Transformers
An Intuitive Understanding

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Attention is All You Need

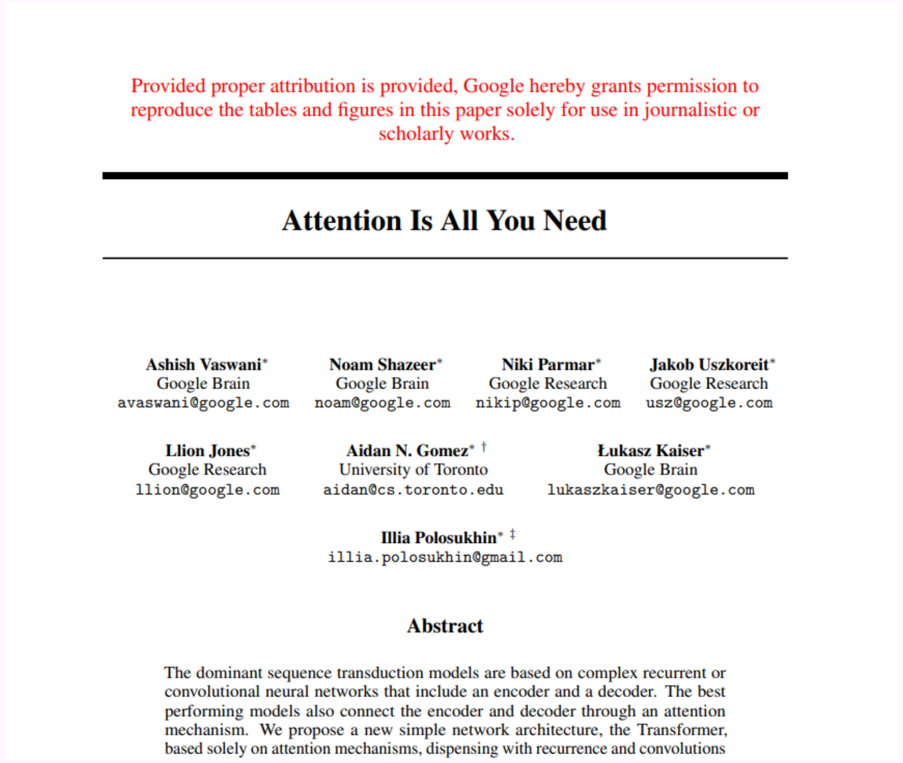
The Transformer model is based on the 2017 Google paper titled "Attention is all you need"

Transformer

The paper introduced a new **deep learning architecture** known as the **transformer**

So, Relax

It is just a complex software program. You don't need to understand every detail of its inner workings. To begin, get an intuitive, high-level understanding.



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Attention Is All You Need

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Abstract

The dominant sequence transduction models are based on complex recurrent or convolutional neural networks that include an encoder and a decoder. The best performing models also connect the encoder and decoder through an attention mechanism. We propose a new simple network architecture, the Transformer, based solely on attention mechanisms, dispensing with recurrence and convolutions

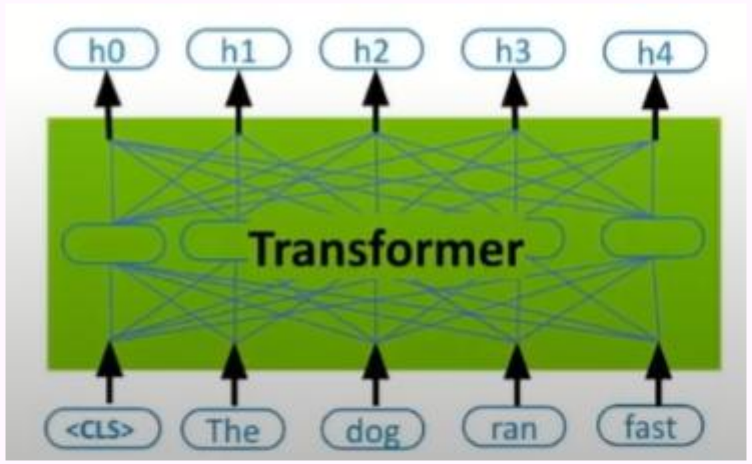
https://arxiv.org/pdf/1706.03762

Architecture

Transformer

With transformer architecture, now you can enter the entire sentence at once.

- The transformer takes the entire sentence as input
- It will understand it using the **encoder block**, and then generate the output using the **decoder**, capturing the full context of the sentence in a parallel and efficient way.



https://www.youtube.com/watch?v=PXc_SlnT2g0

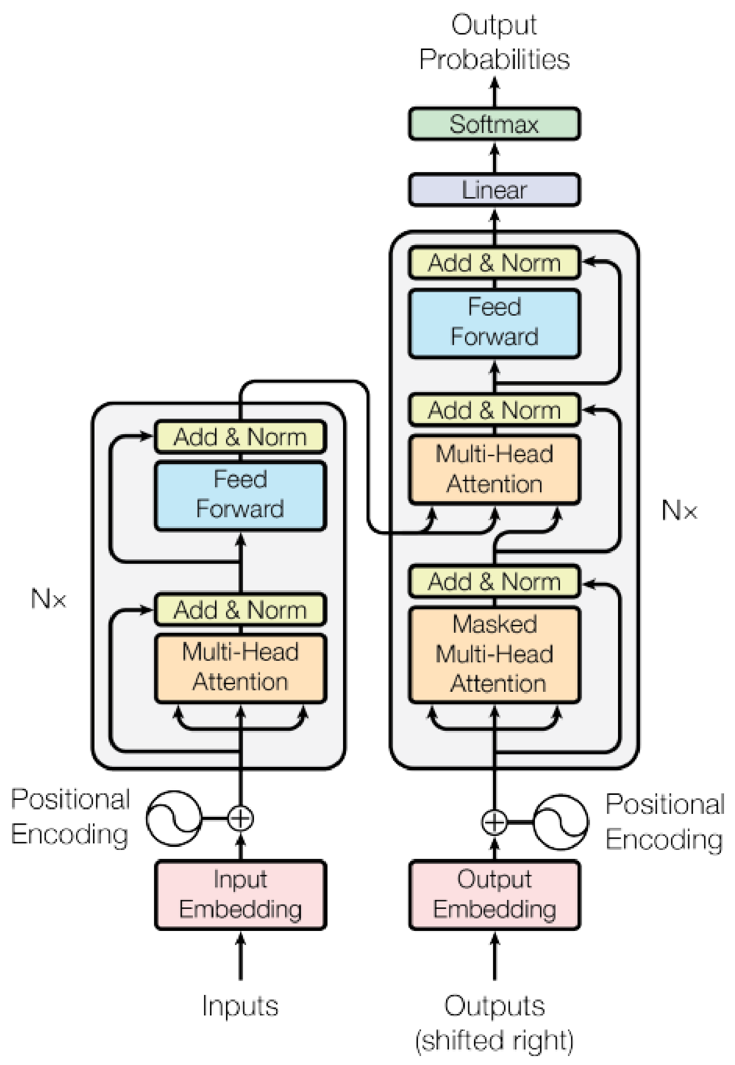


Figure 1: The Transformer - model architecture.

3.1 Encoder and Decoder Stacks

https://arxiv.org/pdf/1706.03762

Transformer

Intuitive Understandings

- Let us first learn how it works when you use (**inference**) it
- Then we will learn how it is **trained**
- Along the way we will learn important concepts

The model has two main parts:
Encoder:
Understands the input and creates feature representations.
Decoder:
Uses those features to generate the output sequence.

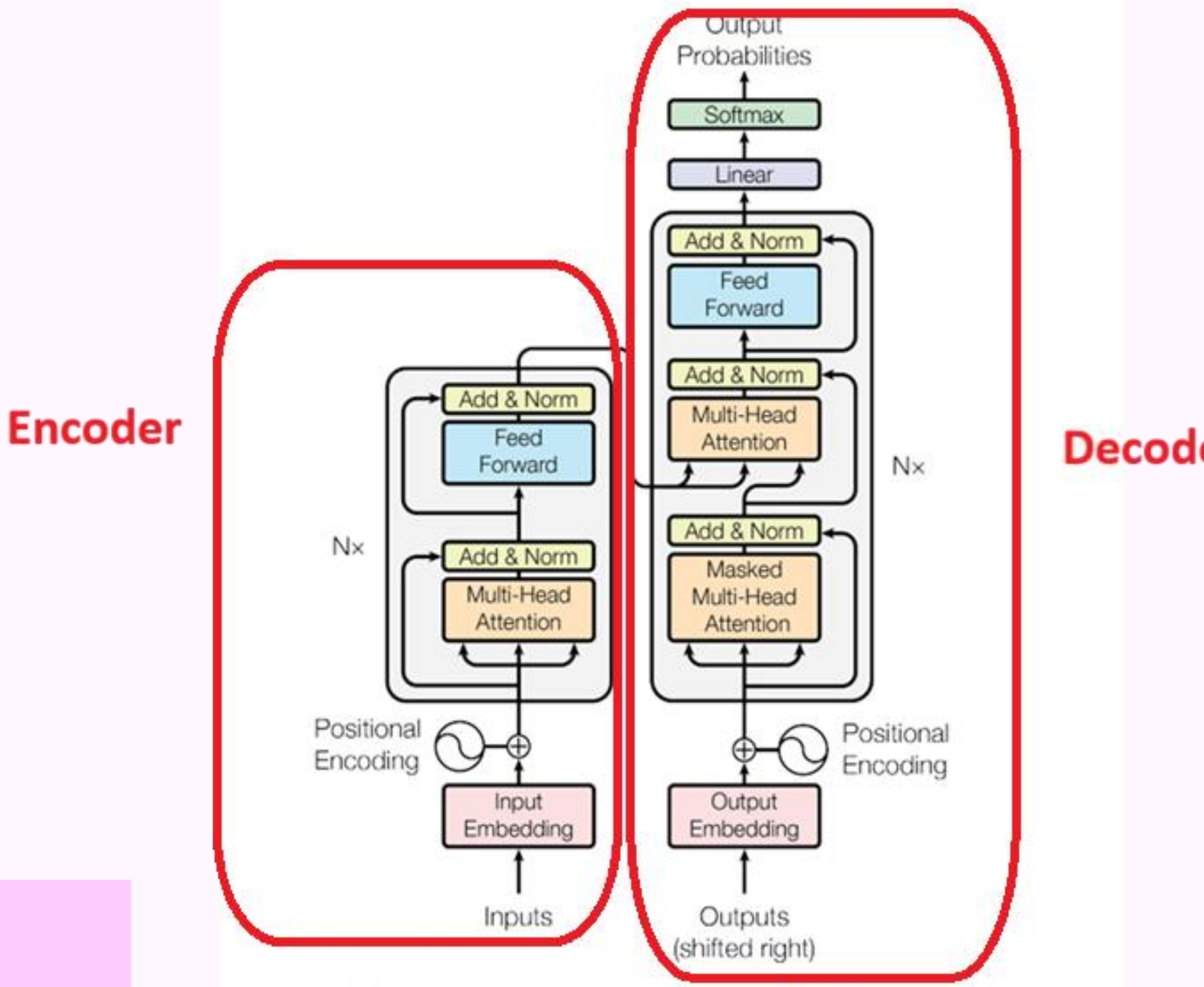


Figure 1: The Transformer - model architecture.

Transformer -Encoder

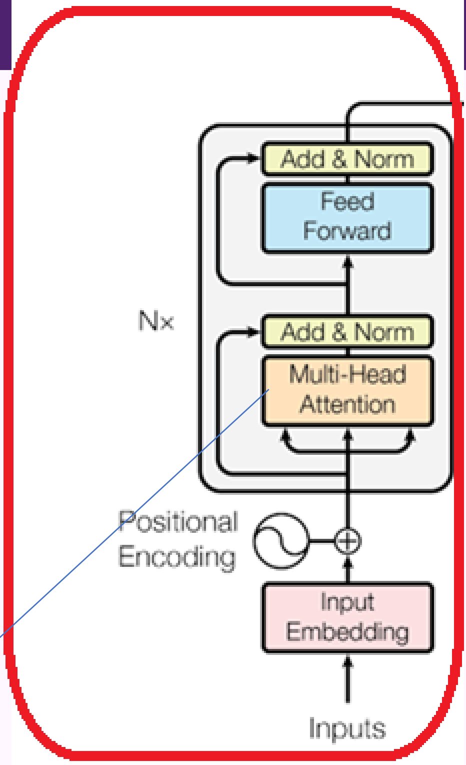
*What is the **Encoder**? What does it do?*

The encoder takes the entire input sentence and builds a rich understanding of it. The understanding is stored in a **matrix** format

*How does it work? Say I enter "**When was Rome Built**?"*

- The input sentence is broken into tokens → ["When", "was", "Rome", "built", "?"]
- Each token is converted into a vector using a word embedding
- A **positional embedding** is added to each token to tell the model the order (e.g., "Rome" came after "was")
- The combined vectors go into a stack of **Nx encoder blocks** (Nx = repeated N times, like 6 or 12 layers)
- In each block, the model uses **multi-head attention** and **feed-forward networks** to build a deep understanding of each word in context
- The final output of the **encoder layer** is a set of **context-rich embeddings** (vectors) — one for each input token — capturing the meaning of each word in relation to the whole sentence.

Encoder



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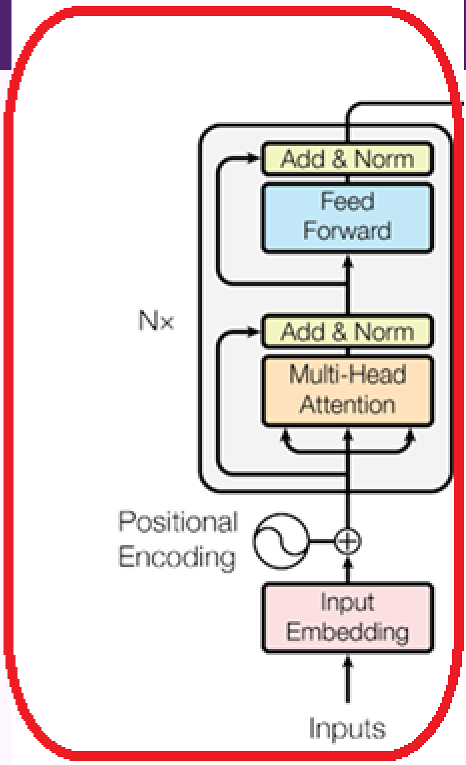

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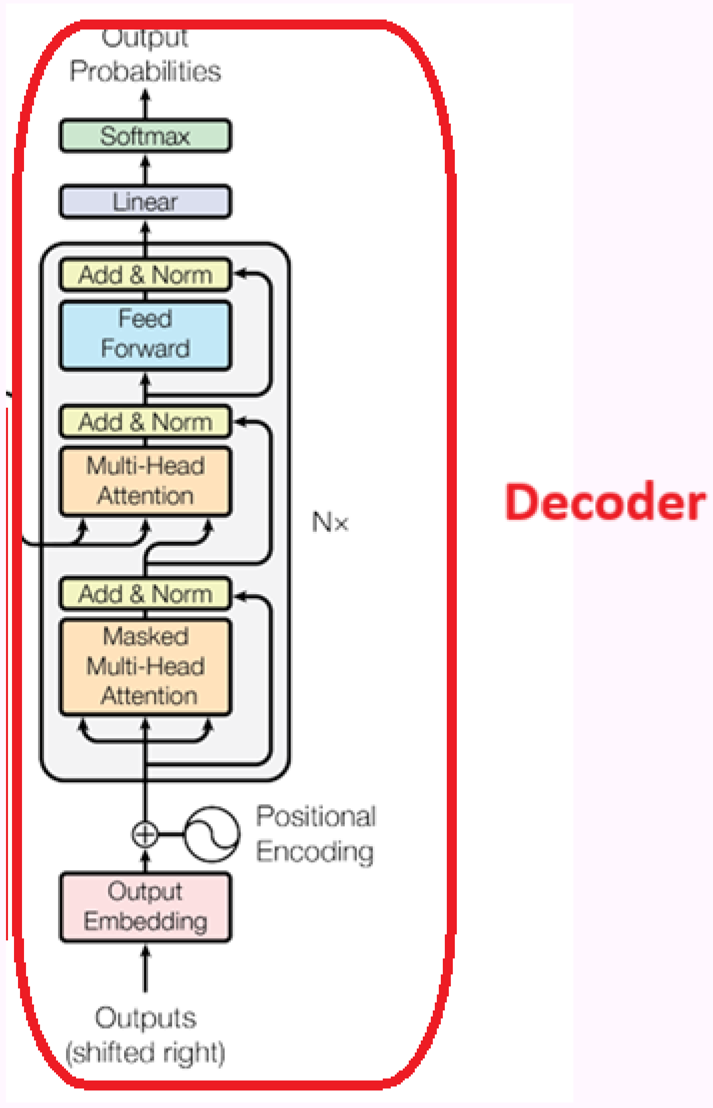
Transformer -Decoder

*What is the **Decoder**? What does it do?*

A **decoder** is the part of the Transformer that **generates the output** (like a translated sentence or answer), one token at a time.



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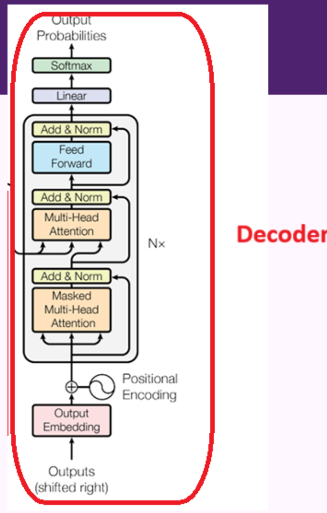
Transformer -Decoder



*How does the decoder work? Say I enter "**When was Rome Built**?"*

- The **encoder** processes the input and outputs context-rich embeddings (one per input token).
- The **decoder** starts with a special start token <START> as input.
- It uses masked **multi-head attention** to focus only on tokens already generated, not future ones.
- Then it performs **cross-attention** to read relevant info from the **encoder output** (e.g., focus on "Rome" and "built").
- Passes through layers that help it understand what to say next based on **input from encoder** and previous output.
- It predicts the next word (like "Rome"), adds it to the sentence, and uses that as input to guess the next one.
- Then it predicts the next word (like "was") based on what it's generated so far — and continues this process until the answer is complete.

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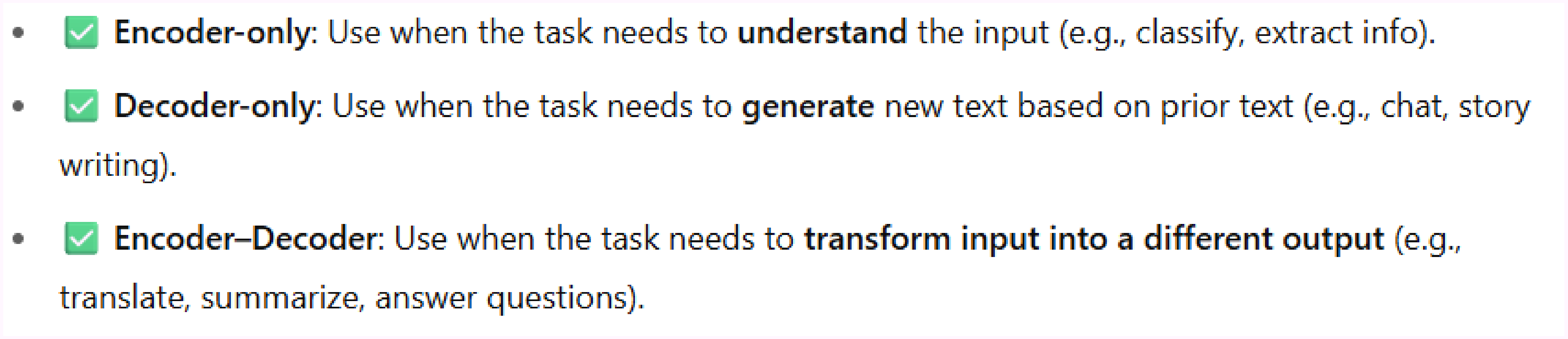
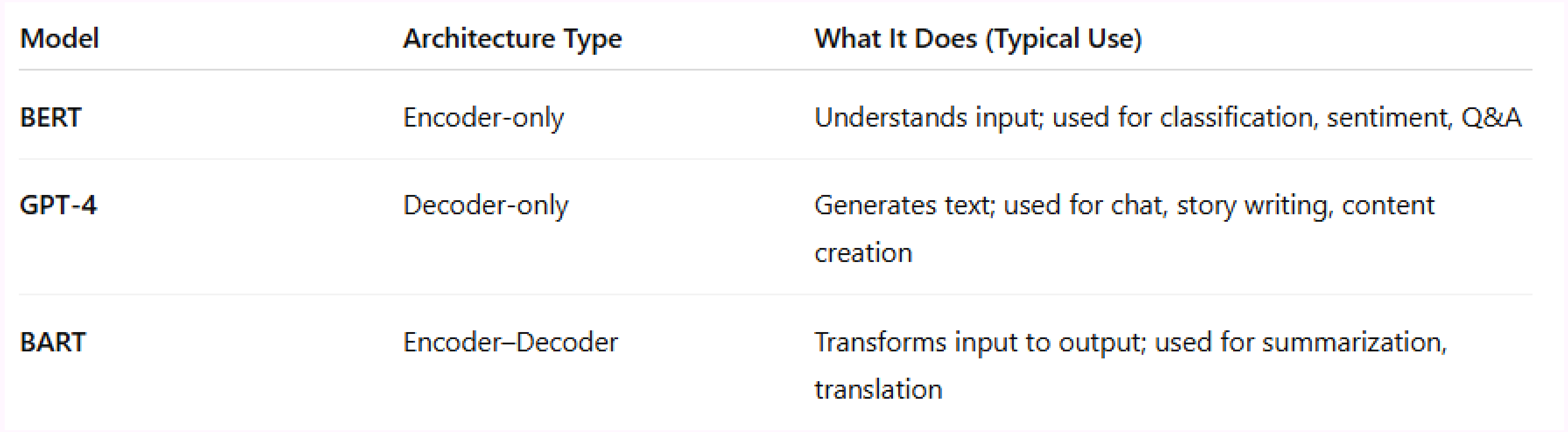
Encoder or Decoder models

Generally speaking below apply but this is not fixed.

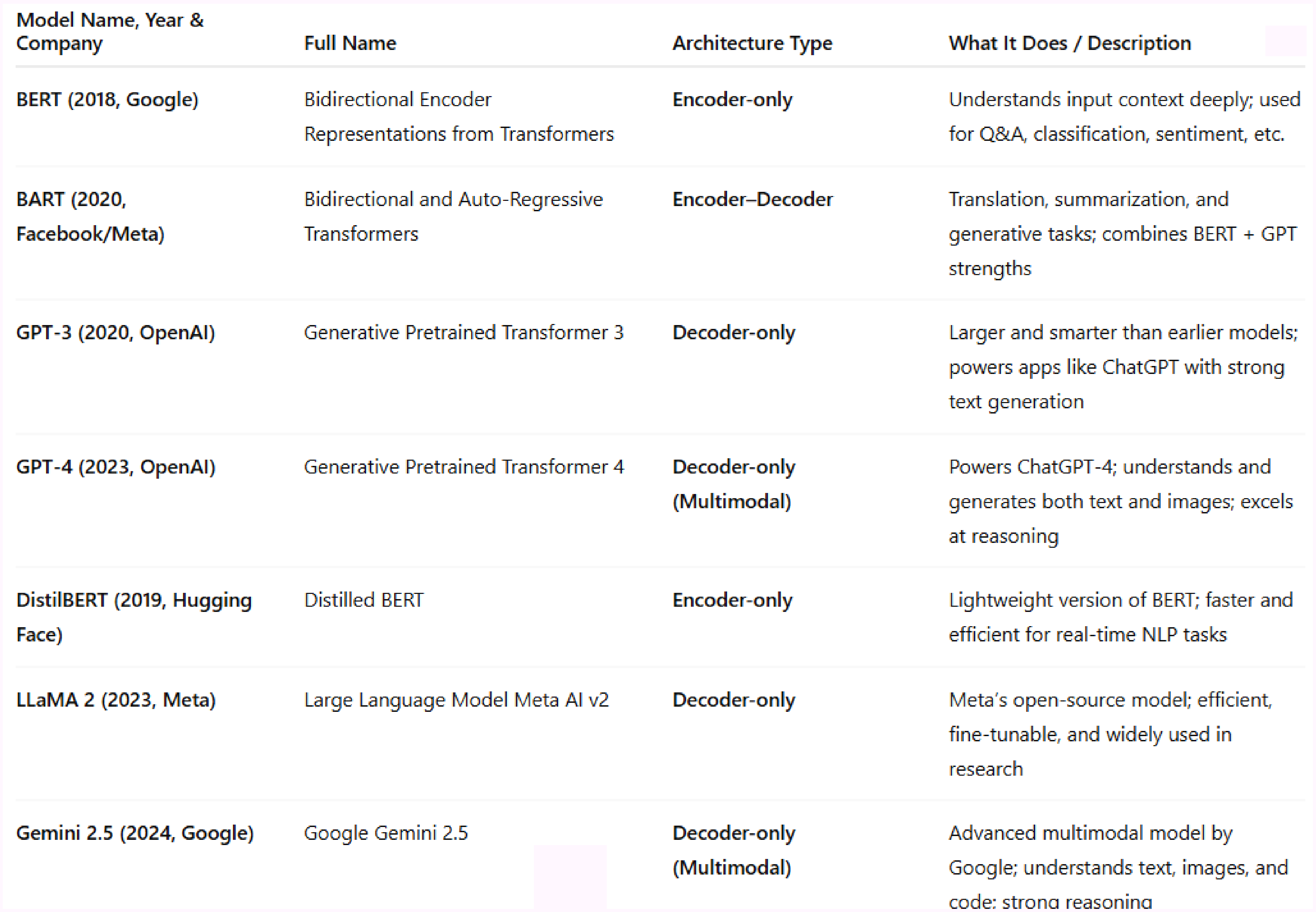


- ✅ **Encoder-only**: Use when the task needs to **understand** the input (e.g., classify, extract info).
- ✅ **Decoder-only**: Use when the task needs to **generate** new text based on prior text (e.g., chat, story writing).
- ✅ **Encoder–Decoder**: Use when the task needs to **transform input into a different output** (e.g., translate, summarize, answer questions).



Model	Architecture Type	What It Does (Typical Use)
BERT	Encoder-only	Understands input; used for classification, sentiment, Q&A
GPT-4	Decoder-only	Generates text; used for chat, story writing, content creation
BART	Encoder–Decoder	Transforms input to output; used for summarization, translation

Examples



Model Name, Year & Company	Full Name	Architecture Type	What It Does / Description
BERT (2018, Google)	Bidirectional Encoder Representations from Transformers	**Encoder-only**	Understands input context deeply; used for Q&A, classification, sentiment, etc.
BART (2020, Facebook/Meta)	Bidirectional and Auto-Regressive Transformers	**Encoder–Decoder**	Translation, summarization, and generative tasks; combines BERT + GPT strengths
GPT-3 (2020, OpenAI)	Generative Pretrained Transformer 3	**Decoder-only**	Larger and smarter than earlier models; powers apps like ChatGPT with strong text generation
GPT-4 (2023, OpenAI)	Generative Pretrained Transformer 4	**Decoder-only (Multimodal)**	Powers ChatGPT-4; understands and generates both text and images; excels at reasoning
DistilBERT (2019, Hugging Face)	Distilled BERT	**Encoder-only**	Lightweight version of BERT; faster and efficient for real-time NLP tasks
LLaMA 2 (2023, Meta)	Large Language Model Meta AI v2	**Decoder-only**	Meta's open-source model; efficient, fine-tunable, and widely used in research
Gemini 2.5 (2024, Google)	Google Gemini 2.5	**Decoder-only (Multimodal)**	Advanced multimodal model by Google; understands text, images, and code; strong reasoning

Appendix

https://community.openai.com/t/is-gpt-group-of-models-decoder-only-model/286586/2