




# Big Data and Machine Learning on Virtual Graphics Processing Units



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# CLOUDUT Project

- **Titlu:** Cloud Cercetare UTCN – CLOUDUT (http://cloudut.utcluj.ro)
- **MySMIS ID:** 124493
- **Contract nr:** 235/ 21.04.2020
- **Tip Proiect:** Program Operațional Competitivitate 2014-2020 (POC)
- **Axa prioritara 1**: Cercetare, dezvoltare tehnologică și inovare (CDI) în sprijinul competitivității economice și dezvoltării afacerilor
- Acțiunea 1.1.2: Dezvoltarea unor rețele de centre CD, coordonate la nivel național și racordate la rețele europene și internaționale de profil și asigurarea accesului cercetătorilor la publicații științifice și baze de date europene și internaționale
- **Finanțare:** Fonduri Europene pentru Dezvoltare Regională, Valoarea totală: 4.955.000 RON, din care 4.950.000 RON din fonduri Europene.

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# Welcome to the Era of AI


Deep Learning is Everywhere [7]

# Cloud Infrastructure

Minimum requirements:

- 20 x 16 core CPU processors, 2GHz, support for VMWare virtualization and hyperthreading
- 2 AI processing servers. Each server is equipped with 2 x 20 core processors, 512GB RAM, 1TB storage, 2 x GPUs with 640 tensor cores, 32 GB, support for virtualization
- 16GB RAM per CPU core, storing capacity 70TB, RAID 5
- 25Gbps internal and external connectivity

# Cloud Infrastructure

- 2 x Dell Poweredge R740 servers
  - (each with) 2 x NVIDIA V100 GPUs, 32 GB


Dell Poweredge R740 [6]

Optimized for workload acceleration

Optimized for AI and GPGPU Computing

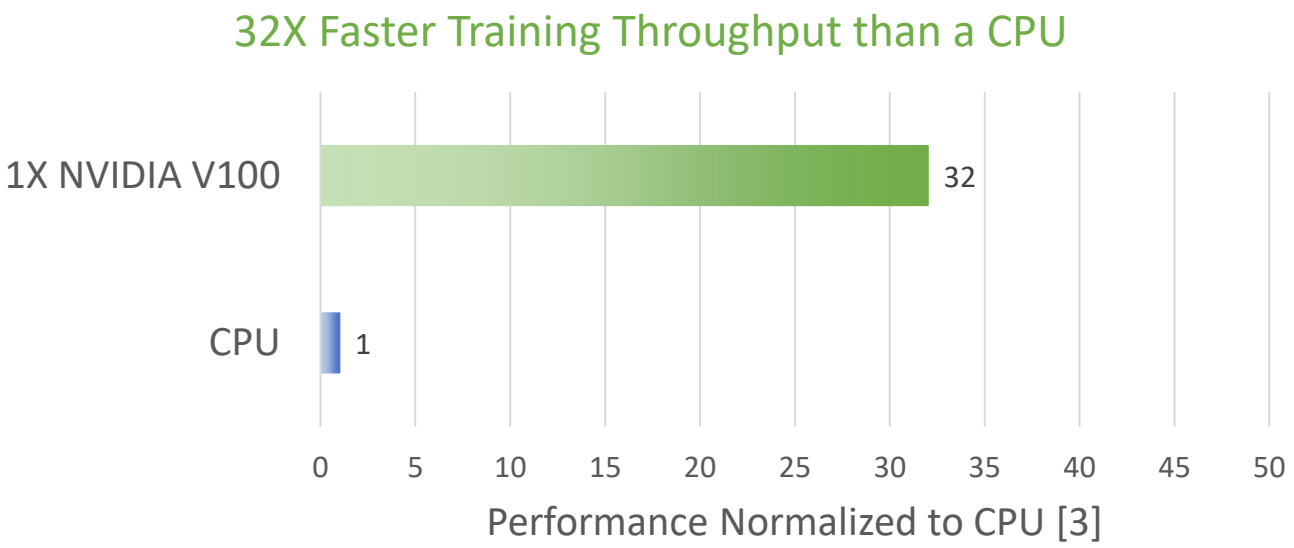

NVIDIA V100 (PCIe) [1]

# NVIDIA V100 – Specifications

| Specification | V100 PCIe | V100 SXM2 | V100S PCIe |
|---|---|---|---|
| GPU Architecture | NVIDIA Volta | | |
| NVIDIA Tensor Cores | 640 | | |
| NVIDIA CUDA Cores | 5120 | | |
| Double-precision Performance | 7 TFLOPS | 7.8 TFLOPS | 8.2 TFLOPS |
| Single-precision Performance | 14 TFLOPS | 17.7 TFLOPS | 16.4 TFLOPS |
| Tensor Performance | 112 TFLOPS | 125 TFLOPS | 130 TFLOPS |
| GPU Memory | 32 GB / 16 GB HBM2 | | 32 GB HBM2 |
| Memory Bandwidth | 900 GB/sec | | 1134 GB/sec |
| Compute APIs | CUDA, DirectCompute, OpenCL, OpenACC | | |

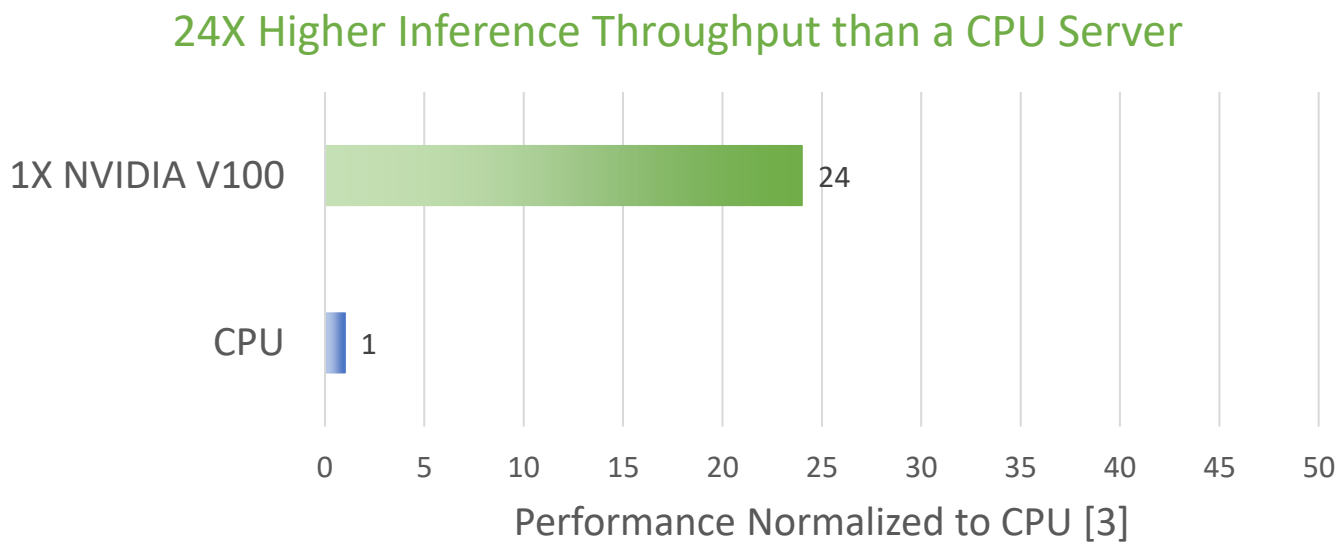
NVIDIA V100 Specifications [3]

# NVIDIA V100 – Acceleration




ResNet-50 training, dataset: ImageNet2012, BS=256 | NVIDIA V100 comparison: NVIDIA DGX-2™ server, 1x V100 SXM3-32GB, MXNet 1.5.1, container=19.11-py3, mixed precision, throughput: 1,525 images/sec | Intel comparison: Supermicro SYS-1029GQ-TRT, 1 socket Intel Gold 6240@2GHz/3.9Hz Turbo, Tensorflow 0.18, FP32 (only precision available), throughput: 48 images/sec [3]

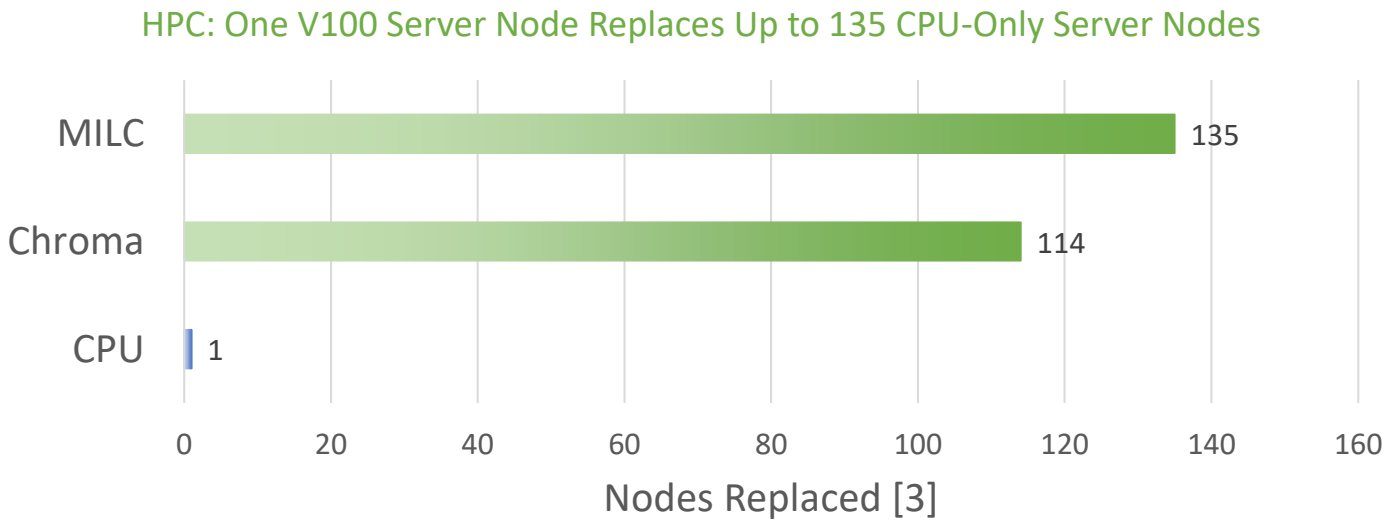
# NVIDIA V100 – Acceleration




BERT Base fine-tuning inference, dataset: SQuADv1.1, BS=1, sequence length=128 | NVIDIA V100 comparison: Supermicro SYS4029GP-TRT, 1x V100-PCIE-16GB, pre-release container, mixed precision, NVIDIA TensorRT™ 6.0, throughput: 557 sentences/sec | Intel comparison: 1 socket Intel Gold 6240@2.6GHz/3.9Hz Turbo, FP32 (only precision available), OpenVINO MKL-DNN v0.18, throughput: 23.5 sentences/sec [3]

More details regarding Deep Learning Performance -
https://developer.nvidia.com/deep-learning-performance-training-inference

# NVIDIA V100 – Acceleration




16x V100-SXM2-32GB in NVIDIA HGX-2™ | Application (dataset): MILC (APEX Medium) and Chroma (szscl21_24_128) | CPU server: dual-socket Intel Xeon Platinum 8280 (Cascade Lake) [3]

More details regarding HPC Performance -
https://developer.nvidia.com/hpc-application-performance

# NVIDIA V100 – DL and HPC

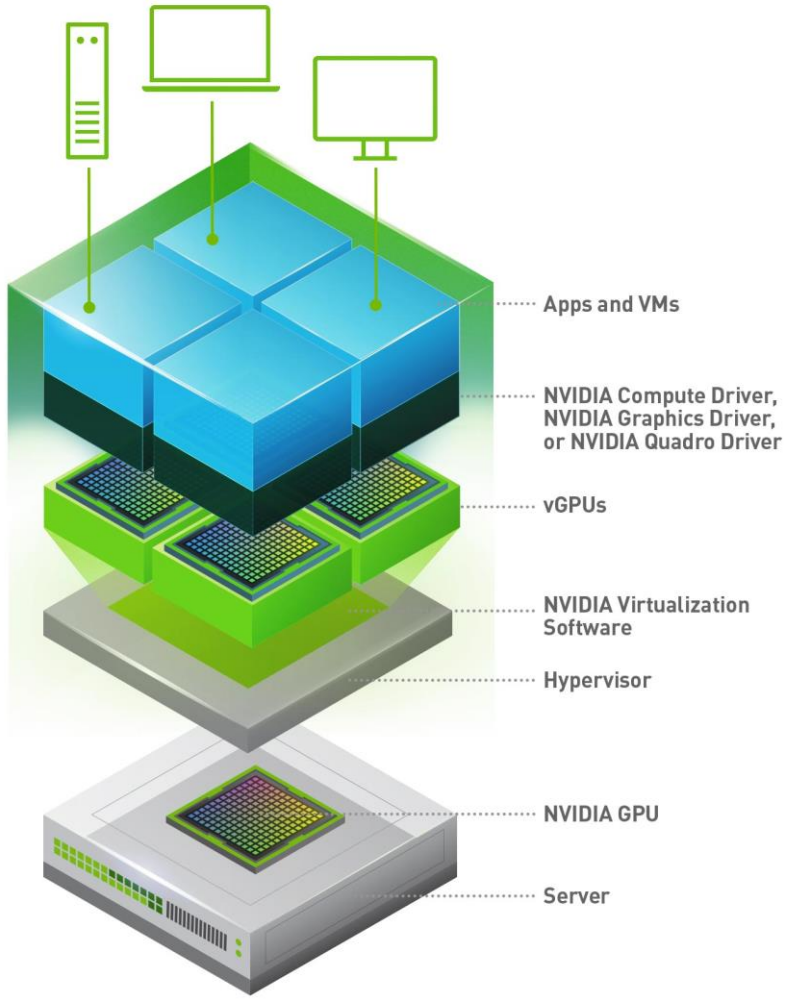
- Compatible with the most popular Deep Learning frameworks and with 600+ HPC applications [3]





Caffe2

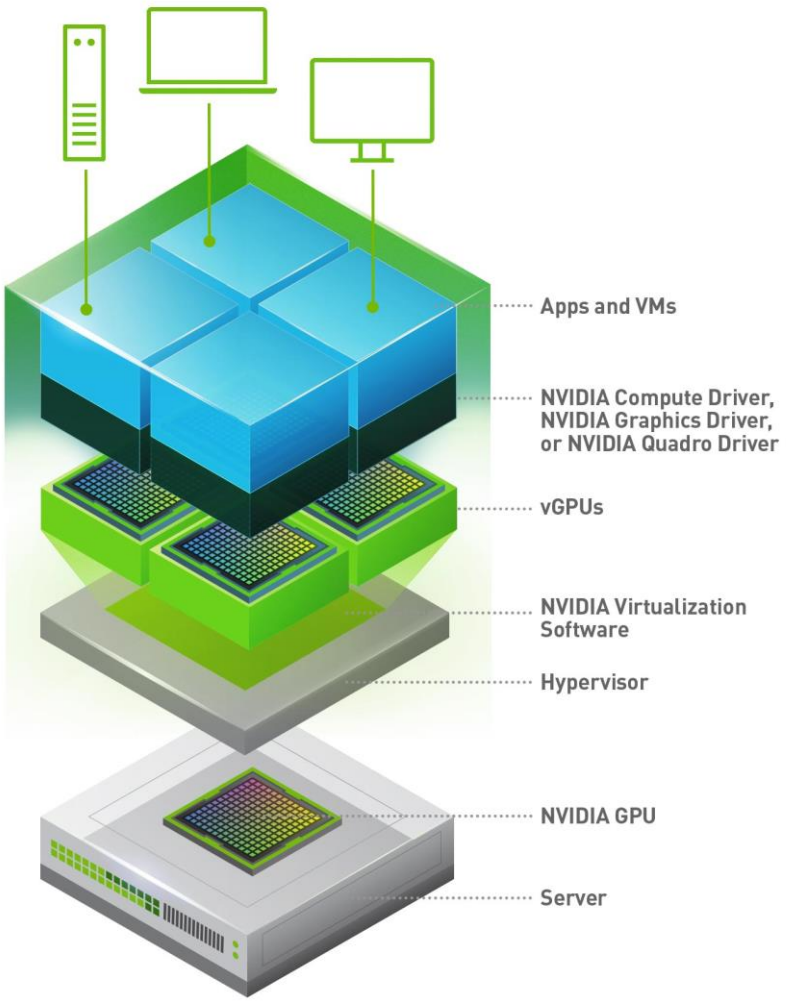
# NVIDIA V100 – Virtualization



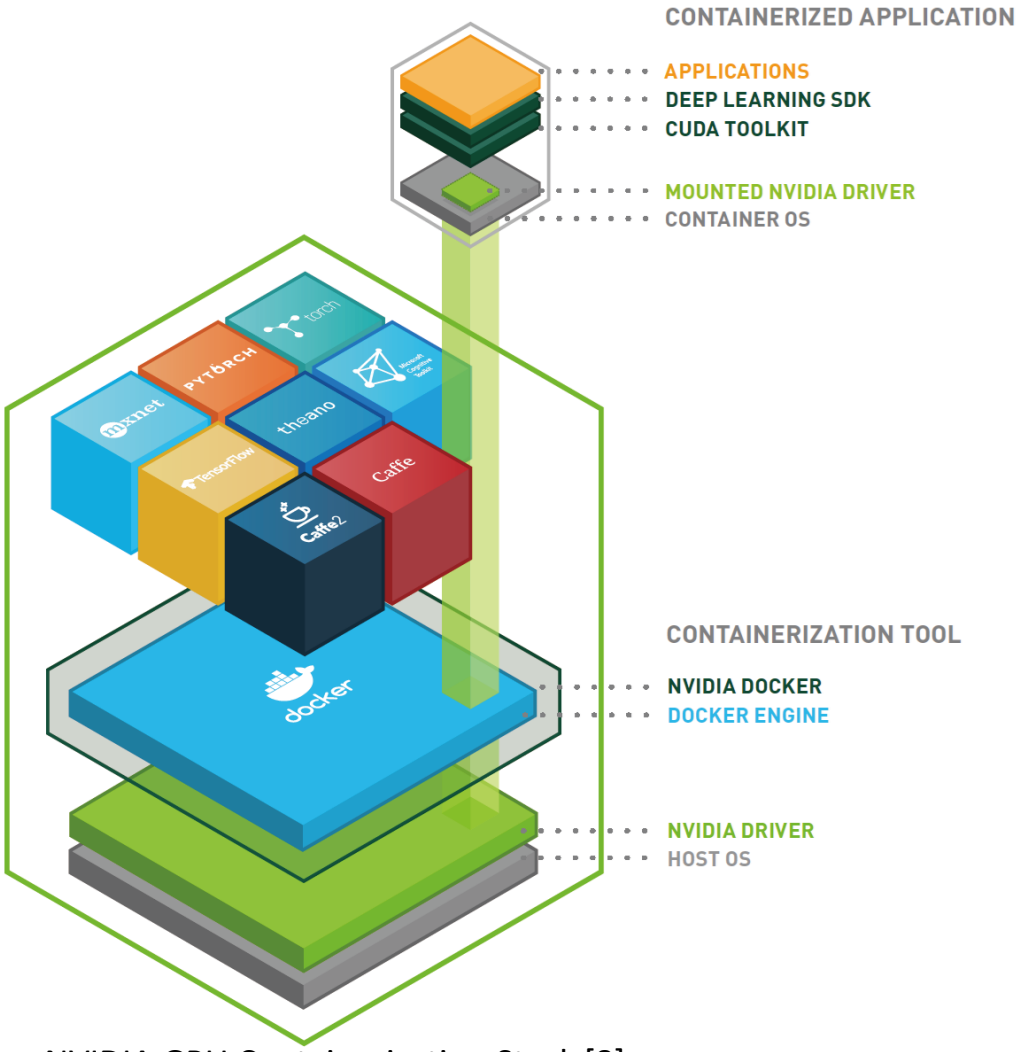

NVIDIA GPU Virtualization Stack [4]

- GPU Virtualization
- NVIDIA Virtual GPU Software Solutions
  - NVIDIA GRID (Virtual PC (GRID vPC) and Virtual Apps (GRID vApps)) (VDI)
  - NVIDIA Quadro Virtual Workstation (Graphics Processing)
  - NVIDIA Virtual Compute Server (Virtualization for complex AI and Compute tasks)

# Virtualization vs. Containerization



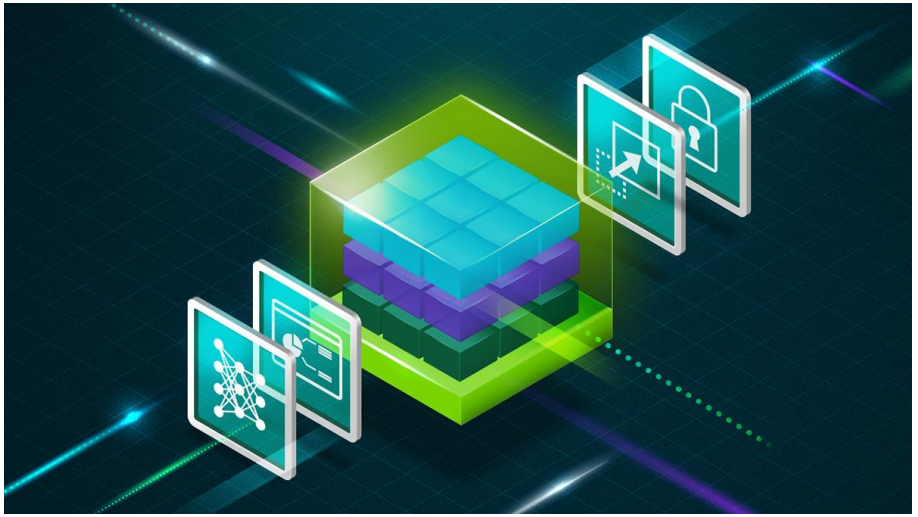

NVIDIA GPU Virtualization Stack [4]




NVIDIA GPU Containerization Stack [8]

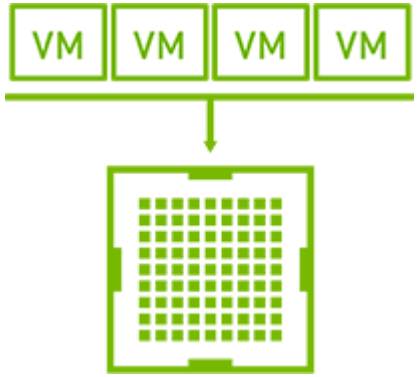
# NVIDIA Virtual Compute Server

- Software solution to virtualize computation for AI, Deep Learning, and Data Science
  - Artificial Intelligence
  - Deep Learning
  - Data science
  - High Performance Computing



NVIDIA Virtual Compute Server [5]

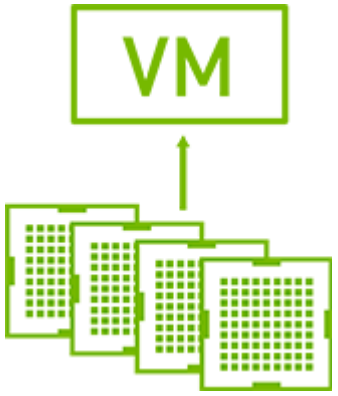
# NVIDIA Virtual Compute Server




GPU Sharing [5]

- GPU Sharing
  - Fractional GPU sharing with NVIDIA vGPU technology
  - Multiple VMs sharing the same GPU
  - Maximizing utilization

- GPU Aggregation
  - A VM can access more than one GPU
  - Multi GPU Computing – GPUs aren't directly interconnected
  - Peer-to-peer Computing – GPUs are interconnected through NVLink for higher bandwidth




GPU Aggregation [5]

# NVIDIA Virtual Compute Server

Management and Monitoring [5]

- Management and Monitoring
  - Support for app-, guest-, and host-level monitoring
  - Live VM migration
  - Suspend, resume, thresholds

- Multi-Instance GPU
  - Specific for NVIDIA A100 Tensor Core GPU
  - Partitioning the cores into up to seven instances
  - Provisioning a VM on an instance

Multi-Instance GPU [5]

# Conclusions

- GPUs – enormous potential for accelerating AI and GPGPU Computation
- GPU Virtualization – Maximum flexibility
- NVIDIA vGPU Software Solutions
  - NVIDIA Virtual Compute Server – AI and GPGPU Compute Tasks
  - GPU Sharing – Maximize utilization
  - GPU Aggregation – Flexible Multi GPU Computing

# References


[1] NVIDIA, "NVIDIA V100 Tensor Core GPU," 2020. [Online]. Available: https://www.nvidia.com/en-us/data-center/v100/.

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# Thank you for your attention!



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