Transformer vs. Mixture of Experts

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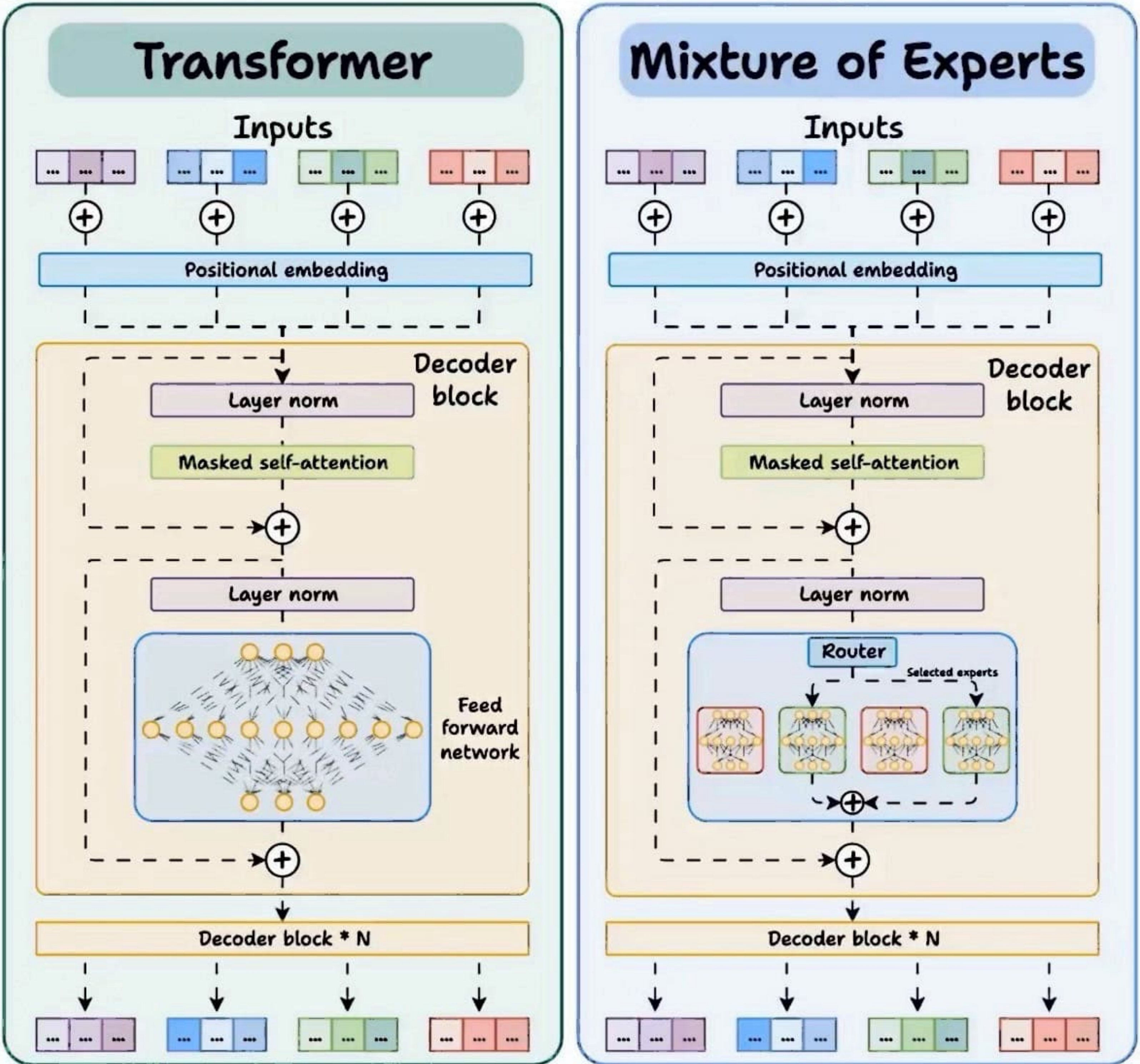

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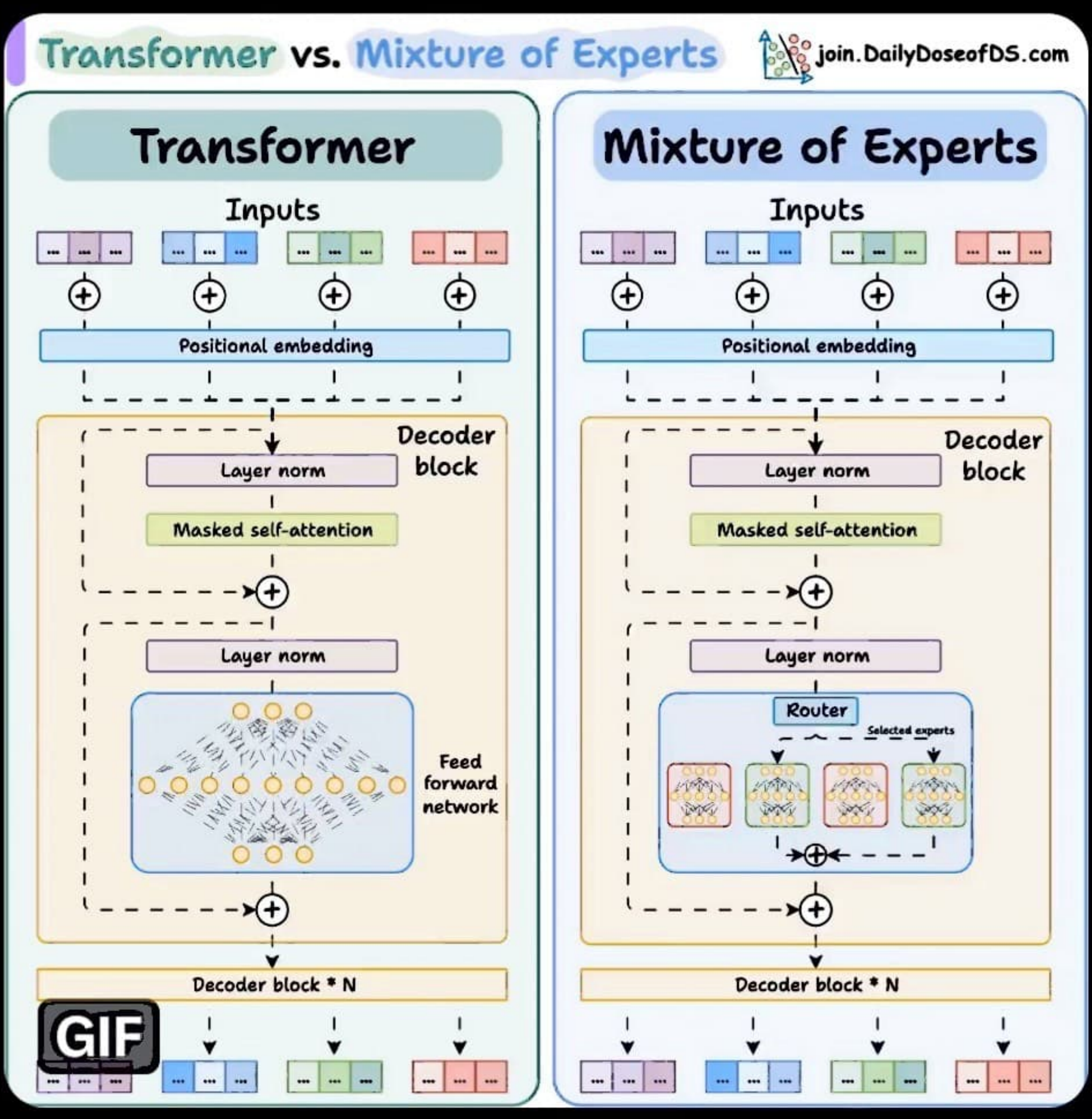
Mixture of Experts (MoE) is a popular architecture that uses different "experts" to improve Transformer models.

The visual below explains how they differ from Transformers.

Let's dive in to learn more about MoE!



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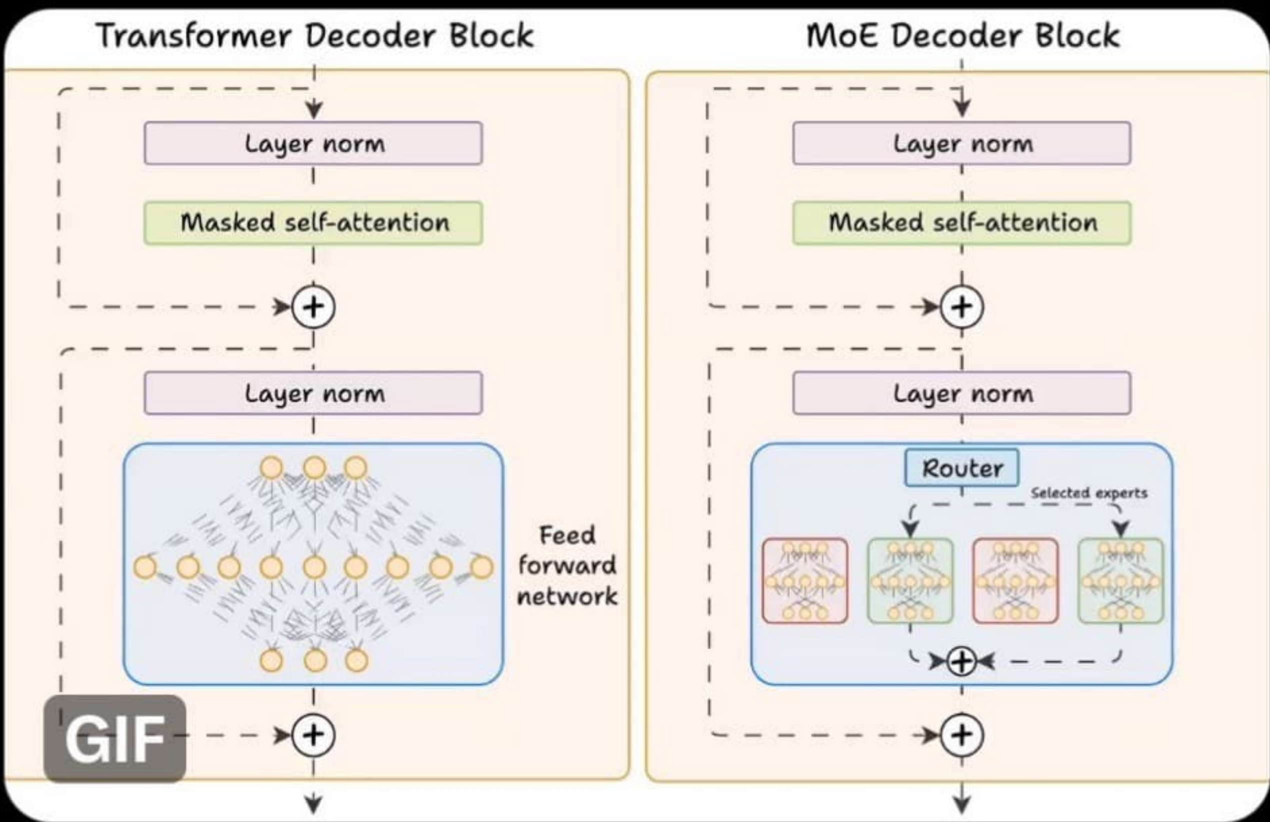
Transformer and MoE differ in the decoder block:

- Transformer uses a feed-forward network.
- MoE uses experts, which are feed-forward networks but smaller compared to that in Transformer.

During inference, a subset of experts are selected. This makes inference faster in MoE.



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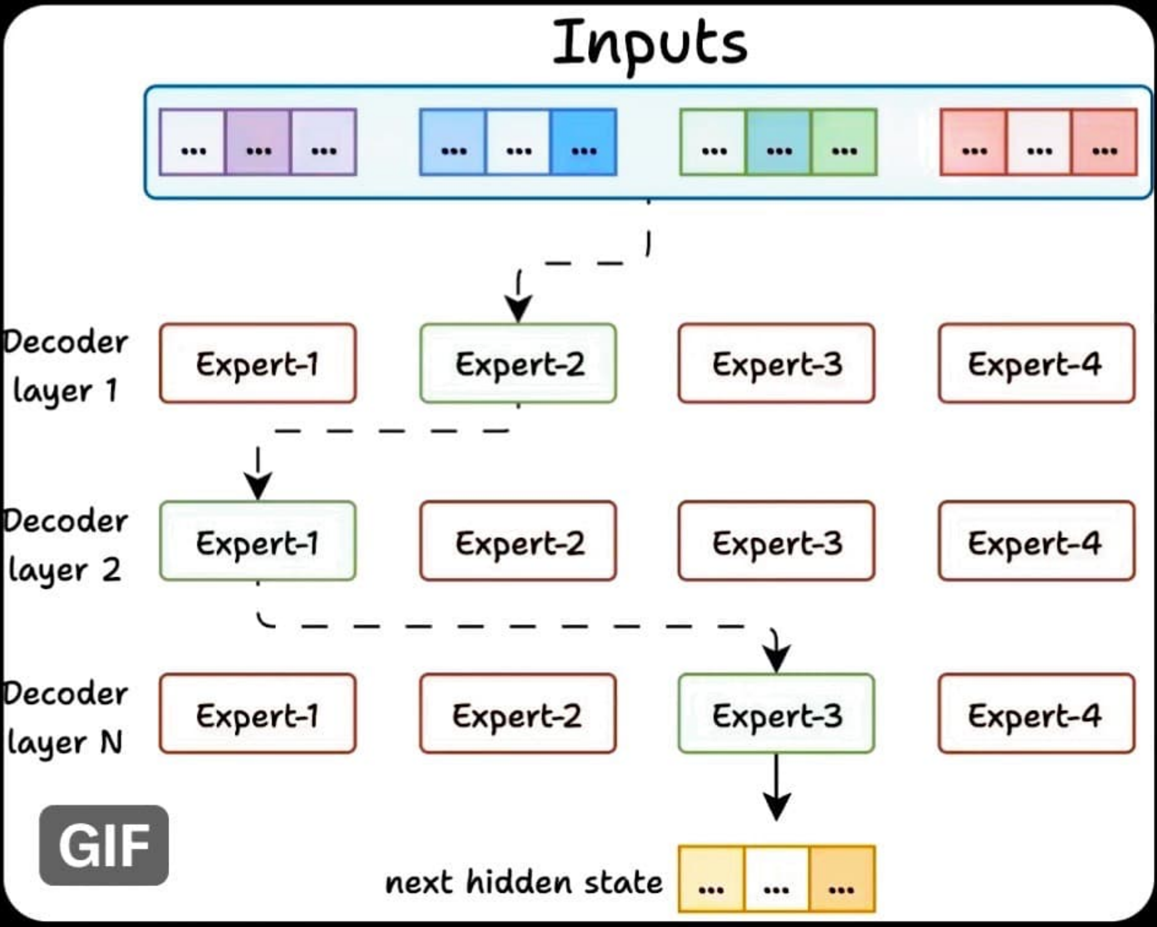
Since the network has multiple decoder layers:
- the text passes through different experts across layers.
- the chosen experts also differ between tokens.

But how does the model decide which experts should be ideal?

The router does that. Let's discuss it next.



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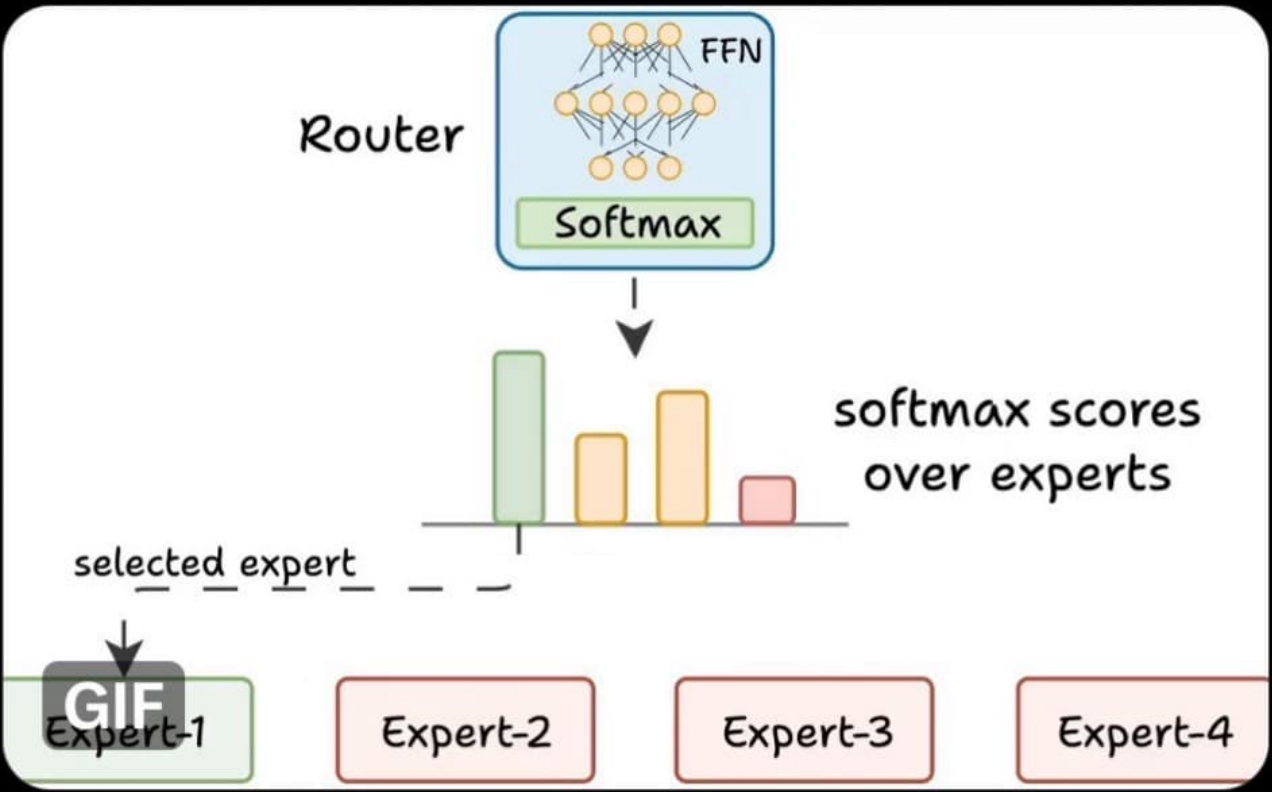
The router is like a multi-class classifier that produces softmax scores over experts. Based on the scores, we select the top K experts.

The router is trained with the network and it learns to select the best experts.

But it isn't straightforward. Let's discuss the challenges!



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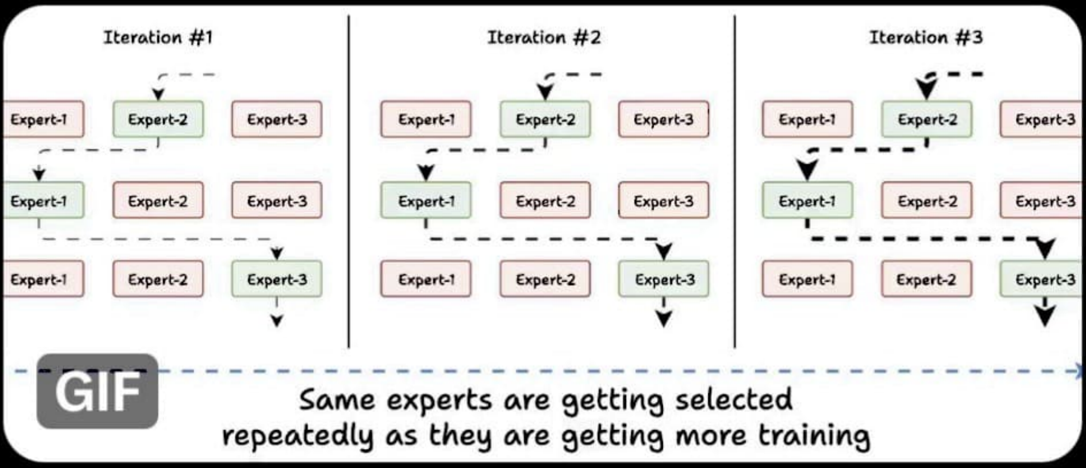
Challenge 1) Notice this pattern at the start of training:

- The model selects "Expert 2"
- The expert gets a bit better
- It may get selected again
- The expert learns more
- It gets selected again
- It learns more
- And so on!

Many experts go under-trained!



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We solve this in two steps:

- Add noise to the feed-forward output of the router so that other experts can get higher logits.

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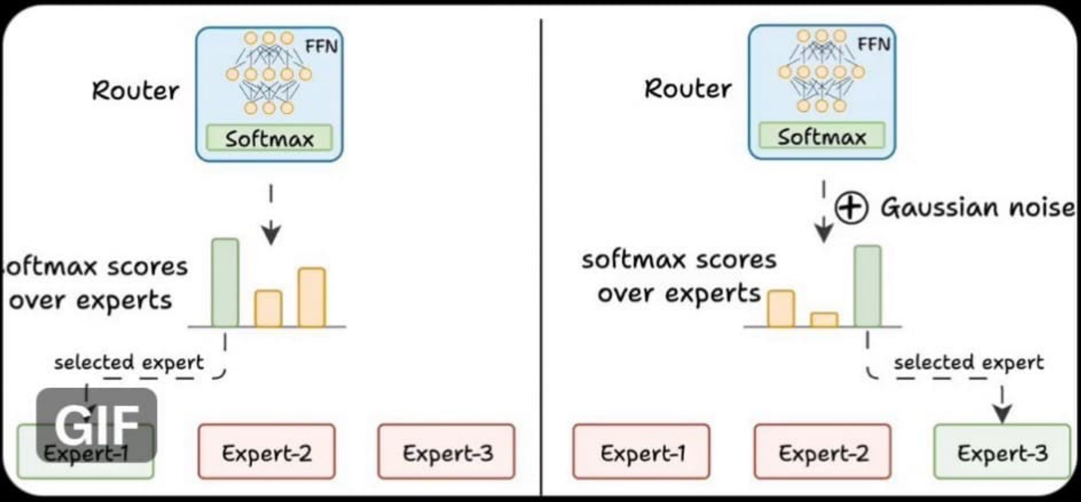
- Add noise to the feed-forward output of the router so that other experts can get higher logits.
- Set all but top K logits to -infinity. After softmax, these scores become zero.

This way, other experts also get the opportunity to train.



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Challenge 2) Some experts may get exposed to more tokens than others —leading to under-trained experts.

We prevent this by limiting the number of tokens an expert can

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We prevent this by limiting the number of tokens an expert can process.

If an expert reaches the limit, the input token is passed to the next best expert instead.

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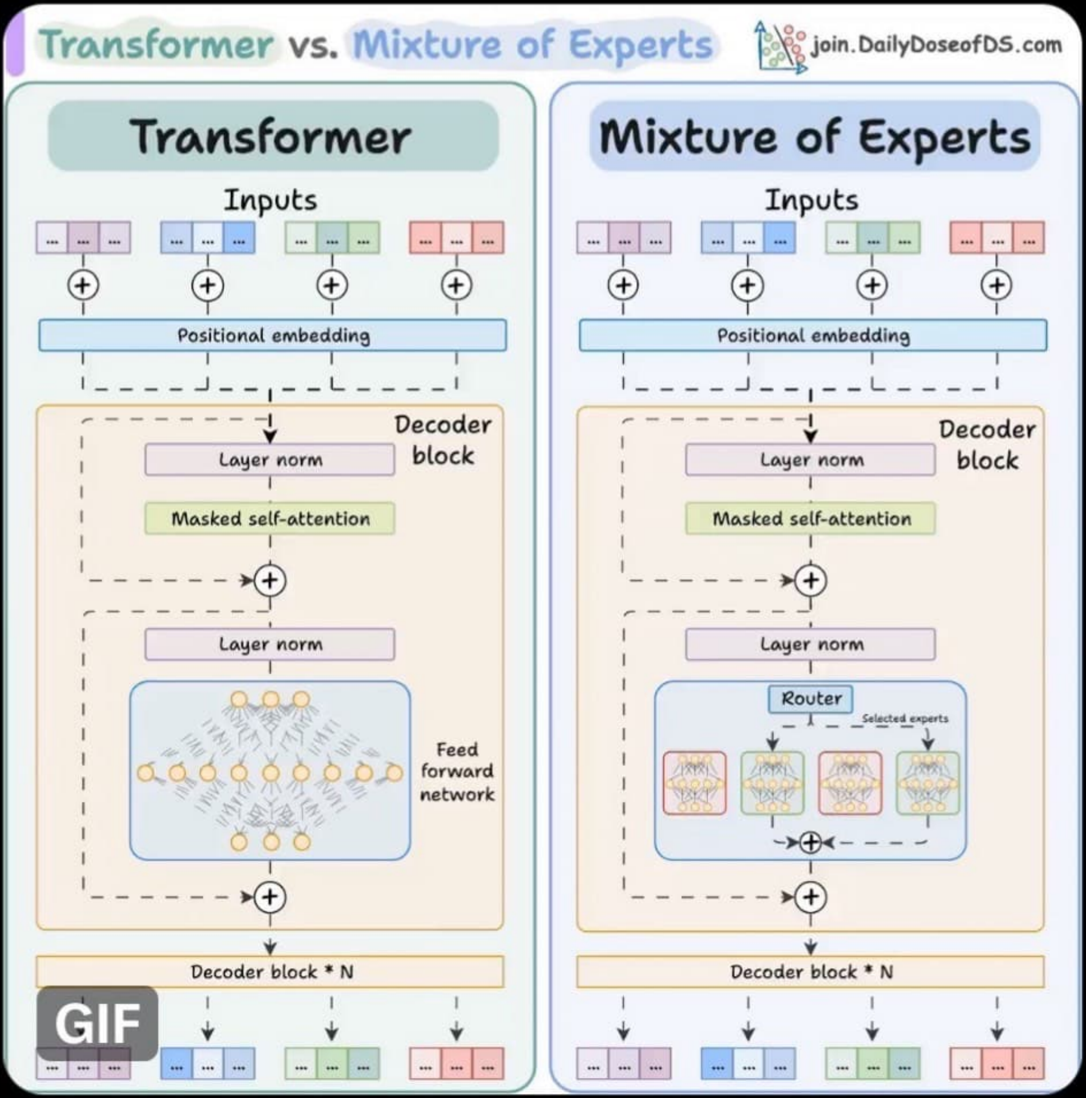
MoEs have more parameters to load. However, a fraction of them are activated since we only select some experts.

This leads to faster inference. Mixtral 8x7B by @MistralAI is one famous LLM that is based on MoE.

Here's the visual again that compares Transformers and MoE!



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