Anchored Diffusion Language Model

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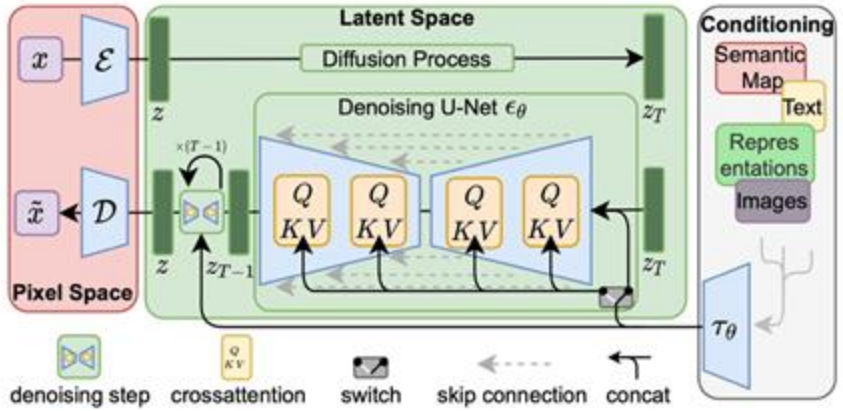
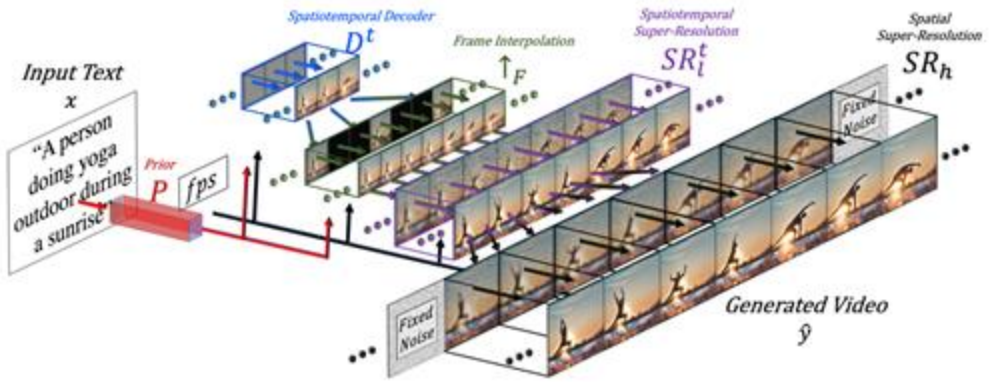
Generative Modeling with Diffusion

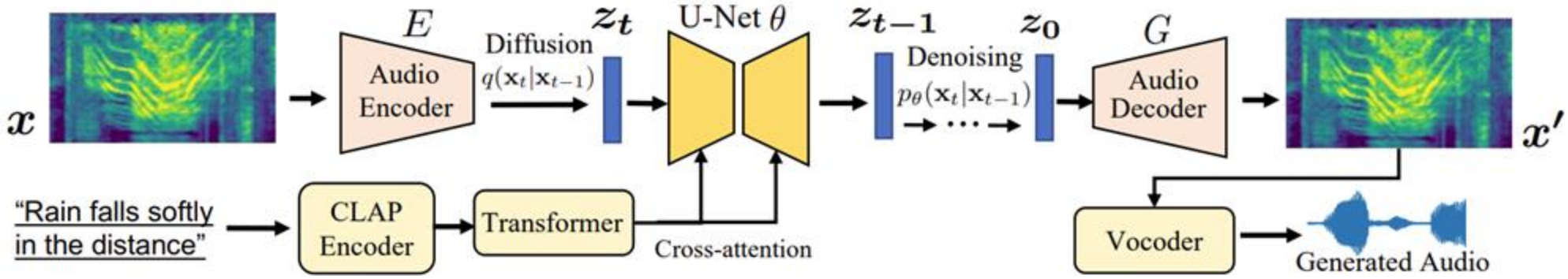
Diffusion Model for Images



Diffusion Model for Video



Diffusion Model for Audio



[1] Image: https://arxiv.org/pdf/2112.10752 [2] Audio: https://text-to-audio.github.io/ [3] Video: https://arxiv.org/pdf/2209.14792

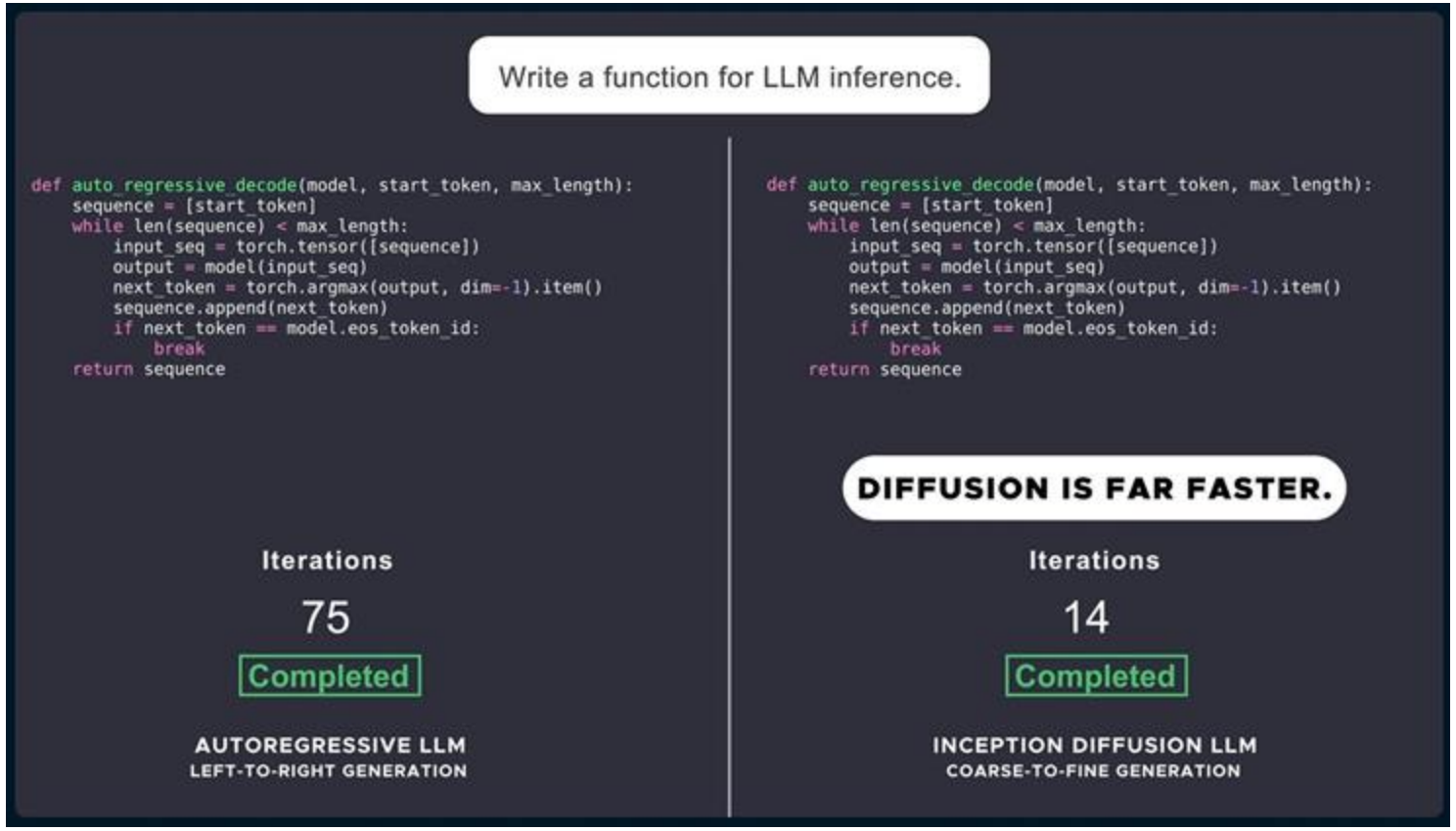
Large-Scale Diffusion Language Models

Gemini Diffusion

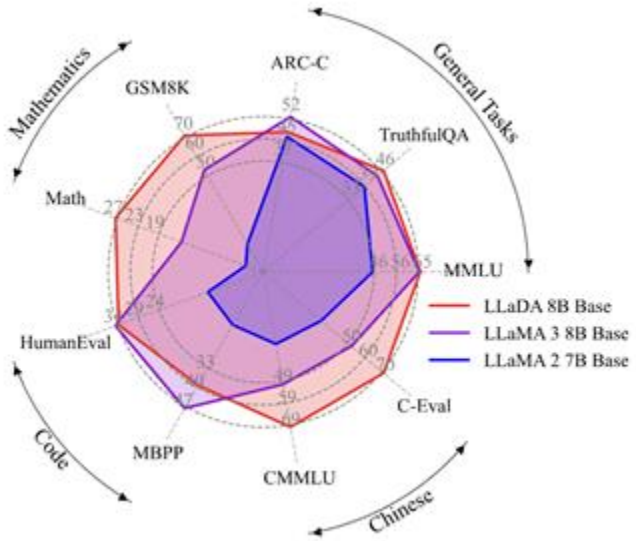
Mercury

Can be more accurate

Significantly faster

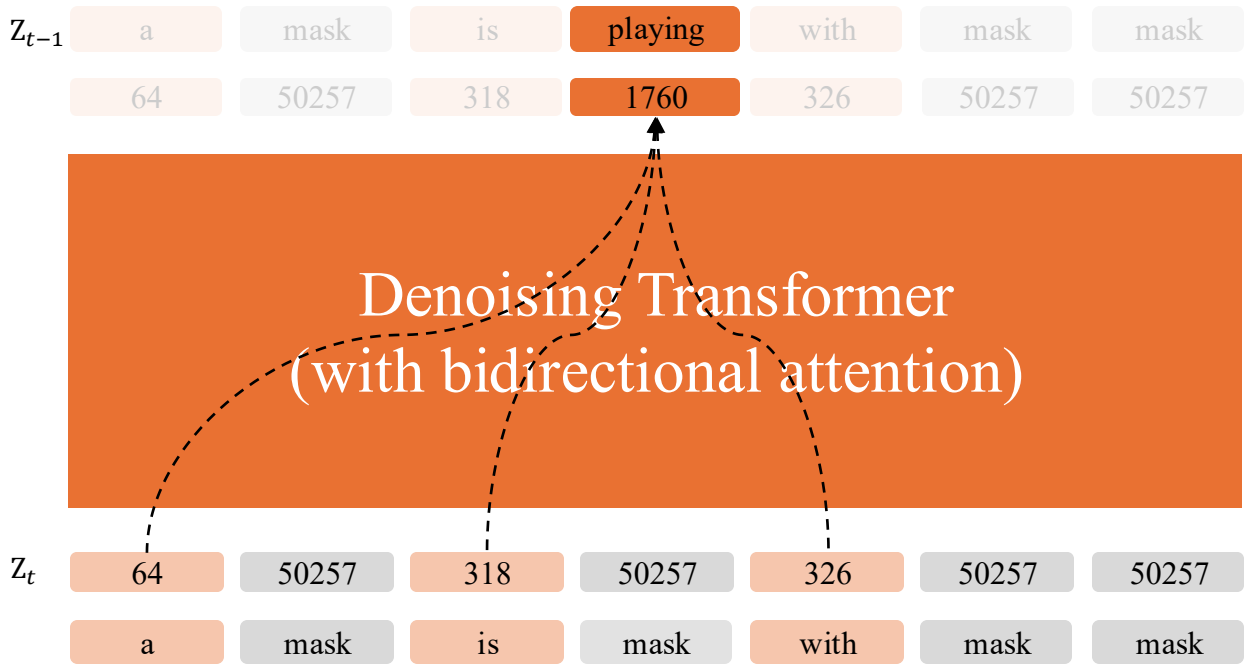


LLaDA



Gemini Diffusion: https://deepmind.google/models/gemini-diffusion/
LLaDA: https://arxiv.org/abs/2502.09992
Mercury: https://www.inceptionlabs.ai/

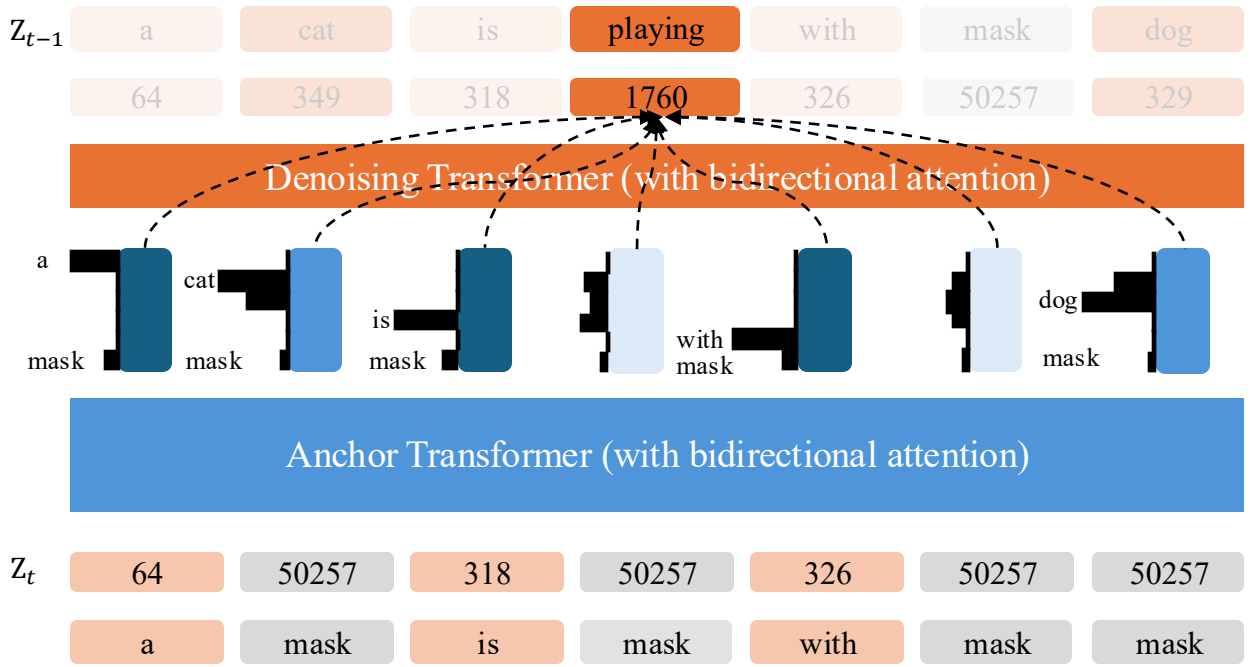
Standard Approach: Masked Diffusion Language Model



- **Denoising Transformer**: Unmasks using already unmasked tokens
- **Our approach:** Improve context using semantically important tokens

D3PM: https://arxiv.org/abs/2107.03006 MDLM: https://s-sahoo.com/mdlm/ MD4: https://arxiv.org/abs/2406.04329

Our Approach: Anchored Diffusion Language Model



- **Anchor Transformer**: Outputs a sequence of anchor predictions
  - Mixture of important tokens interpreted as soft samples
- **Denoising Transformer**: Unmasks tokens using anchored predictions

Our Key Idea: Anchoring

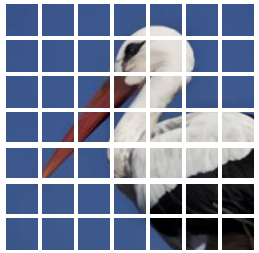
Anchors: Tokens whose inclusion as conditioning variables yields a substantial reduction in the conditional entropy of the remaining tokens

Examples:

1. To decode the sentence: "a **cat** is playing with a **dog**"
   - Tokens '**cat**' and '**dog**' are more useful than 'a' or 'is'

2. To solve the math question: "Janet's ducks lay **16** eggs per day. She eats **three** for breakfast every morning and bakes muffins for her friends every day with **four**. She sells the remainder at the farmers' market daily for $**2** per fresh duck egg. How much in dollars does she make every day at the farmers' market?"
   - Numbers **'16', 'three', 'four',** and **'2'** are more useful than 'breakfast' or 'muffins'

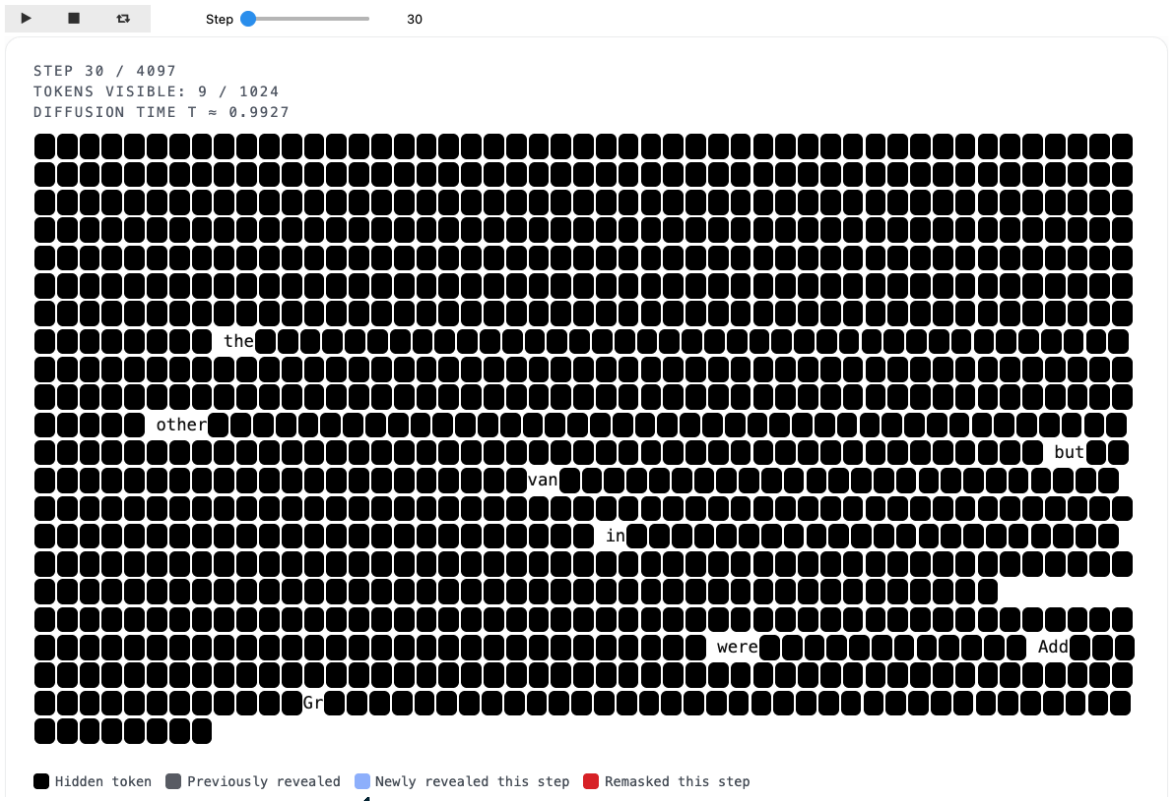
3. To reconstruct the image:



- Tokens in the beak or body (foreground) are more useful than tokens from blue background

Credit: Math question from the GSM8K dataset

Masked DLM vs Anchored DLM – Inference Illustration

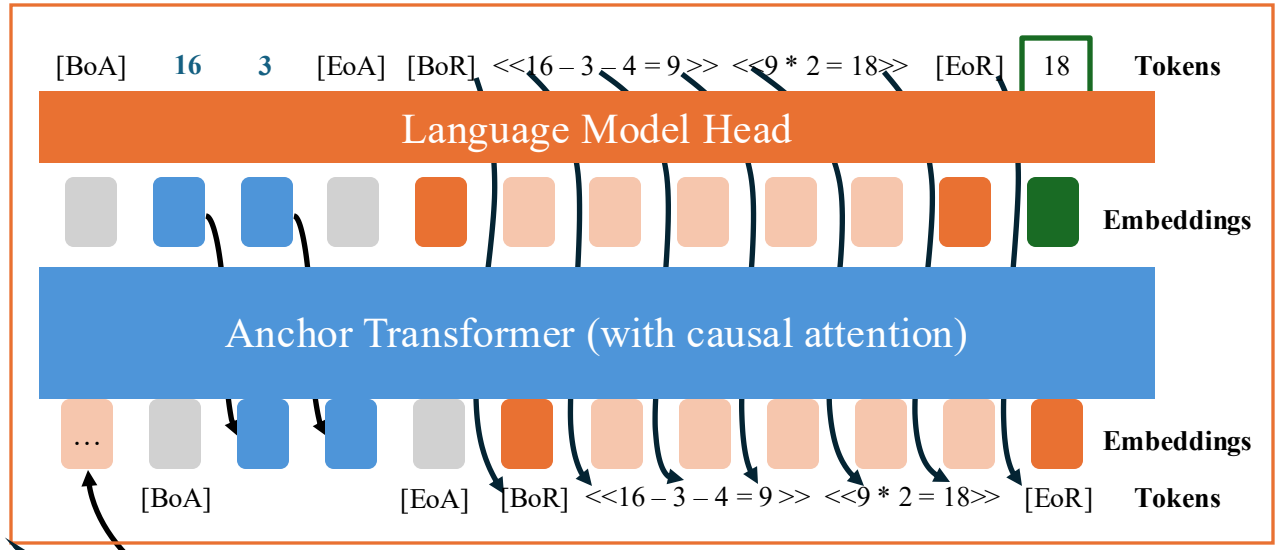


MDLM at time-step 30 / 4097

ADLM at time-step 30 / 4097

- Anchoring has 2 main advantages:
  - unmasks key words first
  - unmasks many tokens in parallel

Anchored Autoregressive Model: Training and Inference

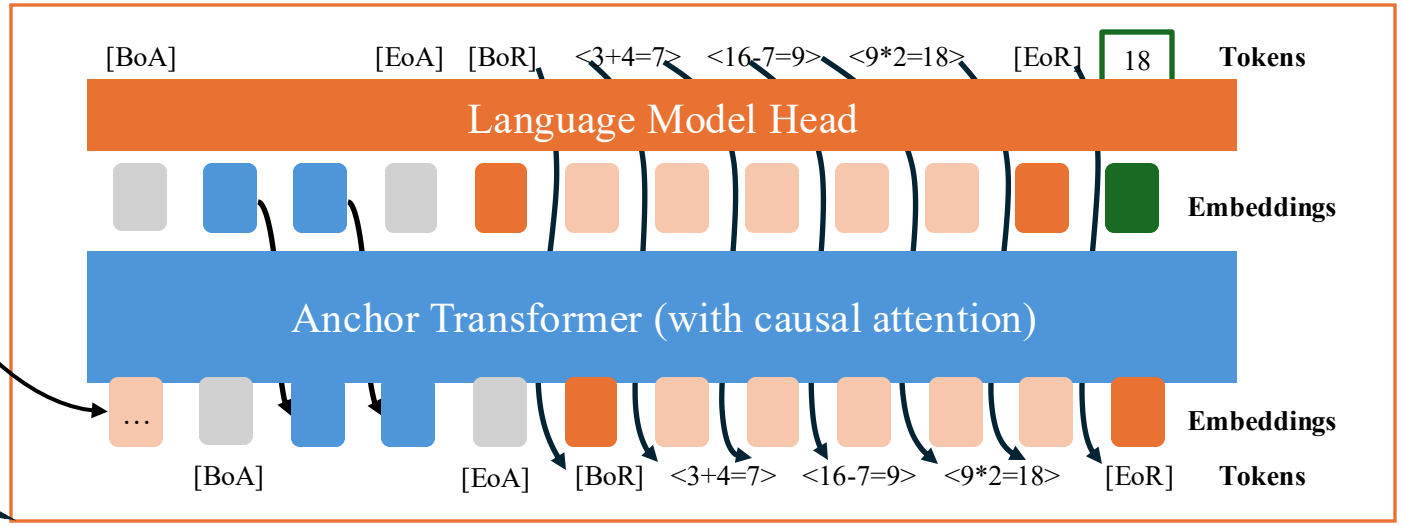


Anchoring enables "look-ahead" planning, unlike the standard left-to-right decoding of chain-of-thought (CoT) reasoning

Janet's ducks lay **16** eggs per day. She eats **three** for breakfast every morning and bakes muffins for her friends everyday with **four**. She sells the remainder at the farmers' market daily for $**2** per fresh duck egg. How much in dollars does she make every day at the farmers' market?

During Supervised Fine Tuning of LLM

During LLM Inference



📄 **Paper:**
openreview.net/pdf?id=E8adS5srd

🌐 **Project Page:**
anchored-diffusion-llm.github.io

💻 **Source Code:**
github.com/LituRout/ADLM