NEURAL INVERTED INDEX

RUCCI EMANUELE , GIANMARCO SCARANO

Deep Learning Course Held by Prof. Fabrizio Silvestri

SAPIENZA
UNIVERSITÀ DI ROMA

INDEX

Emanuele Rucci, Gianmarco Scarano

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Information Retrieval and

DIFFERENTIABLE SEARCH INDEX

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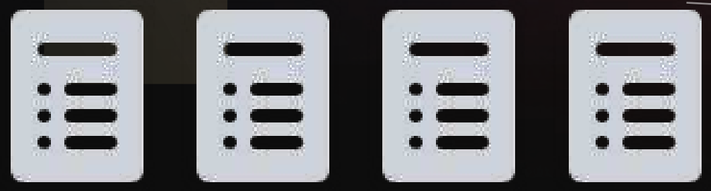
IR & DSI



Documents

Information

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IR & DSI

Query

IR ENGINE

Information

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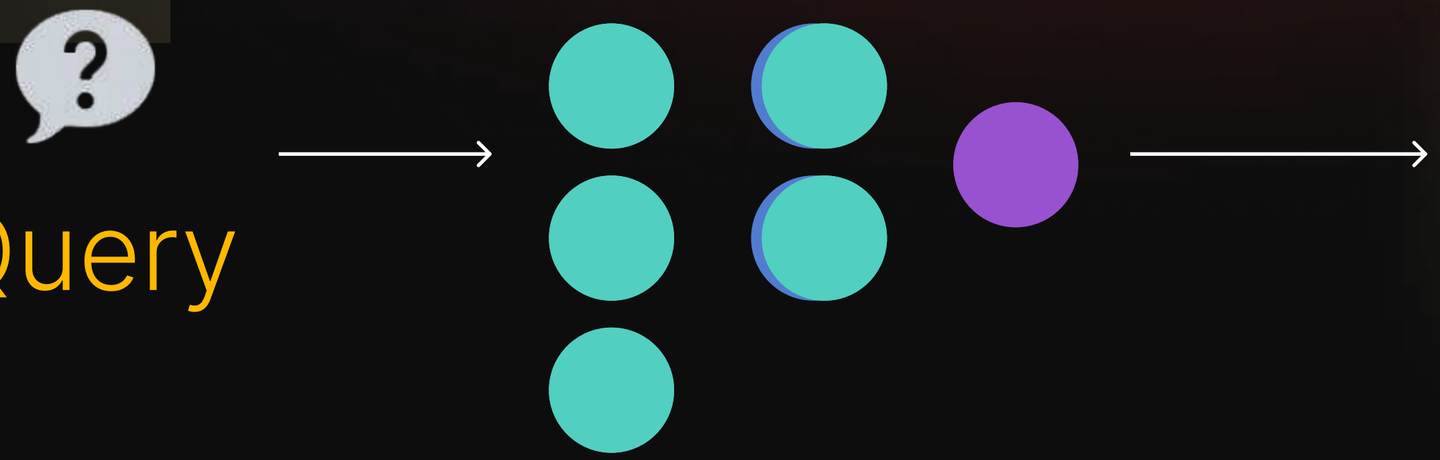

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Query

Information

DOCUMENT IDENTIFIER

RETRIEVAL

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IR & DSI

Information

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INDEXING

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What to Index?

DOCUMENT REPRESENTATION

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DOCUMENT REP.

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Direct Indexing

Select first ***L*** tokens.

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Nullam interdum turpis

BUT, WHAT IF

this chunk misses the needed informations?

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DOC BER

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ations?

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Nullam interdum turpis

SET INDEXING

Remove:

- Stopwords
- Duplicates

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DOC

NG

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Nullam interdum turpis

NINJAS

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Nullam interdum turpis

SUMMARIZATION

Falcon Summarization

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How to Index

DOC ID REPRESENTATION

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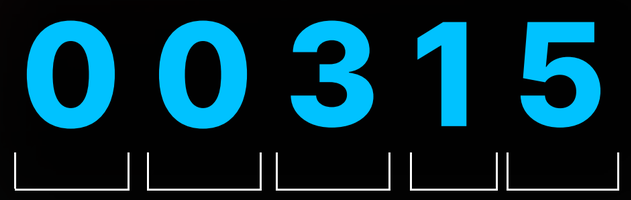
DocID REP.

Naively Structured

In a **Generative setting** the DocID
is treated as a tokenizable string.



Unstructured Atomic

In a **Discriminative setting** the
DocID has to be chosen directly.

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DocID REP.

Conceptual DocID

Treat a DocID as a tokenizable hierarchical string using external knowledge-base, such as WikiData or BabelNet, like:

Prefix + coarse_grained_ID + fine_grained_ID + doc_chunk_ID

docID_fruit_apple_03

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Training Type

DISCRIMINATIVE

GENERATIVE

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TRAINING TYPE

DISCRIMINATIVE

TOKENS

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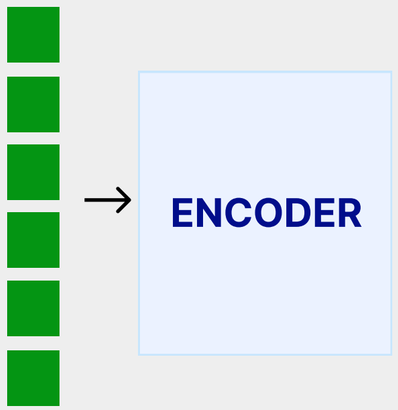
TRAINING TYPE

DISCRIMINATIVE



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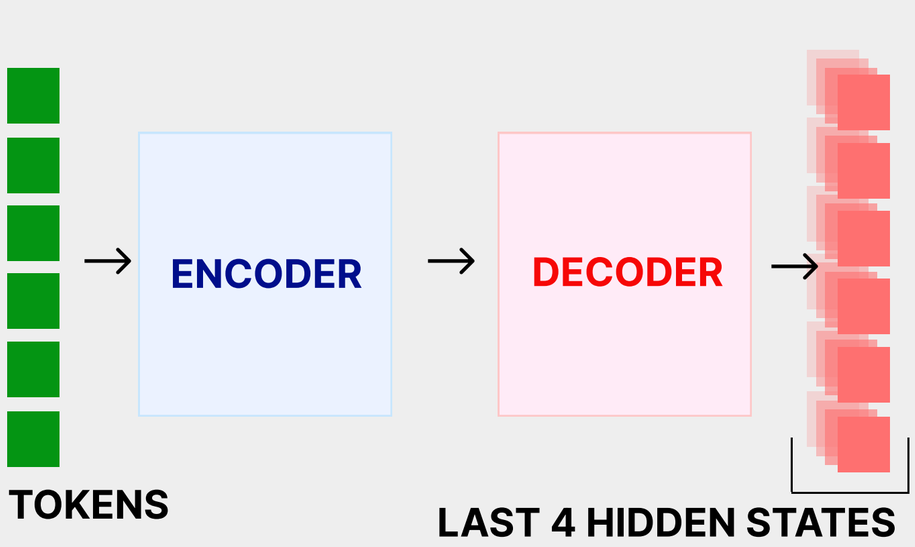
TRAINING TYPE

DISCRIMINATIVE



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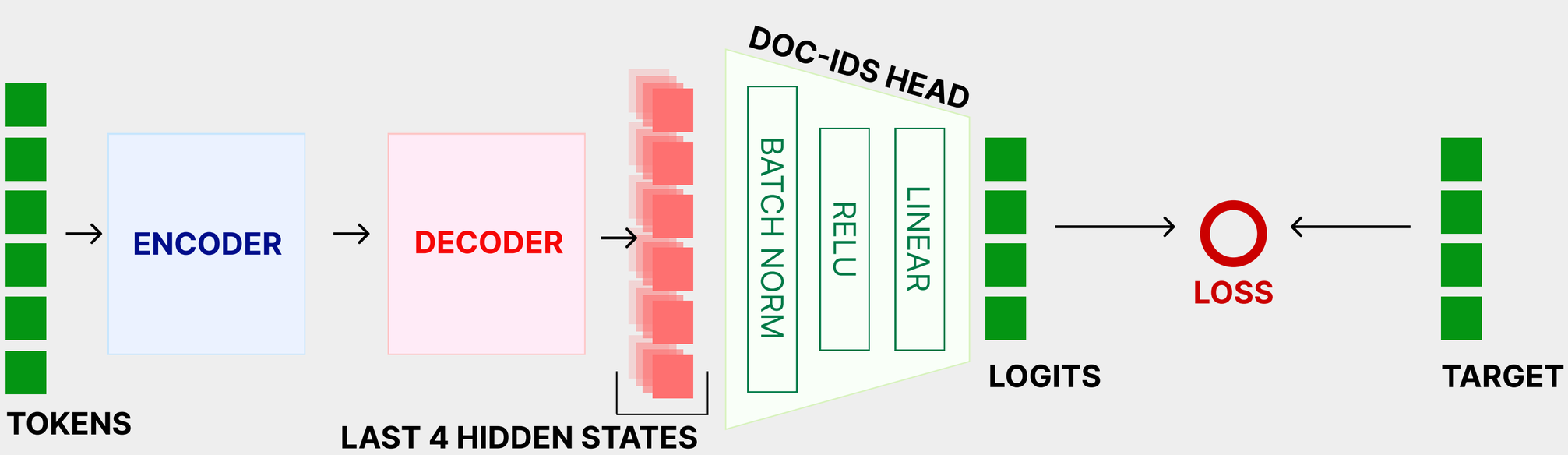
TRAINING TYPE

DISCRIMINATIVE



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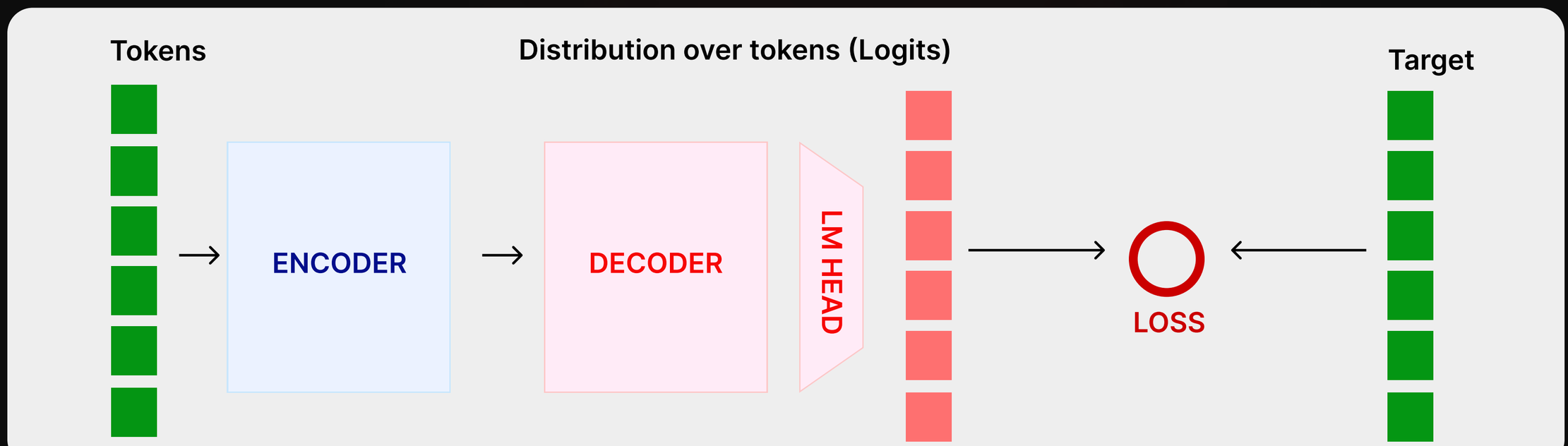
TRAINING TYPE

GENERATIVE



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TRAINING TYPE

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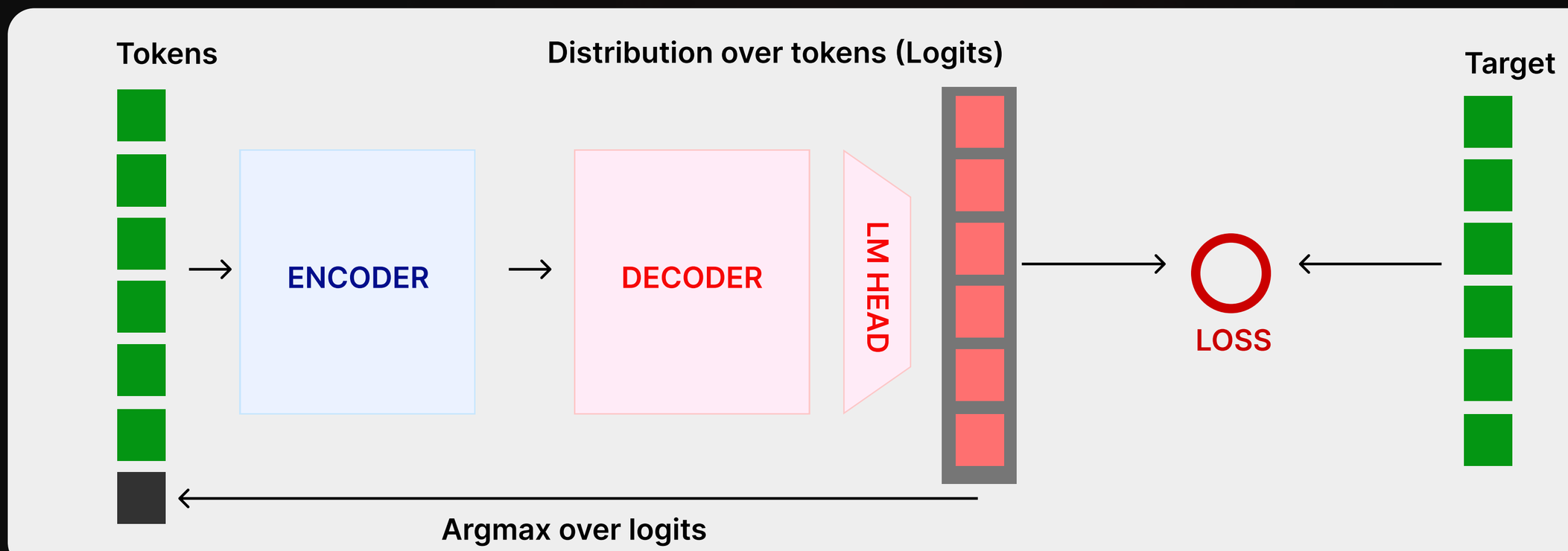

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Architecture Design

FLAN-T5, BERT & MoE

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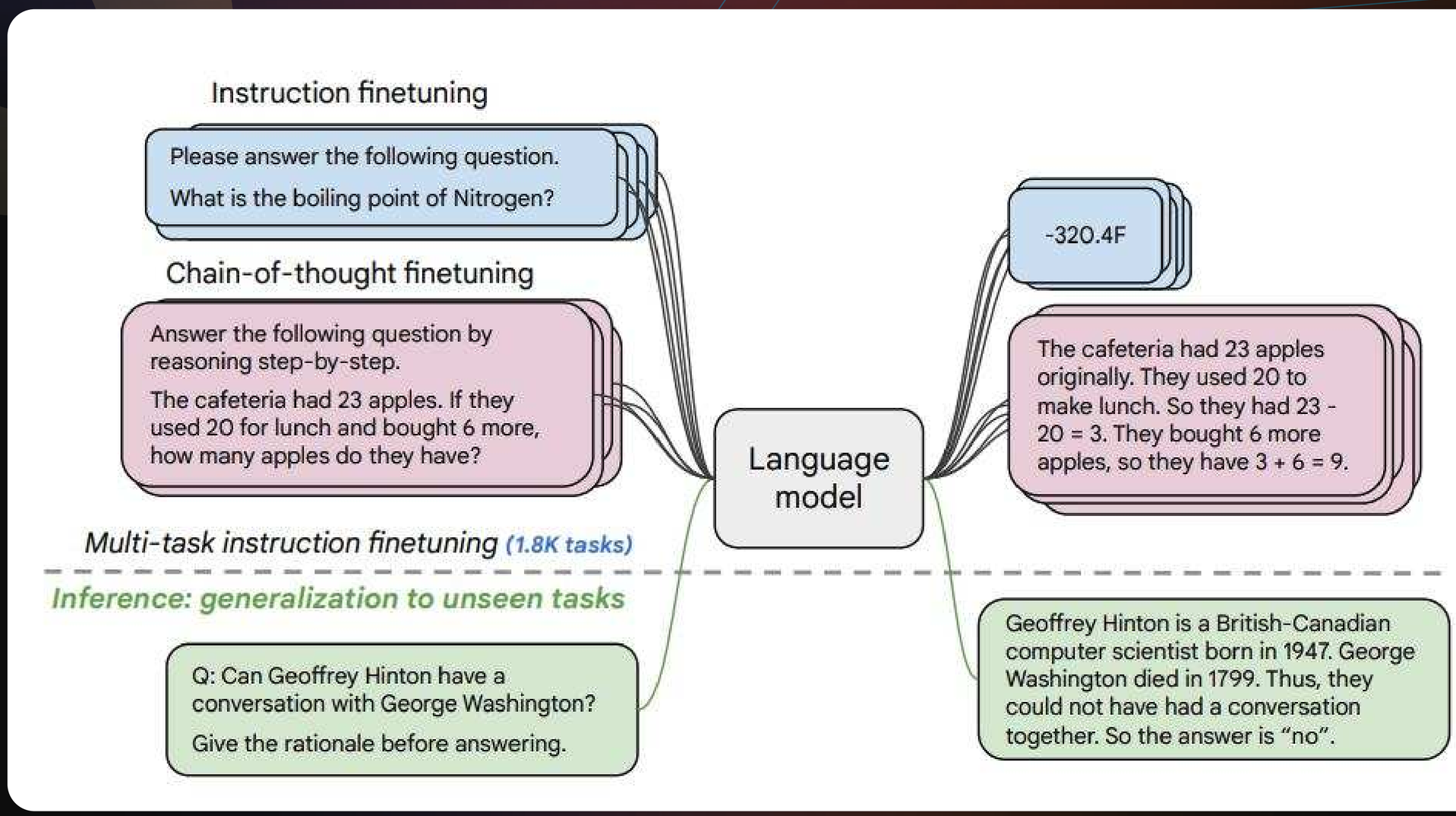
BASELINE: Flan-T5



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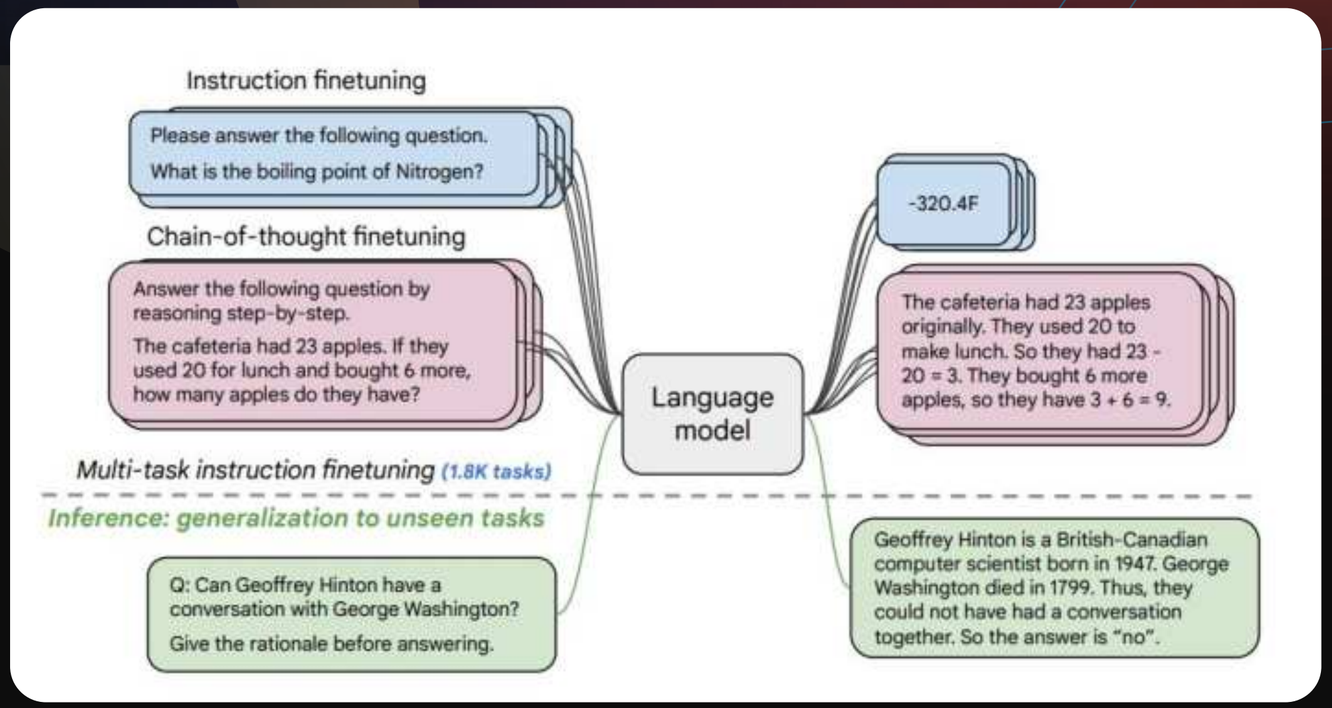
BASELINE: Flan-T5



1800 Tasks

248M Params

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BERT: Shared parameters

Shared parameters leads to more efficient computations?

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BERT: Shared parameters

Shared parameters leads to more efficient computations?

Yes, along with benefits of fewer parameters.

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BERT: Shared parameters

More reasons?

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BERT: Shared parameters

What is the impact of parameters sharing on Index and Retrieval?

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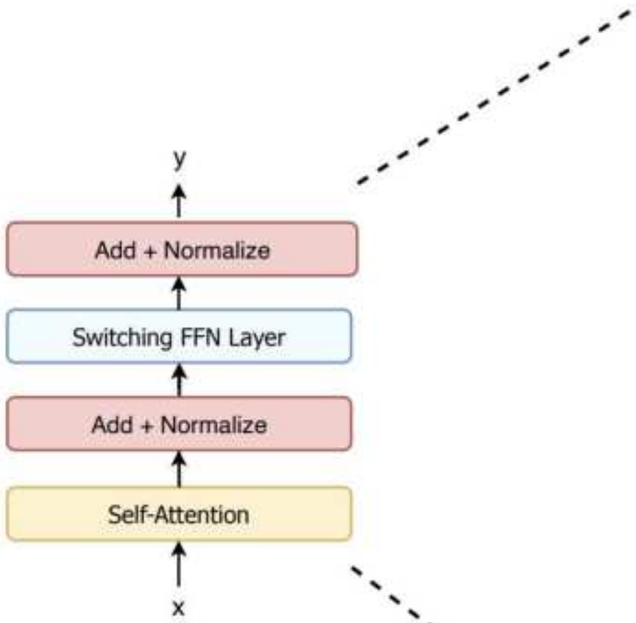
MoE + Flan-T5



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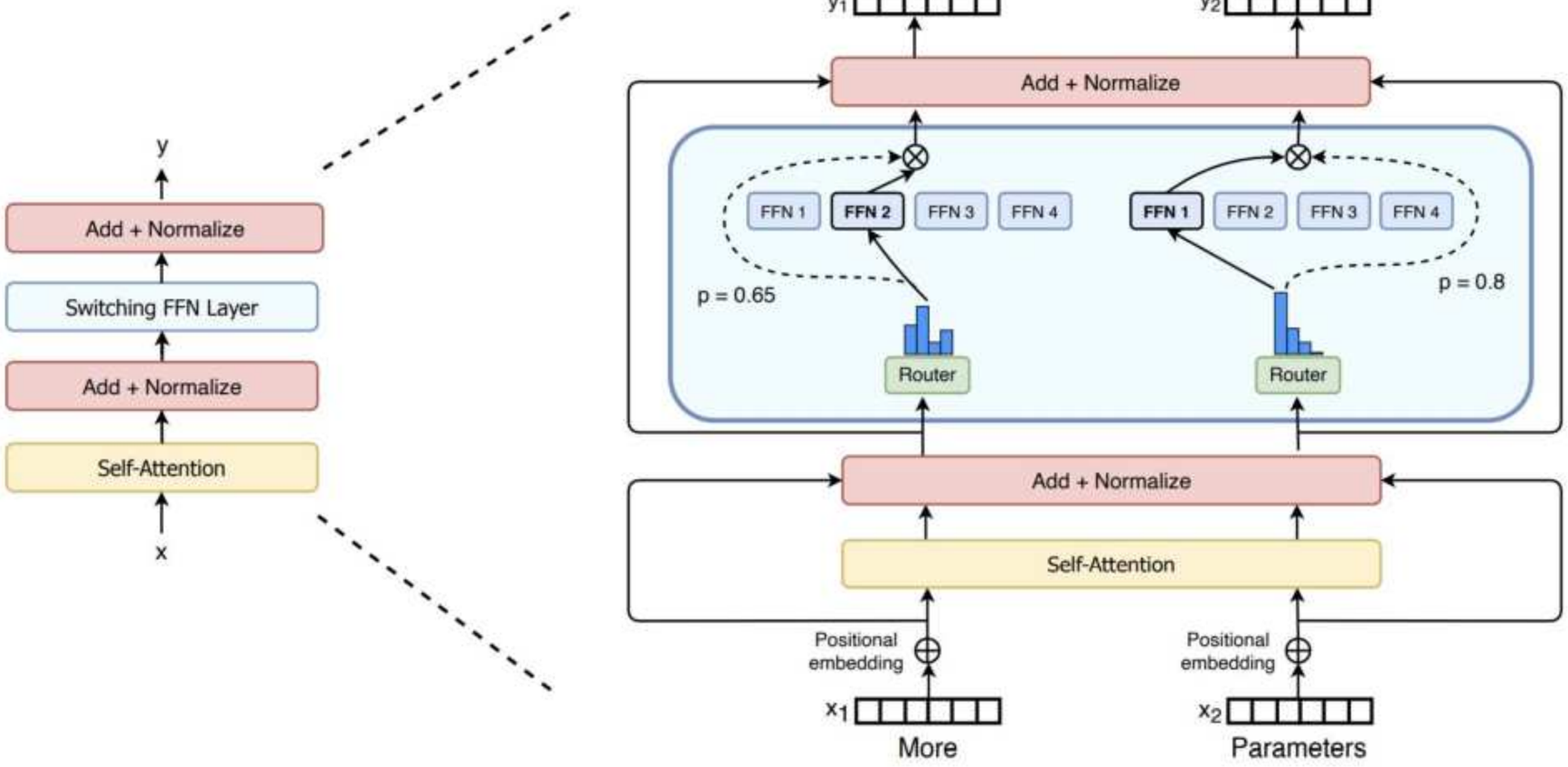
MoE + Flan-T5



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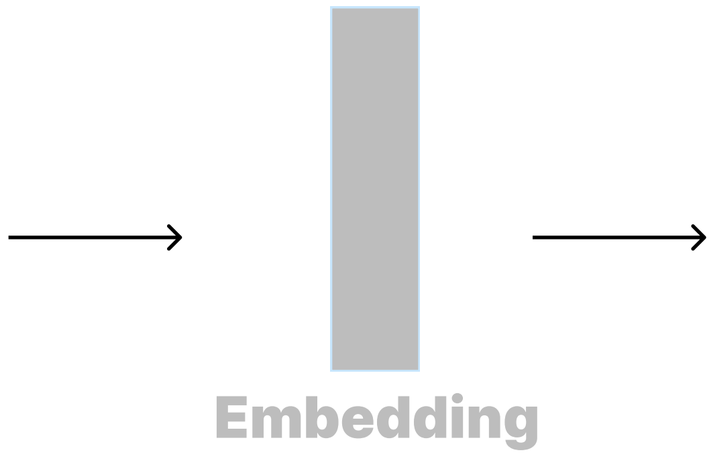
MoE + Flan-T5

Switch Transformer

Encoder



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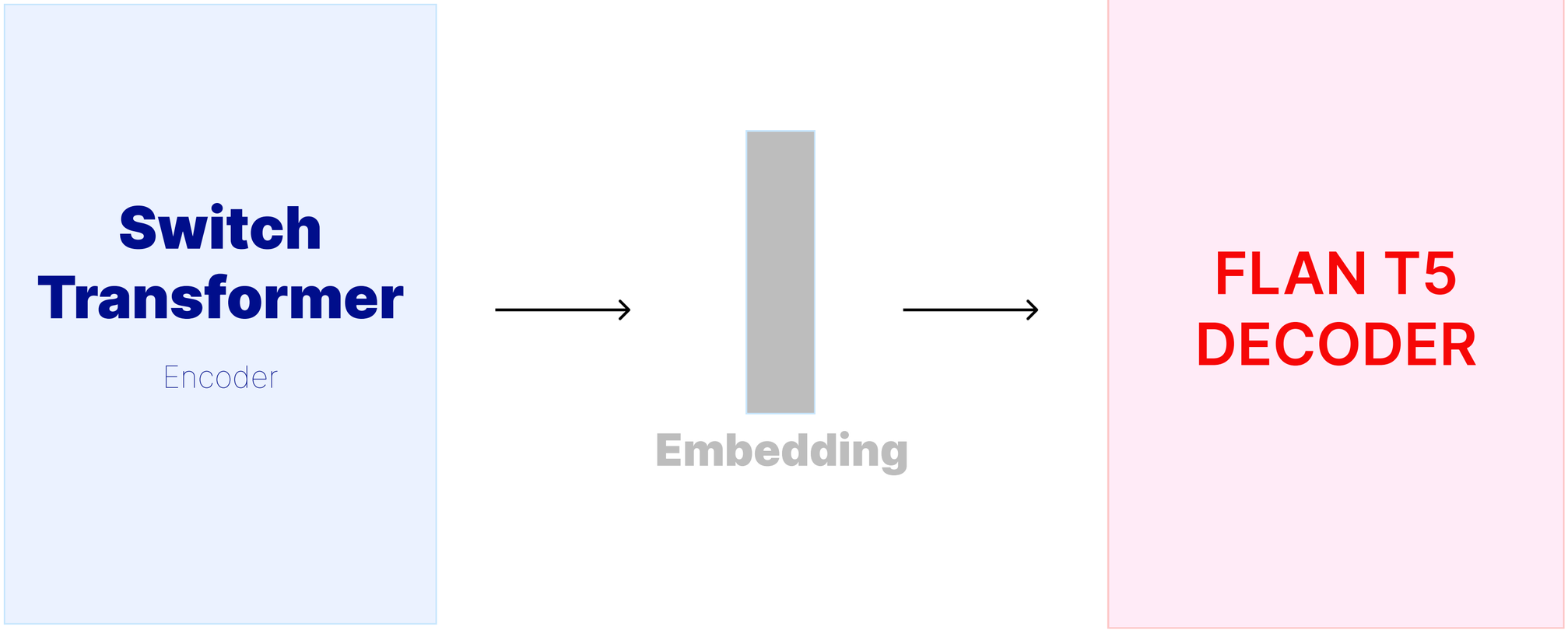
MoE + Flan-T5



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MoE + Flan-T5

Does the MoE specialize on certain aspects of the documents?

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Technical Tricks

QUANTIZATION & FINETUNING

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QUANTIZATION

Before Quantization

FLAN-T5

248 M

Parameters

→ ⟶

BERT

139 M

Parameters

MoE

868 M

Parameters

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QUANTIZATION

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LoRA

$$W_0 + \Delta W = W_0 + BA$$

Large Model

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LoRA

$$W_0 + \Delta W = W_0 + BA$$

Large Model

$$B \in \mathbb{R}^{dxr}$$

$$A \in \mathbb{R}^{rxk}$$

$$rank\ r \ll \min(d, k)$$

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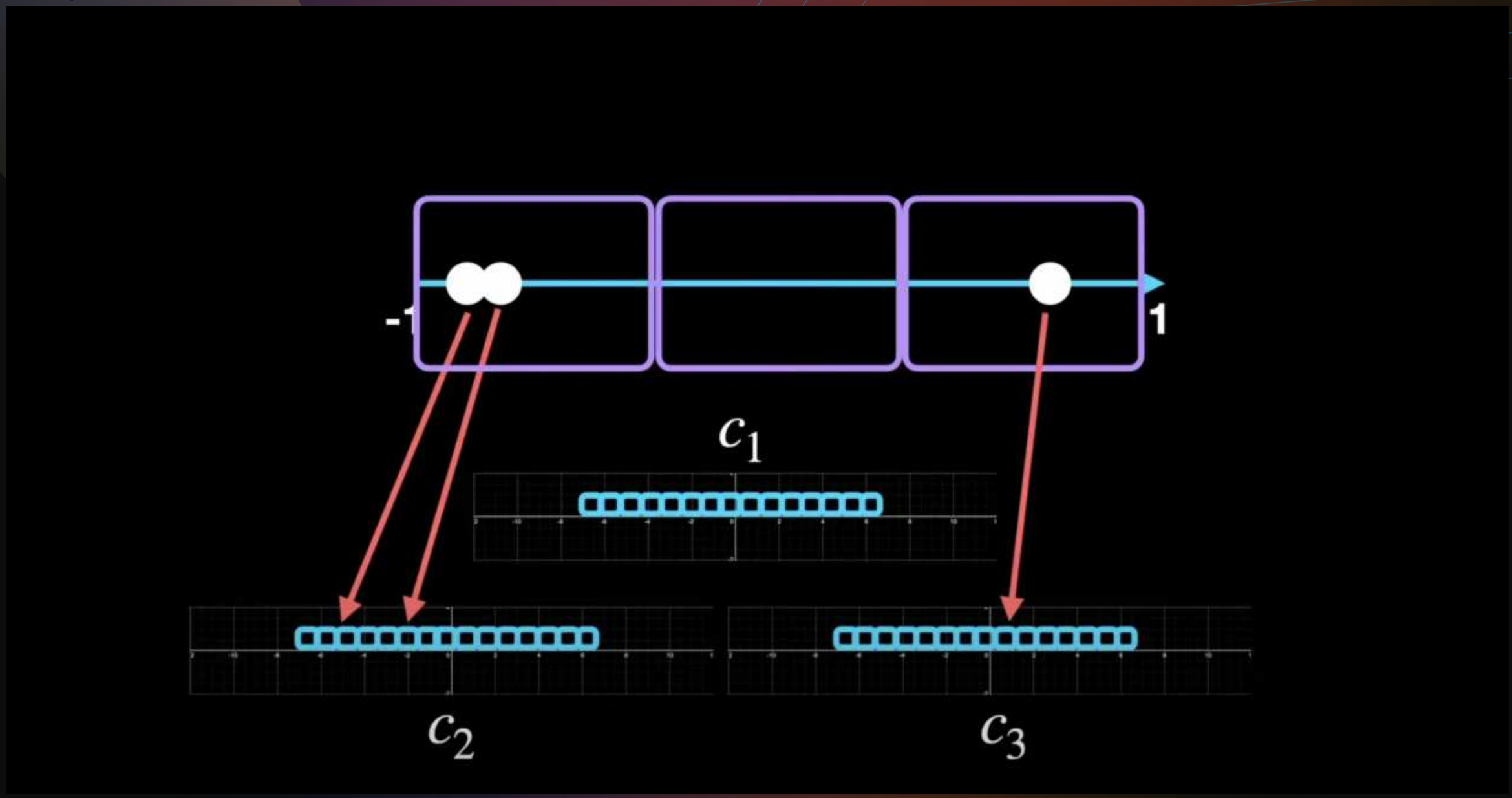
Q-LoRA: NF4



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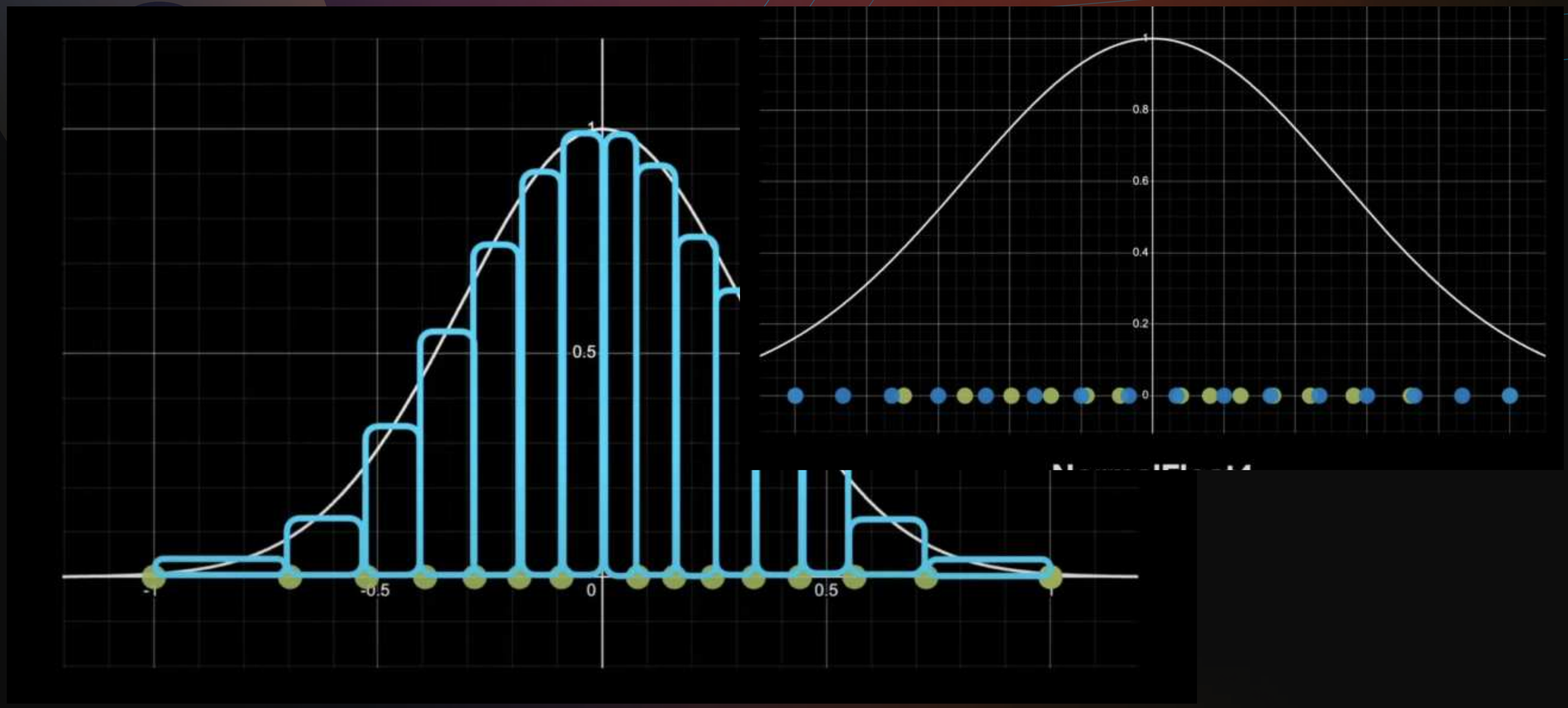
Q-LoRA: NF4



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QUANTIZATION

After Quantization

FLAN-T5

1.3 M

Parameters

→ →

BERT

1.3 M

Parameters

MoE

2.6 M

Parameters

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FINETUNING

FLAN-T5

66 M
Trainable

182 M
Non trainable

Update

4
Last layers of encoder and decoder

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Multitask Setup

INSTRUCTION & RATIO TASKS

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INSTRUCTION

Prefix + Input

INDEXING →

Generate a document identifier with 5 digits between 0 and 9 for the following document:

RETRIEVAL

Generate a document identifier with 5 digits between 0 and 9 as response to the following query:

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TASKS RATIO

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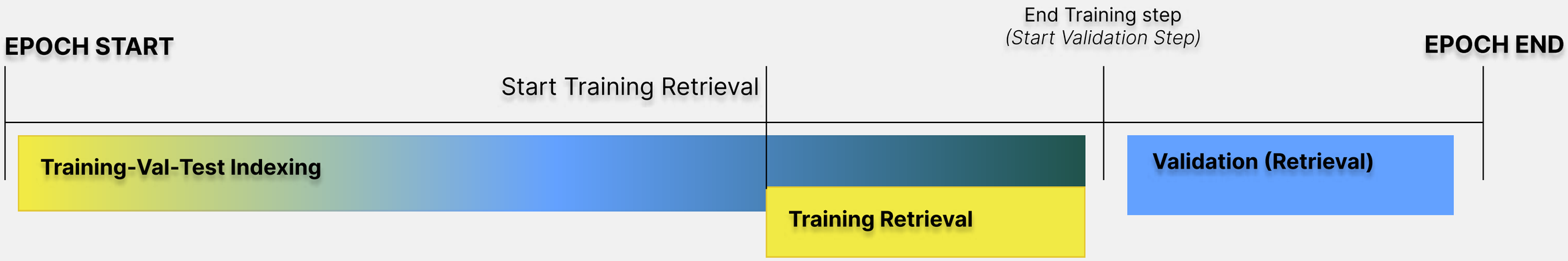
TASKS RATIO



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Dataset and Tests

Data organization & Experiments

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DATASET'S INFORMATION

MS MARCO

Microsoft

General Info

3.21 M
Documents

59
Chunks

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DATASET'S INFORMATION

We focused on

'00'

Chunk

200K

Documents

7773

Words mean per Doc

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EXPERIMENTS

Table 1: Flan-T5, BERT and Encoder MoE-Decoder tests

Model	Doc Strategy	Doc ID Strategy	Prompting	Training Type	N. Docs	Fine-Tuning
Flan-T5	Direct Indexing	Naively Structured	True	Generative	10k	False
Flan-T5	Direct Indexing	Naively Structured	True	Generative	50k	False
Flan-T5	Direct Indexing	Naively Structured	False	Generative	10k	False
Flan-T5	Direct Indexing	Naively Structured	True	Discriminative	10k	False
Flan-T5	Set Indexing	Naively Structured	True	Generative	10k	False
Flan-T5	Summarization	Naively Structured	True	Generative	10k	False
Flan-T5	Summarization	Naively Structured	True	Generative	10k	True
Flan-T5	Summarization	Naively Structured	True	Generative	200k	True
BERT	Direct Indexing	Naively Structured	True	Generative	10k	False
BERT	Summarization	Naively Structured	True	Generative	10k	False
EncMoE-Decoder	Direct Indexing	Naively Structured	True	Generative	10k	False
EncMoE-Decoder	Direct Indexing	Naively Structured	False	Generative	10k	False

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Conclusion

RESULTS, PROBLEMS & FUTURE WORKS

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RESULTS

DECODING WITH

Greedy or Beam Search

Leads to 0% in all metrics: MAP, Recall@1000 & Hits@K

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RESULTS

DISCRIMINATIVE APPROACH

LOSS

Cross-Entropy

TRAINING LOSS

0.001

Retrieval + Indexing

VALIDATION LOSS

>7.000

Retrieval

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RESULTS

DIS

LOS

Cro

TRA

0.0

Retri

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RESULTS

GENERATIVE APPROACH

LOSS

Cross-Entropy

VALIDATION LOSS

2.943

Retrieval

BEST MODEL

BERT

Lowest Loss for the Project

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RESULTS

GE

BE

VAL

2.9

Retrie

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RESULTS

Further relevant Metrics

15% - 20%

Percentage of valid DocIDs generated by the Models

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PROBLEMS

Mismatch

Content of Doc VS Query content

If the answer to the Query is not in the indexed content, this should negatively influence the ability of retrieval.

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PROBLEMS

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Lorem ipsum dolor sit amet, consectetur adipiscing elit. In dictum, lectus et imperdiet viverra, justo justo congue nulla, ut aliquet velit justo sit amet lectus. Cras porta ex metus, at rutrum turpis varius quis. Sed eleifend tincidunt venenatis. Vestibulum ullamcorper laoreet lorem ut fringilla. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Phasellus velit ex, pharetra a dolor eget, ultrices imperdiet arcu. Mauris eu aliquet felis. Duis pulvinar pellentesque eros vulputate pretium. Aliquam faucibus turpis erat, et pretium dolor malesuada quis. Mauris dictum venenatis nisl, non ultricies nunc blandit sit amet. Aliquam maximus dignissim ipsum non euismod. Praesent efficitur est sit amet lacus volutpat, feugiat ullamcorper dolor accumsan.

Nullam interdum turpis

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PROBLEMS

GENERALIZATION

Poor ability to generalize

Learning **Indexing** seems “effective”, but **Retrieval** depends on generalization capabilities.

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PROBLEMS

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Learning **Indexing** seems “effective”, but **Retrieval** depends on generalization capabilities.

1. Setacciare la farina e versarla in una ciotola insieme a zucchero, un pizzico di sale, lievito e scorza grattugiata di limone.
2. Unire ora gli ingredienti umidi, ovvero un uovo, un tuorlo ed il burro fuso nel microonde oppure a bagnomaria. Mescolare per bene, prima con il cucchiaio poi a mano, aggiungendo eventualmente un paio di cucchiai di acqua per rendere più facile la lavorazione.
3. Accendere il forno a 180°C.
4. Foderate 2 teglie da forno con la carta oleata.
5. Spolverizzare la spianatoia con un po' di farina e stendere la pasta con l'aiuto di ...

How many grams of sugar are needed?

What’s the amount of sugar I have to buy for this recipe?

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PROBLEMS

Quantization

Limits the precision

By lowering the precision during computations, the performances are affected negatively.

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FUTURE WORKS

Improvements & Enhancements

Mixtral-8×7B

What is the effect of a MoE-Decoder?

MISTRAL AI_

LoRA-The-Explorer

Optimized Quantization strategy w.r.t standard LoRA[1]

Microsoft's AICI

Constraints the Decoder to output DocIDs[2]

[1]: https://arxiv.org/pdf/2402.16828.pdf
[2]: https://github.com/microsoft/aici

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THANK YOU!

QUESTIONS?

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