AMD × Hugging Face

Deploying Optimized LLMs on AMD GPUs

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AI Group at AMD

AMD
together we advance_

Agenda

1. AMD Software and hardware for LLMs
2. LLM inference challenges and optimization directions
3. Commercial LLM serving deployment with Hugging Face
4. (Demo) Running Llama 3.1-405B
5. Useful AMD ROCm™ software resources & call for contributions
6. QA

AMD Software abstraction for LLMs

LLM libraries and toolkits 🤗 vLLM

PyTorch · TensorFlow · ONNX · Triton · deepspeed · OpenXLA

Ecosystem

Libraries

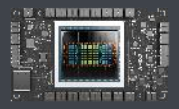
Compilers and Tools

Runtime

AMD AI Software

AMD ROCm

AMD GPUs



AMD Instinct™ Accelerators

AMD Radeon™ Graphics

AMD compute platforms

AMD Instinct™ Platform

Leading Memory and Competitive AI Performance to Power Generative AI Workloads

8x AMD Instinct™ MI300X Accelerators

AMD Instinct™ MI300X Platform

1.5 TB HBM3 memory	10.4 PF FP16 / BF16 FLOPS
896 GB/s Aggregate bi-directional bandwidth	448 GB/s Single node ring bandwidth
Up to 400 GbE NIC / GPU	PCIe® Gen 5 128 GB/s

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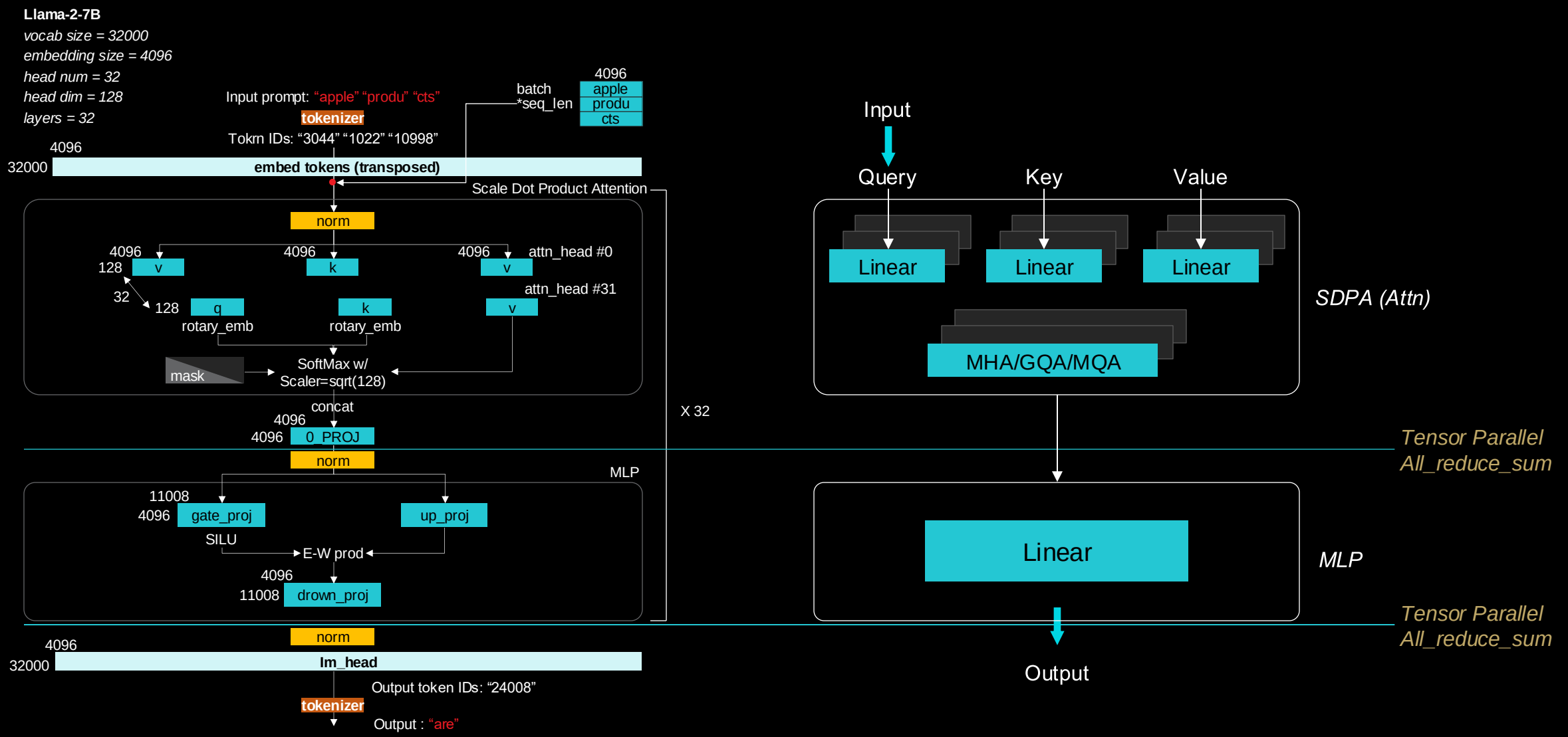
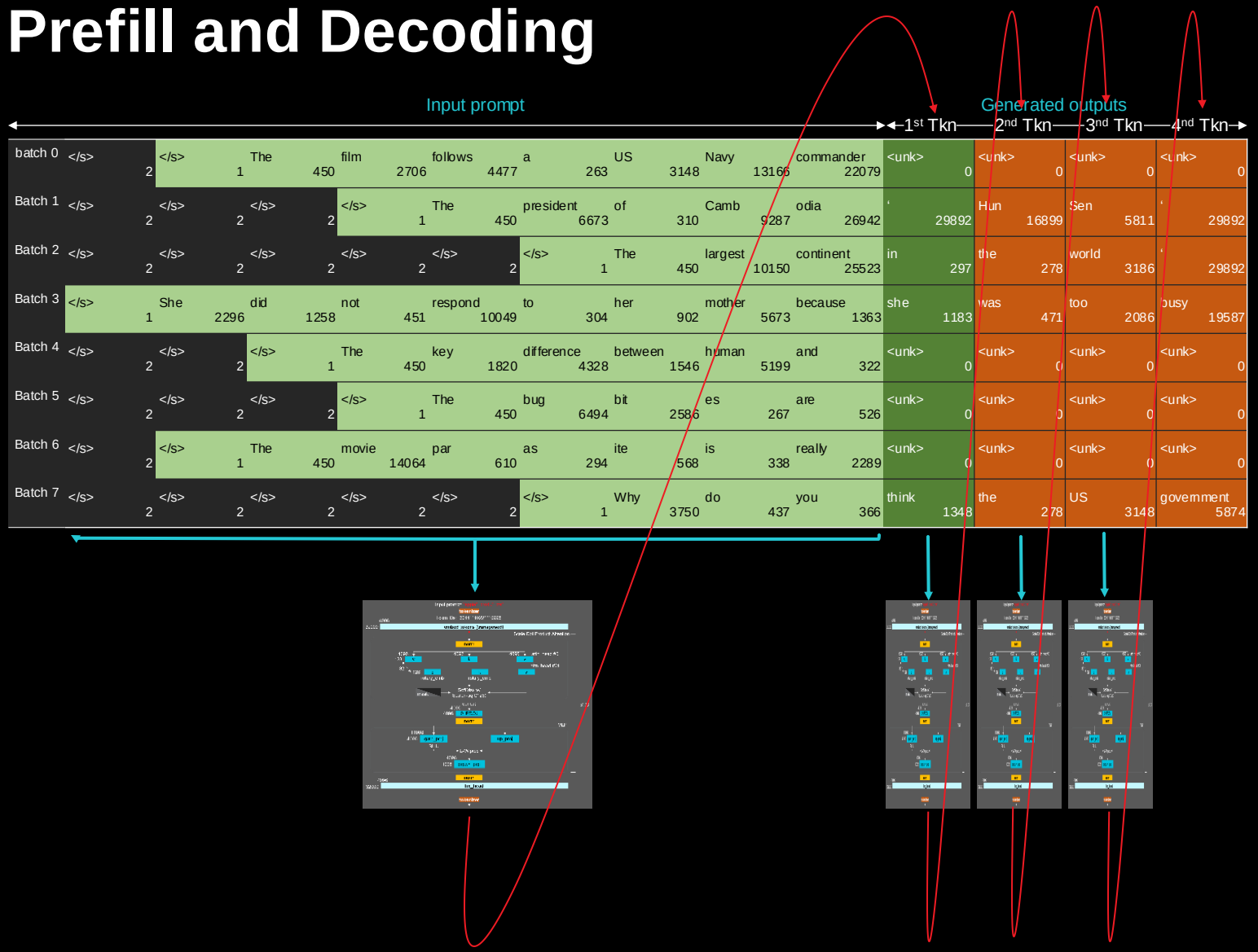
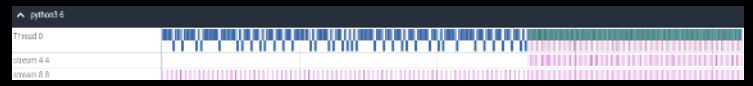
Typical LLM Model Architecture: Llama 7B



Prefill and Decoding



QWEN 1.5 110B, TP4, BS16, IN2048, OUT128



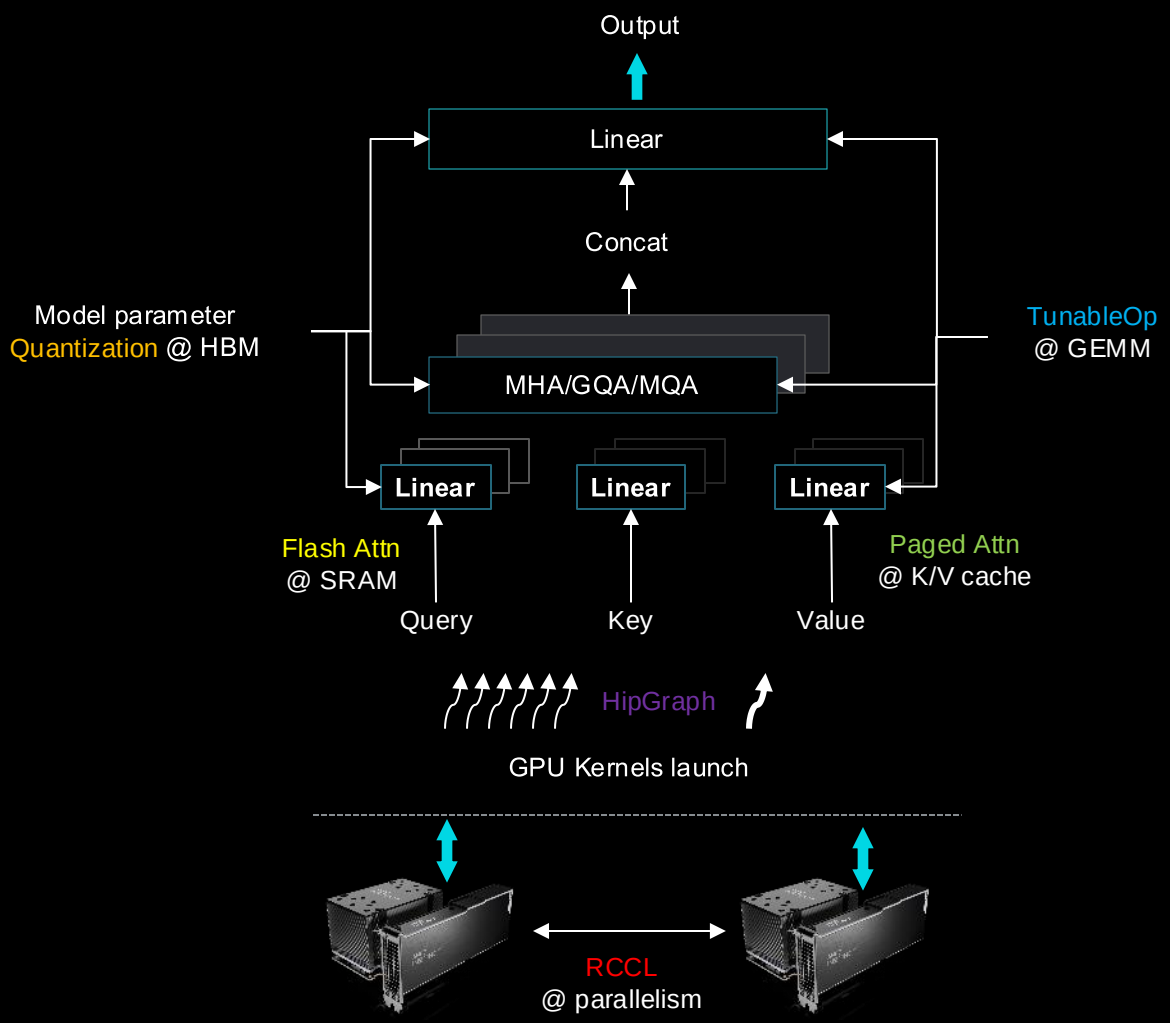
PREFILL
1 token x 80 layers

Compute-bound
(Large GeMM)

DECODING
128 tokens
x 80 layers/token

Memory-bound
(Tall&Skinny
GeMM)

Typical LLM Inference Optimizations



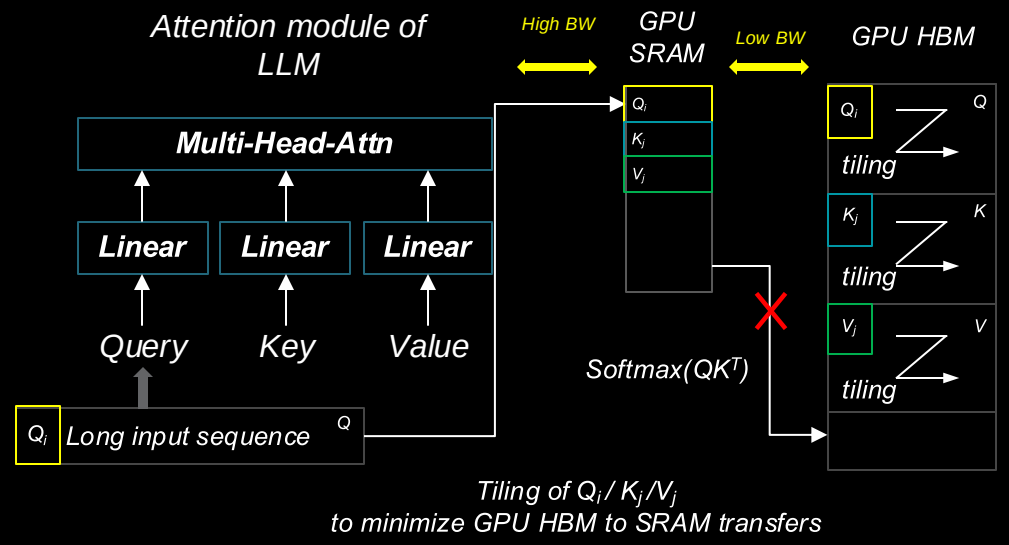
Flash Attention, Xformers	• Tiling of input sequence in GPU SRAM to reduce HBM data movement
Paged Attention	• Partitioned KV cache into fixed size blocks to reduce memory usage
GEMM Optimization – PyTorch TunableOp	• Automatic selection of the best performing GEMM kernels
Graph Optimization – HipGraph	• Launch multiple kernels through a single CPU operation
Collective communication – RCCL	• Collective Ops across multiple devices to support Tensor/ Pipeline parallel
Quantization – GPTQ, Bitsandbytes	• Weight-only compression to reduce HBM memory footprint

Prefill Optimization – Flash Attention

Algorithm Description

- Tiling of Attention Q/K/V to smaller blocks to minimize GPU HBM to SRAM transfers
- Fused computation of partial $Q_i K_j V_j$ to prevent frequent partial *Softmax(QK^T)* writeback to GPU HBM
- Takeaway: **Lower prefill latency**. Most effective for long and large batch sequences

$$Attention(Q,K,V) = softmax(\frac{QK^T}{\sqrt{d_k}})V$$



Basic Usage

1 Install AMD ROCm™ flash attention

```
git clone https://github.com/ROCm/flash-attention
```

2 Utilize FAv2 with Hugging Face transformers Lib

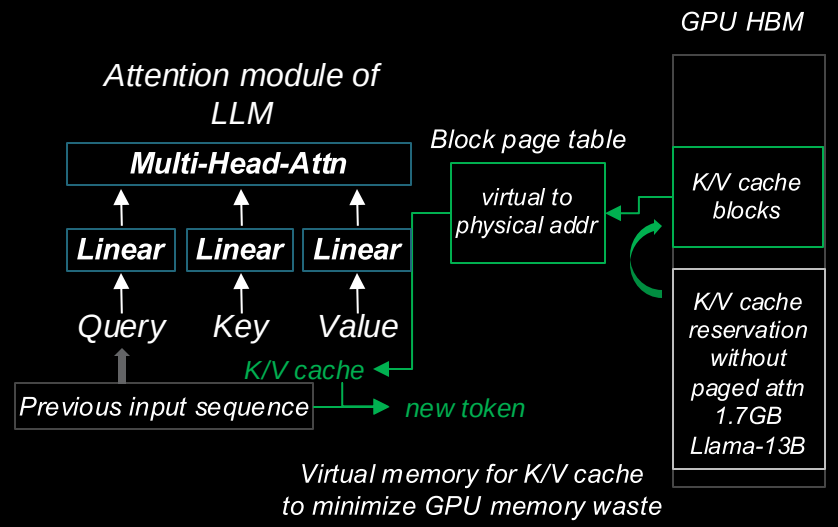
```
import torch
from transformers import AutoModelForCausalLM, AutoTokenizer
model = AutoModelForCausalLM.from_pretrained(model_name, torch_dtype=torch.float16, attn_implementation="flash_attention_2")
```

3 Leverage vLLM or Hugging Face TGI LLM serving framework

Decode Optimization – Paged Attention

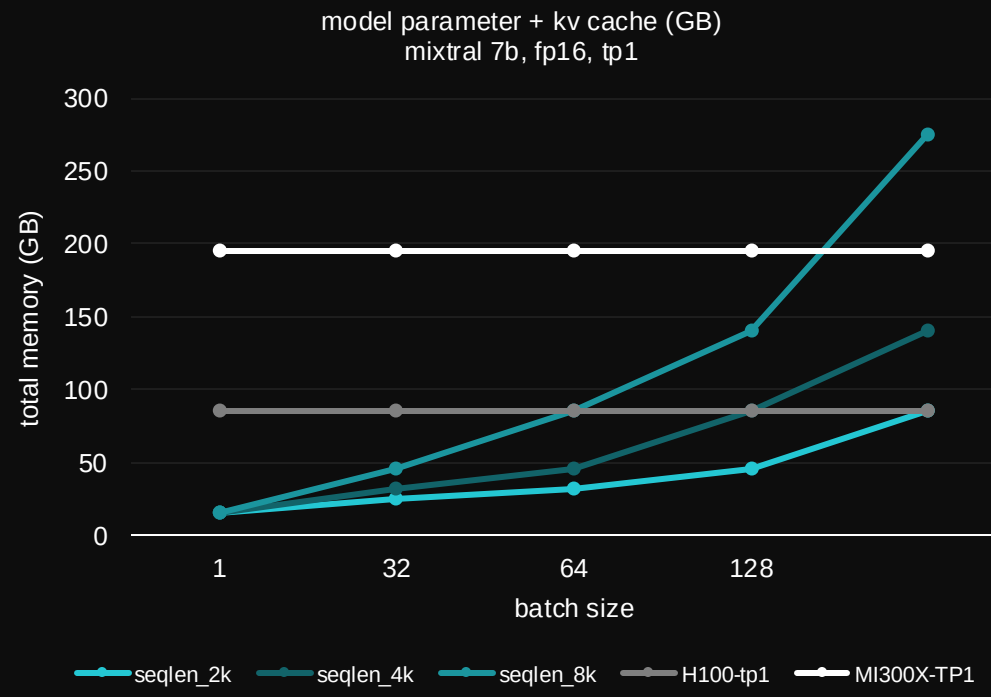
Algorithm Description

- Virtual memory of K/V cache into fixed size blocks to prevent memory waste for dynamic requests
- Parallel accessing (batch & beam search) to K/V cache blocks enables memory sharing
- Takeaway: **Higher output decoding throughput.** Near optimal GPU memory usage



Basic Usage

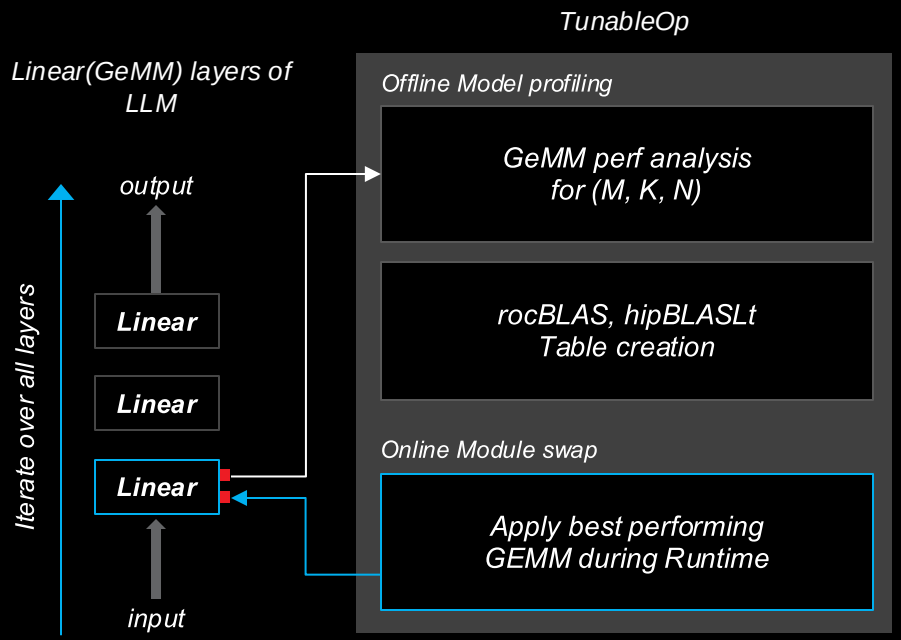
1 Leverage vLLM or Huggingface TGI LLM serving framework



Prefill / Decode Optimization – PyTorch TunableOp

Approach:

- Pick the best performing BLAS algorithms in the GEMM (M, K, N) search space
- Exclusively available in the AMD ROCm™ software
- Takeaway: **Additional GeMM performance gain**



Basic Usage

1 Available on the latest rocm-pytorch stable/nightly

Just turn on env var.

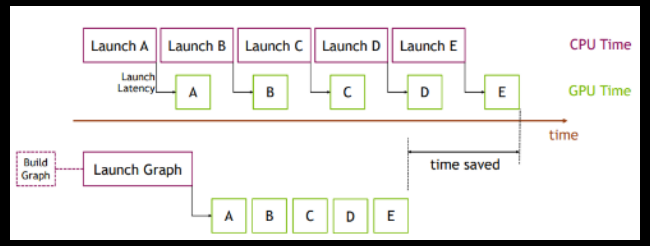
```
export PYTORCH_TUNALBEOP_ENABLED=1
```

https://rocm.blogs.amd.com/artificial-intelligence/pytorch-tunableop/README.html

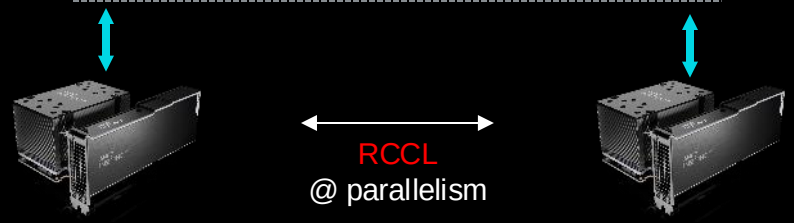
Decode Optimization – HIP Graph

Approach:

- Aggregate multiple kernels in a single graph and launch together
- Refer to this: https://pytorch.org/blog/accelerating-pytorch-with-cuda-graphs/
- Takeaway: **better output decoding performance** due to less asynchronous kernel launch from each GPU

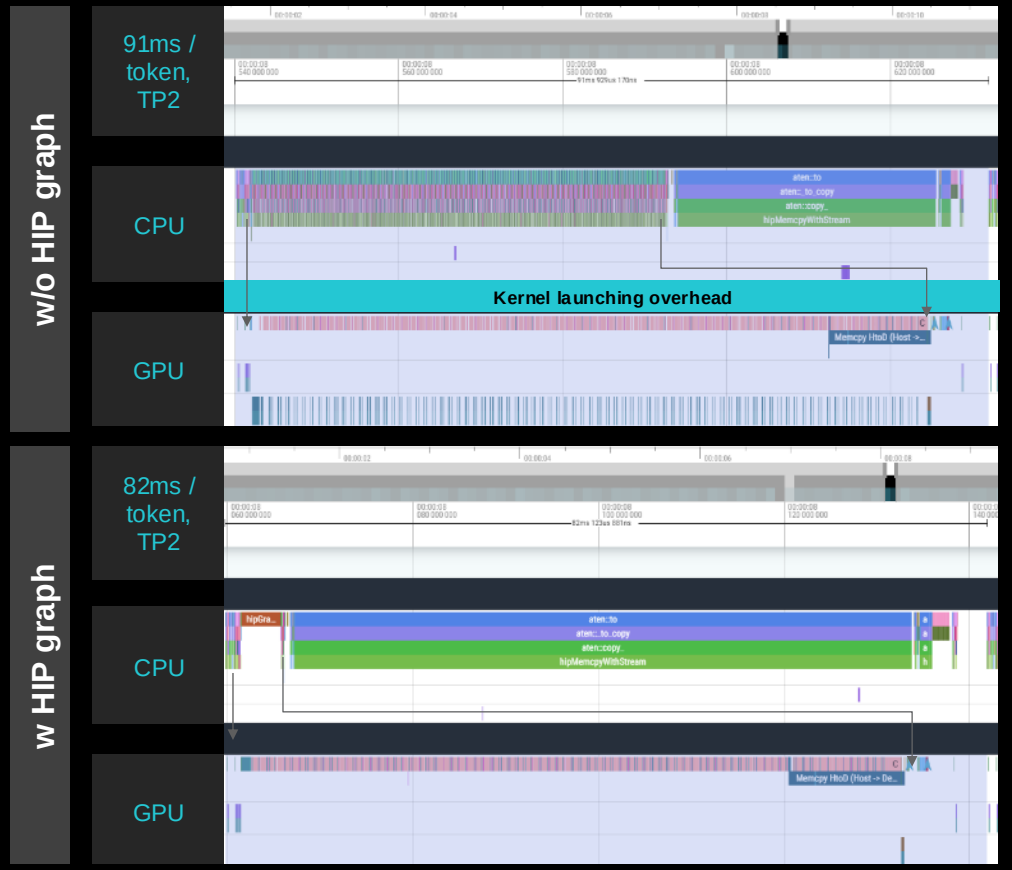


GPU Kernels launch



https://pytorch.org/blog/accelerating-pytorch-with-cuda-graphs

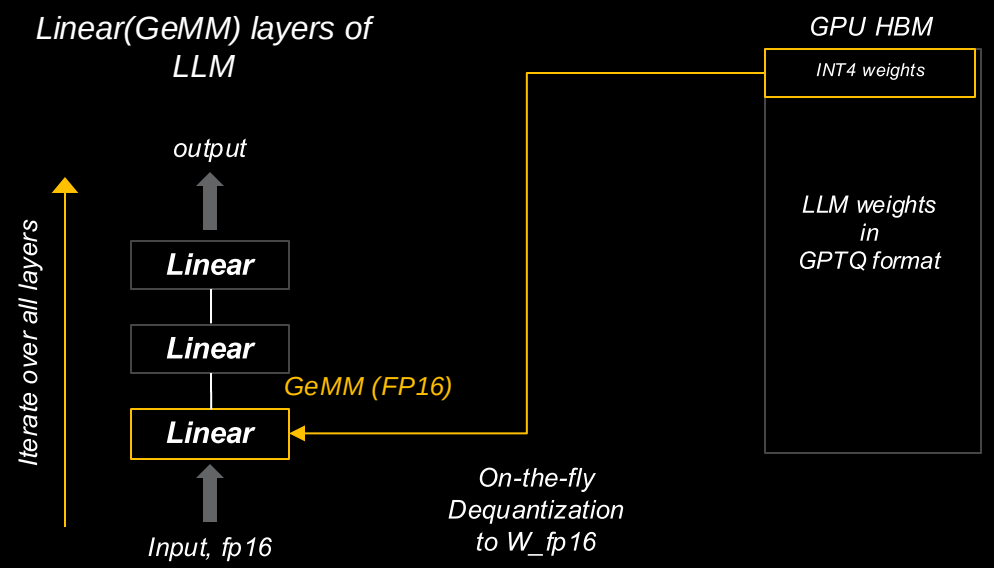
Behavior



Quantization - GPTQ / AWQ

Weights-only quantization to compress large LLMs to INT2, 3 or 4 bits (W4A16) in GPU HBM

Takeaway: **4x lower GPU memory consumption** (INT4), Minor perplexity degradation



Basic Usage

1. AutoGPTQ (install) — https://github.com/AutoGPTQ/AutoGPTQ

2. AutoAWQ & Kernel (install) — https://github.com/casper-hansen/AutoAWQ
https://github.com/casper-hansen/AutoAWQ_kernels
Dependency BNB: https://github.com/ROCm/bitsandbytes

3. Huggingface Transformers lib

```
from transformers import AutoModelForCausalLM, AutoTokenizer, GPTQConfig, AwqConfig
quant_config = GPTQConfig(bits=4, use_exllama=True, version=2)
quant_config = AwqConfig(version="exllama")
model = AutoModelForCausalLM.from_pretrained(model_name, torch_dtype=torch.float16, attn_implementation="eager", device_map=device, quantization_config=quant_config)
```

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Commercial LLM Serving Deployment with Hugging Face

Out-of-the-box optimized LLM inference on the MI300X accelerator

Text Generation Inference (TGI)

DOCs	https://huggingface.co/docs/text-generation-inference/en/index
Git	https://github.com/huggingface/text-generation-inference

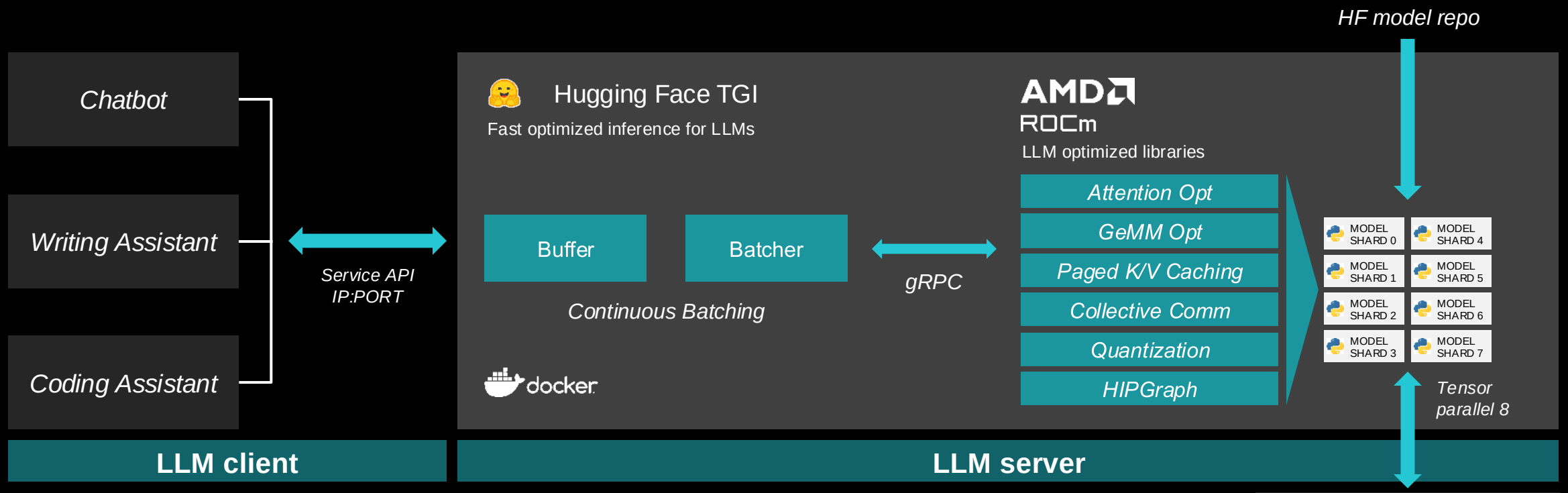
vLLM

DOCs	https://docs.vllm.ai/en/latest/index.html
Upstream Git	https://github.com/vllm-project/vllm
ROCm/vllm Git	https://github.com/ROCm/vllm

AMD Infinity Hub	https://www.amd.com/en/developer/resources/infinity-hub.html#f-amd_hub_category=AI%20%26%20ML%20Frameworks
ROCm/vllm docker	*docker pull rocm/vllm:rocm6.2_mi300_ubuntu22.04_py3.9_vllm_7c5fd50*
ROCm/vllm benchmark	https://github.com/ROCm/MAD/blob/develop/benchmark/vllm/README.md

Hugging Face Text Generation Inference (TGI)

Overall architecture



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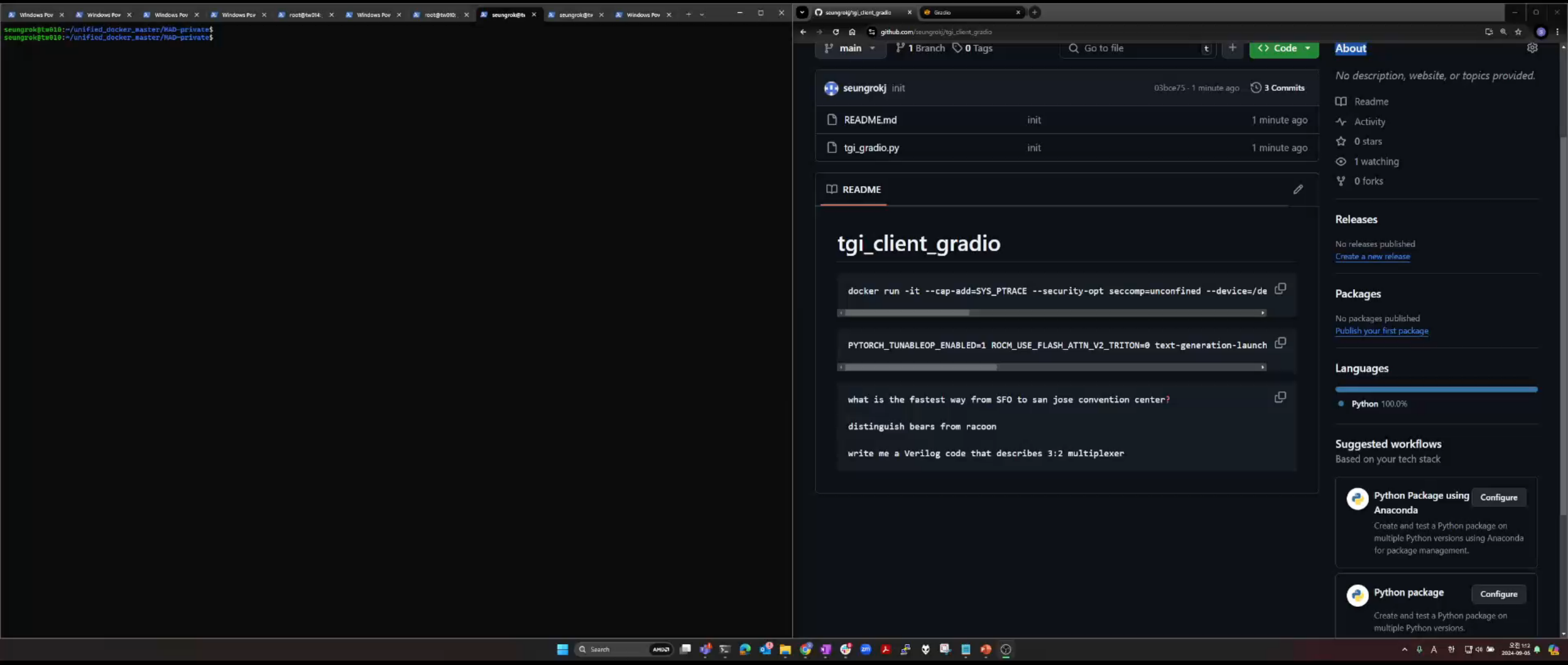
seungrok@tw010:~/unified_docker_master/MAD-private$
seungrok@tw010:~/unified_docker_master/MAD-private$
seungrokj/tgi_client_gradio
Gradio
github.com/seungrokj/tgi_client_gradio
main
1 Branch
0 Tags
Go to file
Code
About
No description, website, or topics provided.
Readme
Activity
0 stars
1 watching
0 forks
seungrokj init
03bce75 · 1 minute ago
3 Commits
README.md
init
1 minute ago
tgi_gradio.py
init
1 minute ago
README
tgi_client_gradio
docker run -it --cap-add=SYS_PTRACE --security-opt seccomp=unconfined --device=/de
PYTORCH_TUNABLEOP_ENABLED=1 ROCM_USE_FLASH_ATTN_V2_TRITON=0 text-generation-launch
what is the fastest way from SFO to san jose convention center?
distinguish bears from racoon
write me a Verilog code that describes 3:2 multiplexer
Releases
No releases published
Create a new release
Packages
No packages published
Publish your first package
Languages
Python 100.0%
Suggested workflows
Based on your tech stack
Python Package using Anaconda
Configure
Create and test a Python package on multiple Python versions using Anaconda for package management.
Python package
Configure
Create and test a Python package on multiple Python versions.

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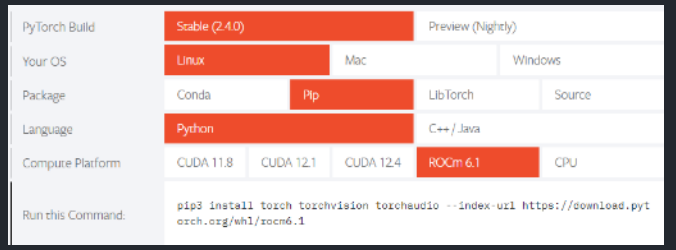
AMD ROCm™ Software Resources

AMD ROCm™ Software Documentation (6.2 is the latest)	• https://rocm.docs.amd.com/en/latest/
Ubuntu Dockers (ubuntu20.04, ubuntu22.04)	• https://hub.docker.com/r/rocm/dev-ubuntu-20.04/tags • https://hub.docker.com/r/rocm/dev-ubuntu-22.04/tags
Ubuntu pyTorch Dockers (ubuntu20.04, ubuntu22.04, CentOS 7 + torch2.1.2)	• https://hub.docker.com/r/rocm/pytorch/tags
pyTorch	• https://pytorch.org • 2.4.0 stable / 2.5.0 nightly



Join the Community and Contribute

ROCm™ Software Blog	• https://rocm.blogs.amd.com/blog.html
AMD Community AI Blog	• https://community.amd.com/t5/ai/bg-p/amd-ai
AMD and Hugging Face Collaboration	• https://huggingface.co/blog/huggingface-and-optimum-amd • https://huggingface.co/blog/huggingface-mi300-amd
AMD Specific LLM Acceleration Libraries	• [flash attention v2] https://github.com/ROCm/flash-attention • [open-ai triton] https://github.com/ROCm/triton • [vllm] https://github.com/ROCm/vllm • [xformers] https://github.com/ROCm/xformers • [hipBLASLt] https://github.com/ROCm/hipBLASLt • [rocBLAS] https://github.com/ROCm/rocBLAS • [composable kernel] https://github.com/ROCm/composable_kernel

Conclusion

AMD Instinct™ MI300 accelerators

Leading Memory and Competitive AI Performance to Power Generative AI

LLM Inference Challenges and Optimization Opportunities

Different techniques required to optimized performance

Running Llama 3.1-405B with Hugging Face text generation inference

Similar development flow compared to CUDA. Easy to develop LLMs.

Try Today

vLLM | AMD INSTINCT

Download vLLM toolkit

First publicly available, pre-optimized, QAed docker image for AMD Instinct MI300X accelerator.

Build your AI Models on the AMD Developer Cloud

Apply for access to AMD Instinct™ accelerators

Q & A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