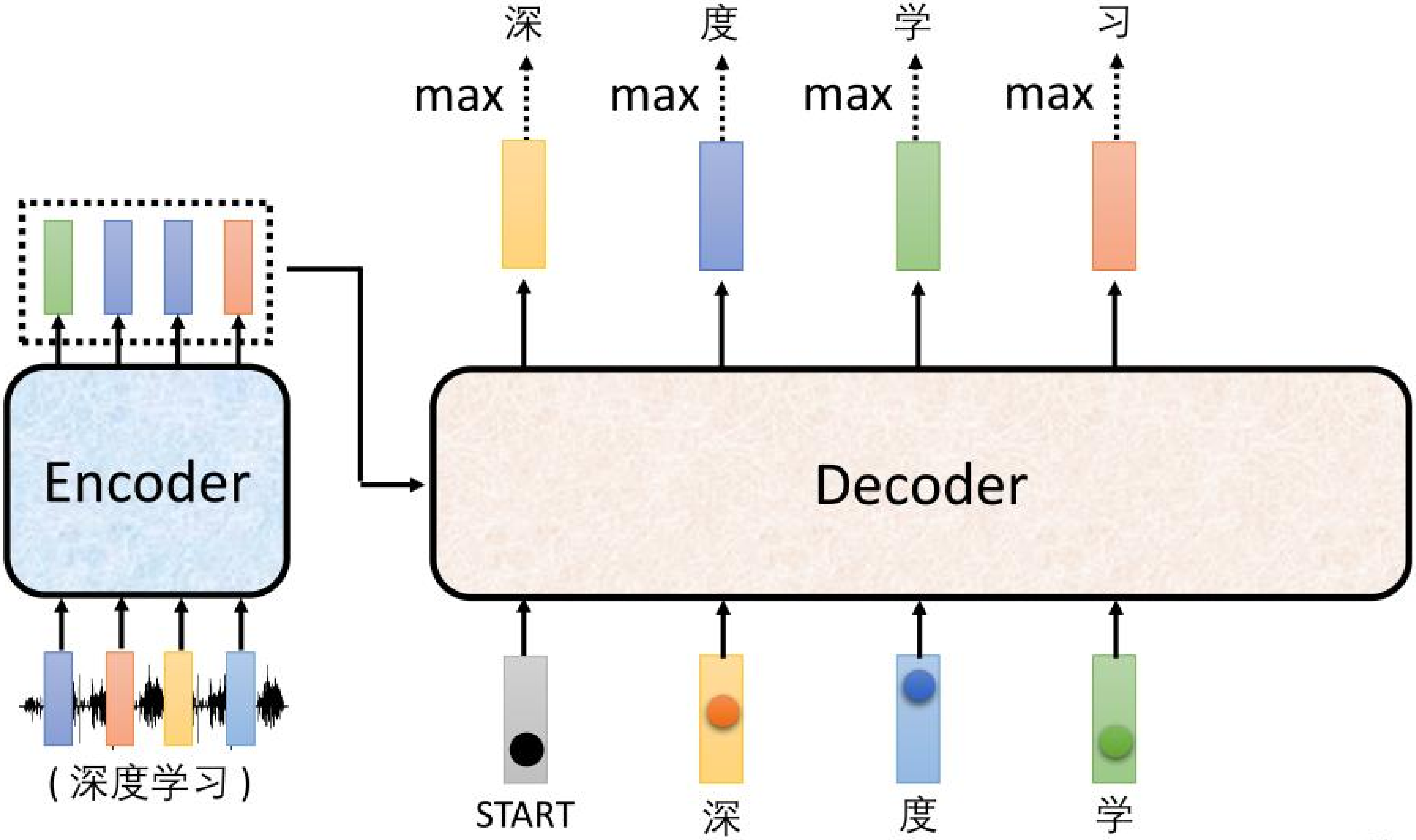


distribution

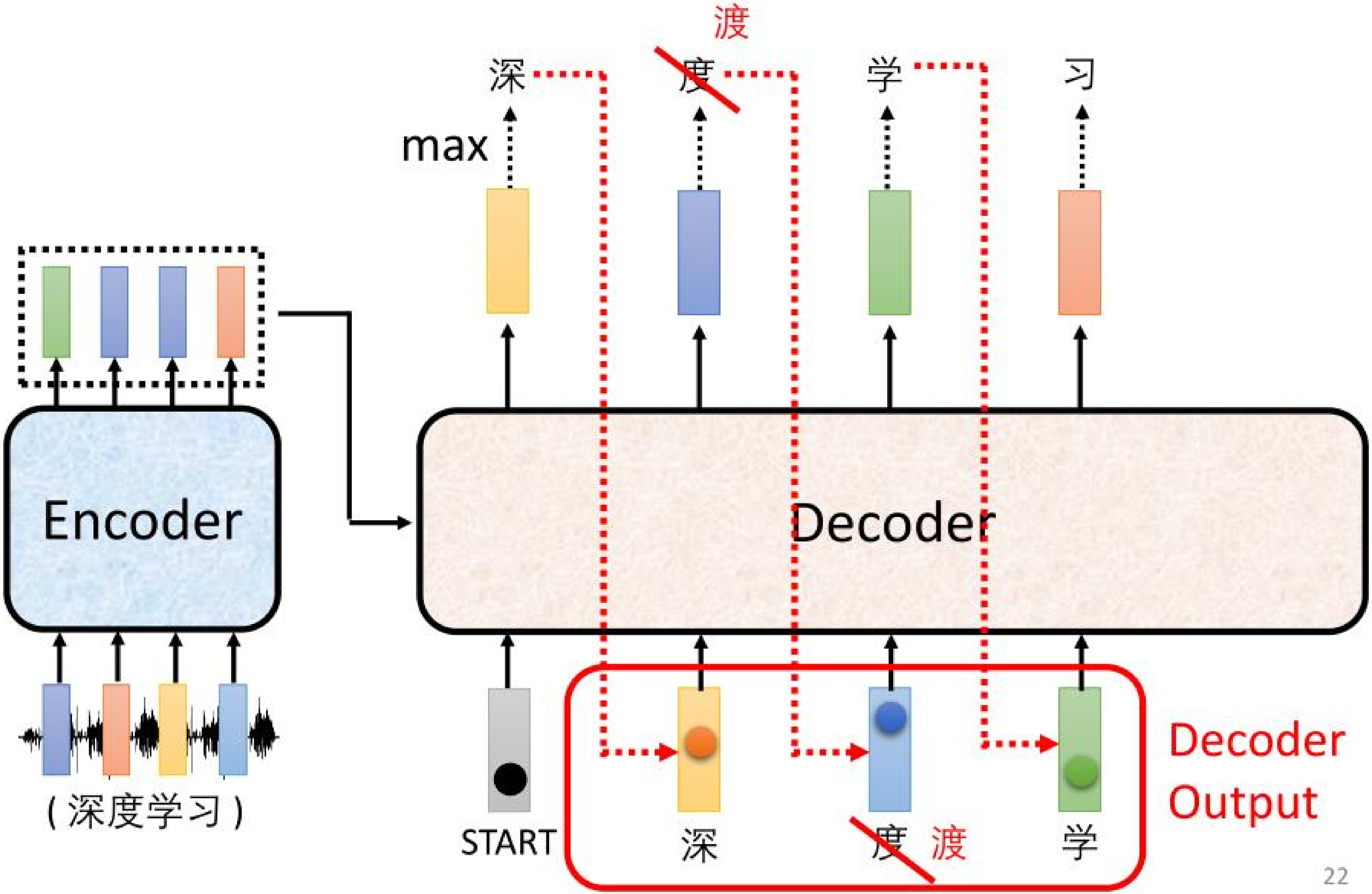
学	0.0
深	0.8
度	0.0
习	0.1
……	……

(special token)

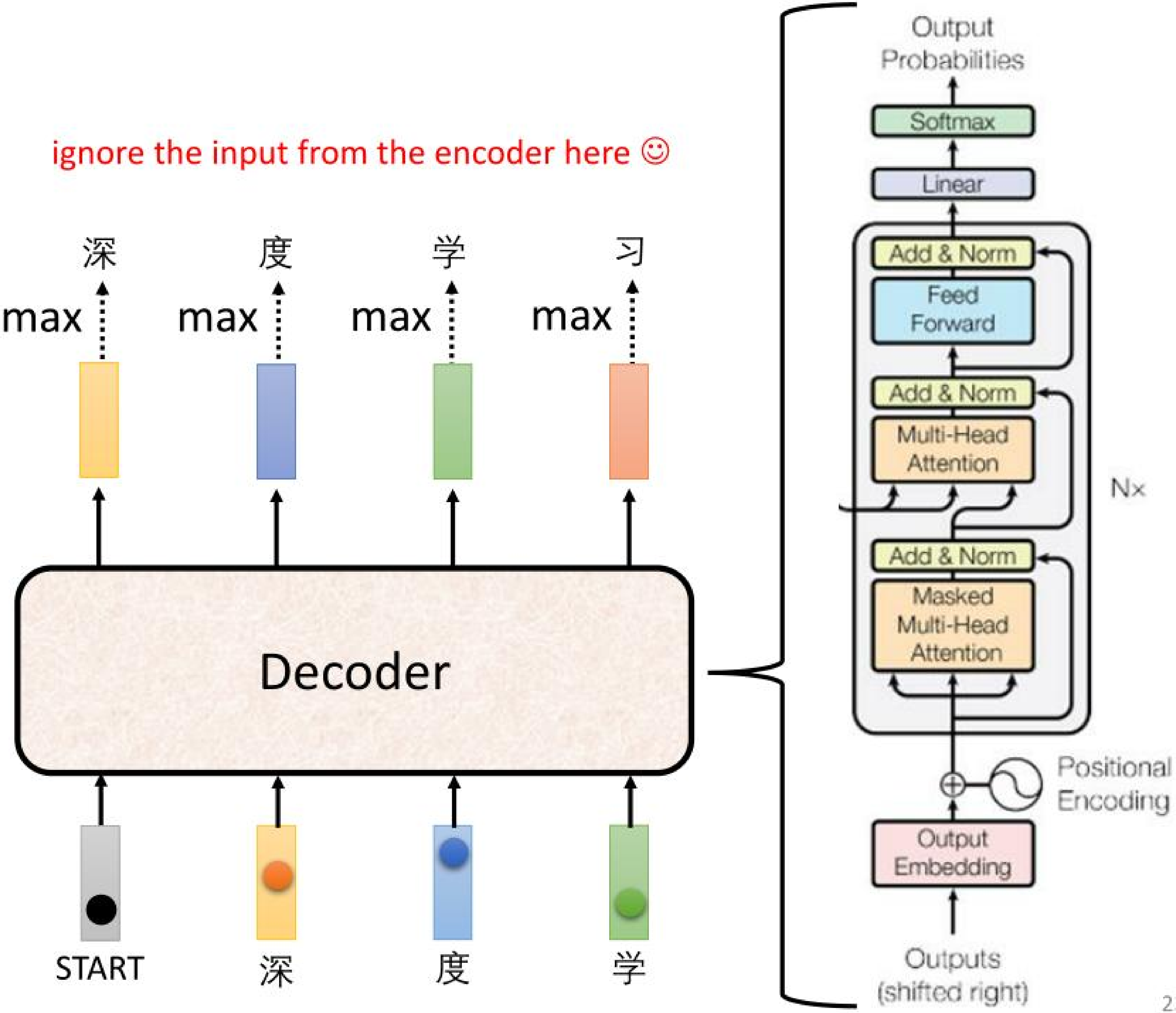
Autoregressive

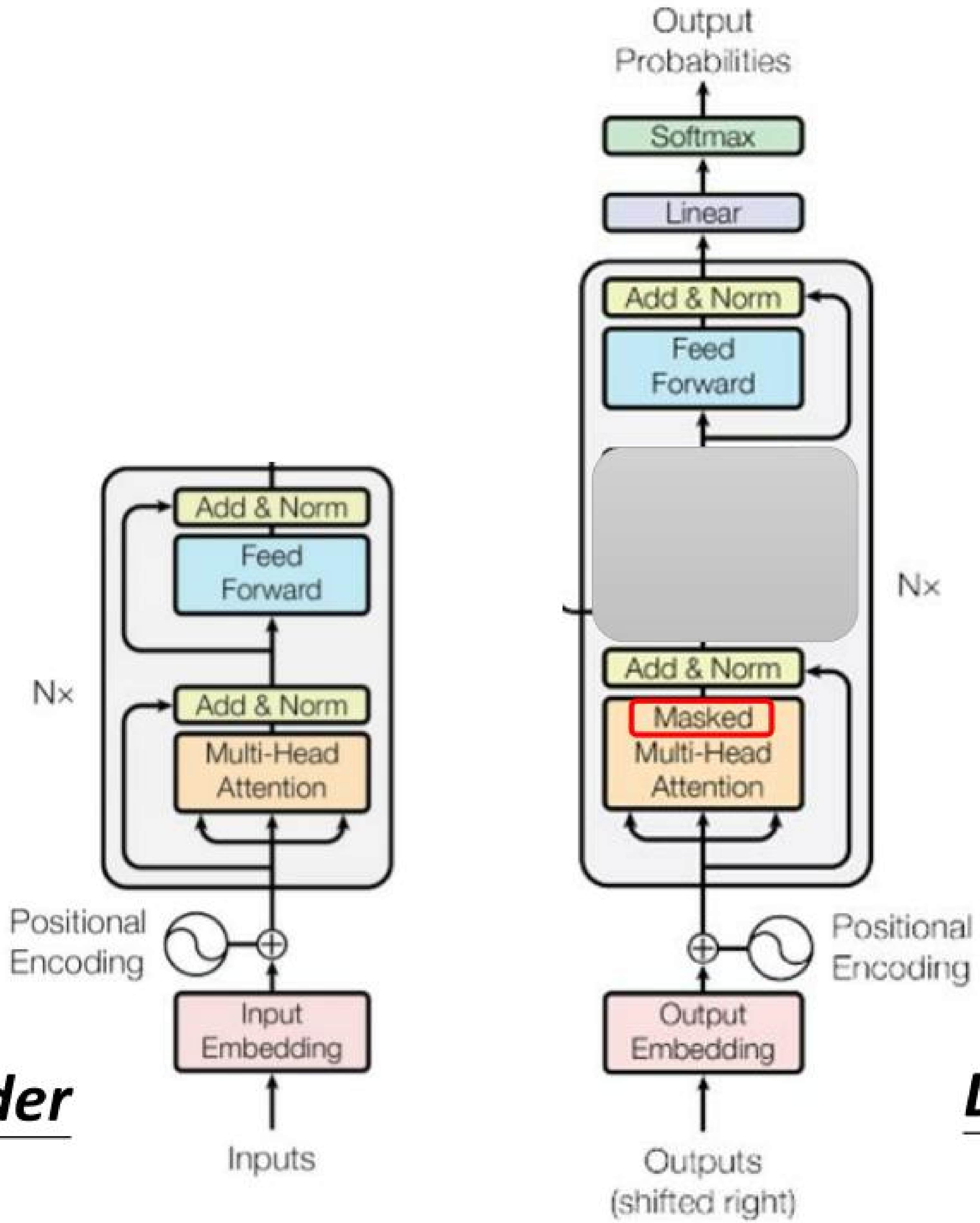


Autoregressive



ignore the input from the encoder here ☺

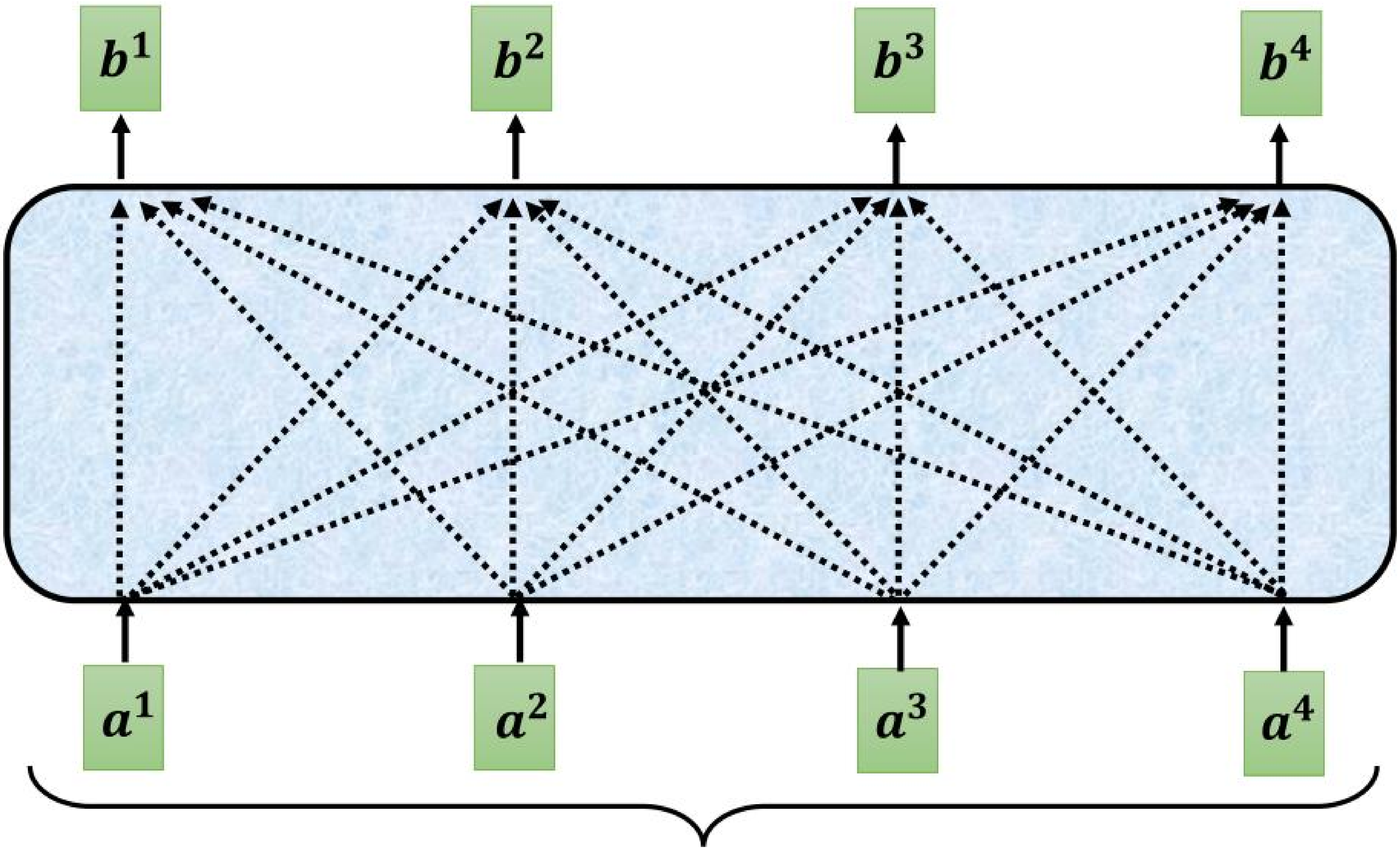




Encoder

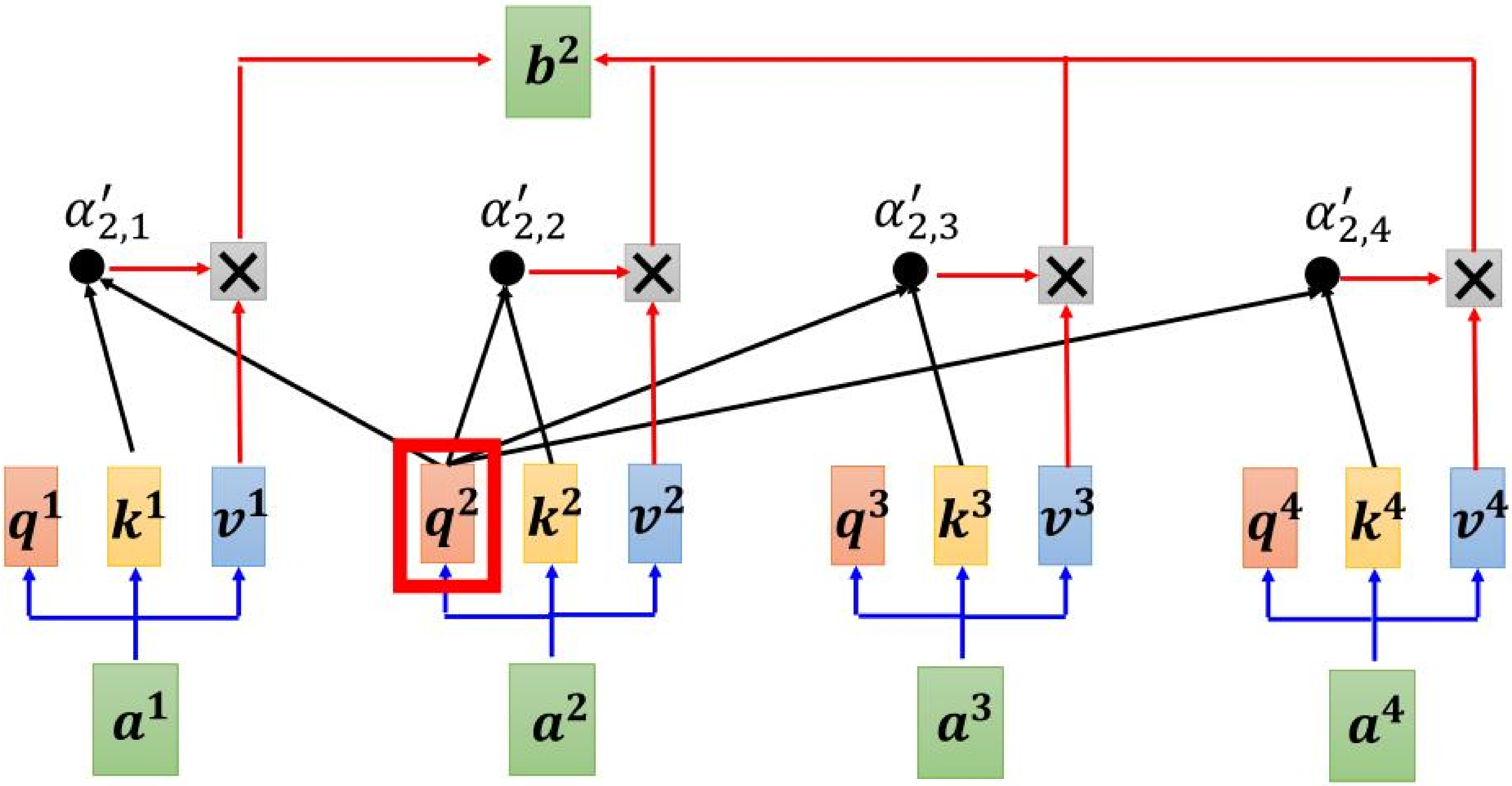
Decoder

Self-attention → *Masked Self-attention*



Can be either **input** or **a hidden layer**

Self-attention → *Masked Self-attention*

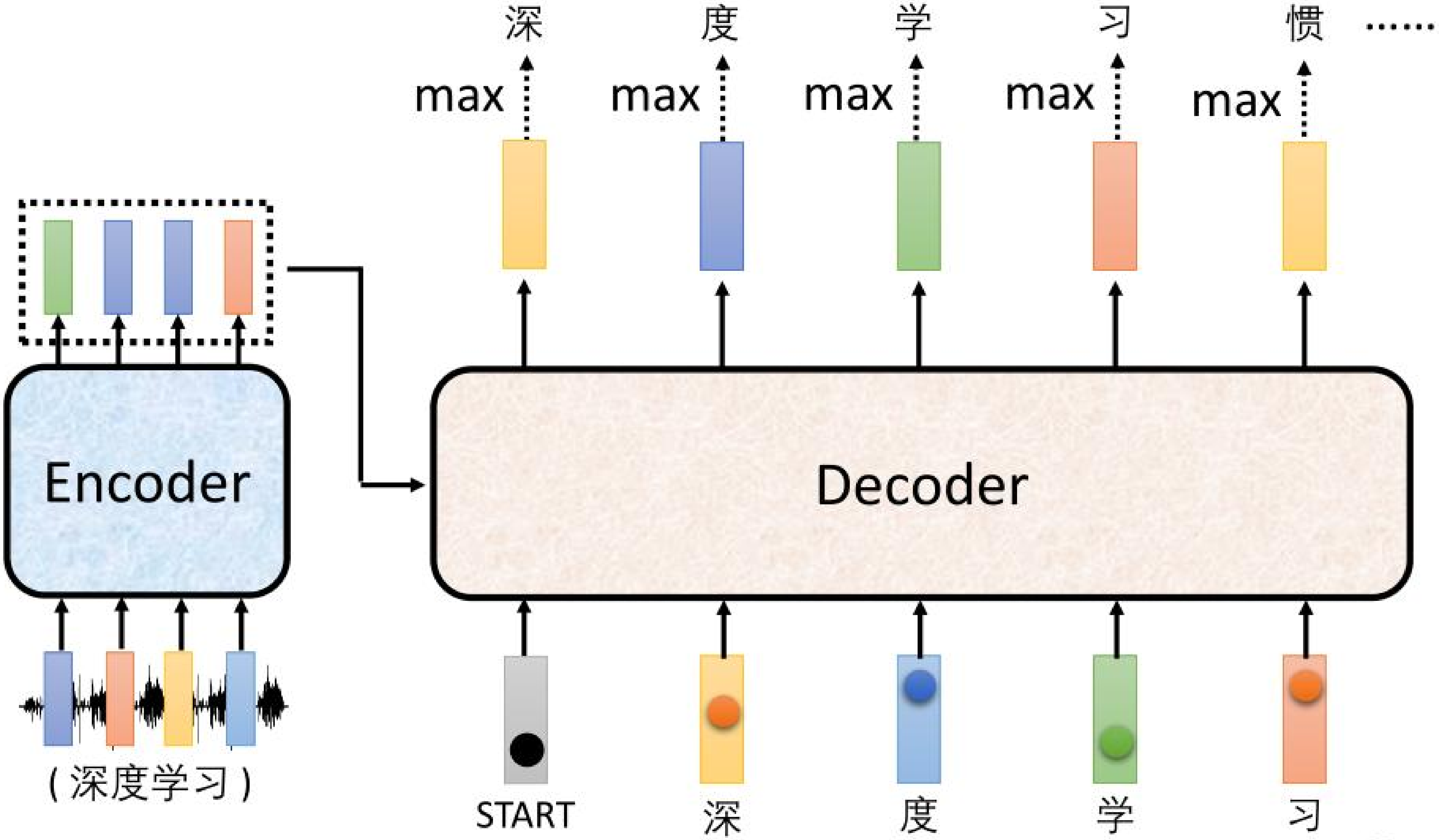


Why masked? Consider how does decoder work

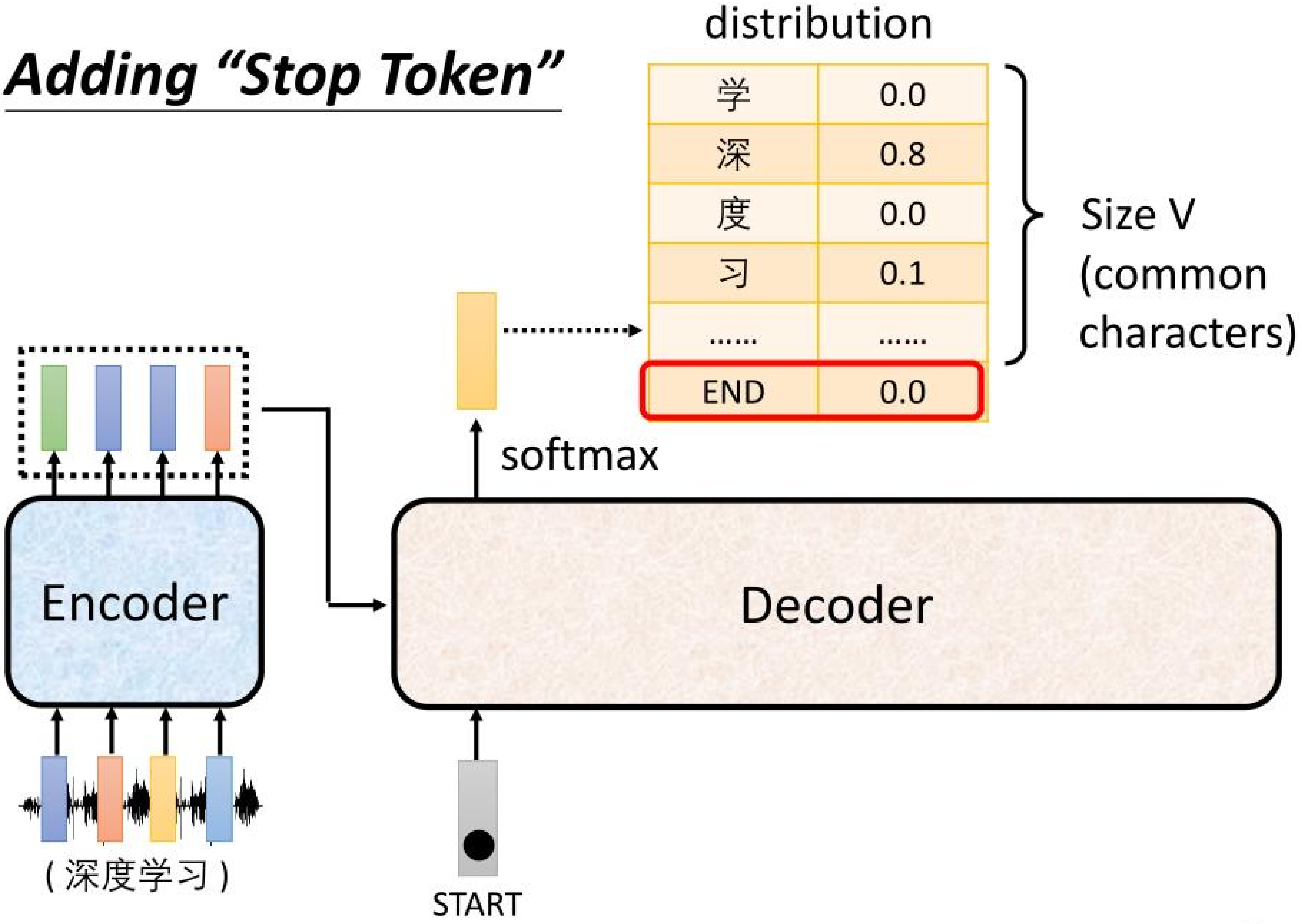
Autoregressive

We do not know the correct output length.

Never stop!



Adding "Stop Token"

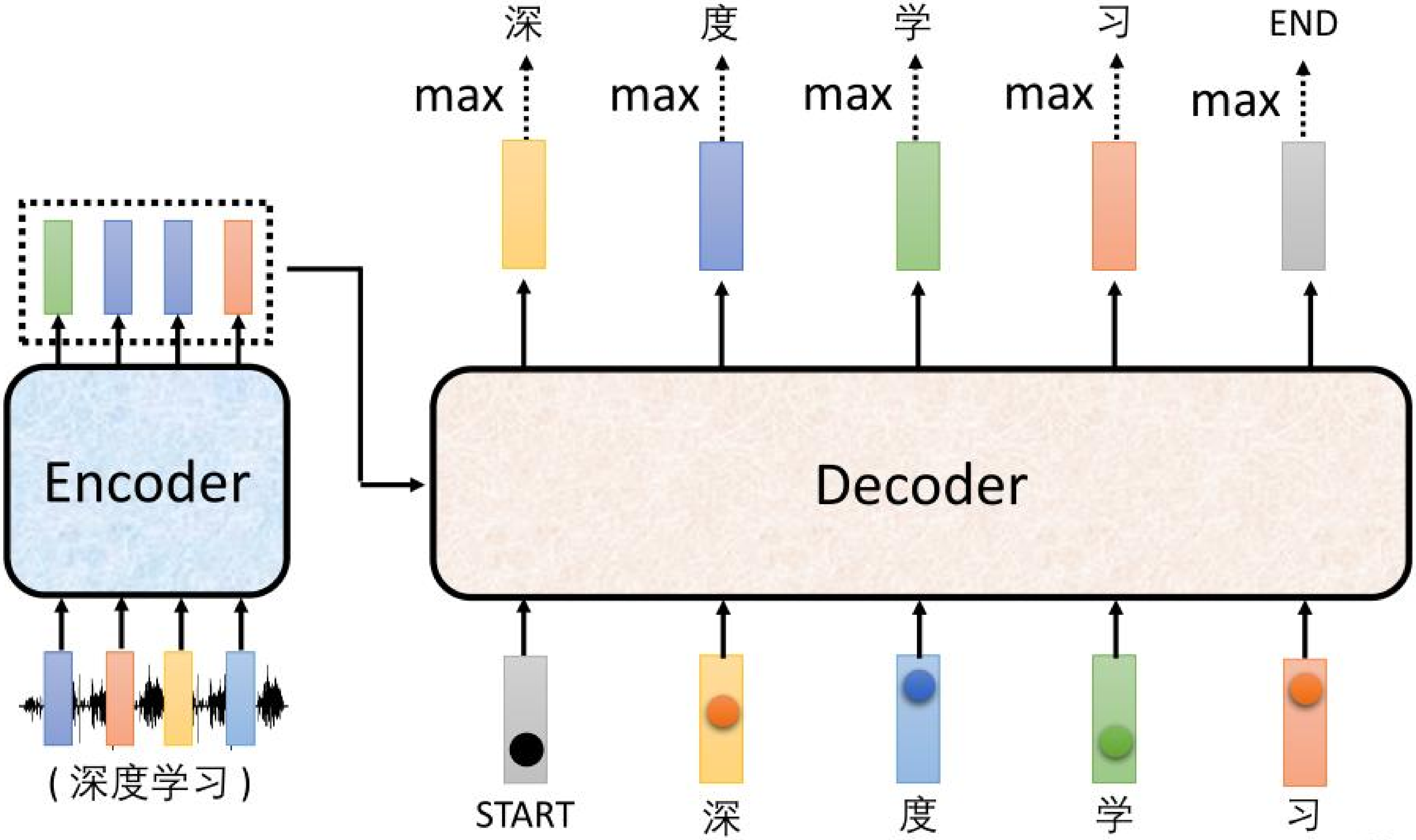


distribution

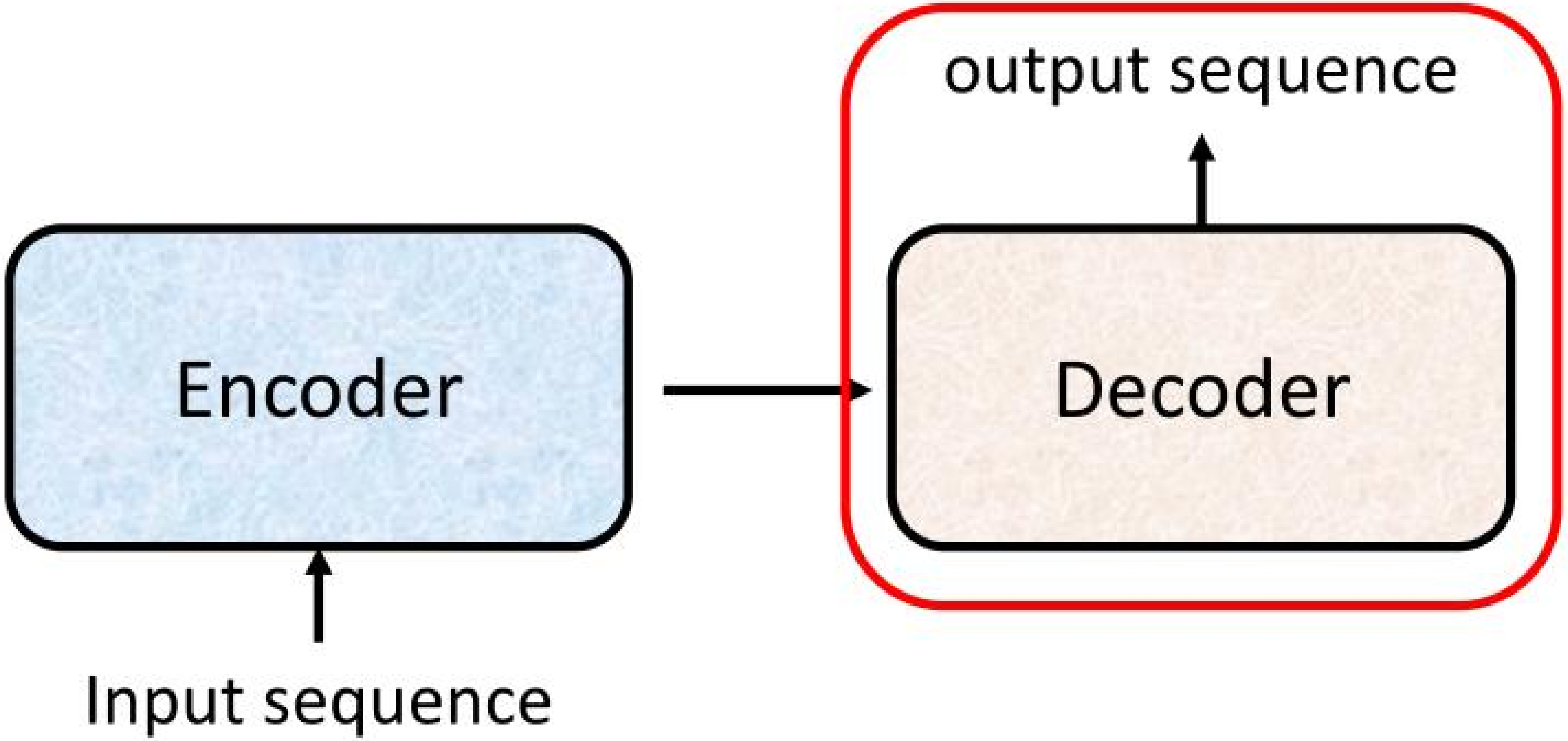
学	0.0
深	0.8
度	0.0
习	0.1
……	……
END	0.0

Autoregressive

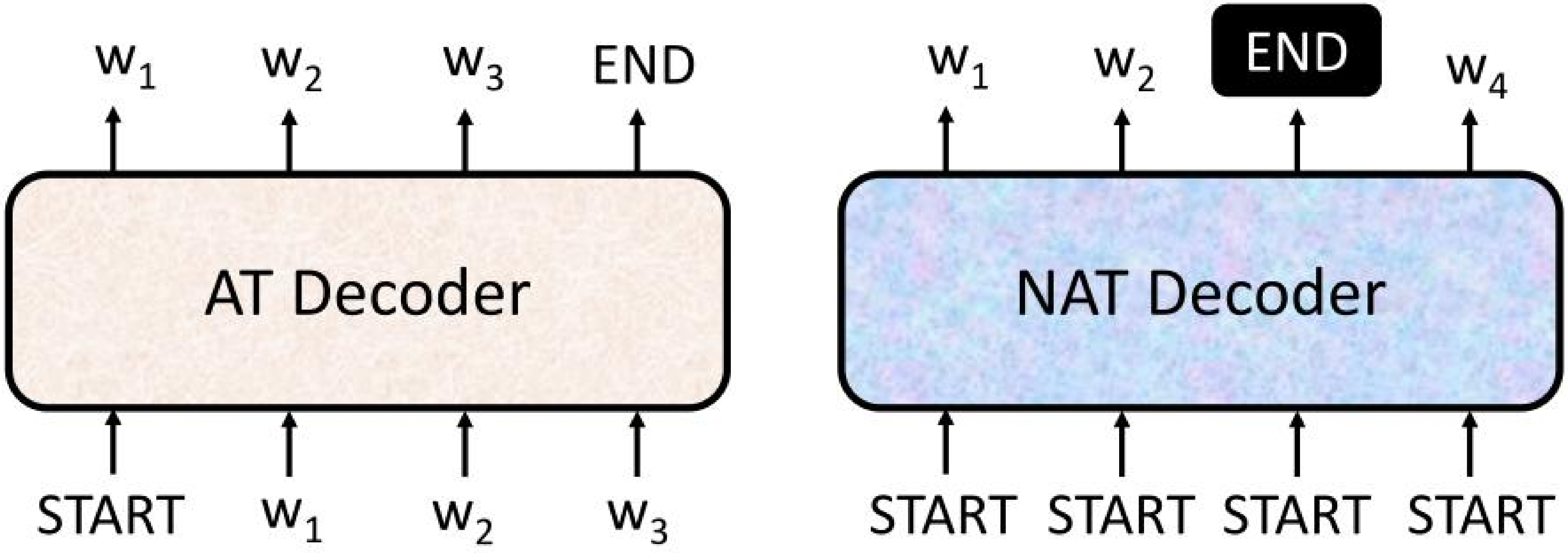
Stop at here!



Decoder
– Non-autoregressive (NAT)

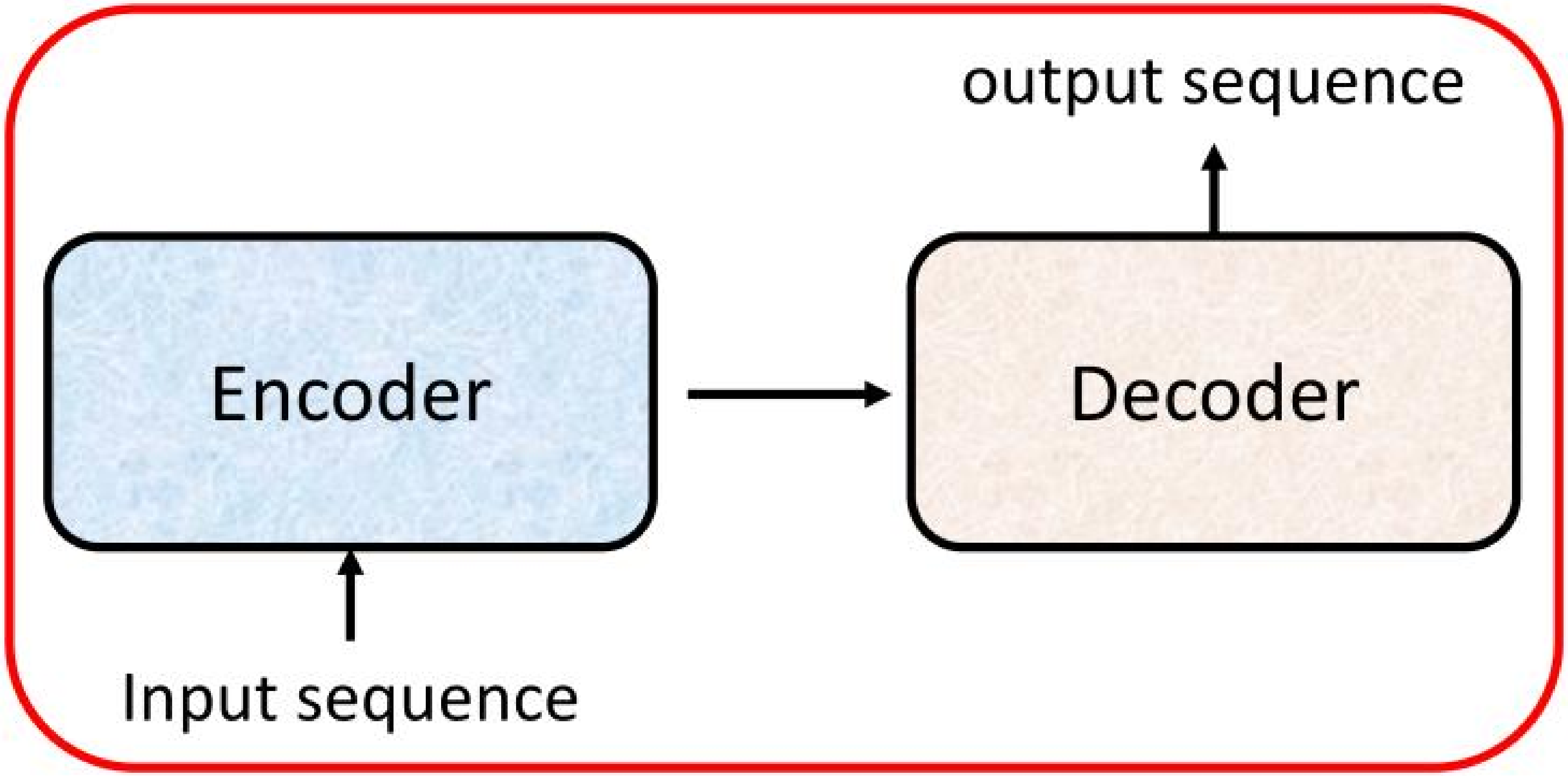


AT v.s. NAT

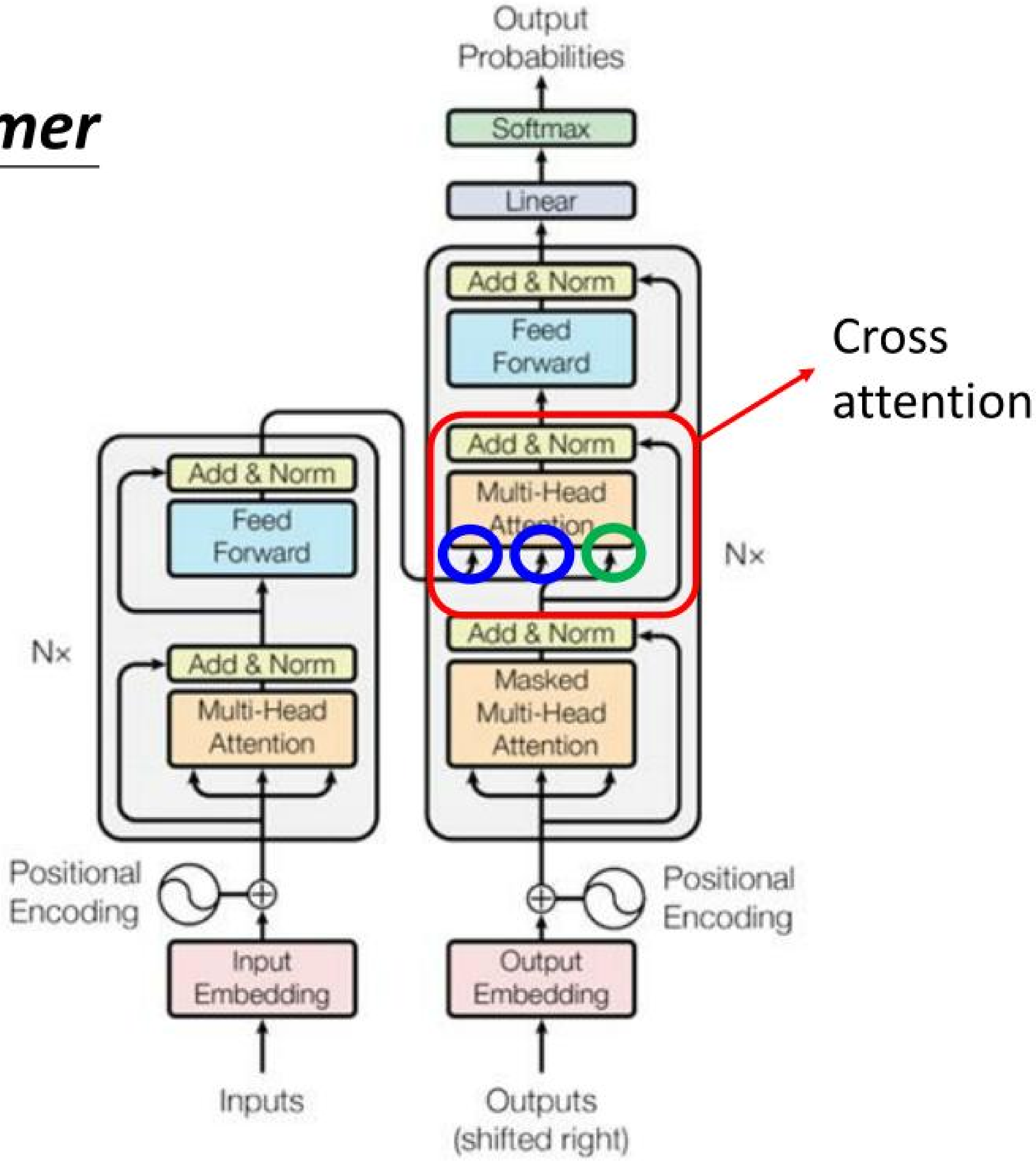


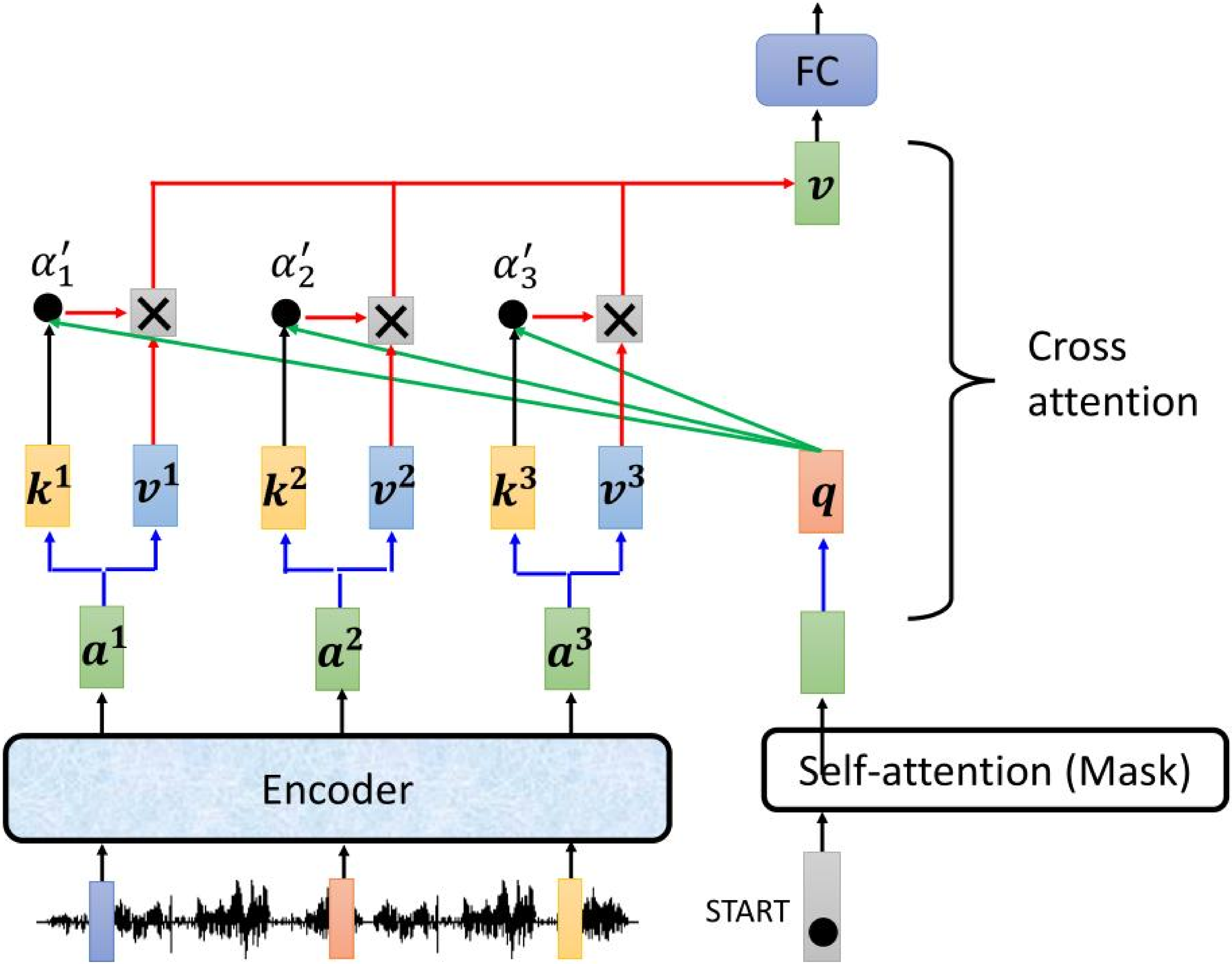
- How to decide the output length for NAT decoder?
  - Another predictor for output length
  - Output a very long sequence, ignore tokens after END
- Advantage: parallel, more stable generation (e.g., TTS)
- NAT is usually worse than AT (why? **Multi-modality**)

Encoder-Decoder



Transformer



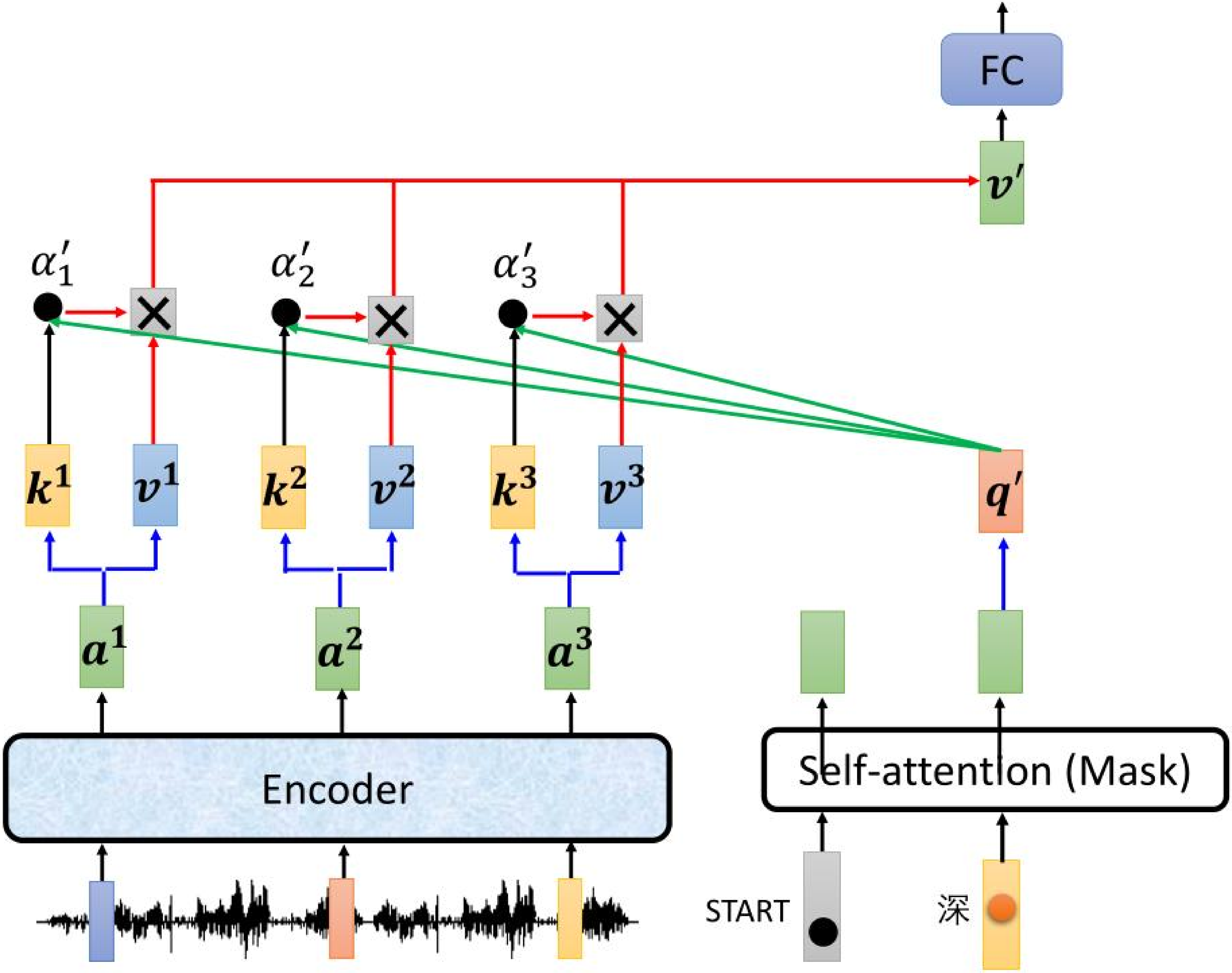


Cross attention

Encoder

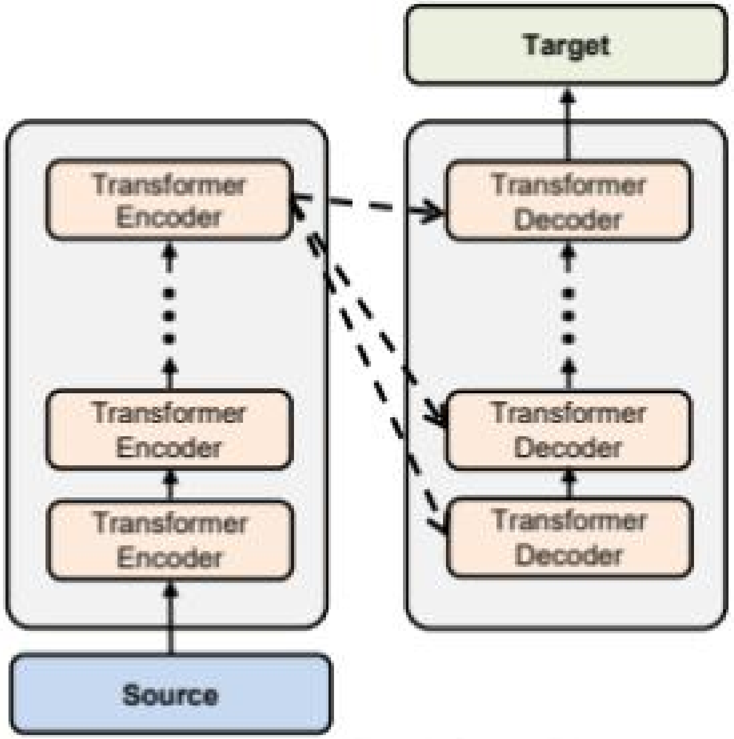
Self-attention (Mask)

START

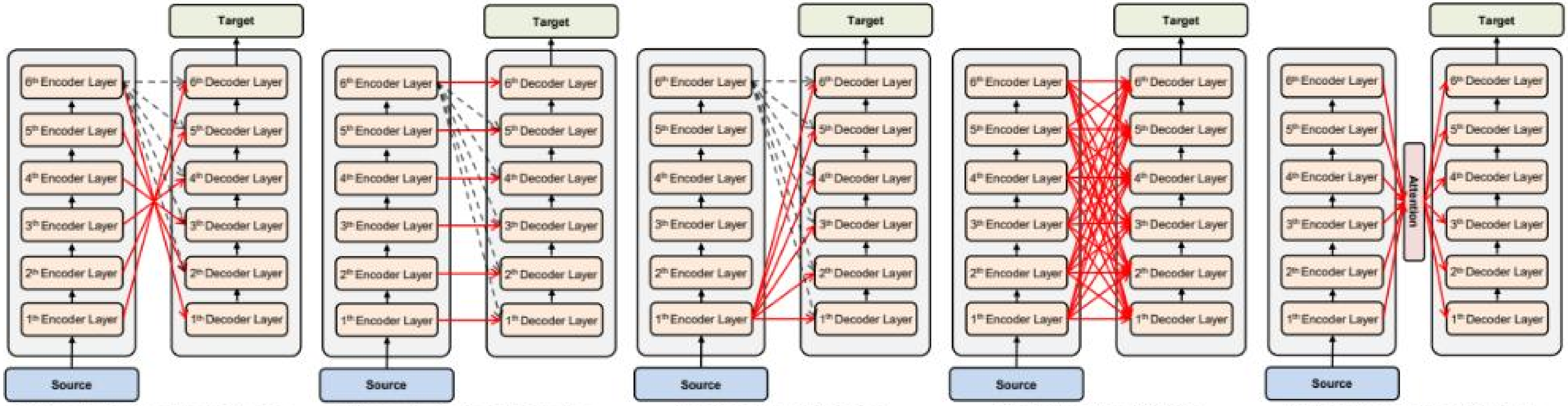

FC
v'
α'_1
α'_2
α'_3
k^1
v^1
k^2
v^2
k^3
v^3
q'
a^1
a^2
a^3
Encoder
Self-attention (Mask)
START
深

Cross Attention

Source of image:
https://arxiv.org/abs/2005.08081



(a) Conventional Transformer



(a) Granularity Consistent Attention

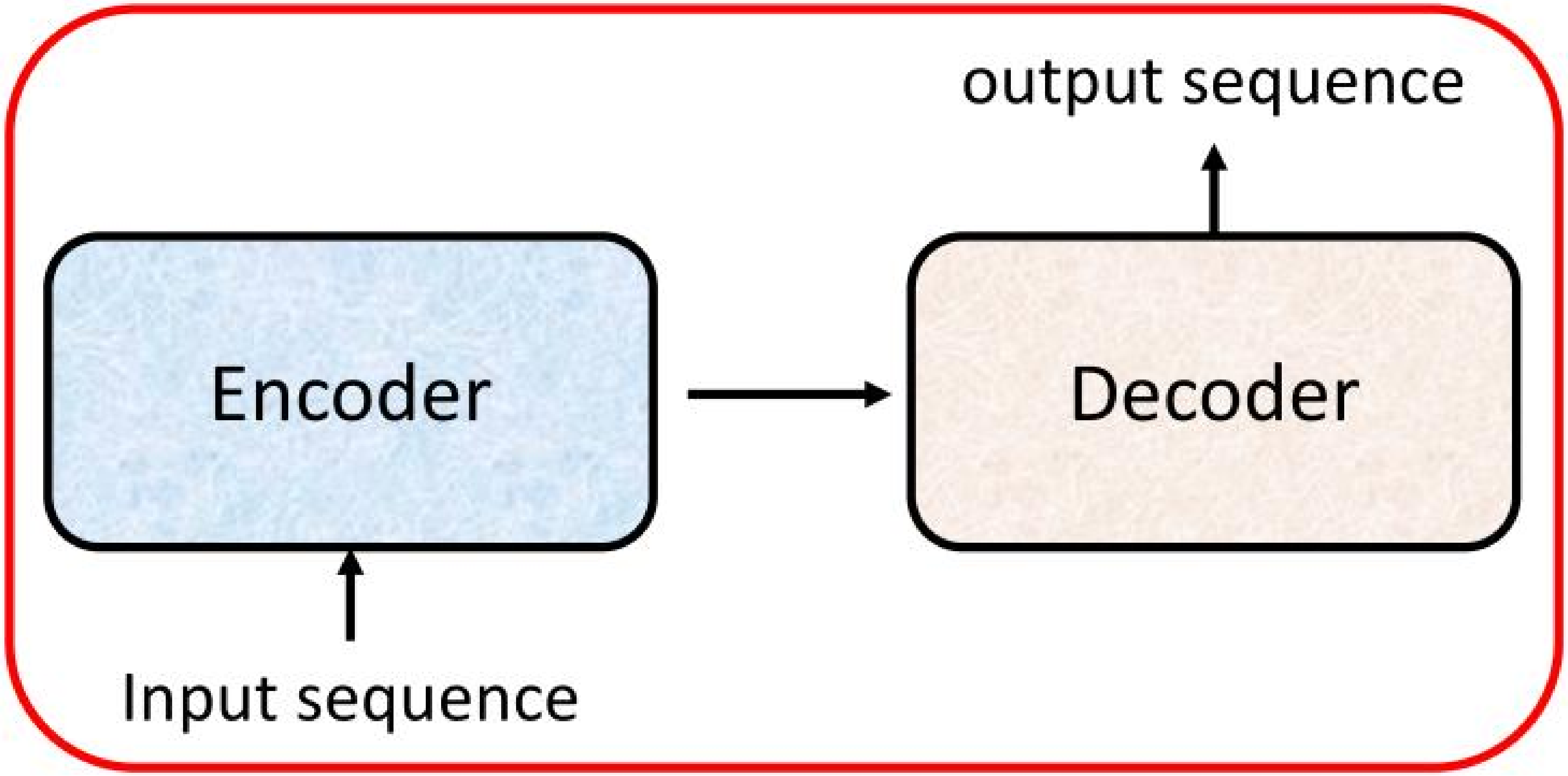
(b) Granularity Parallel Attention

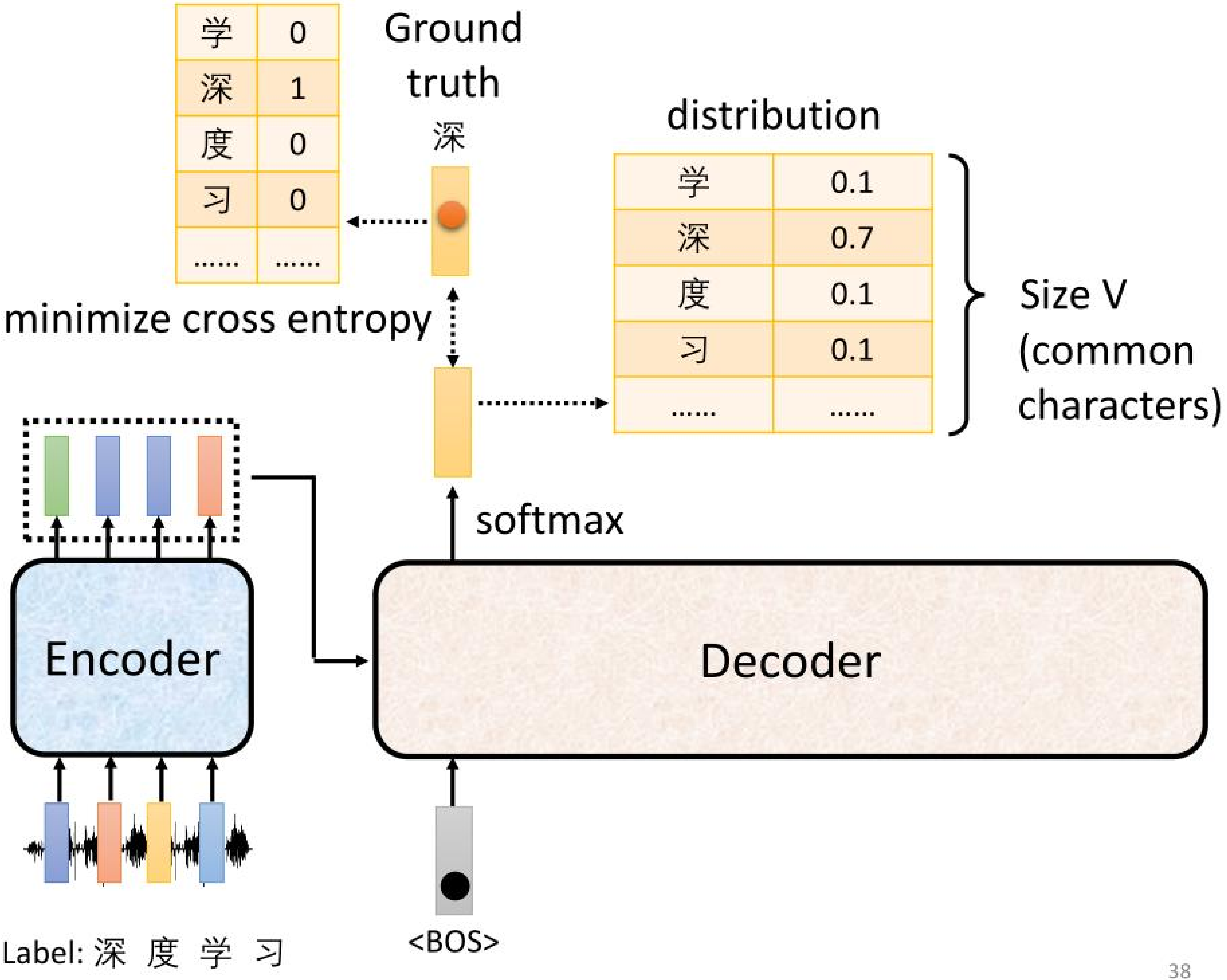
(c) Fine-Grained Attention

(d) Full Matching Attention

(e) Adaptive Matching Attention

Training





Ground truth

深

学	0
深	1
度	0
习	0
……	……

minimize cross entropy

distribution

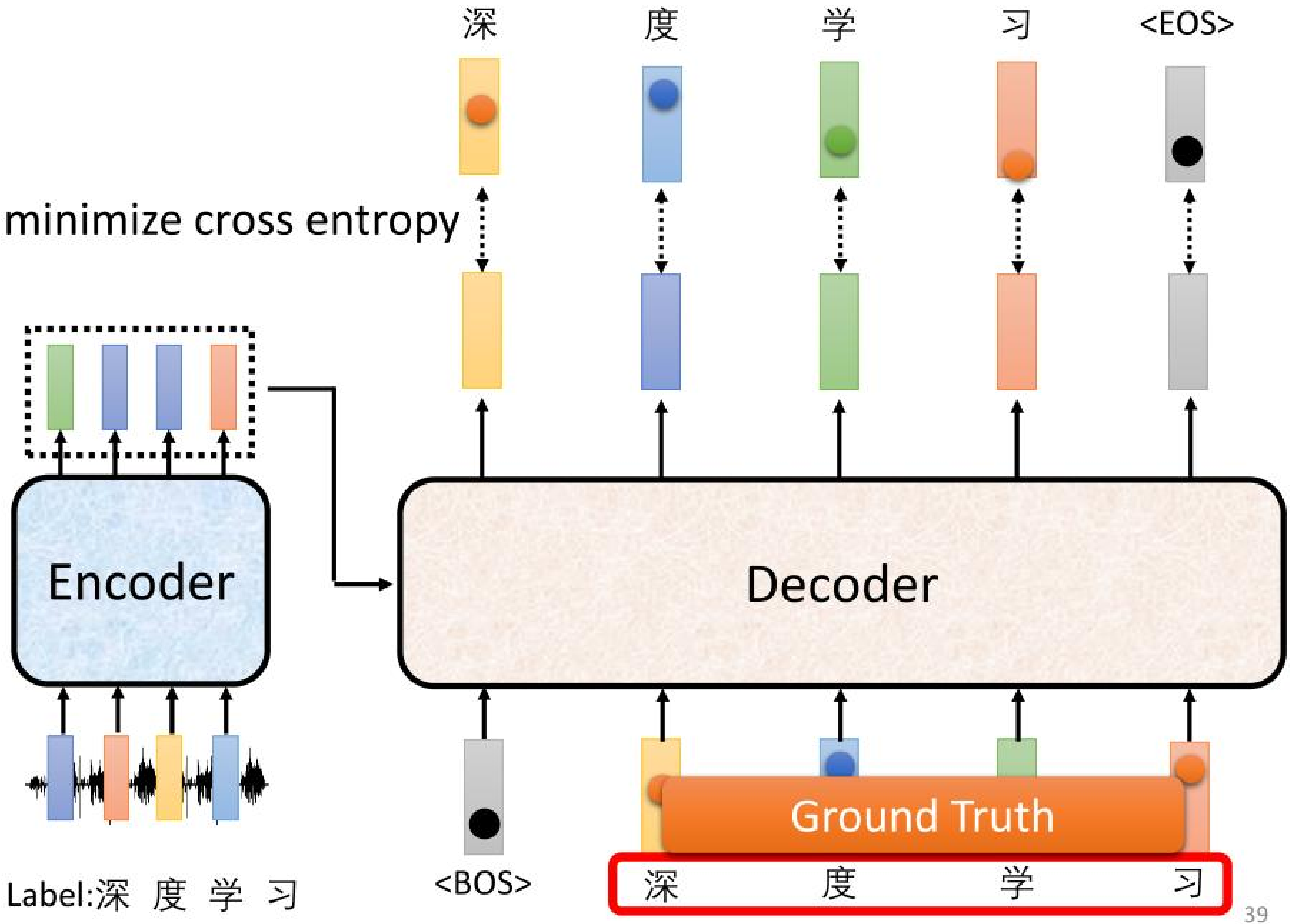
学	0.1
深	0.7
度	0.1
习	0.1
……	……

Size V (common characters)

softmax

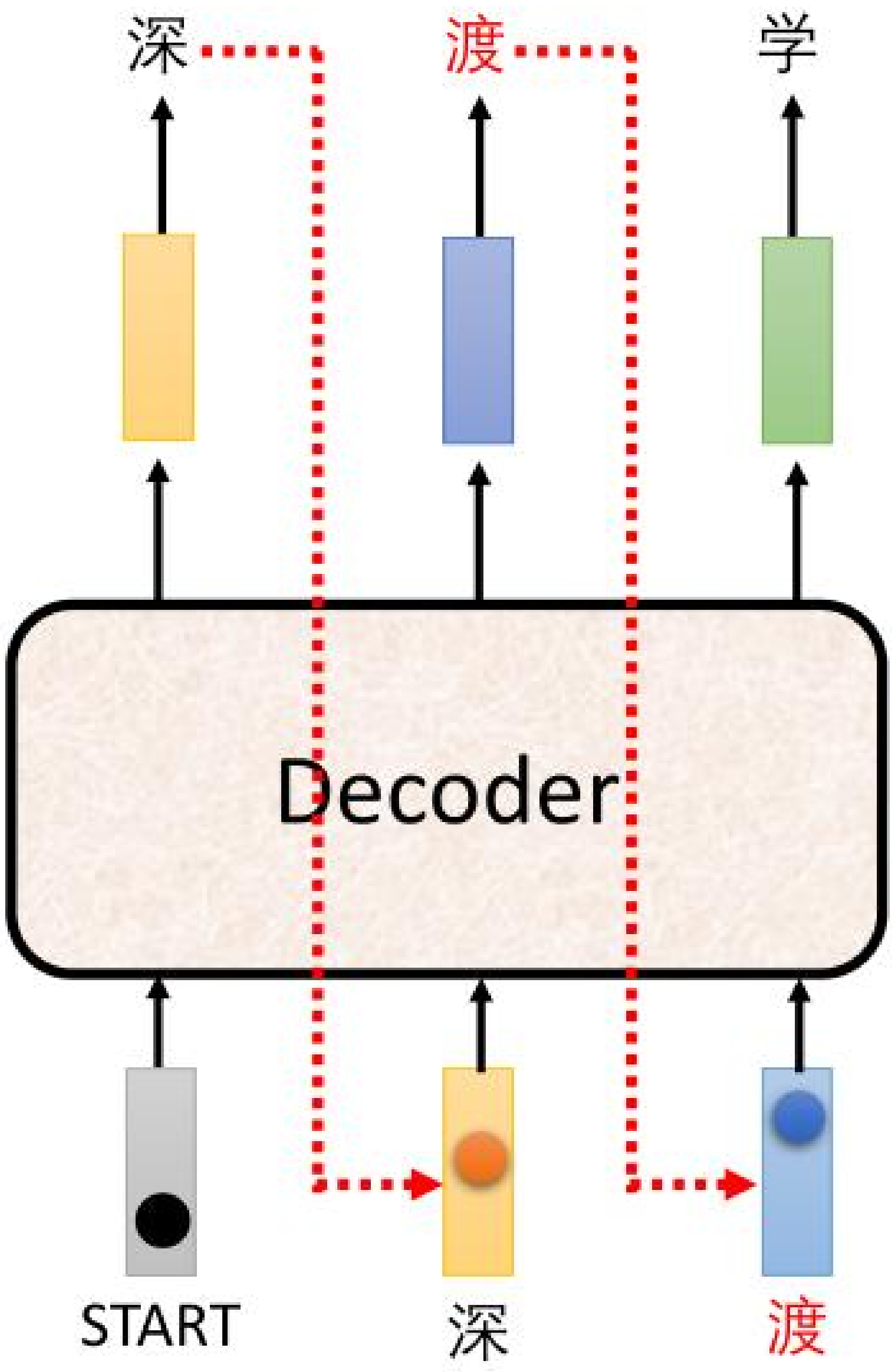
Label: 深 度 学 习

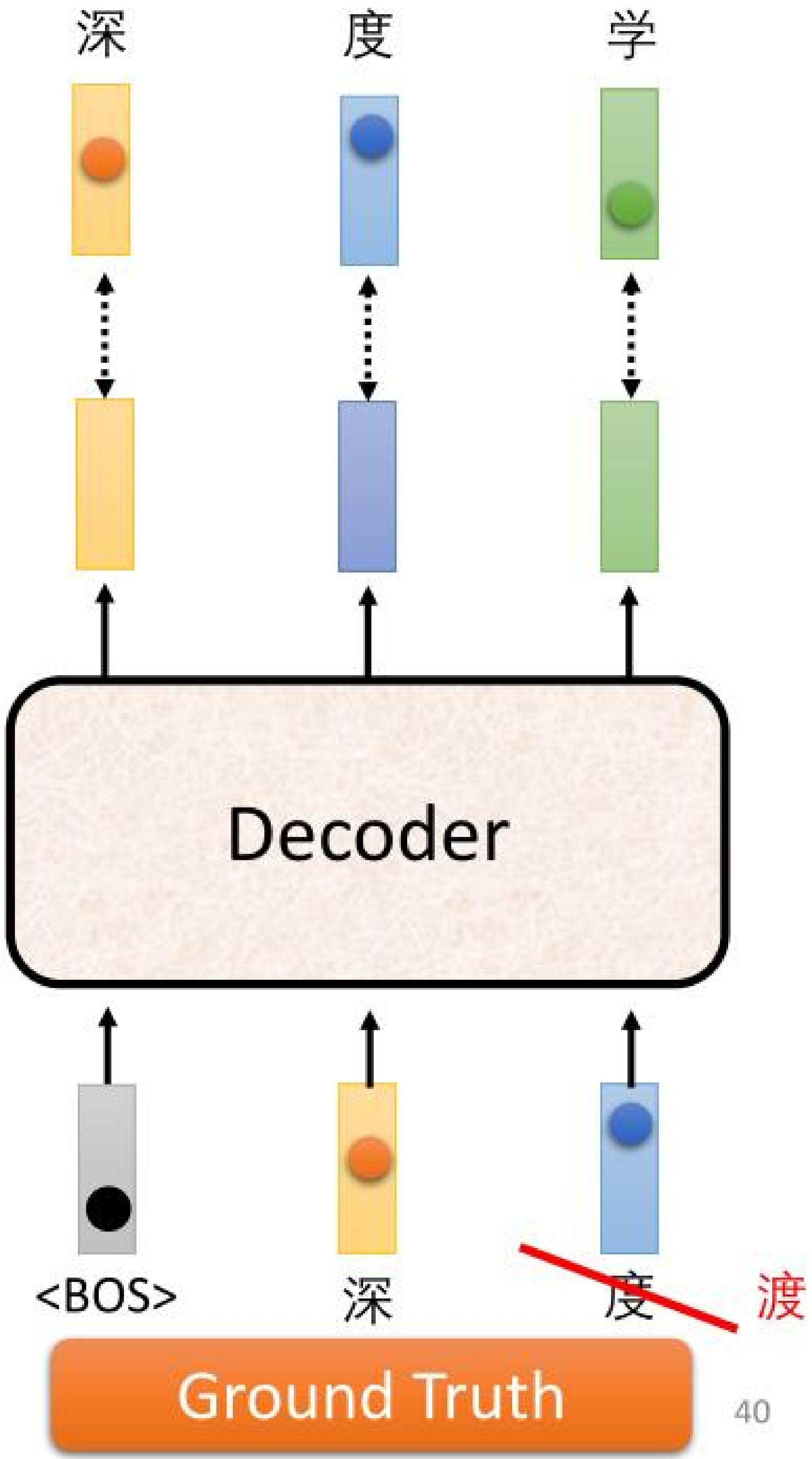
Teacher Forcing: using the ground truth as input.



There is a mismatch! ☹

exposure bias





Scheduled Sampling

- Original Scheduled Sampling

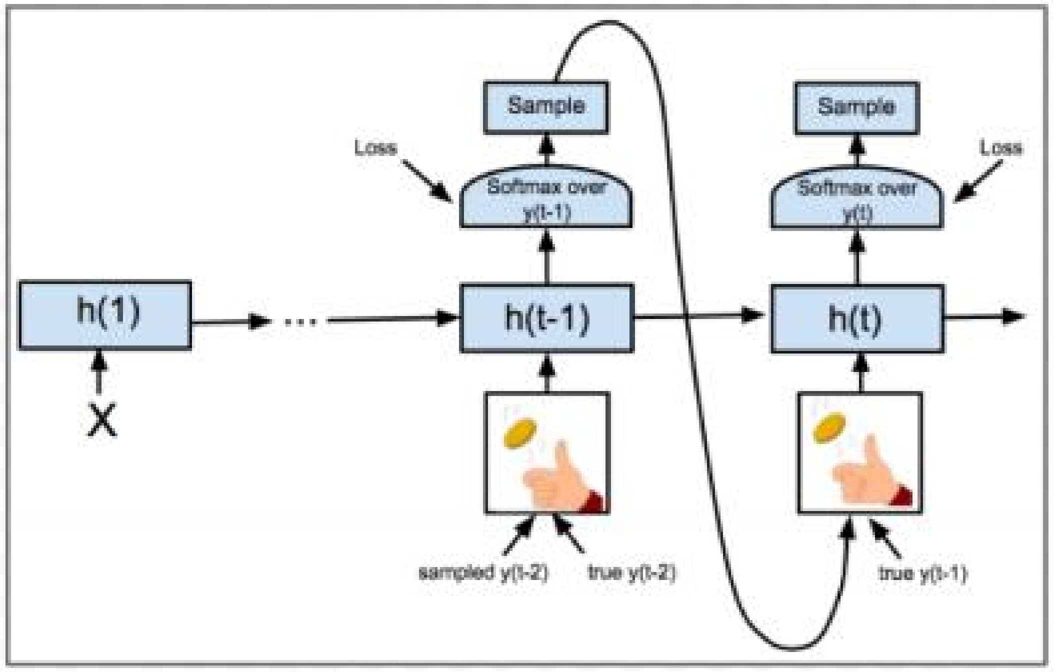
  https://arxiv.org/abs/1506.03099

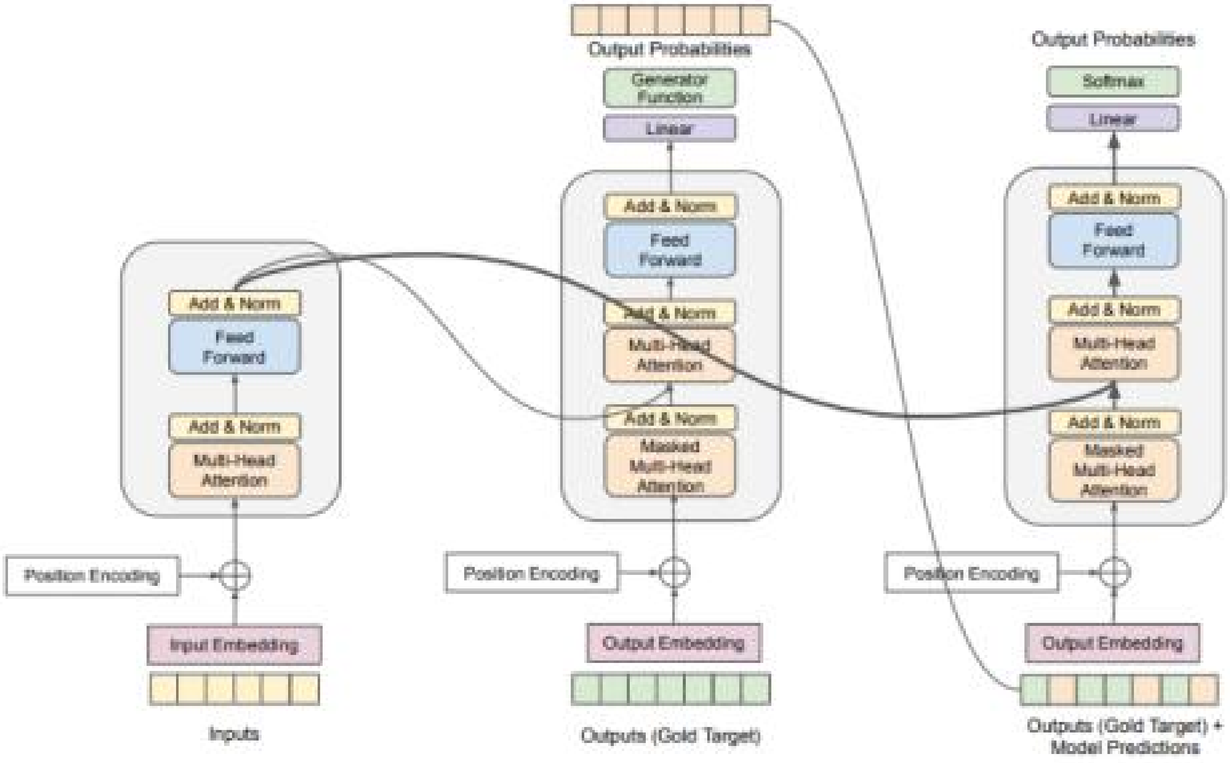
- Scheduled Sampling for Transformer

  https://arxiv.org/abs/1906.07651

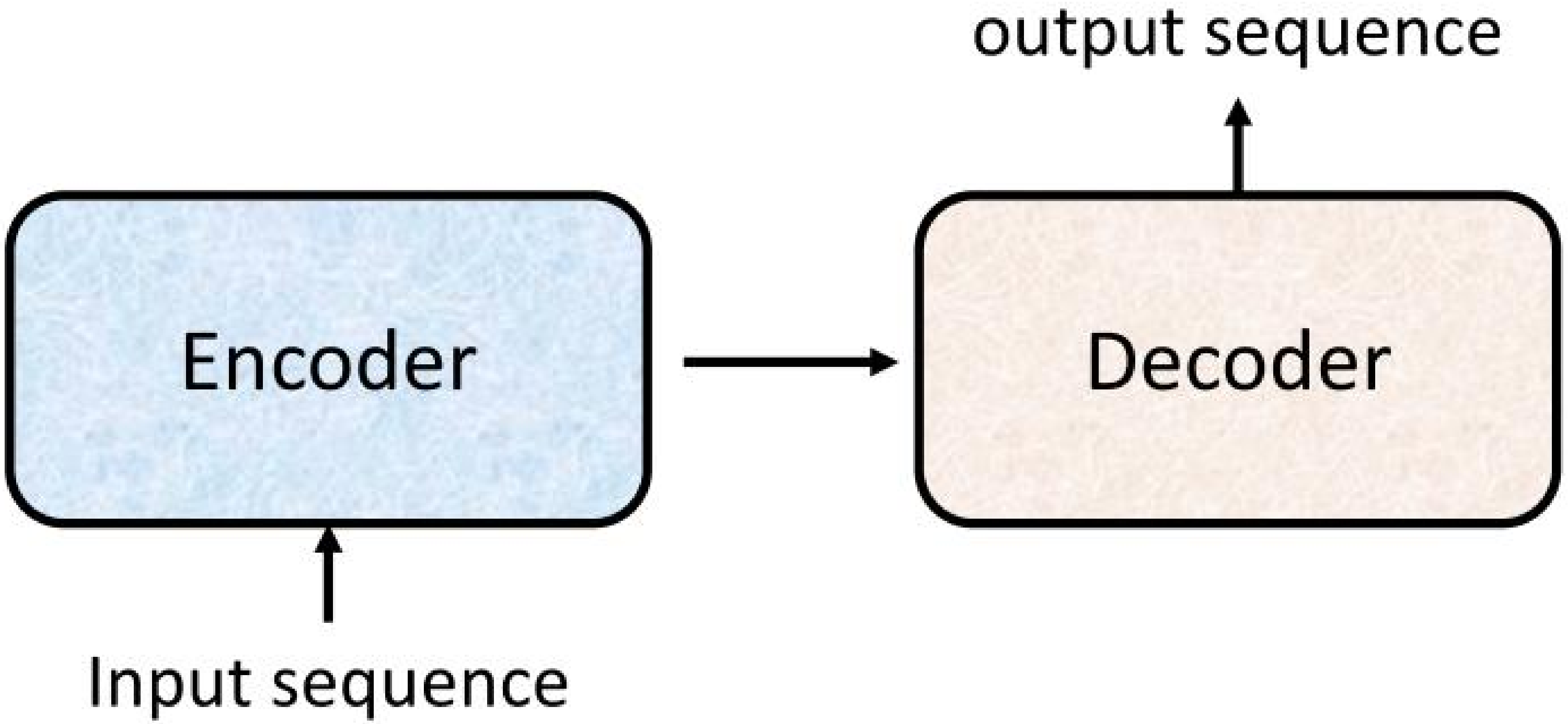
- Parallel Scheduled Sampling

  https://arxiv.org/abs/1906.04331



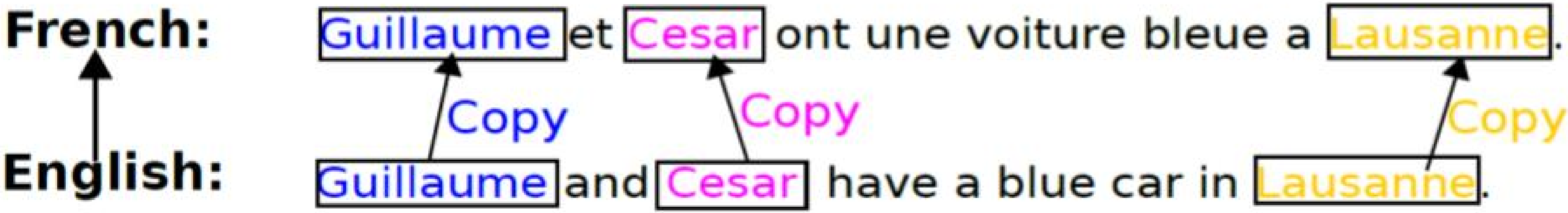


Tips



Copy Mechanism

Machine Translation

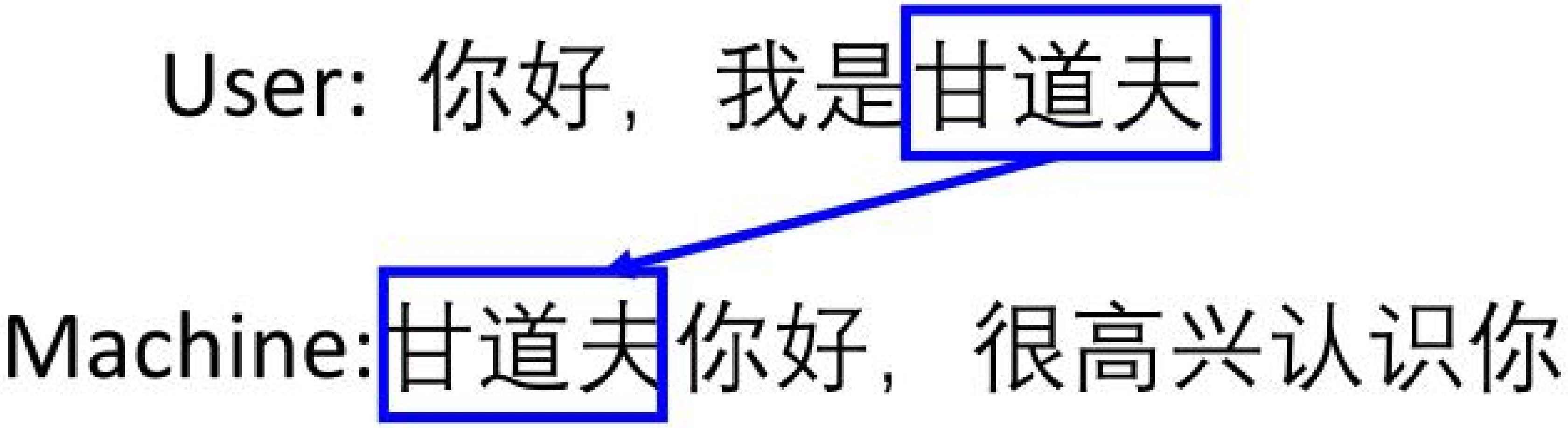


French: Guillaume et Cesar ont une voiture bleue a Lausanne.

Copy Copy Copy

English: Guillaume and Cesar have a blue car in Lausanne.

Chat-bot



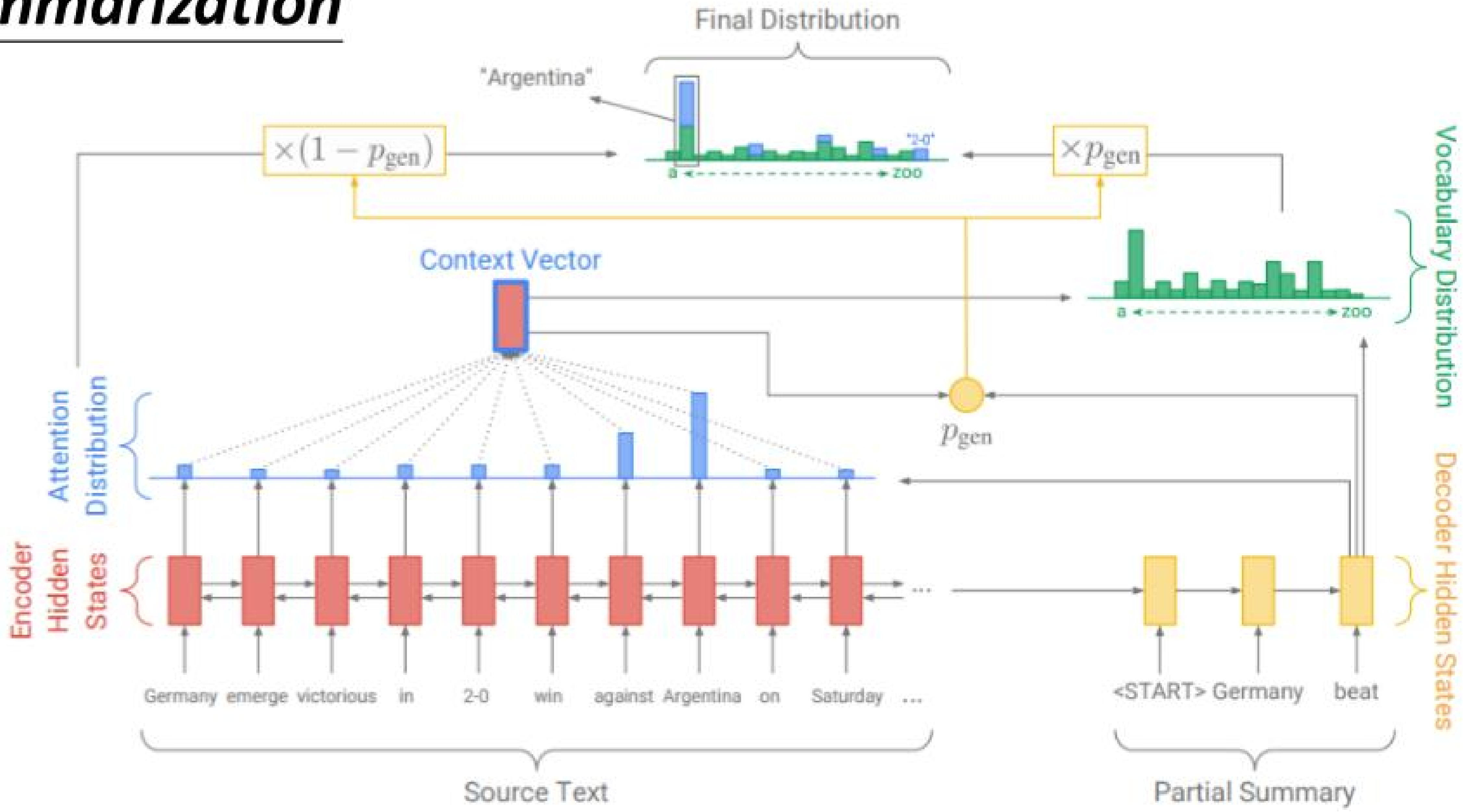
User: 你好，我是甘道夫

Machine:甘道夫你好，很高兴认识你

Copy Mechanism

https://arxiv.org/abs/1704.04368

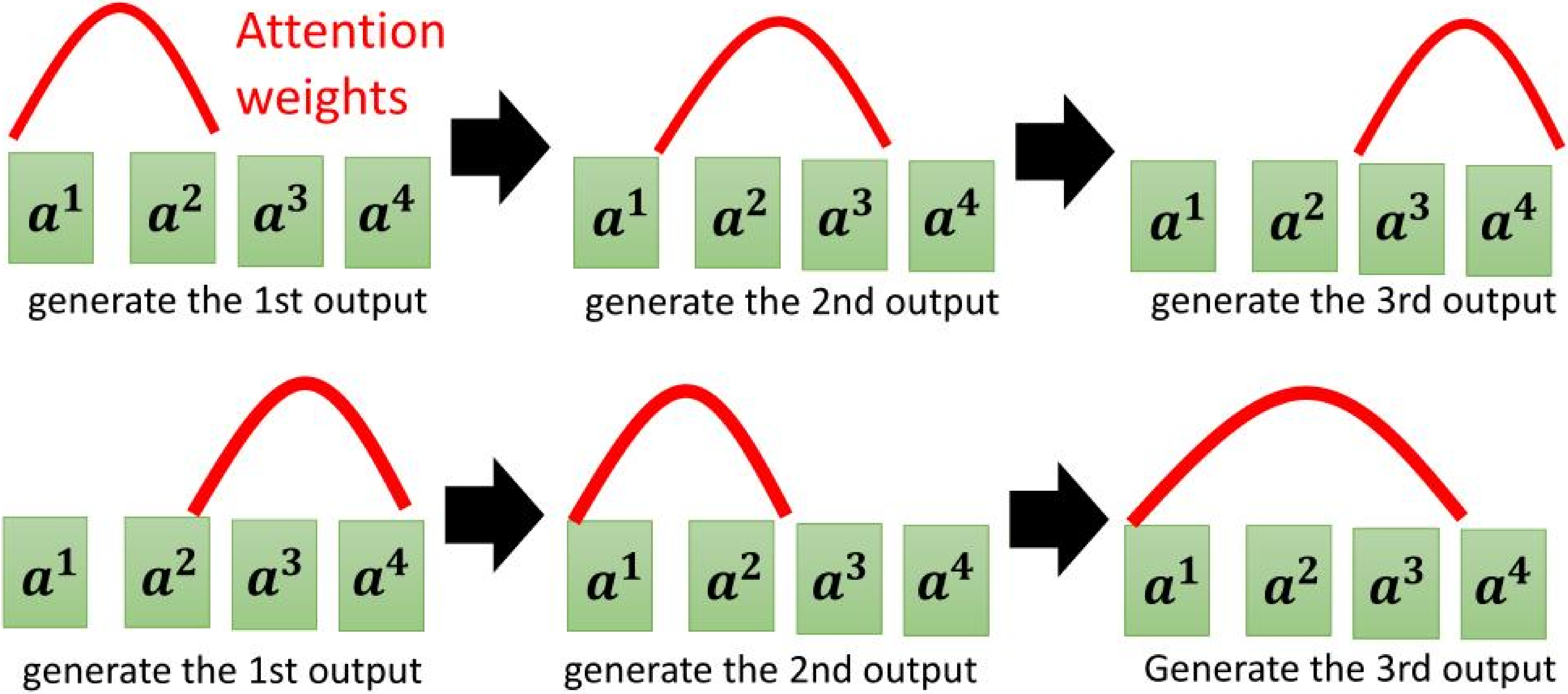
Summarization



Guided Attention

Monotonic Attention
Location-aware attention

In some tasks, input and output are monotonically aligned.
For example, speech recognition, TTS, etc.



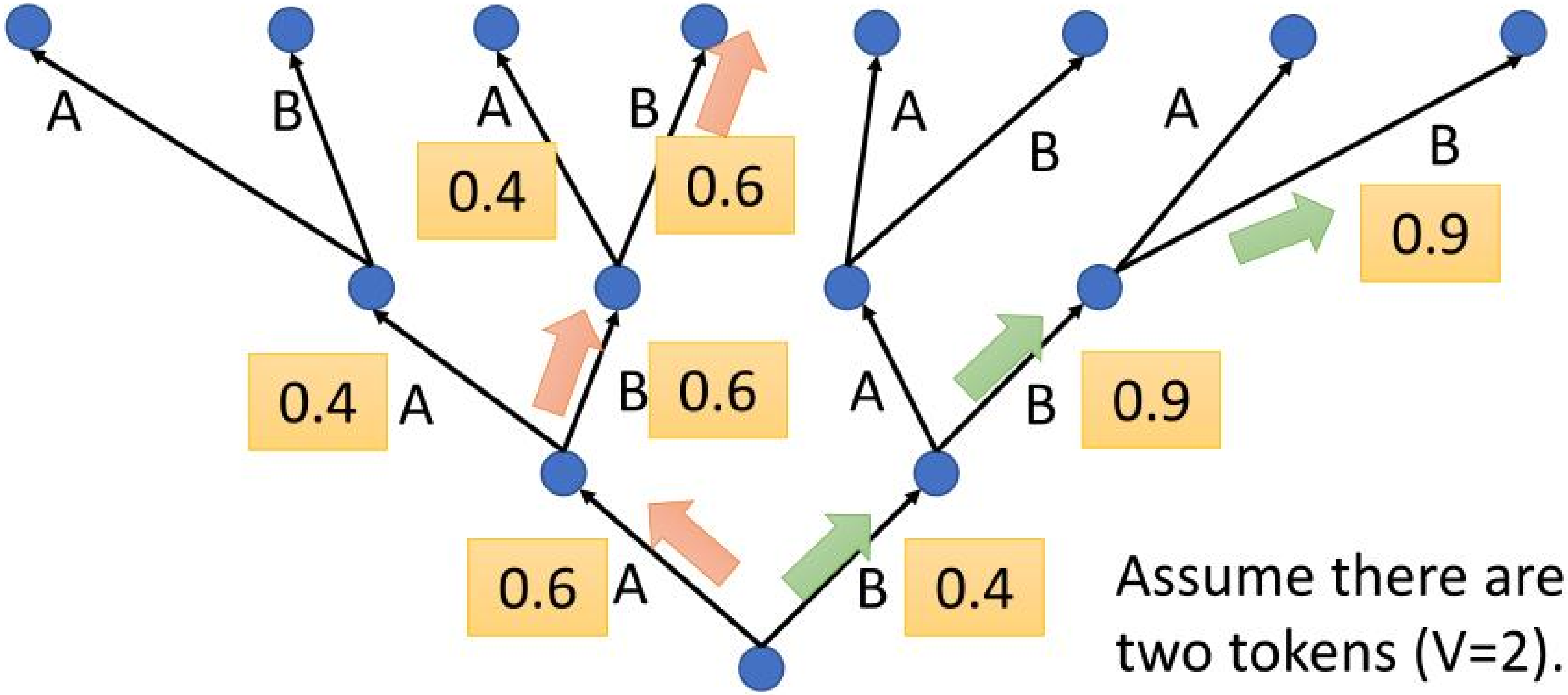
Something wrong!

Beam Search

The red path is ***Greedy Decoding***.

The green path is the best one.

Not possible to check all the paths … → Beam Search

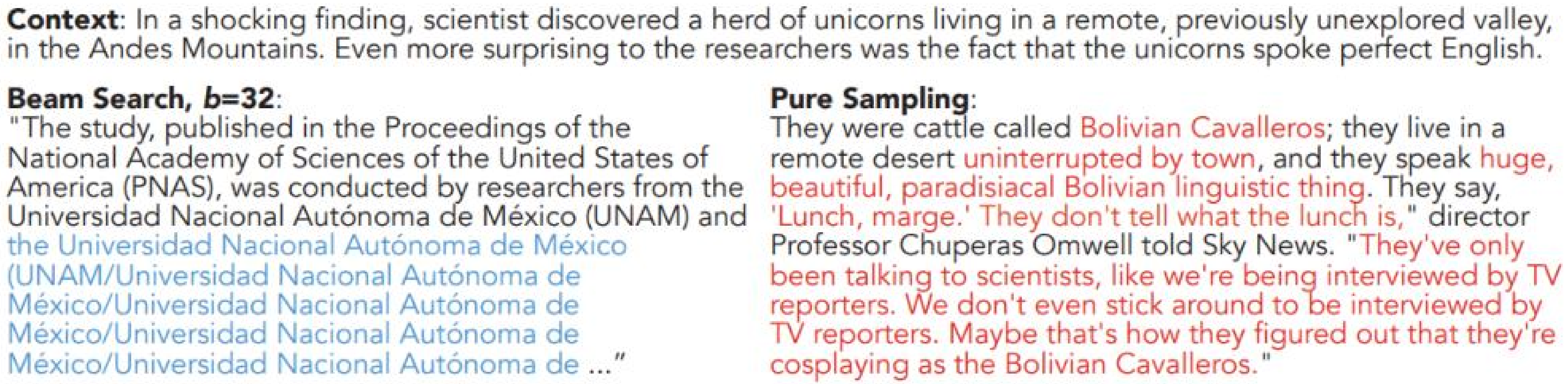


Assume there are only two tokens (V=2).

Sampling

The Curious Case of Neural Text Degeneration

https://arxiv.org/abs/1904.09751



Context: In a shocking finding, scientist discovered a herd of unicorns living in a remote, previously unexplored valley, in the Andes Mountains. Even more surprising to the researchers was the fact that the unicorns spoke perfect English.

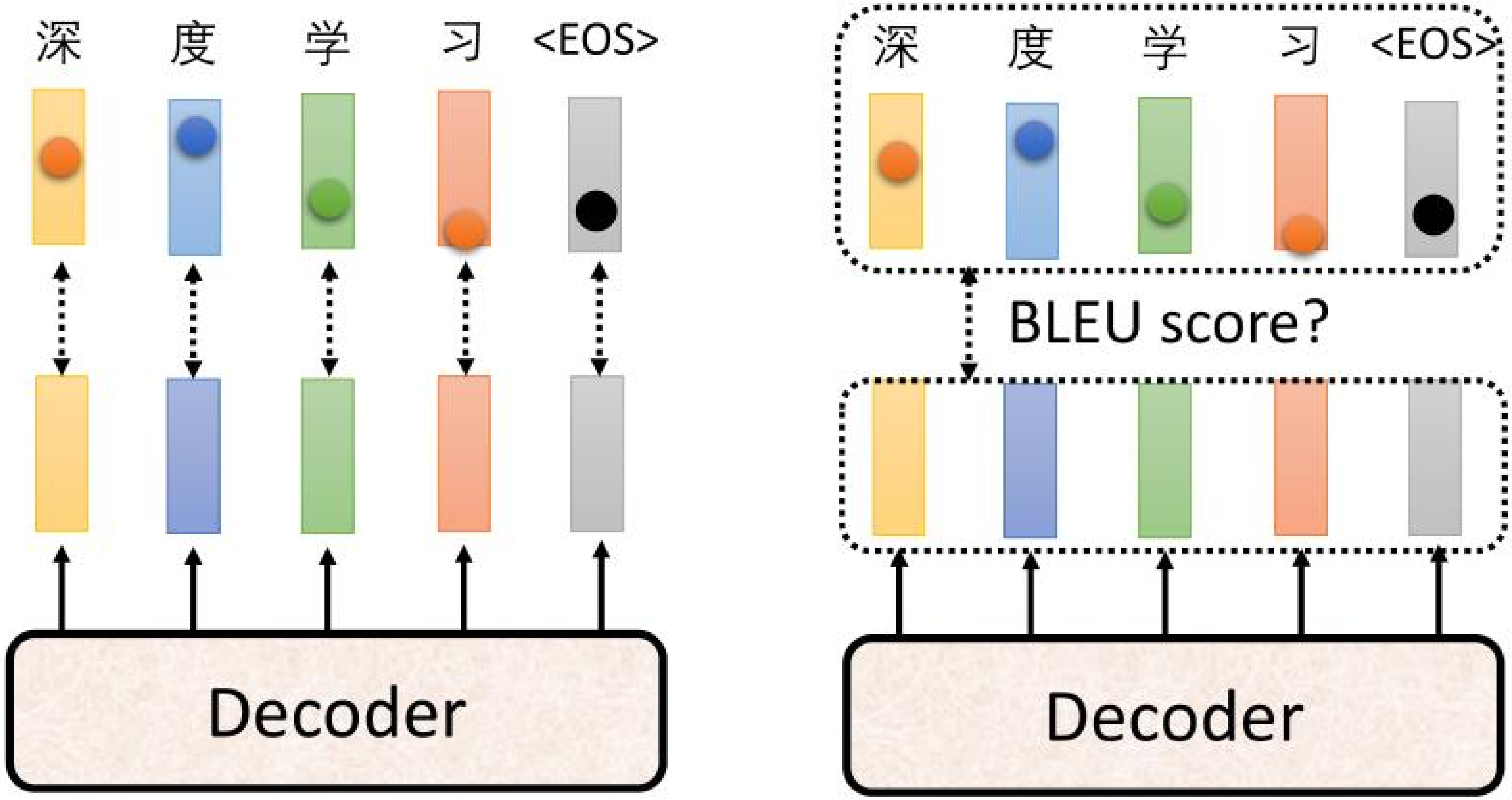
Beam Search, *b*=32:
"The study, published in the Proceedings of the National Academy of Sciences of the United States of America (PNAS), was conducted by researchers from the Universidad Nacional Autónoma de México (UNAM) and the Universidad Nacional Autónoma de México (UNAM/Universidad Nacional Autónoma de México/Universidad Nacional Autónoma de México/Universidad Nacional Autónoma de México/Universidad Nacional Autónoma de ..."

Pure Sampling:
They were cattle called Bolivian Cavalleros; they live in a remote desert uninterrupted by town, and they speak huge, beautiful, paradisiacal Bolivian linguistic thing. They say, 'Lunch, marge.' They don't tell what the lunch is," director Professor Chuperas Omwell told Sky News. "They've only been talking to scientists, like we're being interviewed by TV reporters. We don't even stick around to be interviewed by TV reporters. Maybe that's how they figured out that they're cosplaying as the Bolivian Cavalleros."

Randomness is needed for decoder when generating sequence in some tasks.

Accept that nothing is perfect. True beauty lies in the cracks of imperfection. ☺

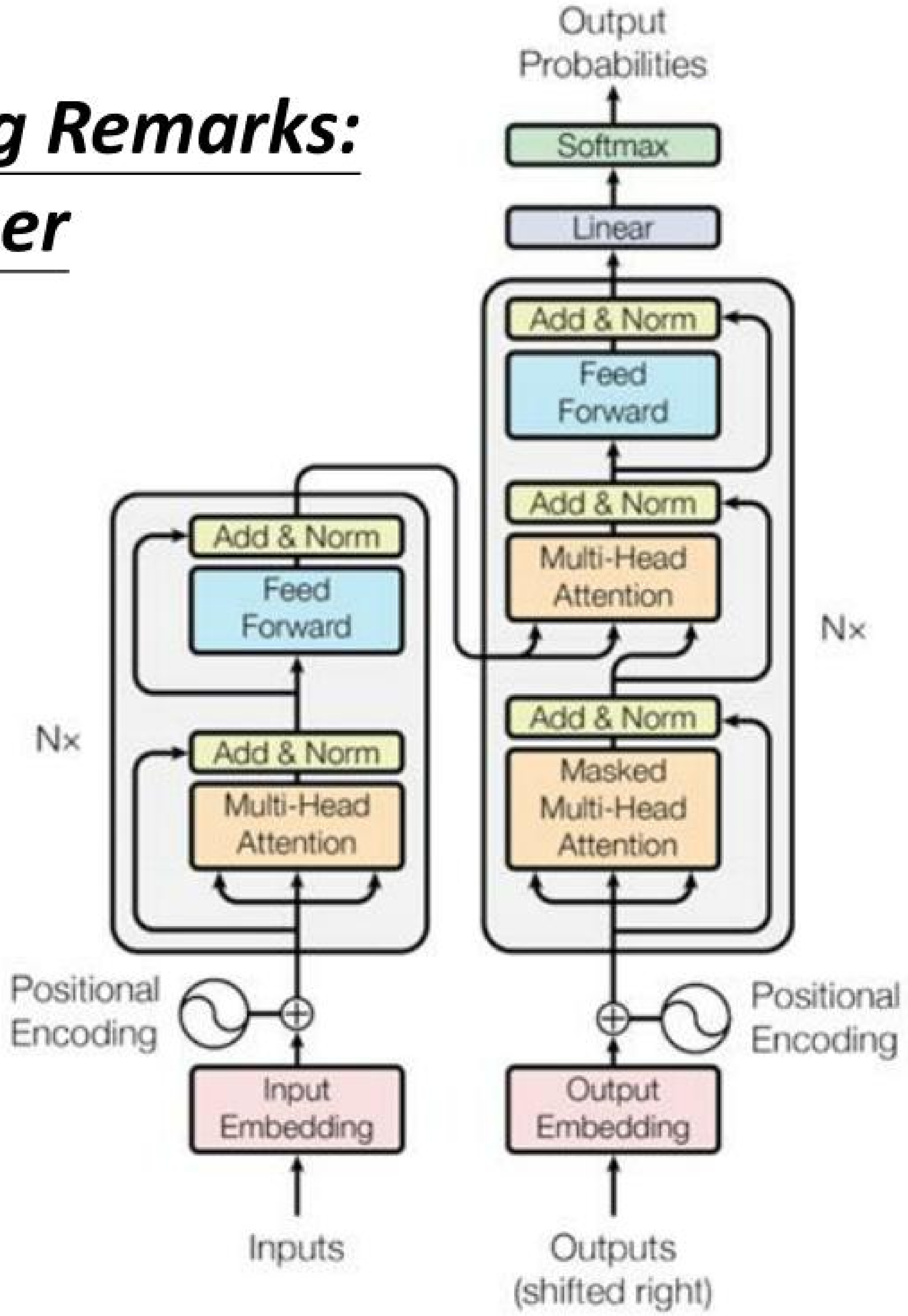
Optimizing Evaluation Metrics?



How to do the optimization?

When you don’t know how to optimize, just use reinforcement learning (RL)! https://arxiv.org/abs/1511.06732

Concluding Remarks: Transformer


Output Probabilities
Softmax
Linear
Add & Norm
Feed Forward
Add & Norm
Multi-Head Attention
Add & Norm
Masked Multi-Head Attention
Nx
Add & Norm
Feed Forward
Add & Norm
Multi-Head Attention
Nx
Positional Encoding
Positional Encoding
Input Embedding
Output Embedding
Inputs
Outputs (shifted right)